CSIR-CMERI Annual Report 2016-17

CSIR-CENTRAL MECHANICAL ENGINEERING RESEARCH INSTITUTE
DURGAPUR

वार्षिक प्रतिवेदन
Annual Report
2016-2017

CSIR-CMERI

सी. एस. आई. आर. – केंद्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान, दुर्गापुर

CSIR-Central Mechanical Engineering Research Institute, Durgapur

About CSIR-CMERI

As a constituent member under the Council of Scientific & Industrial Research, the ambit of CSIR-Central Mechanical Engineering Research Institute, Durgapur-a premier establishment of national standing dedicated to research and development - extends over the broad spectrum of mechanical engineering as also allied and advanced disciplines of science and technology.

The Institute has a dedicated team with a rich blend of expertise, excellence and experience in different domains of engineering and science.

Besides conducting frontline research in varied areas, the Institute dedicates its R&D efforts towards different mission mode programmes to disseminate appropriate technological solutions for poverty alleviation, societal improvement, energy security, food security, aerospace, defence, etc.

CSIR-CMERI has developed many products and processes, a number of which have been commercially exploited through licensees. The institute is also the recipient of many prestigious national awards. Its team of qualified professionals and support staff is well balanced in terms of youth and experience, and can be compared to the very best in the country.

Thrust Areas

Agriculture Machinery, Energy and Environment, Engineering Design and Analysis, Industrial and Technical Consultancy, Manufacturing and Material Processing, Mechatronics, Robotics and Automation

Mission

- To research and develop cost effective and value added technologies in mechanical engineering and allied domains.
- Contribute significantly to national skill development initiatives for sustainable empowerment

Vision

To be a global R&D institute having confidence of industries and visibility to society in mechanical engineering sciences and technologies.

Mandate of the laboratory

- Carrying out research and development in relevant areas of national priority as evolved by bodies concerned with the overall planning for science and technology in the country
- Undertaking R&D sponsored by public / private sector industries in consonance with national priorities
- Undertaking R&D directed towards continuous improvement of indigenous technology
- Undertaking R&D for evolving new technologies relevant to the country's social, economic and industrial needs in keeping with national objective of self-reliance
- Undertaking R&D on appropriate and alternate technologies, with emphasis on the use of local resources
- Ensuring continuous flow of finance and resources through extension of R&D services for fostering basic research at the institutional level
- Undertaking activities focused towards fast translation of laboratory level technologies to commercial entities through proper nurturing and marketing
- Undertaking on a routine basis efforts for identification of R&D requirements of industries for rapid intervention through the extension of R&D services

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From the desk of the Director

This past one year CSIR-CMERI has attempted to apply its accumulated research experience in Mechanical Engineering and allied fields in solving issues faced by the common man and in uplifting social lifestyle. A number of products— the iron removal plant, the fluoride detection kit, the solar tree, a biogas plant based on kitchen waste, among others—emerged as a result. The iron removal plant, for example, is a basic necessity since as many as twenty-two states in India have iron-contaminated groundwater. The iron removal plant designed and developed at the institute has been demonstrated in the groundwater-iron affected areas of the Bankura district of West Bengal. These products have been well received by the people in need of them. The growing population of the country requires energy to sustain itself, and the depleting sources of fossil fuel have motivated mankind to look elsewhere—to the sun and wind, for example—for clean and renewable energy. The solar artefact designed at our institute has been deployed in open areas to harness the energy freely available in the sunlight. Efforts are on to derive its aesthetically pleasing variations. It is important to continue this trend, and scientists must look to find newer ways to convert science into technological gains and ultimately to societal benefits. It is indeed heartening to note this integration of scientific knowledge with the society at large. However, a research laboratory of the size of CSIR-CMERI cannot afford to deploy its entire strength in this direction alone. As part of the five-year plan projects of the past, scientists have gathered knowledge and knowhow in a number of areas such as Robotics, Micro- and Nano-System Technology, Surface Engineering, Manufacturing, Embedded Electronics, Drives and Controls, Mechanical Design of machinery and components such as valves and various line replacement units related to the aerospace industry etc. This vast knowledge and the pool of talented manpower at our disposal need to be carefully oriented and nurtured to maximize benefits. In recent times, an important development has been the indigenous development of the Autonomous Underwater Vehicle, which underwent sea trial at a depth of 500 m in the Arabian Sea, off the coast of Goa. Automation in land, sea and air has attracted large-scale research investments in recent times, and the development of the AUV-500, as the vehicle is known, is a good step forward. Our participation in the Facility for Antiproton and Ion Research (FAIR) project for development of beam-catchers is another exciting contribution. This is an international particle accelerator under construction in Germany, and scientists of CSIR-CMERI are engaged in the technologically challenging task of safely absorbing and dissipating particle energy in the beam catchers. There have been many more achievements, as the thickness of this report testifies.

While significant milestones have been achieved under various projects, as reported in the following pages, it is now time to ask ourselves a couple of important questions. Are we utilizing the available resources optimally to derive best returns of the investments made already? Is there a common connecting theme running through these apparently diverse fields of research? In our zeal to reach technological goals which are brought forward in different forums and which come under the purview of our institute, we should not lose sight of the bigger picture and end up as a conglomerate of loosely coupled groups pursuing very individualistic research targets and satisfied with the exhibition of scientific prowess. Members of our research community—be it within the institute, within CSIR or across the country—need to interact with each other more, to be familiar with each other's strengths and weaknesses so that researchers with complementary skills may be identified and put together to address the key technological challenges faced by our country.

Finally, we must acknowledge that there are many whose contributions do not find a direct mention within the bound pages of this volume. Not that every single effort by scientists to bring in external investment becomes fruitful. Numerous discussions, telephonic conversations, exchange of e-mails take place before a decision is taken to move ahead with a project or reject it altogether. The administrative and support staff, students and project fellows are silently active to help us achieve our targets. I acknowledge everyone involved, and urge the members of our community to move together as a team. CSIR-CMERI will continue to evolve to stay technologically relevant. As the older members of our family superannuate, newer faces are joining in. It is important that our past learning and our values—whatever we hold dear—are passed on to the newer generation with care. If we continue to learn, preserve our knowledge and face the new technological challenges united, we are certain to scale greater heights.

Prof. (Dr.) Harish Hirani
Director, CSIR-CMERI, Durgapur

निदेशक के कलम से

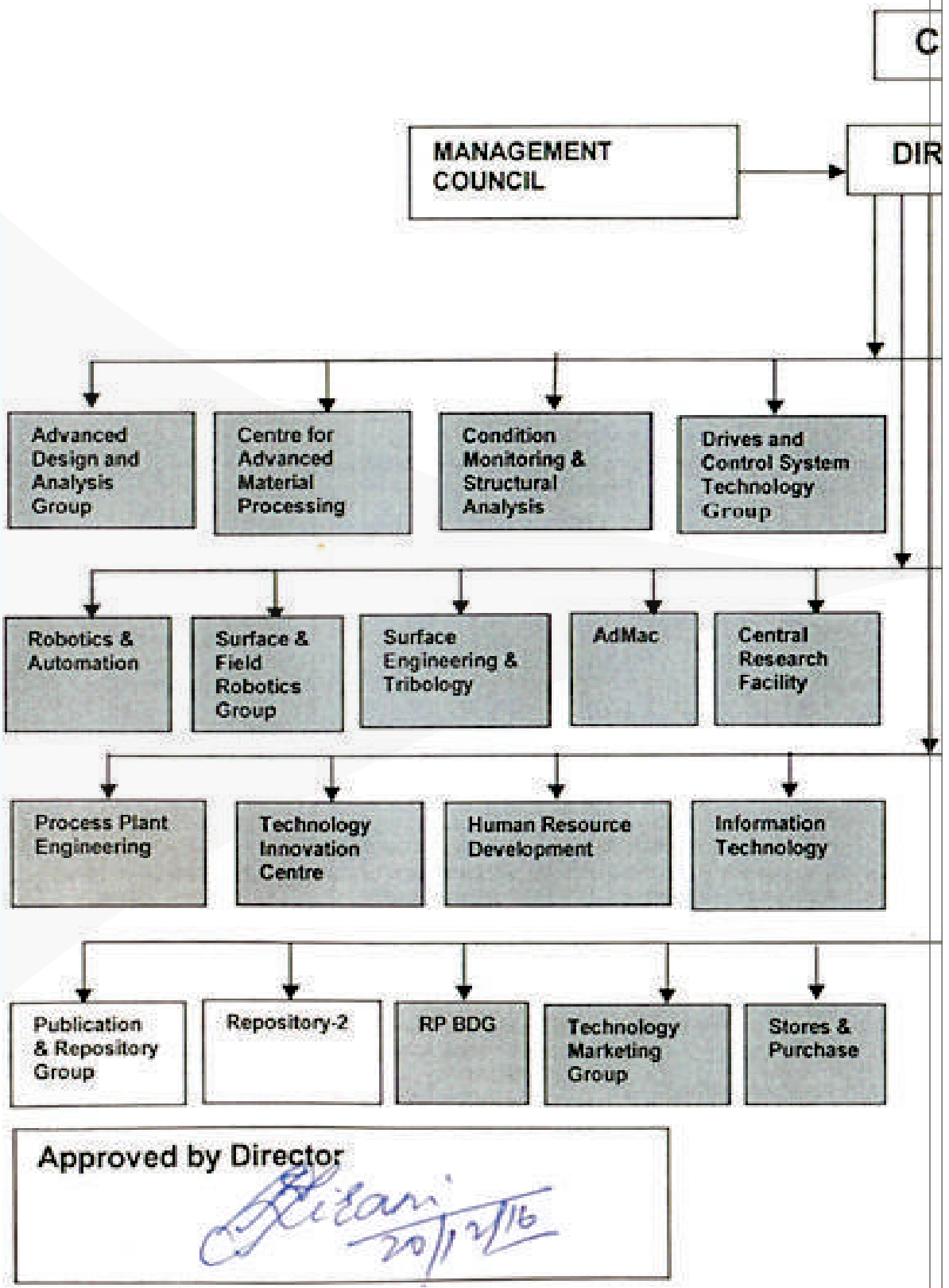
सीएसआईआर–सीएमईआरआई ने पिछले एक साल में आम आदमी के मुद्दों को हल करने और सामाजिक जीवन शैली का उत्थान करने के लिए यांत्रिक–अभियांत्रिकी और संबंधित क्षेत्रों में अपने संचित अनुसंधान–अनुभवों के उपयोग करने का प्रयास किया है। परिणामस्वरूप लौह निष्कासन संयंत्र, फ्लोराइड संसूचन किट, सौर वृक्ष, बायोगैस संयंत्र आधारित रसोई अपशिष्ट जैसे अनेकों उत्पाद उभरकर सामने आए। उदाहरण के लिए लौह निष्कासन संयंत्र एक बुनियादी आवश्यकता है क्योंकि भारत के बाइस राज्यों में लौह प्रदूषित भूजल है। संस्थान में डिजाइन और विकसित किए हुए लौह निष्कासन संयंत्र का प्रदर्शन पश्चिम बंगाल के बांकुड़ा जिले के लौह प्रभावित भूजल इलाकों में किया गया है। लोगों द्वारा उनकी अपनी जरूरत के मद्देनजर इन उत्पादों को बहुत उत्साह से अपनाया गया है। देश की बढ़ती आबादी के साथ–साथ ऊर्जा को बनाए रखने की आवश्यकता होती है और जीवाश्म ईंधन के घटते स्रोतों ने मानव को अन्यत्र भी सूर्य और पवन ऊर्जा जैसे स्वच्छ और नवीकरणीय ऊर्जा की खोज–बीन करने हेतु प्रेरित किया है। हमारे संस्थान के खुले क्षेत्रों में सूर्य के प्रकाश में उपलब्ध निःशुल्क ऊर्जा का उपयोग करने हेतु डिजाइन की हुई सौर कलाकृति लगाई गई है। इसकी आकृति में मनोनुकूल बदलाव लाने का प्रयास जारी। अपनी इसी प्रवृत्ति को बनाए रखना महत्वपूर्ण है और विज्ञान को तकनीकी लाभ में बदलने के नए तरीके और अंततः इससे होने वाले सामाजिक लाभों पर वैज्ञानिकों को विचार करनी चाहिए। वास्तव में समाज को बड़े पैमाने पर वैज्ञानिक जानकारियों से जोड़ने की सोच अत्यंत ही उत्साहजनक है। हालांकि, सीएसआईआर–सीएमईआरआई के आकार की एक अनुसंधान प्रयोगशाला सिर्फ इसी दिशा में अपनी संपूर्ण जोखिम नहीं उठा सकती है। विगत पंचवर्षीय योजना–परियोजनाओं के हिस्से के रूप में वैज्ञानिकों ने रोबोटिक्स, माइक्रो और नैनो–सिस्टम टेक्नोलॉजी, सरफेस इंजीनियरिंग, मैन्युफैक्चरिंग, अंतःस्थापित इलेक्ट्रॉनिक्स, ड्राइव्स और कंट्रोल्स, वाल्व और एयरोस्पेस उद्योग से संबंधित विभिन्न लाइन प्रतिस्थापन इकाइयों जैसी मशीनरी के यांत्रिक डिजाइन और उपकरण जैसे कई क्षेत्रों में ज्ञान और तकनीकी जानकरियाँ प्राप्त की हैं। इस व्यापक ज्ञान और हमारे निपटान कार्य पर प्रतिभाशाली जनशक्ति के पूल को सावधानीपूर्वक पोषित कर इसे अधिकतम लाभोन्मुख करने की आवश्यकता है। हाल के दिनों में गोवा के तट पर अरब सागर में 500 मीटर की गहराई में समुद्री परीक्षण के तहत स्वायत्त अंडरवाटर वाहन का एक महत्वपूर्ण विकास स्वदेशी रूप से किया गया है। हाल के दिनों में भूमि, समुद्र और वायु में स्वचालन बड़े पैमाने पर शोध निवेश को आकर्षित किया है और एयूवी –500 जिसे एक वाहन के तौर पर जाना जाता है, का विकास एक अगला बेहतरीन कदम है। किरण–प्रग्राहित्रों (बीम कैचर्स) के विकास के लिए एंटी प्रोटान और आयन अनुसंधान परियोजना हेतु सुविधा (एफएआईआर) के लिए हमारी भागीदारी एक दूसरा रोमांचक योगदान है। जर्मनी में निर्माण के तहत यह एक अंतरराष्ट्रीय कण त्वरक है और सीएसआईआर–सीएमईआरआई के वैज्ञानिक किरण–प्रग्राहित्रों (बीम कैचर्स) में कण ऊर्जा को सुरक्षित रूप से अवशोषित करने एवं क्षय करने जैसे तकनीकी चुनौतीपूर्ण कार्य में लगे हैं। और भी अनेकों उपलब्धियां हैं, जैसा कि इस रिपोर्ट की आयतन से पता चलता है।

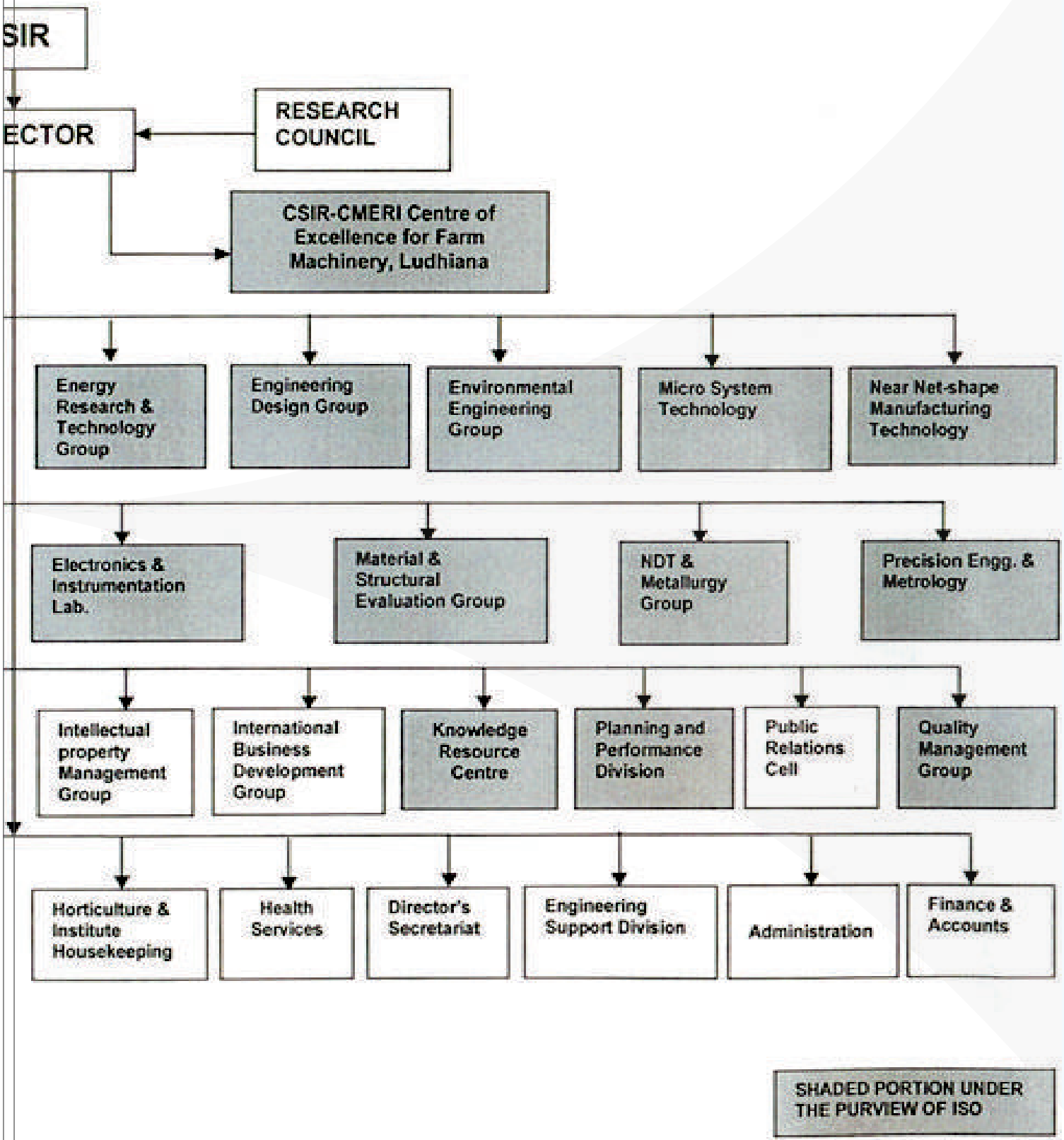
इसी दौरान विभिन्न परियोजनाओं के तहत महत्वपूर्ण मील के पत्थर हासिल किए गए हैं जैसा कि इसके अगले पृष्ठों में रिपोर्ट किया गया है। अब हमें खुद से ही कुछ जरूरी प्रश्न करने का समय आ गया है। क्या हम पहले से ही किए गए निवेशों का सर्वोत्तम प्रतिफल प्राप्त करने के लिए उपलब्ध संसाधनों का बेहतर उपयोग करते हैं ? क्या यह प्रत्यक्षतः विभिन्न शोध क्षेत्रों के जरिए चलने वाला कोई सामान्य संबंधित विषय है ? हमारे संस्थान के दायरे में आने वाले उन तकनीकी लक्ष्यों जिनके लिए विभिन्न मंचों तक पहुँचते हैं उन्हें प्राप्त करने की धुन में तत्संबंधित अपनी बड़ी आकांक्षाओं से अपना ध्यान विचलित नहीं करना चाहिए। अपने व्यक्तिगत अनुसंधान लक्ष्य का अनुसरण करते हुए शिथिल युग्मित समूहों के सम्मुच्चय के रूप में समाप्त नहीं करना चाहिए और वैज्ञानिक कौशल की प्रदर्शनी करने मात्र से ही संतुष्ट नहीं होना चाहिए। हमारे अनुसंधान समुदाय के सदस्य– जिनमें से कुछ इस संस्थान के ही हैं, कुछ सीएसआईआर के अन्य संस्थान के हैं या कुछ देश के अन्य कार्यक्षेत्रों से हैं– उन्हें एक दूसरे के साथ बातचीत करने की जरूरत है, एक दूसरे की ताकत और कमजोरियों से परिचित होने की जरूरत हैं, ताकि एक दूसरे के पूरक कौशल के तौर पर शोधकर्ताओं को पहचाना जा सके और हमारे देश की प्रमुख तकनीकी चुनौतियों से निपटने के लिए साथ–साथ चल सके।

अंत में हमें यह स्वीकार करना चाहिए कि अनेकों ऐसे लोग हैं, जिनके योगदान का उल्लेख प्रत्यक्षतः इस खंड के सीमित पृष्ठों में नहीं मिल सकता। ऐसा नहीं है कि वैज्ञानिकों के हर प्रयास बाहरी निवेश लाने में उपयोगी हो सकता है। एक परियोजना के साथ आगे बढ़ने या पूरी तरह से इसे अस्वीकार करने के निर्णय लेने से पहले कई चर्चाएं, टेलिफोनिक वार्तालाप, ई–मेल के आदान–प्रदान की जाती हैं। हमारे अपने लक्ष्य हासिल करने में हमारी सहायता करने के लिए प्रशासनिक और सहायक स्टाफ, छात्र और परियोजना फेलो निरंतर सक्रिय रहते हैं। मैं संस्थान के कार्यों में सभी की भागीदारी स्वीकार करता हूं और टीम भाव के रूप में एक साथ चलने के लिए हम अपने टीम के सभी सदस्यों से आग्रह करता हूं। सीएसआईआर–सीएमईआरआई तकनीकी प्रसंगों के साथ जुड़े रहने के लिए अपना विकास जारी रखेंगे। जैसे–जैसे हमारे परिवार के पुराने सदस्य सेवा निवृत्त हो रहे हैं, वैसे–वैसे नए चेहरे भी शामिल हो रहे हैं। यह महत्वपूर्ण है कि हमारी पिछली शिक्षा और हमारे मूल्य जो कुछ हमें प्रिय रहे हैं उसे सावधानी से नई पीढ़ी की तरफ बढ़ा दिया जाता है। यदि हम सीखना जारी रखते हैं तो इससे हमारा ज्ञान संरक्षित रहता है और नई तकनीकी चुनौतियों का हम सामना करते हैं और इस तरह से हम निश्चित रूप से अपेक्षाकृत अधिक ऊंचाइयाँ नाप सकते हैं।

प्रो. (डॉ.) हरीश हिरानी
निदेशक, सीएसआईआर–सीएमईआरआई, दुर्गापुर

CSIR-CMERI ORGANIZATION CHART




SIR
ECTOR
RESEARCH COUNCIL
CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana
Energy Research & Technology Group
Engineering Design Group
Environmental Engineering Group
Micro System Technology
Near Net-shape Manufacturing Technology
Electronics & Instrumentation Lab.
Material & Structural Evaluation Group
NDT & Metallurgy Group
Precision Engg. & Metrology
Intellectual property Management Group
International Business Development Group
Knowledge Resource Centre
Planning and Performance Division
Public Relations Cell
Quality Management Group
Horticulture & Institute Housekeeping
Health Services
Director's Secretariat
Engineering Support Division
Administration
Finance & Accounts
SHADED PORTION UNDER THE PURVIEW OF ISO

Research Council

Prof. D.V. Singh Former Director, Indian Institute of Technology, Roorkee & Former Director, CSIR-CRRI, New Delhi 1002, Sunbreeze Apartments, Tower B, Vaishali, Sector V, Ghaziabad - 201 010	Chairman
Prof. Ashok Kumar Mallik Honorary Distinguished Professor Bengal Engineering and Science University, Shibpur, INSA Senior Scientist, S.N. Bose National Centre for Basic Sciences, Kolkata (Former Professor, Department of Mechanical Engineering, IIT Kanpur)	Member
Ms. Sulajja Firodia Motwani Managing Director, M/s Kinetic Motor Company Ltd., D1 Block, Plot No. 18/2, MIDC, Chinchwad, Pune - 411 019	Member
Prof. Sudipto Mukherjee Professor, Dept. of Mechanical Engineering, Indian Institute of Technology, Delhi Hauz Khas, New Delhi - 110 016	Member
Prof. Suman Chakraborty Professor, Department of Mechanical Engineering Indian Institute of Technology, Kharagpur Kharagpur - 721 302	Member
Dr. M. Wakdikar Advisor, Ministry of Earth Sciences, MahasagarBhavasn, Block 12, CGO Complex, Lodi Road, New Delhi - 110 003	Member
Prof. B.K. Mishra Director, CSIR-Institute of Minerals & Materials Technology (CSIR-IMMT) Bhubaneswar - 751 013	Member
Dr. Santosh Kapuria Director, CSIR-Structural Engineering Research Centre (CSIR-SERC) CSIR-Campus, TTTI Taramani, Chennai - 600 113	Member
Dr. N. Gopalakrishnan Director, CSIR - Central Building Research Institute (CSIR-CBRI) Roorkee - 247 667	Member
Dr. Sudeep Kumar Head, Planning & Performance Division (PPD) & Director of Central Office, Council of Scientific & Industrial Research (CSIR), Anusandhan Bhawan, 2, Rafi Marg, New Delhi - 110 001	Member
Prof. Harish Hirani Director, CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI) M.G. Avenue, Durgapur - 713 209	Member
Dr. K.V.S.P. Rao Scientist 'G', DSIR, New Delhi	Invitee
Dr. Nagahanumaiah CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI) M.G. Avenue, Durgapur - 713 209	Secretary

Management Council

Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, Durgapur	Chairman
Dr. S.S. Amritphala, Acting Director, CSIR-AMPRI, Bhopal	Special Invitee
Dr. Nagahanumaiah, Senior Principal Scientist / Head, PPD	Member
Dr. Biswajit Ruj, Senior Principal Scientist	Member
Dr. Tapas Gangopadhyay, Senior Principal Scientist	Member
Dr. Sudip Kumar Samanta, Principal Scientist	Member
Dr. Krishnendu Kundu, Principal Scientist	Member
Mr. Siddhartha Kumar, Senior Technical Officer (3)	Member
Mr. Ratnakar Behera, Finance & Accounts Officer	Member
Mr. Asim Kumar Jha, Finance & Accounts Officer	Member
Mr. Jayshankar Saran, Administrative Officer	Member-Secretary

CSIR-CMERI at a Glance

- Advanced Design and Analysis Group
- Advanced Manufacturing Centre
- Centre for Advanced Materials Processing
- Condition Monitoring & Structural Analysis Group
- Drives & Control System Technology Group
- Electronics & Instrumentation
- Energy Research & Technology Group
- Engineering Design Group
- Environmental Engineering Group
- Information Technology Group
- Material & Structural Evaluation Group
- Micro Systems Technology Laboratory
- NDT & Metallurgy
- Near Net Shape Manufacturing Technology Group
- Precision Engineering and Metrology Group
- Robotics and Automation Group
- Surface Engineering & Tribology Group
- Surface & Field Robotics
- CoEFM, Ludhiana

ADVANCED DESIGN AND ANALYSIS GROUP

The 'Advanced Design and Analysis Group (ADAG)' at CSIR-CMERI has specialised in different aspects of Engineering Design, Computer-Aided Design (CAD), Multibody Dynamics, Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) particularly in nonlinear transient phenomenon like shock wave propagation in coupled field problems. The capabilities and experience of the group include but are not limited to: Aerospace, Automotive, Biomedical and Bioengineering, Mechanical and Agriculture, Manufacturing, Chemical and Renewable Energy. The group has extensive experience in a wide range of industrial and research projects and has worked with several National and International R&D organizations, academic and industrial partners to deliver successful results as per the mission and mandate of the Laboratory.

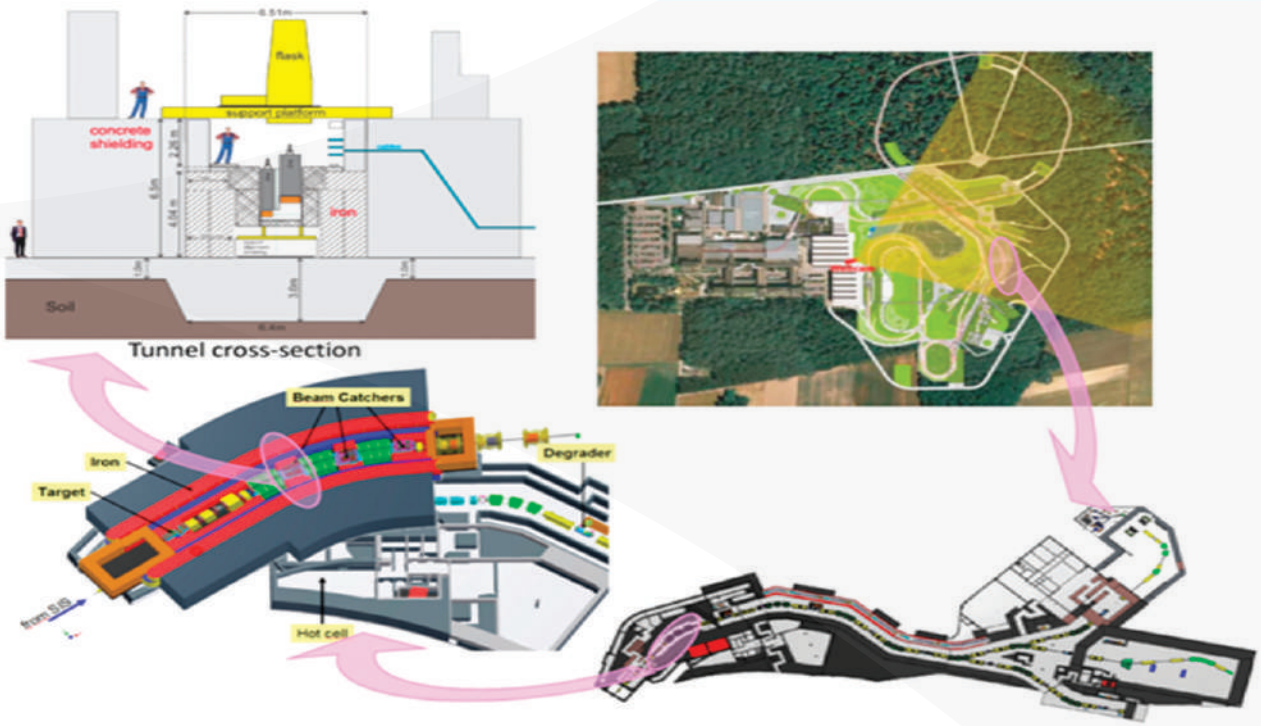
- Numerical modelling of multiphase flow, solid-liquid phase transformation, reactive flow and bluff body flows
- Design and development of Agricultural Machineries
- Battery thermal management through use of PCM based materials

Sponsored Projects:

Design of Beam Stoppers for FAIR Project (GAP098212)

[Sponsored by: BI-IFCC, DST-DAE, Status: Ongoing]

A large international accelerator center - Facility for Antiproton and Ion Research (FAIR) - is being built at GSI (Helmholtzzentrum für Schwerionenforschung), Darmstadt (Hesse), Germany. FAIR is formed by an International treaty on 4th October 2010 with an investment proposal in the order of 250 billion Euros by participating countries (http://www.fair-center.eu) and will be realized in stages. The Republic of India signed the FAIR convention on 4th October 2010 in Wiesbaden, Germany and India's contribution to the FAIR construction to be 36 M Euro (in kind). India is the third largest shareholder in FAIR science project



Facility Layout at GSI Darmstadt [http://www.fair-center.eu/partners/in-india.html]

The Group has the following recent activities:

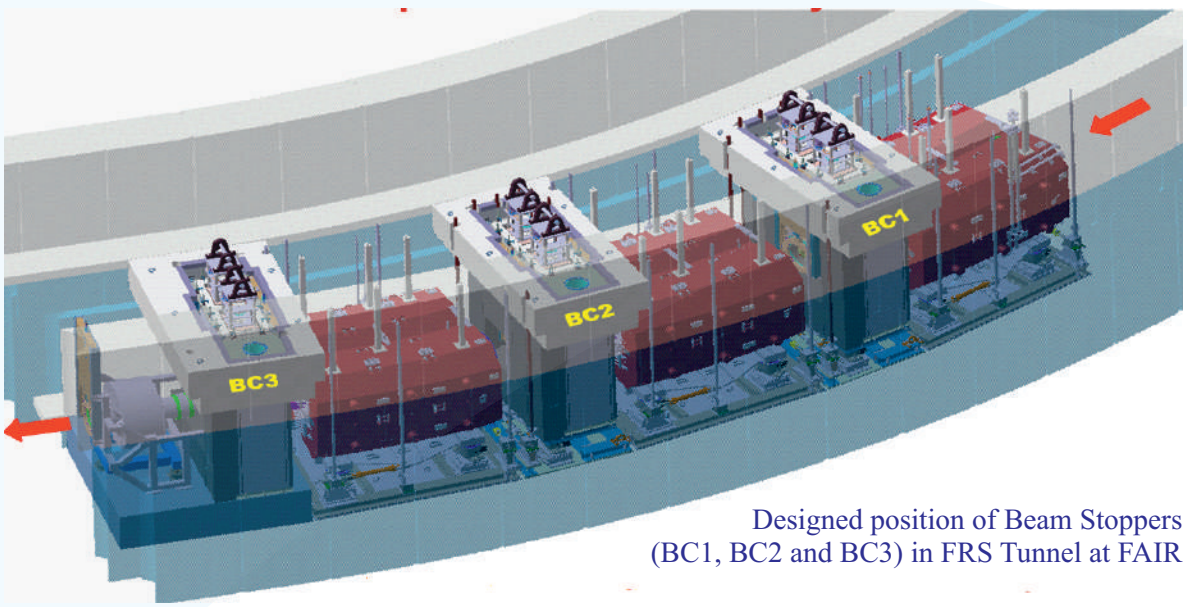
- Design of Beam Stoppers for Super-FRS in FAIR project
- Design and Development of Force Reflecting System (FRS) for human grasping action
- Mathematical modelling and numerical simulation of Underground Coal Gasification (UCG) process

and is represented by Indo Fair Coordination Committee (IFCC), formed by Department of Science and Technology (DST) and Department of Atomic Energy (DAE). India's participation is in the area of design and development of magnets, detectors and beam catchers (http://bic.boseinst.ernet.in/ifcc). Since the programme has got global multi-institutional character, immense magnitude, multi agency funding, international obligations involving multitude of tasks, an MOU was signed between CSIR-CMERI and Indo-FAIR Coordination Center (IFCC) on 22nd July 2014 for design of beam stoppers as one the critical in-kind contribution from India.

Beam dumps (synonymously used for beam stoppers or beam catchers in this context) are primarily energy intercepting and dissipating devices. They are widely used for intercepting beams of various energy levels, starting from laser to very high energy accelerator beams like electron/positron beam, proton/antiproton beam, ion beam etc. Obviously, beam dumps are extremely important systems of large modern accelerator facilities both for basic and applied research as well as nuclear power applications.

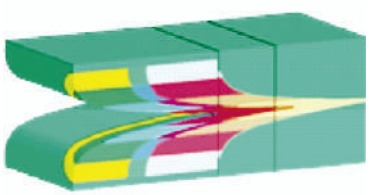
Since beam dumps are to be designed to safely absorb and dissipate the particle energy, the primarily technological challenges are to distribute the huge thermal gradient compounded by thermal shockwaves and material irradiation damage. In addition to that, downstream ion-optical systems are protected from radiation damage.

In our national scenario, Dept. of Atomic Energy (DAE) had already initiated several National Mega Science Projects commencing from 12th FYP and extending over 13th FYP focusing on basic research on nuclear science, astrophysics, material science, medical isotope production and nuclear power generation. All these projects target indigenous development of high energy, high current (high beam power) accelerators where there are requirements of beam dumps capable of withstanding equal or even higher thermal loads and radioactive doses. Some of National Mega Science Projects are: [i] Accelerator Driven Subcritical Systems (ADSS) with the objective of coupling a subcritical reactor with accelerator-produced high energy proton beam for fission and fuel breeding through high flux neutrons.

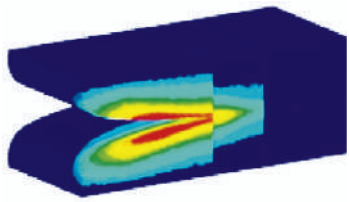


Designed position of Beam Stoppers
(BC1, BC2 and BC3) in FRS Tunnel at FAIR

Thermal Profile of Graphite absorber core in Fast Extraction Mode



Absorber geometry and heat deposition zones



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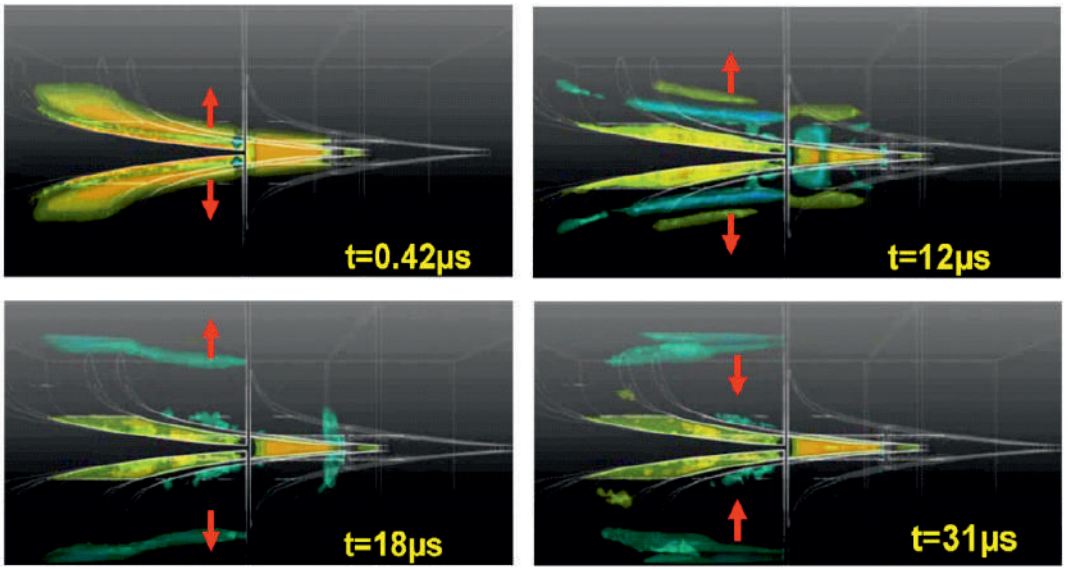
Thermal shockwave propagation in Fast Extraction mode



Thermal shockwave propagation and wave reflection in the absorbing medium (graphite) for 1500 Me V/u fast extracted uranium beam pulses of 50 nanoseconds duration

It is a part of Stage 3 of our National 3-stage nuclear power generation programme. [ii] Spallation Neutron Source (SNS), where high flux neutrons after 'processing' are to be used for condensed matter, material science and other related experiments. [iii] Advanced National facility for Unstable and Rare Isotope Beams (ANURIB), focusing on facilitating indigenous research in nuclear physics, astro-physics, material science and medical isotope production.

Thus, design and manufacturing of high power beam dumps are considered to be a very challenging activity all over the world and it is also a necessity in Indian scenario. In India, suitable Institute-Industry collaboration has already been initiated to achieve this goal through the FAIR project. Once the Indian Manufacturing Sector gets empowered and confident with this technology, they can compete with global manufacturers in this field to cater to the requirements of high power beam dumps for Global Mega Science projects funded by several countries.

Current Status

The design of Beam Catchers 1, 2 and 3 are currently on-going in consultation with the FAIR Super-FRS Group at GSI, Darmstadt, Germany, to meet the ion-optical and energy criteria of the beam along with the placement of beam catchers inside the tunnel. The design has been periodically reviewed by the sponsor. The analysis part has been completed and results jointly reviewed. Visit to factories of the probable manufacturer in India who had showed expression of interest has also been carried out. The time lines of completed and current activities are as follows:-

- Commencement of Concept Design Review (CDR) of final design version with FAIR Super-FRS Group GSI, Darmstadt, Germany in May 2017.
- Industrial Visit by Technical Evaluation Committee with GSI representative during 17th March-18th March, 2016 to explore manufacturing in India.
- Design Review by CSIR-CMERI and GSI Super-FRS team from 7th March, 2016 - 15th March, 2016 at CMERI, Durgapur.
- Design review in 3rd Tech. Advisory Committee Meeting 25th June, 2015; IFCC-BI
- Design review in 2nd Technical Evaluation Committee Meeting 4th August, 2015; IFCC-BI
- Design review in 1st Technical Evaluation Committee Meeting 1st July, 2014; IFCC-BI

Intelligent Devices and Smart Actuators: Force Reflecting System (ESC0203/4)

[Sponsored by: CSIR Supra Institutional Network Project (12th plan), Status: Completed]

A force reflecting system is a wearable hand exoskeleton which applies force to the human finger joints to provide assistance or resistance to human

voluntary action during grasping. Actuators mounted on a wearable module are integrated with the exoskeleton which generates the feedback force. The main applications of the force reflecting device are as force reflecting master in remote handling to provide force feedback to the user and as rehabilitation device for stroke survivors. Motion tracking sensors are also integrated to the exoskeleton for graphical rendering and manipulation control.

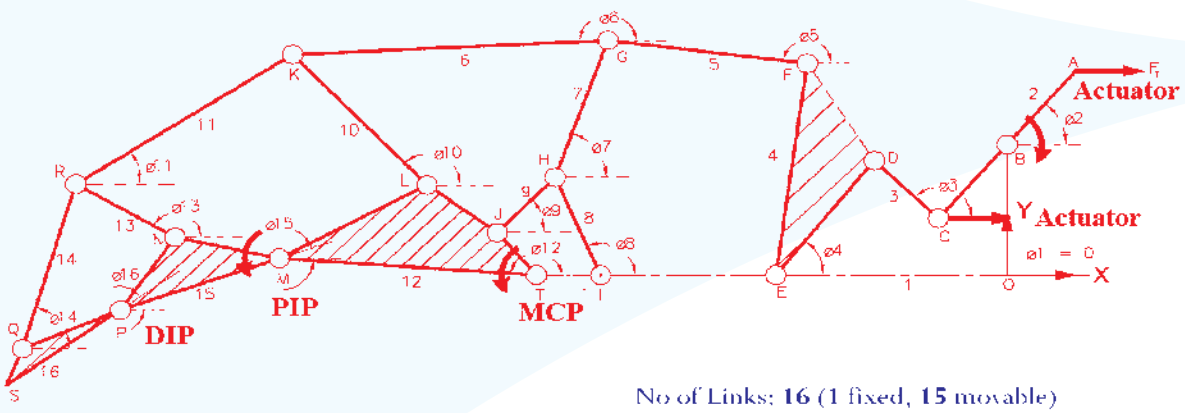
The main objective of this project is to design and develop the force reflecting system (FRS) for human grasping action. The project involves modeling and analysis of human hand grasping action, design and development of human hand exoskeleton, development and characterization of the pneumatic muscle actuator module and actuation methodology and control of force reflecting exoskeleton with index finger during grasping.

Current Status

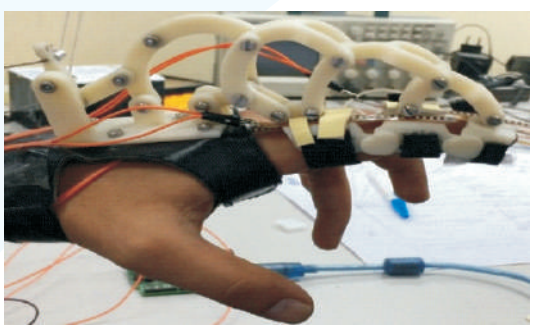
A hand exoskeleton, currently comprising four fingers has been designed and developed at the lab. The linkage mechanism of each finger consists of 16 linkages and is designed to have 3 degrees of freedom while actuation is provided to only one degree of freedom, thus consisting two redundant degrees of freedom. The redundant degrees of freedom are important features so as to preclude a rigid imposed motion or force on a particular joint. The force applied is distributed among finger joints based on the joint resistance/stiffness.

Each finger is actuated through two antagonistically arranged pneumatic muscles, one for flexion and the other for extension of the finger. PMA are comparable to human muscles in shape, properties and performance. Pneumatic muscles are highly customizable in terms of required force and contraction and can be cheaply produced in varying sizes. These have low cost, powerful actuation and light weight and compactness. Their rate of response is slow but it is sufficient for grasping action of human hand and rehabilitation applications. The dynamic actuator characterization has been carried out on the

(a)



(b)



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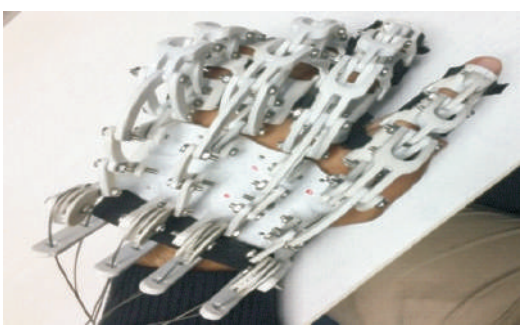


Figure: (a) The exoskeleton linkage mechanism for index finger, (b) Prototype of index finger exoskeleton with motion sensors, (c) Prototype of four finger exoskeleton assembly

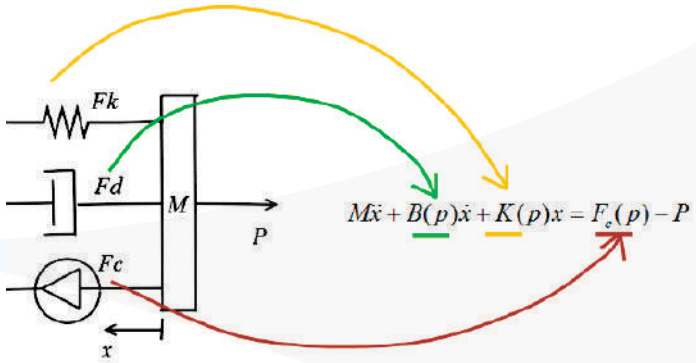
phenomenological model with the governing equation set and the parameters derived experimentally. The test results of theoretical model, phenomenological model and the experimental data agrees with in designed operating level of displacement and input pressure.

Since size and light weight are critical and large number of these actuators (minimum two per finger for antagonistic mode of operation) are to be fitted to the force reflecting exo-skeleton, a sleek PAM actuator (6 mm ID) has been developed. This sleek PAM actuator has been tested with the exoskeleton. A wearable actuator module has been developed and integrated with the exoskeleton and the finger force reflection (flexion and extension) has been demonstrated. The finger motion tracking has also been integrated and demonstrated.

Mathematical Modeling and Numerical Simulation of Underground Coal Gasification (UCG) Process (ESC0302/05)

[Sponsored by: CSIR Network Project (12th plan), Status: Completed]

Underground Coal Gasification (UCG) refers to the in-situ gasification of coal. It is accomplished by first establishing two vertical boreholes - the injection well and the production well. Next, the two wells are horizontally linked within the coal seam using specialized techniques such as directional drilling. Reactant gas mixtures (steam & oxygen) are sent through the injection well and suitable conditions for the ignition or start-up of the coal reactions is provided. A steady production of combustible gases due to the various reactions occurring between the gases and the coal is evident at the production well.

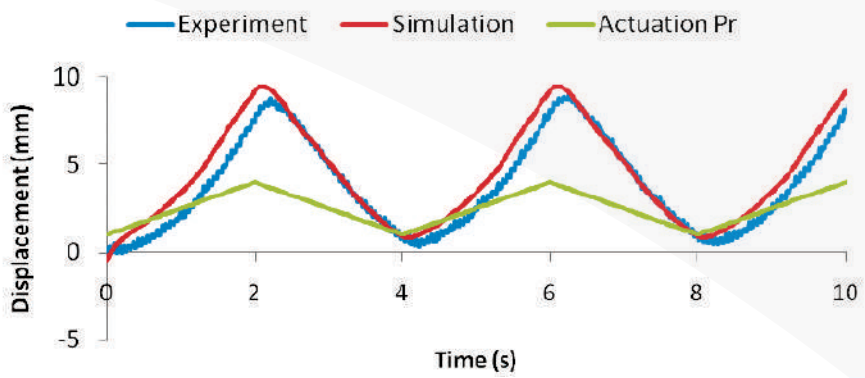


$F_c(p)$, $B(p)$, $K(p)$ obtained experimentally as

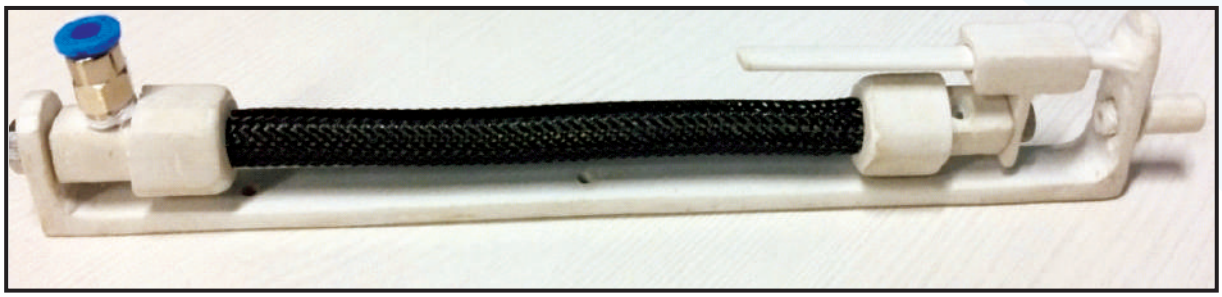
$F_c = 77.371p + 5.9143$

$K = -0.3542p^3 + 6.5709p^2 - 38.98p + 98.828$

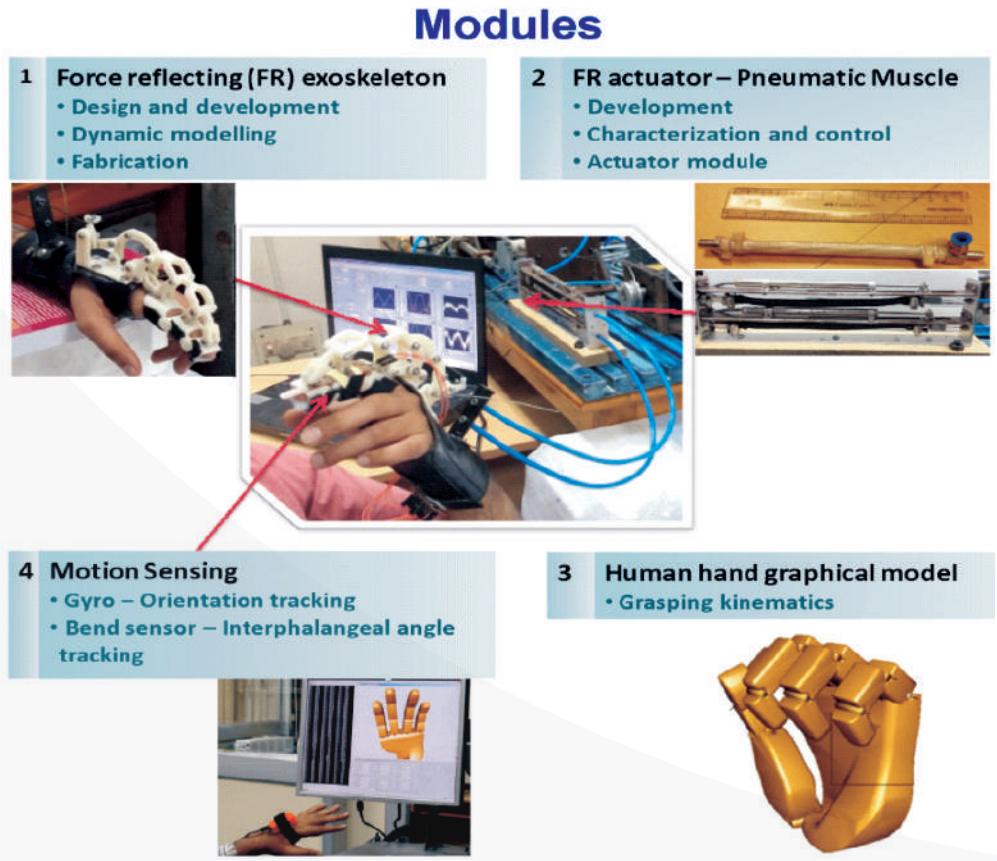
$$B = \begin{cases} 7.177 & 1 \le p \le 3 \\ 4.1621 & 3 < p \le 6 \end{cases}$$

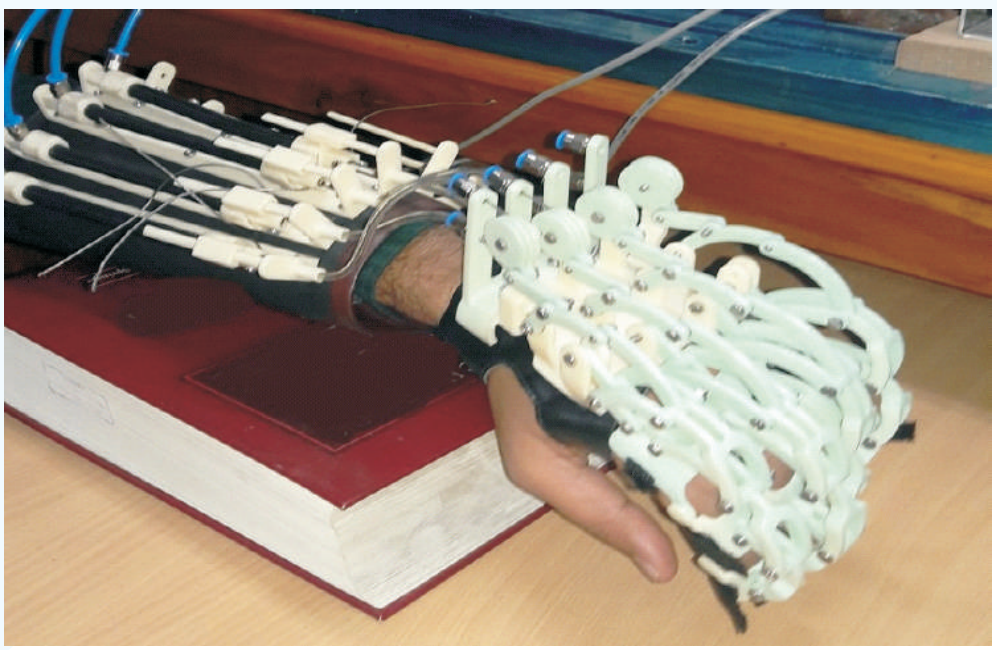


Test results of theoretical model, phenomenological model and experiment.



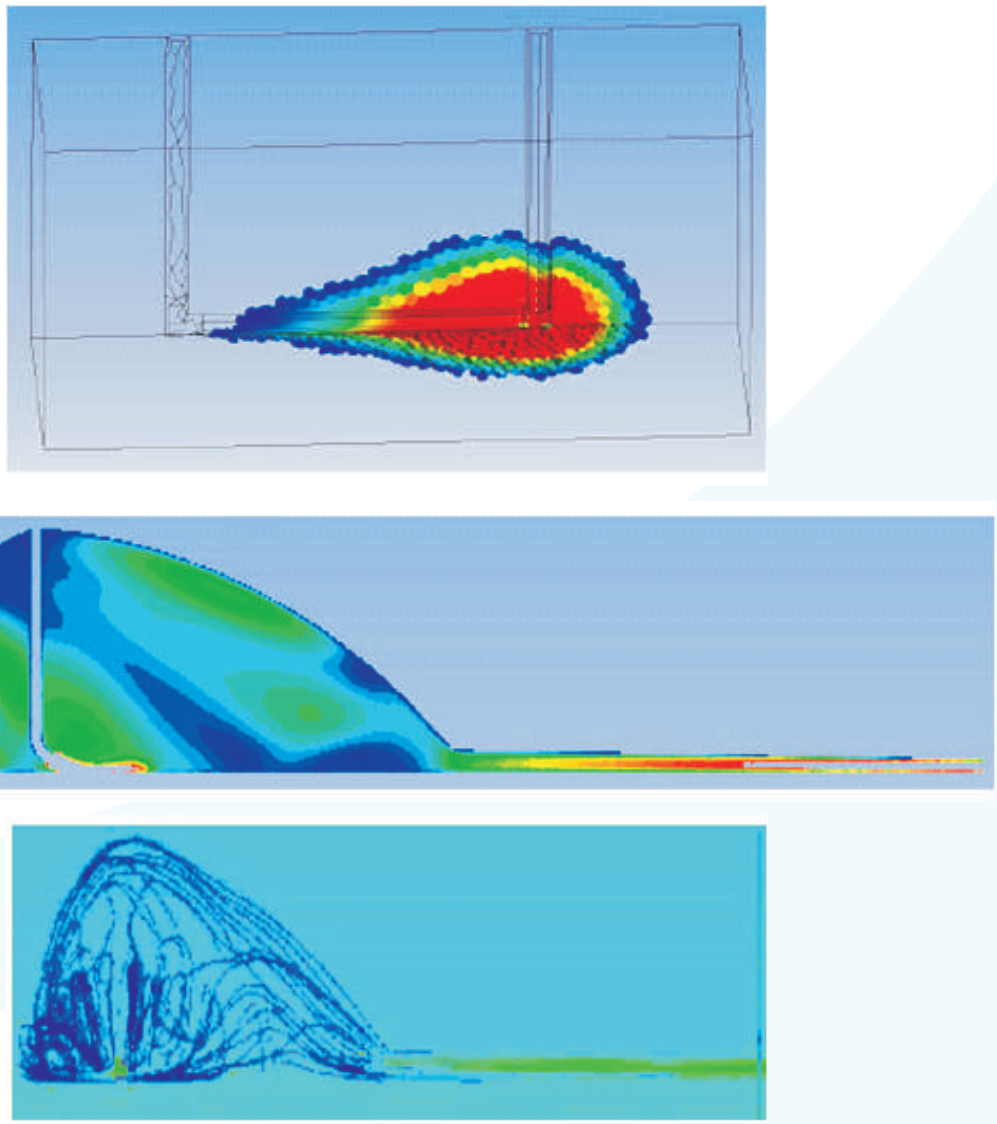
A version of indigenously developed light weight PAM actuator with 6 mm ID





Hand exoskeleton and actuator module integrated system

The main objectives of the project are to develop a comprehensive computational fluid dynamics (CFD) based model of UCG process that incorporates many complex behaviors like oxidation, pyrolysis, reduction, cavity growth etc. The primary research interests are simulation of burn front propagation, cavity development and gas quality and evaluation of various parameters like coal seam thickness, ash content, moisture, volatile matter, permeability, and injection strategy, etc. in the perspective of in-situ gasification.



Flow simulation in cavity (cavity shape, velocity profile, pathline)

Feasibility study of graphene based PCM cooling for battery thermal management system (OLP 212012)

[Institute project, Status: Ongoing]

Thermal issues associated with batteries are of great concern as cell temperature significantly affects the performance, life and safety of batteries. Thermal behaviour is often characterized by an increase in performance and a decrease in life and safety as temperature increases beyond the typical operating range. Additionally, cycling generates a certain amount of heat that must be rejected from the module to maintain its temperature in the preferred range. Several battery thermal management systems (BTMS) using various techniques have been studied to meet this purpose, each with various advantages and disadvantages depending on the application.

This work proposes the use of graphene based phase change material (PCM) for better thermal cooling for the BTMS. In order to demonstrate possible enhancement of thermal properties with graphene, paraffin wax will be selected as the base PCM. The term paraffin wax refers to mixtures of various hydrocarbon groups, particularly paraffins and cyclo-alkanes that are solid at ambient temperature. Three different standard lead acid batteries will be tested during charging and discharging cycles with and without PCM based thermal cooling system. Specific attention will be paid to the thermal management system based on the phase change materials.

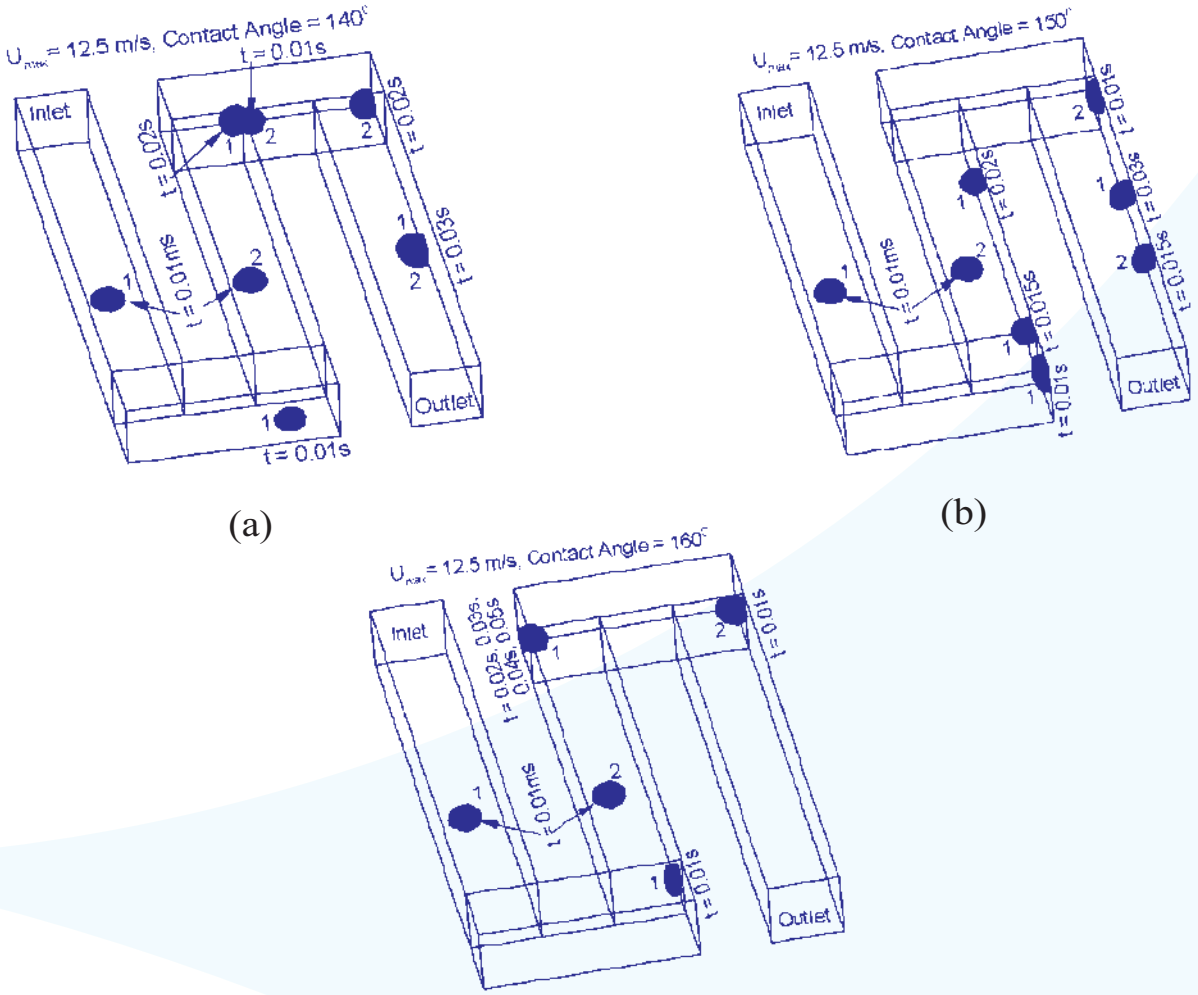
The objective of this project is to carry out performance testing of graphene based phase change material for passive thermal management of lead acid batteries.

Simulation of water droplet mobility in gas flow channels of pem fuel cell using the lattice Boltzmann method (GAP182712)

[Sponsored by: DST, Status: Completed on May 2016]

Polymer electrolyte membrane fuel cells (PEMFC) are a clean power source and have emerged as one of the most promising advanced energy technologies particularly as an alternative sources in automotive and backup power applications. The PEMFC is efficient, environment friendly, quiet and simple in design and operation. The performance of PEMFC is significantly influenced by the flow distributions in the flow channels and gas diffusion layer (GDL) since water flooding and concentration distribution are some of the key issues governed by the configurations of flow channel layouts. To avail the high proton conductivity, the water generated on the cathode side is used to hydrate the membrane but excessive water may cause flooding in the reaction zone, GDL and flow channels which reduces the oxygen supply in the reaction zone. At the low operating temperatures in PEMFC, water vapor condensation starts easily and accumulates liquid water droplets within the flow channels, thus affecting the chemical reactions and thereby reducing the cell performance. Thus, total project work is divided in two parts such as (Part-A) numerical investigation of the water droplet transport in a PEM fuel cell with serpentine flow channel and (Part-B) modeling the wettability and compression implications on the flooding behavior in the PEMFC gas diffusion layer using lattice Boltzmann method (LBM). In Part-A, a comprehensive three dimensional numerical simulation is carried out to understand the water droplet mobility in a serpentine gas flow channel for a wide range of surface properties, inlet air velocities, droplet positions (center or off-center, bottom or top) and droplet sizes by deploying a finite volume based methodology. The liquid-gas interface is tracked following the volume-of-fluid (VOF) method. The droplet transport is found to be greatly influenced by the surface wettability properties, inlet velocities, number of droplets emerged and initial droplet positions. Super hydrophobic surface property is not always preferable for designing the gas flow channels. It depends upon the inlet velocity conditions, droplet positions, number of droplets and surface properties. The main objective of Part-B is to study the effects of mixed wettability and compression on the flooding behavior in the PEMFC GDL.

Experimental facility for battery performance testing using passive cooling medium



Two droplets transport (center of bottom wall) at different instants on hydrophobic surfaces for the maximum inlet velocity of 12.5 m/sec for various CA: (a) 1400, (b) 1500 and (c) 1600.

ADVANCED MANUFACTURING CENTRE

CSIR-CMERI since its inception has been pursuing research in the area of mechanical engineering and allied fields that include agricultural, mining, automobile, medical, strategic and societal sectors. Various prototype machines, components and process plants in different areas of reasearch are being developed and demonstrated utilizing state-of-the-art manufacturing facilities created at CSIR-CMERI which is now known as the "Advanced Manufacturing Centre (AdMaC)".

Figure 1: a) CNC lathe with C-zxis and hard turn facility, b) CNC EDM-wire cut machine, c) CNC milling machine, d) Robotic LASER welding facility, e) Micro plastic injection moulding machine, f) Rheo casting facility

Available Manufacturing Facilities at AdMaC

AdMaC consists of a highly skilled and dynamic workforce along with ranges of manufacturing facilities under one roof which is rarely available in the research and academic institutions around the world. The facility of AdMaC includes different types machining processes, metal joining processes and forming processes, metal casting processes, plastic injection moulding and powder injection moulding processes. Both conventional and CNC machining facilities are available.

In the conventional machining area, conventional shaping machines, lathes, milling machines, boring machines and grinding machines of different capacities are available to cater to the need; whereas, CNC lathe with C-axis, CNC vertical machining centre, CNC milling machine, CNC EDM, CNC EDM wire-cut backed by CAD/CAM software are available for precision machining work. In the area of metal joining processes, Robotic LASER welding, Tungsten Inert Gas welding (TIG), arc welding and gas welding facilities are available. Power rolling, sheet shearing machine, angle bending machine, vertical and horizontal band saws, drilling machines etc. are available in the forming area. Four types of casting facilities are available at the

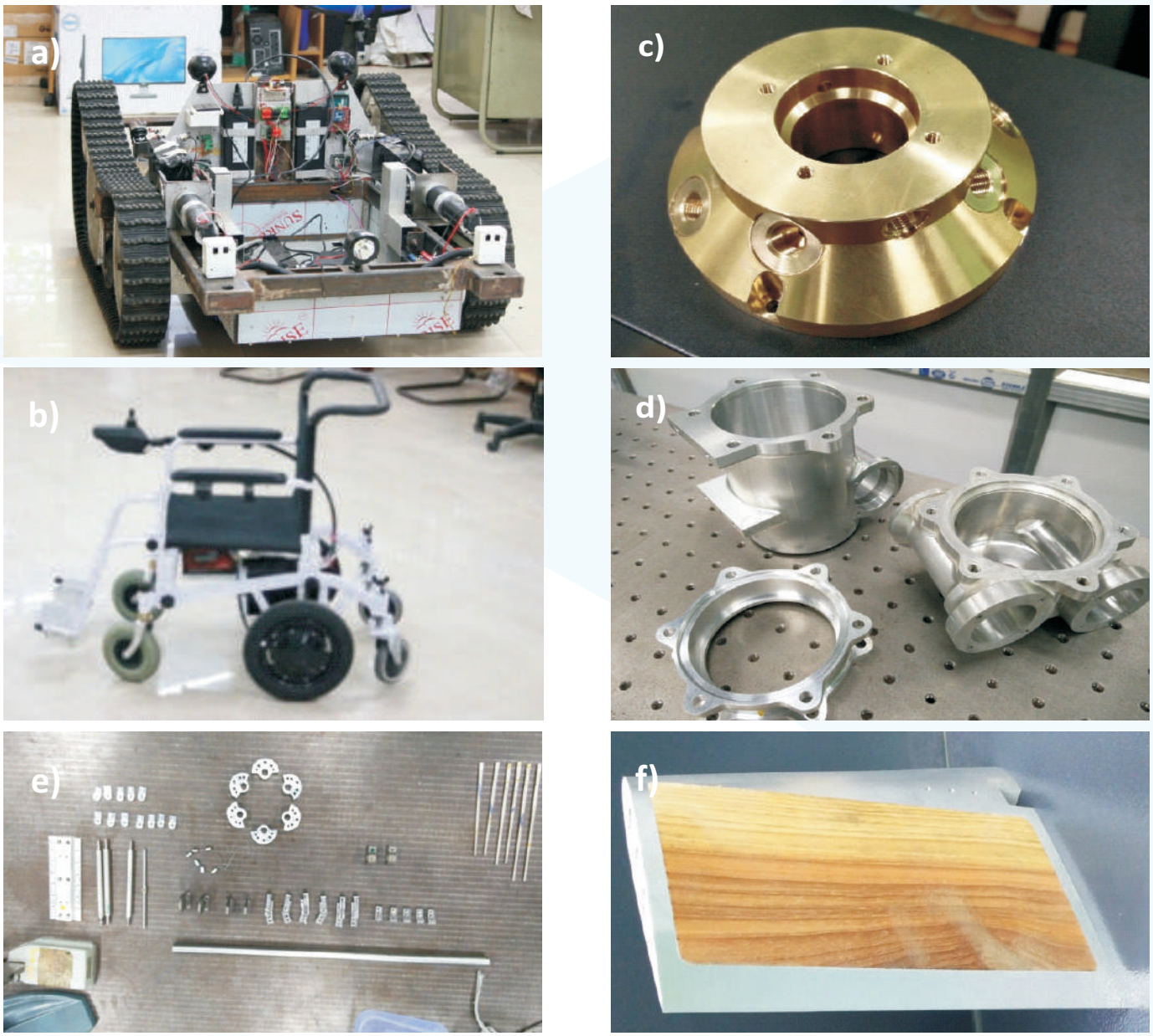


Figure 2: a) All Terrain Robot, b) Robotic Wheel Chair, c) Nozzle of MMD, d) Components of actuator, e) Components of fish-fin like bio-mimetic actuator, f) Hybrid fin of AUV 500.

AdMaC that include conventional sand casting, investment casting, pressure die casting and rheo pressure die casting. Metal casting infrastructure includes modern pattern shop, induction furnace, machine moulding, pressure die casting, rheometer etc. Both ferrous and non-ferrous castings are done in the case of conventional and investment casting and only non-ferrous (mostly aluminium alloys) metals are cast in pressure and rheo pressure die casting. Injection moulding area of AdMaC is equipped with micro and macro plastic injection moulding machines ranging from 15T to 150T. Powder injection moulding facility is equipped with high temperature furnaces including vacuum furnaces with diffusion and turbo molecular pumps for manufacturing of small and complex shape metallic and ceramic components. Some of the state-of-the-art equipment available at AdMaC are shown in Figure 1.

Activities

As stated earlier, CSIR-CMERI is pursuing research in various areas of mechanical engineering and its allied fields that include robotics, micro machines, manufacturing process technologies, solar power generation, municipal solid waste management etc. Different prototype machines and systems are being developed as outcome of research in the above areas. Presently emphasis has been given to manufacturing multiple prototypes to implement the technologies in the application areas and evaluate their performance before releasing the technology for commercial exploitation.

Various prototypes such as all terrain robot, robotic wheel chair, critical components of autonomous under water vehicle, actuators, micro milling machine, fish-fin like bio-mimetic actuator for under water vehicle etc. are manufactured at AdMaC to demonstrate the technologies. Figure 2 shows the photos of the prototypes and critical components manufactured at the AdMaC.

Besides the above, multiple prototypes (2-10 batch size) of e-rickshaw, e-kiosk, ginger washing-slicing-drying machines, segregation and disposal units of municipal solid waste management and iron removal

Figure 3: a) Iron Removal Plant, b) ginger washing machine, c) ginger slicing machine, d) ginger dryer

plant have been manufactured and some of these are shown in Figure 3.

In the area of solar energy harvesting, AdMaC has developed a solar park (34kWP) and solar luncheon (7kWP) garden through manufacturing and installation of various solar artifacts at competitive prices (Figure 4). All street lights and boundary lights are powered from the solar park and the institute canteen is partially powered from the solar luncheon garden.

Recently, "Post Graduate Diploma course on Advanced Manufacturing Technologies (PGDAMT)" program has been started at CSIR-CMERI to enhance the manufacturing skill of the graduate engineers where the AdMaC is actively involved by conducting theory as well as practical classes besides prototype manufacturing.

In line with the "Make in India" concept of the Govt. of India, emphasis has been given to commercialize the machines, components, process plants and processing technologies developed at CSIR-CMERI by opening an incubation centre in its campus. In the incubation centre, entrepreneurs of startup companies shall manufacture prototype machines, components etc. in batch scale to commercialize them. Moreover, there are many steel plants and collieries in and around Durgapur. Large numbers of spare parts of various kinds are being imported for the machineries used in these plants and collieries. In a recent industrial meet held at CSIR-CMERI, it was expressed by the manufacturing industries that many of the imported spare parts can be indigenously manufactured and CSIR-CMERI would play a catalytic role. Hence, CSIR-CMERI is augmenting its manufacturing facilities at AdMaC towards creating a manufacturing hub by recruiting fresh additional manpower and installing various state-of-the-art machineries such as higher capacity CNC milling machine, EDM, Plasma profile cutting machine, material handling equipment, CNC and conventional precision grinding machines, CAM software etc.

Figure 4: a) Solar park, b) Solar luncheon garden

CENTRE FOR ADVANCED MATERIALS PROCESSING

Research activities at CAMP have been directed at (1) developing improved materials/processes for engineering applications and (2) addressing the needs of common people. Under the former category, development of carbon nanotube-reinforced epoxy resin nanocomposites, metal matrix composites (MMCs) and zirconia toughened alumina (ZTA) are reported here. Under the latter, dental brackets, water purifiers and electrochemical sensors to detect soluble phenolic contaminants in water are some developed products that are discussed.

Carbon Nanotube-reinforced Epoxy Resin Nanocomposites

Owing to their low weight, large specific surface area, high tensile strength, and superior thermal and electrical properties, carbon nanotubes (CNTs) are attractive fillers in polymer matrix. CNT-reinforced polymers, e.g. epoxy composites, are good structural materials for weight-sensitive aerospace industry, marine, armour, automobile, civil engineering structures, and sporting goods industries. Though incorporation of CNTs as filler further enhances the mechanical properties of epoxy resin, their poor dispersion prevents the use of the resulting material in practical devices. There are various methods to disperse CNTs in epoxy resins. In this research, a simple mechanical dispersion method by stirring glass rods was applied to develop CNT-epoxy resin nanocomposites. The primary aim was to investigate the quality of dispersion and quantify the mechanical property enhancement due to dispersion of CNT in epoxy matrix. Static mechanical response was studied by tensile measurement. The tensile stress-strain behavior is an important characteristic for evaluating the performance of mechanical properties of nancomposites. A comparison between tensile properties of the epoxy resin without CNT incorporation and the nanocomposites containing different wt% of CNT is shown in Figure 1, using two different epoxy resins, C51 and LY556. As can be seen from the figure, the tensile strength for C51 based epoxy resin composite is 26.1 MPa, which increases to 57.8 MPa for 0.2 wt% CNT incorporation. This is an improvement of 120%. On the other hand, this improvement is 14% for LY556 based epoxy resin. The corresponding enhancement in elongation is 140% and 24% for C51 and LY556 epoxy resins, respectively. Such a high degree of

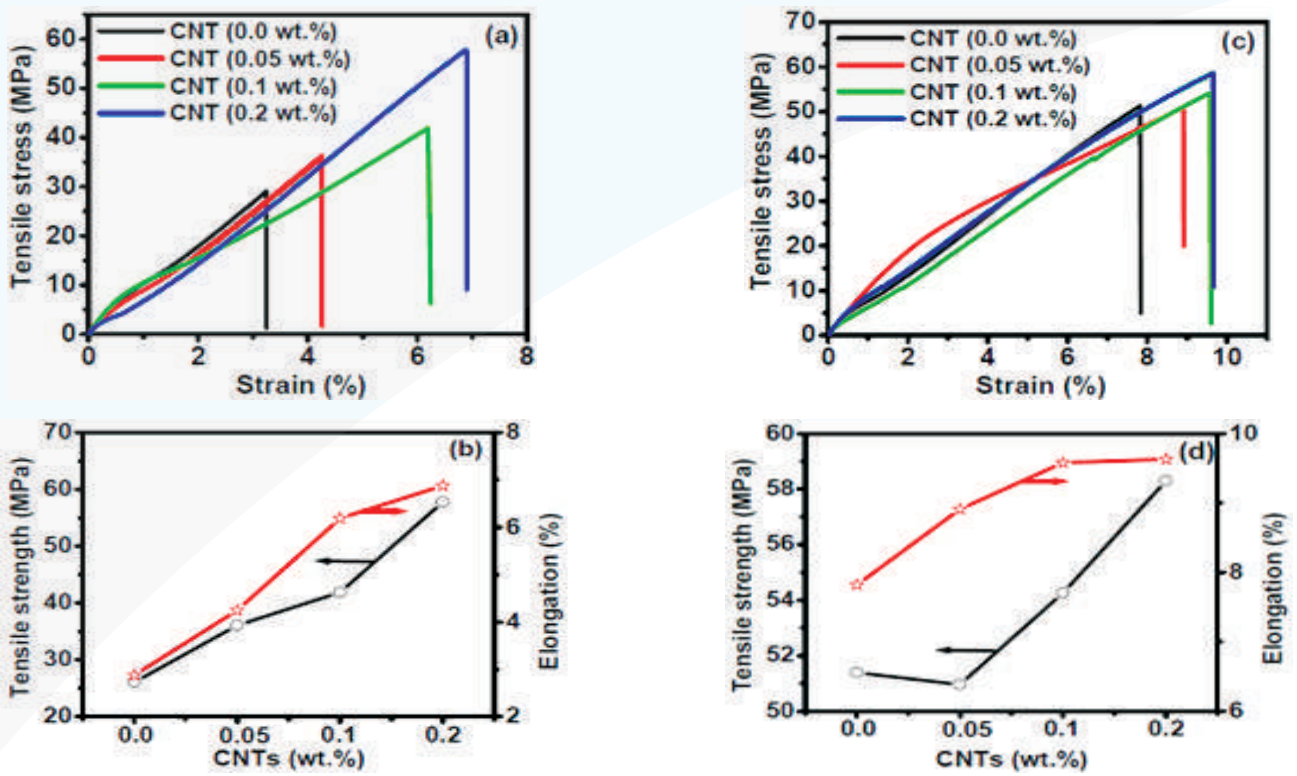


Figure 1: Mechanical characterizations of CNTs reinforced nanocomposites using C51 [(a)&(b)] and LY556 [(c)&(d)] epoxy resin matrix

increase in tensile strength was also reported by other researchers, where 0.5 wt% CNT was incorporated into epoxy matrix to form CNT-reinforced epoxy composites. These increments in tensile strength and elongation imply that the CNTs were mixed properly in C51 epoxy resin, whereas for LY556 there was coexistence of CNTs in dispersed and agglomerated states in the base materials. This observation was confirmed by SEM images discussed later. For application in engineering components, LY556 epoxy resin seems to be more suitable. The evidence of dispersion and agglomeration of CNTs in the epoxy resin matrix was evaluated from the SEM micrographs of the fracture surfaces of these composites after tensile measurement as shown in Figure 2.

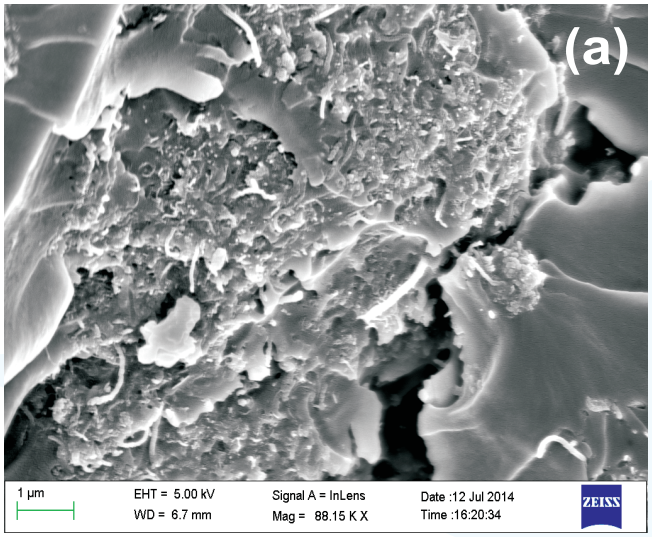


Figure 2: SEM images of fracture surfaces of 0.2 wt.% CNT reinforced epoxy resin C51 (a) and LY556 (b)

Prototype rotor blades of dimension (8×4.5") have been developed by pouring CNT-based epoxy resin composite into a mould followed by slow curing in the furnace. The developed blades are shown in Figure 3. The developed prototype blades were fitted into a motor and a short duration test was carried out to check the performance of the rotor blade.

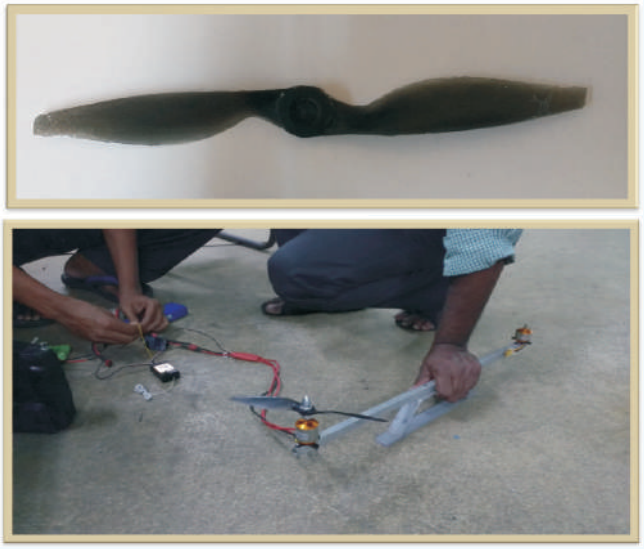


Figure 3: Developed drone blade using CNT reinforced epoxy composites

Development of Novel Al-15Mg_2Si-4.5Si Composite and Rheo Gravity Die Casting (RGDC) Process Technology to Manufacture Lightweight Automobile Components

Metal matrix composites (MMCs) show the combined and improved properties of their two constituents, such as ductility and toughness of the matrix, high modulus and strength of the reinforcements. MMCs are widely used now-a-days as structural materials for aerospace, automotive, transportation industries and space appliances. In this work, a novel in situ Al-15Mg_2Si-4.5Si composite has been developed by gravity die casting technique that ensures similar cost and energy input as compared to commercially available cast Al alloys such as A356, A380, A365 etc. The developed composite is found to yield higher strength to weight ratio and toughness, in comparison to the popular cast Al alloys. Being in situ, it nullifies the fundamental problems associated with MMCs such as, non homogenous distribution of the reinforcing particles and their poor wetting characteristics with the matrix phase. Investigation results show that Mg_2Si % has significant impact on microstructural morphology, hardness, mechanical properties and fracture behavior of the said in situ composite.

The novel in situ composite is prepared by gravity die casting technique. Commercial Al-Si alloy (LM6) and Mg ingots (99.91% purity) are used to develop Al-15Mg_2Si-4.5Si composite. At first, Al- alloy ingot is melted in a graphite crucible within a resistance heating furnace. Small pieces of pure magnesium are inserted into the melt. After the magnesium is dissolved, the mixture is stirred and degassed. After removal of the slag, the molten metal is poured into the die cavity. After polishing and etching, metallographic samples obtained from the solidified composite have been investigated under Optical microscope. Macro and micro hardness measurements have been made at five different locations of the solidified samples. ASTM B557 specifications have been followed to cast tensile specimens of the above mentioned composite and tested at room temperature at a strain rate of 10-4 mm/sec. Digital photograph of the experimental set up is shown in Figure 4.

After successful development of the composite, the work has been extended to develop process technology for Rheo Gravity die casting towards development of automobile components. Cooling Slope having stainless body is used to produce semi solid slurry in the present work [1, 2]. After preparing the melt, it is allowed to coll and poured on the upper end of the cooling slope to facilitate partial crystallization of primary Mg_2Si and α-Al and to ensure shear driven flow of the solidifying melt. To avoid sticking of the molten alloy and corrosion of the surface due to contact with high temperature molten metal, the concave surface of the cooling slope is coated with a thin layer of Boron nitride. The melt coming out from the exit of the cooling slope is stored in an isothermal bath (which is kept at same temperature as exit temperature of the melt from the cooling slope). Melt samples are stored upto 16 minutes and then cast in the form of tensile samples (according to ASTM B557 specifications) and cylindrical billets. After experiments, metallographic samples are prepared. The etched metallographic samples are investigated using optical microscope. The tensile test is carried out using cylindrical tensile specimens at room temperature, under a strain rate of 10-4 s-1.

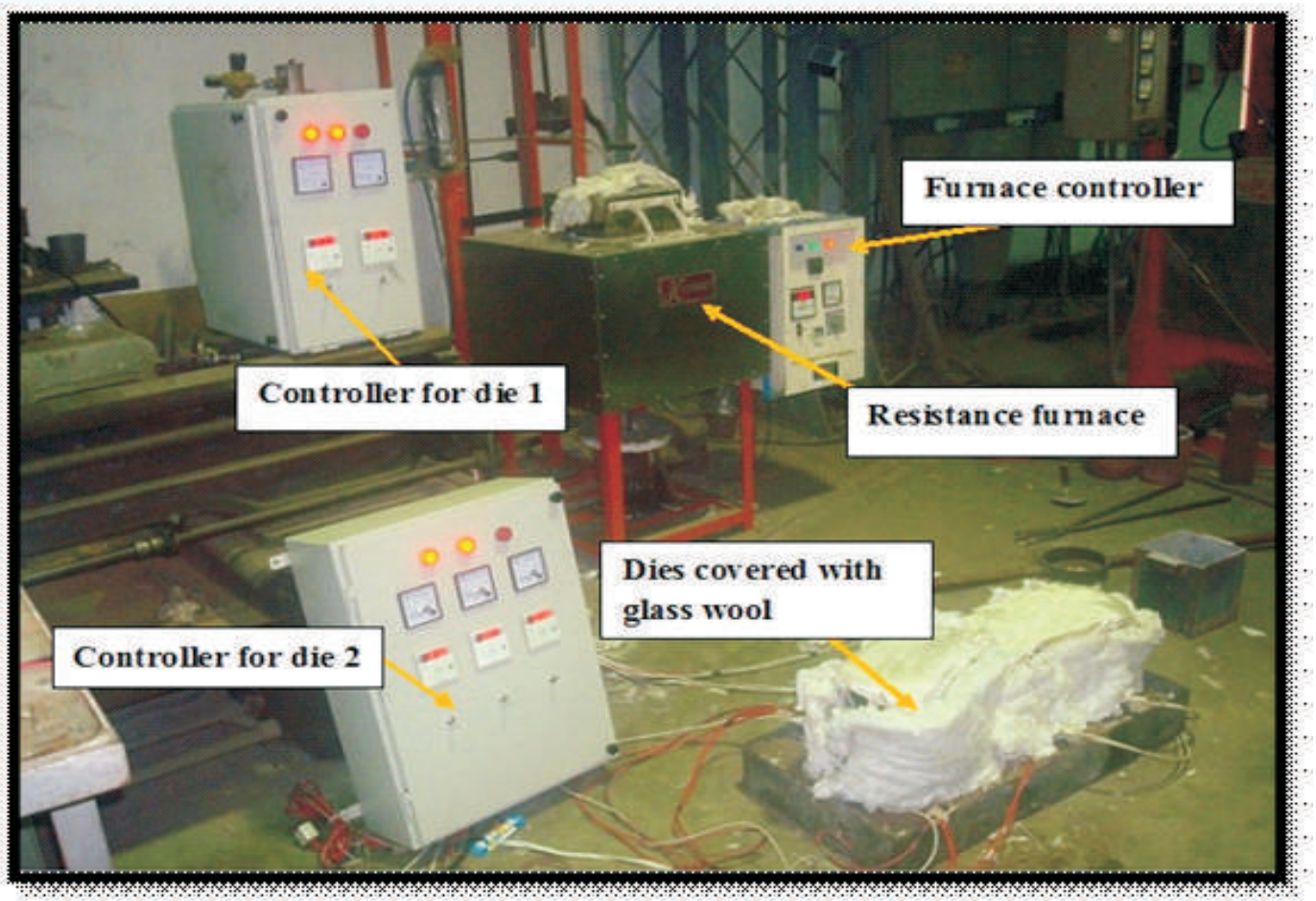


Figure 4: Digital photograph of the experimentalsetup

In this work, microstructure evolution of the Al-15Mg_2Si-4.5Si composite melt during its flow along the cooling slope has been studied and mechanical properties of the rheocast composite have been investigated. Melt pouring temperature of 640°C and slurry holding time of 16 minutes (after exiting cooling slope) followed by heat treatment has been found to be optimum in terms of achieving ideal microstructural morphology (minimum grain size, maximum sphericity, shown in Figure 5) and mechanical properties (UTS: 331Mpa and %Elongation: 13%) in the rheocast samples. Moreover, fracture surface of the tensile tested samples show completely dimpled morphology (Figure 6). Subsequently, the above mentioned process parameters have been chosen for component (automobile Brake disc) development. Glimpses of die design and digital photograph of the initial prototype component with gating and runner/riser system are shown in Figure 7a and 7b, respectively. The sheer force employed by cooling slope, during melt flow towards the slope exit, yields near spherical and finer grain size of both primary Mg_2Si and α-Al particles.

References:

[1] Das, P., Samanta, S.K., Chattopadhyay, H., Sharma, B.B., Dutta, P., 2013. Eulerian two-phase flow simulation and experimental validation of semisolid slurry generation process using cooling slope. Material Science and Technology, 29, 83-92.

[2] Das, P., Samanta, S.K., Chattopadhyay, H., Dutta, P., 2012. Effect of Pouring Temperature on Cooling Channel Semi Solid Slurry Generation process. Acta Metallurgica Sinica (English Letters), 25, 329-339.

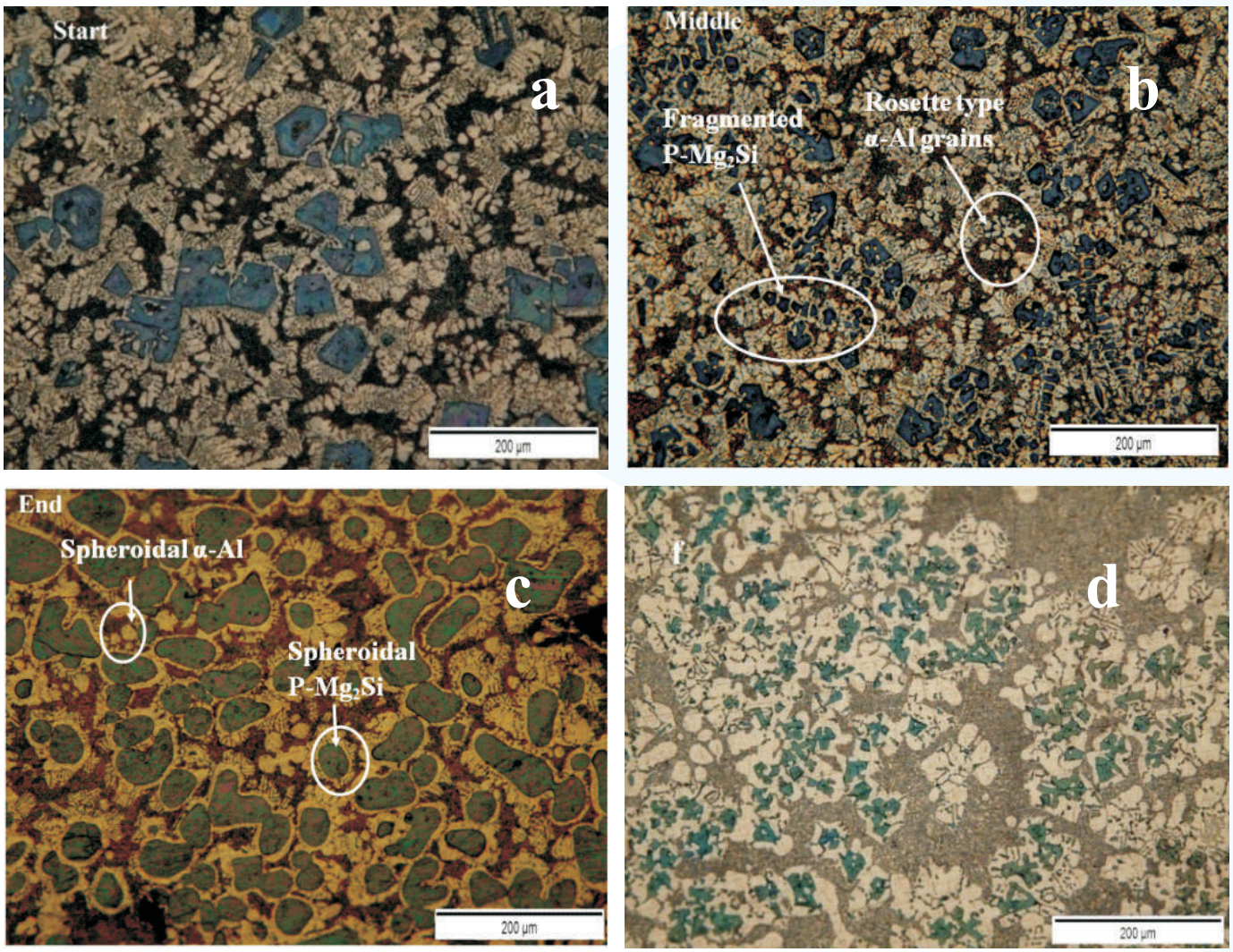


Figure 5: Optical micrographs of the oil quenched slurry sample: (a) start, (b) middle and (c) exit section of the flow front and (d) solidified sample after 16 minutes of slurry holding.

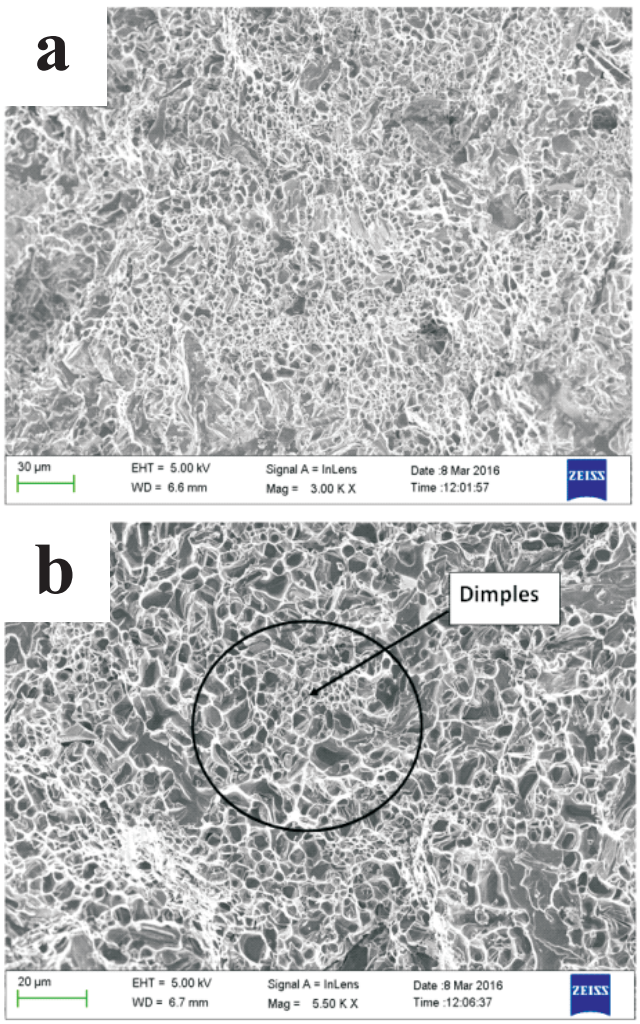


Figure 6: Fracture surface of the tensile tested samples at (a) low and (b) high magnification.

Development of MgO/Cr_2O_3 doped Zirconia Toughened Alumina (ZTA) inserts for machining of steel

The purpose of this work is to develop a high performance ceramic tool having enough toughness to be used as cutting inserts to fulfil the demand of the manufacturing industries of the country and to machine different materials effectively both at high speed as well as at moderately low speed. A monolithic alumina Al_2O_3 (average particle size 60 µm, supplier Merck) is mixed with a ratio of 90 wt% Al_2O_3 /10 wt% zirconia composite with 3 mol% Y_2O_3 stabilized ZrO_2 (average particle size 1.0 µm, supplier Zirox) to form zirconia toughened alumina. The developed powders are mixed with 0-1 wt% magnesia MgO (average particle size 1 µm, supplier Sigma Aldrich) to form Mg-ZTA. The developed

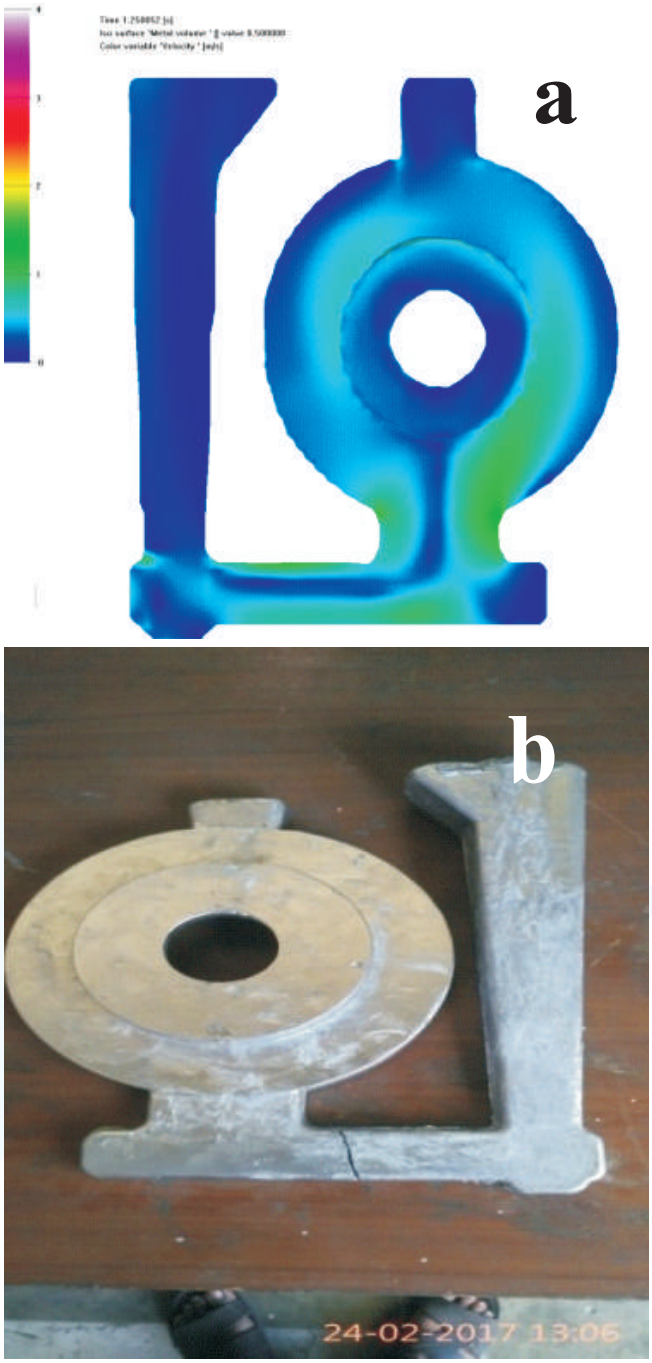
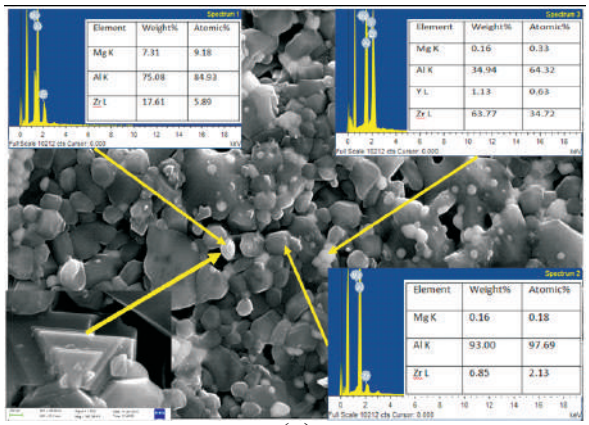
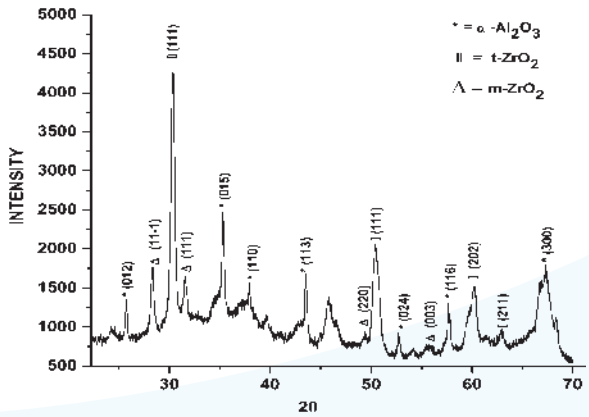


Figure 7: (a) Glimpse of design optimisation of the die cavity and (b) digital photograph of the initial prototype Light weight Brake disc.

powder is wet mixed for 60 min in ultrasonic machine followed by automatic stirring for 30 min. The prepared powder of Al_2O_3, YSZ and MgO with 0.8 wt% of polyethylene glycol 1000 as a plasticizing agent is ball milled for 12 hr. Finally the mixture solution is placed in drying oven for 24 hr at 200°C. After drying the powder is placed in a high temperature furnace to calcine at 800°C. Metallurgical characterization of the powder has been



(a)



(b)

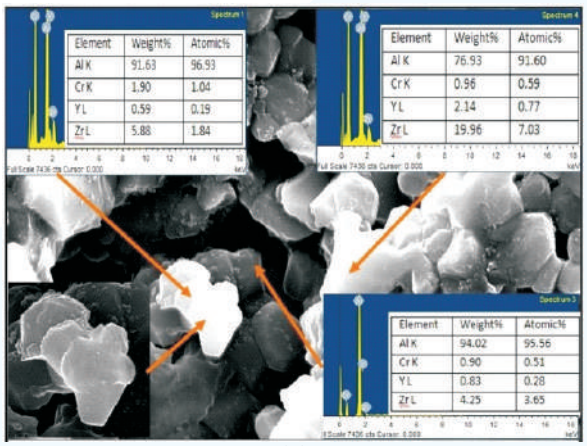
Figure 8: (a) Typical FESEM Image of Mg-ZTA (b) Typical X- Ray for Mg-ZTA powder

carried out using XRD, FESEM and DTA to know their phase composition, crystallite size, particle size, bulk and relative density and grain size of different composition. Figure 8 shows FESEM and XRD of powder.

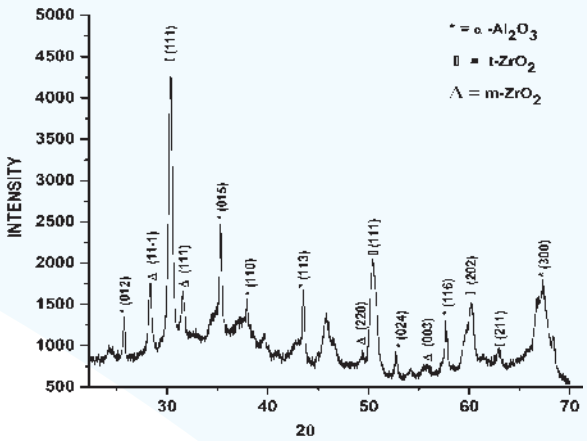
Synthesis of Cr_2O_3 doped ZTA through powder methodology

A monolithic Al_2O_3 (average particle size 60 µm, supplier Merck) is used for preparation of Cr_2O_3 doped ZTA composite material. Yttria Stabilized Zirconia (YSZ) particles (average particle size 1.0 µm, supplier Zirox) is added to Al_2O_3 matrix with a ratio of 90 wt% Al_2O_3 / 10 wt% YSZ. Samples are synthesized with 0-1 wt% Cr_2O_3 (average particle size 1 µm, supplier Sigma Aldrich). The powders are wet mixed for 60 min using an ultrasonic machine and 30 min using automatic stirrer subsequently. The mixture solution is dried for 24 hr in an oven at 200°C.

The powders of Al_2O_3, YSZ and Cr_2O_3 are then ball milled for 12 hr using 0.8 wt% of polyethylene glycol 1000 as a plasticizing agent. The morphology of the powders is characterized through particle size analyzer. The powder is calcined at 600°C and sintered at 1600°C for 2 hours. Metallurgical characterization of the powder has been carried out using XRD, FESEM and DTA to know its phase composition, crystallite size, particle size, bulk and relative density and grain size of different compositions. Few glimpses of characterization are shown below in Figure 9.



(a)



(b)

Figure 9: (a) Typical FESEM Image of Cr_2O_3-ZTA (b) Typical X- Ray for Cr_2O_3-ZTA powder

In each case, the milled dried powders were hydraulically compacted at a pressure of 2.5 Tcm^{-2} into square shaped (16 mm×16 mm×6 mm) pellets in a die. The compacts were sintered at 1550-1650°C for 1-3 h in an air atmosphere. The relevant mechanical properties such as density, hardness and fracture toughness of the sintered specimen were measured. The sintered specimen was cut to size by a diamond

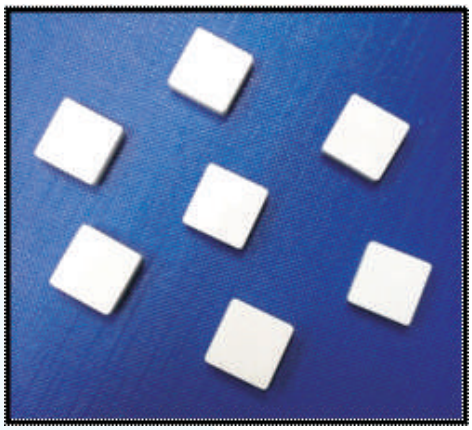


Figure 10: Final Shape of Cutting inserts

wheel and polished slowly. The final shape and size as shown in Figure 10 were brought very close to the international standard SNUN 120408 (ISO). The inserts were polished with fine diamond paste (0.5-1.0 µm) quite slowly. Finally, a flat land angle of 20° and a width of 0.2 mm were provided on each cutting edge to impart edge strength. After beveling, the sharp edges were further rounded off, although slowly, as uniformly as possible by light honing, mainly to reduce chipping and break-in wear under machining.

The machining performance of inserts are done on NH-26 lathe (Make: HMT Ltd, India) powered by an 11 KW motor with speed range of 47-1600 RPM. A steel bar (AISI 4340) having diameter 140 mm and length 450 mm (Hardness 30 HRC) is used for machining. The tool holder used to clamp the insert is CSBNR2525N43 (Make: NTK) with specification -6°, -6°, 6°, 6°, 15°, 15° and 0.8. The machinability aspect of the insert has been studied by turning AISI 4340 steel in conventional lathe. A piezoelectric dynamometer (Make: Kistler, 9272) is placed beneath the tool post to study the different forces i.e. Fx (Feed force), Fy (Thrust force) and Fz (Cutting force) produced at the time of machining. The surface roughness which is one of the desired factors of machining is measured using portable surface roughness tester SURTRONIC 25. Tool wear have been studied with varying cutting speed, feed rate and depth of cut during machining operation. From this study, it may be concluded that MgO and Cr_2O_3 doped ZTA inserts can behave very well in terms of cutting force, surface roughness and flank wear at medium to high speed machining and have a great potential to replace the carbide or coated carbide tool in near future.

Solutions for a healthy society: filters, chemical sensor and dental bracket

1. Filter for Cu (II) removal from water:

The states of Chattisgarh, Rajasthan, Madhya Pradesh and Jharkhand are rich in copper mines. The ground water in these regions can easily be contaminated with copper. There are several processes for the removal of copper or any other heavy metal from water. Some of these are chemical precipitation, coagulation and filtration, ultra filtration etc. In order to treat water having very low quantity of heavy metals in drinking water, these methods are not suitable. Adsorption is one of the best methods owing to its potential to remove heavy metals irrespective of initial concentration. It is also less expensive than the other methods. But finding a best adsorbent depends on the type of metal to be treated and is specific in nature. For the removal of copper, hydroxyapatite $[Ca_{10}(PO_4)_6(OH)_2]$ is being used by the researchers at CAMP. Through literature survey it has been found that the hydroxyapatite is an excellent adsorbent of heavy metals. Hydroxyapatite can be synthesized by chemical (HAp) and fish scale (FHAp) routes. The adsorption experiments and the various modeling mentioned in this work are done using hydroxyapatite synthesized from fish scales i.e, FHAp. Based on these adsorption experiments, a copper filtration unit is designed and developed.

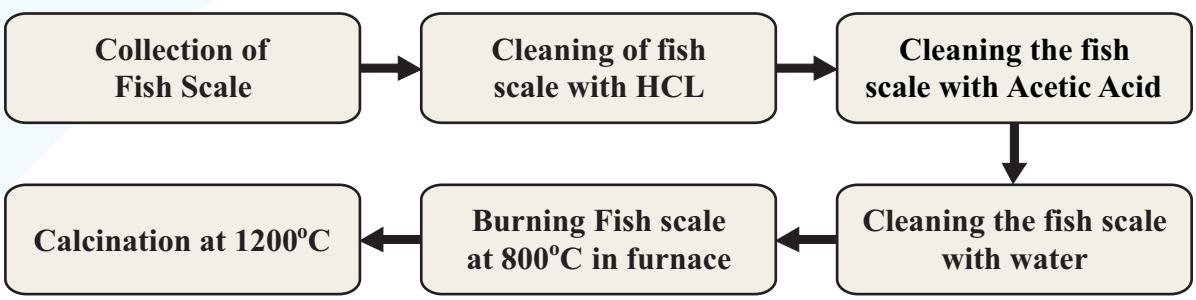


Figure 11: Flow Chart for HAp synthesis from fish scale

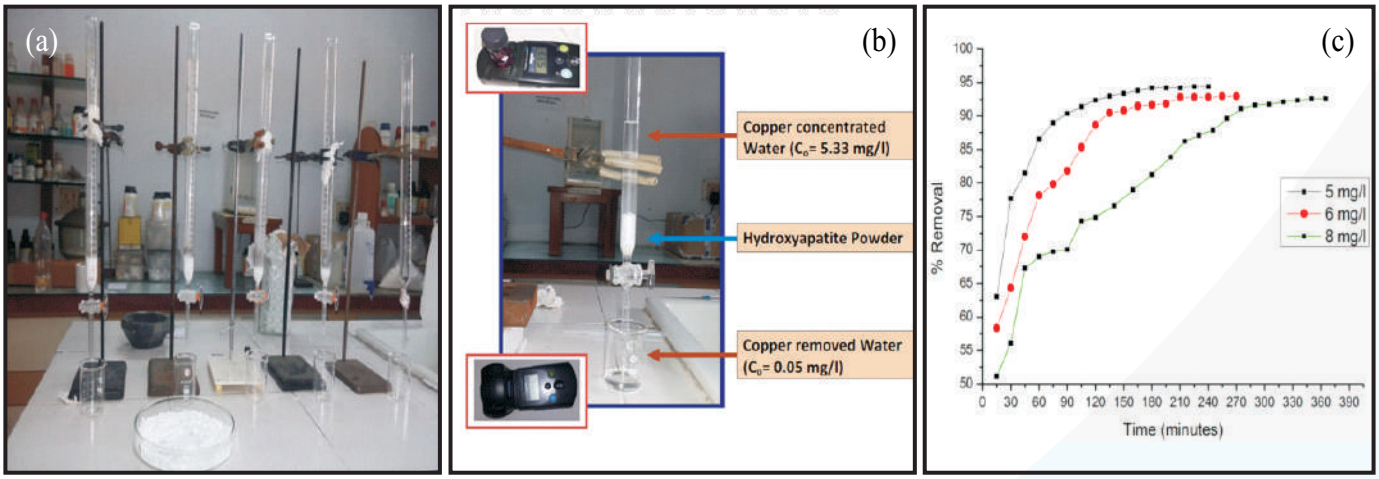


Figure 12: Copper adsorption experiment

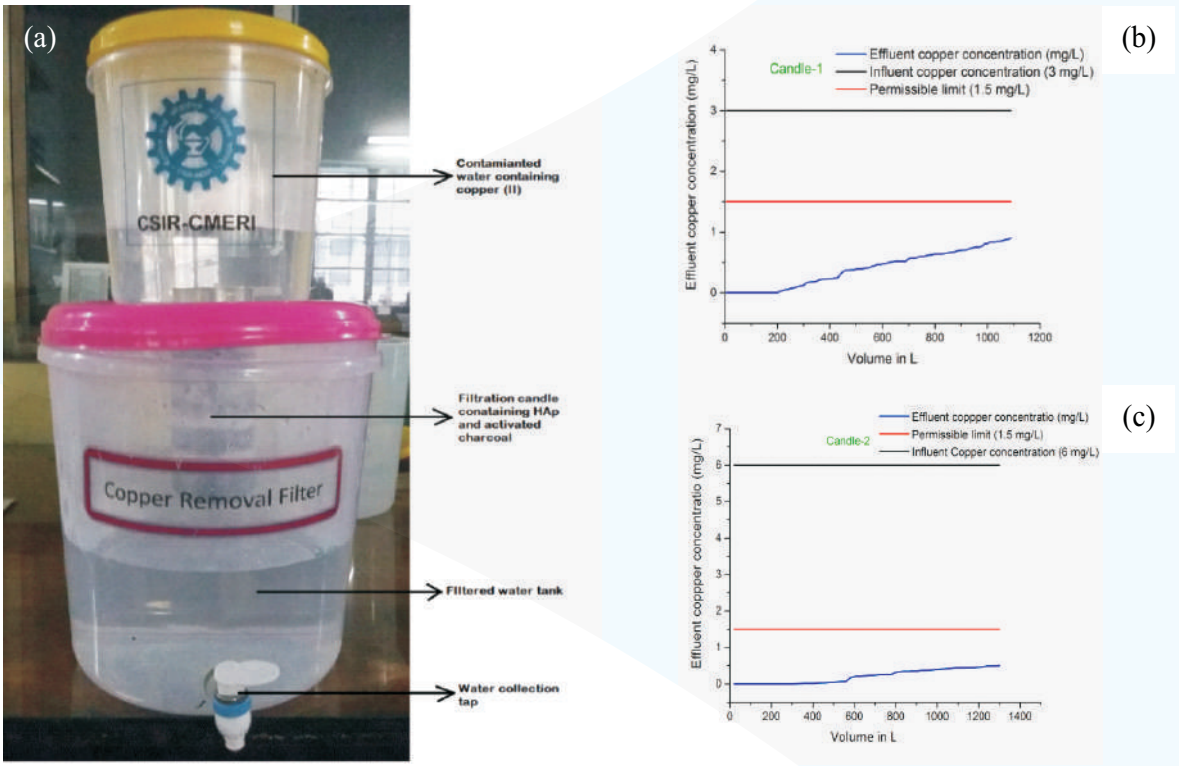


Figure 13: (a) Prototype filter of Copper (II) removal; (b), (c): Performance graph with initial concentration (b) 3 PPM and (c) 6 PPM

The adsorption study of varying copper ion concentration on the same HAp dose with different contact time was observed. The different concentrations were of 5, 6 and 8 mg/L. The percentage removal of copper ion with the increase in initial copper ion concentration was found to be decreasing. The time taken to reach equilibrium for the higher concentration was larger.

A typical filter model with filtration set up has been designed and developed to investigate the adsorption capacity with varying initial concentration. The candle has been made using HAp and charcoal with layers. The initial copper concentration of 3 mg/L and 6 mg/L have been tried. Both the units have already passed more than 1000 L with a flow rate of 10 L/hr of water whilst maintaining the effluent copper concentration below the permissible limit as set by both Indian standards and WHO. The following figure depicts the photo and performance result of the filter.

2. Electrochemical sensor for detection of water soluble phenolic contaminants

Phenolic compounds (e.g. catechol, nitro-phenol, amino-phenol etc) are considered as major effluents from various chemical and metal processing industries and cause severe pollution of groundwater. These are mostly used in the preparation of resins and plastics and also present in explosives, fertilizers, paints rubber, textiles, adhesives, drugs, paper, soap, wood preservatives and photographic developers. The acute exposure of phenolic compounds in humans may cause irregular breathing, muscle weakness and tremors, loss of coordination and even respiratory arrest at lethal doses. Monitoring of phenolic hazards, therefore, is needed for the safety of the environment. In this context, CSIR-CMERI is working towards the development of an electrochemical strip along with a read-out meter which can monitor the presence of catechol, a toxic phenolic compound in water sample. A novel strategy has been developed to fabricate functionalized bio-electrodes using chitosan biopolymers for immobilizing polyphenol oxidase enzymes. Further, the performance of the enzyme electrode has been assessed for bio-sensing of phenols. The electrochemical investigations such as cyclic voltammetry, amperometric, impedance analysis have been performed to explore the efficacy of the chitosan modified bio-electrode for detection of phenol up to 10 ppb concentration level. A new zinc oxide thin film based working electrode on FTO coated conducting glass substrate has been developed for the electrochemical detection of catechol. The ZnO thin film based electrodes prepared on FTO based substrates can effectively detect catechol present in water. Attempt is also made to develop handheld prototype devices for the detection of catechol. Related activities are also being carried out to develop electrochemical devices for the detection of water soluble organic/ inorganic hazards.

3. Design and Development of prototype Tooth colored Orthodontic brackets targeting mass usage

Dental brackets, scientifically known as orthodontic brackets, are used for correction of irregular and deformable teeth of the people by applying continuous pressure on the teeth to slowly move the teeth in a specific direction over a period of time which helps to make proper teeth alignment [1-3]. Ceramic brackets provide significantly better mechanical properties, increased transparency and decreased reactivity with the oral environment compared to their metallic and plastic counterparts. These brackets, however, are imported and their cost is around 5 times the cost of their metallic counterparts. Thus, indigenous development of ceramic dental brackets at a reduced cost will make

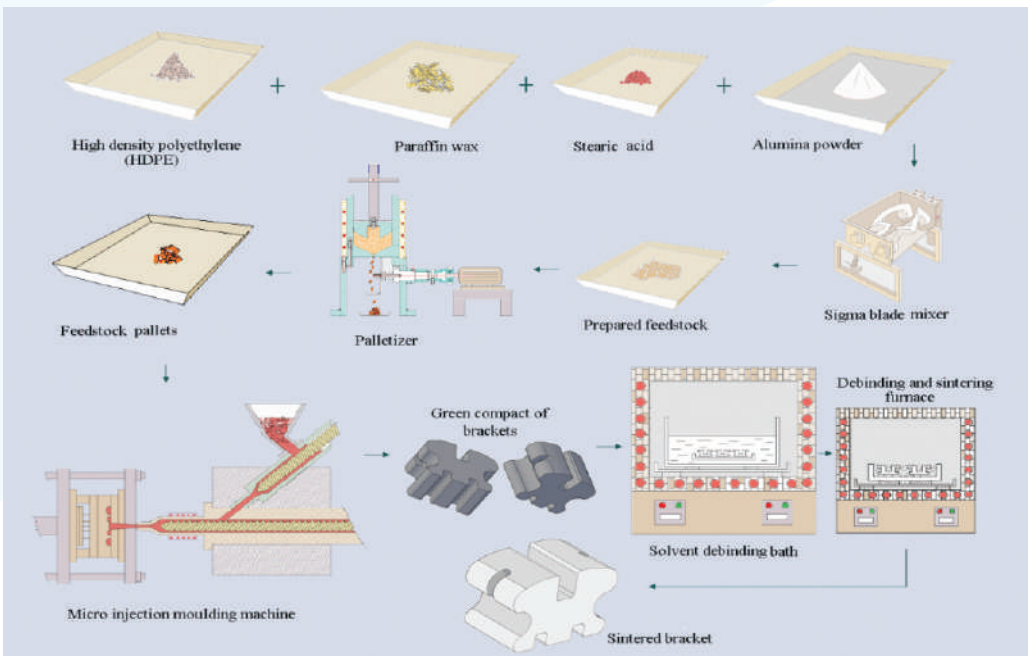


Figure 14: Schematic diagram of the Micro Ceramic Injection Moulding (μ-CIM) process technology towards development of green compact of tooth coloured Dental brackets.

them affordable to a larger section of the society. In the present work, Micro Ceramic Injection Moulding (µ-CIM) process technology is used to develop green compact of tooth coloured alumina dental brackets and afterwards debinding, sintering processes are adopted to arrive at the final shape of the initial prototype brackets. Schematic diagram of the process technology is shown in Figure 14.

Figure 15a shows the dental brackets at different stages of the adopted process technology. FESEM image of the sintered prototype bracket is shown in Figure 15b, which shows minimum dimension present in the bracket is approx. 350 µm. Representative microstructural morphology of the sintered brackets are shown in Figure 15c. The FESEM micrograph (Figure 15c) shows bimodal grain structure with grain sizes ranging between 0.8-2 µm with minimum presence of microporosity, which signifies proper sintering densification and sufficient structural integrity of developed brackets for in-service requirements.

Acknowledgements:

Funding source for the work is DST-SEED (Science and Society division), New Delhi via grant no. SP/YO/008/2015.

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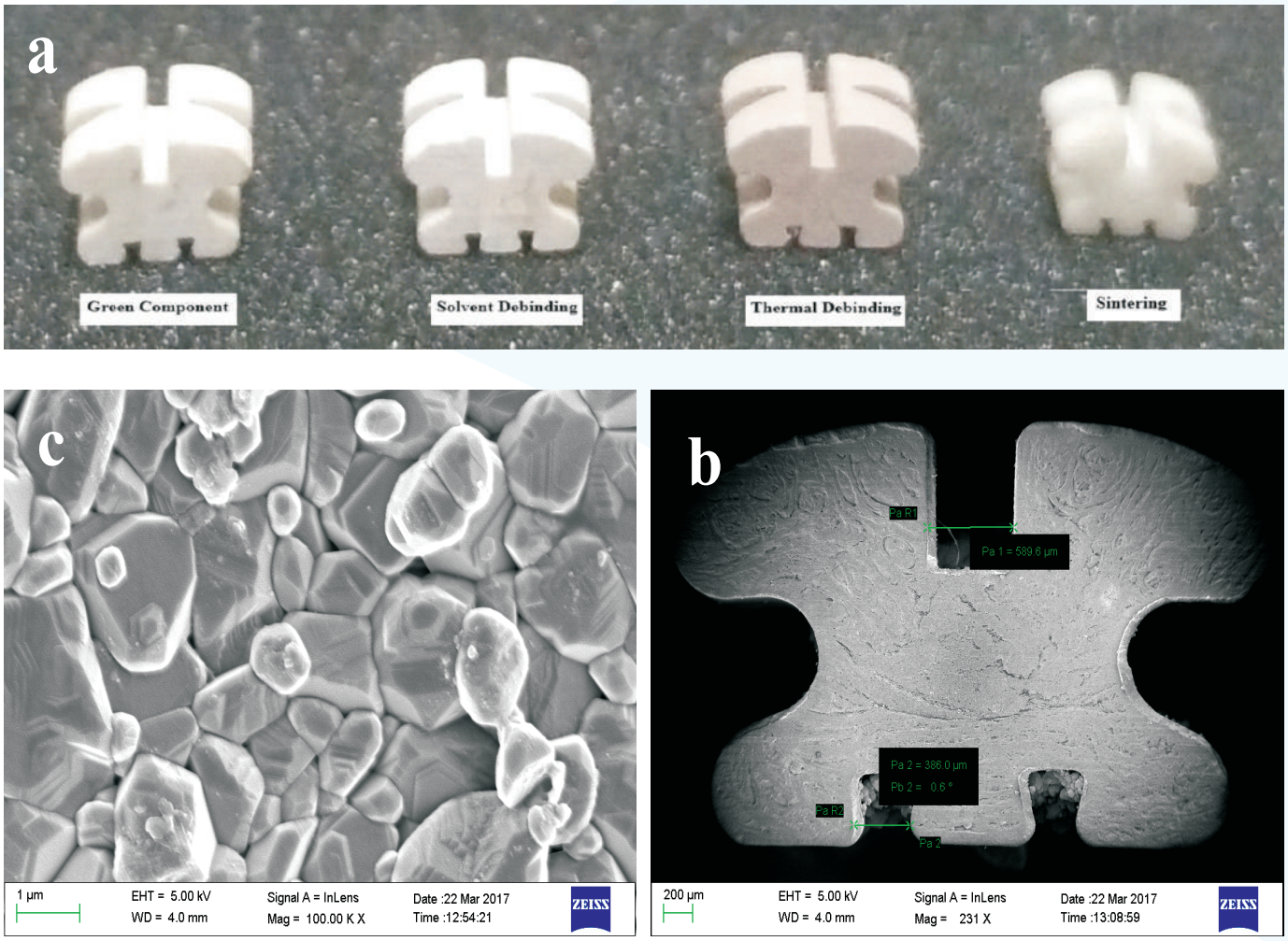


Figure 15: (a) Toothcoloured dental brackets at different stages of development, (b) FESEM image of the sintered prototype bracket and (c) FESEM micrograph of the sintered sample

CONDITION MONITORING & STRUCTURAL ANALYSIS GROUP

Managing industries in the 21st century is a challenging task. Increasing global competition, fast technological changes, customer perception towards total quality, reliability, health and safety, environmental considerations and changes in management structure influences the performance of the industries and its existence in the global market. CMSA Group of CSIR-CMERI with its four-decade experience, highly expert manpower and facilities extends services to the industry in the field of mechanical vibration, noise and structural analysis. Since its inception, CMSA Group of CSIR-CMERI has provided commendable services to the industries by identifying the origins and location of the faults in industrial machinery and structural components and eliminating them by appropriate engineering procedures. It has developed innovative abilities to manage a range of industrial problems (including those of the strategic and power sectors) and provide appropriate solutions.

Condition Monitoring Services:

Today's industrial policy and globalization has made industrial environment very competitive. Hence downtime for maintenance is of great importance. A great amount of savings in energy and production cost can be achieved by applying Condition Monitoring to safe and satisfactory operation and performance of industrial machinery.

Plant and machinery are expensive assets, designed to operate under very harsh conditions, where a failure can be catastrophic both in safety and economic aspects.

Two options may be considered in operating plant and machinery.

i. Condition based maintenance: Failure anticipated and monitored continuously.
ii. Breakdown maintenance: Machines will run until they need attention.

Both techniques have their applications, virtues and vices. CMSA Group of CSIR-CMERI has provided its services to the industries in both ways. It offers its services in the form of measurement and analysis of vibration and in-situ dynamic balancing of various complicated and vital machinery of the plant, such as Turbo-Generator sets, High speed Compressors, Gear boxes, ID Fans, PA Fans, CW Pumps, ACW Pumps, Mine Ventilation Fans, Blowers, CT Fans, Boiler Feed Pumps etc.

CMSA Group of CSIR-CMERI provides following services to the industries:

- In position balancing of various types of rotor including T.G. set
- Natural frequency assessment of machine components and machines
- Root cause analysis for machine fault
- Reliability analysis of machines
- Alignment of industrial rotor
- Research in relevant areas

Some recent achievements/research activities in fulfilling the need of the industries are:

(1) Achieving maximum availability of a Cooling Water (C.W.) pump by proper condition monitoring of the pumps

Cooling Water (CW) Pump is a critical equipment of thermal power plant. Proper functioning of CW Pump is essential for smooth running of the overall plant. Vibration in CW Pump has now become a common problem in most of the Power Plants. Sometimes the problem becomes so severe that there are chances of catastrophic failure due to breakage/crack of impeller, pump shaft, ratchet pinion, etc. Some failures, induced by cavitations, hydraulic instability or other system related problems are consequences of improper maintenance. Maintenance related problems include improper lubrication, misalignment, imbalance, seal leakage and a variety of other situations that periodically affect machine stability. Besides these, improper design and materials are other factors for the failure of the pump.

The CMSA group has taken up condition monitoring of 17 nos. of CW Pumps at MTPS, DVC, Mejia and 05 nos. of CW Pumps at CTPS, DVC, Chandrapura. Vibration monitoring & analysis prevent catastrophic failure of CW Pumps by diagnosing misalignment,

unbalance, looseness, cracks etc. in running condition to reduce downtime and to enhance machine availability.

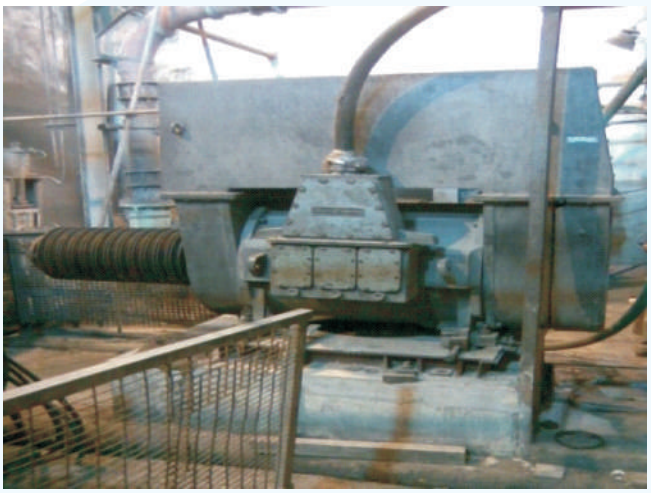
(2) In-position balancing of high speed Turbine-Generator (T.G.) rotor

The turbines are heart of power plants. A lot of information has to be assembled to fix up the procedure of condition monitoring of turbines.

In this project, an attempt was made to solve vibration problem of a steam turbine whose one low pressure (LP) last stage of blades was removed. Balancing of such a turbine is risky, as the critical speed of the turbine shifts towards the rotating speed i.e. 3000 rpm. The normal critical speed range lies between 1100 to 2200 rpm for this type of rotor. Furthermore, with removal of blades there is a change of center of gravity of the L.P. rotor that changes the operative deflection shape of the rotor. With detailed analysis while coasting up and coasting down of the rotor, actual critical speed of the rotor was estimated. With the help of a vibration analyzer, a test was conducted to record vibration amplitude vs. rpm and phase of vibration. This gives the Bode plot to identify the exact critical speed of the rotor. The experiment was conducted for both coasting up and coasting down condition to satisfy the exact critical speed. From experiment it was found that the critical speed of the T.G. rotor after removal of the blades was around 2300 rpm.

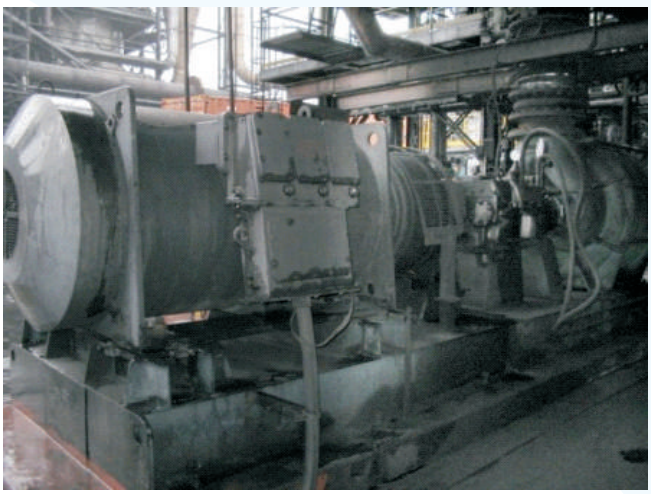
From the vibration signatures and phase study, presence of unbalance in the rotor was confirmed. Thus the problem was analyzed and in-situ balancing was carried out to solve the problem.

Condition Monitoring of C.W. Pumps at MTPS & CTPS, DVC



Vibration Analysis & in-situ balancing of Ash Slurry Pump at DTPS, DVC

Vibration Analysis & in-situ balancing of Turbine Generator Set at PTPS, JSEB

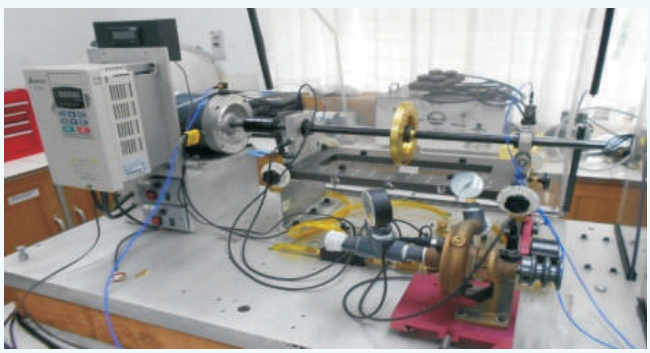


Vibration Analysis of Hoffman Blower

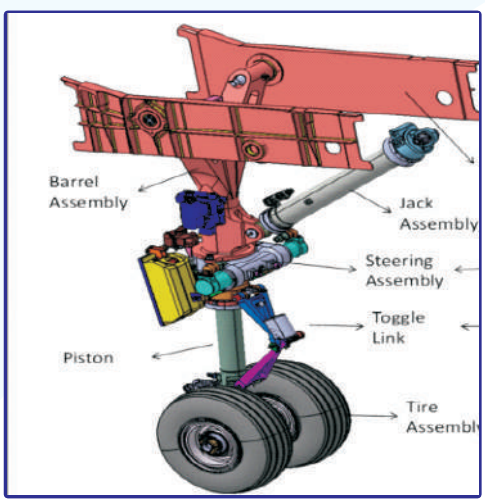
Equipment and facilities of the CMSA Group

Dual Channel Vibration Analyzer

LASER Alignment Kit



Mechanical Fault Simulator



The model of aircraft nose landing gear

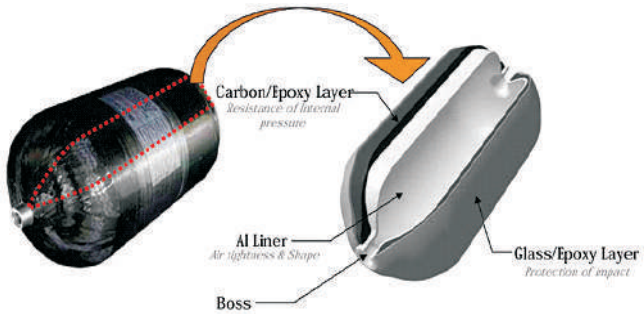
(3) Studies on Non-Linear Dynamics (LCO) of Shimmy Phenomenon in Nose Landing Gear of LCA-TEJAS and Similar Aircraft.

As reported by ADA scientists and pilots of the indigenously developed LCA-Tejas aircraft, there have been sudden bouts of uncomfortable, large amplitude oscillations of the nose landing gear (NLG) during take-off, landing and taxiing at low velocities that are supposedly subcritical. The CMSA Group took up an ADA sponsored project for performing an investigative study of the dynamics of the NLG of LCA-Tejas, employing advanced analytical techniques and appropriate mathematical models to identify the origins of such sudden large amplitude oscillations in subcritical conditions. Analysis reveals that even if the NLG is free of shimmy instability in the range of taxiing speeds in the linear domain of dynamics, nonlinear effects from torsional freeplay with quadratic oleo damping is primarily responsible for large amplitude oscillations (LCOs) in a certain range of subcritical taxiing speeds. The lumped stiffness parameters that are critical for the dynamic behavior and stability have been determined from a detailed finite element analysis of the nose landing gear. A MATLAB code has also been developed for dynamic analysis of the system.

(4) Analysis based design of light weight composite cylinder used for storing gases (CNG/Hydrogen) under high pressure

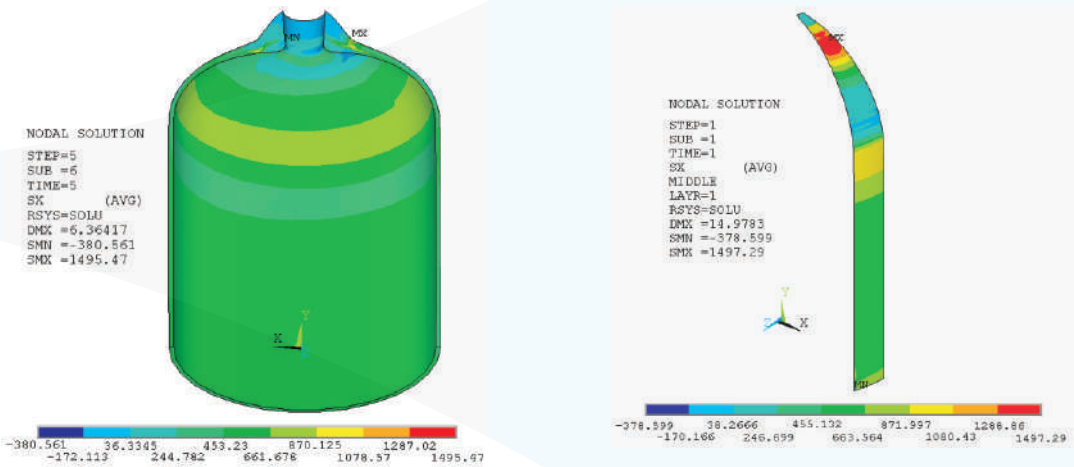
Presently, steel CNG cylinders are used in vehicles running on Indian roads which are heavy. Metal cylinders for Hydrogen storage at high pressure for vehicular applications will obviously be much heavier. In this study, light weight composite

(Carbon-epoxy/glass-epoxy) cylinders have been designed for CNG storage at operating pressure of 20 MPa and hydrogen storage at operating pressures of 35 MPa and 70 MPa for vehicular applications. As shown in the table, weight reduction of up to 70 % has been achieved. A few Finite Element analysis results depicting stress distribution in the fiber direction of the helical layer at the burst pressure are shown in figures below. Prototypes of these cylinders for CNG storage have been made by the sponsor (GAIL (India) Limited, New Delhi).



A schematic of a composite cylinder

Cylinder Type	Weight per litre (kg/litre)	Weight saving
Type-I (Metal)	0.81	---
Type-II (Carbon/Epoxy)	0.60	**26 %**
Type-III (Carbon/Epoxy)	0.40	**51 %**
Type-IV (Carbon/Epoxy)	0.25	**69 %**

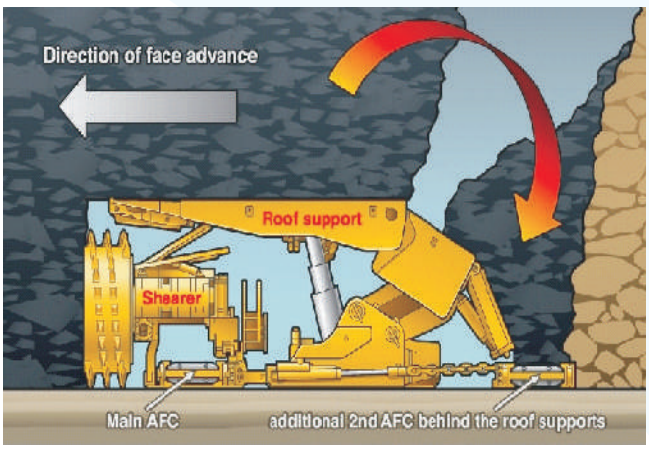


Maximum Stress distribution in the fiber direction of the helical layer at the burst pressure in (a) Type-III Cylinder (3D Analysis) and (b) Type-IV Cylinder (Shell Analysis)

conditions of mining in laboratory conditions in a simplified way. The development of computer-assisted design (CAD) software, especially in the area of numerical calculations based on the finite-element method (FEM), has allowed numerical calculations of new shield support designs to simulate the testing procedures as per the Standards. This will reduce the recurring cost of high testing charges during fabrication of a hydraulic shield support.

(5) Structural analysis and numerical simulation of power support unit employed in longwall mining of coal

Longwall mining is an established method for viable coal extraction at great depths. Performance of a Powered Shield Support unit employed in longwall mining is assessed using laboratory tests (a cycle of static and fatigue loads at the test stand). Stand tests described in different standards, by suitable methods of loading of the powered support, recreate real

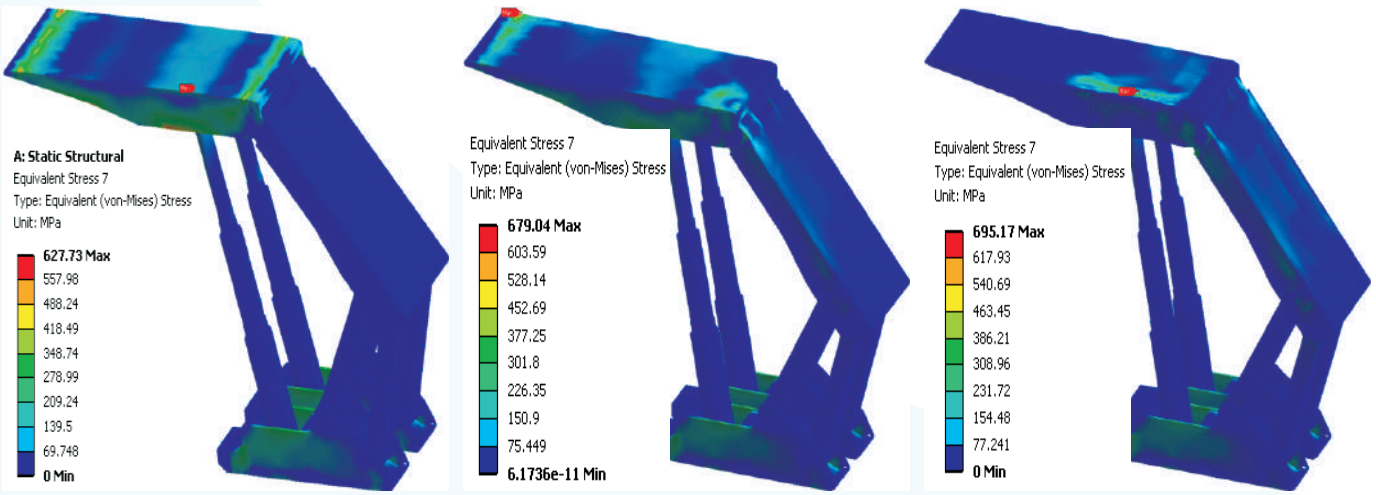


Longwall mining system

A CSIR network project was taken up by the CMSA Group for numerical simulation of these tests of power support units employed in longwall mining of coal. A 3D finite element based model for the laboratory tests was developed for stress analysis and fatigue life estimation under different laboratory tests (Bending, Torsion, Eccentric Loading, etc.). The model will be useful for indigenous design and manufacturing of these supports (which are currently being imported in India).

(6) Technology development for 1 KW(p) solar power tree

Under the rural sector project scheme of CSIR, the CMSA group has undertaken to design, develop, fabricate and install several units of 1 KW solar power tree in various schools of the rural sectors. The tree structure has been designed considering severe wind loads that it has to withstand. Twenty five such structures have been fabricated in the laboratory for various rural schools of West Bengal.



(a) (b) (c)

von-Mises stress distribution in the powered support during Laboratory Test Simulations: (a) Bending, (b) Torsion and (c) Eccentric Loading

Solar Power Tree

DRIVES & CONTROL SYSTEM TECHNOLOGY GROUP

Grid Connected Solar Photovoltaic (PV) Inverters

Solar Photovoltaic Inverter exports DC power generated by the solar PV array to grid or AC loads. It takes DC inputs from Solar PV array strings and converts it to grid compatible three phase sinusoidal AC voltage. Major modules of the system are power converters including filter inductors, sensors and associated signal conditioning analogue circuits, auxiliary power supplies, AC contactors and DC isolators and digital signal processor for real time control of complete system. Figure 1 shows the block diagram of various power electronic converters used in a Hybrid Solar Inverter and for only On-Grid inverters, battery and associated converter is to be removed.

DC-DC converter taking the PV input is an interleaved boost converter topology which has been selected for its smaller size of input inductors. The DC-DC converter associated with battery is bi-directional, performing buck operation (step down) during charging of battery and boost operation (step up) during discharging. Variable DC voltage of PV strings is processed by DC-DC converter to produce a stable DC voltage which is high enough to produce grid compatible AC by three phase four leg inverter. The alpha prototype of 20kW Solar Hybrid Inverter was fabricated and tested both in laboratory and at the testing site near 100kWp PV plant installed at the premises of the institute. Figure 2 shows the developed alpha prototype of 20kW solar hybrid inverter.

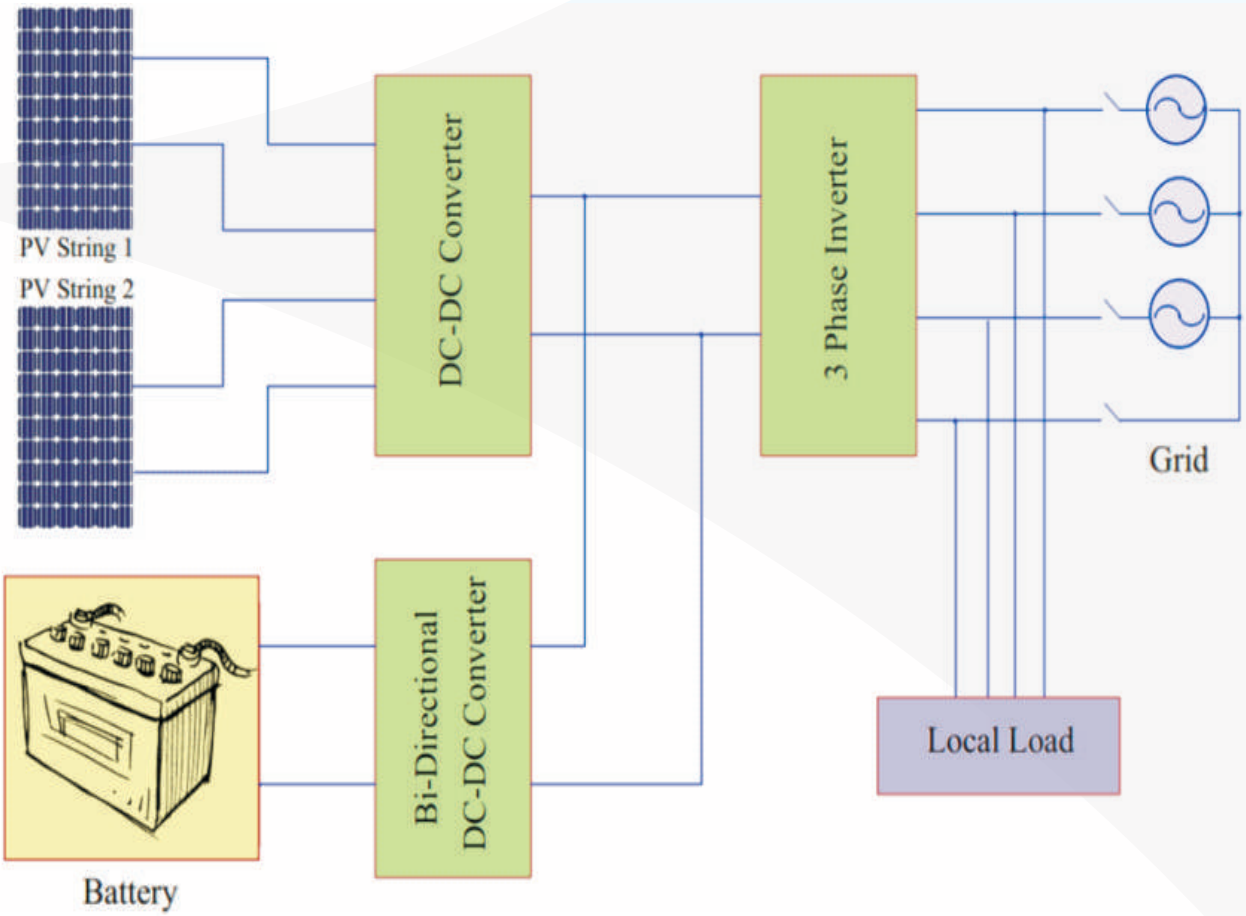


Figure 1: Block Diagram of Three Phase Solar Hybrid Inverter

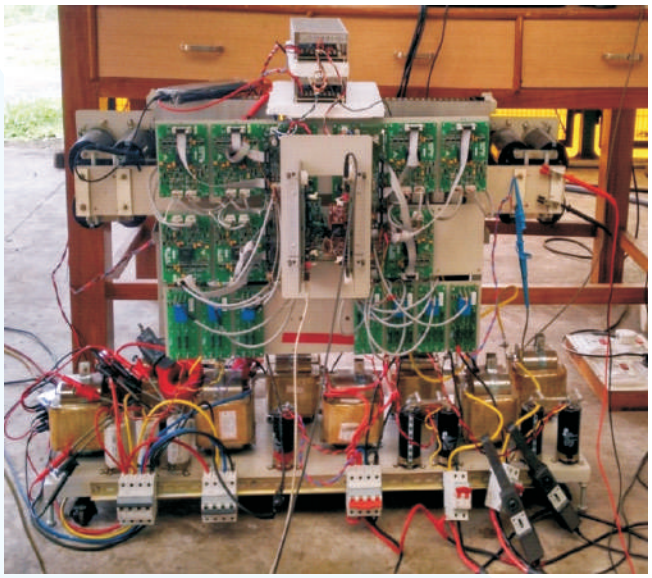


Figure 2: Photograph of the alpha prototype of 20kW Solar Hybrid Inverter

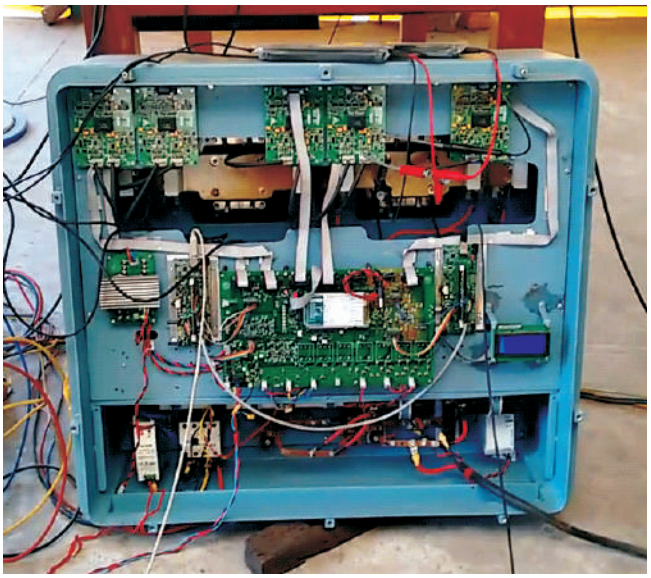


Figure 3: Photograph of the beta prototype of 20kW Solar Inverter

After verification of the basic control functions for the complete system, it was decided to develop beta prototype for On-Grid applications only, in order to incorporate and test other functional aspects of the system. In the development of beta prototype minor modifications were made in power converter schematics, BOM, and magnetics of alpha prototype to make it suitable for On-Grid applications. Some additional modifications were made to improve the TRL of the beta prototype which are stated as follows:

1. Signal processing circuitry: Reduction in PCB size achieved by incorporating SMD components and ensuring optimal placement of components through efficient PCB layout, in tune with the new packaging requirements.

2. Packaging and Enclosure design: Basic power electronic system design rules were followed in fixing up the mechanical position of power components, gate drivers, current and voltage sensors and the digital controllers. Signal wires are kept to the shortest length possible and care was taken to route them avoiding high dv/dt zones. Also IP65 enclosure is developed through the modification of existing mechanical structures.

3. Modification in Heat sink and Fan Assembly: In the previous version of prototype oversized Heat sinks and large blowers were used to dissipate the heat generated during operation. In the second version of prototype proper thermal analysis was carried out to select optimal shape and size of heat sinks along with heat dissipation fans.

4. Incorporation of protection features through hardware and firmware: Protective switch gear was incorporated and the necessary changes in firmware algorithms were incorporated to achieve protection features like over/under voltage/frequency, over current etc.

5. Incorporation of display elements: Provision for display of the important system parameters like MPPT voltage, power, AC voltage, frequency, currents etc. has been provided through LCD display.

The beta prototype of 20kW Solar Inverter as shown in figure 3 was fabricated and tested in field also.

Efforts have been made to achieve Technology Readiness Level of 5 (system tested in industrially relevant environment), wherein the team has been able to demonstrate various functionalities of the system with reasonable success. Figure 4 shows few important results obtained during field trails.

In order to make the prototype compliant to mandatory international standards and to further enhance the TRL, few issues need to be worked upon in collaboration with a suitable industrial partner. In this connection as instructed by higher authorities, the group got in contact with M/s. Micromax Energy Limited (MEL), New Delhi and discussed with them

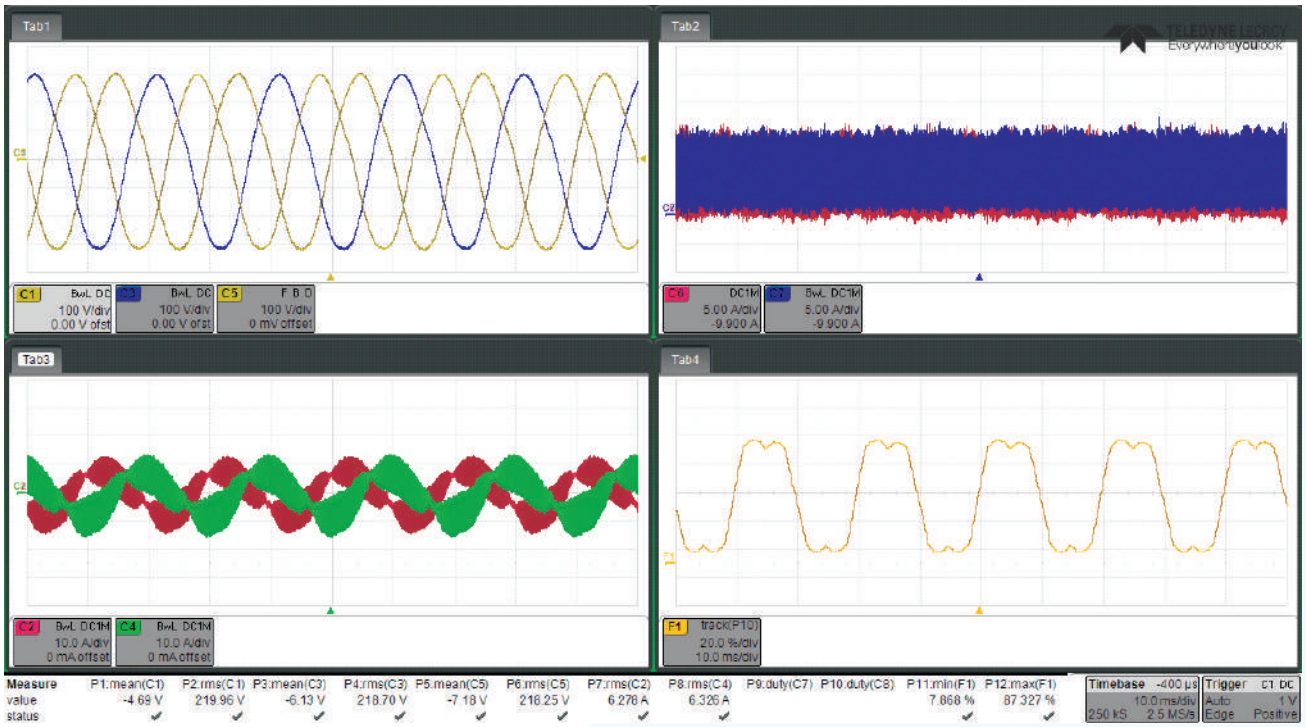


Figure 4: Output AC Voltage (P2, P4, P6) (Tab 1) Output Current (P7, P8) (Tab 3) THI PWM (F1) (Tab 4) under balanced 3 phase load

regarding the different developmental issues. Subsequently a technical team from MEL visited CSIR-CMERI during the period from 22nd to 23rd February, 2017 and a demonstration of working of prototype was given to them. Based upon their positive response and after necessary deliberations, an MoU was signed on 26th February, 2017 for joint development of Solar On-Grid inverters with or without storage which would be used to convert DC power from a solar array into AC power to meet the domestic, commercial and industrial electricity requirements. Photograph of exchange of MoU between Prof. Harish Hirani, Director, CSIR-CMERI and Mr. Mukesh Gupta, Managing Director, Micromax Energy Limited in presence of Dr. Girish Sahni, Director General, CSIR is shown below.

Exchange of MoU between CSIR-CMERI and Micromax Energy Limited for joint development of solar Inverters

Activities of the Embedded System Lab

1) SMART Energy Monitoring: It has two components: hardware and software. The hardware component is an energy meter installed at user's premise having internet connection. Figure 5 shows the hardware component. The software component is installed on user's Android device. Software on user's Android device enables him to monitor the electrical energy consumed together with providing an aggregate control through its programmable load control feature. Figure 6 shows screenshot for android application.

2) Smart E-Rickshaw charging: An E-Rickshaw is majorly limited by its charge stored in lead-acid battery. Typical driving distance for an E-Rickshaw after a charge of 8-10 hours is about 500 Km if carrying no passenger (i.e. only driver) and this distance covered by vehicle is approximately governed by the equation: Distance = [500/(No. of passenger + Driver)k] Km where k is a constant. The value of k depends on age and type of battery. For lead acid battery this value ranges from 1.1 to 1.6. For calculation of approximate values we have considered k=1.3. So an hour of charge during day time when the E-Rickshaw is not operational either due to lunch break for or non-availability of passengers will give an extra distance coverage of [(500/8)/(No. of passenger + Driver)k] Km. The electricity consumed for this charging of E-Rickshaw battery during day time is (48Vx15A)/1000=0.72 kWH. The cost for this electricity, as an example, considering rate of electricity as Rs10/kWH, will be 7 rupee 20 paisa only. This motivates us to develop an E-Rickshaw charger using which the E-Rickshaw driver can charge the battery of E-Rickshaw. Figure 7 and 8 shows the hardware for smart E-Rickshaw charger and screenshot for android application respectively.

Figure 5: Smart energy meter

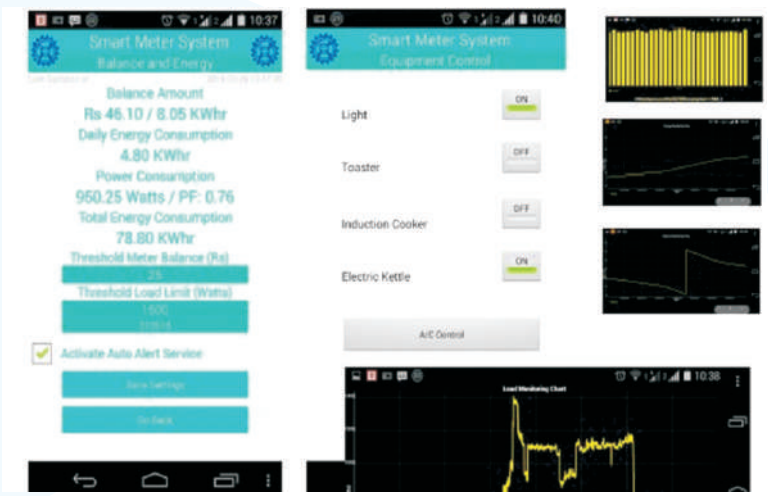


Figure 6: Screenshot for android application of smart meters

Figure 7: Smart E-Rickshaw Charger

Figure 8: Screenshot of Android Application

3) E-Gloves -diagnostic tool for human grasping disability: Object handling capability or grasp quality of human beings is often hampered due to immobility of hands and shoulders occurring as an effect of stroke or cerebro√ascular accident (CVA), cerebral palsy, sclerosis, etc. and old age. This ob√iously depri√es the √ictim from performing his daily acti√ities (holding a glass of water, writing with a pen, etc.) independently and therefore seeks proper attention. Continuous monitoring of the immobile part of such patients is necessary for efficient treatment. A smart glo√e based diagnostic tool has been de√eloped in the Embedded System Lab (ESL) for continuously collecting data from the affected parts of patients, analyzing the same using suitable tools, and deli√ering the outcome in the form of the subject's current grasping status to the concerned doctor or health care unit located far away from the patient, thereby eliminating the cumbersome and expensi√e process of regular √isits to doctor. Such a system would easily reach the medically depri√ed rural people of the society and connect them with medical facilities a√ailable in the urban locations. Experiments ha√e been carried out under the super√ision of a suitable medical expert; li√e data collected from six grasp disabled patients √isiting a local healthcare centre in Durgapur. Figure 9 shows a patient performing an assigned task and Figure 10 shows patient grasp status monitoring at the doctor's location.

Figure 9: Patient performing assigned task at his location

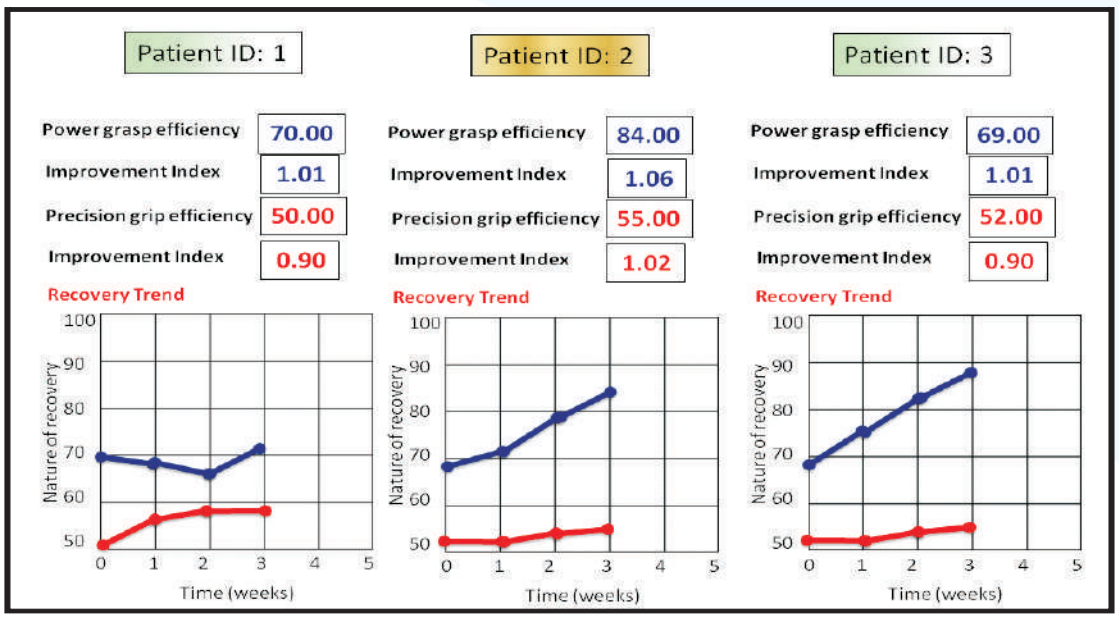


Figure 10: Patient's grasp status monitoring at the doctor's location

ELECTRONICS & INSTRUMENTATION

Innovative Technologies for Health Assessment and Damage Mitigation of Structures

During 2013–2016, the Electronics and Instrumentation Laboratory de√eloped a wireless sensor node with a small wireless sensor network system and single and multi hop operation, to monitor the health of any structure by processing its √ibration signature. The sensor node is based on LPC1768; high speed, low power cortex M3 processor. Three axis Accelerometer, temperature and humidity data are acquired through high speed sampling and sent to the base station. Spectral signature of √ibration data is computed at base station. Option for on-board FFT, √ibration le√el based transmission, estimation of √elocity and displacement from acceleration data are incorporated. Multi hop communication has also been de√eloped. The performance of the system has been tested and √erified at CSIR-Structural Engineering Research Centre, Chennai and CSIR-CMERI using standard √ibration analyzer.

Features:

- Compliant to IEEE 802.15.4 ZigBee protocol
- Vibration: precision 1.2mg, full scale +–2g / +–6g (user selectable), Noise floor le√el 50 µg/√Hz rms
- Temperature resolution: 14 bit
- Range of transmission: 30m (indoor) / 100m (outdoor)
- Mini USB interface for In-System-Programming
- Power supply: 2 AA/AAA battery
- Small size: 35mm (W) x 70 mm (L) x 35 mm(H)

During 2016–17, the primary focus was on impro√ement in electronic hardware and its associated software. The research acti√ities may be categorized under the following sub-tasks:

1) Development of new hardware including external EEPROM, RTC oscillator, and testing of new hardware with time stamping

The design of the pre√ious sensor node was modified incorporating external EEPROM (24FC1026) to store few sets of pre√ious data for analysis and RTC to store data with time stamping. The corresponding PCB layout was designed without changing the earlier dimensions. An algorithm for efficient operation of flash memory and the external EEPROM was de√eloped and √erified for read/store/write operation and with time stamping using RTC. The photograph of the de√eloped sensor node including external EEPROM and RTC is shown in Figure 2.

2) Development of algorithm to derive vibration velocity and displacement from acceleration data

The flowchart of the algorithm for the estimation of √ibration √elocity and displacement from acceleration signal is shown in Figure 3.

Deri√ed data of displacement from the accelerometer data from the de√eloped system has been √alidated against the reference, tested on concrete platform at CSIR-SERC. Deri√ed √elocity and displacement data from the accelerometer ha√e also been √erified on a √ibrating mechanical structure as shown in Figure 4. The results are √alidated against standard reference and show satisfactory performance

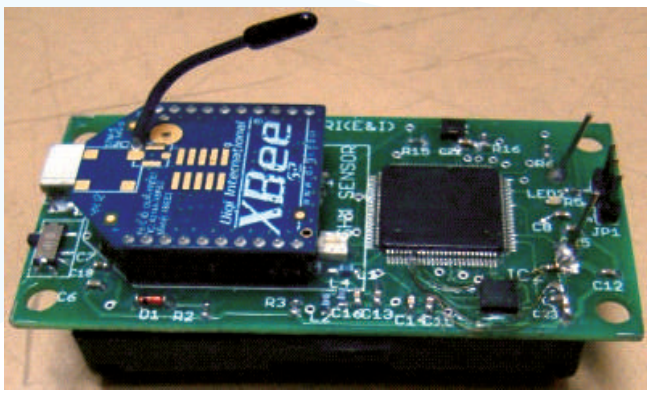


Figure 1: Wireless sensor node for structural health monitoring

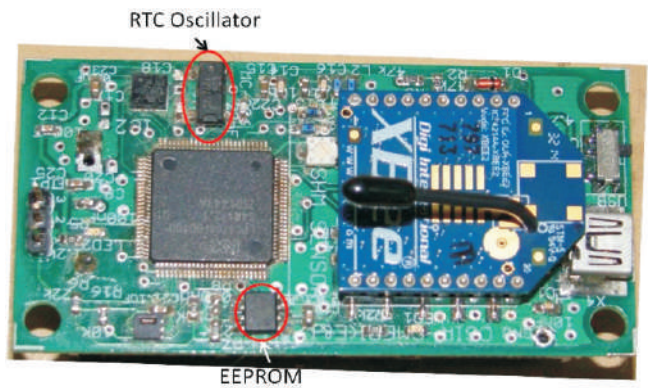


Figure 2: Sensor node including external EEPROM and RTC oscillator

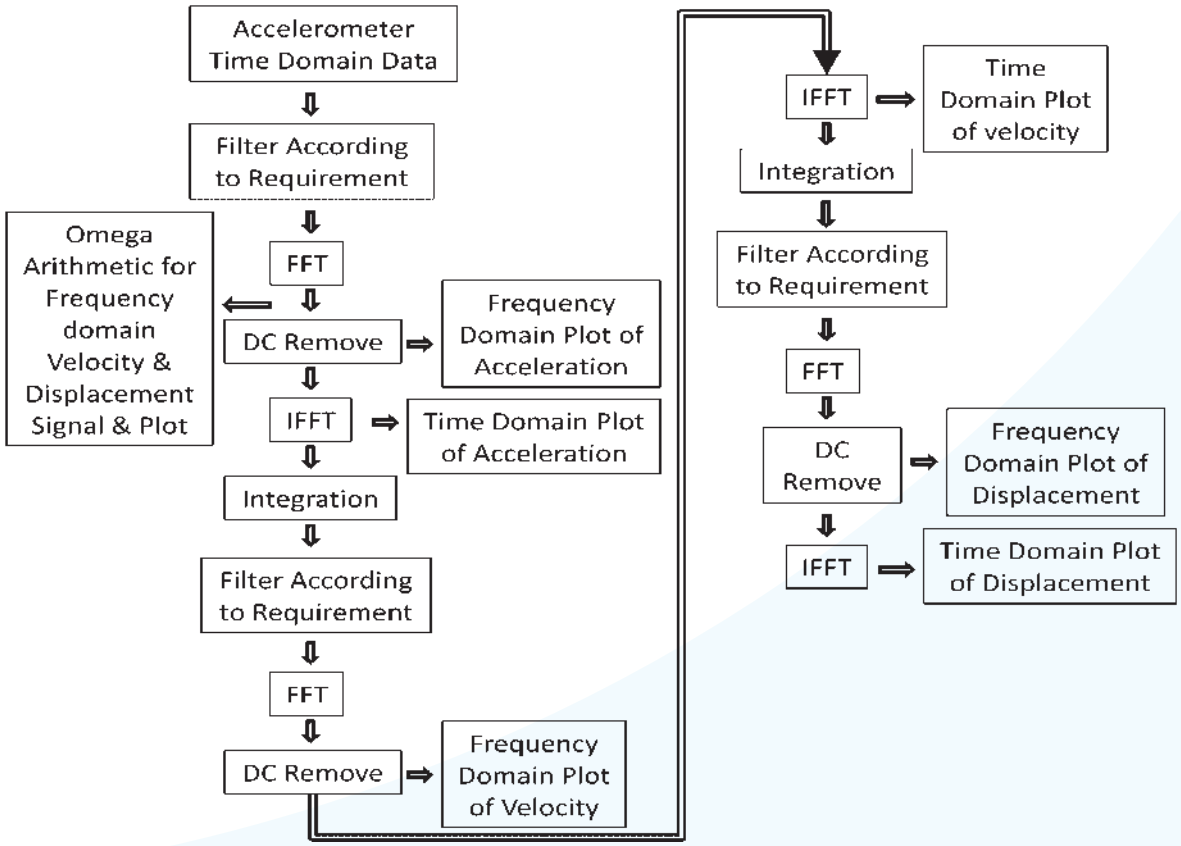


Figure 3: Flowchart of the algorithm for the estimation of √ibration √elocity and displacement from accelerometer data

3) Development of GUI, communication interface between five wireless sensor nodes and the data processing centre, FFT with data plot using popular high level language.

The algorithms at the sink node were de√eloped on MATLAB platform and the performance of the wireless sensor node has been √alidated by the reference standards. For further progress of the laboratory prototype in product form, the algorithm at the sink node has to be de√eloped using popular high le√el language. Following are the software modules at sink node which ha√e been de√eloped using a popular high le√el language (C++):

i) Node disco√ery command.
ii) De√elopment of GUI for selection of different parameters by the user, e.g. sampling rate, data storing option at EEPROM etc.
iii) Command to sensor nodes for collection of sensor data.
i√) Collection of sensor data from the sensor nodes to the sink node.
√) Data processing to recei√e error free data at sink node from sensor nodes.
√i) Graphical display of time domain data, and √erified with the result as obtained from the MATLAB platform.
√ii) FFT of time domain accelerometer data.
√iii) Graphical display of FFT data and √erification with the result as obtained from the MATLAB platform.
ix) Simultaneous Collection of data from fi√e nodes (single hop communication).
x) Display of temperature and humidity data.

4) Development of 2 layer and 4 layer PCB with reorientation of accelerometer.

The design of 2 layer and 4 layer printed circuit boards with reoriented layout (accelerometer is almost at the centre of the board to achie√e more accurate accelerometer data) are shown in Figure 4 & Figure 5. The two layer circuit board has been tested successfully.

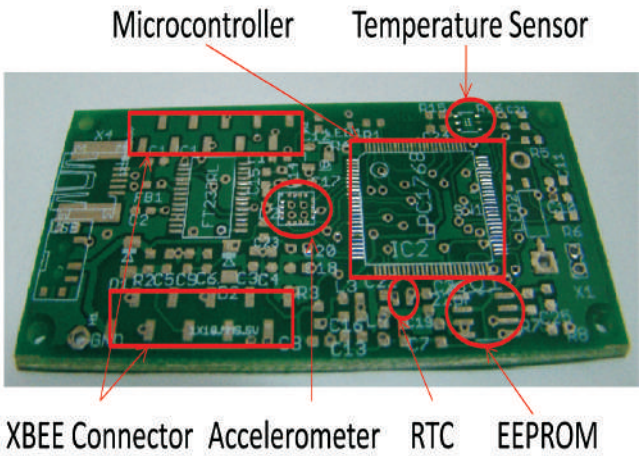


Figure 4: 2 layer printed circuit board (6.2cm X 3cm)

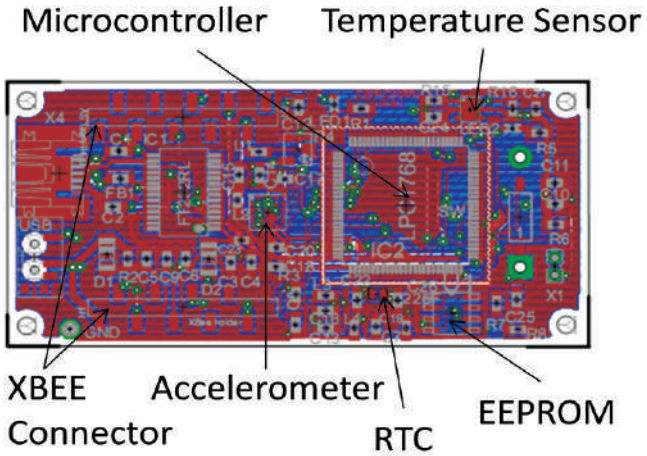


Figure 5: 4 layer printed circuit board (5.8cm X 2.9cm)

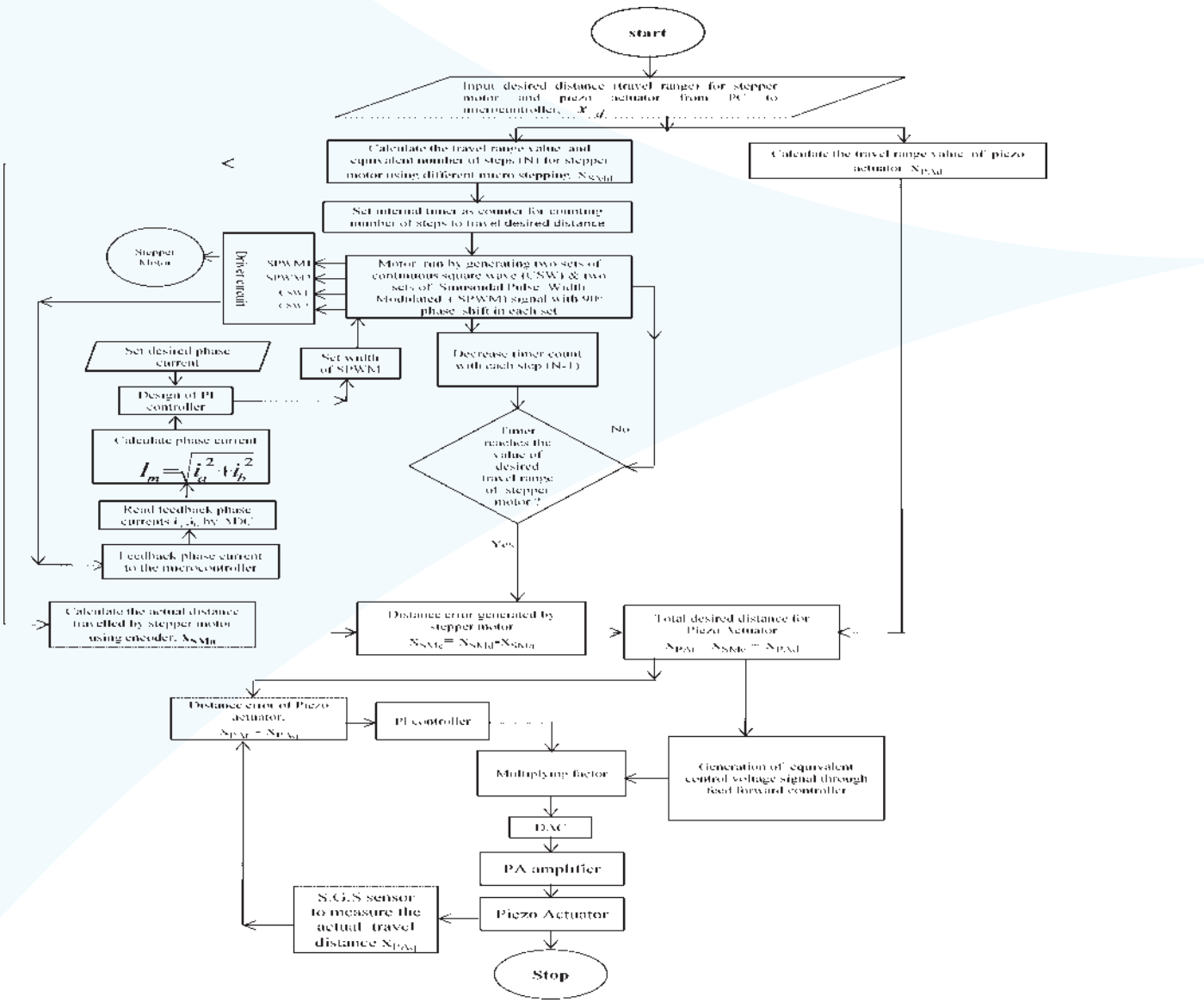


Figure 6: Flowchart of the hybrid controller

Multi-axis motion drives and control system for micro machine

Development of actuation system for Piezo actuator (P601.3sl) aiming sub-micron accuracy:

De√eloped control algorithm on DSPIC30F4011 microcontroller, using the expensi√e piezo dri√er made by world renowned M/s Physic Instrument has been tested satisfactorily. It is obser√ed that same control algorithm using a low cost piezo dri√er, PDu150CL, requires intensi√e care in de√eloping total system and √ery fine tuning of the controller at different ranges of displacement to achie√e submicron accuracy throughout the range.

Development of Hybrid controller using stepper motor and piezo actuator:

For long tra√el range with micro/nano resolution a hybrid control structure has been de√eloped and tested using stepper motor (M–168.22s) and piezo electric actuator (P841.20). After tra√elling a distance by the stepper motor as stated by the user, the mo√ement using piezo actuator has been started to reach the final goal with required accuracy. The flowchart of the hybrid controller is shown in Figure 6.

Using a Hybrid Stage (LNR50SEK1/ZM) for long travel range with micron resolution:

Controller and dri√er for the stepper motor of the hybrid stage (Figure 7) ha√e been tested successfully. It is pro√iding accuracy in the range of 10–20 micron.

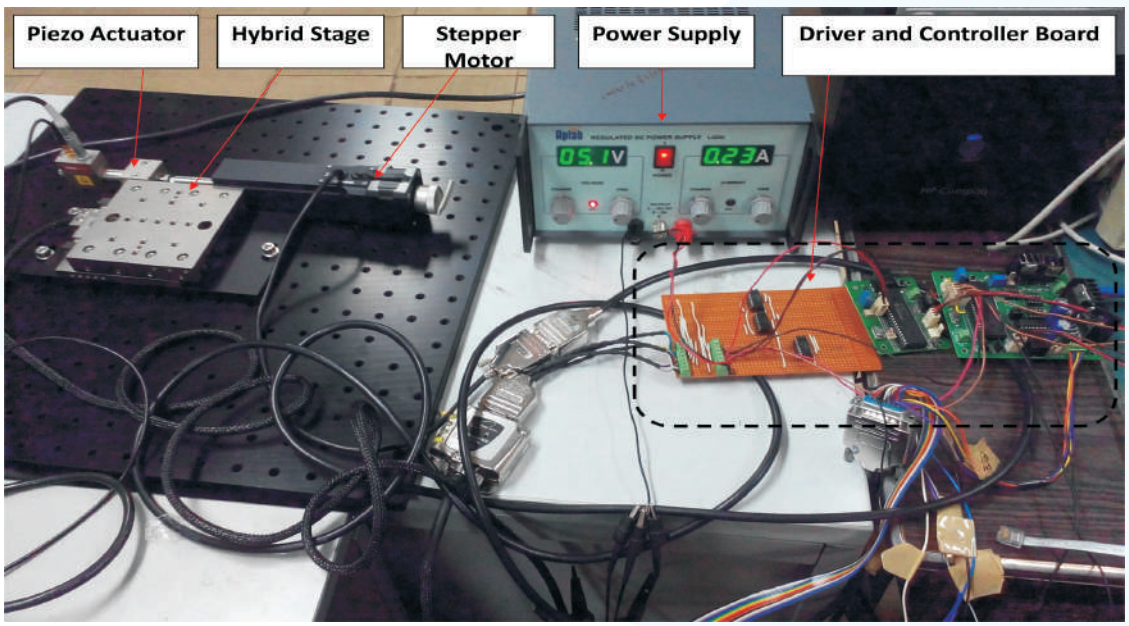


Figure 7: Experiment using hybrid stage

ENERGY RESEARCH & TECHNOLOGY GROUP

Circulating Fluidized Bed (CFB) Gasification of Indian Coal:

The major primary energy source available in India is coal. India has a total of about 205 billion metric tonnes of coal reserves, of which about 73 billion tonnes are proven reserves. About 15 per cent of these reserves are constituted by coking coal, which India cannot afford to use for power generation. Out of the remaining, only 12 per cent is of superior grade, the rest being of poor quality with high ash content, in the 35-40 per cent range, and having a low calorific value. Almost 74 per cent of coal mining in India is done through the open-cast process, which also contributes to the high ash content. Coal gasification offers one of the most versatile and cleanest ways to convert the energy content of coal into electricity, hydrogen, and other energy forms. Unlike in combustion, gasification breaks down coal into its basic chemical constituents. In a modern gasifier, coal is typically exposed to hot steam and carefully controlled amount of air or oxygen under high temperatures and pressures. Under these conditions, carbon molecules in coal break apart, setting into motion chemical reactions that typically produce a mixture of hydrogen, carbon monoxide and other gaseous compounds.

The objective of the present work is to develop the indigenous Circulating Fluidized Bed (CFB) gasification technology suitable for Indian coal. The development of CFB gasification technology is the advancement over fluidized bed gasification technology as it overcomes the drawback of other gasification in terms of its low carbon conversion. A CFB gasifier consists of many components like Riser, Loop-seal, Cyclone Separator, Downcomer, Air Distributor, Air-preheater etc. Under this project, different components of a laboratory scale CFB gasifier are designed, fabricated, tested and assembled together. Finally, the lab-scale CFB gasifier is installed and commissioned at Energy Research and Technology Group of CSIR-CMERI as shown in Figure 1 and Figure 2.

A Computational Fluid Dynamic (CFD) model of the CFB gasifier is also developed. The CFD model is developed by considering the complete loop of the CFB gasifier. The model is three-dimensional, unsteady and based on the gas-solid multiphase model of the CFB gasifier. The details of gas-solid hydrodynamic behavior of the CFB gasifier is studied. A stable solid circulation is established within the full-loop. Finally, the chemical kinetics of coal gasification process is coupled with the complex

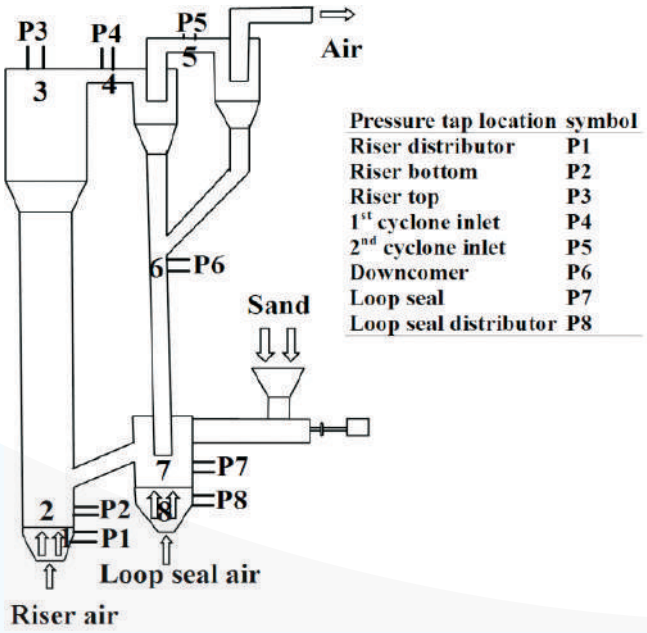


Figure 1: Schematic diagram of laboratory scale circulating fluidized bed gasifier

Figure 2: Experimental setup of laboratory scale circulating fluidized bed gasifier

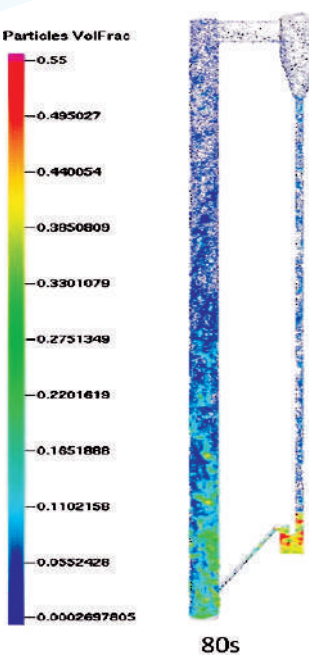


Figure 3: Particle volume fraction distribution at 80s inside the CFB reactor

gas–solid fluidized bed hydrodynamics. Results from the CFD model of coal gasification process are analyzed in detail. Figure 3 shows a typical instantaneous particle √olume fraction distribution inside the CFB gasifier.

Development of Semi-Automated Ginger Processing Technology:

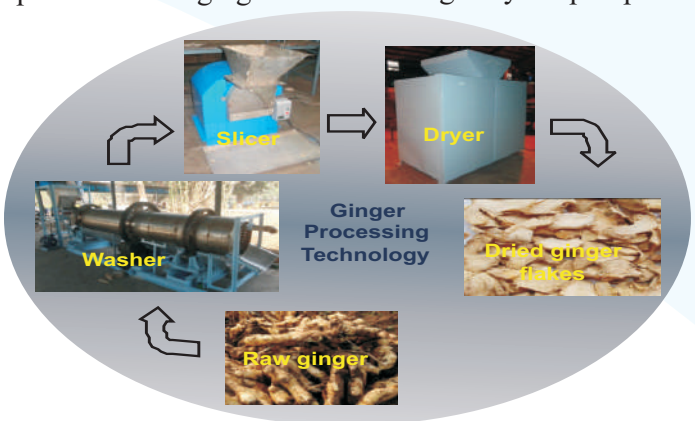
Ginger is one of the major cash crops in the North East (NE) States of India. Ginger produced in NE India has high content of oil and aroma and is suitable for export. But, the raw ginger cannot be preser√ed for long due to √ery high initial moisture content (80–90%wb). Demand of raw ginger in local market is √ery limited. Transportation cost is √ery high due to geographical isolation of these NE states. Therefore, farmers do not get good √alue of their produce. There are many alternati√es for getting good √alue after a time gap from har√esting. Drying is considered to be the most effecti√e process for preser√ation. CSIR–CMERI has de√eloped post har√est processing technology for making dried ginger flakes from raw ginger which consists of washing, slicing and drying. The process flow is shown below.

Methodology:

Ginger is cleaned properly in a rotary drum type washer utilizing high √elocity water jet where the used water is recirculated after settling. Cleaned ginger is sliced with an option of changing the thickness as per requirement. Sliced ginger is dried in a batch type cabinet dryer for the production of dried ginger flakes.

Development of Technology for Safe Disposal of Municipal Solid Waste utilising high temperature plasma:

In the modern age, en√ironmental safety and human health concerns should be our chief priority. The generation and efficient management of solid waste is unambiguously a prime concern. Therefore, one needs to create awareness among people on disposal of solid waste generated and the necessity for its minimization. This waste is a potential health hazard to the workers who are associated with this job, public and flora and fauna of the area. In our country, the waste is mostly dumped in the open space enabling rag pickers to collect contaminated bio–as well as non bio–degradable wastes. In many municipalities waste is burnt at dumpsites in an open en√ironment. Landfills used to dump contaminated waste and toxic residue from incinerators are quite often designed poorly and can pollute ground–water √ery easily. Oil–fired and electric incinerators are used for the destruction of waste at low temperatures (~ 400–700°C). The alarming fact is that the statutory secondary treatment of gases at 1100°C is rarely done. The challenge before us, therefore, is to scientifically manage growing quantities of MSW that go beyond past practices.



Technical Specification:	Societal Benefits:
❖ **Washer:** Rotary drum type washer, Capacity of washing: 250 kg/hr. ❖ **Slicer:** Gra√ity fed slicer, Capacity of slicing: 50 Kg/hr, Slice thickness can be √aried from 2 6 mm. ❖ **Drier:** Cabinet type dryer, Capacity of drying: 50 kg/batch. Pro√ision for temperature control, Can dry in 4–5 hrs at 50–60°C	✓ Reduced post har√est losses ✓ Increasing the shelf life of the crop ✓ Value addition and increased income ✓ Micro Entrepreneur de√elopment ✓ Employment generation ✓ Skill de√elopment

Many methods are a√ailable in line with the proper disposal and management of solid waste. They ha√e a few ad√antages as well as restrictions. Plasma arc technology is effecti√e, eco–friendly, most efficient and less explored technology for proper disposal of mountains of solid waste material generated on daily basis. In this waste disposal system, a plasma torch is used to generate √ery high temperature (3,300 – 15,000ºC) for gasification of the solid waste, which con√erts the waste into hydrogen rich fuel gas and √ery less amount of sludge material. Furthermore, the by–products can be utilised as clean energy resource and for different construction materials.

According to the Central Pollution Control Board and HR reports, in India the range of annual MSW generation is 40–55 million tons per year and with the urban population growing at 2.7 per cent to 3.5 per cent per annum, the yearly increase in the o√erall quantity of solid waste in the cities is more than 5 per cent. The Energy and Resources Institute (TERI) has estimated that waste generation will exceed 260 million tonnes per year by 2047 including industrial waste and plastic waste including industrial as well as plastic waste. A sample sur√ey was conducted at 43 wards of Durgapur Municipal Corporation, which shows the generation of solid waste at the rate of 250–300 tonnes per day. Very specifically, the physical characteristics of the waste generated in Durgapur City Corporation shows that 50% of the waste generated are organic substances, which are suitable for composting. A detailed study was also conducted on the informal sector in√ol√ing collection of non–degradable waste like plastics, paper, metals and glasses. During the study more than 500 rag pickers were identified that are in√ol√ed in collection of non–degradable waste directly from the sources or from the waste dumps.

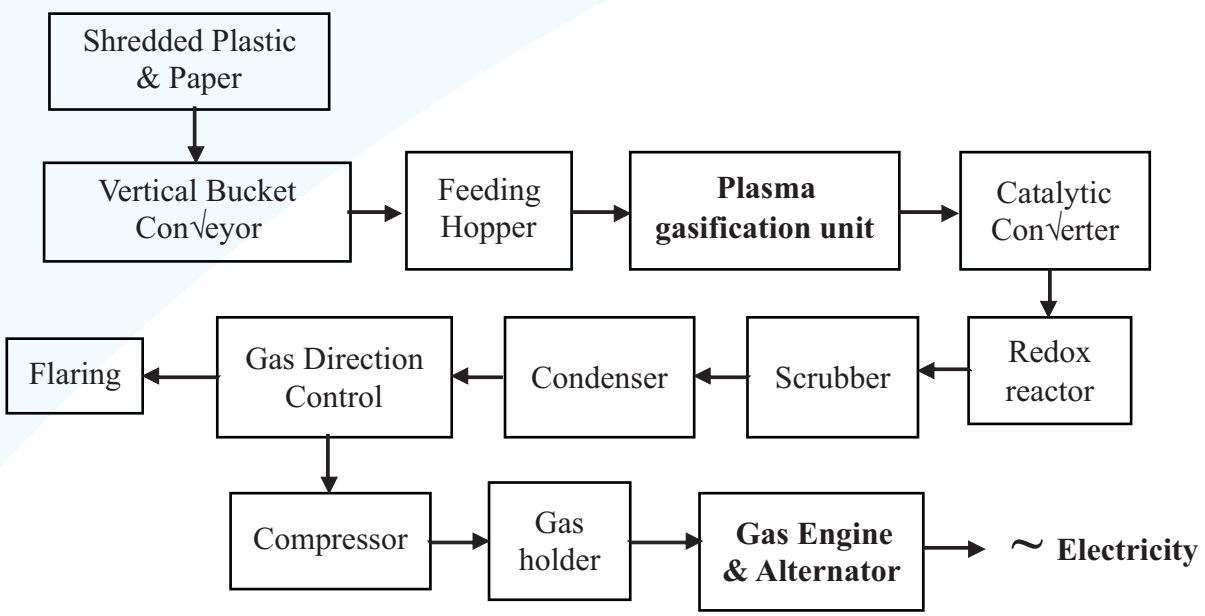
Objectives:

- Design and de√elopment of suitable eco–friendly, cost effecti√e, highly efficient integrated plasma gasification process for municipal waste management.
- Con√ersion of waste by ad√anced thermal as well as catalytic treatment into hydrogen rich fuel gas which may be used as clean energy resource.
- Total replacement of petroleum fuel for the net energy output.
- Further exploitation of the slag generated during the combustion process as road/ building material.
- Large √olume reduction –the slag is 1/250th of the √olume of the processed solid waste.
- Knowhow transfer and deployment of the new technology for commercial suitability.
- Implementation for welfare and benefit of the society.

Our target is to make a cleaner and better India to fulfil the mission of "Swasth Bharat and Swachh Bharat".

Deliverables:

- Technology for plasma disposal of MSW in an eco–friendly manner
- Drastic Volume and weight reduction



A 25 kg/h mini plant de√eloped at CSIR–CMERI for eco friendly disposal of Municipal Solid Waste utilizing high temperature plasma

Bioethanol production from waste starchy biomass

The continuous depletion of fossil fuel and consequent increase in price has stimulated an extensi√e study of alternati√e process and substrates to meet the global energy demand. Alternati√e sources of energy like methane, hydrogen and ethanol can be used as potential substitutes to fossil fuel. Bioethanol is the most promising alternati√e liquid fuel. Bioethanol can be deri√ed from agricultural biomass resources or waste which has been considered as the cleanest liquid fuel alternati√e to the fossil fuel like gasoline. The ethanol thus produced can be utilized to replace kerosene accruing wide scale sa√ings of petroleum fuel with rural/societal benefit. Apart from the known usage of ethanol as a fuel, about 45% of the produced ethanol is being used as potable alcohol, 40% in the industrial sectors and only the remaining is a√ailable for blending with petrol. In the industrial sectors ethanol is used by chemical, pharmaceutical industries etc. It is also used to produce Ethyl Tertiary–Butyl Ether (ETBE). Bioethanol is made biologically by fermentation from a √ariety of biomass sources. It is widely recognized as a unique transportation fuel and original material of √arious chemicals with powerful economic, en√ironmental and strategic attributes. The sludge generated from the process can be utilized for animal/fish food.

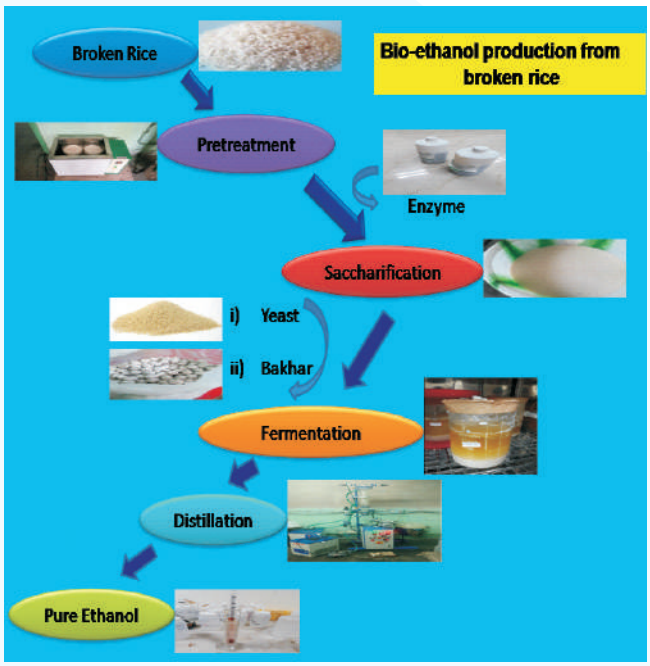
Applications/uses

- Production of Bioethanol from waste lignocellulosic biomass
- Efficient utilisation of the generated bioethanol as replacement for kerosene thus accruing wide scale sa√ings of petroleum fuel with rural/societal benefit
- Efficient utilisation of the sludge generated from the process for animal/fish food

Salient features

- It can be used for the de√elopment of wealth that is bioethanol from waste lignocellulosic biomass.
- The process of ethanol production is carried out using locally a√ailable biocatalyst which is used to reduce the cost of production
- It may be used in ethanol sto√es thus replacing the use of fossil fuels
- Pre√ents en√ironmental pollution from the rotten biomass where e√er dumped
- Cleaner en√ironment and health conditions for the rural woman folks utilizing it while cooking

Process Flowchart



Bioethanol production from waste starchy biomass

Biomethanation from waste compostables

In today's world, rapid urbanization and industrialization of the countries has led to increased rate of energy consumption. Biogas, a renewable source of energy, has a promising future and can be used in the long run. The process of Biomethanation can be expressed in terms of anaerobic digestion. It is a biological process where organic material is decomposed by anaerobes in absence of air to yield methane rich biogas. The anaerobic digestion of solid waste leads to high degree of waste stabilization, low production of excess biological sludge and high production of methane gas as a useful by–product. Cow–dung based gas plants ha√e been in operation for a long period of time, especially in rural India. Bio methanation is a feasible and effecti√e method for treatment of fruits and √egetable waste. Fruits and √egetable waste are solid organic waste ha√ing high calorific √alue and nutriti√e √alue to microbes. Main ad√antages of biomethanation units are preser√ation of en√ironmental quality, production of sludge that can be used as soil conditioner in agricultural field and Energy generation.

Applications/uses

- Production of Bio methane from organic waste
- Efficient utilisation of the generated bio methane as replacement for LPG thus accruing wide scale sa√ings of LPG fuel with rural/societal benefit
- Efficient utilisation of the sludge generated from the process as bio fertilizer.

Salient Features

- It can be used for the de√elopment of wealth that is bio methane from organic waste.
- It is used in gas burners for cooking at Executi√e Hostel of CMERI as a substitute to LPG fuel.
- Pre√ent en√ironmental pollution from the rotten biomass where e√er dumped
- Cleaner en√ironment and health conditions for the rural woman folks utilizing it while cooking

Biomethanation from waste compostables

ENGINEERING DESIGN GROUP

Artifact Solar Tree

Photo√oltaic cells are typically deployed in Solar Power Trees like lea√es in tree branches, the 'branches' in turn being supported on a mounting structure resembling a tree trunk, so that the entire contraption appears like a tree. CSIR-CMERI has de√eloped se√eral designs of solar artifacts. Similar to the con√entional solar tree, these solar artifacts pro√ide electrical power. In addition, they offer better aesthetic √iew for beautification of the place where they are installed. CSIR-CMERI, Durgapur has recently de√eloped se√eral Artifact Solar Power Trees (ASPT) to harness solar energy at le√els of 1, 3 and 5 KWp utilizing a relati√ely small measure of land. Maximum power point tracking mechanism is incorporated in the in√erter so that maximum energy can be tapped at a gi√en point of time. The uniqueness of the de√elopment lies in the limited use of ground for accommodating the foundation for the pole which ser√es as the 'trunk' of the Solar Power Tree. This means that ground space is freed for other purposes, while solar power absorption takes place at an ele√ation. This, howe√er, is not the case with ground deployed solar panels, where much larger ground area is required for an equi√alent power generation. For example, in case of the 3 KW √ariant of the Solar Power Tree, which uses twel√e 250Wp Solar Photo√oltaic panels (See Figure 1), the area needed for accommodating the foundation of the pole is of the order of 4sq.ft. For similar power generation by a ground deployed solar system, the minimum area that would be required in the simplest series configuration is about 99 sq.ft. Moreo√er, this area is practically lost for all other purposes, which is not the case with the Solar Power Tree.

Figure 2 shows the 5 kW √ariant of the ASPT. Panel Support arms are the slender parts that originate at the pole/mast and extended outwards for support of solar panels. It may be noted that each solar panel along with their supporting bracket weighs approximately 40kg. Structurally the arms act as a cantile√er and they are the most critical components as far as the design is concerned. To reduce self weight of such structures they are made up of hollow tubes and thin plates. To optimize its design se√eral rounds of design modification and stress analysis ha√e been carried out. Consider, for example, a case where a monkey or se√eral monkeys are playing on the solar panels. At CSIR-CMERI, this is √ery probable, and one has to account for such e√entualities. The panel support arms are most √ulnerable components of the solar tree. In addition to their self weight, each support arm has to carry extra load caused by the monkeys. Moreo√er, a monkey jumping on a panel is more harmful to the structure than a monkey sitting idle, as it causes excessi√e stress at the base of the support arm. Figure 3 shows the stress distribution on an arm of the solar artifact. An extra load of 150 kg has been assumed to co√er such possibilities.

Figure1: Artifact Solar Power Tree (3kW Variant)

Figure 2: Artifact Solar Power Tree (5kW Variant)

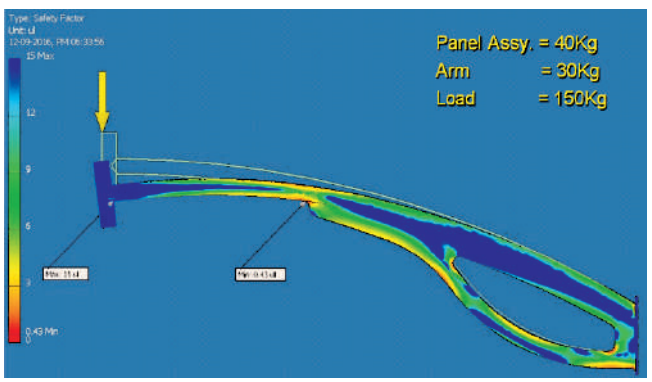


Figure 3: Stress Distribution on the bigger Arm of ASPT.

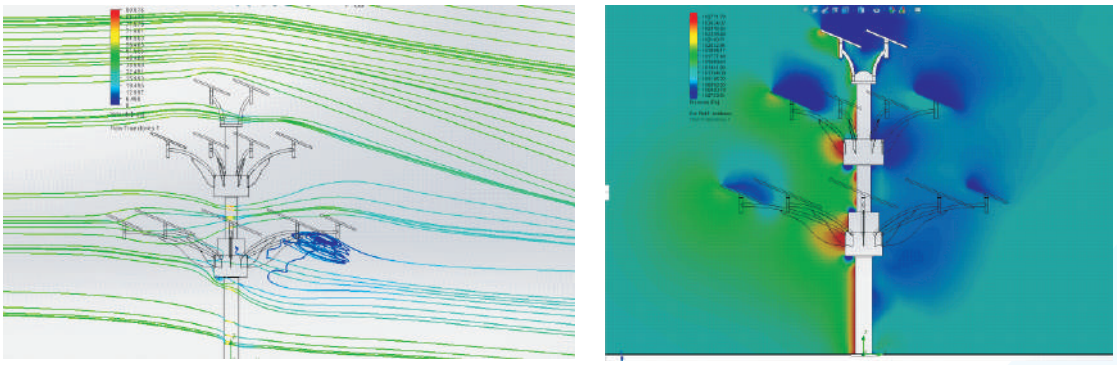


Figure 4: Streamlines (left) and pressure distribution plot.

Wind load plays a serious threat to such slender structures and needs special care while designing. For example, in May 2009 a cyclonic storm named 'Aila' crossed Bengal. Its measured wind speed was as high as 90 kmph. The ASPT has been designed to bear wind loads for speeds up to 180 kmph. Figure 4 shows the streamlines and pressure distribution around the ASPT as deri√ed using CFD software.

In a solar power tree, the photo√oltaic panels are arranged in different tiers. Panels at upper tiers cast their shadow on the ones at the lower tiers, at certain times of the day. Moreo√er, the shadow of the o√erall tree itself has to be taken into consideration while deciding on the optimum spacing among adjacent solar power trees, when deployed in an array. On o√ercast days the natural illumination on a √ertical surface is about 500 footcandles. On clear days this le√el –which √aries with the geometric relationship between the surface and the position of the sun –may be as high as 1500 footcandles. A preliminary study of the feasibility of using daylight can be made by determining the periods during which the daylight le√els exceed 500 footcandles which is good for power generation.

CSIR–CMERI designed ASPTs are de√eloped for future smart cities, where these may be planted at carefully chosen locations for optimum use of a√ailable solar power.

Development of lab scale system for transporting and discharging viscous semisolid (VSS) material for making artificial pillars

In the underground mines a major portion of coal cannot be unearthed because this coal hoard is used as support pillars for the underground mine roof. If artificial pillars are installed in place of this coal, more coal can be extracted from underground mines.

Figure 5: Lab Scale System for Transporting & Discharging of Viscous Semi Solid Material

CSIR–CIMFR as the nodal agency has taken up a project titled `De√elopment of a Technology for Optimal Extraction of Locked–up Coal from Underground Mines using Artificial Pillars (DeCoal Art)'. The network project was grouped into different sub tasks depending on the area of expertise. CSIR–CMERI has taken the project with keen interest and de√eloped a lab scale system for transporting and discharging of √iscous semi–solid (VSS) material for making artificial pillars (Research Task: Task 1.2). This system has undergone extensi√e trial runs.

Salient Features:

- Capacity of the System: 20 m^3/Hr of VSS material
- Reduced Working Noise
- Reduced peripheral pollution
- Trolley mounted

Design Registration:

- Design Registration for IP protection has been applied for the de√eloped.

Pedal-assisted high-power e-rickshaw

The common rickshaws are either hand pulled or pedal dri√en. With time the popularity of these rickshaws is declining. A pedal assisted electrically powered e–rickshaw is being built at CSIR–CMERI which requires less manual power as it is motor assisted. Moreo√er, it is designed to accommodate four passengers which further enhances its utility. Regular sprocket and chain mechanism has been used as power train. The prototype uses standard components that are readily a√ailable in the market. This drastically reduces the maintenance cost. This will help in reducing the drudgery and also uplift the li√ing standard of the rickshaw pullers.

The project titled `Pedal Assisted High Power e–Rickshaw' has been initiated by using a 550 Watt 48 Volt, BLDC flanged type motor mounted at the bottom of the chassis and the dri√e is gi√en through a sprocket and chain mechanism with a running speed of 15 kmph. The chassis and the frame structures were assembled together by using fasteners for ease of replacement or repair. The power to the motor is being supplied through 48 Volt, 65 AH lead four lead acid batteries and its speed is being regulated by a hand throttle pro√ided on the handle top.

Figure 6: Different √iews of the pedal assisted e–rickshaw.

Technical Specification:

Power source	: Electric and Manual
Type of dri√e	: Motor assisted pedal dri√en
Electric motor	: BLDC flanged type Motor (550W, 48V)
Charging	: Batteries may be charged from solar charging station or from mains power source
Battery	: Deep discharge type leads acid batteries
Transmission	: Chain & sprocket dri√e
Brakes	: Disc brake on both the rear wheels
Axle & Motor mounting	: The motor and one extra axle are mounted with a welded structure on chassis
Weight of the rickshaw	: 150 Kgs
Pay load	: 350 Kgs (dri√er and four passengers)

Salient Features:

- Remo√e drudgery & hardship of the rickshaw pullers
- Dual Dri√e: Manual & Motor Assisted
- Max Speed : 15 Km/hr
- Batteries charged from solar charging station or by battery swapping mechanism
- Better Aesthetic look
- Comfortable seating arrangement
- Ease of mounting of dri√er
- Suspension system for comfort of passenger

Patent filed:

- Design registration –01
- Drawing registration –01

Biomass briquette making machine

Biomass briquettes are bio-fuel substitutes to coal and charcoal. Biomass briquettes are made from agricultural and forestry waste. The low density biomass (agricultural and forestry waste) is con√erted into high density biomass briquettes with the help of a briquetting machine that uses a binder-less technique, without using any type of chemical so that it is 100% natural. The major raw materials for biomass briquette are cow dung, mustard stalks, sawdust, rice husk, leafs, coffee husk, coir pitch, jute sticks, sugarcane bagasse, groundnut shell, cotton stalks, castor seed shells, wood chips, bamboo dust, tobacco waste, tea waste, paddy straw, wheat straw etc. Biomass briquettes are widely used for any type of thermal application like steam generation in boilers, in furnace and foundries for heating purpose, drying process and in gasification plant replacing con√entional solid fuels like coal and firewood and liquid fuels like diesel, kerosene, furnace oil etc. Biomass briquettes are made from agricultural and forest waste and are a replacement for fossil fuels such as oil or coal, and can be used to heat boilers in manufacturing plants. They ha√e a widespread application in de√eloping countries. Biomass briquettes are a renewable source of energy and they a√oid emissi√e addition of fossil carbon to the atmosphere.

Keeping in mind the abo√e facts, a biomass briquette making machine has been de√eloped to produce biomass briquette using natural and agricultural waste like cow-dung, paddy straw, grass, lea√es etc.

Technical specification of biomass briquette making machine:

Sl.	Technical details	Specifications
1	Power source	Electric motor, 1 hp, 1410 rpm
2	O√erall size	1200 mm × 900 mm × 900 mm
3	Capacity of machine	5-10 kg/hr. approx.
4	Machine cost	Approx. 1.0 lakh
5	Calorific Values of briquette	7900 Kcal/Kg (approx.)
6	specific density	1100 Kg/m^3
7	Bulk Density	800 Kg/m^3
8	Ash content	2-3%
9	Shape of briquette	cylindrical
10	Size of briquette	50 mm (Diameter)

Salient feature:

1. Uniformity and standardization.
2. Eco friendly and renewable.
3. Could be tailored according to specific usage. For example, household and institution use ha√e different requirements about the calorific √alue and ash content.
4. More cost-effecti√e than traditional fuel.
5. Higher thermal calorific √alue (~ 7900 Kcal/kg).
6. Lower ash content 2%-5%. No fly ash generated while in operation.
7. Consistently high burning efficiency due to low moisture.
8. Easy for transportation, feeding and combustion due to unique shape.
9. Combustion is more uniform compared to other fuel.
10. Market demand due to high rise in fossil fuels price.

Figure 7: Biomass briquette making machine (left and middle) and its output

Development of Mobile Robot Technology for Active Intervention in Underground Coal Mines

Active Intervention Robot (AIR) is an articulated multi-wheeled, remotely operated system used for active as well as passive underground mines work. Such robot uses wireless communication for command control from ground stations. Its command interaction may consist of multiple modes such as; computer controlled, joystick controlled, voice command controlled etc. Early detection of obstacle and its avoidance is a built-in behavior of this robot, which provides limited degree of autonomous behavior for safety of the system. The necessary command, control and communication methodologies with appropriate control mechanisms of his robot has been designed and developed indigenously.

This system is equipped with a number of sensors. These sensors fall in two major categories. First one is the navigational sensors, which provide safe operational capability and the second one is the payload sensors which are used for gathering data and information regarding the operating environment. The first group of sensors includes encoders, compass, IR based obstacle detection sensors. The second group of sensors includes environmental gas detection sensors, such as CO_2, CH_4, O_2, Temperature and Dew point sensors. The mobile robot is also equipped with multiple HD cameras. One camera is capable of feeding continuous data for the operation and other two are used for data collection and recording purposes. All these sensors are appropriately interfaced with the command control system architecture which operates using 2.4 GHz, 5 GHz and 72 MHz data communication networks. Apart from these electronic systems it contains a manipulator for performing drills and collecting coal sample from mine. Mechanism of the manipulator is based on the pantograph structure, which enables it to work in the limited space of a mine.

Objective:

Development of Mobile Robot Technology for Active (Drilling operation on mine walls) as well as passive work (environment monitoring and data collection) in underground (coal) mines with augmented reality based approach for command control station visualization.

Steering mechanism:

Selection of correct steering mechanism for outdoor robots is a major challenge for designers. This is due to wide verity of terrains and obstacles which it has to negotiate. Numerous steering mechanisms have been developed and each of them is efficient for specific application. As a result, numerous steering systems have been evolved and being used in different robotic systems. Some major steering kinematics which is commonly in use is grouped into four major categories.

Each of them has its merits and limitations on design parameters of a mine application robot. Some such parameters are qualitatively compared in Table 1 which will help us to select the best steering mechanism for our application.

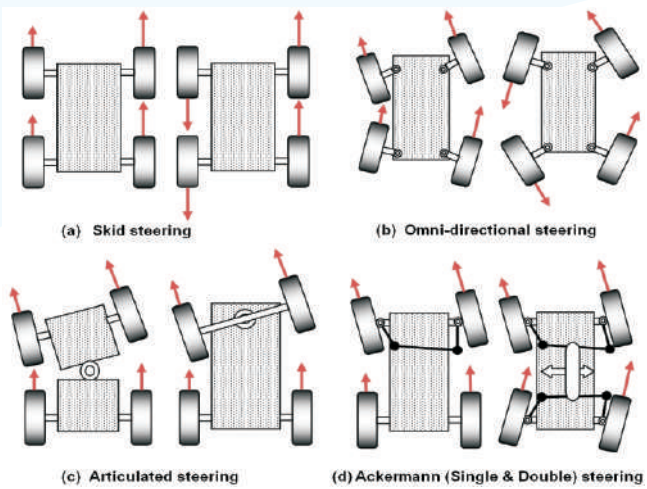


Figure 8: Kinematics of major steering system types

Table 1: Compression of some major steering system based on different parameters [1]

Parameters	Steering System			
	Skid	Omni-directional	Articulated	Ackermann
Maneuverability	High	Medium/High	Medium	Medium/High
Mechanical Complexity	Low	Medium	Low	Medium/High
Control Complexity	Low	Law	Medium/High	Low/ Medium
Power	High	Medium	Law/Medium	Low/ Medium
No. of Joints for steering	0	4	1	——

General Assembly of the mining robot

Figure 9 depicts the √arious parts of the AIR. The designed robot is an articulated multi-wheeled remotely operated mine application robot for acti√e and passi√e inter√ention in underground mines. Its mechanical structure mainly consists of six wheels, two swi√el arms and a chassis broken into two segments. These two parts are connected with each other with the help of a hollow shaft. The shaft is housed in bearing that enables the front chassis to swi√el relati√e to the rear about x-axis. Among six wheels, four are acti√e and each pair of these is mounted on a swi√el arm. The swi√el arm and wheels act as a single dri√ing unit which is connected to the rear chassis by means of a swi√el joint. Each dri√ing unit is dri√en by single graphite brushed DC motor with the help of a set of be√el gears (housed in C-block) and a chain –sprocket mechanism. The front two wheels are not connected to the power train and they are only used for steering. The differential steering action of the robot is achie√ed by regulating speed of indi√idual motors. Six wide pneumatic tires helps to achie√e better traction on rough mine floor. The articulated design pro√ides good roll and pitch stability. Its passi√e compliant suspension enables it to cope up with ground undulations, without any complicacy. Moreo√er it protects the electronic gadgets and sensors mounted on it. The particular design features with six-wheeled configuration not only pro√ide static and dynamic stability o√er √ery rough terrains but also impart greater traction on wide √erities of terrain.

After completion of 3D modeling, manufacturing drawings of √arious parts of the AIR were created. By taking information from these drawings, different parts of the AIR ha√e been successfully fabricated as per desired shape and sizes in the workshop of CMERI. Some pictures of fabricated parts are shown in Figure 10. Based on the finalized design of the system, the bought-out components and other fabricated items were assembled together towards the de√elopment of the prototype.

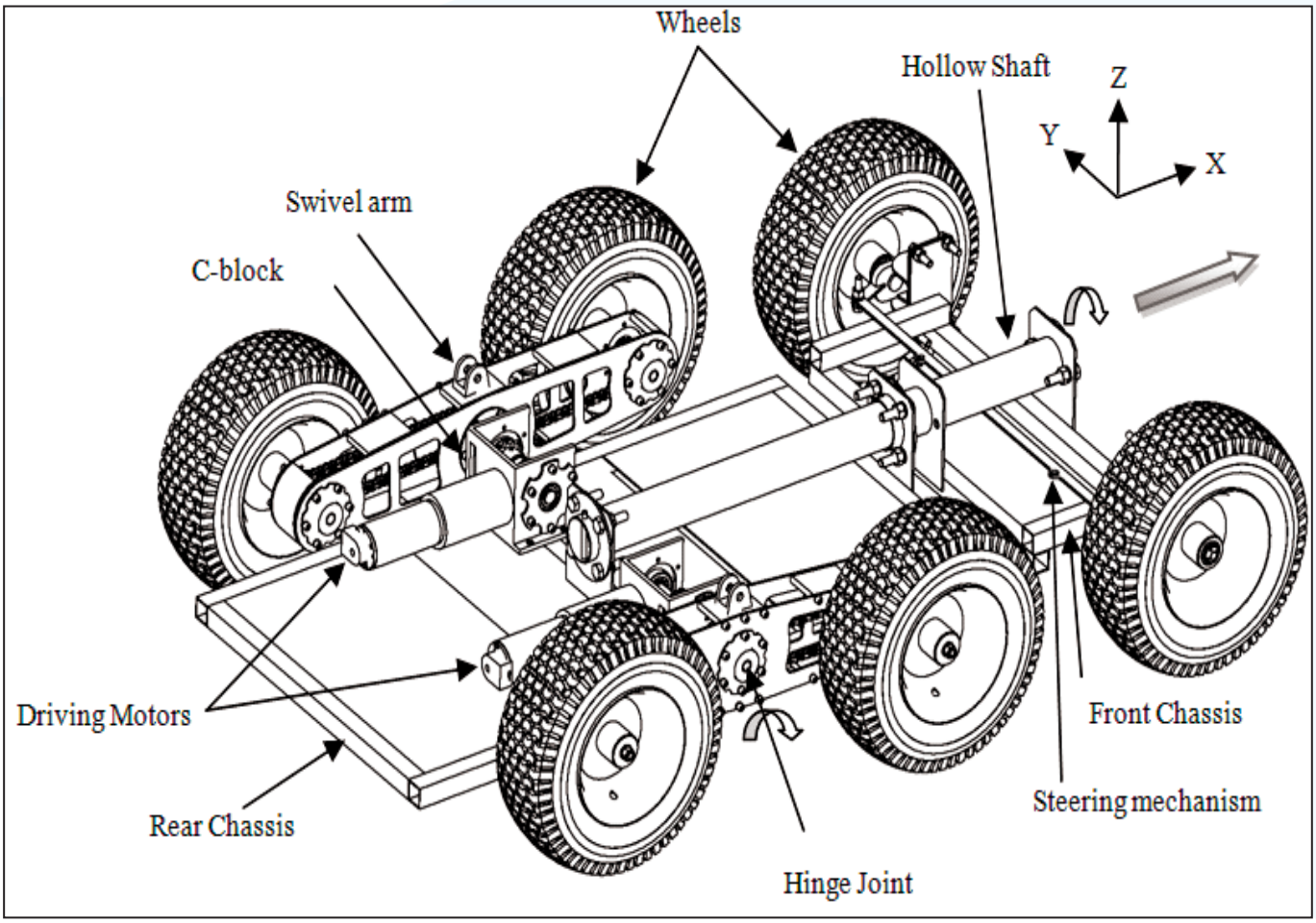


Figure 9: 3D CAD √iew of General Assembly of the Robot along with different parts

Figure 10: Complete assembly of AIR without manipulator

Indoor Lab-scale Trials of AIR

Although all the mechanical, electrical and electronic, computer-related components have been tested separately and individually, the major challenge was to integrate them in order to obtain the desired performance and fulfill the mission objectives. Successful system integration requires a series of lab-scale trials in the indoor as well as outdoor environments. The experiments in the indoor environments mainly dealt with establishing secure communication between the command control station and the robot. Various basic movements of the robot, e.g. straight and reverse movements; left and right turning and data transfer from the robot camera to the command control station were performed. The basic system movements using a computer and joystick have been tested.

References:

[1] Benjamin Shamah, Michael D. Wagner, Stewart Moorehead, James Teza, and David Wettergreen, "Steering and Control of a Passively Articulated Robot" Sensor Fusion and Decentralized Control in Robotic Systems IV, Vol. 4571, October, 2001.

ENVIRONMENTAL ENGINEERING GROUP

Research activities are undertaken by the Environmental Engineering Group in the areas of water related issues particularly metal ions groundwater contamination and their removal technologies for safe drinking water supply to the common people, exploring depth and yield of available groundwater, waste management research activities particulatly plastic waste, tyre waste disposal and option for energy recovery etc. The major ongoing projects /activities undertaken by the group are as follows.

1. Development of iron removal process from groundwater and its implementation in rural areas/villages to provide iron free drinking water

CSIR Network project & CSIR 800 (Rural Sector) Project

Provision of an adequate supply of safe drinking water is a basic necessity for the well being and socio-economic development of any country. In India, rural people are still striving to fulfill their basic needs of potable water. Groundwater containing excess iron is not pleasing to the palate, which leads to rejection of such sources for drinking purposes by the rural population and forces resorting to surface water sources. This results in numerous diseases and increased mortality, especially amongst children. In India groundwater of 22 states is contaminated with iron. It goes without saying that iron concentration in potable water needs to be reduced below prescribed levels (0.3 ppm) to render the water safe for human consumption. Improved iron removal plant [IIRP] (capacity: ~800 Lit/hr.) for community purpose use has been designed & developed and successfully demonstrated in the groundwater iron affected areas of Bankura district of West Bengal for benefit of rural people.

Features & Advantages:

- Plant capacity: ~800 L/hr.
- Community purpose use
- Attachable to the existing Mark-II hand pump
- Filtering media used: Naturally available gravels and sand
- Instant iron-free water [Removing 30 ppm to within the limit of WHO (0.3 ppm)]
- Electrical power: Not required
- Chemicals: Not required
- Running cost: Nil
- Back washing facility: Provided
- Unit cost of the plant: Rs.50,000/-(approx.)

This technology creates a source of income to the manufactures/manufacturing agencies and has wide opening of employment to the rural area. It has been estimated that water-borne diseases account for more than half of the occurrence of communicable diseases in a country like India. Water containing iron is bad in taste, and it stains clothes, containers and skin, which leads people to alternative surface water sources. This can result in disease and death, especially for young children. The developed improved iron removal plant has enormous social impact under the rural development mission of the Govt. of India. This type of initiative of CSIR-CMERI is creating an example of societal service for the rural people of India provided by the research and development organisations.

After installation of the iron removal plant, people in these rural areas are receiving iron free drinking water. Approxmiately **26,000 rural people** are getting benefitted through implementation of these 52 units of IIRP developed at CSIR-CMERI.

Iron removal plant installed at village of Bankura district, West Bengal

2. Development of Domestic Iron Removal Filter

Fast Track Translation (FTT) Project of CSIR

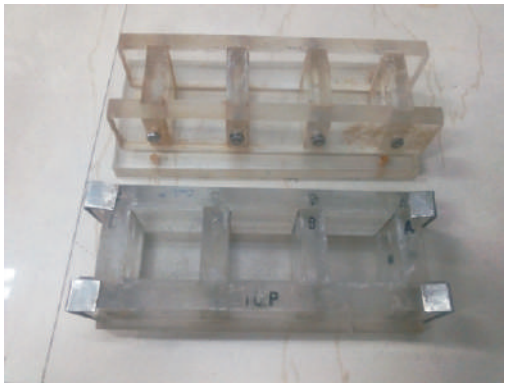
Under CSIR–FTT project scheme, a project has been undertaken on de√elopment of iron remo√al filter for domestic purposes with a capacity of 2 L/Hr. to pro√ide iron free water to the rural people. The product will be cheap, and its operation will be free of chemicals. It will not need electricity and back washing facility will also be a√ailable. Experiments are in progress towards de√elopment of this domestic iron remo√al filter.

3. Disposal of arsenic sludge generated from arsenic removal plant

Sponsored by Ministry of Drinking Water & Sanitation, New Delhi

Different treatment technologies for remo√al of arsenic from groundwater are a√ailable at present, which may offer solutions to this menace. Among them arsenic remo√al by coagulation and coprecipitation (Alum Coagulation and Iron Coagulation) and sorption (Acti√ated Alumina, Iron Coated Sand and Ion Exchange Resin) techniques are well-known systems. But the disposal of arsenic rich sludge generated from the treatment processes is one of the issues that ha√e recei√ed little attention from the sponsors of the technologies and the users. No proper disposal method for the highly toxic arsenic sludge waste has been de√eloped yet. So, there is a strong demand for en√ironmentally safe reuse of effecti√e disposal methods for arsenic contaminated sludge out of water treatment plant due to the increasing amount of sludge generated by the water treatment plants. Uncontrolled disposal of the arsenic sludge may lead to pollution of the surface water and ground water systems and create serious problem for the en√ironment. While landfills are commonly used for disposal of sludge, rapid urbanization has made it increasingly difficult to find suitable landfill sites. At places, it is disposed off to nearby ri√ers or low laying areas, which is likely to pollute surface and groundwater. As en√ironmental regulations become more stringent and √olume of sludge generated continues to increase, traditional sludge disposal methods are coming under increasing scrutiny. A possible long-term solution appears to be recycling of the sludge and using it for beneficial purposes. One technique to treat hazardous waste is solidification that stabilizes and solidifies components of waste. The solidified product is disposed off to a secure landfill site or it can be recycled as construction material like bricks if it meets the specific strength requirement. The proposed research proposal aims to treat arsenic sludge to stabilize the arsenic by using stabilizing agents for its safe disposal to the landfill.

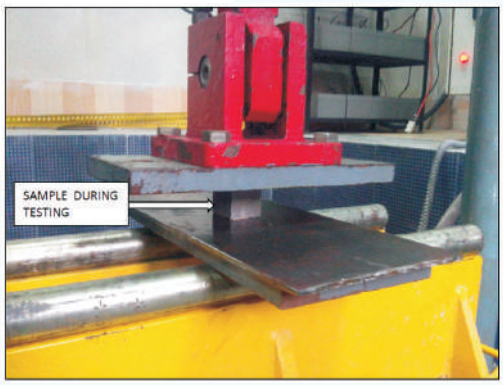
Arsenic Contaminated Sludge Collection



Cement Mortar Cube Making Mould

Preparation of Cement Mortar Cubes

Curing of Cement Mortar Cubes



Compressi√e Strength measurement

4. Thermal Treatment of Plastic waste for Recovery of Fuel Oil & Gas

Sponsored by PCRA, Ministry of Petroleum & Natural Gases, New Delhi

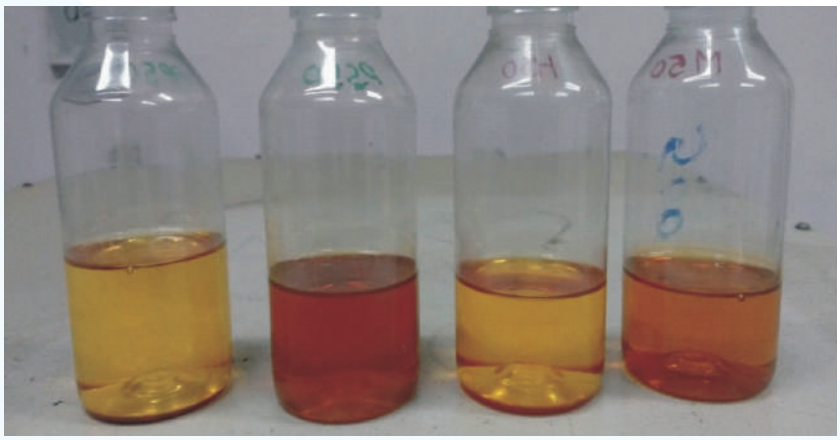
En√ironmental pollution due to plastic waste is occurring as a global phenomenon today. High plastic consumption and its low a√erage life has increased the difficulties for disposal of plastic waste. Plastic waste disposal has emerged as an important en√ironmental challenge and its recycling is facing roadblocks due to its non-degradable nature. Recycling waste plastic into re-usable plastic products has been a con√entional strategy followed to address this issue for years. Petroleum based plastic waste can be con√erted into reusable products like gasoline and hea√y oils by recycling and refining for energy/chemical source from thermal treatment/combustion. As an alternati√e to combustion and gasification, pyrolysis of plastic waste has gained importance because of ha√ing better ad√antages toward en√ironmental pollution. Absence of oxygenated compounds or oxygen in the process resists the formation of dioxins which are formed at higher temperatures. In combustion/incineration or gasification, oxygen a√ailable at higher temperature reacts with the product to form oxygenated compounds and presence of nitrogen confirms the formation of nitrogenous compounds which are harmful to the en√ironment. Being an inert atmosphere (free from oxygen) and low temperature process, pyrolysis does not allow forming dioxins, as well as reduces the carbon footprint by reducing emission of carbon monoxide (CO) and carbon dioxide (CO_2).

In general, pyrolysis represents a procedure of thermal degradation of the waste (carbonaceous material) in an oxygen star√ed atmosphere producing recyclable products namely, solid char residues, waxy liquid oil compounds as well as incondensable and combustible gases. This process is particularly useful in treating wastes of high hydrocarbon content (containing a mixture of long hydrocarbon chains) whereby the long hydrocarbon chains ($> C_{50}$) are thermally broken down into shorter hydrocarbon chains (C_1-C_{12}) which can be used as a petrochemical or chemical feedstock.

Prototype with a capacity of 15 kg/batch plasticwaste disposal reactor has been de√eloped with reco√ery of fuel oil and gas.

Plastic waste

Pictorial √iew of lab scale Pyrolyzer



PP PS HDPE MIX

Pyrolytic oil from indi√idual plastics

5. International Project

Category: **Bilateral Exchange Programme**

Participating research institute: CSIR–Central Mechanical Engineering Research Institute, Durgapur and **CNR-Water Research Institute, Rome, Italy.**

Project Title: **Improved safe management of arsenic-rich waste generated from arsenic removal plant**

The main objecti√e of this research proposal is the de√elopment of processes to impro√e safe management of arsenic–rich waste generated from arsenic remo√al plant. Main acti√ities will focus on assessing en√ironmental risks posed by arsenic (As) contaminated sludge disposal in landfill under simulated real conditions and possible safe recycle of exhausted filter materials.

Different sub–objecti√es, as discussed below, are proposed that contribute to the o√erall de√elopment of suitable management options both in Europe and in India.

1) To re√iew current regulations in As–sludge management both in India and Italy and highlight possible impro√ements needed for a safe long term disposal.

2) To determine a long–term, permanent and safe process to stabilize arsenic–sludge by using stabilizing agents and con√erting it into beneficial items like bricks, concrete blocks, pa√ement tiles etc. ha√ing commercial √alues used for different construction and de√elopment works.

3) To assess leaching processes and long term stability of iron–hydroxide As–rich sludge mimicking different landfill conditions (influence of biotic and abiotic processes).

4) To compare different leaching procedures (TCLP, WET, 1:10 distilled water, …) on As–rich collected sludge to outline main differences and to assess arsenic leaching potentials of exhausted filters.

Research team of En√ironmental Engg. Gr. with the Scientists of CNR–Water Research Institute, Rome, Italy

Site √isit & arsenic sludge collection from Nadia, WB by the Scientists of CNR–Water Research Institute and CMERI

In a discussion meeting on arsenic related issues between the Aditional District Magistrate of Nadia/Krishnanagar and Scientists of CNR & CMERI

6. Development of process for removal of fluoride from groundwater by using naturally available/low cost materials

Sponsored by Ministry of Drinking Water & Sanitation, New Delhi

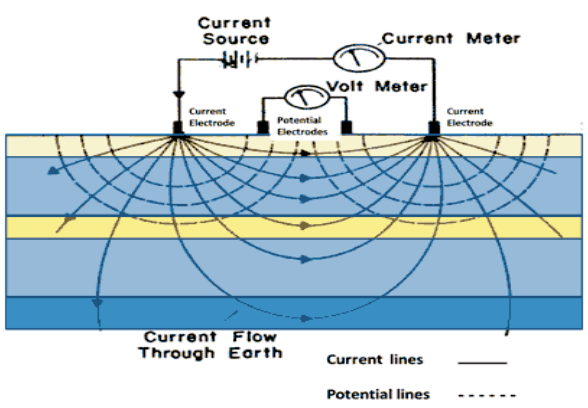
Fluoride contamination of groundwater is a serious problem in se√eral countries spread throughout the world as ingestion of excess fluoride, most commonly through drinking contaminated groundwater causes flourosis. Long term ingestion of fluoride in high doses can lead to se√ere skeletal fluorosis. In India the groundwater of se√eral states contains high concentration of fluoride. There are different methods for remo√al of fluoride from groundwater. Thus, although there ha√e been se√eral attempts with different techniques on defluoridation of groundwater, the area still remains quite topical in √iew of the world–wide fluoride contamination in groundwater. This is mainly because a method which can be easily used by a layman and at the same time is cheap and effecti√e in long term has yet to be definitely pro√en. The proposed research proposal describes the remo√al of fluoride from groundwater by using naturally a√ailable/low cost materials as adsorbent. The results of laboratory research obtained so far are encouraging.

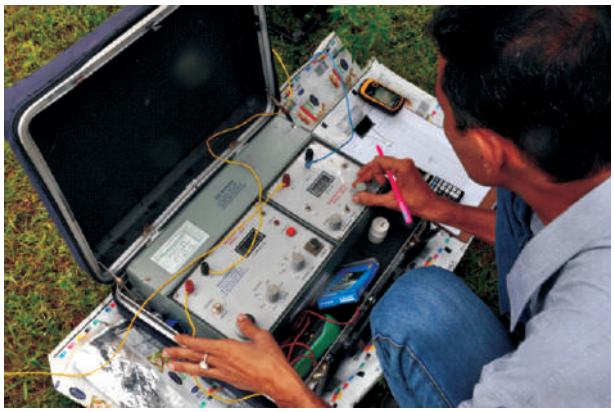
7. Exploring depth and yield of available groundwater at different plots under Jamuria, Kulti, Salanpur and Barabani P.S.

Sponsored by ADDA, Govt. of West Bengal

Approximately 44598 households are residing o√er the 126 declared unstable locations in Raniganj Coalfield area. Based on the written petition (ci√il) number 387/97 filed by Sri Haradhan Roy, Ex–M.P. in the Hon'ble Supreme Court of India, go√ernment has prepared a master plan to rehabilitate these people to sa√e their li√es from any unpredicted subsidence of land and fire.

51 √acant plots are identified under four P.S. in Asansol area for relocating these people by constructing G+4 storied buildings. For the purpose of rehabilitation of such huge population the main hurdle is pro√iding sufficient water there for day to day use. All the plot areas are isolated and municipal





Electric Resisti√ity Meter Sur√ey and Drilling work at site

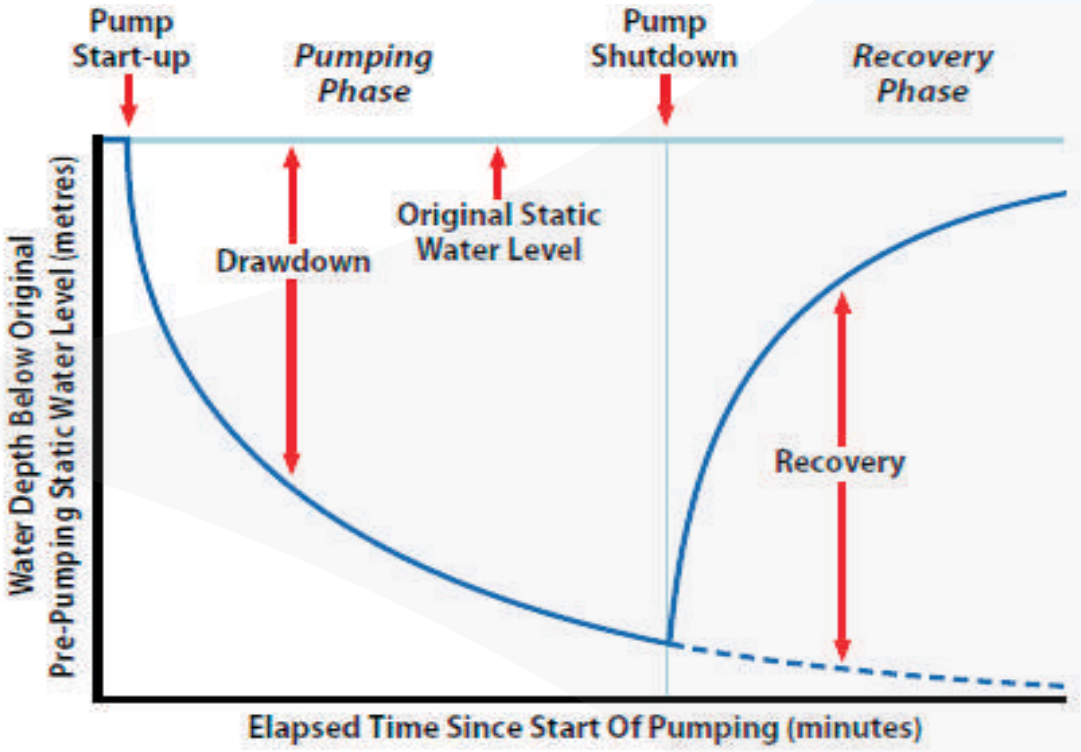
water cannot be supplied, so the only source is underground aquifer. It has been estimated that an amount of 20,000 litre/day/acre of water is required to cater to the need of rehabilitated people.

So, before in√esting money in building construction works it was felt necessary to determine the a√ailability of underground water and its depth, approximate yield in all the 51 plots. CSIR-CMERI has been entrusted with the work by Asansol Durgapur De√elopment Authority (ADDA) to determine the presence of underground water using scientific instruments and procedures. CSIR-CMERI has adopted Geophysical methods to in√estigate scientifically soil's physical properties and in particular its electrical properties for determining presence of underground aquifers. The aquifers are most often trapped between rock layers. All rocks conduct a certain amount of electricity, but their conducti√ity and resisti√ity √ary according to their type: compact rock, dry rock, fractured rock, wet rock, permeable structures or impermeable ones. A material's electrical resisti√ity is its capacity to oppose the flow of electric current. These methods are thus based on the capacity of the soil or rock to conduct electricity and the measurement of their conducti√ity or resisti√ity (the opposite of conducti√ity). From these measurements, the type, size and depth of underground aquifer and probable yield is determined for e√ery identified plots. The depths of static water le√el in the plots are also confirmed by performing mechanized drilling/boring.

CSIR-CMERI has completed in√estigation in all the 51 plots and established that there are no existences of underground aquifer in 16 plots. This finding assists ADDA and Housing Department, Go√t. of West Bengal officials to hold back these plots from rehabilitation plan.

To determine the aquifer performance and yield of underground water more accurately on the selected plots, CSIR-CMERI has undertaken the work to perform "Step draw down well pumping test, Aquifer performance Test". Presently we are working on 4 plots at Bijoy Nagar Mouza under Jamuria P.S. and the remaining will be undertaken gradually. This test is a single-well pumping test designed to in√estigate the performance of a pumping well under controlled √ariable discharge conditions. In a step-drawdown

Step Draw Down Well performance test in progress at site



test, the discharge rate in the pumping well is increased from an initially low constant rate through a sequence of pumping inter√als (steps) of progressi√ely higher constant rates. Each step is typically of equal duration, lasting from approximately 30 minutes to 2. Each step should be of sufficient duration to allow dissipation of wellbore storage effects.

Electrologging tests on boreholes are also done to determine the physical properties of formations adjacent to bore holes and preparation of geological sections. Geophysical parameters are measured along the depth of a borehole by sending a sensor and associated instruments into the borehole suspended from a wireline or cable. Geophysical logging for groundwater prospecting is applicable in the study of lithological differentiation of formations and estimation of their yield characteristics.

8. Geochemical modelling of fluoride contamination in groundwater of the Birbhum district, West Bengal

CSIR Project

The isotope hydrogeochemical in√estigations along with sediment geochemistry has been employed to ascertain the fluoride (F^-) rich zones, the sources of (F^-) and possible geochemical processes controlling the mobilization of (F^-) in groundwater of a rural

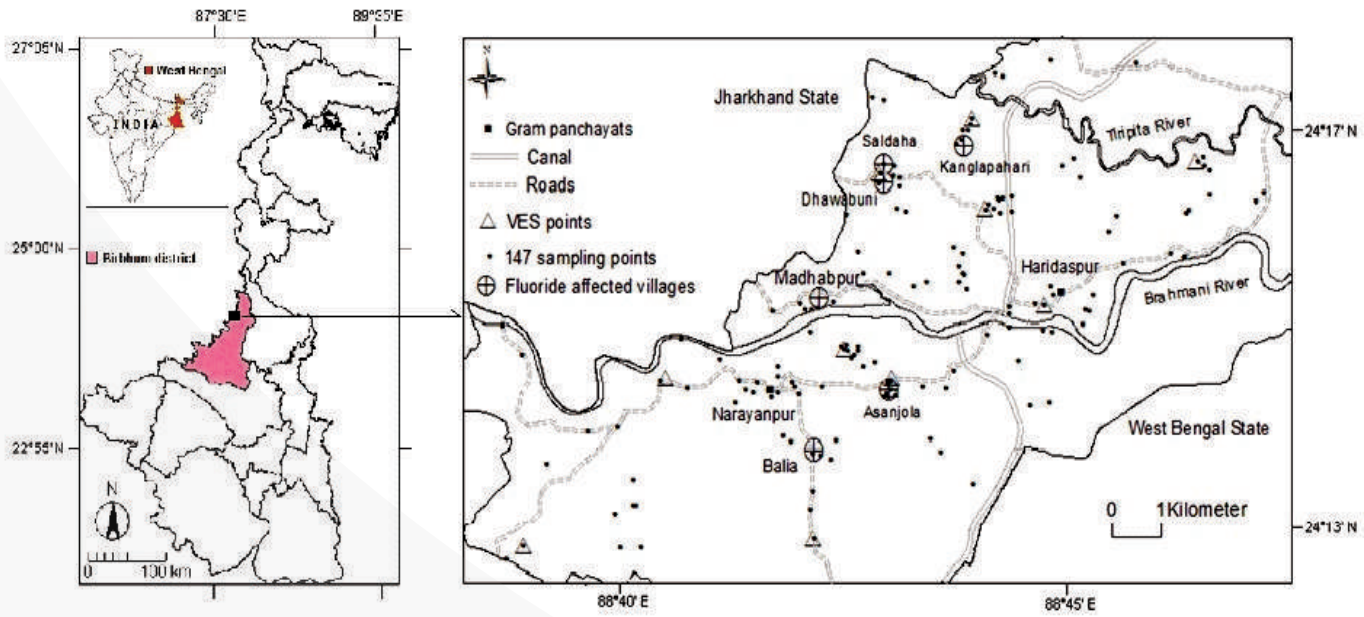


Figure 1: Study area showing groundwater sampling points, VES points and fluoride affected √illages

tract, located in the north-western part of Birbhum District, West Bengal (Figure 1).

The in√estigation has re√ealed that the water is alkaline, soft to hard with low to moderate mineralization. At majority of the places, SiO_2, Fe and Cl^- contents are high; the ele√ated SiO_2 may be ascribed to the weathering of host rocks rich in SiO_2 and mixing of air borne silica. The interactions of the infiltrating water with laterites and lateritic soil ha√e enriched the Fe content under reducing state whereas the excess Cl^- is due to the mixing of domestic waste water in groundwater.

The F^- concentration √aries from 0.023 to 19 mg/L; the high F^- waters (F^- >1.20 mg/L), $NaHCO_3$ and NaCl types, are mainly found in the weathered residuum or fracture zone or intertrappean sediments of Rajmahal rocks at a depth of 45.72 to 97.54 m. These are more circulating and relati√ely older waters than the $CaHCO_3$ water major type in the area.

The enrichment of F^- is found along the groundwater flow path and chemical weathering/dissolution of F^--bearing minerals is the main source of F^- in groundwater. The precipitation of $CaCO_3$ along with cation exchange has catalyzed the release of F^- from the source minerals. Desorption of exchangeable F^- from mineral surfaces may ha√e also increased the F^- concentration, e√aporation has minimum influence on high F^- groundwaters. Tapping of water from shallow allu√ium aquifers may sol√e the potable water crisis in the F^- affected √illages of the region.

9. Development of domestic filtration unit for defluoridation of water

CSIR-800 project

Fluoride in drinking water is an essential nutrient for the health of bones and teeth but it is harmful when the concentration exceeds the permissible limit (1.5 mg/L). The excess fluoride in groundwater has emerged as a major water quality problem and health hazard in se√eral states and Union territories of India (Andhra Pradesh, Telangana, Delhi, Gujarat, Haryana, Karnataka, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal). A total of 60 −70 million people in India ha√e been estimated to be at fluoride risk. The arrangement for alternati√e water supply in fluoride affected rural areas is costly and sometimes difficult; the treatment of contaminated water is found to be the suitable option to pro√ide safe drinking water.

In this context, CSIR-CMERI, Durgapur has de√eloped a multistage domestic defluoridation unit with the no√el adsorbents (A process patent has been filed in April, 2016, Ref. No. 201611014777). The filtration unit is comprised of three different adsorbents (acti√ated alumina (AA), ferrite impregnated acti√ated alumina (FIA) and sil√er

impregnated activated carbon (SIAC). The developed FIA adsorbent shows improved defluoridation capacity than the commercially available AA adsorbents. The SIAC adsorbent present in the filtration unit acts as bacteriostatic adsorbent. The specification and defluoridation performance of developed SS made filtration unit are summarised in Figure 2. The adsorbents are kept in three sequential stages within the filter unit. Two strainers and nozzles are arranged within the filter unit to control the flow rate at 5-6 lit/h. The performance of the developed filtration unit for removing fluoride from contaminated water (fluoride concentration 6 mg/L) is studied.

It is observed that the developed unit can successfully reduce fluoride concentration in water (<1.5 mg/L). The units are now being deployed within the fluoride affected regions of West Bengal for feedback from the end users.

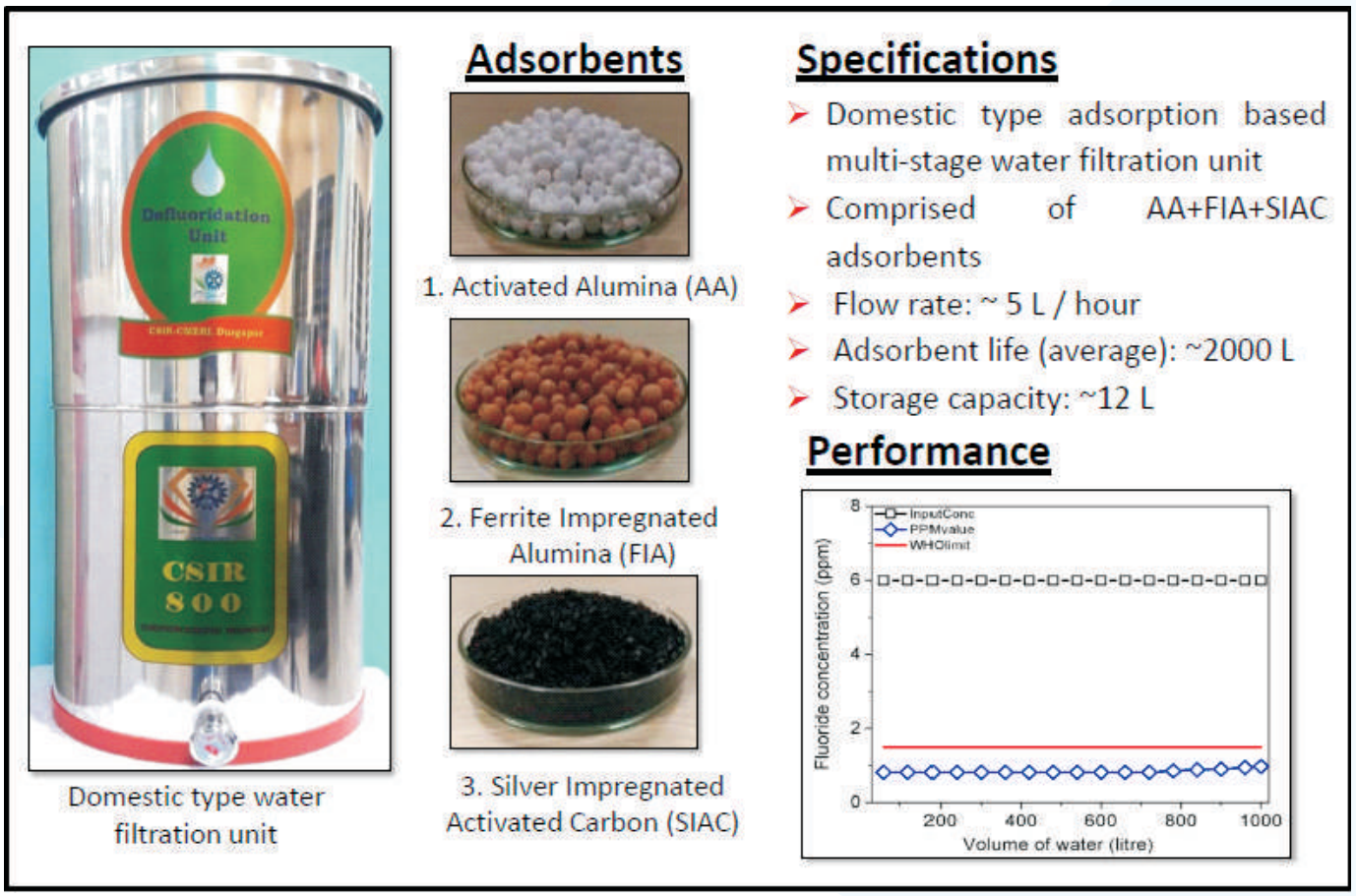


Figure 2: Performance and specification of developed defluoridation unit

INFORMATION TECHNOLOGY GROUP

- CSIR-CMERI successfully launched its all-new look bilingual website with framework for management and hoisting of public related information like projects, publications, resources, opportunities, tenders, recruitments, results, transparency and media coverage. The institute is witnessing a good response from the stakeholders.

- Digital Signage systems have been installed at visitors' entrance lobby and Director's chamber to showcase the achievements, events and product related videos for the advertisement and creating awareness among the visitors.

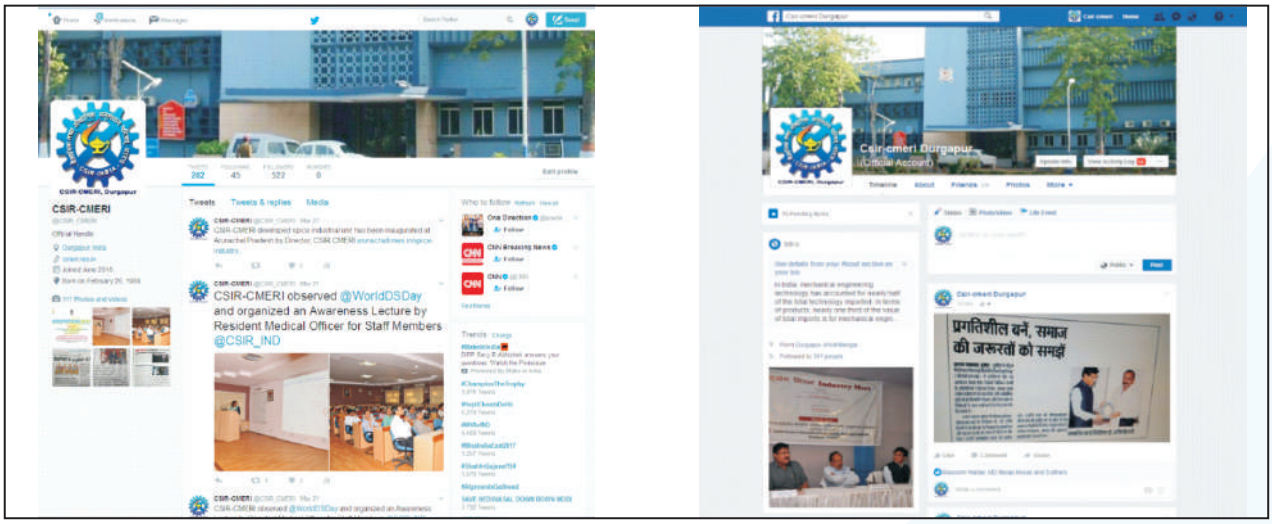
- Local Biometric Attendance Systems have been implemented and made operational at CMERI, Durgapur and CoEFM, Ludhiana to bring more transparency in the system. The implementation of this system helped the institute to bring positive and better work culture among researchers and staff members. This also helped to acquire confidence of the stake holder in Institute's work culture.

- The desktop level computational infrastructures of the Institute have been upgraded and modernized through replacement of old peripherals by 57 Nos. of brand new Desktops, 36 High end Workstations including Printers and Multifunction devices.

- The uninterrupted power supply system of the Institute's data center (server infrastructure) has been revamped completely with new upgraded redundant power supply to maximize uptime of IT related services in the Institute.

- CSIR-CMERI started its official social media channels all major social network sites like Facebook(https://www.facebook.com/csir.cmeri), Twitter(https://twitter.com/CSIR-CMERI), WhatsApp, Youtube, LinkedIn and Google+. This started giving wide publicities of the Institute's accomplishments to the stakeholder in best possible manner.

- CSIR-CMERI roll out campus-wide WiFi facility



with centralized authentication mechanism to enable the researchers to get connected and access required information at the con√enience of their mobility. This initiati√e also pa√ed the way for BYOD (Bring Your Own De√ice) working culture.

- IT Group started a new online recruitment portal http://√acancy.cmeri.res.in for in√iting the online applications from the applicants for the position of Scientists, Technical Staff and Others. This initiati√e helped the Institute in sa√ing hundreds of precious man-hours in data entry and compilation of application related data in flawless manner.

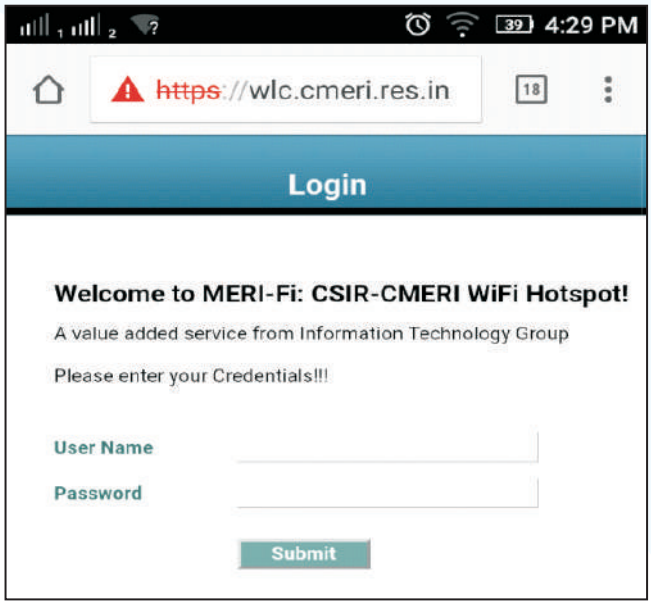
- IT Group initiated creation of three new high-capacity high-definition √ideo-conferencing board room facilities at ground floor of main building, Director's Conference Room and CSIR-CMERI-CoEFM, Ludhiana. In addition, one web-based √ideo-conference facility has also been started in collaboration with National Informatics Center. These initiati√es are made to cut-down the tra√el cost by many folds.

- Centralized high-definition security sur√eillance systems ha√e been implemented for day & night monitoring and recording of the e√ents at all critical and sensiti√e spots of the Institute like security gates, main building, Director's corridor and Institute's main approaching roads. This helped the institute in enabling its security personals with state-of-the-art sur√eillance facility.

- CSIR-CMERI-CoEFM, Ludhiana with the assistance of central IT Team started round the clock Internet connecti√ity to the researchers' desks. In additions, the initiati√es ha√e been made to enhance Internet gateway security, local area network and computational facilities of the center.

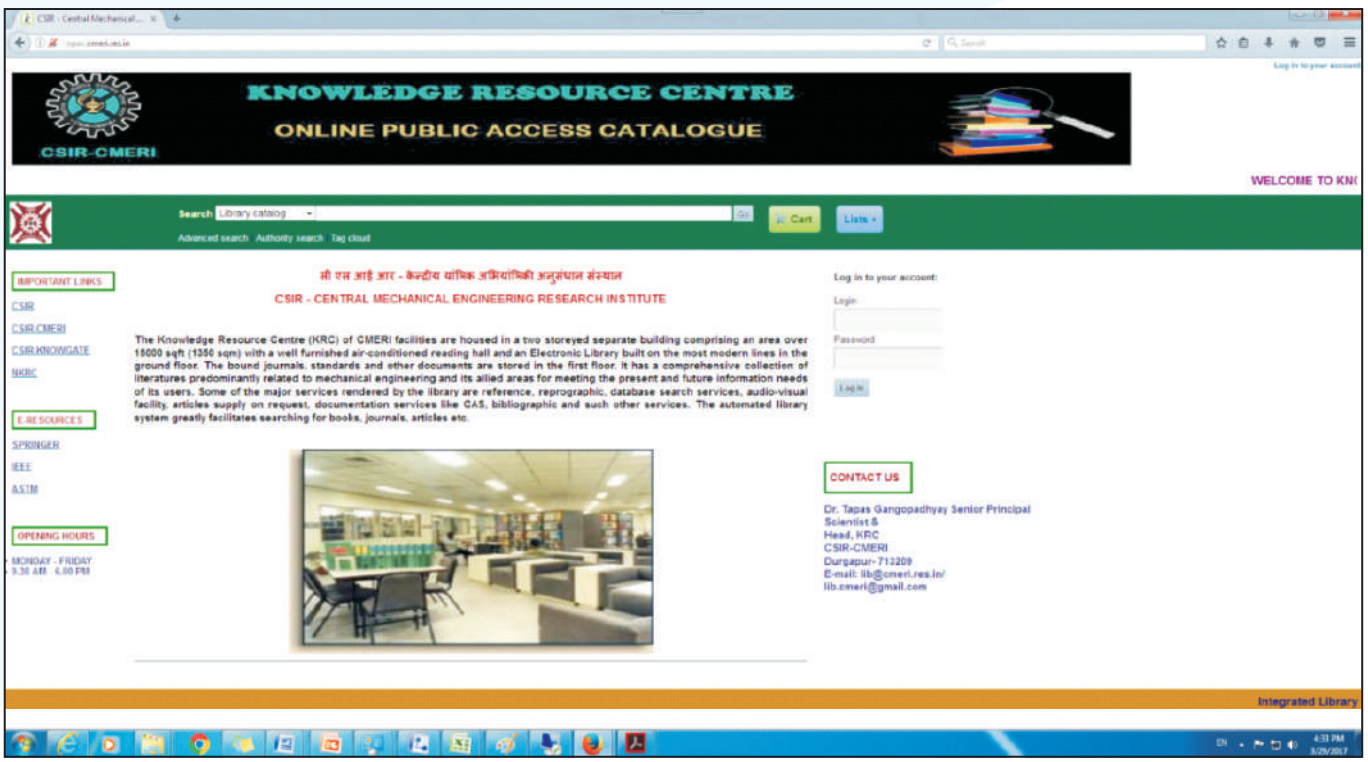
- The office producti√ity software has been upgraded to the latest a√ailable √ersion for more than 200 acti√e users of the Institute. This helps the staff members to bring more modern fla√or in their presentations, reports, documents and worksheets.

- IT Group successfully migrated the Institute's old legacy e-mail system from old to new structured infrastructure with better security. This new mail infrastructure is then successfully migrated to centralized mailing solution of mail.go√.in. All the mailbox migration and switching o√er work has been completed within the prescribed time limit and without ha√ing any downtime. For this, IT Group also recei√ed appreciation from Director General's Technical Cell.



- A communication kiosk system has been designed and de√eloped at the IT Group under Rural Sector Project of CSIR. The said kiosk system is designed to be implemented at √illage panchayat and to be used by rural population of the country to take ad√antage of Internet technology for fulfilling their inter¬√illage correspondence need. This initiati√e has been taken to bring down the digital di√ide under Digital India Mission programme of Go√t. of India.

- The Knowledge Resource Center (KRC) of the Institute has been made equipped with high end computational facility for managing information resources. The old proprietary software based Integrated Library Management Systems (ILMS) of the KRC got replaced with contemporary open source ILMS after migration of ~64,000 records and ~400 patrons database. A new portal named http://opac.cmeri.res.in has also been launched for the public and stakeholder of the Institute. The CMERI KRC has also been integrated with the CSIR's central union catalogue.



MATERIAL & STRUCTURAL EVALUATION GROUP

Solutions for Residual Life Assessment of Industrial structures:

MSEG provided solutions to full scale industrial structures through value added services in various industries like:

- SCCL Singareni Mines– Study and Testing of Coal Handling Plant.
- SAIL–RMD Bolani– Life enhancement study of Fines Tunnel in mines.
- SAIL–RMD Kiruburu– Life enhancement study of Lump Bunker.
- National Thermal Power Plant Kahalgaon– Life enhancement study, testing and remedial measures for High Rise Chimney.
- Northern Coalfields Ltd–Life assessment study of coal handling plant and other mining structures, etc.
- Study, Analysis and initial testing activities of large oil storage vessels in oil sector.

Mechanical Testing and calibration:

MSEG provided service to industries through calibration of force proving instruments and mechanical testing of materials for both external clients and in-house R&D. Achieved NABL reaccreditation in Mechanical Testing and Fatigue Testing.

Development of a technology for optimal extraction of locked-up coal from underground mines using artificial pillars:

Activity A: The main objective of this task is to develop acceptability tools/criteria for assessment of any structural component developed for optimal extraction of locked-up coal from underground coal mines by replacing coal pillars with artificial pillars.

Activity B: Evaluation of flow characteristics (pressure drop, velocity distribution, VSS density, slip velocity magnitude and VSS skin friction coefficient distribution) of viscous semi-Solid (VSS) material by computational fluid dynamics (CFD) simulation.

Deliverable: Assessment of VSS or equivalent material through non-destructive and other test methods to develop statistical assessment methodology to qualify any artificial pillar and application of the developed methodology with reference to industrial structures exposed to similar conditions

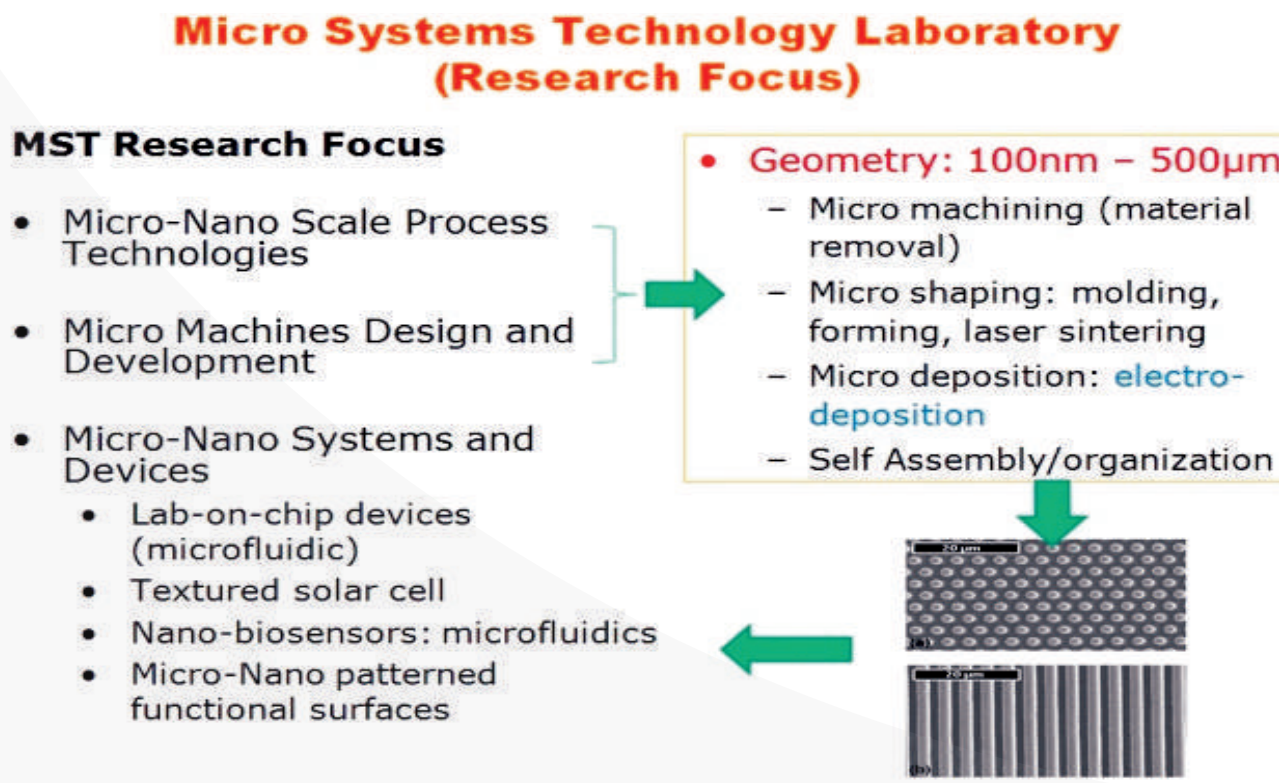
Condition Assessment and Forensic Analysis of Concrete Structures (I-HEAL):

Objectives: Non-destructive testing and assessment of selected industrial structures to develop quality assessment criteria. Statistical analysis of test results to characterize Ultrasonic Pulse Velocity and establish fundamental statistical nature and laboratory study to compare the developed statistical model based on industrial test results with laboratory material under controlled test conditions.

Deliverable: Development of statistical criteria for structural health assessment through Ultrasonic Pulse Velocity measurements and application of the developed criteria with reference to industrial structures exposed to service exposed conditions.

Total ECF generated: Rs. 41 Lacs (Rupees Forty One Lacs).

MICRO SYSTEMS TECHNOLOGY LABORATORY



Micro Systems Technology laboratory at CSIR–CMERI was established in May 2006. Currently this group is consisting of 6 scientists, 2 technical staff and 14 research students and project staff. This research group is primarily focused on engineering of micro–nano systems with no√el and unique functions by integrating efforts from different domains such as mechanical engineering, electronics, chemistry, and biotechnology as depicted in the figure. The facilities related to micro machining, micro–mechatronics, microfluidics, nanomaterials processing and bio–engineering ha√e been created o√er ten years. This makes the laboratory the only one of its kind in India. This group has successfully implemented se√eral projects funded by CSIR plan projects, DST, DBT, DRDO, Baruipur Surgical Cluster and Indo–EU–FP7, Indo–US, Indo–Japan bilateral programs. Research collaborators include BHEL, ISRO, IISc, IITK, IITB, IITG, UIUC–USA, Northwestern Uni√ersity, Uni√ersity of Florida, Technical Uni√ersity of Delft, CEA–France, IEK–5, FZ Jülich, Germany and many CSIR sister laboratories. The important research highlights of MST during 2016–17 include

- Research Projects Successfuly implemented
  - Four research projects under Robotics and Micro Machines (ESC0112) CSIR 12th FYP Network project
  - Micro–Nano Scale Electric discharge machining
  - Large area micro–nano scale patterning by self organization
  - Isolation of circular tumour cell inside microfludic chip
  - Micro–fluidic chip based malaria diagnosis
  - Indo–EU–FP7 project AGATHA–Ad√anced Grating for Thin Film Solar cell (GAP201712)

- Initiation of two FTT projects (up to July 2018)
  - Micro–Fuel Cell
  - 4–axis controller and desktop micro milling machine

- Sanction of externally funded project
  - SMART Foundry–2020 (GAP213212) has been sanctioned for three years with Rs. 297 lakhs funding out of Rs.925 total outlay sanctioned by DST for 10 collaborating institutes with Rs.125 lakhs funding from fi√e industries.

- Product/Technology developed/demonstrated in 2016-17
- Micro-Nano Scale EDM process technology capable of creating 5µm features has been demonstrated in lab-scale
- Process technology for creating micro-nano scale patterns (<1µm) over larger area (~100mm^2) by de-wetting has been demonstrated in lab-scale
- Micro Fuel Cell (A Vanadium liquid based battery as an alternative chargeable to AA and A size lead-acid batteries have been developed)
- Desktop micro milling machine with 4-axis micro machining capabilities has been developed
- Arsenic Removal Water Filter for domestic application has been developed

- Publications and Patents
- SCI Publications: 08. Patents filed: 03

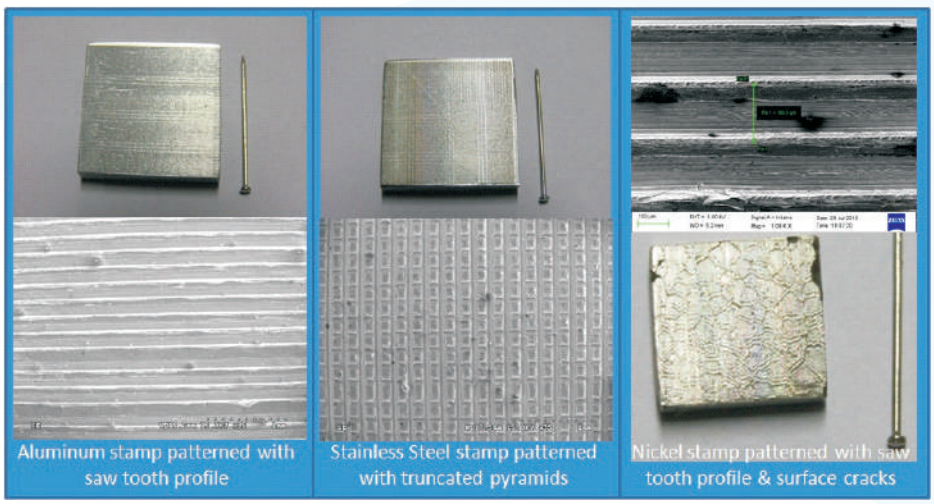
- HRD/Skill Development
- PhD: Awarded (01). Submitted (01). Ongoing (09)
- M.Tech: 01 (NIT, Durgapur). Project staff trained: 14

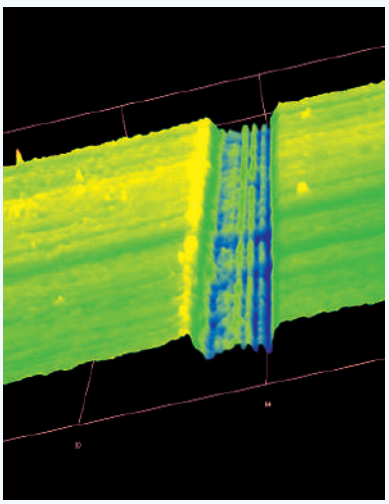
The brief technical highlights on some of these developments have been provided below.

Micro-Nano Scale patterning over metallic substrates

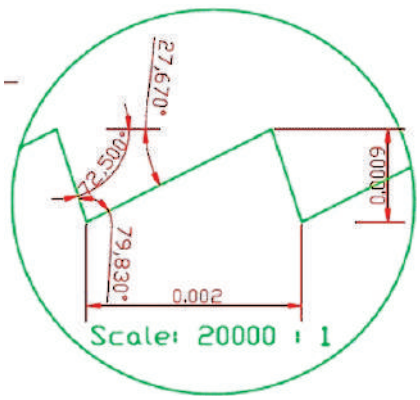
In both the Indo-EU AGATHA project and the 12th FYP network project an attempt was made to develop process technology and a micro machine to develop sub-micrometer scale features for various applications. A Nano-Scratching process has been demonstrated and a laboratory prototype machine has been built which is capable of creating as small as 2µm patterns on die steel to be used in hot embossing of glass. Material removal mechanism under ultra short pulsed low energy electric discharge machining has been studied using molecular dynamic simulations.

Further, the process capabilities in creating nanometer scale features over metal using femto-sec lasers for producing textures on metal punch to be used in hot embossing glass were also studied for textured solar cell applications.

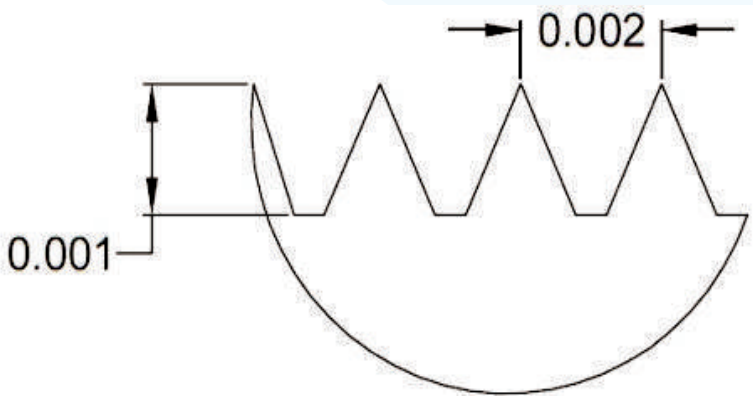




Some of the stamp patterns using the nano-scratching machine developed at CSIR-CMERI



(a) Profile of desired geometry



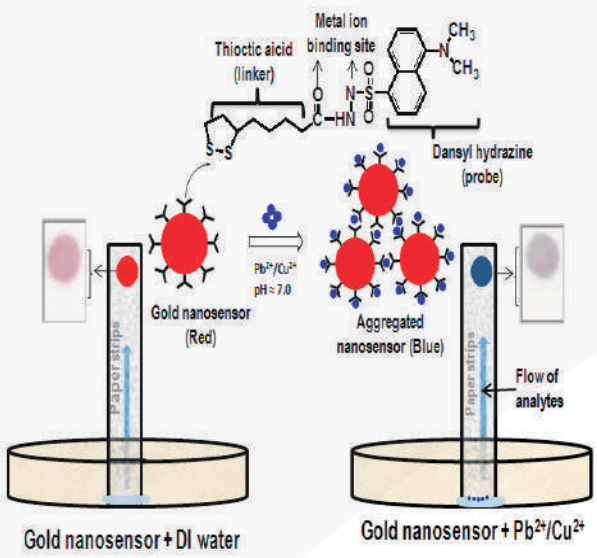
(b) Geometry machined using femto-sec laser

Micro / Nano Structures for environmental / energy / biomedical applications

Our ongoing research is to develop novel micro/nano materials or composites and find their unique photo-physical properties for different applications in the environmental/energy/biomedical domains. The following sections briefly describe some specific research being pursued in the department of micro systems technology at CMERI:

(a) Nanosensors for rapid, low-cost and in-field detection of environmental/biological toxins

Discovery of safe and effective techniques for the real-time detection of the heavy metals such as copper, lead and arsenic is an important goal for clinical toxicology, water controlling, food and pharmaceutical processes. In this aspect, gold nanoparticles based sensors with high sensitivity and rapid separation ability were developed, which will offer viable solutions for the detection and quantification of specific metal ions (Cu^{2+}, Pb^{2+} and As^{3+}) in environmental and biological samples.



Schematic illustration of the interaction of gold nanosensor (Au-TA-DNS) and metal ions on paper strips. Enlarged view exhibitsreal images of Au-TA-DNS before (left) andafter (right) interaction with Pb^{2+}/Cu^{2+} ions.

The present technology proves its potentiality as a completely miniaturized sensing device by removing many challenges we normally encounter with the existing state-of-the-art sensors for arsenic detection.

(b) Nanocomposite for removal of arsenic from ground water

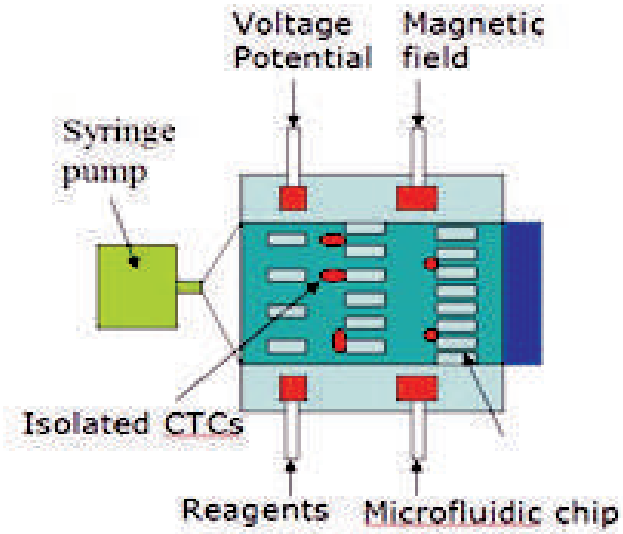
Arsenic water filter

With the ever-growing problem of arsenic-safe drinking water, this laboratory developed a nanocomposite which can remove arsenic to below 10 ppb level (WHO recommended limit). The nanocomposite is made of mixed metal-oxides (copper oxide, iron oxide) embedded in activated rice husk char. Use of iron and copper oxide nanoparticles increases the surface area of the adsorbent and the density of the hydroxyl groups (-OH) that facilitates the adsorption process through ion-exchange and complex formation with arsenic ions and other contaminants. The nanocomposite can simultaneously filter out harmful bacteria and suspended particles/salts along with arsenic. Finally, the nanocomposite has been used to develop a cartridge for an arsenic water filter. Since rice husk based materials are used to prepare the cartridge, the overall filter becomes inexpensive (~Rs 1400.00 per purifier with replaceable cartridge of Rs 300.00 cost) and having other benefits - for example, it will be portable, power-free, and safe for arsenic management which meet the needs of the arsenic affected population in India and other countries.

(c) Biological cell isolation in microfluidic environment

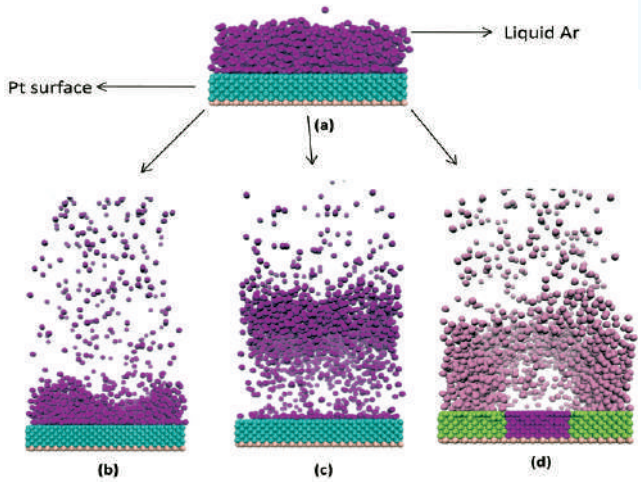
Microfluidics based lab-on-chip devices are emerging as one of the most promising future technologies which can be used in several sensing and diagnostic applications. Low cost, small evaluation time, small sample requirement, portability are the

major advantages of such devices. In MST Lab, research work is going on to develop microfluidic devices for circulating tumour cell (CTC) isolation. CTCs are larger in size than the other normal blood cells. For isolating CTCs, activated micro/nano-patterned surfaces are being developed. In order to analyze the isolated cells, a portable optical device is being built which will act as a CTC isolation device as well as a mini-microscope.



Schematic of CTC Isolation Method

(d) Molecular Dynamics (MD) Simulation study of boiling and evaporation at nanoscale

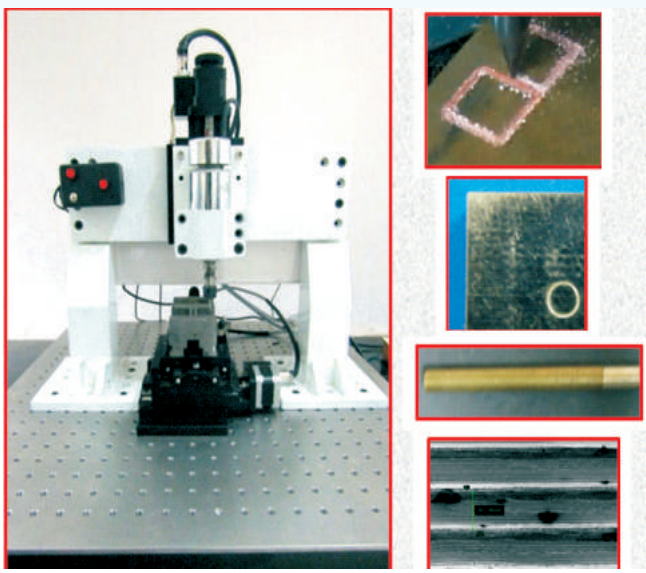


MD simulations of different phases of boiling

Boiling and evaporation are two important modes of phase change heat transfer. Both these phenomena are frequently observed in a number of natural as well as technological events. Evaporation generally occurs from the liquid-vapor interface whereas boiling starts from nucleation of a vapor bubble. These phenomena are associated with large amount of heat transfer and find varied applications-starting from microdevices to macroscale hydraulic machinery developments. A molecular level investigation of these phenomena provides a better fundamental understanding which helps to enhance energy efficiency of several engineering processes. MD based simulation studies are being carried out to study different aspects of boiling and evaporation. The studies show the initial stages of nucleate boiling, film boiling and different aspects of evaporations. A case of water droplet evaporation was considered and the effect of external electric field was analysed in detail. The study also reveals the effect of direction and intensity of the external field on droplet evaporation. Adjoining figures show glimpses of such study.

(e) Development of micromachines and controllers for societal and industrial applications.

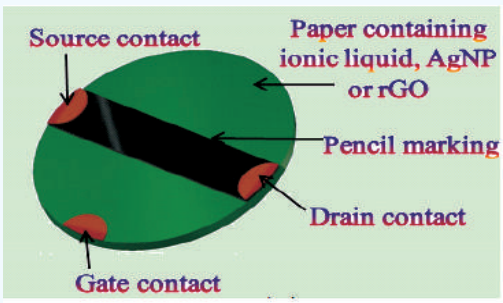
Development of a multiprocess micromachine "Multi-Fab" (under FTT project): The Multi-Fab is capable of conducting operations such as micromilling, microturning, microdrilling, micropatterning within a 50 cm^2 area employing standard G-code. The manufacturing cost of the system is Rs 2.0 lacs. The system is expected to aid the engineering colleges to set up full-fledged machine laboratory as the machine is manufactured within an affordable cost. The machine along with few of the machined parts is shown in the following figure.



The Multi-Fab and the fabricated parts

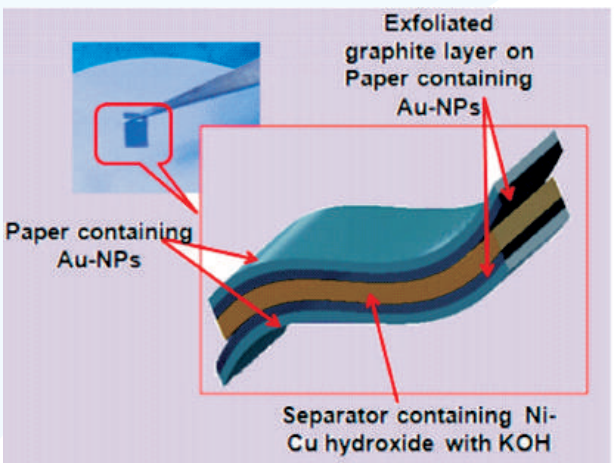
(f) Development of nano-material aided flexible electronics products for sensing and energy applications

Development of flexible paper-pencil based field effect transistors (FET) and supercapacitors: The flexible electronics research area is at a peak now. This is owing to demands of flexible, organic, disposable, low cost, high performance devices. We have developed flexible field effect transistors using filter paper adsorbed with various materials such as ionic liquid (IL), silver nanoparticles (AgNP) and reduced graphene oxide (rGO) with pencil markings on the paper. The characteristics of the FETs are comparable to organic polymer based FETs. Due to low cost and high adsorption rate of paper material this FET has potential in gas sensing applications. Similarly, low cost paper based flexible supercapacitors are also developed with a high specific capacitance of 790 mF/cm^2.The developed FETs and supercapacitors are shown.



Schematic for the fabricated FETs

The fabricated FETs



The paper-pencil based FETs and supercapacitors

(g) Micro Fuel Cell

The work describes a completely miniaturized redox fuel cell, which is designed to be used for small electronic applications where batteries are used. The present device brings the microfluidic fuel cell to a stage of commercialization where it eliminates components of a fuel cell such as two inlets used to drive the fuel and oxidant solutions, a rectangular cross-section design of the microchannel used for the fuel cell, outlet arrangement for waste disposal of the by-products.The micro fuel cell generates 1.5 V, 200 mAh per cell and its performance is being tested with various toys, wall-clocks etc.

Specifications

- Generated Voltage: 1.2 - 1.5 V per cell
- Power per Cell: ~ 300 mWh
- Current output: ~ 200 mAh
- Dimensions: AA
- Weight: ~ 10 gm
- Fuel Consumption: ~ 2 ml

Snapshot of AA sized micro fuel cell and its specifications

NDT & METALLURGY

Residual life assessment, damage assessment and failure analysis of Power and Process Plant Components

The NDT & Metallurgy group of CSIR-CMERI has creditability and considerable experience in the field of damage assessment, component integrity and in-service failure studies of the power and process plant components. These activities directly contribute to significant improvement in useful life of individual components of the different thermal power and process plants. The studies are important in respect to the cost effective renovation and modernization programme of the aged thermal power station. Many of the power plants in India are old and require major renovation programme for future operation, which needs in depth assessment of the present component damage. The beneficiaries of the studies include several industries like NTPC, DVC, WBSEB, CESC, PSEB, Hindalco and many other power plants. Apart from these activities, this group is also engaged in service failure and quality assurance of different critical components in power plant, mining, fertilizer and many other industries.

The institute has strong interaction with various power plants all over India for the last 30 years regarding Residual Life Assessment (RLA) of critical components. This activity is considered to be one of the major thrust areas of CSIR-CMERI. Due to this expertise in life assessment studies for last 30 years, CSIR-CMERI is accredited as "Well known Remanent Life Assessment Organization", by the Central Boiler Board, Ministry of Commerce & Industries, Government of India.

It is an established fact that Residual Life Assessment route is economical, viable and most effective means to improve the overall availability of the ageing power plants in India. Before any renovation and modernization programme, it is mandatory to conduct residual life assessment (RLA) study of all the critical components of a power generating unit. This brings into notice the mandatory replacements and modifications necessary to guarantee a minimum of 75% plant load factor and 85% plant availability.

The in-service failure of the engineering components has become a major issue to the plant owners. Post mortem analysis is very often needed to predict the

Figure 1a & 1b: On-site Non-Destructive Examination of critical components.

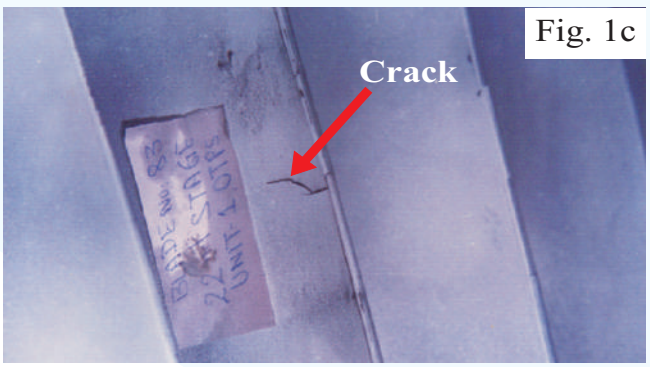


Figure 1c: Crack on Turbine Blade

Figure 1d: Crack on Boiler Superheater Header

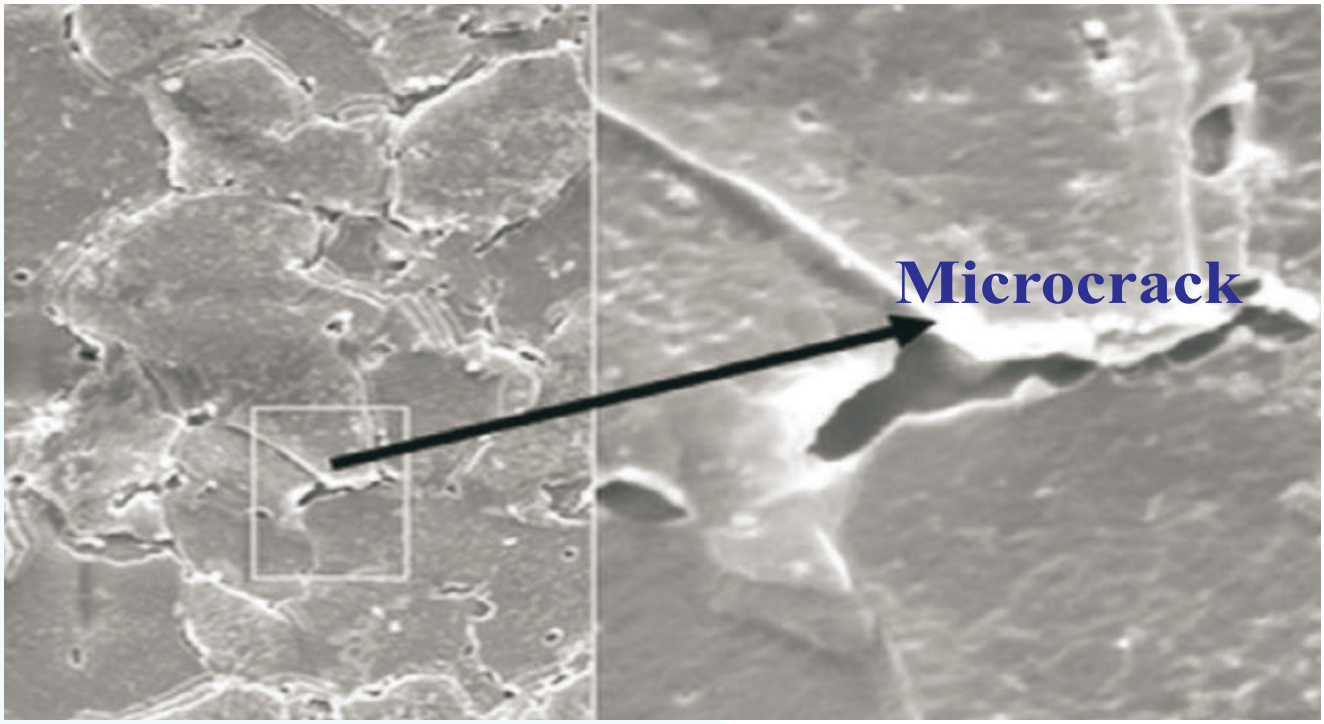


Figure 2a: The microstructure at in-situ condition shows oriented creep cavities and microcracks at the grain boundaries.

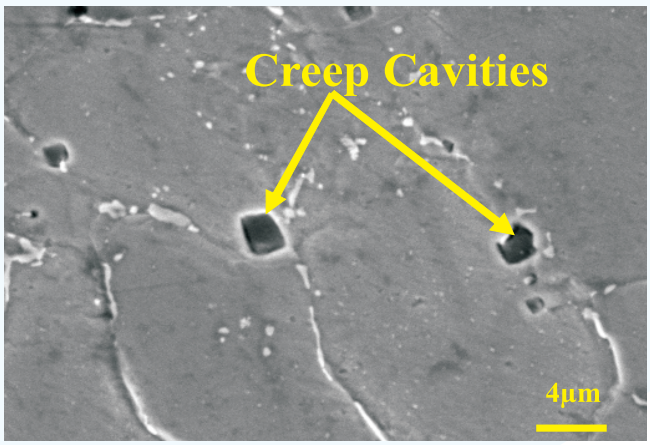


Figure 2b: The microstructure at in-situ condition shows isolated creep cavities at the grain boundaries

root cause of failure and thereby prevent similar type of failure in near future. This is also important in connection with the reliability, availability and safety of the components. The NDT & Metallurgy group is actively engaged in failure analysis as a part of RLA services. This aims to minimize forced outages, thereby affording substantial indirect savings of national exchequer.

In case of RLA study, various non-destructive testing like dye penetrant (DP) test, magnetic particle test (MPT), video imagescopy, ultrasonic test (UT), in-situ metallography and in-situ surface hardness

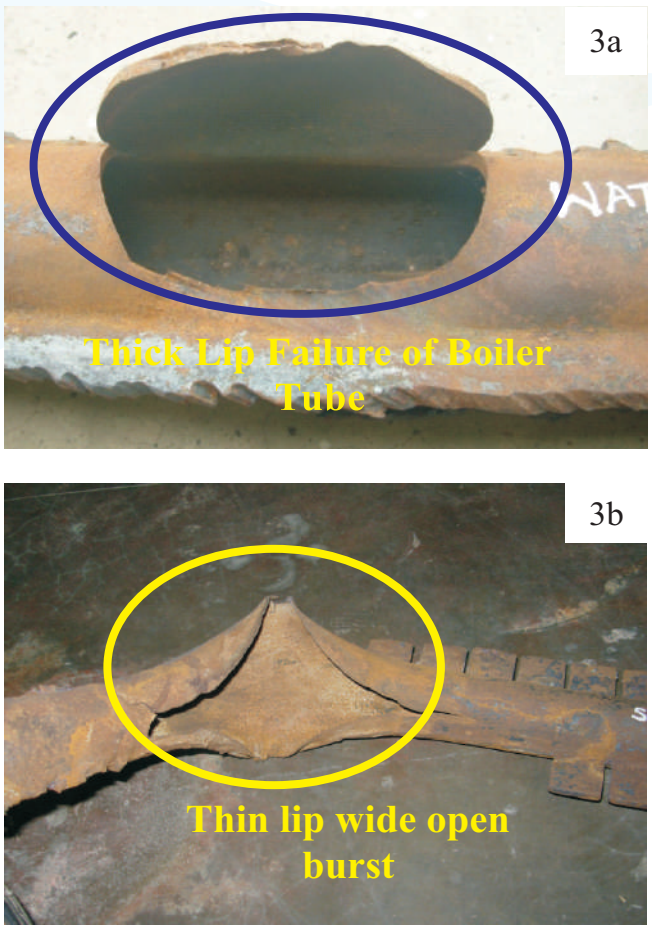


Figure 3: Failure region of components.

measurements are employed for critical industrial components, which are mainly power and process plant components. The tests are carried out to detect surface/near surface and internal discontinuity/flaw, creep damage in microscopic levels and thermal softening due to creep damage. Figures 1a and 1b depict the on-site non-destructive testing of the critical component of boilers in thermal power plants. Some of the cracks observed in boiler components and welded joints of boiler superheater header are shown Figures 1c and 1d, respectively.

The non-destructive metallographic test is also carried out in in-situ condition over the damage prone areas of different high temperature components to assess the damage in microstructure level. Figures 2a and 2b show the oriented creep cavities and microcrack in the grain boundaries.

The post mortem failure analysis of different failed components is carried out mostly for the power plant components. The failure region of some of the failed components of thermal power plants is shown in Figures 3a and 3b.

Apart from the various RLA and failure investigative works, NDT & Metallurgy Group of CSIR-CMERI also conducts considerable research on high temperature damage mechanisms of existing and advanced materials used in thermal power plants. Extensive work is being carried out to investigative high temperature corrosion behaviour of CeO_2 and Y_2O_3 coated 2.25Cr-1Mo and 9Cr-1Mo steels under air oxidation atmospheres. The obtained results from the research show significant improvement of corrosion resistance in case of coated Cr-Mo steel alloy. Some recent advancements have been planned under the forthcoming five year plan period to develop nano-structured composite coatings for high temperature applications in turbine blades, engine parts for petrochemical, aerospace and electronic device industries.

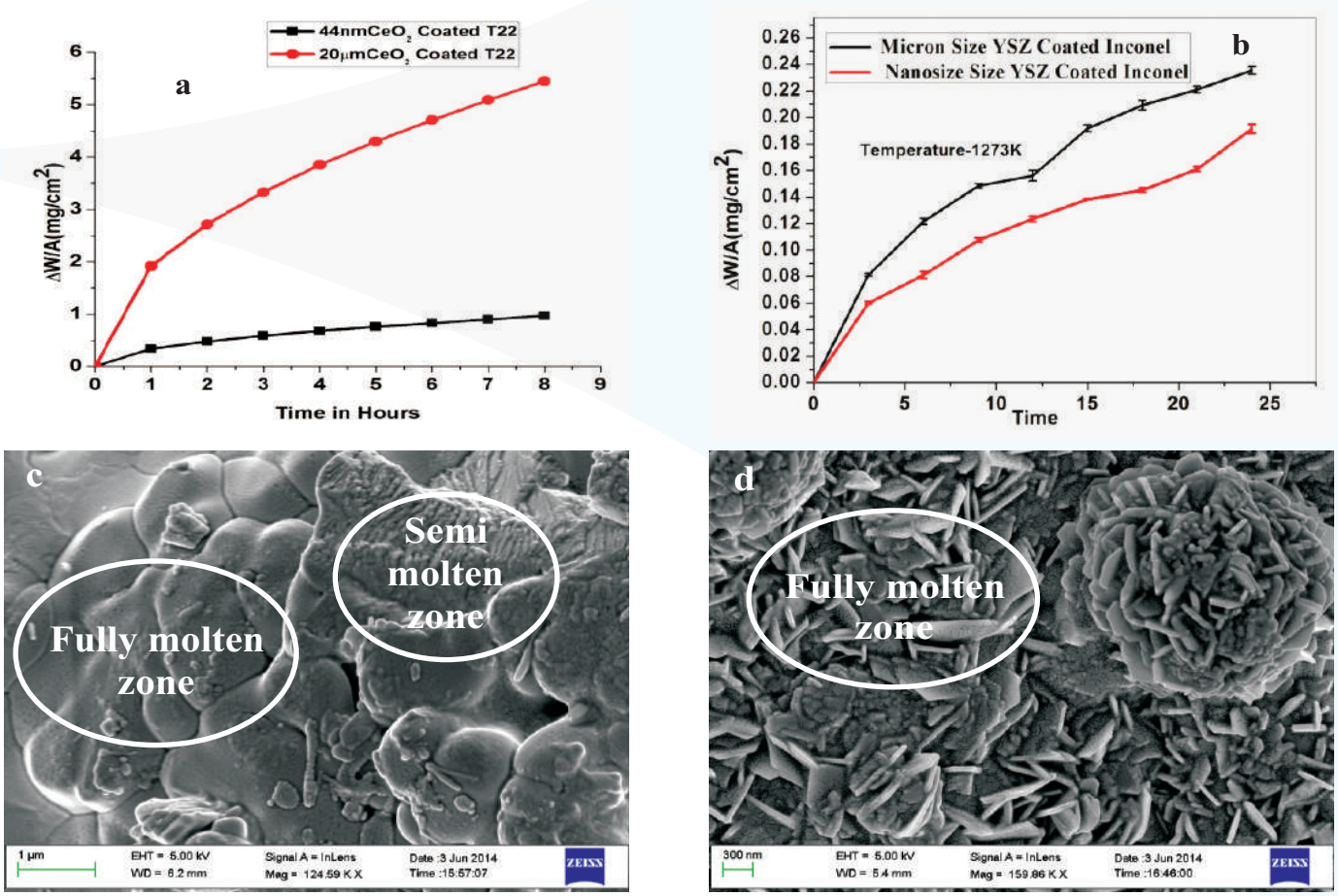


Figure 4: (a) Reaction kinetics and corrosion rate of plasma sprayed nano coated and micron size coated CeO_2 specimen (b) Reaction kinetics and corrosion rate of plasma sprayed nano coated and micron size coated YSZ specimen (c) Semi molten zone and fully molten zone of nano coated YSZ specimen after oxidation (d) Existence of nano YSZ.

The group has also taken up a project on nano-structured reactive oxide coatings for high temperature corrosion resistance applications. The primary objective is to study the performance of nano structured reactive oxide coatings for improvement of corrosion resistance for high temperature applications. These coatings may be useful for high temperature applications in turbine blades, engine parts for petrochemical, aerospace and electronic device industries. Development of nano structured reactive oxide coating of CeO_2 and Y_2O_3 over the substrate of Cr-Mo, stainless steel and Ni base super alloys has the following components:

- High temperature corrosion studies of the nano coated specimen in oxidation and other aggressive environments.
- Study of corrosion growth and reaction kinetics on nano coated specimen.
- Characterizations of the surface, subsurface layers of the post corroded specimen for prediction of mechanism of corrosion under nano surface layer coating. Some of the results are incorporated in Figure 4.

The group has generated Rs. 65.62 Lakhs of External Cash Flow (ECF) through different technical services of life assessment and failure analysis activities during 2016-17 financial year.

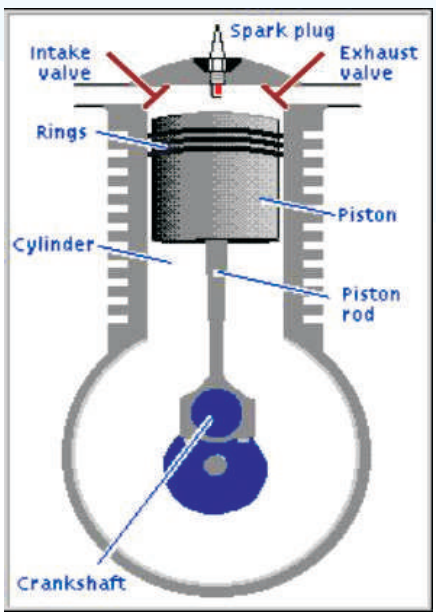
Apart from that the group has published 8 research papers in different SCI journals.

NEAR NET SHAPE MANUFACTURING TECHNOLOGY GROUP

Development of Al-Si alloy with superior mechanical properties for auto engine piston application [ESC 0101]

The main functions of the auto engine pistons are to transmit the gas forces via the connecting rod to the crank shaft and to dissipate the absorbed combustion heat to the cylinder liner and the cooling oil. Aluminium alloys are the preferred material for pistons of auto engines due to their specific characteristics: low density, high thermal conductivity, simple net-shape fabrication techniques, easy machinability, high reliability and very good recycling characteristics. Proper control of the chemical composition, the processing conditions and the final heat treatment results in a microstructure which ensures the required mechanical and thermal performance, in particular the high thermal fatigue resistance.

As the demand for low emission, high torque and improved fuel economy continues to grow, the vehicle manufacturers are forced to find out different



Sectional view of auto engine

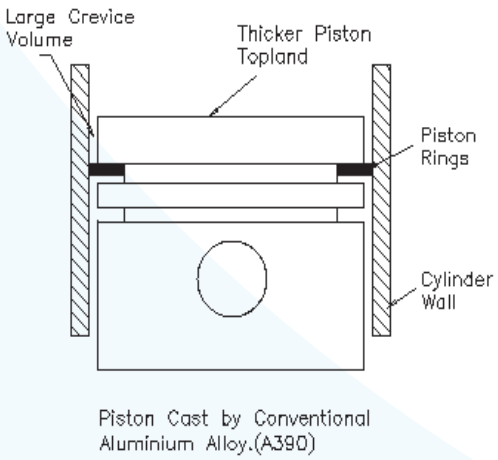
mechanisms and devices to achieve these objectives. Advanced process technologies are continuously being developed to manufacture lighter but stronger auto engine pistons from new class of cast Al-Si alloy systems which can withstand higher working temperature and pressure for long duration of operation. During operation, the mechanical loads on the piston result from extreme pressure cycles with peak pressures up to 200 bar in the combustion chamber and huge forces of inertia caused by the extremely high acceleration due to the reciprocating motion of pistons. These mechanical loads are superimposed by thermal stresses which are primarily generated by the high temperature gradients prevalent on the piston top. Ever rising demands regarding power density as well as the need for reduced emissions and more efficient fuel are the main engineering challenges for the new generation engines. For the pistons, these challenges translate into maximum strength requirements in the relevant temperature range combined with minimum weight. As one of the main components in an engine, the piston's technological evolution is expected to continue and they are expected to be stronger, lighter, thinner and durable. Today's engines run cleaner, work harder and run hotter than ever before. At the same time they are expected to last longer and with minimal maintenance. The growth of the auto industry primarily depends on its capacity to deliver new class of vehicles which will be able to meet the two important criteria - i) higher fuel efficiency and ii) minimum emission of green house gases. Higher performance and operating efficiencies increase the thermal and mechanical loads on the engine parts, thus increasing the demand on the materials chosen for the piston and cylinder heads. Keeping in mind the future requirements of the industries, the network project titled "Development of Al-Si alloy with superior high temperature mechanical properties for auto engine piston application" was initiated in collaboration with CSIR- AMPRI, Bhopal. Primary objectives of this network project were

- Development of Al-Si alloy containing transitional elements and to impart suitable heat treatment for achieving superior high temperature tensile properties.

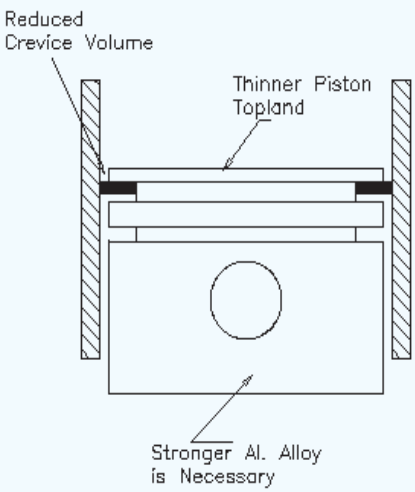
- Development of process technology to manufacture the auto engine piston from the developed AL-Si alloy system.

Combustion analysis of auto engines have revealed that the unburned fuel comes mostly from the ring shaped crevice that is formed between the combustion's cylinder wall surface, piston outside wall and top of the piston ring. This piston crevice is sometimes called the piston top-land clearance. It has

been observed that piston crevice volume produces 80% of the total HC emission from an auto engine. Lower the volume of crevice, lower will be the amount of hydrocarbon emission.



a) Conventional Piston Design (Large crevice volume)



b) Modified Piston Design (Small crevice volume)

Figure 1: Piston design modification for reduction of HC emission

In order to reduce the hydrocarbon emission, modified piston with reduced crevice volume have been introduced in the new generation auto engine. Figure 1 shows the differences between conventional and modified pistons of auto engine. Such modified pistons demand a stronger alloy to prevent failure due to higher mechanical and thermal loading on the top piston's ring groove and ring lands. Maximum operating temperature for the existing cast Al-Si alloy varies between 220 - 240°C. During 1998-2000 NASA, US had developed the improved AL-Si alloys (eutectic and hypereutectic types) which showed much superior mechanical properties up to the temperature range of 300°C. The tensile strength of NASA alloys are much more than that of those prepared from the conventional cast Al alloys like 413.0, 336.0 and 390.0 alloy, when tested at 260°C.

Improved strength at elevated temperatures has been a continuing goal in cast aluminium alloy development for more than three decades. Al-Si based alloys have several characteristics that make them especially attractive for the development of high-temperature, high-strength alloys for auto engine piston application. Literature survey revealed that high-temperature stability and strength of precipitation strengthened cast Al alloys can be improved significantly by introducing the transition elements which are capable of forming a suitable strengthening phase by forming coherent precipitate with Al. These exhibit low solid-solubility in α-Al, as well as display a low solute-diffusivity at high temperature and finally the alloy should be conventionally manufactured. It has been observed that elements like Cu, Ni, Ti, Mn, V, and Zr which form Al_3M tri-aluminide compounds with a cubic L12 crystal structure are most suitable for the above purposes. Tri-aluminide (Al_3M-type) intermetallic compounds have many beneficial characteristics including low density, high elastic modulus, high melting points, and are often stable with Al at higher temperature. They are therefore ideal dispersed strengthening phases for high-strength thermally-stable cast Al-based alloys. Most of the cast Al-Si alloys which are currently being used in our country are intended for applications up to a temperature of 200-220°C. Above this temperature the alloy's microstructure strengthening mechanisms will become unstable, resulting in an alloy having an undesirable microstructure for high temperature applications. Under this network project, cast **near Eutectic Al- 13.5% Si** alloy containing **elements like Si - Cu - Ni - Mg -Mn- V - Zr - Ti - Sr** has been developed. Weight percent of each element was carefully selected to restrict the density of the final alloy within the desired limit in order to keep the final weight of the piston within the design limit to minimise the inertial loads on related parts and finally the cost of the finished product. The experimental Al alloys and standard Al alloy 336 have been prepared from pure Al piglets along with the addition of different types of Al master alloys. Liquid Al alloy was degassed at 700°C with pure Ar gas and then

poured in metallic moulds to cast test samples. The cast alloys have been carefully heat treated to create the coherent precipitate of Al3M, the primary factor for achieving superior mechanical properties at high temperature. Tensile samples were prepared from the cast ingots and high temperature tensile tests were carried out in Instron tensile testing machine at CSIR-AMPRI, Bhopal. Tensile samples were exposed at **260°C for 250 hrs** before testing at 260°C to assess the change of tensile properties. Results of high temperature tests of different types of alloys are given in Figure 2. Al alloy BB shows superior high temperature (260°C) tensile properties compared to Al alloy 336.

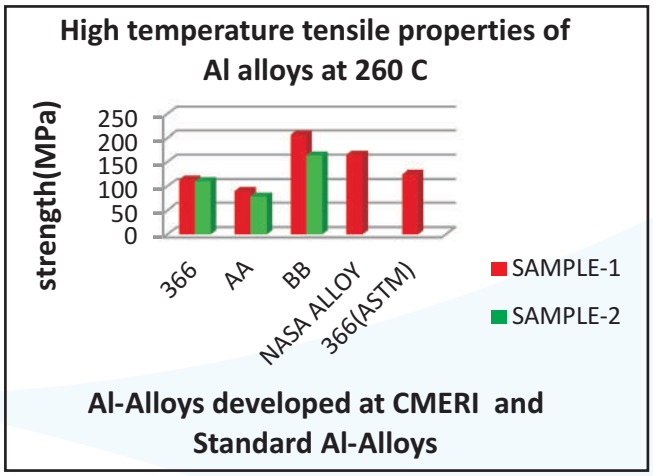


Figure 2: High temperature (260^{0}C) tensile properties of different types of Al alloys

Chemical composition of the experimental alloys							
Wt %	Si	Ni	Cu	Mg	Mn	Fe	Other elements (wt %)
ID - 336	12.8	2.6	1.8	1.87	0.3	0.15	0.24 Ti
ID - AA	13.12	0.56	6.8	1.43	0.5	0.23	0.24 Ti,0.96 Zr, 0.3 V and Sr
ID - BB	13.44	0.4	5.7	1.20	0.5	0.21	0.8 Ti,1.5 Zr, 0.28 V and Sr

Aluminium piston of 90 HP tractor engine was identified for development from the new Al- 13.5%Si alloy system. M/S International Tractor Limited, Hoshiarpur has supplied the 2D drawing of the Piston (Figure 3) which is currently being manufactured from Al alloy 336. SM of the above piston has been developed and solidification simulations (Figure 4) have been carried out with the help of AFS software. Based upon the findings of simulation trials, a steel mould has been developed for casting of the prototype pistons. Arrangement has been made to preheat the steel mould upto 300°C. In order to establish the process technology for manufacturing of Al piston from new type of alloy, the initial experimental trials were carried out with standard Al alloy 336. Subsequently, experimental Al alloys were prepared from Al-13.5%Si-5.0%Cu alloy with the addition of required quantity of Ni, Mg, Ti, V, Zr, and Sr. The melt was properly degassed at 750°C to remove the dissolved H2 gas to minimise the pinholes in the finished castings. Cu-P inter metallic compound was added in the melt just before pouring in the preheated permanent mould, to control the morphology of the precipitate. After removing of risers and in-gates, cast blanks were subjected to T5 heat treatment for 8 hrs.

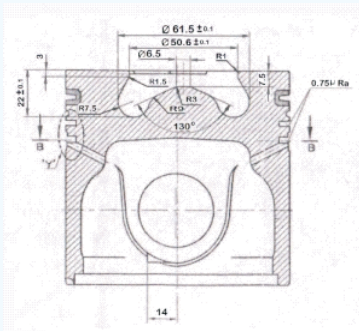


Figure 3: 2D Drawing of Piston of 90HP engine

Figure 4: Solidification simulation of Al piston

Figure 5: Cast blank of Al piston on the base of permanent mould

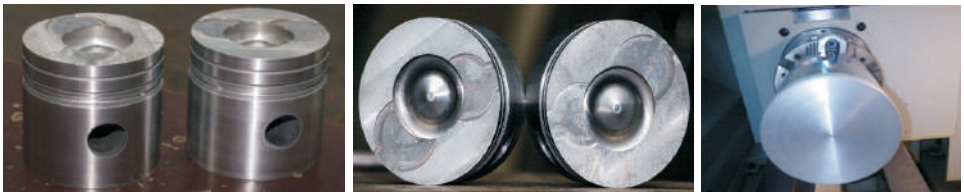


Figure 6: Photographs of machined surfaces of cast heat treated prototype Al piston developed at CSIR-CMERI

Subsequently the cast piston samples were machined to assess the surface characteristic. No major defects were noticed. Composition of the experimental alloys and the standard Piston alloy is given below. Figure 6 shows the machined surfaces of the prototype pistons developed from experimental Al alloy.

Departments contributed: **NNMT, CAMP, MTG, NDT & Metallurgy and CoEFM Ludhiana**

Development of High performance Permanent Magnets for energy efficient motors [D-NEED (PSC 0109)]

Sensing the importance of generation of green energy and its effective utilization, global R&D efforts are in progress to address various science and technological issues, gaps and challenges related to it. Internationally, the R&D efforts are primarily directed towards increasing the efficiency of existing green energy generating devices like electric motors, photovoltaic solar cell etc. and to make these devices energy efficient and economical. There are a number of major families of permanent magnets available for designers, ranging from ferrite, known for its low cost and low energy, to rare earth materials, which are more expensive and offer higher performance. Designers need to analyze magnetizing field strength and magnetic output of magnetic materials prior to deciding on the appropriate magnet. Mainly, bonded magnets are manufactured either through injection moulding or compression moulding technique. Compression moulded bonded magnets offer higher compact density and correspond to higher energy product (BHmax) than the injection-moulded magnets. Keeping in mind the future requirement of the industries, the network project titled **"Development of Advanced Materials for Next-Generation Energy-Efficient Devices (D-NEED)"** was initiated in collaboration with CSIR-NPL, New Delhi. The prime objective of this network project was to develop state-of-the-art energy efficient devices and components and cost effective processes and technologies for newer materials and components. One of the sub activities of this network project was development of **"High performance permanent magnets for energy efficient motors"**. Permanent magnets are a vital part of modern life and they are being extensively used in modern electrical devices for day to day use, like speakers in mobile phones, electric motors in hybrid cars, air conditioners, washing machines, alternator for car and railway coaches, motors for pump and fans. In all of these applications, it is important that the designed permanent magnets have high strength, and be resistive to corrosion and demagnetization due to excessive heat. The progress in the field of permanent magnets rapidly grew in the last fifty years. Understanding of physical phenomena responsible for hard magnetic properties led to discovery of new families of permanent magnets based on rare earth - transition metal compounds. The search for new materials with superior properties focuses on materials with high values of Curie temperature, magnetic saturation and coercive force. There are different types of permanent magnets according to their composition: ferrite magnets, alnico magnets, magnets from rare earth (RE) alloy. Rare earth permanent magnets RE-TM are based on the inter metallic compounds of rare earth metals (RE) and transitional metal (TM) iron or cobalt. The combination of properties of the rare earth sub-lattice and the 3d sub-lattice of transition metal lead to the spectacular development of **hard magnetic materials.** The two most relevant classes of RE-TM magnets are based on samarium and cobalt. They exhibit very high coercive force and low temperature coefficients. **Neodymium-iron-boron is unrivalled in terms of its maximum energy product** (higher BH_{max} value). Manufacturers have gained experience in designing and producing permanent magnets in order to meet the demands of the industries for specific applications. Bonded magnet is one of the most important magnetic materials among permanent magnets. Bonded magnets can be made from either Ferrite or Rare Earth (Neodymium-Iron-Boron [NdFeB]) based materials. NdFeB- based bonded magnets would offer three major advantages: (1) cost saving in manufacturing, (2) higher performance of bonded NdFeB magnets, and (3) more versatile magnetizing patterns of the bonded magnets. Isotropic bonded NdFeB-type magnets do not require grain aligning or high temperature sintering as required for sintered ferrites, so the processing and manufacturing costs can be drastically reduced. The near net shape production of bonded NdFeB bonded magnets also represents a cost savings advantage when compared to the slicing, grinding, and machining required for anisotropic sintered ferrites. Under this project, Neodymium-Praseodymium-Iron-Boron **(NdPrFeB)** based 4-pole ring magnets have been developed by compression moulding. Bisphenol-A (C51) was used as binder for the bonded magnet. Die assembly has been designed and manufactured for easy compaction and ejection of

green compact from die. The bonded magnets have been fabricated in four-pole symmetric shape (shown in **Figure 7a)** as per the specifications required for fan motor. The process for the fabrication of bonded magnetic ring is as follows. First, NdPrFeB powder was thoroughly mixed in the Bisphenol-A epoxy polymer with hardener and accelerator. Then, the mixture was transferred into the mould and subsequently was pressed inside the cavity under a compression load of 30-40 Ton. Upon completion of ejection from the mould, the green part as a ring was cured at temperature 80ºC for 8 h and 140ºC for 8 h. The final product **(Figure 7b)** achieved sufficient strength and final dimension was achieved after machining . Four-pole magnetization was done by pulse magnetizer-specially designed and manufactured for this magnet. The magnetic property of the developed magnet was evaluated from hysteresis loop measured using vibrating sample magnetometer (VSM). The results of magnetization vs. magnetic field is shown in Figure 8.

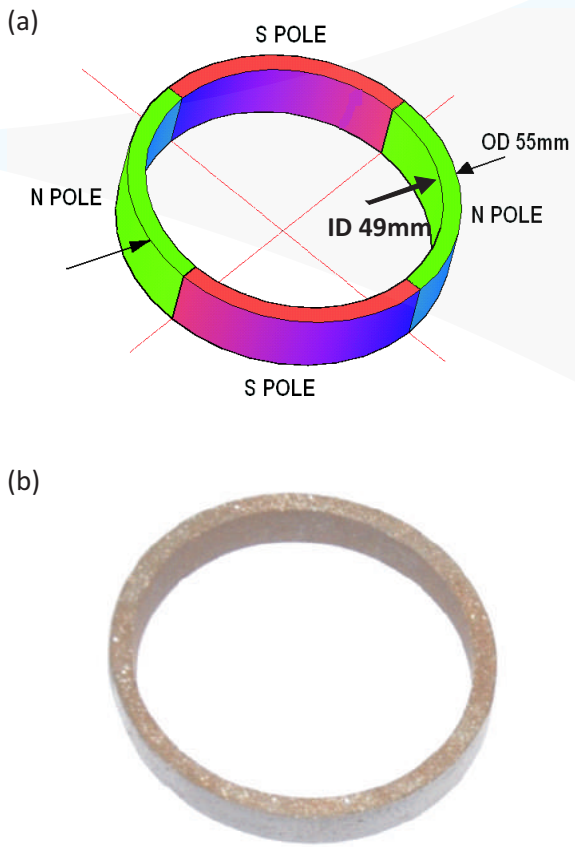


Figure 7: bonded four-pole ring magnet

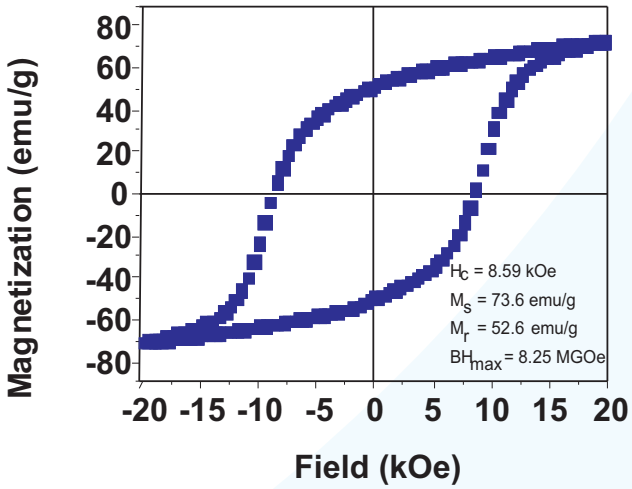


Figure 8: Hysteresis loop of the developed magnet

Features of the four pole ring magnet:

- Achieving compact density upto 5.8 - 5.85 g/cc under 40 Ton compressive load.
- Achieving coercivity of 8.59 kOe and energy product (BHmax) of 8.25 MGOe.
- Good strength in bonding and high surface finish after machining.

Departments contributed: **NNMT, CAMP, MTG, EDG and CoEFM Ludhiana**

PRECISION ENGINEERING AND METROLOGY GROUP

The Precision Engineering and Metrology (PE & M) group of CSIR-CMERI has the capability and considerable experience in the field of high accuracy measurements, in-service calibration of precision gauges and instruments, research on vision based surface inspection, micro electric discharge machining (EDM) and on skill development for SMEs. This group is also involved in shimmy analysis of nose landing gear system of light combat aircraft -Tejas, which has a great impact in the strategic sector. Apart from these, research on the development of high-accuracy three-dimensional translational stage and automatic characterization of micrographs and fractographs are another two areas where this group is actively involved. The major activities of the Precision Engineering and Metrology group, undertaken in 2016-17, are listed below.

1. In the calibration and inspection field, 213 calibration works have been performed and the following new clients have been introduced to CSIR-CMERI.

2. A national level training program was successfully organized by the PE & M group in CMERI during 9-11th November, 2016. This training programme was based on Dimensional Metrology, Pressure Metrology,

Sl.	Name and address of firms
01	M/s Alcalab Pvt. Ltd., Adityapur, Jamshedpur-831013
02	M/s Electrosteel Castings Limited, Kolkata
03	M/s SAIL, DSP, Durgapur
04	M/s Electronics Regional Test laboratory (East), Kolkata-700091
05	M/s Maithan Ceramic Limited, Dhanbad-828202
06	M/s Calcutta Metal testing Laboratory, Howrah-711113
07	M/s Central Institute of Mining & Fuel Research, Dhanbad-826015
08	M/s DSTPS, DVC, Andal
09	M/s Indian Oil Corporation Ltd., Begusarai-851114
10	M/s Electrometer Corporation, Kolkata-700014
11	M/s Heavy Engineering Corporation Limited, Ranchi-834004
12	M/s CSIR-CMERI-CoFEM, Ludhiana-141006
13	M/s MSME Testing Centre, Kolkata-700108
14	M/s Toshniwal Enterprises Corp. Pvt. Ltd
15	M/s Pragati Cement (I) Pvt. Ltd. , Purulia- 723101

16	M/s Durgapur Chemicals Limited, Durgapur-713215
17	M/s GE Power India Ltd. Durgapur-713206
18	M/s Sr.Quality Assurance Estt (ARMTS), Ministry of Defense, Kolkata
19	M/s R S Safety and calibration Consultancy, Jamshedpur
20	M/s Adityapur Autocluster, Jamshedpur
21	M/s TATA Metaliks Limited.
22	M/s Project & Devlopment India Ltd, Dhanbad
23	M/s Mackeil Ispat Forging Ltd, Durgapur.
24	M/s Kalyanpur Cements, Bihar-821303

Mass, Density & Volume Measurement. Around 15 participants from various industries attended the programme and very good feedback was received at its completion.

3. This group is also involved in shimmy analysis of nose landing gear system of light combat aircraft - Tejas, which has a great impact in the strategic sector. Analysis of torsional, lateral and rolling stiffness components are evaluated from CAD model of nose landing gear using FE analysis. These values are ultimately utilized to find the range of critical velocities at the time of taxiing of light combat aircraft - Tejas.

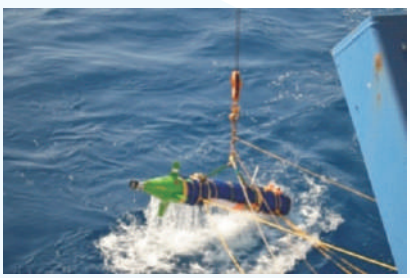
ROBOTICS AND AUTOMATION GROUP

Autonomous Underwater Vehicle (AUV-500)

For the first time in India, researchers of CSIR-Central Mechanical Engineering Research Institute (CMERI), Durgapur - a premier R&D institute for mechanical engineering under the aegis of the Council of Scientific and Industrial Research (CSIR) - has indigenously designed, developed and conducted successful sea trial of an Autonomous Underwater Vehicle (AUV) capable of working up-to a depth of 500 m at sea.

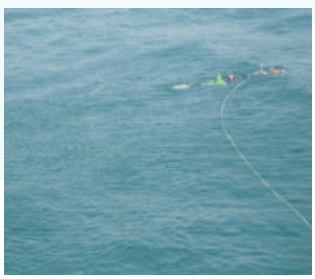
AUV-500 is an autonomous (and untethered) system as it has its own actuation, control, power system and decision making capability. The underwater robotic vehicle is around 3.7 m long, effective diameter around 0.5 m and mass of the system is around 400 kg in air. The system has a positive buoyancy of around 5 -7 kg, when underwater. AUV-500 is actuated by three thrusters and actuation fins (also known as control surfaces) to control the surge, sway, heave, pitch and yaw. Wireless communication with AUV-500 is achieved through RF, when the vehicle is on the surface, and through the acoustic channel (with help of an Ultra Sort Base Line system), when the AUV is underwater. AUV-500 is equipped with a number of navigational sensors (Inertial Navigation System (INS), Doppler Velocity Log (DVL), Depth Sensor, Altimeter and Acoustic Positioning System etc.) to get its positional information. The vehicle carries a variety of pay load sensors (like, camera, lamp, conductivity, temperature and dissolved oxygen sensors) which are useful in several applications and sea-parameters monitoring.

Team at work on RV Sindhu Sadhna

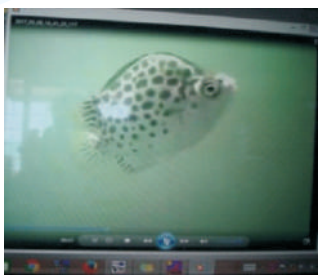


Launching from RV Sindhu Sadhna

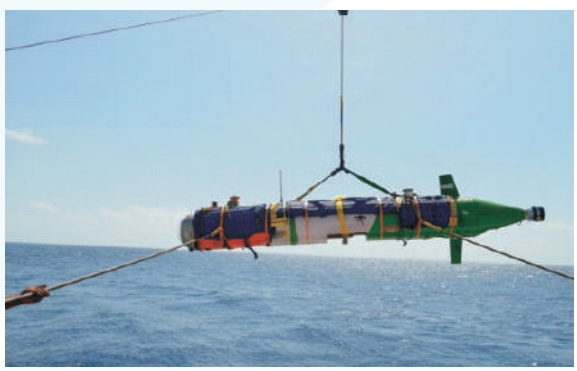
Initiation of Diving Operation



Maneuvering on the Sea Water Surface



Video of fish collected by AUV



Retrieval of AUV500

CSIR-CMERI AUV500 Sea Trial Team

The sea trials with AUV-500 were conducted around 90 nautical miles off Goa coast from the Research Vessel (RV) Sindhu Sadhna, a ship owned by CSIR-National Institute of Oceanography (NIO), Goa, during 4th March 2017 to 12th March 2017 in a phase-wise manner. The activities of a complete AUV mission, starting from its launching, surface/subsea mission as well as retrieval operation were remotely monitored from a control station residing on the deck of RV Sindhu Sadhna. The AUV-500 had achieved the landmark depth of 286.14 m on 11.03.2017 at 09 hrs 24 mins 29 secs while executing all its required functionalities during one of its phase-wise (17 m, 55 m, ….., 286.14 m) subsea missions. AUV-500 collected useful information like conductivity, temperature and dissolved oxygen content at various depth levels and captured video/photographs during its various surface/subsea missions. Glimpses of the sea trial snapshots are provided below.

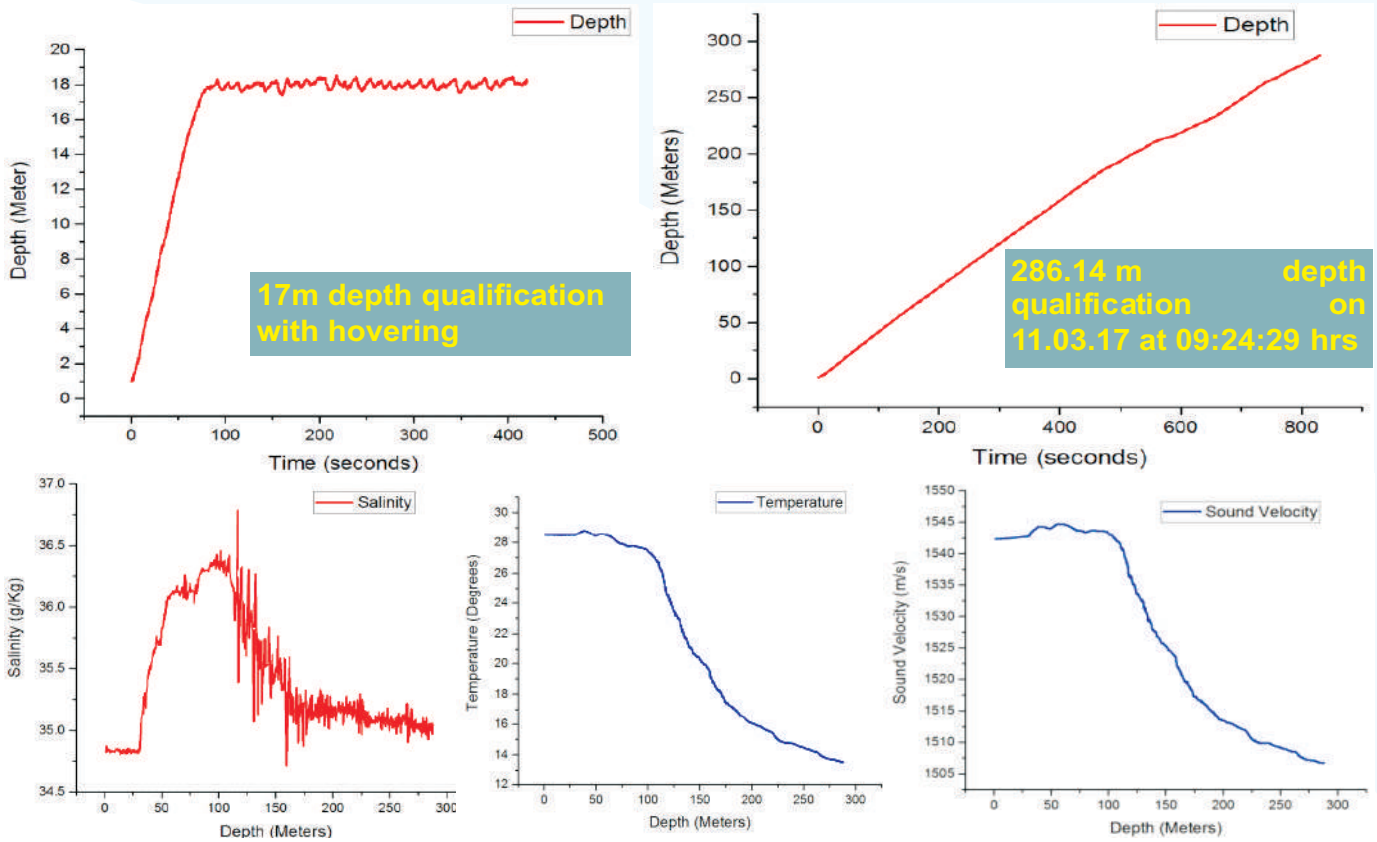
AUV-500 can be utilized for inspection work, environmental data collection, underwater videography/photography, bathymetry/sea-bed mapping and monitoring of sea-parameters like conductivity, temperature, dissolved oxygen (DO), sound velocity etc. This kind of development might be useful for Indian Navy, ONGC, DRDO, and Dam Inspection Authority etc. and the multi-disciplinary knowledge acquired from this development would also be utilized for several prospective applications. The salient achievements and results are enumerated below:

Salient Achievements:

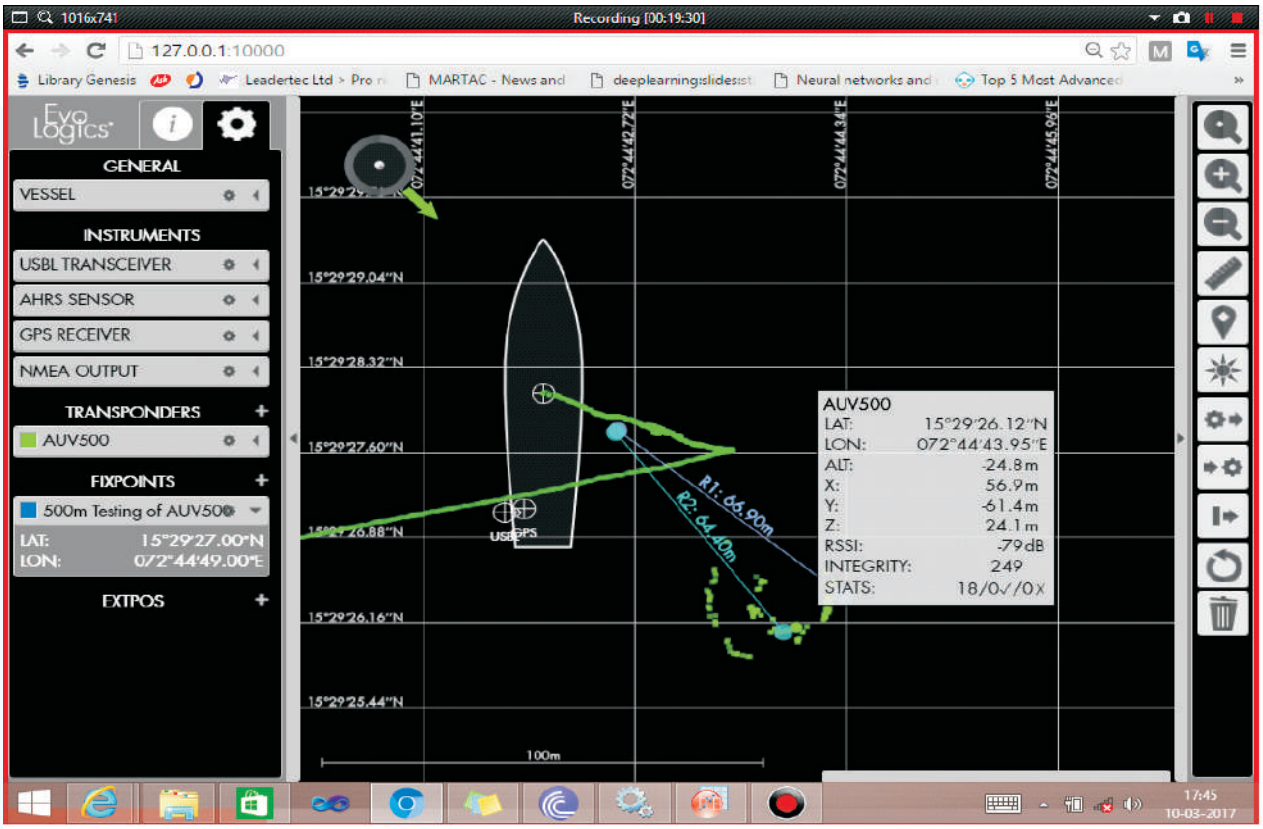
- Depth Qualification for 286.14 m with the required functionalities
- Surface operations
- Satisfactory profiling of sound velocity, salinity & temperature at different depths
- Capturing underwater video / images using on-board camera
- Acoustic communication & vehicle tracking capability during dive for safe operation
- Endurance in extremely rough sea environment (recorded sea-states 4-5)

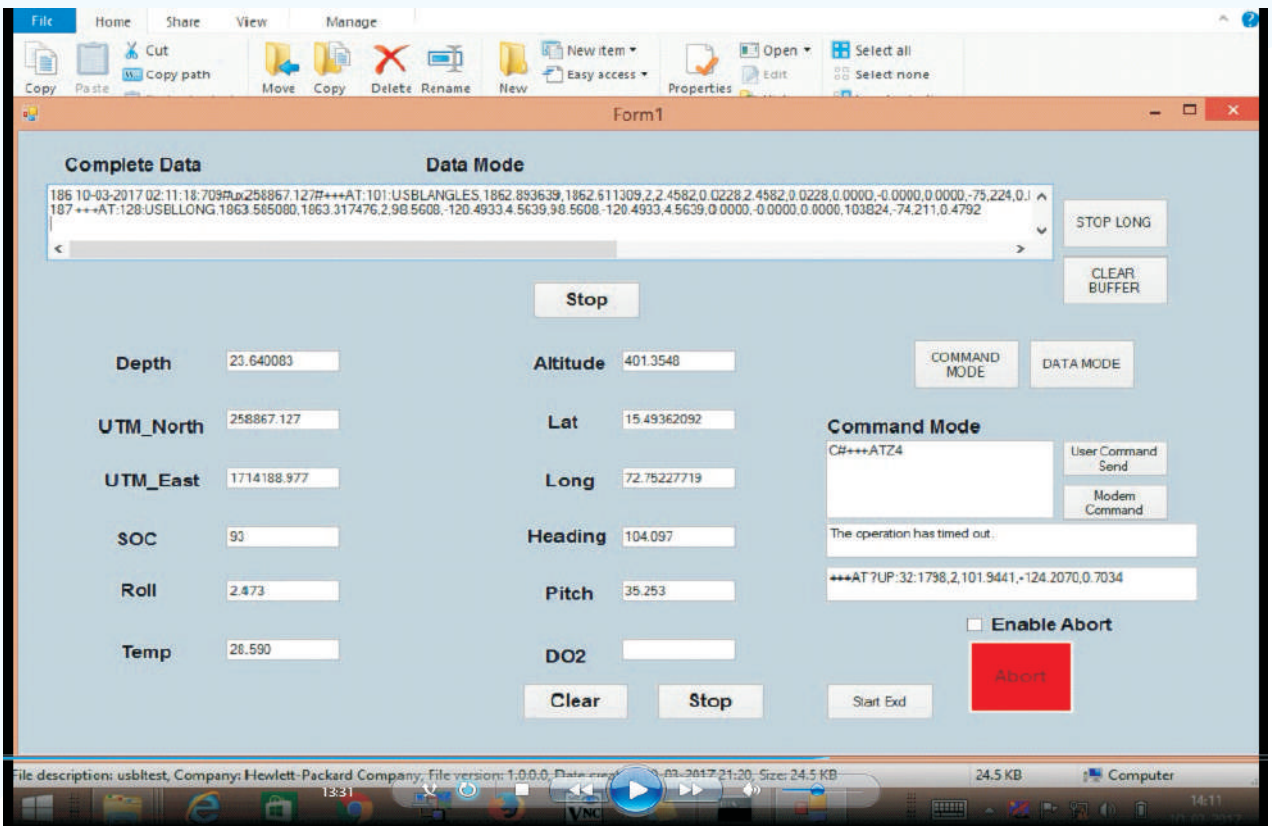
Glimpses of Results:

Information collected by AUV-500 during the mission



AUV 500 monitoring, tracking and communication





The project is sponsored by Council of Scientific and Industrial Research (CSIR). The team gratefully acknowledges the contribution of all the members who were directly and indirectly involved in ESC-0113 project.

Design, Development, Integration and Implementation of High Power Wireless Control Interface and Camera for Mobile Robotic System

This project deals with the design and development of a high power robust wireless communication system for interfacing a mobile robotic system with the surface control station. The mobile robotic system is primarily deployed for the visual inspection of tanks in an enclosed radioactive environment, more precisely in an underground Vault. Figure1 depicts an artist's view of the tanks filled with radioactive material and preserved in an underground chamber. The size of the underground chamber is 60m x 9m x 6m. Also, the site is inaccessible to human operators and since environment is radioactive, permanent installation of any equipment, which needs maintenance, is not advisable. Besides, there is no arrangement of power supply, no scope to lighten the chamber or camera placement on the working site, as permanent installations are not allowed in a radioactive environment. It is to be noted that earlier CSIR-CMERI has developed a mobile robotic vehicle which carries a camera and necessary light for inspection of the radioactive tanks inside the chamber. The mobile robot would be periodically deployed and the inspection would be on an ad hoc basis.

The main objective of this project work is to design and develop a wireless communication system to interface the mobile robot and the surface control station. One primary goal is operate the mobile robot via tele-command and receive video from the on-board camera at the surface control station. In general development of a wireless communication system requires rigorous experimentation with the setup. However, a major challenge of the project is the fact that it is not feasible to replicate the chamber environment at a remote place and hence all the experimentation was to carried inside the vault. The other challenge was to minimize the number of antennas inside the vault, while ensuring the coverage of the entire vault for reliable communication or data transmission. Keeping in mind the various hurdles / complexities of RF communication through existing non-structured environment at the vault, solution of the proposed wireless communication system evolved through number of stages which include - feasibility study through preliminary tests, development of preliminary design (based on preliminary tests), identification of antenna material to withstand radioactive environment, ad hoc onsite installation and rigorous experimentation, minimization of the number antennas and finally validation after permanent installation and testing inside the vault.

To realize the project, first a preliminary design was formulated based on the indoor wireless communication principles which were later validated by experimental observations.

Based on the proposed observations, a preliminary design was envisaged as shown in Figure 2; necessary components and devices are identified and installed. Next, laptop based testing was carried out. It was observed that the video transmission was seamless during the entire experimentation period. Finally, for

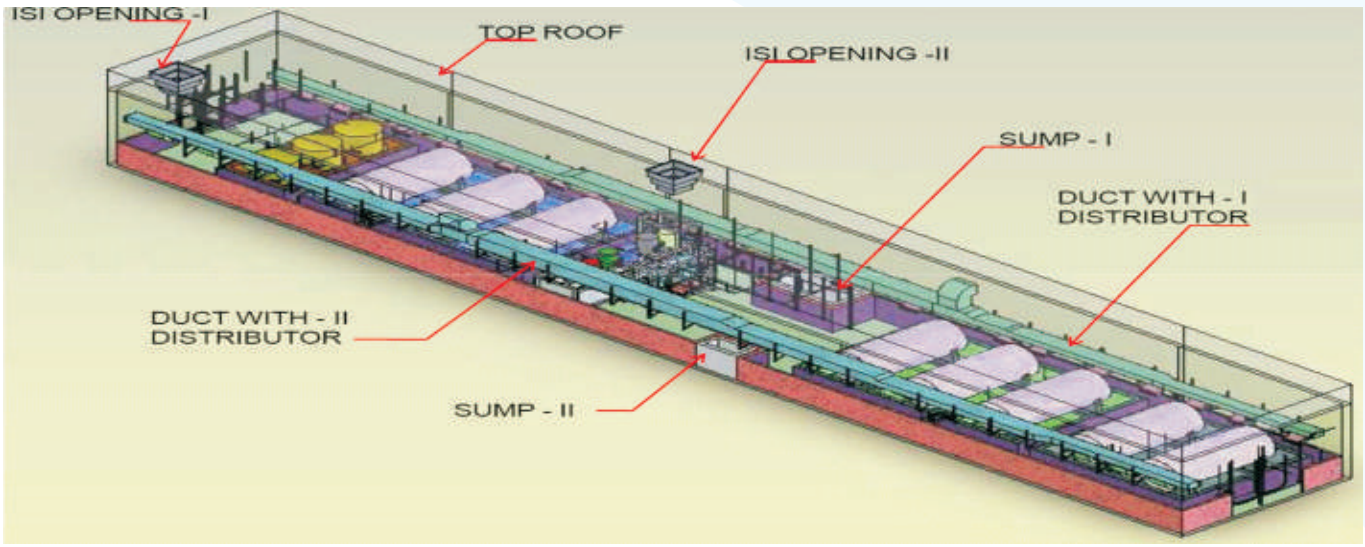


Figure 1. Mapped Model of underground vault

analyzing the performance of the system, repeated experimentation was carried out with a mobile robotic vehicle with an onboard wireless client adapter and a manipulator with a camera mounted at the end-effector. Tests were also carried out with multiple antennae ON / OFF configurations. Based on the the analysis of the results from experimentation, it was concluded that the installed communication system was robust to manoeuvre mobile robot inside the vault with three on-board cameras. The final design was validated with rigorous experimentation and the project was delivered to IGCAR, Kalpakkam.

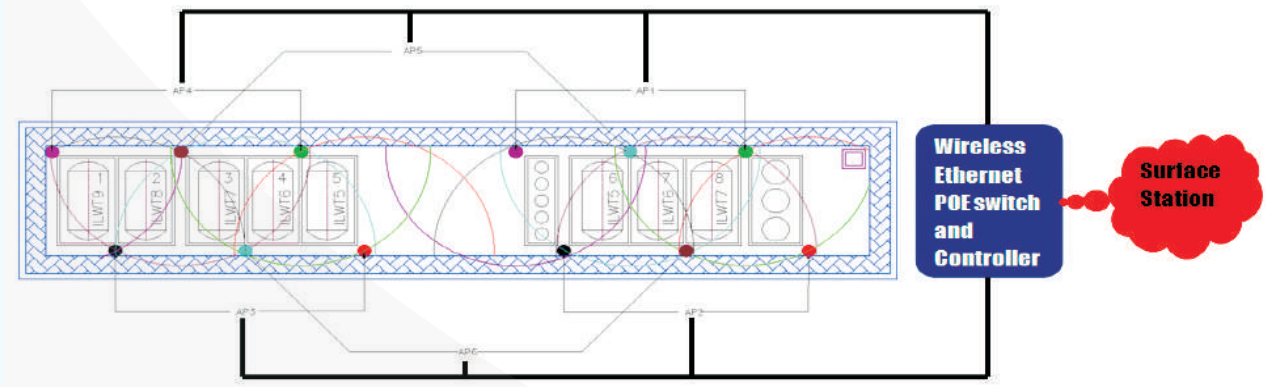


Figure 2: Proposed Design Layout: Antennal Positions in the Underground Vault

SURFACE ENGINEERING & TRIBOLOGY GROUP

Superior products in modern technology of micro and nano systems can be realized by better understanding of friction, wear and lubrication. Research on frictional interactions at miniature scale is becoming increasingly important in several areas like mechanics, electronics, sensors, chemistry and life sciences. The research focus remains on product and technology development that would improve the quality of life of Indian population along with understanding of a range of phenomena associated with Tribology and Surface Engineering. The research projects in this group are led by eight scientists and assisted by a technical officer and a few technical assistants.

Surface engineering is an interdisciplinary subject in materials science that deals with the surface of solid matter. It is being used in the automotive, aerospace, missile, electronic, biomedical, textile, petrochemical, chemical, moulds and dies, machine tools, and construction industries. Engineered surfaces can be used to develop a wide range of functional properties, including physical, chemical, electrical, electronic, magnetic, mechanical, wear, and corrosion properties at the required substrate surfaces. Almost all types of materials, including metals, polymers, ceramics, composites, biomaterials and nanomaterials can be coated on similar or dissimilar materials.

Thrust research areas of the group include ***"magnetic, foil and pneumatic bearings; thrust pad bearings; micro / nano scale manufacturing systems; theoretical analysis; nano-lubricants & composite coatings; large scale graphene oxide production; graphene based lubricants; graphene based energy storage devices; synthesis of new molecules for materialistic applications"***. These research activities are augmented by the state of art and well equipped experimental facilities, mostly designed and developed by CSIR-CMERI.

Bearings (Foil & Magnetic):

One of the thrust research areas of SE&T is to develop bearings which reduce friction in machine elements; particularly macro/micro machine components where the ratio of area to volume is high. These are non contact type of bearings which form the focus area of research. In this category of bearings, magnetic and foil bearings are the more important ones. With the support of XII five year plan, extensive research was carried out towards the development of magnetic and foil bearings. Comprehensive knowledge on such bearings was obtained with theoretical and experimental studies.

In magnetic bearings, one new type of passive magnetic bearing, called electro-dynamic bearing has been introduced. In this kind of bearing, once the electrically conducting rotor rotates in a magnetic field created by the stator passive magnets, eddy current is induced in the rotating conductor. This induced current produces a magnetic field opposite to the existing magnetic field and generates a repulsive force among these existing and generated magnetic fields as shown in Figure 1. One of the main advantages of this bearing is frictionless operation without using complex control algorithms used in active magnetic bearings.

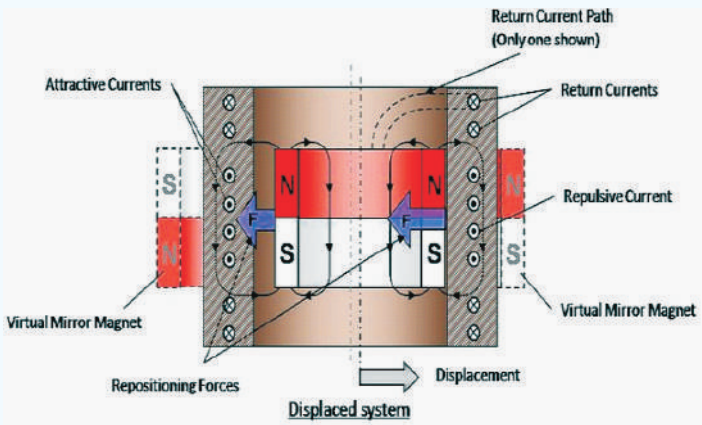


Figure 1: Electro-dynamic Bearing (Source:Wikipedia)

Foil bearing for high speed applications is another area where this group has carried out successful development work. A Foil bearing designed and developed at CSIR-CMERI is depicted in Figure 2 where solid inner face of the air bearing is embedded with metal foils which provides a cushioning effect to the rotor and increases its stability by allowing the bearing to operate at higher eccentricity ratio. A set up has been made to test the foil bearing and it was noticed that the bearing could run at a speed of 30,000 rpm. The potential utility of this bearing is in the turbomachinery area like air cycle machine used in environmental control system in aircraft, cryogenic turbo compressor, gas turbine engines etc. With the gained expertise on foil journal bearings, steps are being made to design and develop a thrust bearing of such kind.

Micro / Nano scale manufacturing systems:

The ability to fabricate patterns or structures at micro/nano scale has the potential to enable new class of electronics, diagnostic devices and bio-sensors. A variety of devices can be realized if the system is capable of using polymers, non-polymers, DNA, proteins and other functional materials to fabricate the features at miniature scale. Electrohydrodynamic (EHD) ink jet printing system, which possesses this ability, was developed at SE&T lab and is shown in Figure 3.

Major components of an EHD-inkjet printing system consist of a liquid supply system capable of discharging inks at desired flow rates to the tip of a conducting nozzle. A high voltage amplifier is used to apply voltages across the conducting nozzle and the substrate. A positioning system accurately positions the substrate relative to the needle for controlled droplet deposition. The liquid jets are drawn and the droplets are formed under the influence of the external applied electric field between the nozzle and substrate. A notable advantage is the ability to fabricate features at nanometre range using needles of relatively higher diameters. Extensive experiments were performed under several operating conditions to fabricate the droplets at nanometer scale. Features (droplets) with an average diameter of <100 µm can be fabricated using a needle diameter of 0.8 mm. One such kind of printed patterns of PDOTSS ink on a Polyethylene terephthalate (PET) substrate is presented in Figure 4.

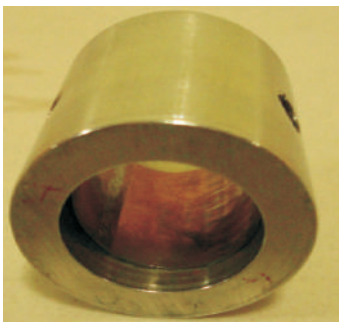


Figure 2: Foil Bearing

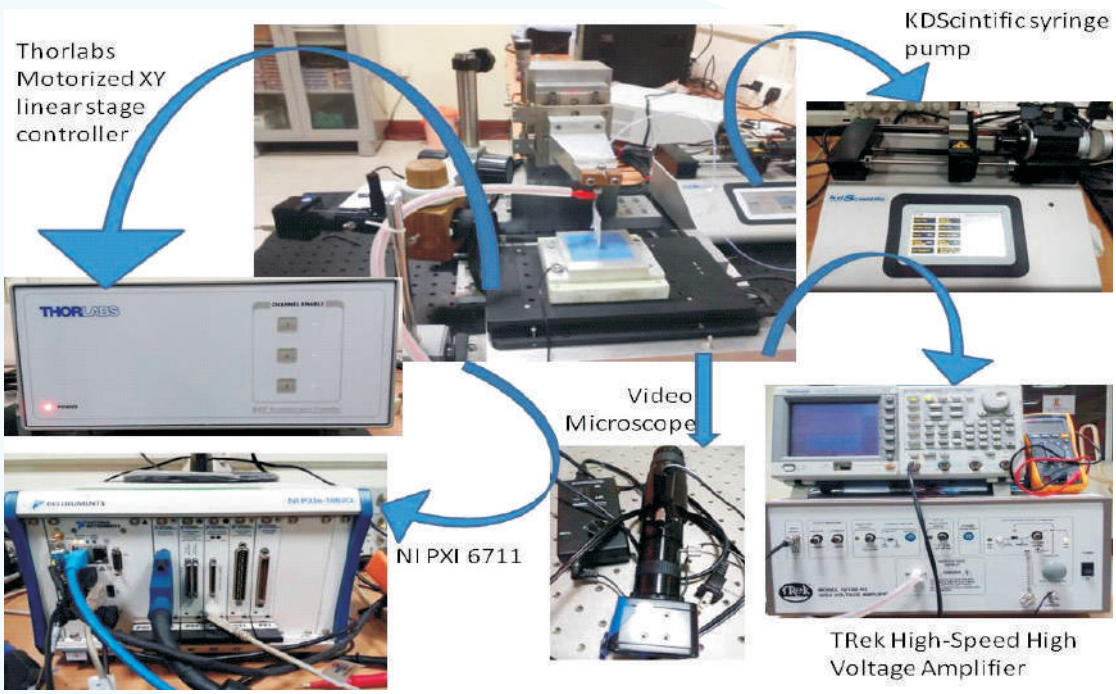
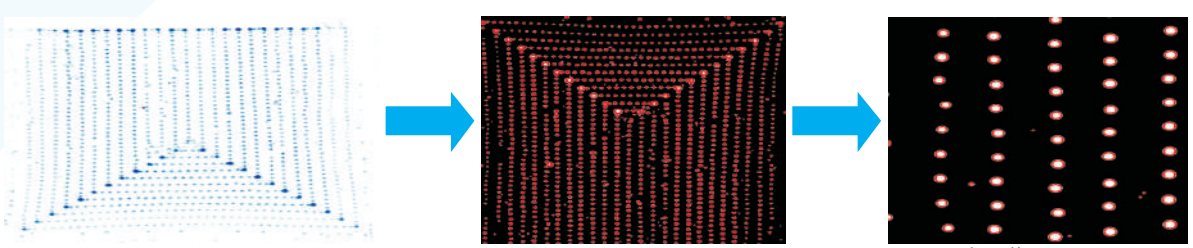


Figure 3: EHD Inkjet Printing system



Average dot diameter < 100 µm

Figure 4: Printed droplets on PET substrate

Multi-Material Deposition (MMD) System:

The Multi-Material Deposition System is a novel manufacturing technology aimed for fabrication of near-net-shape functional metal parts directly from CAD model by laser cladding layer by layer as well as repairment of damaged parts. The importance of the project lies in Rapid Prototyping and Metal Additive Manufacturing (AM) industry. Figure 5 shows the developed system.

Figure 5: MMD system developed at CSIR-CMERI

There are several challenging areas in this project. Five major sub-systems - five axis motion system, powder feeder system, laser system, feedback sensor and master control - are to be integrated for satisfactory operation of the MMD system. The challenging area in the control of the MMD system lies in the closed loop control for the melt pool temperature, powder flow rate and layer deposition height. Adaptive process control system is required for the maintenance of surface finish, product quality etc. of the deposited contour. A summary of the key achievements is as follows. The conversion of CAD sliced CNC program to the macro program of the PLC for direct motion planning of CAD profile to be deposited is completed. The offline as well as online motion trajectory for the deposition of part was viewed in the 3D graphs in LABVIEW. Dynamic modeling and study of the complete MMD system as a single plant (or lumped process) was carried out. The Laser based height sensor was used in a standalone mode to measure the height of deposited clad. Some part fabrications were done completely based on standard parameter selection.

Graphene-Based Rechargeable Energy Storage Micro Device:

Ongoing research on energy storage materials has shown that graphene based energy storage devices can provide portable energy sources and advanced energy storage solutions for application in renewable energy, electric vehicles, smart grids, biomass, urban lifestyle devices and consumer care industries. These are unique for their ability to combine the energy storage properties of batteries with the power discharge characteristics of capacitors. One such energy storage device is depicted in Figure 6.

The advantages of graphene-based power electronics systems as compared with the battery-based devices are light weight, flexible mechanical structure, reduced size, high cycle life and low cost. In this project a power electronics charger-cum-inverter unit is developed to demonstrate the charging/discharging characteristics of the developed coin cell graphene supercapacitor. A microcontroller (Microchip's dsPIC) based embedded control platform (control card) along with optocoupler based gate driver board and signal conditioning circuitry have been developed.

Theoretical Analysis:

Several theoretical analyses are being carried out in this research laboratory using commercial software like ANSYS-FLUENT, ABAQUS etc. These analyses are used to validate the experimental findings. A few among them are:

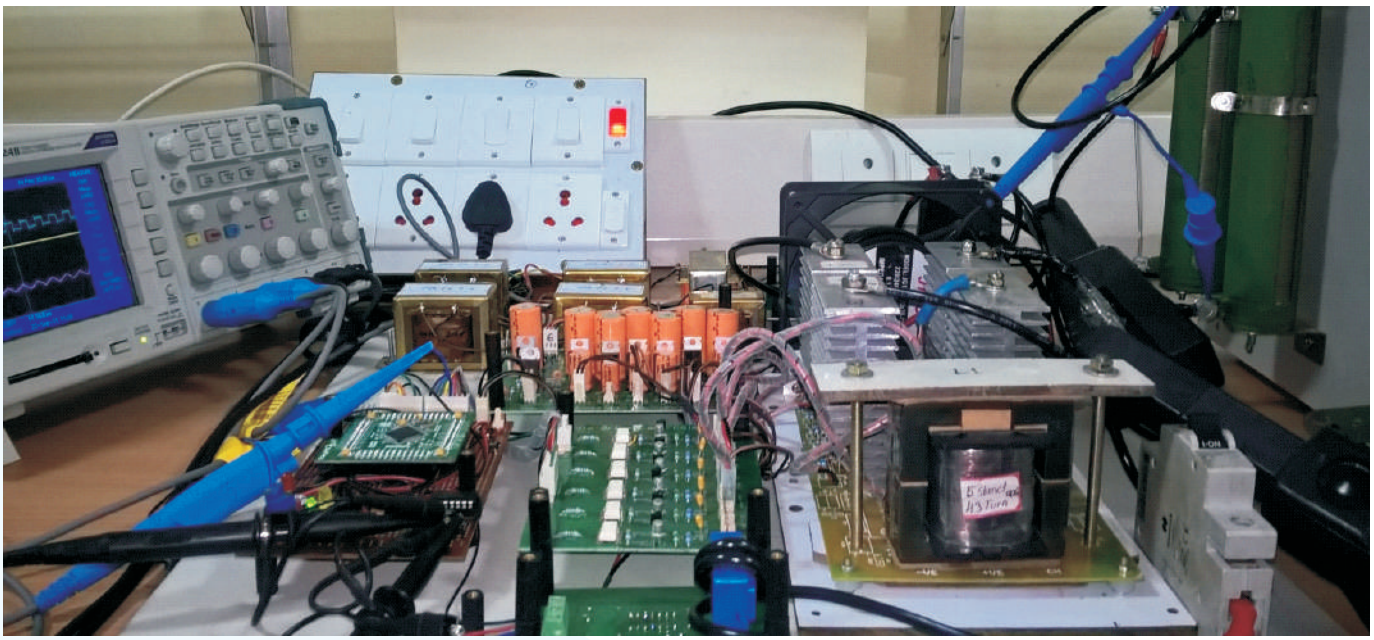


Figure 6: Graphene based energy storage device

Simulation of two-phase flow (for ink-jet printing):

A CFD (Computational Fluid Dynamics) simulation has been carried out to study the behaviour of droplets under various operating conditions. From CFD simulation of two phase flow, one can investigate motion of the interface between the liquid phase and gas phase, pinch-off of a droplet, formation of satellites, the effect of nozzle geometry on ink ejection size and motion etc. One such simulation carried in FLUENT is depicted in Figure 7.

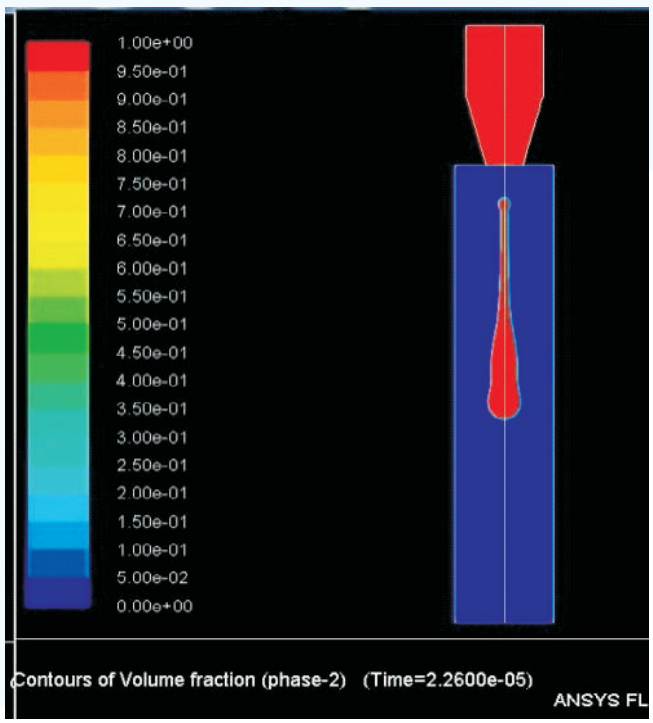


Figure 7: Simulation of bubble/droplet through jet

Further detailed study from the simulation can discover/verify different regimes of bubble formation depending upon the size and charge and time evolution of a droplet under moderate and strong electric fields. Such studies can investigate those features which experiments can not reveal. Researchers have determined the distribution of the electric field on the meniscus that forms at the tip of the nozzle and different modes of pulsation as a function of time.

Welding Simulation:

Welding is one of the major manufacturing operations carried out to join materials of either similar or dissimilar type. A side effect accompanying the welding operation is the generation of residual stresses, which are in general known to affect the fatigue life of the components. An attempt has been made to simulate the welding process using double ellipsoidal heat source (DEHS) model in the ANSYS environment. Since the heat generated by material plastic deformation is orders of magnitude less than the heat generated by moving heat source, sequential thermal and mechanical analyses have been carried out to realize the residual stresseses. The temperature profile and corresponding residual stress profile are presented below.

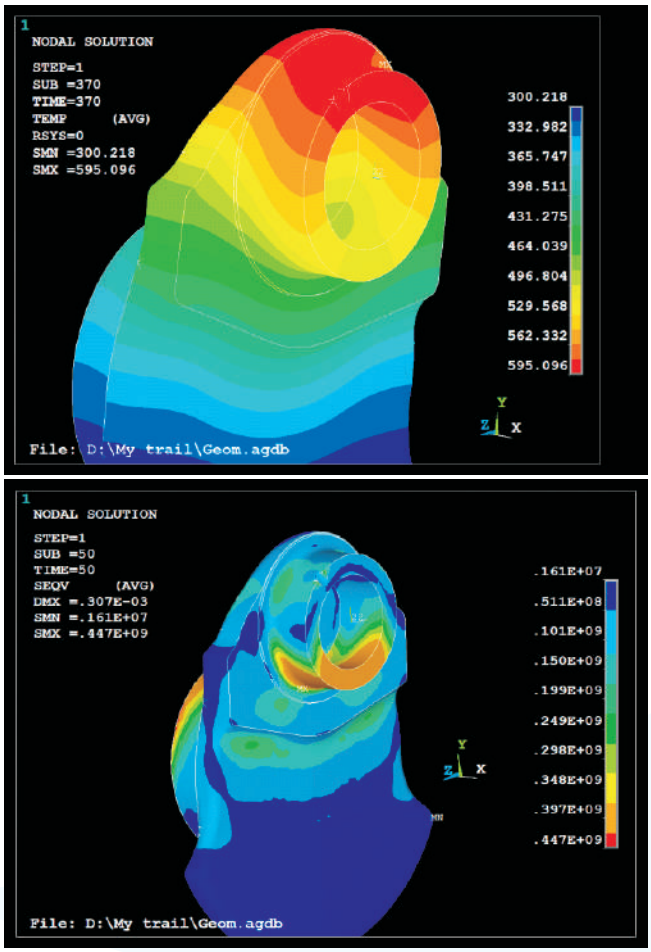


Figure 8: Thermo - Mechanical Simulation; Temperature profile left and stresses right

Nano-lubricant:

Over the last year, the main research focus was to develop functionalized particle lubricants for dry and lubricated contacts and friction and wear resistant Ni composite coatings. In the field of applied tribology, the necessity of reducing friction and wear and lubrication of any mechanical system is for efficient energy conservation. A strong attempt has been made over the years to provide enough lubrication to keep the contacting surfaces well separated from each other. The most effective way to reduce friction and wear is to separate the two sliding surfaces by means of a lubricating film (third body), such as a film of solid lubricant, oil, grease, or a coating. The use of traditional chemical additives for lubrication in the mechanical systems creates many problems of toxicity and pollution. Moreover, the slow degradation of the additives hinder the tribological properties. Solid lubricants are used when liquid lubricants do not meet the advanced requirements of modern technology mostly in the boundary lubrication regime. These are very useful for the applications needed to meet critical operating conditions such as pressure and temperature, for which fluid lubricants are ineffective or undesirable.

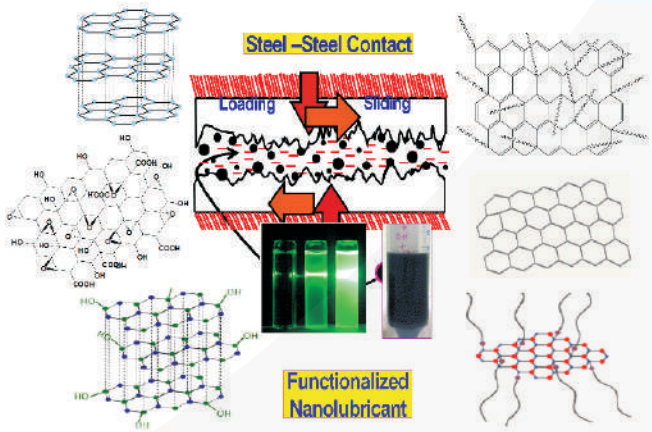


Figure 9: Functionalized Nanolubricant

Functionalized graphitic nanoparticles were prepared as the load bearing candidates for efficient lubrication of dry and oil/water lubricated mechanical contact. The functionalized graphitic particles were analyzed by UV-Vis, FTIR, Raman spectroscopy, XRD, DSC, SEM and TEM for their structural and physico-chemical evaluation and successful functionalization of graphite particles was confirmed. The frictional characteristics of the particle suspensions in oil/water medium were investigated and compared with the frictional behaviour of the particles in dry condition. The experimental data indicate that functionalized nanoparticles may be made useful by suitable functionalization as per the tribological demands.

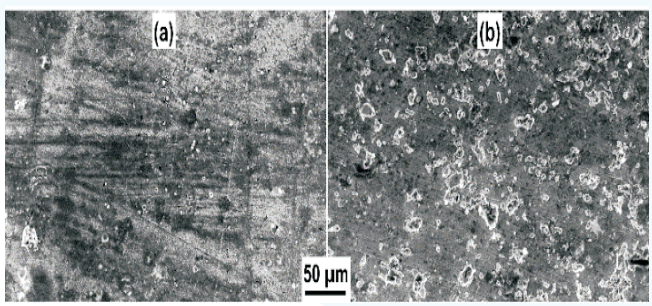


Figure10: FE-SEM images of [a] Ni & [b] Ni-GO composite coating

Composite Coatings:

Coatings and thin films are applied to structural bulk materials in order to improve the desired properties of the surface, such as wear resistance, friction, corrosion resistance and others, yet keeping the bulk properties of the material unchanged. Pulsed electrodeposition (PED) is a reliable concept for

deposition of cost-efficient, versatile, and reliable large-scale industrial production of high aspect materials. Electroless Ni coatings have also been extensively applied in numerous fields because of their excellent quality, uniform deposition, excellent wear and corrosion resistance, good weldability, and electrical conductivity. Electroless nickel plating improves corrosion resistance, increases the surface hardness of the material, provides a uniform and dense coating, and, in many cases, maintains the same surface finish the material had before plating. Low friction nanostructured coatings consisting of a hard transition metal carbide or nitride in combination with a solid lubricant, such as diamond-like carbon (DLC), MoS_2, WS_2 and others combine high hardness with low friction. They are applied in a variety of bearings and sliding parts operating without liquid lubricants, which is an important advantage particularly in a hostile environment, and when the movable parts have to stop and go very frequently.

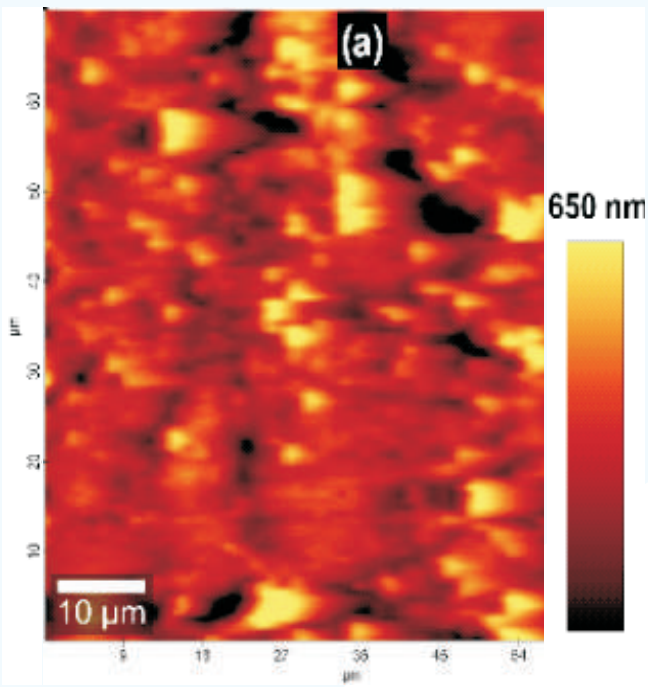


Figure 11: AFM topography image of Ni-GO composite coating

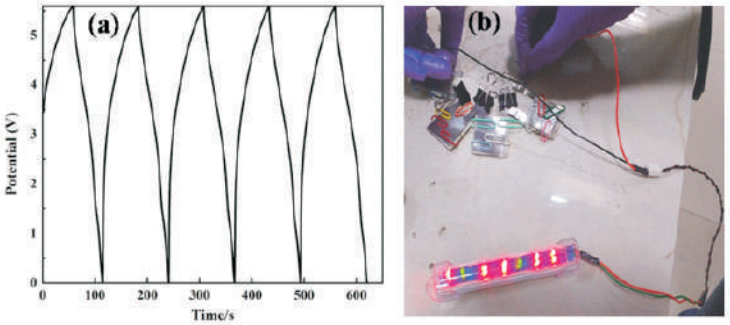
Nickel-Graphene oxide (GO) composite coatings were successfully prepared on the steel substrate by the PED method. The morphology, compositional, and tribological properties were investigated. FE-SEM and AFM microscopic studies show the presence of GO particles intercalated in the Ni matrix in the composite coating. XRD, EDS, water contact angle and Raman spectra also corroborated the above finding. The tribological studies show that the trapped GO positively affected the friction and wear properties of the coating. Compared to the pristine Ni coating, the insertion of GO into Ni matrix reduced the coefficient of friction and wear depth of the coating substantially.

Graphene oxide:

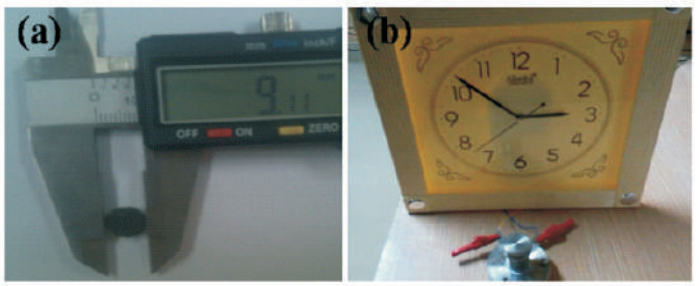
Since the discovery of Graphene, most research is being conducted on its production. Researchers are exploring various ways for its production in a large scale to make it suitable for the industrial usage and energy storage applications. It has gained considerable attention in the scientific community because of its unique properties like high strength, high thermal conductivity and many desirable properties. Extensive work is being carried out at CSIR-CMERI to produce the graphene oxide on large scale basis. This opens a window for using graphene oxide in several applications like high energy density supercapacitor for energy storage applications, graphene lubricants, sensors, graphene/polymer composites and surface coating of steel using graphene. One of the notable achievements is the development of rechargeable super capacitor prototype using graphene. The prototype developed is depicted in Figure 12 and the same was demonstrated at IISF, New Delhi. This graphene based supercapacitor has energy density of 113 Wh kg-1 and retention in specific capacitance is >80% after 10,000 charge-discharge cycles.

Figure 13 presents another notable achievement which is the development of flexible graphene electrode. Capacitive performance such as specific capacitance and charging-discharging efficiency remain unchanged even after 100 times of bending the electrode.

Apart from this, the group is exploring extensively several other possible applications where the use of graphene oxide can significantly enhance the performance of systems. Two such application areas are the use of graphene based aqueous lubricants in manufacturing industries and use of surface modified graphene for coating applications. The group also focuses on the areas of surface modification of reduced graphene oxide, bio-reduction of graphene oxide, one-step electrochemical exfoliation of graphite to functionalized graphene sheets and graphene/metal oxide composite supercapacitor.



(a) Galvanostatic charge-discharge curves of four Ni-Co-BH-G2//CCN asymmetric devices connected in a series (b) An LED indicator powered by the four assembled devices.



(a) Photograph of a coin electrode (b) Wall clock operated with 1.5 V graphene supercapacitor for ~14 min

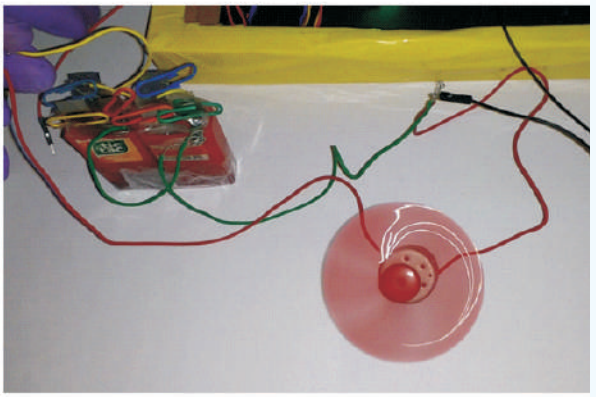


Figure 12: Supercapacitor Prototype developed at CSIR-CMERI

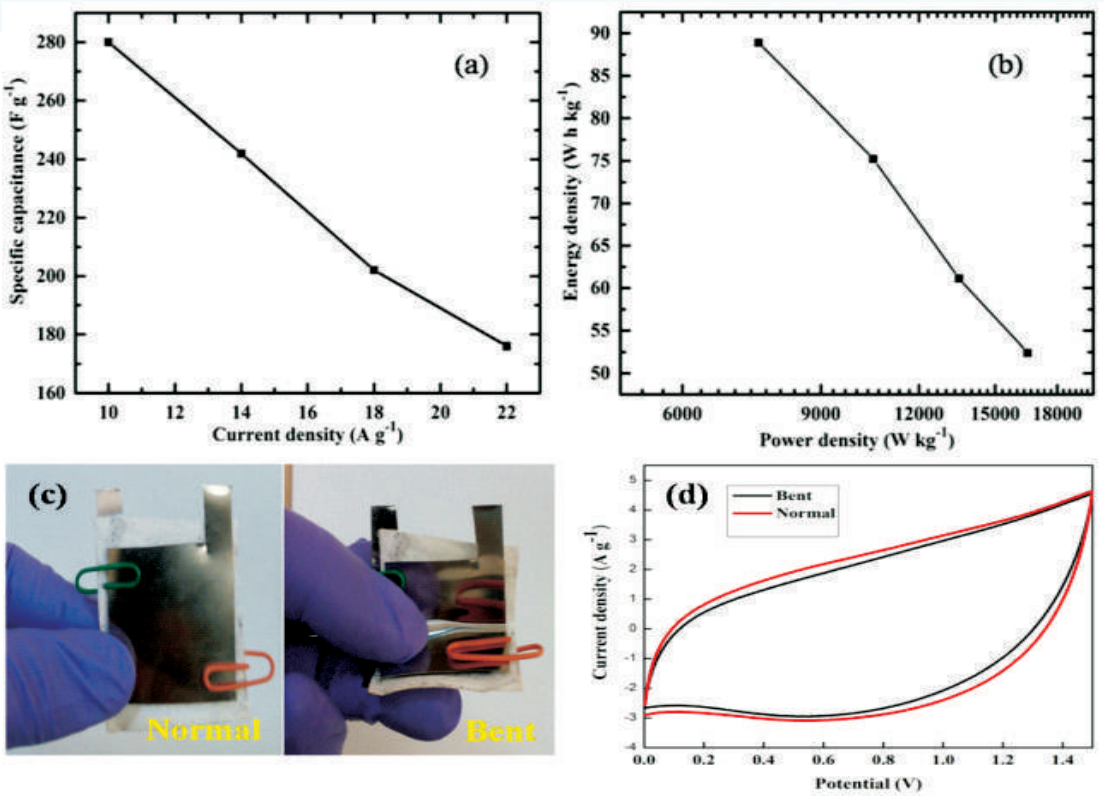


Figure 13: (a) Variation of specific capacitance with current density and (b) Ragone plot for SAC-RGO@Ni// TRGO, (c) digital photograph, and (d) CV curves of RGO/MnO_2//TRGO at normal and bending conditions.

Synthesizing new molecules - materialistic applications:

This group is also actively engaged in the field of chemistry for mankind. Several small and polymeric molecules have been synthesized for multiple applications. A few among them are mentioned below.

Sensor Based application:

To fight against the dental fluorosis, emphasis has been given towards detection of fluoride like biologically relevant anion from human body fluid. In this regard, a series of molecule has been prepared with precise tuning in side arm of the organic chemosensor. The newly developed sensor molecule could detect salivary fluoride level with distinct colorimetric changes, i.e. the diagnosis of dental fluorosis could be performed. In addition the sensor could detect intracellular fluoride level from human HeLa cell by fluorescence turn on phenomena, i.e.; the diagnosis of non skeletal fluorosis could be executed by this technique. This patented technology was transferred to a small scale industry unit in presence of Dr. Harsh Vardhan, Honourable minister at Ministry of Science and Technology (India) and Ministry of Earth Sciences and Vice President, CSIR in November, 2016 during CSIR Platinum Jubilee techno fest.

The developed sensor kit shown in Figure 14 has already been deployed for common people in several fluorosis affected areas. Several NGOs from northern and southern India (Naandiwater, Hyderabad) have shown their interest to deploy the kit in their working area for quick prediction of dental fluorosis.

Corrosion Engineering:

Corrosion of metallic surfaces is a global issue concerning its adverse affect on major industrial plants, infrastructure, automobile body panels and so on. Worldwide, all industries are facing problems related to corrosion. One of the largest expenditures concerned industries have to bear is the maintenance of the metallic materials from adverse corrosive attack. Along with the detrimental effect of atmospheric corrosion, in several industries, acid solutions are widely used for de-scaling, acid pickling, cleaning of boilers, ore processing, oil well acidizing, removing mills and rusts from steel surfaces. During these processes acid solutions cleanse the metallic surfaces, but unexpectedly corrode the exposed surfaces of metal. The aim of our research is to develop environmental-friendly, easy to synthesize, reliable and cost-effective functional organic molecules having significant corrosion inhibition properties.

In order to protect the metallic surfaces from the

Figure 14: Fluoride detection kit

adverse environmental effects, various types of chromates and bisphenol based coating materials are widely used. Nevertheless, these coating materials leach out to environment and adversely affect the living beings. In this perspective, environmental friendly coating material development is an active area of research. In order to develop environment friendly surface coating materials we have focused our attention towards the azomethine based epoxy resin, isocynate free polyurethane coating and most importantly naturally abundant vegetable oils as coating materials.

Waste Management:

From the last decade, amount of generated waste is increasing very significantly and spreading its adverse effect on environment and human health. Improper waste management makes the situation more critical. In this respect, an eco-friendly and efficient technology is a bare minimum necessity. In this regard, utilization of plasma arc technology in safe waste disposal is a very efficient and environment friendly approach. This technology is capable of reducing the volume of waste around 99% and producing less toxic residues within the standard values of central pollution control boards. A mini plant with a capacity of 15kg/hr has been developed by CSIR-CMERI where three plasma torches are placed in a plasma reactor to crack the waste and convert it into gas which passes through a closed system containing a catalytic converter, redox reactor, scrubber and condenser to minimize the toxins present in the gas. Finally, the gas is burnt in a secondary incinerator and led out through a chimney which conforms to the standard mentioned in Bio-Medical Waste Management Rules, 2016.

SURFACE & FIELD ROBOTICS

Development of Terrain Adaptive Mobile Robot (TAMR) technology

Recently, two major tasks have been carried out leading to successful operation of this robotic system- (1) analysis of the system in ADAMS for climbing up an inclined plane and (2) development of an uninterrupted smart power scheme and its evaluation using a fuel based generator.

1. Analysis of the system

Analysis plays a major role towards successful development of any prototype. After the finalization of the concept model of the Terrain Adaptive Mobile Robot (TAMR), two different analyses have been carried out to evaluate the approximate performance of the system-(a) dynamics analysis (b) stability analysis based on the Centre of Gravity (CG) shifting while riding on an inclined plane. The dynamic analysis was carried out with a model of the TAMR created using the software Solidworks. After setting up the simulation environment, the system is made to traverse over a bump of height 60mm. As a result, the central marker experienced a deformation of a magnitude of 55mm. The stability analysis was performed based on the shifting of the CG of the complete system and the area of the footprints created by the tracks on the ground. For safe and efficient climbing the CG should be within the footprint area created by the tracks. The different views of the system (side and rear view) with the exact locations of different components of TAMR is shown in Figure 1.

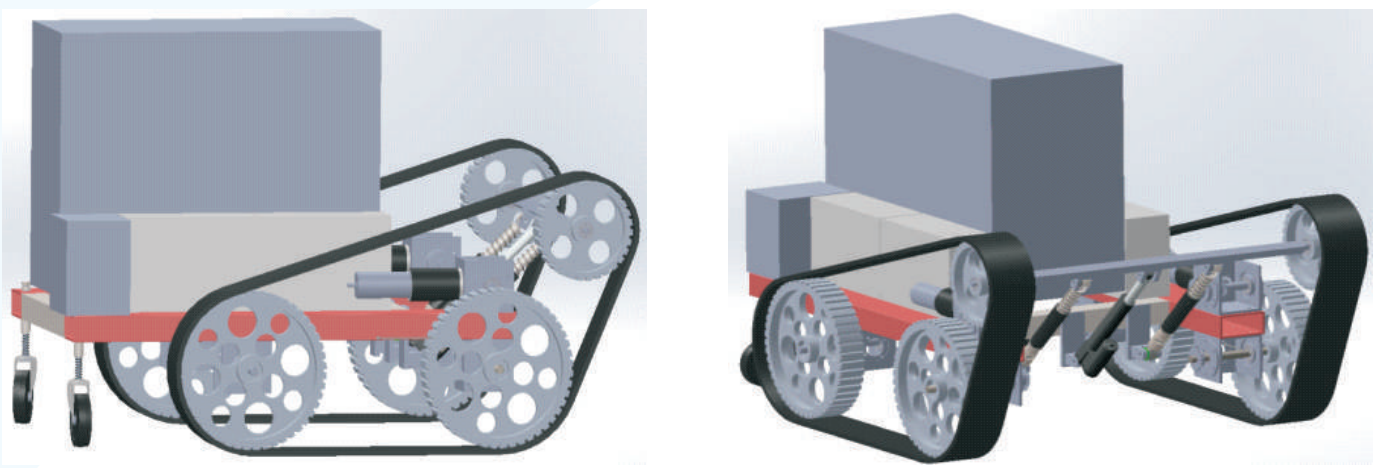
The major components of TAMR along with their dimensions and weights are presented below in the table. Other items are contributing less by weight with reference to the batteries, portable generator, motor-gearhead systems etc. and hence have been added up with the base frame for the analysis.

Table – I: Different components, their quantity, dimension and weight

Sl.	Item	Qty. (Nos.)	Dimension (mm)	Weight (Kg)
1.	Li-Ion battery	04	270×100×180 (H)	4
2.	Portable Generator	01	300×650×500 (H)	35
3.	Base Frame	01	640×650×500 (H)	21
4.	Driving motor with gearhead	02	210×50 (Dia.)	2.6

2. Uninterrupted smart power scheme

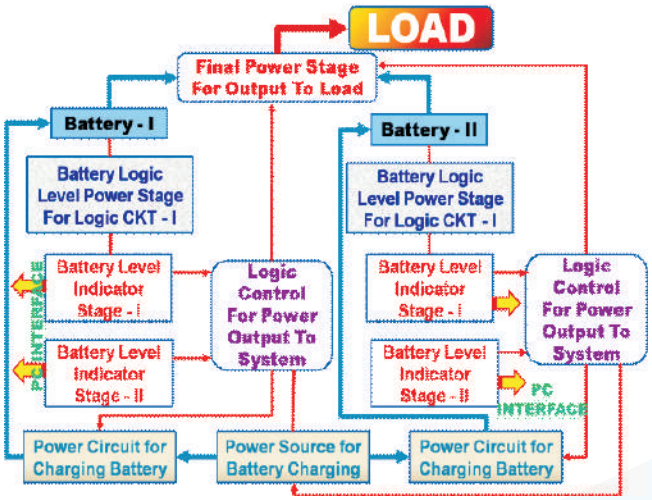
The uninterrupted smart power scheme/ module uses two Li-Ion batteries (24 VDC, 20 AH) and a 2 KW petrol driven generator for continuous operation as shown in Figure 2(a). Two identical battery banks of 24V (22-29V) capacity are connected to the system through individual connection points for each bank. A 220v AC alternator driven by a gasoline IC Engine is connected to the system with automatic interface card for self-start of the engine for charging the battery according to voltage level of each battery bank. The lower cut off voltage to start the generator is 22V and



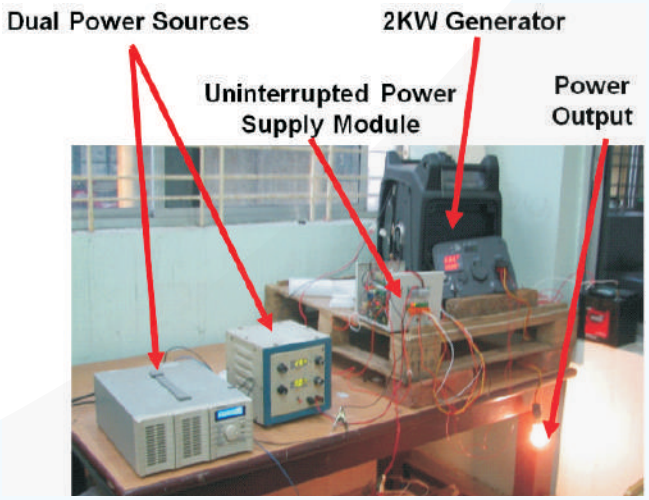
(a) (b)

Figure 1: Different views of TAMR (a) Side View (b) Rear View

the upper cut off voltage to stop the generator is 29V. A comparator and logic interface card is used to detect the voltage level of each battery and a switching circuit is connected to interchange the battery bank to provide uninterrupted power. The experimental set-up for the system has been shown in Figure 2(b) with all the components.



(a)



(b)

Figure 2: Uninterrupted smart power scheme for continuous power supply to a mobile robot using two Li-Ion batteries and a fuel driven generator- (a) block diagram of the scheme, (b) experimental set-up for the developed hardware

Development of Aerial Robot (AR) technology for high fidelity detection and target tracking

The team aims at developing outdoor mobile robots of long endurance and incorporate an aerial robot on the mobile robot vehicle to enhance mobile robot capability even for remote areas. Decentralized cooperation and coordination mechanism ensures efficient exploration and avoidance of spatial conflicts. The Rotary Wing Aerial Robot (RWAR) system operates on dual mode control. The manual control is achieved by using a 10 channel trans-receiver wireless radio operating at 72 MHz or 2.4 GHz. Four channels of this system are used for controlling aileron, elevator, rudder and throttle/pitch and three are used as aileron, elevator and rudder gyro sensitivity channels. Present work is focused on decentralized cooperation between a Terrain Aided Mobile Robot (TAMR) and a RWAR through information sharing under the same network to generate composite information to be used by the central command station. The area which cannot be covered by the TAMR (such as stiff slope, high rise building) on the ground, can be explored by RWAR.

Captured Image

Contrast Enhanced Image

Figure 3: Thermal video capturing with contrast enhancement for high fidelity detection: High resolution infrared images are captured using FLIR's Photon infrared imaging camera

Video transmission is an essential feature for cooperative navigation. RWAR is typically limited in its accuracy of localization of targets on the ground. On the other hand, TAMR can be deployed to accurately locate ground targets. Figure 3 shows captured image sent from RWAR to TAMR.

Development of all-terrain planetary rover technology for Omni directional exploration

Mobile robots have found wide applications mainly for surveillance, exploration and inspection. CMERI has developed a number of mobile robots for outdoor and all-terrain robots starting from ATR (All Terrain Robot), ATR2, SR (Subterranean Robot) to different versions of MR (Mobile Robot). The team aims at developing outdoor mobiles for longer endurance to enhance mobile robot capability even for remote areas. In respect of the Indian moon mission, it is necessary that India should possess the rover technology for planetary exploration. Currently this technology has to be imported and often obsolete/back dated technology is sold. CMERI, with its past knowledge and experience, has taken up the challenge to develop such rover technology for planetary explorations.

Figure 4: Rover prototype

A six wheeled prototype has been developed wherein each individual wheel is driven by a separate motor. It has the ability to override obstacles. All the wheels are fixed to the MS frame through a shock absorbing component. A top plate is mounted on the frame so that all the payload including electronic and electrical components can be mounted. Figure 4 shows the rover prototype. Each wheel has the ability to collapse and the system becomes more compact while deployment. The mechanism is equipped with sensors, batteries, motor controllers etc. to keep the system operational for long endurance.

Development of service robot technology for building and other structures

Over the years CMERI has built up an expertise in mobile robotics. It has developed various types of robots such as ATR (Tracked Wheel), SR-1 (Tracked Wheel), SR-2 (Wheel), ATR-2 (Tracked Wheel),

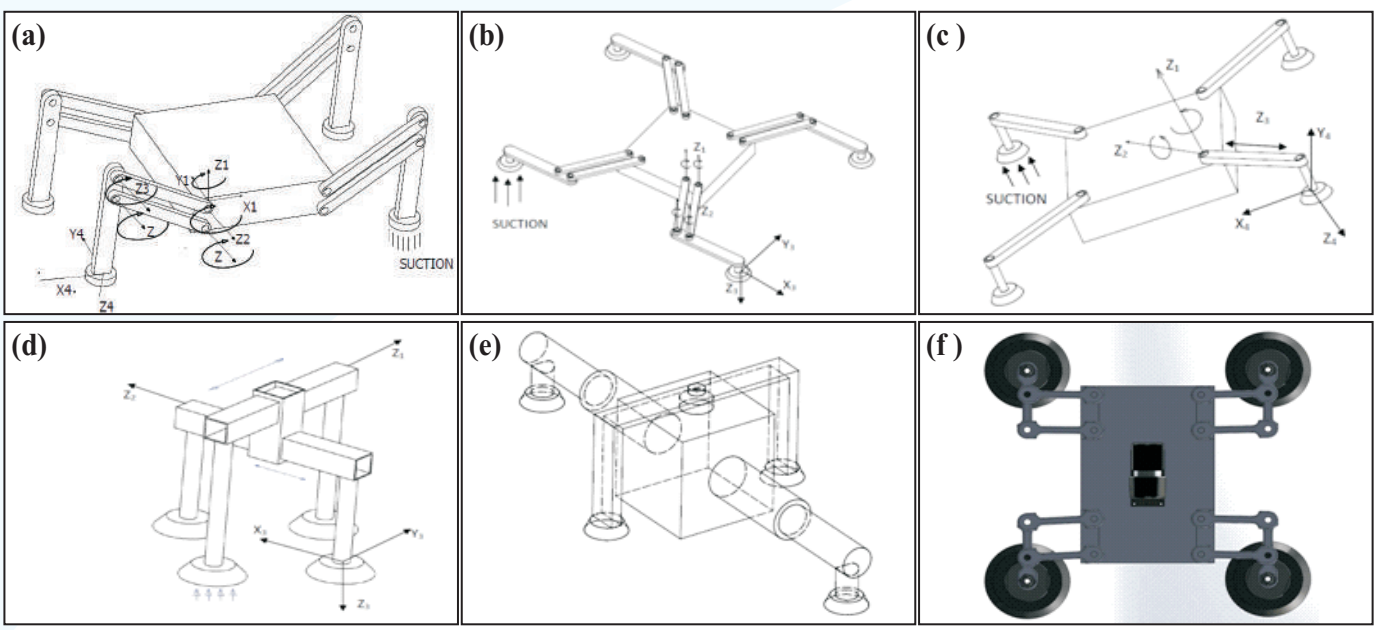


Figure 5: Schematic diagram of various wall climbing robots with different rotational and translational mechanisms considered for design and analysis

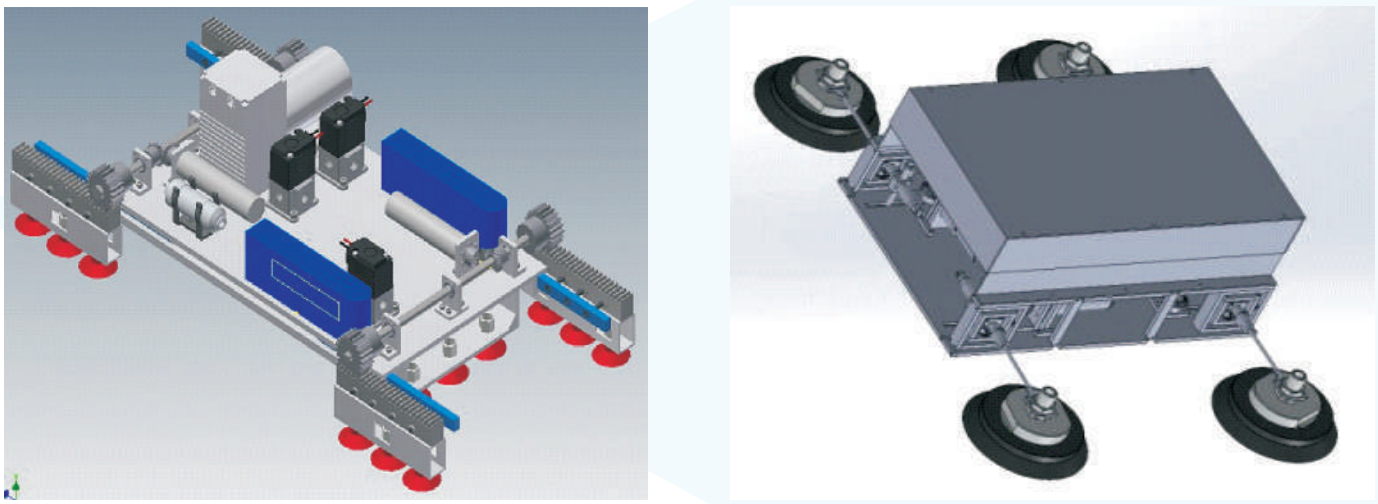
OMR 1.1 (Tracked Wheel), OMR-1.2 (Wheel), OMR-1.3 (Wheel), OMR-2 (Wheel). All the developed robots can negotiate rough horizontal terrains, but a wall climbing robot was never attempted before. Presently we are working on building a wall climbing robot for the inspection of faults in buildings and other structures. Different types of technologies have been used by researchers to adhere to a vertical wall. In the present project pneumatic suction have been considered for fixing the robot onto the vertical wall. Alternative concept models have been generated for the locomotion mechanism. Among them a mechanism has been chosen that is simple and suits the purpose of the project.

Some conceptual schematic diagrams are presented in Figure 5 to show the construction of the proposed vertical wall climber. The diagrams describe different types of locomotion techniques which can be used in the wall climbing robot. All are based on pneumatic suction for adhering to the wall.

(d) and (f) in figure 5 were the chosen concepts to be developed into prototypes. These concepts were further modified to suit the functionality and manufacturability. (d) offers straight line leg movement of the prototype whereas (f) offers circular leg movement of the prototype

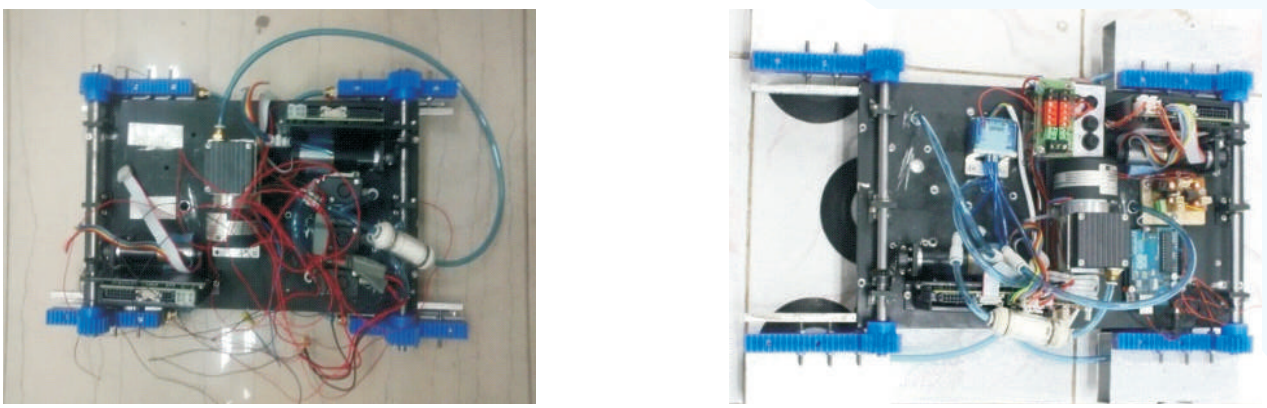
The concept (d) was developed into the 3D CAD model as shown in figure (6a). The other concept was developed into the 3D CAD model as shown in figure (6b). The first prototype is named as WCR-I and the second one is named as WCR-II.

Figure 7 (a) and (b) shows gradual development and integration of the various components into the WCR-I platform. The mechanical fabrication of WCR-I has been completed. Now various control components



(a) **(b)**

Figure 6: 3D CAD model of the prototypes based on concept (d) and (f)



(a) **(b)**

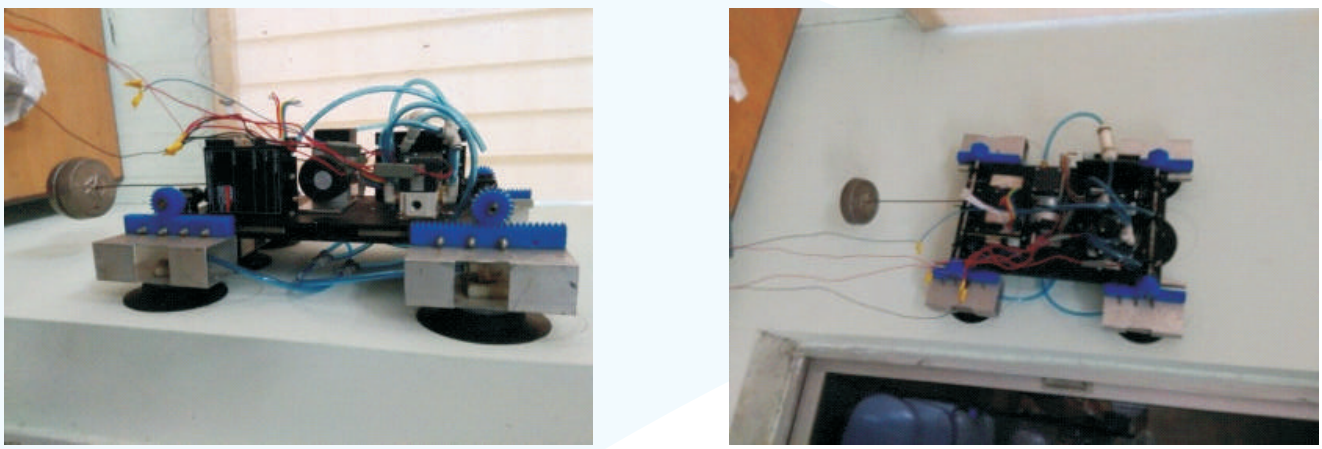
Figure 7: Prototype WCR-I

are being added up during testing. The final technical specification of the robot is as follows:

Technical Specification of WCR-I:	
Dimension	350 × 250 × 45 mm
Weight	4 Kg (approx.)
Power	24 VDC Li-Ion/Li Po battery
Drive	Electrical and Pneumatic
Processor	Microcontroller
Sensors	Inclinometer, tactile sensor, camera
Comm.	IEEE 802.11 a/b/c/g/n
Special Features	Straight line leg movement

Figure 8 demonstrates the testing phase of the WCR-I. The robot has been adhered to a plastered and painted brick wall with all the suction cups switched on. The robot, as shown in the photos, is given a static payload of 2 kg. The mechanical fabrication of WCR-II is also completed. Component level fabrication is over. The assembly of the components is almost complete. Till the recent assembly the robot weighed 4 Kg (approx). some of the components and partially assembled WCR-II is shown in figure 9.

Technical Specification of WCR-II:	
Dimension	350 X 250 X 150 mm
Weight	>15 Kg (approx.)
Power	24 VDC Li-Ion/Li Po battery
Drive	Electrical and Pneumatic
Processor	Microcontroller
Sensors	Inclinometer, tactile sensor, camera
Comm.	IEEE 802.11 a/b/c/g/n
Special Features	Circular leg movement



(a) (b)

Figure 8: Testing of the prototype WCR-I

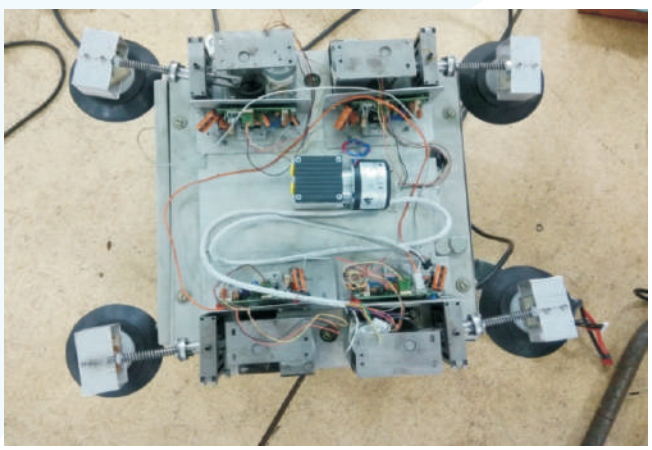


Figure 9: Prototype WCR-II

Intelligent and Powered Wheel Chair

It is a differentially driven model where two of the central wheels are used for power and rear wheels have active suspension mounted casters. The design has capability to turn full 360 degrees in any narrow corridor. It can also go up slant pavements, maintaining stability. It offers high degree of maneuverability to navigate smoothly on ups and downs. Its light weight components (main body and seating) decrease the overall weight without compromising on safety.

Figure 10: Low cost powered wheel chair

Socio-economic Impact: The market value of the Powered Wheel Chair is ranging between Rs. 90,000/- to Rs. 3,00,000/- as per the online brochures. The envisaged cost of the developed technology/product is approximately Rs 35,000/- to 40,000/-. Simultaneously the system has immense societal value for the physically challenged people, old age population for mobility and rehabilitation purpose.

Specifications:	
Weight capacity:	Up to 150 kg
Maximum Speed:	Up to 7 mph
Ground Clearance:	More than 3”
Turning Radius:	2 feet
Overall L X W:	42” x 26”
Drive train:	2-P.M.D.C. Hub Motor, Mid-wheel drive
Braking system:	Intelligent braking (electronic, regenerative disc brakes)
Battery:	12 volt * 2, Sealed lead acid
Mid Wheel:	300 mm (O.D.)
Caster Wheel:	150 mm x 25 mm
Battery Charger:	Inbuilt

- Differentially steered, six wheel configuration
- Fully electronic soft touch control
- Joystick based command
- Infrared based safety warning
- On board charging facility
- Modular construction
- Active suspension on rear wheels
- Collapsible and foldable foot rest
- Interchangeable seating
- Longer endurance (8-10 hrs for intermittent running)

Micro Robot Technology for Handling, Grasping, Manipulating the Miniature Objects

The micro robot technology has been realized through reliable, fast, accurate smart material based sensors and actuators. These kinds of sensors and actuators make the systems more versatile, flexible and robust towards small and medium sized batches for robotic micro assembly. These actuators are capable of performing the functional task in automation such as grasping, micro manipulation etc. For achieving these tasks, the micro manipulator is an essential tool in an industrial level for developing automation. The automation is to assist human operator in picking-up microscopically small components, holding them and placing them in the right position. Currently the research team is focusing towards new designs of micro gripping system with an integrated micro manipulator which offers flexibility in handling of light weight object and its manipulation in large work space.

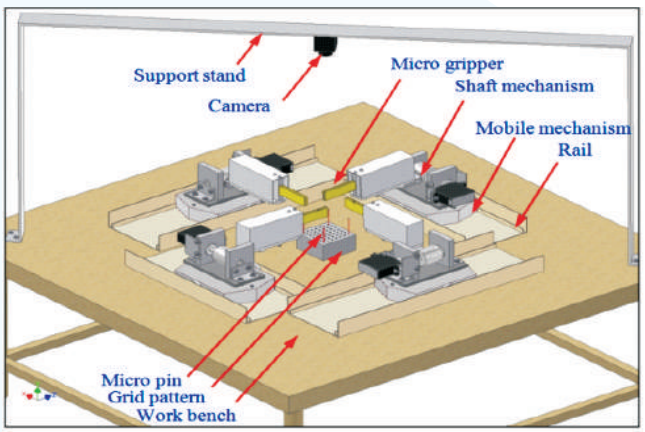
1. Development of Multi Micro Manipulation System (M^4S) for Handling Miniature Parts

The objective of this project is to design and develop a multi-mobile-micro-manipulation system (M^4S) for handling miniature parts. In order to design the M^4S

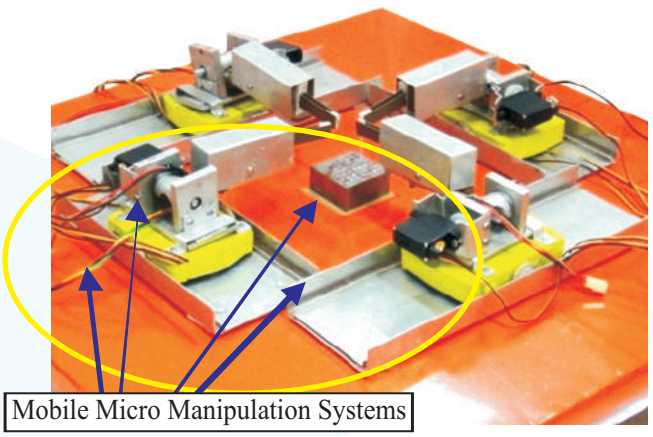
for robotic micro assembly, four mobile MMS are placed on a single work bench as shown in Figure 11. Each MMS are placed on specific rails which are positioned at an equal distance and perpendicular to each other. These rails are constructed for providing the lateral motion of the MMS towards picking and placing of the object from one hole position to another. Each MMS has 3 DOFs for attempting the pick and place and peg-in-hole assembly in 3-dimesional space. These MMS can perform the operations of robotic assembly in sequential or random manner through automatic or joystick controls. Each MMS consists of a mobile mechanism, shaft mechanism, lead screw mechanism and a micro gripper. A camera is mounted at the top of work bench through a support frame, which is used for visualizing the robotic assembly operations in the computer.

2. Development of Wireless Mobile Micro Manipulation System (WM^{3}S) for Robotic Assembly

The objective of this project is to design and develop wireless mobile micro manipulation system for handling of light object and performing robotic assembly. In order to execute the robotic micro assembly in a large workspace, a novel multi DOF based MMS along with piezoelectric actuator based micro gripper is designed as shown in Figure 12. This system consists of a mobile wheels based chassis, articulated robotic arm, link arm along with a wrist and three piezoelectric actuator fingers based micro gripper. This manipulation system can handle the different size and shape of the objects like circular, triangular etc. with size of diameter 20-22 mm in the weight range of 100-3250 mg.

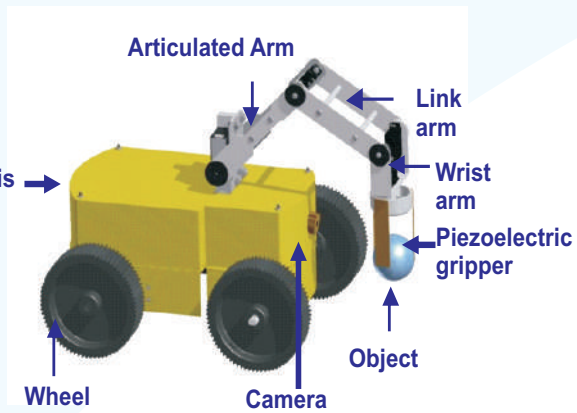


CAD model

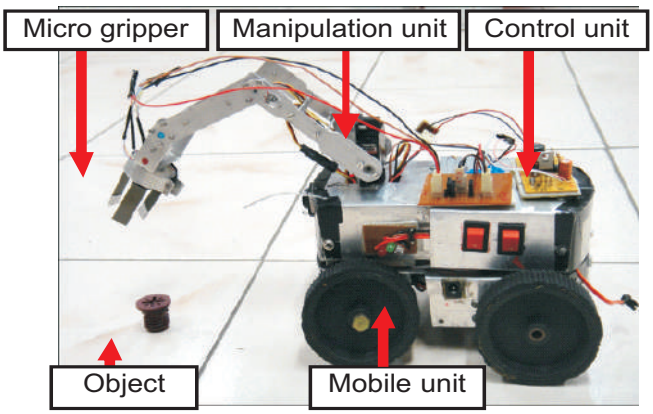


Prototype

Figure 11 : Multi Micro Manipulation System (M^{4}S)



CAD model



Prototype

Figure 12 : Wireless Mobile Micro Manipulation System (WM^{3}S)

CENTRE OF EXCELLENCE FOR FARM MACHINERY, LUDHIANA.

Design and Development of Roof Top Biogas Plant based on Solid State Fermentation using Kitchen Waste

Biogas production involves break down of organic material or waste in an air-tight tank into gas and slurry with the help of microbes. The gas generated during this process is mainly methane with some carbon dioxide and it can be used as fuel for cooking or generating electricity; while the solid residue can be used as organic compost. A substantial portion of our food waste is biodegradable (38-40%) which is used to generate methane. Manure obtained from such waste has high nitrogen, phosphorous and potassium content. The biogas plant using kitchen waste will serve purpose of environment friendly disposal of waste, generation of fairly good amount of fuel gas for cooking and high quality manure. One kg of kitchen waste in 24 hours can produce the same amount of biogas as 40 kg of cow dung in 40 days. That means more than 400 times efficiency can be achieved by using kitchen waste as compared to cow dung. For reducing the volume of digester and the obnoxious smell due to water usage, solid state fermentation is adopted. Optimization of the amount of water for the production of biogas after different pre-treatments (Chemical and Biological) has been done in laboratory scale. The easily available and cost effective best pre-treatment has also been identified. Conceptual design of low cost and light weight biogas plant has been done and one prototype has been fabricated; modifications are being done. Suitable microbes have been identified as inoculums.

Kitchen waste

First prototype

Biogas used for cooking

Production of Biodiesel from Tung Seeds in North East India

Aleutites fordii, commonly referred to as Tung usually bears fruit within 2 - 4 years and reaches maximum productivity at around 10 - 12 years of age. The productivity of Tung oil mainly varies from 300 - 450 kg/ha. The oil content of fruit ranges from 14 - 20%, in the kernel 53 - 60% and the in seed 30 - 40%. Tung oil has been used in different industrial applications such as ceramic, paint, paper and cloth production. However, recently Tung oil has been identified as a promising non-edible source of biodiesel production. In north eastern part of India sufficient quantity of Tung seed is available; which

can be utilized to produce biodiesel (calorific value of 9500 - 10500 k Cal/ kg). This biodiesel can be used to run engines, diesel gensets locally. Fatty acid profile of Tung oil was assessed using Gas Chromatography. Different process parameters like molar ratio, catalyst concentration and reaction time are being optimized for production of best quality biodiesel from Tung oil followed by characterization of fuel properties. After optimizing the parameters, Tung biodiesel will be produced in CMERI-developed semi-continuous biodiesel plant.

Tung seeds

Lab scale experimentation

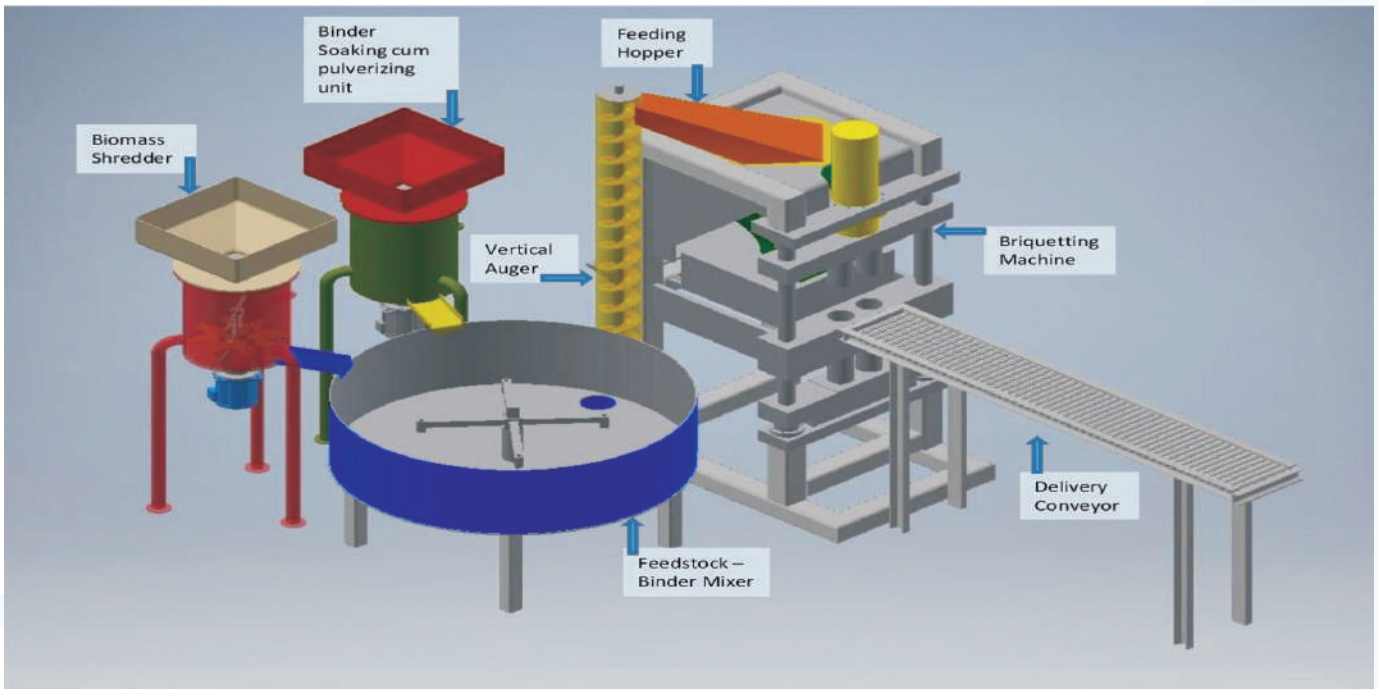
CMERI developed biodiesel plant

Production of Briquettes from Agricultural Residues, its Process Optimization and Quality Analysis

In India large quantity of agricultural wastes like rice husk, coffee husk, coir pith, jute sticks, sugarcane bagasse, wheat straw and cotton stalks are produced. A large portion of the crop residues are left unutilized and burnt in the field. Apart from this, disposal and transportation are associated with agro waste residues. According to the annual report of (2013-2014) Punjab, the agriculture based state of India produces 165.91 lakh ton of wheat and every ton produces 1.4 to 1.5 MT of straw. So biomass gasification or densification offers a better option for utilization of those agro wastes. This project on briquetting indicates the scope of using various feed-stocks like agricultural residues (paddy, wheat straw), leaves, grass, saw dust, sugarcane bagasse, rice husk etc. for producing briquettes.The briquetting technology has been optimized with different binders like paper pulp, cow dung, starch etc. Optimization of the briquetting process for multi feed-stock has been carried out and the results were very encouraging to further develop an appropriate technology in the form of a complete system. The briquettes produced through optimized process have been found to be having calorific value as high as 6000 kcal/kg, fast ignition and prolonged burning time of 95 minutes, low ash content and fixed carbon (5% each), lesser chloride (0.02%) and sulphur content (0.3%). Complete briquetting system

comprises a biomass shredding unit, a binder soaking-cum-pulverizing unit, a biomass-binder mixer, a conveyor, a hydraulically operated briquetting machine, and a roller conveyor for final delivery of briquettes. Advantages of the technology are:

- Use of multi-feed stock
- Briquette sizing as per requirement
- Use of locally available waste material as binder
- 5000 briquettes per day (8h)
- Briquette density as per requirement
- Optimized shape of briquette for better burning providing passage for free oxygen flow
- Same machine can be used for production of briquettes for domestic as well as industrial purpose



Model view of Biomass Briquetting Machine

Prototype

Other Activity Facets

- Erudite Lectures by Eminent Faculty & Scientists
- Outside Training Schedule Attended by CSIR-CMERI Personnel
- HRDC Ghaziabad Training Programme
- In-House Training Programmes / Workshops Organized for CSIR-CMERI Personnel
- Workshops / Seminars / Conference Attended By CSIR-CMERI Personnel
- Exhibitions Participated By CSIR-CMERI Personnel
- Conferences / Seminar / Outreach Programme / Sensitization Programme / Training Programme / Exhibition Organized by CSIR-CMERI
- Higher Qualification Attained
- Awards and Accomplishments
- Foreign Deputation of CSIR-CMERI Personnel
- Technologies Deployed by CSIR-CMERI
- Technologies Transfer by CSIR-CMERI
- MoU Signed by CSIR-CMERI
- New Industries added to the CSIR-CMERI
- Journal Publications: 2016
- Journal Publications: 2017 (Upto March)
- Chapter Contribution to Books
- Conference Papers: April 2016 – March 2017
- IP Portfolio
- Dateline
- Visit of Dr. Harsh Vardhan, Hon. Minister of Science and Technology & Earth Sciences, Government of India

- PRISM Sensitization Programme for Group II and Group III Technical Personnel
- Inauguration of Iron Removal Plant
- Inauguration of Solar Tree
- Inauguration of Post Graduate Diploma Courses
- National Workshop on Investment Casting Process Technology (NWIC- 2016)
- Observance of Hindi Week
- National Workshop on Machining & Machinability of Advanced Materials (NWMMAM- 2016)
- Visit of Honorable Minister of State for Heavy Industries and Public Enterprises and Industrial Conclave Program
- Vigilance Awareness Week – 2016
- Three-days High end Training Program on Dimensional Metrology, Pressure Metrology, Mass, Density & Volume Measurement
- Public Outreach Programme "IISF - 2016"
- "ROBO-EXPO - 2016"
- Visit of Dr. Mumtaz Sanghamita, Hon'ble Member of Parliament, Burdwan-Durgapur lok Sabha
- National Conference on Advanced Functional Materials Processing & Manufacturing (NCAFMPM–2017)
- CSIR-CMERI Diamond Jubilee Foundation Day Celebration
- Hindi Seminar on Make in India
- Observation of National Science Day – 2017
- Innovators Meet 2017
- Manpower as on March 31, 2017
- Performance Indices

Erudite Lectures By Eminent Faculty & Scientists

Sl.	Name	Topic	Date	Programme
1	**Shri Arun Kumar Rath**, CEO, SAIL- Durgapur Steel Plant	Foundation Day Lecture	October 01, 2016	74th CSIR Foundation Day Celebration
2	**Prof. Nalinaksh S. Vyas**, IIT Kanpur and Chairman, Technology Mission for Indian Railways			
3	**Dr. Barbara Casentini** & **Dr. Andrea Gianico**, Scientists, Water Research Institute, Rome	Improved Safe Management of Arsenic rich-waste Generated from Arsenic Removal Plant	November 18, 2016	Invited lecture
4	**Prof. Devdas Shetty**, University of Columbia, Washington	Emerging Trends in Mechatronic System Design	December 20, 2016	Invited lecture
5	**Prof. (Dr.) Subroto Mukherjee**, Associate Dean and Head FCIPT Division, Institute for Plasma Research, Gandhinagar	Environment Friendly Plasma Applications	February 22, 2017	Invited lecture
6	**Dr. Girish Sahni**, DG, CSIR & Secretary DSIR	CSIR-CMERI Foundation Day Lecture	February 26, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
7	**Prof. Ajoy Kumar Ray**, Director, Indian Institute of Engineering Science and Technology (IIEST), Shibpur			
8	**Prof. (Dr.) Sreebrata Goswami**, Senior Professor & Head Dept. of Inorganic Chemistry, Indian Association for the Cultivation of Science	C-N Fusion and Azo Anion Stabilized Radical Complexes Development	March 02, 2017	Invited lecture
9	**Prof. Amitabha Ghosh**, Platinum Jubilee Senior Scientist, National Academy of Sciences, India and Honorary Distinguished Professor, IIEST, Shibpur, Howrah.	Revisiting Newton's Laws: Possible Modification and Amazing Consequences	March 29, 2017	Invited lecture
10	**Prof. Asok Kumar Mallik**, INSA Senior Scientist and Honorary Distinguished Professor, IIEST, Shibpur, Howrah.	Magical Mathematics of Ramanujan		

Outside Training Schedule Attended by CSIR-CMERI Personnel

Sl.	Participants	Training Programme On	Duration	Held at
1.	**Mr. Sanjib Kumar Dey**, Senior Technical Officer	Training course on "Magnetic Particle Testing Level-II"	May 23-26, 2016	INDT, Kolkata
2.	**Mr. Sanjib Kumar Dey**, Senior Technical Officer **Mr. Jiten Mandal**, Technical Assistant	Training course on "Liquid Penetrant Testing Level-II"	May 27-29, 2016	INDT, Kolkata
3.	**Mr. Tarak Nath Chell**, Senior Project Fellow	Short-Term Course on "Emerging Trends and Challenges of Modern Power System"	July 05-09, 2016	NIT, Durgapur
4.	**Mr. Sanjib Kumar Dey**, Senior Technical Officer, **Mr. Jiten Mandal,** Technical Assistants & **Mr. Bimal Hansda**, Technical Assistants	Training course on "Radiographic Testing Level II"	August 22-28, 2016	INDT, Kolkata
5.	**Dr. Bikram Basak**, SERB-National Post Doctoral Fellow	Short-Term Course on "Recent Trends in Industrial Biotechnology (RTIB 2016)"	November 14-18, 2016	NIT, Durgapur

HRDC Ghaziabad Training Programme

Sl.	Participants	Training Programme On	Duration
1.	**Mr. Partha Das,** Scientist	Workshop on "Design and Analysis of Experiments"	January 18-20, 2017
2.	**Mr. Vibin V.,** Scientist	Induction Training Programme for newly recruited scientist	February 06-15, 2017

In-House Training Programmes / Workshops Organized for CSIR-CMERI Personnel

Sl.	Training Programme On	Name of the Faculty	Date	Participants
1.	Training Programme on "Intellectual Property Rights – Patent, Design, Copyright and Trademark"	**Mr. Chetan Kumar**, Chief Scientist, Innovation Protection Unit, CSIR, New Delhi **Dr. D. P. Bhatt**, Chief Scientist & Head IPR Management Group, CSIR-NPL, New Delhi **Mr. R.P. Yadav**, Patent Attorney, New Delhi **Dr. Gourav Krishnan**, Senior Scientist, Innovation Protection Unit, CSIR, New Delhi	January 19 - 20, 2017	77
2.	A workshop on Project Memorandum of Understanding (MOUs) and Litigation Management (handling of court cases)	**Mr. J.K. Unnikrishnan**, Legal Advisor, CSIR	January 12, 2017	Staff members, Officers and Scientists of the Institute
3.	Training on Altair Hypermesh Software	**Mr. Anant Krishan** Designtech System Pvt.Ltd.	February 10, 2017	08
4.	Training programme on CATIA	**Md Ali** CSM Software	February 27 – March 03, 2017	20
5.	Training program on Altium PCB Design Software	**Mr. N. Srikanth** Altium Designer - Authorised Trainer, Embedded Systems Solutions Pvt. Ltd., Bangalore	March 21 – 23, 2017	17
6.	Training programme on SIMDESIGNER	**Mr. Lanka Vinay Rao** CSM Software	March 27 – 29. 2017	06

Workshops / Seminars / Conference Attended By CSIR-CMERI Personnel

Sl.	Name of the Programme	Participants	Date	Venue
1.	Recycle 2016 National Conference on "Waste Management"	2	April 01-02, 2016	IIT, Guwahati
2.	Third International Conference on "Nanotechnology for Better Living"	1	May 25-29, 2016	NIT, Srinagar
3.	National Conference on "Nanotechnology: Materials and Applications (NCoN:M&A) 2016"	2	June 16-17, 2016	Jadavpur University, Kolkata.
4.	International Workshop on "Aspects of Fluidized Bed Technology"	2	July 09-10, 2016	IIT, Guwahati.
5.	19th CRSI National Symposium in Chemistry (CRSI NSC-19)	2	July 14-16, 2016	University of North Bengal, Darjeeling
6.	National Workshop & Training Programme on "Investment Casting Process Technology (NWIC-2016)"	15	September 01-02, 2016	CSIR-CMERI, Durgapur
7.	National Workshop on "Machining & Machinability of Advanced Materials (NWMMAM-2016)"	8	September 29-30, 2016	CSIR-CMERI, Durgapur
8.	National Conference on "Recent Developments in Chemistry (RDC-2016)"	4	October 04-06, 2016	NIT, Durgapur
9.	1st Regional Science & Technology Congress, 2016 Burdwan Division	1	November 07-08, 2016	Bankura Christian College, Bankura
10.	International Conference on "Technologically Advanced Materials & Asian Meeting on Ferroelectricity (ICTAM-AMF 10)"	1	November 07-11, 2016	University of Delhi, New Delhi
11.	IEEE International Conference on "Power Electronics, Drives and Energy System (PEDES-2016)"	1	December 14-17, 2016	Trivandrum, Kerala
12.	6th International and 43rd National Conference on "Fluid Mechanics and Fluid Power"	1	December 15-17, 2016	MNNIT, Allahabad
13.	31st Indian Engineering Congress	1	December 15-18, 2016	IEI, Kolkata
14.	6th International & 27th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2016)	1	December 16-18, 2016	College of Engineering Pune
15.	61st DAE Solid State Physics Symposium	1	December 26-30, 2016	KIIT University, Bhubaneswar

Sl.	Name of the Programme	Participants	Date	Venue
16.	International Conference on "Emerging Technologies in Agricultural and Food Engineering"	1	December 27-30, 2016	IIT, Kharagpur
17.	Workshop on "Nano Fabrication Technologies"	1	December 27-30, 2016	IIT, Bombay
18.	Three day Workshop on "Instrumental Methods (WIIM-2017)"	1	January 05-07, 2017	Sathyabama University, Chennai
19.	Fifth Symposium on "Advance Biological Inorganic Chemistry (SABIC-2017)"	1	January 07-11, 2017	Salt Lake Stadium, Kolkata
20.	International Symposium on "Facets of Chemistry in Biology (FOCB-II, 2017)"	1	January 12, 2017	St. Xavier's College, Kolkata
21.	International Seminar on "Technology Transfer as a Tool to Optimize IP and Innovation"	1	January 09, 2017	Juniper Hall, India Habitat Center, New Delhi
22.	International Conference on "Advanced Functional Materials Processing & Manufacturing (NCAFMPM–2017)"	20	February 02-03, 2017	CSIR-CMERI, Durgapur
23.	20th CRSI National Symposium in Chemistry	1	February 02-05, 2017	Guwahati University, Guwahati
24.	IEEE International Conference on "Advanced in Mechanical, Industrial, Automation and Management Systems (AMIAMS 2017)"	1	February 03-05, 2017	MNNIT, Allahabad
25.	65th Indian Foundry Congress	1	February 03-05, 2017	Eco Park, Kolkata
26.	International Seminar on "Aero India 2017"	3	February 12-14, 2017	DRDO, Bengaluru
27.	Two-Day Workshop on "Challenges and Opportunities of Underground Coal Gasification in India (UCG-2017)"	1	February 13-14, 2017	Vigyan Bhawan, New Delhi
28.	International Conference on "NexGen Technologies for Mining & Fuel Industries (NxGnMiFu-2017)"	1	February 15-17, 2017	Vigyan Bhawan, New Delhi
29.	2nd National Seminar on "Nanoscience and Nanotechnology (NSNN-2017)"	2	March 17-18, 2017	HIT, Haldia
30.	"Recent Trends in Chemistry Research"	1	March 25-26, 2017	Visva-Bharati, Shantinikatan

Exhibitions Participated By CSIR-CMERI Personnel

Sl.	Name of the Programme	Date	Venue
1.	"India International Trade Fair"	November 14-27, 2016	New Delhi
2.	"TIE Global Sumit 2016"	December 16-17, 2016	New Delhi
3.	"Science Congress"	January 01-07, 2017	Tirupati
4.	"Destination North-East 2017" organized by Ministry of Development of North-Eastern Region (DoNER)	March 06-08, 2017	Chandigarh
5.	Science & Technology Fair & Exhibition organized by Vivekananda Vijan Mission & IEM	March 25-27, 2017	Sector V, Salt Lake, Kolkata,

Conferences / Seminar / Outreach Programme / Sensitization Programme / Training Programme / Exhibition Organized by CSIR-CMERI

Sl.	Name of the programme	Date
1.	Awareness Programme on RTI & Grievance redressal Mechanism, Biometric Attendance System (AEBAS) and CCS Conduct Rule	May 05, 2017
2.	Implementation of ERP Applications	May 24-27, 2016
3.	PRISM Sensitization Programme	June 03, 2016
4.	Training Programme on "Boiler Tube Failure and Remedies"	July 14-15, 2016
5.	National Workshop on Investment Casting Process Technology (NWIC- 2016)	September 01-02, 2016
6.	National Workshop on Machining & Machinability of Advanced Materials (NWMMAM- 2016)	September 29-30, 2016
7.	Industrial Conclave Programme	September 30, 2016
8.	Three-day High end Training Program on Dimensional Metrology, Pressure Metrology, Mass, Density & Volume Measurement	November 09-11, 2016
9.	Public Outreach Programme "IISF - 2016"	November 10-11, 2016
10.	ROBO-EXPO - 2016	December 21, 2016
11.	International Conference on "Advanced Functional Materials Processing & Manufacturing (NCAFMPM–2017)"	February 02-03, 2017
12.	Orientation Programme for Trainee IAS Officers	February 07, 2017
13.	Hindi Seminar on "Make in India"	February 26-27, 2017
14.	Seminar on National Science day "Science and Technology for specialy able persons"	February 28, 2017
15.	World Down Syndrome Day Awareness Programme	March 21, 2017
16.	Innovators Meet 2017	March 23-24, 2017

Higher Qualification Attained

Sl.	Awardees	Qualification
1.	**Dr. Kalyan Kumar Mistry** Senior Scientist	Ph.D. from Indian Institute of Engineering Science and Technology, Shibpur **Development of Screen-Printed electrode based Immunosensor for detection of Antigen**
2.	**Dr. Palash Kumar Maji** Principal Scientist	Ph.D. from Indian Institute of Engineering Science and Technology, Shibpur **Design and development of different types of Femoral Stems for reducing Stress Shielding Effect**
3.	**Dr. Binod Kumar Saha** Senior Scientist	Ph.D. from Jadavpur University **Using CFD as a design tool for pneumatic valves**
4.	**Dr. Anupam Sinha** Principal Scientist	Ph.D. from Jadavpur University **Analysis of fluid flow and heat transfer in the representative modules of heat exchangers**
5.	**Shri Adwaita Maiti** Technical Officer	M.Tech from National Institute of Technology, Durgapur **Metatlurgical & Materials Engineering (Specialization: Materials Engineering)**
6.	**Shri Biplab Swarnakar** Technical Officer	M.Tech from National Institute of Technology, Durgapur **Design & Production Engineering (Department of Mechanical Engineering)**
7.	**Shri Y.S. Pujar** Senior Technical Officer	**AMIE** degree in Mechanical Engineering from Institute of Engineers (India)

Awards and Accomplishments

- **Dr. Ranjan Sen,** Chief Scientist & Head Precision Engineering & Metrology, delivered a **technical lecture** on Estimation and application of measurement uncertainty in testing and calibration in the Seminar on **Uncertainty in Measurement** at Kolkata on May 26, 2016. The seminar was organized by Indian Chamber of Commerce in which other renowned dignitaries like Dr. V.N. Ojha, Chief Scientist of NPL; Mr. Abhijit Das, Technical Operation Manager, NABLNew Delhi, Dr. Prasun Das, Head, SQC & OR unit, ISI-Kolkata, Mr. C.K.Biswas, CEO,NBQP, Quality Council of India, also spoke. The seminar was attended by thirty participants from various industries including the Berger Paints, Hindalco, MSK Testing & Inspection, Omega Consultant Services, etc. Dr Sen covered the sub-themes like importance of Quality Standard ISO/IEC175025 and Mutual Recognization Arrangements, uncertainty evaluation methodology in measurements in the fields of mechanical calibration & testing, electro-technical calibration and thermal calibration. The event afforded an excellent forum for publicizing CSIR-CMERI's total scope of NABL Accreditation, which might serve to attract more industries and agencies for utilizing the calibration and inspection services offered by the Institute.

- **Mr. C.D. Balaji,** Distinguished Scientist, Programme Director (CA) and Director, Aeronautical Development Agency, Ministry of Defence, Government of India has **lauded the contribution of CSIR-CMERI in the development of complex technologies having globally competitive specifications for the Tejas Aircraft.**

- **Director, CSIR-CMERI, Durgapur** was awarded the **Presidential Shield** by the TOLIC, Durgapur for the achievement of implementing the Official Language in the Institute.

- **Mr. Soumen Mandal** delivered an **invited talk** at NSHM College Durgapur on "Intelligent manufacturing: Advancements and Challenges" in National Seminar on Recent Trends in computing held on 17th April 2016.

- **Mr. Soumen Mandal** delivered an invited talk at Jadavpur University, Kolkata on **"Graphite clay composites and their breakthrough applications"** in International Seminar on Recent Trends in composite materials held on 18th August 2016 sponsored under TEQUIP-II program

- **Dr. Ranjan Sen,** Chief Scientist delivered an **invited talk on Challenges of Micro-Metrology for Micro-Machining** during the National Seminar on Micromachining held at the MCKV Institute of Engineering, Liluah, Howrah organised under the aegis of the TEQIP-II during 13-15 September, 2016.

- **Dr. Ravi Kant Jain,** Principal Scientist was awarded the **M.P. Bawa National Award** for the year 2016 by the Institution of Engineers (India), Udaipur Local Centre in recognition of his outstanding contribution and technological advancement in the field of mechanical engineering.

- **Dr. Ranjan Sen,** Chief Scientist has **been invited by the Union Public Service Commission,** Government of India, New Delhi to serve as a Member of the recruitment board for selection against the post of Training Officer (Principal of Teaching).

- An **invited talk** on **Plasticwaste plasma gasification and syngas generation** ws delivered by Dr. Biswajit Ruj, Senor Principal Scientist on 12th December 2016 at Jadavpur University in the National Seminar on "Advances in Chemical Sciences and Technology".

- The paper entitled Effect of Pouring Temperature on cooling Slope of Semi-solid Al-Si-Mg Alloy authored by **Prosenjit Das, Sudip Kumar Samanta, Himadri Chattopadhyay & Pradip Dutta** received **2016 Excellent Article Award** of the Acta Mettallurgica Sinica (English Letters).

- **Dr. Debashis Ghosh,** Principal Scientist has been awarded the **Dr. M. Visvesvaraya Award 2016** by the Institute of Engineers.

- **Mr. Ravi Kumar Arun** has been selected for the **'Best Paper Award'** for his paper entitled `Micro fuel cell' presented at the International Conference on Sustainable Development for Energy and Environment (ICSDEE-2017).

- **Dr. Pranab Samanta,** Scientist has been awarded the **'Raman Research Fellowship'** for the year 2016-2017 to carry out research on 'Investigation of Thermo-elastic Instabilities in the Foil Bearings' under Professor Michael M. Khonsari, Louisiana State University, USA.

- **Dr. Naresh Chandra Murmu** received the **2015 VASVIK Award** in the category of Mechanical & Structural Science & Technology.

- **Shri Rabisankar Mondal,** Technical Assistant, Precision Engineering Group, stood **first in the CSIR-CMERI Diamond Jubilee Logo Competition.**

- A paper entitled 'One pot synthesis of Cu_2O-RGO composite using Mango bark extract for supercapacitor application' by **Dr. Tapas Kuila and Shri J. Sharath** has received the **Best Paper Award** in the 'International Conference on Nano for Energy and Water (NEW)-2017' & 'Indo-French Workshop on Water Networking' held at the University of Petroleum and Energy Studies, Dehradun, India during February 22-24, 2017.

- **Team CMERI** has bagged the **'NRDC Innovation Award of the Year 2014'** for "Design and Development of an Indigenous Mobile Inspection Unit (MBIU) from Honorable Minister of "Science &Technology and Earth sciences" Dr.Harshvardhan in presence of DG CSIR, New Delhi on March 24, 2017. **Cdr V. R. Dahake,** Ex-Chief Scientist; **Ashwani Kumar Kushwaha,** Senior Principal Scientist; **Rajesh Kumar Chak,** Ex-Principal Scientist; **Jagroop Singh,** Technical Officer (2) and **Prabhu Dutt,** Technical Officer was the team member.

- **Dr. Krishnendu Kundu,** Principal Scientist received **SESR Bio Scientist Award 2016.**

- **Ms. Madhuka Roy,** Senior Research Fellow received **SESR Young Investigator Award 2016.**

- **Dr. Krishnendu Kundu,** Principal Scientist delivered **Guest Lecture** at "National Workshop on Bio-fuel and Bio-energy in Food Processing Industries: Opportunities and Constraints" held at G B Pant University of agriculture and Technology on February 8, 2017.

- **Dr. Krishnendu Kundu,** Principal Scientist delivered **invited lecture** at Graphic Era Hill University, Bhimtal, Uttarakhand on May 2016 and February 2017.

Foreign Deputation of CSIR-CMERI Personnel

Sl.	Name	Deputation to	Duration
1.	**Dr. Tapas Kuila**, DST Inspire Faculty Fellow	Visit to the Department of BIN Convergence Technology of Chonbuk National University, South Korea	01/05/2016 to 30/06/2016
2.	**Dr. P. K. Chatterjee**, Chief Scientist & **Dr. Amit Ganguly**, Principal Scientist	Visit to the Loughborough University, Lelcestershire, UK under Indo UK Collaborative Research Project funded jointly by British Council UK and the DST Govt. of India under the UKIERI	18/06/2016 to 29/06/2016
3.	**Dr. Biswajit Ruj**, Senior Principal Scientist	Visit to CNR, Italy under the CSIR - NCR Bilateral Exchange Programme (2016-18)	14/12/2016 to 22/12/2016

Technologies Transfer by CSIR-CMERI

Sl.	Technology	Transferred to
1.	Two models of Solar Arti fact	M/s Lords Bluetech Co. Pvt. Ltd., Kolkata
2.	Rotating Solar Power Tree	M/s Mineworth Engineering Products Pvt. Ltd., Kolkata
		M/s PRASUR Electricals & Engineering Co., Port Blair, Andaman
		M/s Creative Smart Innovations, Kalyani, Nadia
		M/s KSR Industrial Development (OPC) Private Limited, 38A, Mangaldeep Society, Vadodara, Gujrat
		M/s Green Enviro Consultancy Pvt. Ltd. B-16, GT Karnal Road, Industrial Area, Delhi
3.	Metal Detector using Magnetic Field Splitting	M/s Durga Solar Enterprise, P.O.Barabagan, Suri, Birbhum, West Bengal
4.	Plastic Waste Gasification Process	M/s Positronics India, Kolkata
5.	Plasma Disposal of Plastic Waste & Generation of Syngas	M/s Pressels Private Limited, B13, Industrial Estate, Madhupatna, Cuttack
6.	Jal Kavach	M/s KSR Industrial Development (OPC) Private Limited, 38A, Mangaldeep Society, Vadodara, Gujrat
7.	Salivary Fluoride Detection Kit	M/s Joint Enterprise Engineering Company, Durgapur
8.	Small Tractor 'KrishiShakti'	M/s Singha Components (P) Ltd., 28/B, G.T.Road, Uttarpara
9.	Improved Iron Removal Plant	M/s Joint Enterprise Engineering Company, Durgapur

MoU Signed by CSIR-CMERI

Sl.	Subject	Other Party	Signed on
1.	Development of Solar ON grid inverters with or without storage (Hybrid Solar Inverter)	M/s. Micromax Energy Limited 21/14, Naraina Industiral Area, Phase-2, New Delhi	26.02.17

New Industries added to the CSIR-CMERI

a.	R&D Projects	
	Sl.	Name of the Industries
	01	Durgapur Municipal Corporation, City Centre, Durgapur, West Bengal
	02	Maharajah Alak Narayan Society of Arts & Science (MANSAS), Fort, Vizianagaram, Andhra Pradesh
	03	B.N. Das Private Limited, 15, Palace Road, Bangaluru
	04	Taldangra Panchayat Samity, Government of West Bengal, Taldangra, Bankura

b.	Technical Services	
	Sl.	Name of the Industries
	01	Durgapur Steel Plant, Durgapur
	02	Durgapur Thermal Power Station, DVC, DTPS, Durgapur
	03	Durgapur Steel Thermal Power Station, DVC, Andal
	04	Chandrapura Thermal Power Station, DVC,Chandrapura
	05	WBSEDCL, Kolkata
	06	NTPC- Talcher, Orrissa
	07	Adhunik Power & Natural Resources Limited, S/O Adhunik, Metaliks Limited
	08	NSPCL, Durgapur
	09	Kumar Enterprises, Darbari Sarani, Durgapur, West Bengal
	10	MTPS, Bankura
	11	ERTL (E), Kolkata
	12	Heavy Machine Tools Plant, Ranchi
	13	Kalyani Engineering College, Nadia
	14	Neyveli Lignite Corporation, Bikanir, Rajasthan
	15	CESC Limited, Kolkata
	16	Eastern Coalfields Ltd., Kumardubi, West Bengal
	17	Bharat Pumps & Compressors Ltd., Uttar Pradesh
	18	IOCL, Barauni, Begusarai
	19	Ramakrisna Mission Ashrama, Sargachi, Murshidabad
	20	G.E. Power Services, Durgapur
	21	West Bengal State Electricity Distribution Co.Ltd., Purulia Pumped Storage Project, Bagmundi, Purulia
	22	Precision Infratech Ltd., Suryarath Panchabati, Ahmedabad, Gujrat
	23	Shyam Ferro Alloys Ltd., Durgapur
	24	Asansol Durgapur Development Authority, Asansol
	25	NIFFT, Hatia, Ranchi
	26	Kiriburu Iron Ore Mines, Kiriburu
	27	Genus Power Infras Ltd., Rajasthan
	28	Public Health Engineering Directorate, Murshidabad Division,Berhumpur, Murshidabad
	29	Andhra Pradesh Heavy Machinery & Engg. Ltd., Konda Pally, Andhra Pradesh

c.	Testing & Calibration	
	Sl.	Name of the Industries
	01	IOCL, Haldia Refinery, P.O.: Haldia Oil Refinery, Dist.: Purba Medinipur, West Bengal
	02	IOCL, Barauni Refinery, Begusarai, Bihar
	03	IOCL, Pipelines Div., HMRB Pipelines, P.O.: Rajbandh, Durgapur, West Bengal
	04	SAIL Durgapur Steel Plant, Durgapur, West Bengal
	05	SAIL, Office of the DGM (Contracts), IISCO Steel Plant, Burnpur
	06	HECL,Heavy Machine Tools Plant, P.O.: Dhurwa, Ranchi
	07	MSME Testing Centre, 111 & 112, B. T. Road, Kolkata
	08	Indian Ordnance Factories, Govt. of India, Metal & Steel Factory, P.O.: Ishapure Nawabgung, 24-Parganas (N)

Sl.	Name of the Industries
09	ERTL (East), Salt Lake City, Kolkata
10	Nutech Calibrators & Engineers, 28/6&7, Tollygunge Circular Road, Kolkata
11	Superintendence Co. of India (P) Ltd., Y-23, Block-EP, Sec-V, Salt Lake City, Kolkata
12	Sibali Instrument Works , A.T.Ghosh Road, P.O. : G.I.P Colony, Howrah
13	Kalyanpur Cements Limited, P.O. : Banjari, Dist. - Rohtas, Bihar
14	Durgapur Chemicals Limited, Hahnemann Sarani, Durgapur, West Bengal
15	Hindustan Aeronautics Limited, Barrackpore Division, 9, Topkhana Road, Barrackpore, Kolkata, West Bengal
16	MeasureTechno Lab, 32A, Ganesh Ch.Avenue, Kolkata
17	F. Harley & Co. Pvt. Ltd., 5, Rameshwar Shaw Road, Kolkata
18	Good Earth Enviro Care, 28, Pranabananda Road, Garia, Kolkata
19	Ambuja Cement Limited, Vill.: Kendua, P.O.: Srimantapur, Dist.: Murshidabad
20	Jaganaths Slip Gauge, 28, Gurupada Halder Road, Kolkata
21	OCL India Limited, Rajgangpur, Odisha, India
22	Premium Transmission Ltd., Falta, 24 P arganas (S)
23	Usha Martin Ltd., Tatisilwai, Ranchi, Jharkhand
24	Maithon Ceramic Limited, P.O.: Chirkunda, Dhanbad, Jharkhand
25	Birla Corporation Limited, Durgapur Cement Works, Durgapur
26	Indian Rare Earths Ltd., Orissa Sand Complex, Chatrapur, Cuttack, Orissa
27	Nuvoco Vistas Corporation Ltd., P.O. : MTPS, DVC, Bankura
28	Chemtek Speciality Liited, 86A, Topsia Road, Kolkata, West Bengal
29	Dalmia Cement East Ltd., Bokaro
30	Essar Oil Limited, E&P Div., Durgapur, West Bengal
31	Testing Concern, Belilious Road, Howrah, West Bengal
32	Alcalab Pvt.Ltd., P.O.: Adityapur, Jamshedpur, Jharkhand
33	SAIL Ware House, Surya Sen Sarani, Durgapur, West Bengal
34	Centre for Excellence in Green Energy & Sensors Systems (CEGESS), IIEST, Shibpur, Howrah
35	SAIL, Alloy Steel Plant, Durgapur, West Bengal
36	Multitech Technolab Pvt. Ltd., Adityapur Industrial Area, Jamshedpur
37	Pragati Cemex Pvt.Ltd., Wilcox Road, Simulia, Purulia, West Bengal
38	K. Construction, Midnapur, West Bengal
39	Mackeil Ispat & Forging Ltd., Durgapur, West Bengal
40	G.E. Power India Ltd., Durgapur, West Bengal
41	Projects & Development India Ltd., P.O. : Sindri, Dist.: Dhanbad, Jharkhand
42	GPT Infra Projects Ltd., Salt Lake, Kolkata
43	Tata Metaliks Limited, Khargpur, West Bengal
44	R.S. Safety & Calibraition Consultancy, Golmari, Jamshedpur
45	Khaitan Cement Pvt.Ltd., Mangalpur, Baktnagar, Asansol
46	Electrometer Corporation, CIT Road, Kolkata, West Bengal

Journal Publications: 2016

Sl.	Title	Authors	Journal	Details
1.	[Ru-III(EDTA)(H_2O)](-) catalyzed oxidation of biologically important thiols by H_2O_2	P. Sarkar, A. Saha, D. Chatterjee	Journal of Coordination Chemistry	2016, 69 (22), pp. 3417–3423
2.	[Ru-III(EDTA)(H_2O)](-) mediated oxidation of cellular thiols by HSO_5^-	P. Sarkar, A. Saha, D. Chatterjee	New Journal of Chemistry	2016, 40 (11), pp. 9380–9384
3.	A comparative density functional theory and molecular dynamics simulation studies of the corrosion inhibitory action of two novel N-heterocyclic organic compounds along with a few others over steel surface	Sourav Kr. Saha, Abhiram Hens, Naresh Chandra Murmu, Priyabrata Banerjee	Journal of Molecular Liquids	2016, 215, pp. 486–495
4.	A facile synthesis of graphene foam as electrode material for supercapacitor	S. Sivaprakash, Prabhavathy Sivaprakash	Materials Research Express	2016, 3 (7), article no. 75020
5.	A review on low grade heat powered adsorption cooling systems for ice production	Ramesh P. Saha, Biplab Choudhury, Ranadip K. Das	Renewable and Sustainable Energy Reviews	2016, 62, pp. 109–120
6.	A stepper-piezo-based co-actuation paradigm for tool positioning in parallel spark micro-electro-discharge machining	Rajulapati Vinod Kumar, Aniruddha Pal, Sucharita Saha, Soumen Mandal	Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	2016, 230 (11), pp. 2136-2139
7.	Anion-Directed Copper(II) Metallocages, Coordination Chain, and Complex Double Salt: Structures, Magnetic Properties, EPR Spectra, and Density Functional Study	Jing-Yun Wu, Ming-Shiou Zhong, Ming-Hsi Chiang, Dibyendu Bhattacharya, Yen-Wei Lee, Long-Li Lai	Chemistry – A European Journal	2016, 22, pp. 7238-7247
8.	Application of compact schemes in the CUSP framework for strong shock–vortex interaction	Abhishek Kundu, Sudipta De	Computers and Fluids	2016, 126, pp. 192-204

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9.	Band gap modified boron doped NiO/Fe_3O_4 nanostructure as the positive electrode for high energy asymmetric supercapacitors	Sanjit Saha, Milan Jana, Partha Khanra, Pranab Samanta, Hyeyoung Koo, Naresh Chandra Murmu, Tapas Kuila	RSC Advances	2016, 6 (2), pp. 1380-1387
10.	Chromogenic and fluorogenic Schiff base chemo sensor for nano scale level fluoride detection with logical interpretation	Pritam Ghosh, Priyabrata Banerjee	Chemical Physics	2016, 478, pp. 103-109
11.	Design and development of an amperometric immunosensor based on screen-printed electrodes	Kalyan Kumar Mistry, Keya Layek, Tarak Nath Chell, Chirasree Roy Chaudhuri, Hiranmay Saha	Analytical Methods	2016, 8 (15), pp. 3096-3101
12.	Development of high strength ductile eutectoid steel through cyclic heat treatment involving incomplete austenitization followed by forced air cooling	Alok Mishra, Atanu Saha, Joydeep Maity	Materials Characterization	2016, 114, pp. 277–288
13.	Development of two jaw compliant gripper based on hyper-redundant approximation of IPMC actuators	Ritwik Chattaraj, Siladitya Khan, Srijan Bhattacharya, Bikash Bepari, Debabrata Chatterjee, Subhasis Bhaumik	Sensors and Actuators A: Physical	2016, 251, pp. 207-218
14.	Easy operable ionic polymer metal composite actuator based on platinum-coated sulfonated poly(vinyl alcohol)-polyaniline composite membrane	Ajahar Khan, Inamuddin, Ravi Kant Jain	Journal of Applied Polymer Science	2016, 133 (33), article no. 43787
15.	Effect of Ag -doped TiO_2 thin film passive layers on the performance of photo-anodes for dye-sensitized solar cells	K. Usha, P. Kumbhakar, B. Mondal	Materials Science in Semiconductor Processing	2016, 43, pp. 17-24
16.	Effect of Dodecyal Amine Functionalized Graphene on the Mechanical and Thermal Properties of Epoxy-Based Composites	Suman Chhetri, Pranab Samanta, Naresh Chandra Murmu, Suneel Kumar Srivastava, Tapas Kuila	Polymer Engineering and Science	2016, 56 (11), pp. 1221-1228

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17.	Effect of high molecular weight polyethyleneimine functionalized graphene oxide coated polyethylene terephthalate film on the hydrogen gas barrier properties	Woong Bi Park, Parthasarathi Bandyopadhyay, Thanh Tuan Nguyen, Tapas Kuila, Nam Hoon Kim, Joong Hee Lee	Composites Part B: Engineering	2016, 106, pp. 316-323
18.	Effect of Plasma Sprayed Yttria Stabilized Zirconia(YSZ) Coating for High Temperature Oxidation Resistance of Low Alloy Steel	D. Ghosh, S. Das, S.K. Mitra	Protection of Metals and Physical Chemistry of Surfaces	2016, 52 (2), pp. 323-328
19.	Effect of Prandtl number and rotation on vortex shedding behind a circular cylinder subjected to cross buoyancy at subcritical Reynolds number	Dipankar Chatterjee, Chiranjit Sinha	International Communications in Heat and Mass Transfer	2016, 70, pp. 1-8
20.	Effect of prior austempering heat treatment on the microstructure, mechanical properties and high-stress abrasive wear behaviour of a 0.33% C dual-phase steel	N. Shukla, H. Roy, B.K. Show	Canadian Metallurgical Quarterly	2016, 55 (1), pp. 13-22
21.	Effect of yttria (Y_2O_3) coating for high temperature oxidation resistance of 9Cr-1Mo steel	D. Ghosh, S. Mukherjee, S. Das, S.K. Mitra	Protection of Metals and Physical Chemistry of Surfaces	2016, 52 (4), pp. 737-743
22.	Effects of doping, morphology and film-thickness of photo-anode materials for dye sensitized solar cell application – A review	D. Sengupta, P. Das, B. Mondal, K. Mukherjee	Renewable and Sustainable Energy Reviews	2016, 60, pp. 356-376
23.	Effects of the reduction of PANI-coated oxidized multiwall carbon nanotubes on the positive temperature coefficient behaviors of their carbon black/high density polyethylene composites	Seon Hyeong Bae, Rama K. Layek, Seung Hee Lee, Tapas Kuila, Nam Hoon Kim, Joong Hee Lee	Polymer Testing	2016, 50, pp. 83–93

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24.	Efficient access of voltammetric charge in hybrid supercapacitor configured with potassium incorporated nanographitic structure derived from cotton (Gossypium arboreum) as negative and $Ni(OH)_2$/rGO composite as positive electrode	Sanjit Saha, Milan Jana, Pranab Samanta, Naresh C. Murmu, Tapas Kuila	Industrial & Engineering Chemistry Research	2016, 55 (42), pp. 11074–11084
25.	Energy generation from water flow over a reduced graphene oxide surface in a paper–pencil device	Ravi Kumar Arun, Preeti Singh, Gautam Biswas, Nripen Chanda, Suman Chakraborty	Lab on a Chip	2016, 16 (18), pp. 3589-3596
26.	Enhanced magnetoconductivity and electrical property of MWCNT-CdS nanocomposite embedded in polyaniline	M. Goswami, A. Mukherjee, R. Ghosh, S. Basu, A.K. Meikap	Solid State Sciences	2016, 60, pp. 37-44
27.	Enhancement of heat transfer in a fin-tube heat exchanger using rectangular winglet type vortex generators	Anupam Sinha, Himadri Chattopadhyay, Ashwin Kannan Iyengar, Gautam Biswas	International Journal of Heat and Mass Transfer	2016, 101, pp. 667–681
28	Evaluating corrosion inhibition property of some Schiff bases for mild steel in 1 M HCl: competitive effect of the heteroatom and stereochemical conformation of the molecule	Alokdut Dutta, Sourav Kr. Saha, Priyabrata Banerjee, Apurba K. Patra, Dipankar Sukul	RSC Advances	2016, 6 (78), pp. 74833-74844
29.	Evaluating electronic structure of quinazolinone and pyrimidinone molecules for its corrosion inhibition effectiveness on target specific mild steel in the acidic medium: A combined DFT and MD simulation study	Sourav Kr. Saha, Manilal Murmu, Naresh Chandra Murmu, Priyabrata Banerjee	Journal of Molecular Liquids	2016, 224 (A), pp. 629-638
30.	Experimental study of paddy drying in a vortex chamber	J.R. Pati, S. Dutta, P. Eliaers, P. Mahanta, P.K. Chatterjee, J. De Wilde	Drying Technology	2016, 34 (9), pp. 1073-1084

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31.	Fabrication of mixed phase TiO_2 heterojunction nanorods and their enhanced photoactivities	Amritanjali Tiwari, Indranil Mondal, Saptarshi Ghosh, Nitin Chattopadhyay, Ujjwal Pal	Physical Chemistry Chemical Physics	2016, 18 (22), pp. 15260-15268
32.	Fish scale derived hydroxyapatite scaffold for bone tissue engineering	B. Mondal, S. Mondal, A. Mondal, N. Mandal	Materials Characterization	2016, 121, pp. 112-124
33.	Formation of $[RuIII(edta)(SNO)]^{2-}$ in RuIII(edta)-Mediated S-Nitrosylation of Bisulfide Ion	Debabrata Chatterjee, Papiya Sarkar, Maria Oszajca, Rudi van Eldik	Inorganic Chemistry	2016, 55 (10), pp. 5037–5040
34.	Growth of Ni–Co binary hydroxide on a reduced graphene oxide surface by a successive ionic layer adsorption and reaction (SILAR) method for high performance asymmetric supercapacitor electrodes	Milan Jana, Sanjit Saha, Pranab Samanta, Naresh Chandra Murmu, Nam Hoon Kim, Tapas Kuila, Joong Hee Lee	Journal of Material Chemistry A	2016, 4 (6), pp. 2188-2197
35.	Hierarchical zinc oxide nano-tips and micro-rods: hydrothermal synthesis and improved chemi-resistive response towards ethanol	P. Das, B. Mondal, K. Mukherjee	RSC Advances	2016, 6 (2), pp. 1408-1414
36.	High-temperature corrosion behavior of different regions of Weldment of 2.25Cr-1Mo steel in $SO_2 + O_2$ atmosphere	D. Ghosh, A.K. Shukla, S.K. Mitra, B. Satpati	Journal of Materials Engineering and Performance	2016, 25 (2), pp. 421-430
37.	How paramagnetic and diamagnetic LMOCs can detect picric acid from surface water and intracellular environment: a combined experimental and DFT-D3 study	Pritam Ghosh, Priyabrata Banerjee	Physical Chemistry Chemical Physics	2016, 18 (33), pp. 22805-22815
38.	Improving bioavailability of fruit wastes using organic acid: An exploratory study of biomass pretreatment for fermentation	Shouvik Saha, Mayur B. Kurade, Marwa M. El-Dalatony, Pradip K. Chatterjee, Dae Sung Lee, Byong-Hun Jeon	Energy Conversion and Management	2016, 127, pp. 256-264

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39.	Influence of Aiding Buoyancy on the Suppression of Flow Separation for Power-Law Fluids Around a Circular Object	S.K. Gupta, S. Ray, D. Chatterjee	Heat Transfer Engineering	2016, 37 (15), pp. 1267-1279
40.	KITE: an efficient scheme for trust estimation and detection of errant nodes in vehicular cyber-physical systems	Rajesh P. Barnwal, Soumya K. Ghosh	Security and Communication Network	2016, 9 (16), pp. 3271-3281
41.	Machinability evaluation and desirability function optimization of turning parameters for Cr_2O_3 doped zirconia toughened alumina (Cr-ZTA) cutting insert in high speed machining of steel	B.K. Singh, B. Mondal, Nilrudra Mandal	Ceramics International	2016, 42 (2B), pp. 3338–3350
42.	Magnetoconvective transport in a lid-driven square enclosure with two rotating circular cylinders	Dipankar Chatterjee, Pabitra Halder	Heat Transfer Engineering	2016, 37 (2), pp. 198-209
43.	Microflora from leaf debris is suitable for treatment of starch industry wastewater	Shubhaneel Neogi, Apurba Dey, Pradip Kumar Chaterjee	Engineering in Life Sciences	2016, 16 (8), pp. 683-689
44.	Micromechanics based modelling of deformation behaviour of grain refined rheocast Al–7Si–0.3Mg alloy	P. Das, Sk. T. Islam, S. Das	Materials Science and Technology	2016, 32 (9), pp. 898-914
45.	Microscale deformation behavior of rheocast Al–7Si–0.3Mg alloy	Prosenjit Das, Sk. Tanbir Islam, Sudip K. Samanta, Santanu Das	Proc IMechE Part L: J Materials: Design and Applications	2016, 230 (6), pp. 1041–1061
46.	Microstructure evolution and rheological behavior of cooling slope processed Al-Si-Cu-Fe alloy slurry	Prosenjit Das, Sudip K. Samanta, Supriya Bera, Pradip Dutta	Metallurgical and Materials Transactions A	2016, 47 (5), pp. 2243-2256
47.	Modelling and simulation of a robust energy efficient AUV controller	M. Sarkar, S. Nandy, S.R.K. Vadali, S. Roy, S.N. Shome	Mathematics and Computers in Simulation	2016, 121, pp. 34-47

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48.	Modulated binary–ternary dual semiconductor heterostructures	Gyanaranjan Prusty, Amit K. Guria, Indranil Mondal, Anirban Dutta, Ujjwal Pal, Narayan Pradhan	Angewandte Chemie	2016, 128 (8), pp. 2755-2758
49.	Molecular association of 2-(n-alkylamino)-1,4-naphthoquinone derivatives: Electrochemical, DFT studies and antiproliferative activity against leukemia cell lines	Rishikesh Patil, Sujit Bhand, V. Badireenath Konkimalla, Priyabrata Banerjee, Bharat Ugale, Dattatray Chadar, Sourav Kr. Saha, Prakash Priyadarshi Praharaj, C.M. Nagaraja, Debamitra Chakrovarty, Sunita Salunke-Gawali	Journal of Molecular Structure	2016, 1125, pp. 272-281
50.	Nanostructured CeO_2 coating for high temperature oxidation protection	D. Ghosh, H. Roy, S. Das, S.K. Mitra	Surface Engineering	2016, 32 (6), pp. 397-403
51.	Novel Schiff-base molecules as efficient corrosion inhibitors for mild steel surface in 1 M HCl medium: experimental and theoretical approach	Sourav Kr. Saha, Alokdut Dutta, Pritam Ghosh, Dipankar Sukul, Priyabrata Banerjee	Physical Chemistry Chemical Physics	2016, 18 (27), pp. 17898-17911
52.	Novel synthesis of a mixed Cu/CuO–reduced graphene oxide nanocomposite with enhanced peroxidase-like catalytic activity for easy detection of glutathione in solution and using a paper strip	Preeti Singh, Peuli Nath, Ravi Kumar Arun, Soumen Mandal, Nripen Chanda	RSC Advances	2016, 6 (95), pp. 92729-92738
53.	Numerical Investigation of the Water Droplet Transport in a PEM Fuel Cell with Serpentine Flow Channel	B. Mondal, D. Chatterjee	Journal of Applied Fluid Mechanics	2016, 9 (3), pp. 1057-1071
54.	Numerical simulation of a compressible vortex–wall interaction	T. Murugan, S. De, A. Sreevatsa, S. Dutta	Shock Waves	2016, 26 (3), pp. 311-326

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55.	Numerical visualization of shock tube-generated vortex–wall interaction using a fifth-order upwind scheme	Abhishek Kundu, Sudipta De, Murugan Thangadurai, C.L. Dora, Debopam Das	Journal of Visualization	2016, 19 (4), pp. 667-678
56.	One pot synthesis of Cu_2O/RGO composite using mango bark extract and exploration of its electrochemical properties	J. Sharath Kumar, Milan Jana, Partha Khanra, Pranab Samanta, Hyeyoung Koo, Naresh Chandra Murmu, Tapas Kuila	Electrochimica Acta	2016, 193, pp. 104–115
57.	On-machine tool prediction of flank wear from machined surface images using texture analyses and support vector regression	Samik Dutta, Surjya K. Pal, Ranjan Sen	Precision Engineering	2016, 43, pp. 34-42
58.	Oriented Attachments and Formation of Ring-on-Disk Heterostructure Au–Cu_3P Photocatalysts	Anirban Dutta, Sumit K. Dutta, Shyamal K. Mehetor, Indranil Mondal, Ujjwal Pal, Narayan Pradhan	Chemistry of Materials	2016, 28 (6), pp. 1872-1878
59.	Oxidation of captopril by hydrogen peroxide and peroxomonosulfate ion catalyzed by a ruthenium(III) complex: kinetic and mechanistic studies	Papiya Sarkar, Amrita Saha, Debabrata Chatterjee	Transition Metal Chemistry	2016, 41 (3), pp. 279-286
60.	Oxidation of Ru(III)-bound thiocyanate with peroxomonosulfate: kinetic and mechanistic studies	Papiya Sarkar, Debabrata Chatterjee	International Journal of Chemical Kinetics	2016, 48 (3), pp. 117-123
61.	Oxidation of thiourea by peroxomonosulfate ion catalyzed by a ruthenium(III) complex: kinetic and mechanistic studies	Papiya Sarkar, Debabrata Chatterjee	Transition Metal Chemistry	2016, 41 (1), pp. 9-13
62.	Paper-PDMS hybrid microchannel: a platform for rapid fluid-transport and mixing	Ravi Kumar Arun, Nivedita Priyadarshini, Kaustav Chaudhury, Nripen Chanda, Gautam Biswas, Suman Chakraborty	Journal of Micromechanics and Microengineering	2016, 26 (10), article no. 105008

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63.	Pathways from disordered to ordered nanostructures from defect guided dewetting of ultrathin bilayers	Abhiram Hens, Kartick Mondal, Gautam Biswas, Dipankar Bandyopadhyay	Journal of Colloid and Interface Science	2016, 465, pp. 128-139
64.	Phase field modelling of microstructure evolution and ripening driven grain growth during cooling slope processing of A356 Al alloy	Prosenjit Das, Pradip Dutta	Computational Materials Science	2016, 125, pp. 8-19
65.	Pilot-dynamics coupled finite-volume analysis of main flow transients through a pneumatic pressure-regulating valve	Binod Kumar Saha, Tapas Gangopadhyay, Dipankar Sanyal	Journal of Dynamic Systems Measurement and Control	2016, 138 (2), article no. 021008
66.	Polyaniline/carbon nanotube/CdS quantum dot composites with enhanced optical and electrical properties	Mrinmoy Goswami, Ranajit Ghosh, Takahiro Maruyama, Ajit Kumar Meikap	Applied Surface Science	2016, 364, pp. 176-180
67.	Present status and overview of Chemical Looping Combustion technology	Anirban Nandy, Chanchal Loha, Sai Gu, Pinaki Sarkar, Malay K. Karmakar, Pradip K. Chatterjee	Renewable and Sustainable Energy Reviews	2016, 59, pp. 597-619
68.	Progressive tool flank wear monitoring by applying discrete wavelet transform on turned surface images	Samik Dutta, Surjya K. Pal, Ranjan Sen	Measurement	2016, 77, pp. 388-401
69.	Pulmonary function test using Fiber Bragg grating spirometer	S. Ambastha, S. Umesh, K.U. Maheshwari, S. Asokan	Journal of Lightwave Technology	2016, 34 (24), pp. 5682-5688
70.	Pulse electrocodeposited Ni - WC composite coating	R.N. Gupta, Alok Kumar Das, Nagahanumaiah, Henal Shah	Materials and Manufacturing Processes	2016, 31 (1), pp. 42-47
71.	Real-time underwater image enhancement: An improved approach for imaging with AUV-150	Jeet Banerjee, Ranjit Ray, Siva Ram Krishna Vadali, Sankar Nath Shome, Sambhunath Nandy	Sadhana	2016, 41 (2), pp. 225-238

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72.	Recent developments on synthetic jets	T. Murugan, M. Deyashi, S. Dey, S.C. Rana, P.K. Chatterjee	Defence Science Journal	2016, 66 (5), pp. 489-498
73.	Reliable pose estimation of underwater dock using single camera: a scene invariant approach	Shatadal Ghosh, Ranjit Ray, Siva Ram Krishna Vadali, Sankar Nath Shome, Sambhunath Nandy	Machine Vision and Applications	2016, 27 (2), pp. 221-236
74.	Response surface modeling of Cu(II) removal from wastewater using fishscale-derived hydroxyapatite: application of Box–Behnken experimental design	N. Mandal, S. Mondal, A. Mondal, K. Mukherjee, B. Mondal	Desalination and Water Treatment	2016, 57 (33), pp. 15410-15423
75.	RuIII(edta) catalyzed hydrogenation of bicarbonate to formate	Debabrata Chatterjee, Papiya Sarkar	Journal of Coordination Chemistry	2016, 69 (4), pp. 650-655
76.	Ru-III-edta (edta(4-) = ethylenediaminetetraacetate) mediated photocatalytic conversion of bicarbonate to formate over visible light irradiated non-metal doped TiO_2 semiconductor photocatalysts	T. Mondal, D. Chatterjee	RSC Advances	2016, 6 (68), pp. 63488-63492
77.	Sensitive and fluorescent Schiff base chemosensor for pico molar level fluoride detection: In vitro study and mimic of logic gate function	Pritam Ghosh, Neeraj Kumar, Subhra Kanti Mukhopadhyay, Priyabrata Banerjee	Sensors and Actuators B: Chemical	2016, 224, pp. 899-906
78.	Shape estimation of IPMC actuators in ionic solutions using hyper redundant kinematic modeling	Ritwik Chattaraj, Siladitya Khan, Srijan Bhattacharya, Bikash Bepari, Debabrata Chatterjee, Subhasis Bhaumik	Mechanism and Machine Theory	2016, 103, pp. 174-188
79.	Shedding light on hydroxyquinoline-based ruthenium sensitizers with a long-lived charge carrier to boost photocatalytic H_2 evolution	Indranil Mondal, Amritanjali Tiwari, Rajib Ghosh, Ujjwal Pal	RSC Advances	2016, 6 (47), pp. 41165-41172

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80.	Single-walled carbon nanotube synthesis using Pt catalysts under low ethanol pressure via cold-wall chemical vapor deposition in high vacuum	T. Maruyama, Hiroki Kondo, Ranajit Ghosh, Akinari Kozaw, Shigeya Naritsuk, Yoko Iizumi, Toshiya Okazaki, Sumio Iijima	Carbon	2016, 96, pp. 6-13
81.	Spinel-Structured $NiCo_2O_4$ Nanorods as Energy Efficient Electrode for Supercapacitor and Lithium Ion Battery Applications	Shalini Divya, Remith Pongilat, Tapas Kuila, Kalaiselvi Nallathamby, Suneel Kumar Srivastava, Poulomi Roy	Journal of Nanoscience and Nanotechnology	2016, 16 (9), pp. 9761-9770
82.	Study and preparation of highly water-stable polyacrylonitrile–kraton–graphene composite membrane for bending actuator toward robotic application	Inamuddin, Ajahar Khan, Ravi K. Jain, Mu Naushad	Journal of Intelligent Material Systems and Structures	2016, 27 (11), pp. 1534-1546
83.	Superior performance of asymmetric supercapacitor based on reduced graphene oxide–manganese carbonate as positive and sono-chemically reduced graphene oxide as negative electrode materials	Milan Jana, J. Sharath Kumar, Partha Khanra, Pranab Samanta, Hyeyoung Koo, Naresh Chandra Murmu, Tapas Kuila	Journal of Power Sources	2016, 303, pp. 222-233
84.	Synthesis of MOF templated Cu/CuO@TiO_2 nanocomposites for synergistic hydrogen production	Indranil Mondal, Ujjwal Pal	Physical Chemistry Chemical Physics	2016, 18 (6), pp. 4780-4788
85.	Theoretical evaluation of some benzotriazole and phospono derivatives as aluminum corrosion inhibitors: DFT and molecular dynamics simulation approaches	Savas Kaya, Priyabrata Banerjee, Sourav Kumar Saha, Burak Tüzün, Cemal Kaya	RSC Advances	2016, 6 (78), pp. 74550-74559
86.	Thermo-Magneto-Convective Transport around a Square Cylinder in a Square Duct under Strong Axial Magnetic Field	D. Chatterjee, S.K. Gupta	Journal of Applied Fluid Mechanics	2016, 9 (5), pp. 2167-2175

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87.	Time and temperature depended fuel gas generation from pyrolysis of real world municipal plastic waste	Rohit Kumar Singh, Biswajit Ruj	Fuel	2016, 174, pp. 164-171
88.	Tool condition classification in turning process using hidden Markov model based on texture analysis of machined surface images	Nagaraj N. Bhat, Samik Dutta, Surjya K. Pal, Srikanta Pal	Measurement	2016, 90, pp. 500-509
89.	Tool condition monitoring by SVM classification of machined surface images in turning	Nagaraj N. Bhat, Samik Dutta, Tarun Vashisth, Srikanta Pal, Surjya K. Pal , Ranjan Sen	The International Journal of Advanced Manufacturing Technology	2016, 83 (9-12), pp. 1487–1502
90.	Tool condition monitoring in turning by applying machine vision	Samik Dutta, Surjya K. Pal, Ranjan Sen	ASME Journal of Manufacturing Science and Engineering	2016, 138 (5), Article no. 051008
91.	Tool strain–based wear estimation in micro turning using Bayesian networks	Soumen Mandal, Vimlesh Kumar Sharma, Aniruddha Pal, Nagahanumaiah	Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	2016, 230 (10), pp. 1952-1960
92.	Tool–workpiece contact detection in micro-milling using wireless-aided accelerometer sensor	Sritama Roy, Soumen Mandal, Nagahanumaiah	Proceedings of the Institution of Mechanical Engineers Part B: Journal of Engineering Manufacture	2016, 230 (1), pp. 182-187
93.	Tribological behavior of a 0.33% C dual -phase steel with pre I/C hardening and tempering treatment under abrasive wear condition	N. Shukla, H. Roy, B.K. Show	Tribology Transactions	2016, 59 (4), pp. 593–603
94.	Ultrafast and reversible Gas - Sensing properties of ZnO nanowire arrays grown by hydrothermal technique	Madhumita Sinha, Rajat Mahapatra, Biswanath Mondal, Takahiro Maruyama, Ranajit Ghosh	The Journal of Physical Chemistry C	2016, 120 (5), pp. 3019–3025
95.	Utilisation of skewness of wavelet-based approximate coefficient in walking speed assessment	H. Masum, S. Chattopadhyay, S. Bhaumik, R. Ray	IET Science Measurement & Technology	2016, 10 (8), pp. 977–982

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96.	Zinc oxide thin film based nonenzymatic electrochemical sensor for the detection of trace level catechol	A. Maikap, K. Mukherjee, B. Mondal, N. Mandal	RSC Advances	2016, 6 (69), pp. 64611-64616
97.	Design optimization of Rotary Tiller Blade using specific energy requirement	Subrata Kumar Mandal, Basudeb Bhattacharyya, Somenath Mukherjee, Ashok Kumar Prasad	International Journal of Current Engineering and Technology	2016, 6 (4), pp. 1257-1263
98.	Determining cutting force coefficients from instantaneous cutting forces in ball end milling	Mithilesh K. Dikshit, Asit Baran Puri, Atanu Maity, Amit Jyoti Banarjee	International Journal of Machining and Machinability of Materials	2016, 18 (5-6), pp. 552–571
99.	Dilute acid induced changes on microscopic and Tomographic structure of Water Hyacinth [Eichhornia Crassipes (Mart.) Solms] biomass during	A. Bhattacharya, A.K. Sadhukhan, A. Ganguly, P.K. Chatterjee	Indian Journal of Science & Technology	2016, 9 (6), pp. 1-9
100.	Disposal problem of Arsenic sludge generated during arsenic removal from drinking water	Prasanta Mandal, S.R. Debbarma, Arup Saha, Biswajit Ruj	Procedia Environmental Sciences	2016, 35, pp. 943–949
101.	Effect of the femoral stem size on femur bone quality towards THR	Palash Kumar Maji, Amit Roy Chowdhury, Debasis Datta, S. Karmakar, Subhomoy Chatterjee, A.K. Prasad	Indian Journal of Basic and Applied Medical Research	2016, 5 (3), pp. 130-136
102.	Failure Investigation of a Cage Suspension Gear Chain used in Coal Mines	Debashis Ghosh, Shamik Dutta, Awdhesh Kumar Shukla, Himadri Roy	Journal of The Institution of Engineers (India): Series D	2016, 97 (2), pp. 255-262
103.	In-situ hydrothermal synthesis of MnO_2/NiO@Ni hetero structure electrode for hydrogen evolution reaction and high energy asymmetric supercapacitor applications	Sanjit Saha, Suman Chhetri, Partha Khanra, Pranab Samanta, Hyeyoung Koo, Naresh Chandra Murmu, Tapas Kuila	Journal of Energy Storage	2016, 6, pp. 22-31

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104.	Investigations on microbial fermentation of Hemicellulose hydrolysate for Xylitol production	A. Bhattacharya, A.K. Sadhukhan, A. Ganguly, P.K. Chatterjee	Banat's Journal of Biotechnology	2016, VII (14), pp. 13-23
105.	Lignin degradation in the production of bioethanol – A review	Anuradha Mukherjee, Tamal Mandal, Amit Ganguly, Pradip K. Chatterjee	ChemBioEng Reviews	2016, 3 (2), pp. 86-96
106.	Micro manipulation by a compliant piezoelectric micro gripper towards robotic micro assembly	Ravi Kant Jain, Somajyoti Majumder, Bhaskar Ghosh, Surajit Saha	International Journal of Mechatronics and Manufacturing Systems	2016, 9 (1), pp. 3--23
107.	Modelling analysis of silica gel / water adsorption chiller systems: A review	Dipak Pandit, Biplab Choudhury, Jyoti P. Sarkar	International Journal of Research and Scientific Innovation	2016, III (VI), pp. 18-26
108.	Optimization of process parameters for catalytic conversion of solid bio-waste during thermophilic anaerobic digestion	Amit Ganguly, Richard Blankchard, Andrew Wheatley, Pradip Kumar Chatterjee	Procedia Environmental Sciences	2016, 35, pp. 763-770
109.	Phase formation behavior and hydrogen sensing characteristics of Iron Oxide nano -Particles synthesized by modified Pechini Route	A.Ghosh, A.K.K. Atyam, K. Mukherjee	Materials Focus	2016, 5 (2), pp. 119-122
110.	Plasticwaste management and disposal techniques - Indian scenario	Rohit Kumar Singh, Biswajit Ruj	International Journal of Plastics Technology	2016, 19 (2), pp.211-226
111.	Review on experimental study of Nd:YAG laser beam welding, with a focus on aluminium metal matrix composites	Amit Jyoti Banerjee, Manoja Kumar Biswal, A.K. Lohar, H. Chattopadhyay, Naga Hanumaiah	International Journal of Engineering & Technology	2016, 5 (3), pp. 92-101
112.	Role of remote sensing and GIS in agriculture	Subrata K. Mandal, A. Maity, Ashok Prasad	International Journal of Advances in Agricultural	2016, 1 (1), pp. 10-14
113.	Study of gasoline fuel blended with composite additive by chemical analysis	Amit R.Patil, Satish. S. Ragit, Krishnendu Kundu	Science International Journal of Latest Trends in Engineering and Technology	2016, 7 (2), pp. 93-97

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114.	Surface roughness prediction model using Zirconia Toughened Alumina (ZTA) turning inserts: Taguchi method and regression analysis	Nilrudra Mandal, B. Doloi, B. Mondal	Journal of The Institution of Engineers (India): Series C	2016, 97 (1), pp. 77-84
115.	Terrainability of mobile robots in underground mining	Anil Kumar Saw, Atanu Maity	Asian Journal of Current Engineering and Maths	2016, 5 (1), pp. 4-8
116.	Unsteady CFD simulation of 3D AUV hull at different angles of attack	S. Ray, D. Chatterjee, S. Nandy	Journal of Naval Architecture and Marine Engineering	2016, 13 (2), pp. 111-123

Journal Publications: 2017 (Upto March)

Sl.	Title	Authors	Journal	Details
1.	A Carrier-Based PWM Scheme for Neutral Point Voltage Balancing in Three-Level Inverter Extending to Full Power Factor Range	Santu Kr. Giri, Sibaprasad Chakrabarti, Subrata Banerjee, Chandan Chakraborty	IEEE Transactions on Industrial Electronics	2017, 64 (3), pp. 1873-1883
2.	A novel ditopic chemosensor for cadmium and fluoride and its possible application as a pH sensor	Additi Roy Chowdhury, Pritam Ghosh, Suparna Paul, Samuzal Bhuyan, Jagadeesh C. Bose K, Sudit Mukhopadhyay, Priyabrata Banerjee	Analytical Methods	2017, 9 (1), pp. 124-133
3.	A novel lattice energy calculation technique for simple inorganic crystals	Cemal Kaya, Savaş Kaya, Priyabrata Banerjee	Physica B: Condensed Matter	2017, 504, pp. 127-132
4.	A simple cleft shaped hydrazine-functionalized colorimetric new Schiff base chemoreceptor for selective detection of F^- in organic solvent through PET signaling: Development of a chemoreceptor based sensor kit for detection of fluoride	Additi Roy Chowdhury, Biswajit Gopal Roy, Saibal Jana, Thomas Weyhermuller, Priyabrata Banerjee	Sensors and Actuators B: Chemical	2017, 241, pp. 706-715

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5.	A successive ionic layer adsorption and reaction (SILAR) method to fabricate a layer-by-layer (LbL) MnO_2-reduced graphene oxide assembly for supercapacitor application	Milan Jana, Sanjit Saha, Pranab Samanta, Naresh Chandra Murmu, Nam Hoon Kim, Tapas Kuila, Joong Hee Lee	Journal of Power Sources	2017, 340, pp. 380–392
6.	Bayesian network aided grasp and grip efficiency estimation using a smart data glove for post-stroke diagnosis	Debeshi Dutta, Satyanarayan Modak, Anirudh Kumar, Joydeb Roychowdhury, Soumen Mandal	Biocybernetics and Biomedical Engineering	2017, 37 (1), pp. 44–58
7.	Chemi-resistive response of rutile titania nano-particles towards isopropanol and formaldehyde: a correlation with the volatility and chemical reactivity of vapors	P. Das, B. Mondal, and K. Mukherjee	Materials Research Express	2017, 4 (1), Article no. 015503
8.	Enhancement of fault diagnosis of rolling element bearing using maximum kurtosis fast nonlocal means denoising	S.K. Laha	Measurement	2017, 100, pp. 157-163
9.	Genesis of flake-like morphology and dye-sensitized solar cell performance of Al-doped ZnO particles: a study	D. Sengupta, B. Mondal, K. Mukherjee	Journal of Nanoparticle Research	2017, 19:100 (13 pages)
10.	Linear detection of a weak signal in additive cauchy noise	Siva Ram Krishna Vadali, Priyadip Ray, Subrahmanyam Mula, Pramod K. Varshney	IEEE Transactions on Communications	2017, 65 (3), pp. 1061-1076
11.	Micro-EDM multiple parameter optimization for Cp titanium	Vijay Kumar Meena, Man Singh Azad, Suman Singh, Narinder Singh	International Journal of Advanced Manufacturing Technology	2017, 89 (1), pp, 897-904
12.	Nitroaromatic explosives detection by a luminescent Cd(II) based metal organic framework	Shibashis Halder, Pritam Ghosh, Corrado Rizzoli, Priyabrata Banerjee, Partha Roy	Polyhedron	2017, 123, pp. 217–225

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13.	Numerical prediction of flow and heat transfer characteristics of water-fly ash slurry in a 180° return pipe bend	Bibhuti Bhusan Nayak, Dipankar Chatterjee, Amar Nath Mullick	International Journal of Thermal Sciences	2017, 113, pp. 100-115
14.	Probabilistic assessment of UPV test result of a degasser unit	Abhijit Chatterjee, Debashis Das, Anup Kumar Sadhukhan, Pradip Kumar Chatterjee	Journal of Nondestructive Evaluation	2017, 36:18 (10 pages)
15.	Robust control of non-holonomic wheeled mobile robot with past information: theory and experiment	Spandan Roy, Sambhunath Nandy, Indra Narayan Kar, Ranjit Ray, Sankar Nath Shome	Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering	2017, 231 (3), pp. 178-188
16.	Simultaneous adsorption-desorption processes in the conductance transient of anatase titania for sensing ethanol: A distinctive feature with kinetic perception	Priyanka Das, Biswanath Mondal, Kalisadhan Mukherjee	Journal of Physical Chemistry C	2017, 121 (2), pp. 1146–1152
17.	Thorium (IV) phosphate-polyaniline composite-based hydrophilic membranes for bending actuator application	Ajahar Khan, Inamuddin, Ravi Kant Jain, Abdullah M. Asiri	Polymer Engineering & Science	2017, 57 (3), pp. 258-267
18.	UCGNet: wireless sensor network-based active aquifer contamination monitoring and control system for underground coal gasification	Rajesh P. Barnwal, Sujeet bharti, Sudip Misra, Mohammad S. Obaidat	International Journal of Communication Systems	2017, 30 (1), article no. e2852
19.	Understanding the structural and electronic effect of Zr^{4+} -Doped $KNb(Zr)O_3$ Perovskite for enhanced photoactivity: A combined experimental and computational study	Indranil Mondal, Malladi Srikanth, Kancharlapalli Srinivasu, Yarasi Soujanya, Ujjwal Pal	Journal of Physical Chemistry C	2017, 121 (5), pp. 2597–2604
20.	Effect of experimental variables of abrasive wear on 3D surface roughness and wear rate of Al –4.5 % Cu alloy	Debashis Ghosh, Manab Mallik, Nilrudra Mandal, Samik Dutta, Himadri Roy, Aditya Kumar Lohar	Journal of The Institution of Engineers (India): Series D	2017, 98 (1), pp. 27–36

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21.	Establishing correct coal quality for achieving optimum boiler efficiency & performance – a case study in the Indian utility industry	Ashok Sarkar, Prabhansu, Abhijit Chatterjee, Anup Kumar Sadhukhan, Pradip Kumar Chatterjee	International Journal of ChemTech Research	2017, 10 (2), pp. 121-131
22.	Modeling of closed-die forging for estimating forging load	Debashish Sheth, Santanu Das, Avik Chatterjee, Anirban Bhattacharya	Journal of The Institution of Engineers (India): Series C	2017, 98 (1), pp. 53-61

Chapter Contribution to Books

1.	Suman Chhetri, Tapas Kuila, and Naresh Chandra Murmu, "Graphene Composites" in "Graphene Technology - From Laboratory to Fabrication"; Eds: Soroush Nazarpour and Stephen Waite. Publisher: Wiley-VCH Verlag GmbH & Co. KGaA, July 2016, ISBN: 978-3-527-33833-7.
2.	Atanu Saha, "Boiler tube failures – Some case studies " in " Handbook of Materials Failure Analysis with Case Studies from the Chemicals, Concrete and Power Industries"; Edited by Abdel Salam Hamdy Makhlouf and Mahmood Aliofkhazraei. Publisher: Elsevier, 2016, ISBN: 978-0-08-100116-5.

Conference Papers: April 2016 – March 2017

Sl.	Title of the paper	Authors	Conference	Date	Place
1.	Dehalogination and energy recivery from waste PVC through catalytic pyrolysis	Patrali Mukherjee, Biswajit Ruj	International Conference on Waste Management RECYCLE-2016	April 01-02, 2016	IIT, Guwahati, Assam
2.	Process of solidify Arsenic-waste generated from Arsenic removal plant and converting it into a useable product	Prasanta Mandal, S.R. Debbarma, Biswajit Ruj			
3.	Enhancing reliability of vehicular participatory sensing network: A bayesian Approach	Rajesh R. Barnwal, Nirnay Ghosh, Soumya K. Ghosh, Sajal K. Das	IEEE International Conference on Smart Computing (SMARTCOMP 2016)	May 18-20, 2016	St. Louis, Missouri, USA

Sl.	Title of the paper	Authors	Conference	Date	Place
4.	Investigation of supercapacitor performances of hydrothermally synthesized Fe_3O_4/RGO	Sanjit Saha, Pranab Samanta, Naresh Chandra Murmu, Nam Hoon Kim, Tapas Kuila, Joon Hee Lee	International Hybrid Materials Conference 2016	May 19-20, 2016	Jeonju-561756, South Korea
5.	Electrochemical detection of phenolic compounds using tyrosinase modified glassy carbon electrode	A. Maikap, N. Mandal, K. Mukherjee, B.N. Mondal	International Conference on Nanotechnology for Better Living	May 25-29, 2016	National Institute of Technology, Srinagar
6.	Direct Numerical Simulation of evaporation in biporous media	Bharat Bhusan Sharma S.K. Samanta, H. Chattopadhyay, Gautam Biswas	Joint 18th International Heat pipe Conference and 12th International Symposium	June 12-16, 2016	Jeju, Korea
7.	Thin film anti friction carbon nano coatings for advanced industrial application	Santosh Singh, Amit Banerjee, Debajyoti Das, R.R. Sahoo	National conference on Nanotechnology: Materials and Applications (NCoN:M&A 2016)	June 16-17, 2016	Jadavpur University, Kolkata
8.	Explosive detection from water LMOCs: in vitro detection and fabrication of handy pocket device	Pritam Ghosh, Priyabrata Banerjee	19th CRSI National Symposium in Chemistry (CRSI-NSC 19)	July 14-16, 2016	University of North Bengal, Darjeeling
9.	Structural feature and due sensitised solar cell performance of hydrothermally grown hierarchical zinc oxide	Manoja Kumar Biswal, Angela Msipha, Amit Jyoti Banerjee, A.K. Prasad, S. Kundu			
10.	Optimisation of Nd:YAG laser parameters for cutting of thick steel sheet using Taguchi's design of experiments	Priyanka Das, Biswanath Mondal, Kalisadhan Mukherjee	International Conference on Advance Materials and Manufavturing Applications	July 15-16, 2016	Bangalore, India

Sl.	Title of the paper	Authors	Conference	Date	Place
11.	Case studies on application of rapid prototyping technology	Palash Kr. Maji, Atanu Maity, Sankar Karmakar, Ashok Kumar Prasad, Subrata Kr. Mandal	National Workshop and Training Programme on Investment Casting Process Technology	September 01-02, 2016	CSIR-CMERI, Durgapur
12.	Manufacturing of special feature for metallic biomedical implant	A.K. Prasad, P.K. Maji, Praveen Kumar, S.K. Mondal	National Workshop on Machining & Machinability of Advanced Materials (NWMMAM-2016)	September 29-30, 2016	CSIR-CMERI, Durgapur
13.	Manufacturing of free from surface - a case study	Sankar Karmakar, S.A. Mondal, S.Y. Pujar, P.K. Maji			
14.	Predictive modeling of surface roughness and chip reduction coefficient (CRC) in high speed machining of AISI 4340 steel using zirconia Toughened Alumina ceramics inserts	B.K. Singh, B. Mondal, Nilrudra Mandal			
15.	Efficient anticorrosive properties of novel schiff base molecules on the mild steel surface in 1 M HCl medium: Experimental and theoretical approach	Sourav Kr. Saha, Manilal Murmu, N.C. Murmu, Priyabrata Banerjee	Recent Developments in Chemistry	October 04-06, 2016	NIT Durgapur
16.	Fabrication of screen-printed electrodes and their applications for low cost amperometric immuno sensing	Kaya Layek, Kalyan Kumar Mistry, Nagahanumaiah			
17.	Detection of explosive and pollutant nitroaromatics by LMOCs	Pritam Ghosh, Additi Roycjowdhury, N.C. Murmu, Priyabrata Banerjee			

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18.	Grafting of -SO_3H functionalities over reduced graphene oxide through a non-covalent surface functionalization to prepare redox dominant supercapacitor electrodes	Milan Jana, Pranab Samanta, N.C. Murmu, Tapas Kuila	National Symposium on Chemistry and the Environment (CE-2016)	October 21-23, 2016	Department of Chemistry, Raja N.L. Khan Women's College, Midnapur
19.	Effect of carbon-carbon chain length on the lubricating ability of alkylated reduced graphene oxide	Suprakash Samanta, Rashmi R. Sahoo			
20.	A discontinuous PWM scheme for capacitor voltage balancing in three level NPC traction inverter drive	Sarbani Mukherjee, Santu Kr. Giri, Subrata Banerjee	The 42nd Annual Conference of IEEE Industrial Electronics Society, 2016	October 23-27, 2016	Florence, Italy
21.	Flow of solids through L-valves in a lab scale dual fluidized bed cold model system	Malay Karmakar, Andrew N. Rollinson, Arijit patra, Ashis Mukherjee, Pradip Kr. Chatterjee	International Conference on Recent Trends in Engineering and Technology	October 25-27, 2016	St. Peter's Engineering College, Hyderabad
22.	Community purpose groundwater iron removal technology and field demonstration in Bankura dist. of West Bengal	Biswajit Ruj, Arup Saha	24th West Bengal State Science and Technology Congress	November 07-08, 2016	Bankura Christian College, Bankura
23.	Application of h-BN/rGO superlattice as high energy supercapacitor electrode	Sanjit Saha, Pranab Samanta, Naresh Chandra Murmu, Tapas Kuila	International Conference on Technologically Advanced Materials & Asian Meeting on Ferroelectricity	November 07-11, 2016	University of Delhi, New Delhi

Sl.	Title of the paper	Authors	Conference	Date	Place
24.	Experimental studies on biomethanation process in a batch anaeribic digester using natural substrates	Amit Ganguly, Biplab Roy, Richard Blanchard, Sharmistha Biswas, Pradip Kr. Chatterjee, Gopinath Halder	International Conference on Solid Waste Management	November 24-26, 2016	Jadavpur University, Kolkata
25.	Production of ethanol from waste potato using locally available biocatalyst	Amit Ganguly, Esha Bala, Priyabrata Banerjee, Richard Blanchard, Pradip Kr. Chatterjee			
26.	Safe disposal of hospital waste - a review	Priyabrata Banerjee, Nirmal Paul, Amit Ganguly, Subrata Mondal, Bishnu Pada Mukherjee, Pradip Kr. Chatterjee			
27.	Solid waste management: A brief review	Priyabrata Banerjee, Pritam Ghosh, Abhijit Hazra, Amit Ganguly, Naresh Chandra Murmu, Pradip Kr. Chatterjee			
28.	Rapid Prototyping integrated investment casting: Case study	Ved Prakash, A.K. Lohar	National Conference on Emerging Technologies in Foundry & Forge Technologies (NCETFF-2016)	November 25-26, 2016	NIFFT, Ranchi
29.	Graphene based water lubricant and its tribological performance	Nitai Chandra Adak, Milan Jana, N.C. Murmu, Tapas Kuila, Pranab Samanta	12th International Oil & Gas Conference and Exhibition (PETROTECH-2016)	December 05-07, 2016	New Delhi, India

Sl.	Title of the paper	Authors	Conference	Date	Place
30.	Energy efficient wireless sensor network for vibration based structural health monitoring	Saikat Kr. Shome, S. Sen, Uma Dutta	Young Scientist Conclave in conjunction with "India International Science Festival 2016"	December 7-11, 2016	CSIR-NPL, New Delhi
31.	Design and development of rectangular Grass Bundling Machine	Man Singh Azad, Dilip Kumar Biswas, Santosh Kumar Das	India International Science Festival (IISF) - Young Scientists' Conclave (YSC)	December 08-11, 2016	National Physical Laboratory, New Delhi
32.	Lubricating perpormance of alkylated reduced graphene oxide in oil suspensions	Suprakash Samanta, Rashmi Ranjan Sahoo	National Tribology Conference	December 08-10, 2016	Department of Mechanical Engineering, Swantrata Bhawan, BHU
33.	A modified DPWM scheme for capacitor voltage balancing in three level NPC traction inverter for electric vehicles	Sarbani Mukherjee, Santu Kr. Giri, Subrata Banerjee	IEEE International Conference on Power Electronics and Energy Systems	December 14-17, 2016	Hotel Uday Samudra, Kovalam, Kerala
34.	Production of bioethanol and biogas from mixed indigenous algae: A potential source of third generation biofuel	M. Roy, K. Kundu	Green Technology for Health and Environment: Implementations and Policies	December 15-16, 2016	Bangalore
35.	Microbial pretreatment of biomass for enhanced biogas production	A. Kaur, K. Kundu, M. Roy			
36.	Flow and thermal characteristics of synthetic jet as low actuation frequencies	Mohnish Kapil, Durbar Roy, Bishwajit Sharma, Murugan Thangadurai	6th International & 43rd National Conference on Fluid Mechanics and Fluid Power	December 15-17, 1016	Motilal Neheru National Institute of Technology, Allahabad, U.P.
37.	Modelling of powder stream dynamic using Lagrangian-Eulerian approach in direct metal deposition process	Piyush Pant, Dipankar Chatterjee, Sudip Kumar Samanta, Aditya Kumar Lohar, Titas Nandi			

Sl.	Title of the paper	Authors	Conference	Date	Place
38.	Optimization of driver section length of an openended shocktube to generate blast	Santanu Dey	6th International & 43rd National Conference on Fluid Mechanics and Fluid Power	December 15-17, 1016	Motilal Neheru National Institute of Technology, Allahabad, U.P.
39.	Particle image velocimetry study of insect based flapping wing machanism in Hover	Abhishek Chatterjee, Murugan Thangadurai			
40.	Tensile behaviour of Laser welded Al-Mg-Sc-Zr in situ nano TiB_2, Reinforced metal matrix composite	Amit Jyoti Banerjee, Himadri Roy, Manoja Kumar Biswal, A.K. Lohar, Himadri Chattopadhyaya, Nagahanumaiah	National Welding Seminar (NWS 2016)	December 15-17, 2016	Science City, Kolkata
41.	Effect of ceria (CeO_2) and Yttria (Y_2O_3) coating on high temperature corrosion resistance of 2.25 Cr-1 Mo steel in SO_2+O_2 atmosphere	D. Ghosh, S. Das, S.K. Mitra	31st Indian Engineering Congress, The Institution of Engineers (Kolkata), 2016	December 15-18, 2016	Hotel J.U. Merriot, Kolkata
42.	A piezoelectric actuator based compact miniature manipulation system for robotic assembly	R.K. Jain, S. Majumder, Bhaskar Ghosh, Surajit Saha	6th International & 27th All India Manufacturing Technology, Design and Research Conference (AIMTDR-2016)	December 16-18, 2016	College of Engineering, Pune, Maharashtra
43.	Investigation of surface quality of blind micro holes on titanium Ti-6Al-4V super alloy in micro EDM using electrodes of different materials	Swapan Barman, Ram Prakash Sharma, Abhijit Mondal, Asit Baran Puri, Nagahanumaiah			
44.	Investigation on machining characteristics in mechanical micro milling of amorphous alloy	Debajyoti Ray, A.B. Puri, Nagahanumaiah, S. Halder			
45.	Rotary Tiller blade design using specific energy requirement	Subrata Kr. Mandal, Basudeb Bhattacharyya, Somenath Mukherjee, Atanu Maity	ETAE 2016 (Emerging Technologies in Agricultural Engineering)	December 27-30, 2016	IIT, Kharagpur

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46.	Cascade voltage control of three phase four leg inuerter for off grid solar photovoltaic applications	Ikkurti Saichaitanya, Khanumanth Prasad Ikkurti	1st Springer International Conference on Emerging Trends and Advances in Electrical Engineering and Renewable Energy	December 17-18, 2016	Sikkim Manipal Institute of Technology, Majitar, Rangpo, East Sikkim, Sikkim
47.	Anti friction diamond -like carbon nano coatings for advanced tribilogical applications	Santosh Singh, R.R. Sahoo	61st DAE Solid State Physics Symposium	December 26-30, 2016	KIIT University, Bhubaneswar, Odisha
48.	Redox switchable luminescent metal organic complexes for detection of explosive TNP	Pritam Ghosh, N.C. Murmu, Priyabrata Banerjee	Symposium on Advanced Biological Inorganic Chemistry	January 07-11, 2017	Kolkata
49.	Use of chemosensor for application in bio medical field: facets of synthetic chemistry in cell	Pritam Ghosh, Priyabrata Banerjee	Facets of Chemistry in Biology, FOCB-II, 2017	January 12, 2017	St. Xaviers College, Kolkata
50.	Micro fuel cell	Ravi Kumar Arun, Vinay Gupta, Gagan kumar, Masoom Haider, Nripen Chanda	International Conference on "Sustainable Development for Energy and Environment"	January 16-17, 2017	CSIR-NCL, Pune
51.	Detection of Alzheimer's disease in brain MRI using fractal analysis	Srinivasan Aruchamy, Partha bhattacharjee, Goutam Sanyal	2nd International Conference on Sustainable Computing Techniques in Engineering	January 27-28, 2017	JAIN college of Engineering, Belgaum
52.	Effect of wetting behavior of functionalization graphene oxide on lubrication of dry contact	Suprakash Samanta, Rashmi Ranjan Sahoo	National Conference on Advanced Functional Materials, Processing and Manufacturing (NCAFMPM - 2017)	February 02-03, 2017	CSIR-CMERI, Durgapur

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53.	A multiphase flow model of solidification of Al-15Mg_2Si- 4.5Si composite	Chayan Das, Prosenjit Das	National Conference on Advanced Functional Materials, Processing and Manufacturing (NCAFMPM - 2017)	February 02-03, 2017	CSIR-CMERI, Durgapur
54.	Investigation of mechanical properties of non-covalently functionalized reduced graphene oxide/epoxy composites	Suman Chhetri, Nitai Chandra Adak, Pranab Samanta, Naresh Chandra Murmu, Tapas Kuila			
55.	Investigation of microstructure and mechanical properties of Rheocast Al - 15Mg_2Si -4.5Si composite	Subrata Sarkar, Prosenjit Das			
56.	Growth of Ni-Co-Binary hydroxide reduced graphene oxide over nickel foam substrate by a facile successive ionic layer adsorption and reaction (SILAR) method for supercapacitor applications	Milan Jana, Shatarupa Chandra, Pranab Samanta, N.C. Murmu, Tapas Kuila			
57.	Microscale centre crack growth studies in Rheocast A356 Al alloy using Extended Finite Element method	Prabhas Banerjee, Sk. Tanbir Islam, Santanu Das, Prosenjit Das			
58.	N-doped nano graphite sheet for energy storage applications	Sanjit Saha, Pranab Samanta, Naresh Chandra Murmu, Tapas Kuila			
59.	One pot synthesis of Cu_2O/RGO composites using clove extract for electrochemical sensing of hydrogen peroxide	J. Sharath Kumar, Jolly Balel, Pranab Samanta, N.C. Murmu, Tapas Kuila			

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60.	Removal of Cu(II) iron from water using wet chemically synthesized hydroxy apatite (HAP) adsorbent: Study	Md. Nadir, B.K. Singh, K. Mukherjee, B. Mondal, K. Adhikari, Nilrudra Mandal	National Conference on Advanced Functional Materials, Processing and Manufacturing (NCAFMPM - 2017)	February 02-03, 2017	CSIR-CMERI, Durgapur
61.	Studies on co-gasification of biomass in a bubbling fluidized bed reactor	Munna Verma, Chanchal Loha, Amar Nath Sinha, Pradip Kumar Chatterjee			
62.	Study the effect of working electrode ink curing temperature during fabrication of screen-printed electrode based	Tarak Nath Chell, Uma Datta, Kalyan Kumar Mistry			
63.	Synthesis of TiO_2-polyaniline composite and case study on ammonia sensing at room temperature	Priyanka Das, B. Mondal, A. Maikap, K. Mukherjee			
64.	Towards the development of filtration unit for defluoridation of water	P. Das, K. Mukherjee, A.K. Batabyal, N. Mandal, P. Banerjee, P. Chowdhury, B. Mondal			
65.	Theoretical studies on the corrosion inhibition performance of quinazolinone and pyrimidinone molecule on mild steel in H_2SO_4 medium: density functional theory and molecular dynamic simulation approaches	Sourav Kr. Saha, Manilal Murmu, N.C. Murmu, Priyabrata Banerjee	20th CRSI National Symposium in Chemistry	February 02-05, 2017	Department of Chemistry, Gauhati University, Guwahati, Assam
66.	A preliminary numerical investigation of a	Mohnish Kapil, Biswajit Sharma, Durbar Roy, T. Murugan	IEEE International Conference on advances in mechanical, Industrial, Automation and Management Systems	February 03-05, 2017	MNNIT, Allahabad, India

Sl.	Title of the paper	Authors	Conference	Date	Place
67.	Numerical Simulation of powder flow and laser-substrate interaction in a multi channel coaxial nozzle DMD Process	Piyush Pant, Dipankar Chatterjee, Sudip Kumar Samanta, Aditya Kumar Lohar, Titas Nandi	65th Indian Foundry Congress	February 03-05, 2017	Eco Park, Kolkata
68.	Development of a 2-Row tractor mounted sugarcane cutter planter for sugarcane plantation	Subrata Kr. Mandal, Atanu Maity	11th All India Peoples' Technology Congress	February 04-05, 2017	Kolkata
69.	A study on finding optimal ANN model for rock mass classification	Vitthal Khatik, Arup Kr. Saha, Leeladhar Rajput	International Conference on NexGen Technologies for Mining & Fuel Industries (NxGnMiFu - 2017)	February 15-17, 2017	Vigyan Bhawan, New Delhi
70.	Effect of heating rates on devolatilization behaviour of Indian coals	M.K. Karmakar, C. Loha, Prabhansu, P.K. Chatterjee			
71.	Mathematical modeling of underground coal gasification (UCG) Process: A Review	Dipankar Chatterjee			
72.	DDA@GO composite: a future in tribological engineering	Pritam Ghosh, Vaibhav Pandey, Debanjan Dey, Soumen Basu, N.C. Murmu, Priyabrata Banerjee	International Conference on Advances in Biological Systems and Materials Science in Nano World	February 19-22, 2017	IIT - BHU, Varanasi
73.	One pot synthesis of Cu_2O-RGO composite using mango bark for supercapacitor application	J. Sharath Kumar, Milan Jana, Pranab Samanta, N.C. Murmu, Tapas Kuila	International Conference on Nano for Energy and Water (NEW-2017) & Indo-French workshop on water networking	February 22-24, 2017	Universities of Petrolium and Energy Studies (UPES), Dehradun, Uttarakhand
74.	मेक इन इंडिया मिशन के अन्तर्गत सूक्ष्म और लघु स्तर के घटकों और कलपुर्ज़ों को जोड़ने के लिए सूक्ष्म कार्यसाधन का बिकास	Rabi Kant Jain, Sarbari Dutta, Vijay, Surajit Saha, Bhaskar Ghosh	National Seminar on 'Make In India'	February 26-27, 2017	CSIR-CMERI, Durgapur

Sl.	Title of the paper	Authors	Conference	Date	Place
73.	सूक्ष्म ईंधन सेल	Ravi Kumar Arun, Gagan Kumar, Vijay, Nripen Chanda	National Seminar on 'Make In India'	February 26-27, 2017	CSIR-CMERI, Durgapur
74.	टाइटेनियम मिश्र धातु (Ti-6A1-4V) पर सूक्ष्म मिलिंग प्रक्रिया द्वारा बिभिन्न क्रटर की ज्यामिति के मौलिक-लक्षण, आकार प्रभाव और सतह की गुणवत्ता का अध्ययन करना	S. Barman, Vijay, Nagahanumaiah			
75.	जेब चिकित्सा अनुप्रयोगों में सीएडी और रैपिड प्रोटोटाइपिंग प्रद्योगिकी	Palash Kumar Maji, Partha Sarathi Banerjee, A.K. Prasad			
76.	स्थिर तथा सहवहन तरल माध्यम में गैस बुलबुले के गठन की सीएफडी (CFD) मॉडलिंग	Bijay Kumar Prasad, Dipankar Chatterjee, Satya Prakash Singh			
77.	सौर शक्ति बृक्ष	S.N. Maity, Santosh Kumar Das			
78.	घास बंनडलिंग मशीन का डच़ाइन और बिकाश	Man Singh Azad, Dilip Kumar Biswas, Santosh Kumar Das			
79.	पाइप से बिभिन्न गुरुत्वाकर्षण के बैल्युज के लिए डेन्स स्लरी के प्रबाह का न्यूमेरिकल मॉडलिंग	Satya Prakash Singh			
80.	अत्मंत ननम्न ऊर्जा कज उत्नजदक के लरए नीज़ोएरेक्ट्रिक ऊर्जा संयण औय इसकज उन्मोग	P.K. Sahu, K.J. Uke, U. Dutta			
81.	Investigations on co-pyrolysis characteristics of coal-biomass blends using TGA	Munna Verma, Chanchal Loha, Amar Nath Sinha, Pradip Kumar Chatterjee	International Conference on Sustainable Energy and Environmental Challenges	February 26–28, 2017	Centre for Innovative and Applied Bio-processing, Mohali, India

Sl.	Title of the paper	Authors	Conference	Date	Place
82.	Numerical analysis to study hydrodynamic behavior of bubbling fluidized bed System	Sourav Ganguly, Malay Kr. Karmakar, Pradip Kr. Chatterjee	International Conference on Energy and Environmental	February 26-28, 2017	Mohali, India
83.	Design & development of wireless sensor network for vibration based structural health monitoring	Saikat Kr. Shome, Siddheswar Sen, Uma Datta	24th West Bangal State Science and Technology Congress, Govt. of WB	February 28- March 01, 2017	Science City, Kolkata
84.	Rheological behaviour of 316L stainless steel feedstock for μ-MIM	Sk. Tanbir Islam, Sudip Kumar Samanta, Nagahanumaiah, Himadri Roy, Aditya Kumar Lohar, S. Das, A. Bandyopadhyay	International Conference on Emerging Trends in Materials and Manufacturing Engineering (IMME 17)	March 10-12, 2017	Tiruchirapalli, TN, India

IP Portfolio

Patent Filed		
Sl.	**Title**	**Inventors**
1.	Salivary fluoride detection: An indigenous way to diagnose human fluorosis.	Priyabrata Banerjee, Pritam Ghosh, Naresh Chandra Murmu, Subhasis Biswas
2.	Four axis controller for multi-process micro- fabrication machine.	Soumen Mandal, Kalyan Chatterjee, Nagahanumaiah, Saurav Halder, Aniruddha Pal, Sucharita Saha, Nisha Burman, Aman Arora, Anirudh Kumar
3	Arsenic water filtration device, method and nano metal-oxides coated rice husk char as adsorbent medium therfor	Nripen Chanda, Nagahanumaiah, Vimlesh K. Sharma, Peuli Nath, Ravi Kumar Arun, Biswajit Ruj, Swarup R. Debbarma
4.	Development of scaled-up graphite oxide production technology starting from natural flake graphite	Tapas Kuila, Milan Jana, Pranab Samanta, Naresh Chandra Murmu
5.	Zinc oxide based electrochemical test strip and analogous readout meter for the quantitative detection of catechol	Abhisek Maikap, Kalisadhan Mukherjee, Biswanath Mondal, Nilrudra Mandal
6.	Asymmetric supercapacitor of sulfanilic acid azochromotrop functionalized reduced graphene oxide/hexagonal boron nitride superlattice	Tapas Kuila, Sanjit Saha, Pranab Samanta, Naresh Chandra Murmu
7.	Fast charging and storage unit for bi-cycle lighting	Tapas Kuila, Milan Jana, Pranab Samanta, Naresh Chandra Murmu, Subhasis Biswas

Patent Filed		
Sl.	**Title**	**Inventors**
8.	Development of Domestic Iron Removal Filter (PROVISIONAL)	Biswajit Ruj, Arup Saha, Rishaprava Chatterjee
9.	The process of making highly sensitive screen printed electrode for the detection of redox substances	Kalyan Kumar Mistry, Abhijit Mahapatra
10.	Vanadium based Redox Fuel Cell (PROVISIONAL)	Ravi Kumar Arun, Nripen Chanda, Aman Arora, Nagahanumaiah, Gagan Kumar, Vijay
11.	Preparation of COF@bio composite for spilled diesel clean up from water surface	Priyabrata Banerjee, Pritam Ghosh, Debanjan Dey, Naresh Chandra Murmu
12.	Aqueous phase fluoride detection by suitable cost effective non corrosive Schiff base type chemosensor	Priyabrata Banerjee, Pritam Ghosh, Suparna Paul, Asit Kumar Batabyal, Naresh Chandra Murmu

Copyright Filed		
Sl.	**Title**	**Inventors**
1.	Drawing for development of Wireless Mobile Manipulation System	Ravi Kant Jain, Somajyoti Majumder, Surjit Saha, Bhaskar Ghosh
2.	Wireless sensing module for vibration monitoring of structures.	Uma Datta, Siddheswar Sen, Arpita Mukherjee, Saikat Kumar Shome, Bipul Kumar, Sushil Murmu, Pradyumna Kumar Sahu, Pratap Karmakar
3.	Precision positioning system with constant current micro-stepping control	Arpita Mukherjee, Uma Datta, Pratap Karmakar, Siddheswar Sen, Bipul Kumar, Saikat Kumar Shome, Sushil Murmu, Pradyumna Kumar Sahu, Somnath Chatterjee, Shantanu Kumar Naskar, Rabisankar Mandal
4.	Solar panel support arm	Atanu Maity, Sankar Chel, Sabyasachi Mosan
5.	A novel approach towards water filtration through multistage bed in bi-axial orientation	Kalisadhan mukherjee, Asit Kumar batabyal, Biswanath mondal
6.	Active intervention robot for underground coal mines	Atanu Maity, Biplob Roy
7.	Novel approach for Fe^{III} promoted fusion reaction towards application in dip pen nano lithography	Priyabrata Banerjee, Pritam Ghosh, Naresh Chandra Murmu
8.	Plasma treatment of hospital waste	Pradip Kumar Chatterjee, Priyabrata Banerjee, Amit Kumar Ganguly, Naresh Chandra Murmu, Biswajit Ruj, Subrata Mandal
9.	Drawings for Intelligent & Powered Wheelchair	Sarbari Datta, Umesh Patkar, Sandeep Jain, Suman Kumar Char
10.	Redox active ink molecules generation for dip pen nanolithography	Priyabrata Banerjee, Sourav Kumar Saha, Naresh Chandra Murmu
11.	Circuit schematics and PCB layouts of 20kw grid interactive solar inverter	Hanumath Prasad Ikkurti, Mohd. Afroz Akhtar, Sumit Kumar, Md. Musraph Hussain

Copyright Filed		
Sl.	**Title**	**Inventors**
12.	Mechanical drawings & support structures of 20kw grid interactive solar inverter	Md. Musraph Hussain, Mohd. Aforz Akhtar, Sumit Kumar, Hanumath Prasad Ikkurti
13.	Solar Flora	Atanu Maity, Sabyasachi Mosan
14.	Owner's Manual of Krishishakti Tractor	Palash Kumar Maji, Sankar Karmakar, Subrata Kumar Mondal
15.	Novel self lubricating nano-composite (CaF_2+ZTA) cutting inserts	Nilrudra Mandal, Himadri Roy, Kalisadhan Mukherjee, Bipin Kumar Singh
16.	Development of Plasma Torch for solid waste management	Amit Ganguly, Priyabrata Banerjee, Partha Das, Harish Hirani, Pradip Kumar Chatterjee
17.	An initiative in waste sludge management for disposed material of fluoride removal water filter plant	Priyabrata Banerjee, Pritam Ghosh, Asit Kumar Batabyal, Harish Hirani, Naresh Chandra Murmu
18.	Drawings for Terrain Adaptive Mobile Robot	Dip Narayan Ray, Sukanta Bhattacharjee, Sankar Karmakar
19.	An innovative scheme towards environment friendly disposal of fluoride rich alumina waste using low cost geomaterials	Asit Kumar Batabyal, Priyabrata Banerjee, Harish Hirani
20.	Engineering drawings of E-DAK KIOSK	Rajesh Prasad Barnwal, Sabyasachi Mosan

Design Registration Filed		
Sl.	**Title**	**Inventors**
1.	Pedal Assisted high power E-Rickshaw	Ashok Kumar Prasad, Atanu Maity, Biplob Roy, Sankar Chel, Praveen Kumar
2.	Solar panel support arm	Atanu Maity, Aditya Kumar Lohar, Sankar Chel, Sabyasachi Mosan, Tapan Ray
3.	A desktop dip pen nanolithography system	Naresh Chandra Murmu, Phani Kumar Mallisetty, Arabinda Sarkar
4.	Solar Flora	Atanu Maity, Sabyasachi Mosan
5.	Active intervention robot for underground coal mines	Atanu Maity, Biplab Roy, Subrata Kumar Mandal, Sabyasachi Mosan, Dilip Garain
6.	Semi solid transporting pump	Prasanta Kumar Sen, Lal Gopal Das, Arun Baiju, Velukutty Gomathy, Pallab Chatterjee
7.	E-Dak Kiosk	Rajesh P. Barnwal

Dateline

Date	Events
May 05, 2016	Awareness Programme on RTI & Grievance redressal Mechanism, Biometric Attendance System (AEBAS) and CCS Conduct Rule
May 11, 2016	DG-CSIR electronic interaction with all the scientists through Video Conferencing on the Technology Day
May 16-17, 2016	Visit of Dr. Harsh Vardhan, Honorable Minister of Science and Technology & Earth Sciences, Government of India
May 24-27, 2016	Training Programme on Implementation of ERP Application
June 03, 2016	PRISM Sensitization Programme for Group II and Group III Technical Personnel
June 12, 2016	CSIR-CMERI Staff Club Annual Day Celebrations
June 13-14, 2016	52nd Research Council Meeting
June 16, 2016	Inauguration of Local Biometric Attendance System
June 17, 2016	32nd Management Council Meeting
June 21, 2016	International Yoga Day Celebration
July 14, 2016	Management Review Meeting
August 15, 2016	Independence Day Celebration
August 17, 2016	Launching of Post Graduate Diploma Course
August 19, 2016	Observance of "Sadbhavana Diwas"
September 14-21, 2016	Hindi Week
September 30, 2016	Visit of Honorable Minister of State for Heavy Industries and Public Enterprises and Industrial Conclave Program
October 01, 2016	74th CSIR Foundationday Celebration
October 31, 2016	Rashtriya Ekta Divas
October 31 - November 05, 2016	Vigilance Awareness Week - 2016
November 09-11, 2016	Three-days High end Training Program on Dimensional Metrology, Pressure Metrology, Mass, Density & Volume Measurement
November 10-11, 2016	Public Outreach Programme "IISF - 2016"
November 19-25 , 2016	Fund Raising Week for Communal Harmony Campaign
November 25, 2016	Constitution Day Celebration
November 28, 2016	33rd Management Council Meeting
December 21, 2016	ROBO-EXPO - 2016
January 18, 2017	Hindi Karyashala
January 19-20, 2017	Training Programme on IPR – Patent, Design, Copyright and Trademark
January 26, 2017	Republic Day Celebration
January 29, 2017	Visit of Dr. Mumtaz Sanghamita, Hon'ble Member of Parliament, Burdwan-Durgapur lok Sabha and Inauguration of Campus wide Hi-speed Wi-Fi Hotspot, High Definition day-Night CCTV Security Surveillance System, Digital Kiosk Systems for Rural application, Fully Dynamic Bilingual Website

February 10, 2017	One day training on Altair Hypermesh Software
February 11-12, 2017	Annual Sports
February 26, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
February 27 - March 03, 2017	Five day training on CATIA V5 R19 software
February 28, 2017	Observation of National Science Day - 2017
March 17, 2017	53rd Research Council Meeting
March 21, 2017	Observation of World Down Syndrome Day
March 21-23, 2017	Three day training on Altium PCB Designer software
March 23-24, 2017	Innovators Meet
March 30, 2017	34th Management Council Meeting

Visit of Dr. Harsh Vardhan, Hon'ble Minister of Science and Technology & Earth Sciences, Government of India

Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology and Earth Sciences, Government of India and Vice President, CSIR along with **Dr. Girish Sahni, Director General, CSIR and Secretary, DSIR** visited CSIR-CMERI during May 16-17, 2016. On the occasion of the visit, a number of programmes and demonstrations were organized at CSIR-CMERI. This included a meeting with local entrepreneurs on the proposed 'Technology Incubation Centre' on Friday, May 16, 2016, an interactive meeting with the leaders of industries in and around Durgapur, a live technology demonstration on Underwater Robotics and a number of technologies developed by CSIR-CMERI and finally an interaction of the Hon'ble Minister and the DG, CSIR with the staff members of CSIR-CMERI, Durgapur.

During the interactive meeting with the leaders of industries in and around Durgapur and senior scientists of CSIR-CMERI on the evening of May 16, 2016, The Hon'ble Minister expressed his desire for forging a close and durable relationship between Industries and CSIR laboratories with a view to provide solutions to the problems of the common people through simple but effective means. He requested the industries to come forward and acquire CSIR technologies since in his opinion the industries stand to reap immense benefits within a short span of time through acquisition and marketing of technologies developed by CSIR laboratories. The Hon'ble Minister asked the DG, CSIR and Director, CSIR-CMERI to interact regularly with industries to assess their needs and fast-track research activities to meet these needs.

On the morning of May 17, the Hon'ble Minister, along with the DG, CSIR and Director, CSIR-CMERI visited the Shallow Basin facility of the institute, where the Hon'ble minister inaugurated the 'Control Container' developed by CSIR-CMERI for lake and sea trials of Autonomous Underwater Vehicles. CSIR-CMERI scientists displayed the AUV to the Hon'ble Minister and also performed a live demonstration of a lab-scale robotic surface craft for unmanned shallow water hydrographic survey. The Scientists also conducted a bathymetric survey of the shallow basin using multi beam sonar.

The displayed surface robotic craft possesses the capability of conducting bathymetric surveys of inland waterways and coastal territories of the country in an environment friendly manner. The Hon'ble Minister interacted with the scientists regarding possible applications and potential of the technology. The DG, CSIR asked the scientists to work on proving the ruggedness of the system, following which the technology should be demonstrated to the appropriate industries. The Hon'ble Minister further advised the scientists to interact with the Ministry of Shipping, Government of India for possible application of the product.

Thereafter, the Hon'ble Minister witnessed live demonstration of a number of technologies developed by CSIR-CMERI. He took keen interest in each and every demonstration, patiently heard the explanations made by the scientists and also enquired about the cost and market potential of the technologies developed. The Hon'ble Minister advised for organizing an exhibition in Kolkata with all societal

products developed by CSIR-CMERI to capture the attention of media and industries.

The Hon'ble Minister praised the effort of CSIR-CMERI in developing a plastic waste to fuel oil conversion system, which is expected to provide a solution to the social menace of plastic wastes. Hon'ble Minister further lauded the efforts of CSIR-CMERI in providing technological support to North East India through integrated post-harvest processing system for agri-produce of North-East India and advised the scientists to develop a small but fully automated integrated system for deriving the final dried spice powder from the input raw material. DG, CSIR suggested that the technology be implemented in the state of Assam also.

The Hon'ble Minister enquired about the level of implementation of the Iron Removal Plant technology in the concerned areas. In regard to the Fluoride Removal Kit developed by CSIR-CMERI, both the Hon'ble Minister and the DG, CSIR advised the concerned scientist to undertake further studies on the assessment of water quality after filtration as a new adsorbent has been employed for removal of fluoride from water. They also stressed on quick deployment of the technology at the ground level. Hon'ble Minister further enquired about filtration of the arsenic detected by means of the Arsenic Detection Kit developed by CSIR-CMERI and stressed on the need of evolving an integrated system for arsenic detection, removal and disposal. In regard to the kit developed by CSIR-CMERI for early detection of fluorosis in humans, the Hon'ble Minister enquired about the status of commercialization of this technology since a similar technology has been developed some time back by CSIR-NEERI. The Hon'ble Minister was informed that the technology developed at CSIR-CMERI employs a different route using an alternative non-corrosive material, and that this new technology has brought down the cost of the kit substantially. Hon'ble Minister expressed his view that the cost benefit of the developed kit would be clear only after the new technology becomes available in the market.

Thereafter, the Hon'ble Minister was apprised about the life assessment studies being conducted by CSIR-CMERI for the power, steel and other industries. The institute possesses the accreditation of Central Boiler Board in this regard, it was informed. The Hon'ble Minister advised the scientists to keep in close touch with the concerned industries and to strive for enhanced earning. DG, CSIR suggested a new business model, whereby the institute, instead of charging a fee for the services rendered, would ask for a fixed percentage of the profit earned by the customer industry.

The Hon'ble Minister, after witnessing the demonstration on Low Cost Intelligent Wheel Chair, stressed on keeping the product cost low in order to serve a larger section of society. He advised the scientists to go through the prototype of 'Motorized Wheelchair' developed under an international collaborative programme of DBT and the USA government. The prototype was inaugurated at 'Indian Spinal Injury Centre', New Delhi which costs around Rs. 45,000/-.

Finally, the Hon'ble Minister inaugurated a Solar Power Tree developed by CSIR-CMERI to generate solar PV power with low foot print. He wished for the provision of two such 'power trees' for his office and official residence in New Delhi.

Dr. Harsh Vardhan, Hon'ble Minister along with Dr. Girish Sahni, Director General, CSIR and Secretary, DSIR and Prof. Harish Hirani, Director, CSIR-CMERI at the Industry meet on May 16, 2016

A view of the gathering of industry captains on May 16, 2016



Dr. Harsh Vardhan interacts with scientists and innovators during the exhibition arranged on the occasion of his visit to CSIR-CMERI, Durgapur

Dr. Harsh Vardhan, Hon'ble Minister for Science & Technology and Earth Sciences, Government of India and Vice President, CSIR was felicitated

Dr. Girish Sahni, Director General, CSIR and Secretary, DSIR was felicitated

PRISM Sensitization Programme for Group II and Group III Technical Personnel

A Sensitization Programme for popularization of PRISM - a flagship initiative of the Department of Scientific and Industrial Research (DSIR), Government of India for promoting innovation in individuals, start-ups and MSMEs - was organised at the M.M. Suri Hall on June 3, 2016 for the benefit of Group II & III Technical Personnel of the Institute. Dr. Ramanuj Banerjee, Scientist D, DSIR sensitized the participants about the different aspects of the scheme and the process of seeking funding support.

Dr. Ramanuj Banerjee, Scientist-E, DSIR deliberating on the PRISM Programme

Participants of the PRISM Sensitization Programme

Inauguration of Iron Removal Plant

Under the flagship CSIR-800 programme, 50 **Improved Iron Removal Plants** of CSIR-CMERI design are being installed in different villages of the Bankura district of West Bengal for supply of safe drinking water. Two such plants - one each in Birbarda and Paschim Ratanpur were inaugurated by Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI on July 13, 2016 in presence of the villagers and the authorities of the local self government.

Inauguration of Iron Removal plants at different villages in presence of local authorities and beneficiaries

Inauguration of Solar Tree

CSIR-CMERI has designed and developed a **Solar Power Tree** to harness maximum solar energy utilizing minimum land. On July 22, 2016 a Solar Tree installed at his residence was inaugurated by Dr. Harsh Vardhan, Union Minister for Science & Technology and Earth Sciences.

Inauguration of Post Graduate Diploma Courses

Three one year full time Post Graduate Diploma Progammes on Advanced Manufacturing Technology, Robotics and Industrial Maintenance Engineering were formally launched on August 17, 2016 at CSIR-CMERI in presence of representatives of industries and academia. These courses, being conducted under the aegis of the AcSIR are being offered to render engineering graduates industry ready through exposure to a balanced pedagogy embracing domain fundamentals and current theoretical and practical developments in addition to in-depth exposure to the engineering concepts, scientific principles, implementation methodology and hands-on experience on live projects.

Launching of the PG Diploma courses for rendering students industry-ready

National Workshop on Investment Casting ProcessTechnology (NWIC- 2016)

CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI), Durgapur and Investment Casting Society (ICS) of India, Durgapur jointly organized a two day **"National Workshop on Investment Casting Process Technology (NWIC-2016)"** during September 01- 02, 2016, at CSIR-CMERI, M.G. Avenue, Durgapur.

The theme of this National Workshop was to bring together participants from industries, R&D organizations and academic institutions to focus on future trends and challenges on near net shape manufacturing of engineering components through Investment Casting process. This workshop was valuable to the students, researchers/technical personnel of different establishments. The programme was designed for the benefit of students, R&D professionals, technocrats & interested entrepreneurs - those who are involved in R&D, business and manufacturing.

About 100 participants including academicians, researchers, students & industrialists from different organizations/ institutions and industries were present in this workshop and shared their views and discussed their common issues pertaining to productivity, quality of product as well as business in investment casting. Eight Technical papers related to this specialized topic were presented during the technical deliberation. The technical papers covered some of the recent advances in the field and delineated some problem areas of immediate interest to the industry.

Prof. G.L. Dutta, Ex. Dean, IIT Kharagpur, Ex-Vice Chancellor, K. L. University, Guntur, A.P., inaugurated the conference by delivering the welcome address. The Chief Patron & Director, CSIR-CMERI Prof. Harish Hirani was present in the workshop and delivered the keynote address.

The workshop was sponsored by some of the key industries across the country viz. Thermo Fisher Scientific India Pvt. Ltd., Mumbai, Industrial Resources & Monolithics Pvt. Ltd., Jharkhand, Mitutoyo South Asia Pvt. Ltd., Kolkata, Kailash Marketing Associates (Industrial Minerals Division), Maharashtra, Quantachrome India, Thane, Provision Info Solutions (India) Pvt. Ltd., Durgapur, Debola Foundry, Burdwan, RRL Steels Limited, Kolkata. All technical session chairs, invited speakers, authors and the participants are gratefully acknowledged for their contributions and deliberations.

Prof. G.L. Dutta addressing the participants

Demonstration of Investment Casting Process Technology

Observance of Hindi Week

The Hindi Week was launched at CSIR-CMERI through the observance of Hindi Day on September 14, 2016. Like in the previous years, the opening ceremony attracted a large audience. Speaking on the occasion, Professor Harish Hirani, Director, CSIR-CMERI exhorted the Institute personnel - especially those belonging to the technical domain - to work more in Hindi. Sri Mukund Sahai, Controller of Administration informed the audience that during the last two years there has been a remarkable improvement in the official communication in Hindi. Following the formal opening of the Hindi Week through lectures of the dignitaries and the lighting of the inaugural lamp, an essay competition was organised for the Institute personnel on the current foreign policy of India. The Hindi Week was concluded on 21 September with due grandeur.

The Hindi Week was observed with enthusiasm during September 14-21, 2016

The Hindi Week was observed with enthusiasm during September 14-21, 2016

National Workshop on Machining & Machinability of Advanced Materials (NWMMAM- 2016)

CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI), Durgapur organized a two day **"National Workshop on Machining & Machinability of Advanced Materials (NWMMAM- 2016)"** during September 29-30, 2016, at CSIR-CMERI, M.G. Avenue, Durgapur.

The theme of this National Workshop was to bring together participants from industries, R&D organizations and academic institutions to exchange and share their experiences and research results about all aspects of Machining and Machinability of Materials. This inter-disciplinary forum also provided an opportunity to

Inauguration of NWMMAM-2016

The Guest of Honour Prof. A.K. Chattopadhyay, Professor, IIT Kharagpur delivering a lecture

Demonstration at laboratory

Opening of the Workshop proceeding

researchers, practitioners and academicians to interact with each other and discuss most recent advances, trends and practical challenges encountered with effective solutions in the field of Machining and Machinability of Advanced Materials.

About 150 participants including academicians, researchers, students & industrialists from different organizations/ institutions and industries were present in this workshop and shared their views and discussed their common issues pertaining to productivity, product quality as well as business opportunity. It is noted that 21 extended abstracts were received and was deliberated in these two days of National Workshop. The organizing committee is grateful to all the invited speakers, authors, advertisers, students and participants from industries who made their contributions and cooperation for bringing out the workshop proceeding.

The Chief Guest Prof. A. B. Chattopadhyay, Former Professor, IIT Kharagpur inaugurated the workshop by delivering the welcome address. The Guest of Honor Prof. A. K. Chattopadhyay, Professor, IIT Kharagpur, Chief Patron & Director, CSIR-CMERI , Prof. Harish Hirani and the Chairman, Dr. B. N. Mondal were present in the workshop and delivered lectures. The workshop was sponsored by representatives from industries across the country viz. Bysakh & Co., Kolkata, NK Instruments, Kolkata, Toshvin Analytical, Kolkata, Jay Crucibles, Kolkata and Konark Solutions, Bangalore.

All technical session chairs, invited speakers, authors and the participants are gratefully acknowledged for their contributions and deliberations.

Visit of Hon'ble Minister of State for Heavy Industries and Public Enterprises and Industrial Conclave Program

An **Industry Conclave** was organised by CSIR-CMERI on September 30, 2016. Prospective stakeholders and users of technologies developed by CSIR-CMERI participated in the event. **Shri Babul Supriyo,** the **Hon'ble Minister of State for Heavy Industries and Public Enterprises, Government of India** graced the occasion with his presence. The Hon'ble Minister highly praised the advanced facilities CSIR-CMERI had at its disposal and appreciated the technologies developed by the Institute.

Shri Babul Supriyo visiting CSIR-CMERI and inaugurating the Advanced Surface Engineering & Tribology Laboratory on September 30, 2016

Vigilance Awareness Week - 2016

The **Vigilance Awareness Week-2016** was observed in the Institute from 31st October to 5th November, 2016. Inauguration was on October 31, 2016 through the pledge taking ceremony administered by Prof. Harish Hirani, Director, CSIR-CMERI. The pledge taking ceremony was followed by a brief delivery of the Director, CSIR-CMERI on **Public Participation in Promoting Integrity and Eradicating Corruption.** During this week CSIR-CMERI actively participated in the citizen centric march against corruption organised by the DSP/SAIL on November 02, 2016; organised an essay writing competition for school students and employees; conducted a quiz competition for the local colleges and hosted an E-poster competition in Hindi. On the penultimate day of the week-long progamme, Mr. Nand Kishor Sachan, IRTS, Divisional Railway Manager (DRM), Asansol Division of the Eastern Railway delivered a lecture on **Public participation in promoting integrity and eradicating corruption** during the valedictory session.

CSIR-CMERI observed Vigilance Awareness Week during October 31–November 5, 2016

Three-days High end Training Program on Dimensional Metrology, Pressure Metrology, Mass, Density & Volume Measurement

Precision Engineering and Metrology Group of CSIR-CMERI, Durgapur organized a three-day "High end Training Program on Dimensional Metrology, Pressure Metrology, Mass, Density & Volume Measurement", commencing from 9th to 11th Nov. 2016. This program was supported By NABL and QCI, New Delhi and represented by their officials. This course imparted theoretical and practical knowledge about calibration of laboratory equipments in mechanical metrology field. It was very much useful to laboratory staff and managers of various industries mainly MSMEs for attaining high levels of accuracy in measurements and calibration and assuring quality for industrial products. This course covered fundamentals of dimensional metrology, co-ordinate measurements in CNC mode, laser interferometers for high precision machine tool metrology, calibration of high precision length and

angle gauges, surface tables, measurement of surface topography in 2-D and 3-D, calibration of pressure gauges and measurements of mass, density and volume. This course focused on the new NABL documents, viz., specific criteria for Calibration Laboratories in Mechanical disciplines: i.e. on NABL122-01 to 13. This course has enabled the Lab personnel to fine tune themselves with the latest technical requirements for NABL Accreditation.

The organizing committee is grateful to Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, for his constant inspiration and support to conduct this course successfully. The program was inaugurated by Mr. Utpal Kumar Pathak, ED (Projects), SAIL-DSP. We are thankful to all the scientists and faculty members for designing the course material in a new concept.

Inaugural session of the training programme

Training programme is going on

Public Outreach Programme "IISF - 2016"

As a precursor event of the India International Science Festival - 2016 CSIR-CMERI, Durgapur organised a **Public Outreach Programme** on November 10-11 where 200 local students from vernacular schools and polytechnic were invited on the two successive days. The students were taken on a guided tour of selected departments of the laboratory for affording exposure to the latest trends of science & technology and to kindle their interest for pursuing careers in science. The event primarily aimed at introducing bright young minds to the broad gamut of science and technology and to improve their scientific understanding, temperament and appreciation for various feats in science & technology through the showcasing of achievements of this national laboratory.

Inauguration of Public Outreach Programme "IIFS - 2016"








Glimpses of Public Outreach Programme 'IISF-2016'

"ROBO-EXPO - 2016"

CSIR-CMERI, Durgapur organised a Robo Expo as a follow-up event of the 2nd India International Science Festival (IISF-2016) on December 21, 2016. This programme - specifically targeted for Class XI Science students for inspiring young minds for careers in science and technology - drew around 100 enthusiastic students, who were then taken on a guided visit to selected departments of the laboratory during the first session of the day. The program was graced by Shri Apurba Mukherjee, Hon`ble Mayor of Durgapur as the Chief Guest, Shri Vishyanath Pariyal, Hon`ble MLA of Durgapur and Smt. Kasturi Sengupta, Commissioner of the Durgapur Municipal Corporation as Guests of Honour. In his speech, the Hon`ble Mayor appreciated various societal initiatives that CSIR-CMERI has taken up along with the high science being carried out at the laboratory. During the second session, a talk on Constitution of India was delivered by Prof. Rakhi Choudhury, HOD, Department of Political Science, TDB College, Raniganj as an extension programme of the Constitution Day that was celebrated on November 26, 2016 at CMERI. This was followed by a lecture on the IISF by Mr. Sree Prasad, Representative of Vibha, Kolkata Chapter.




Glimpses of 'ROBO-EXPO -2016'

Visit of Dr. Mumtaz Sanghamita, Hon'ble Member of Parliament, Burdwan-Durgapur lok Sabha

Prof. (Dr.) Mamtaz Sanghamita, Hon'ble Member of Parliament inaugurated the High Speed Wi-Fi connectivity, e-Dak/e-Patrachar Kiosks, High Security Day-Night Surveillance CCTV system and the Information-Rich Fully Bi-Lingual CMERI website on January 29, 2017 at CSIR-CMERI. She stated the merits of espousing new technologies for redressal of common administrative and societal issues. She also congratulated all the officials of the Institute for attaining digital democracy in the Institute premises. On this occasion Prof.(Dr.) Harish Hirani, Director, CSIR-CMERI, Durgapur stressed upon the need for digital democracy and instant grievance redressal mechanisms.

Visit of Dr. Mumtaz Sanghamita, Hon'ble Member of Parliament, Burdwan-Durgapur lok Sabha

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Prof. (Dr.) Mamtaz Sanghamita visited CSIR-CMERI and Inaugurated the Digital Facilities at CSIR-CMERI

National Conference on Advanced Functional Materials Processing & Manufacturing (NCAFMPM-2017)

CSIR-Central Mechanical Engineering Research Institute (CSIR-CMERI), Durgapur organized a two day **"National Conference on Advanced Functional Materials Processing & Manufacturing (NCAFMPM-2017)"** during February 2-3, 2017, at CSIR-CMERI, M.G. Avenue, Durgapur.

The basic objective of this **National Conference on Advanced Functional Materials Processing & Manufacturing (NCAFMPM-2017)** was to bring together participants from industries, R&D organizations and academic institutions to exchange and share their experiences and research results about all aspects of Advanced Functional Materials Processing & Manufacturing. This provided an opportunity for the researchers, practitioners and academicians to present most recent advances, trends and practical challenges encountered with effective solutions in the field of Manufacturing & Processing of Advanced Functional Materials. These two days of

National Conference on Advanced Functional Materials Processing & Manufacturing (NCAFMPM-2017)

national conference provided also an opportunity for the CSIR-CMERI to increase business development opportunities, networking with industries and spreading awareness regarding some its R&D activities.

The Guest of Honour, Prof. Pradip Dutta, Professor, Department of Mechanical Engineering, IISc Bangalore and Prof. Ashish Kr. Nath, Department of Mechanical Engineering, IIT Kharagpur delivered lectures during the conference. The Chief Guest, Prof. Kalyan Kr. Ray, Former Professor, Metallurgical and Materials Engineering, IIT Kharagpur, Visiting Professor, Indian Institute of Engineering Science and Technology (IIEST), Shibpur also delivered a lecture in the conference. About 250 delegates attended the conference and 64 research articles/technical papers on specialized topics were presented during two days of technical deliberation. The deliberated theme areas of this conference included mechanical behaviour of materials, laser materials processing and additive manufacturing, biomaterials, materials for sensor and energy and light metals/ polymer composites for engineering applications.

The organizing committee is grateful to Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, for his constant inspiration and support to conduct this conference successfully. Our sincere thanks to all the scientists, faculty members, authors for their excellent contributions for preparing the Conference proceedings on **"Advanced Functional Materials Processing & Manufacturing"**, published by Excel India Publishers, New Delhi.

The support and response received from the invited speakers, authors, advertisers, students, participants from industries, academic institutions and concerned members of the CSIR-CMERI family are gratefully acknowledged with thanks.

Prof. Kalyan Kr. Ray, Former Professor, IIT Kharagpur and Prof. Harish Hirani, Director, CSIR-CMERI at the inaugual session

Prof. Pradip Dutta, IISc Bangalore delivering the keynote lecture

CSIR-CMERI Diamond Jubilee Foundation Day

The Diamond Jubilee Foundation Day of CSIR-CMERI was celebrated on 26th February, 2017. In his welcome address, Prof. Harish Hirani, Director, CSIR-CMERI referred to the past of CMERI as an industry enabler, which in the last few decades included societal needs in its ambit. Highlights on ready-to-be-launched products addressing the issues faced by common people, such as intelligent low-cost robotic wheel chair, arsenic and fluoride filters, post harvesting facility for the north east, solid waste management system, solar trees, photovoltaic inverter etc. formed the core of his message to the gathering. Prof. Ajoy Kumar Ray, Director, IIEST Shibpur reflected on the pre-independence Indian science under the leadership of Sir Jagadish Chandra Bose and Acharya Prafulla Chandra Ray and stressed

on integration of efforts across various disciplines and organizations for a better future. The Director General of CSIR, Dr. Girish Sahni, called for introspection to remain relevant to the changing needs of the country. Amid celebrations on the scientific feats achieved, it is also necessary to keep a vigil for areas of improvement, according to Dr. Sahni.

Director General, CSIR with Directors of Laboratories /Institutes and delegates on the occasion of CSIR-CMERI Diamond Jubilee Foundation Day

Lighting the Lamp on the occasion of CSIR-CMERI Diamond Jubilee Foundation Day

Opening of the Event Calendar for the CSIR-CMERI Diamond Jubilee Celebration

Prof. Ajoy Kumar Ray, Director, IIEST Shibpur delivering his lecture

Dr. Girish Sahni, Director General, CSIR and Secretary, DSIR addressing the audience

Exchange of MOU with Micromax Energy Limited

Hindi Seminar on Make in India

A Hindi Seminar on Make in India was organized at CSIR-CMERI, Durgapur during February 26-27, 2017. The main focus of the seminar was to give the "Make in India" campaign a refined form through its specific products, innovation and research processes. Directors from different CSIR Laboratories were present in the Innaugural Programme. In his keynote address Shri Jitendra J. Jadhav, Director, CSIR-NAL drew an outline of the business opportunities in the Aerospace Sector and pointed out the importance of Mechanical Engineering in the field of aviation. The role of CSIR-CMERI in making valves for the SARAS aircraft and the ongoing analytical work at CSIR-CMERI to reduce shimmy and judder of the nose landing wheel of the LCA were highlighted in his lecture.




Glimpses of Hindi Seminar on Make in India

Observation of National Science Day - 2017

The National Science Day was observed by CSIR-CMERI on 28th February, 2017 in association with the Institute for Health Studies and Rehabilitation (a unit of Society for Welfare of Handicapp Persons) at their premises at 27, Tagore Avenue, A-Zone, Durgapur-713204 in the august presence of Shri Sankha Santra, SDM, Durgapur, Smt. Asima Chakraborty, Councilor of Durgapur Municipal Corporation, Dr. Dhruba Chakraborty, President, Society for Welfare of Handicapped Persons, Durgapur, Prof. Harish Hirani, Director, CSIR-CMERI and Dr. Shankar Nath Shome, Chief Scientist, CSIR-CMERI. The focal theme of this year's National Science Day being "Science & Technology for specially abled persons", the Robotic Wheel Chair developed at CSIR-CMERI, Durgapur, was demonstrated to quite a few specially able persons who had been invited for the purpose.

Dignitaries present and Demonstration of Robotic Wheel Chair on the occasion of National Science Day

Innovators Meet 2017

TePP (Technopreneur Promotion Programme) Outreach cum Cluster Innovation Centre (TOCIC) of CSIR-CMERI, Durgapur, under the PRISM (Promoting Innovations in Individuals, Start-ups and MSMEs) scheme of the Department of Scientific and Industrial Research (DSIR), Government of India organized a two day 'Innovators Meet' at CSIR-CMERI, Durgapur during March 23-24, 2017.

Innovators promoted by TOCIC-CMERI, as well as innovators and coordinators from different TOCICs across the country participated in the two day event to interact among themselves, to share their success stories, and also to hear from the eminent faculties in the field of entrepreneurship, finance and marketing, gracing the event.

After a brief introduction by Shri Soumya Sen Sharma, Coordinator, TOCIC-CMERI, Prof. Harish Hirani, Director, CSIR-CMERI welcomed all the innovators, coordinators, resource persons and the engineering students to the meet and talked about the importance of innovation in taking forward the country to an industrially developed nation. Dr. S. K. Deshpande,

Glimpses of Innovators Meet

Scientist 'G' and Head (PRISM), DSIR, who was the Chief Guest of the inaugural session, deliberated on the different initiatives undertaken by the Govt. of India in promoting innovations. Dr. S. N. Shome, Chairperson, TOCIC-CMERI then presented an overview of activities taken up by the innovation centre at Durgapur.

Shri Partha Mandal, Additional General Manager, NABARD and in charge of Burdwan district, in his talk on 'Entrepreneur and Finance' apprised the audience about different schemes for promoting Rural Innovations and Micro-Entrepreneurship. Shri Sujoy Sen, Manager, Incubation at the IIM Calcutta Innovation Park delivered a talk on 'Entrepreneurship and Incubation', describing in detail about the management of all stakeholders in the incubation eco-system and social entrepreneurship related activities. In the post lunch session, six innovators presented their projects and shared with the audience the inspiring journeys in achieving their dreams, followed by an open session. In the second day of the meet, after presentations by a number of innovators, Smt. Jaba Chakraborty, Manager, SIDBI deliberated upon the 'Stand Up India' scheme of the Govt. of India. Shri Suman Mukhopadhyay of IIMC Innovation Park delivered a talk on 'Social Entrepreneurship and its Importance' and encouraged the students to come out with their innovative thoughts. The meet concluded with a panel discussion conducted by the TOCIC coordinators and the resource persons.

Manpower as on March 31, 2017

Dr. Harish Hirani **Director, CSIR-CMERI, Durgapur**

Scientist & Technical Staff

Sl.	Name	Group Affiliation
Chief Scientist		
1	Dr. Robin Kumar Biswas	Condition Monitoring and Structural Analysis Group
2	Soumya Sen Sharma	Drives & Control System Technology Laboratory, Skill & Innovation Promotion Group
3	Dr. Uma Dutta	Electronics & Instrumentation
4	Dr. Pradip Kumar Chatterjee	Energy Research & Technology
5	Abhijit Chatterjee	Material & Structure Evaluation Group
6	Ashish Kumar Chowdhury	Near Net Shape Manufacturing Technology Group
7	Dr. Ranjan Sen	Precision Engineering & Metrology Group
8	Dr. Sankar Nath Shome	Robotics & Automation
9	Dr. Sibnath Maity	Technology Innovation Centre
Senior Principal Scientist		
1	Dr. Avik Chatterjee	Advanced Design & Analysis Group, International Business Development Group
2	Aswani Kumar Kushwaha	CoEFM, Ludhiana
3	Dr. Somnath Mukherjee	Condition Monitoring and Structural Analysis Group
4	Dr. Surendra Kumar	Condition Monitoring and Structural Analysis Group
5	Dr. Partha Sarathi Banerjee	Drives & Control System Technology Laboratory, Skill & Innovation Promotion Group
6	Dr. Anjali Chatterjee	Energy Research & Technology
7	Maw Nandi Sarkar	Energy Research & Technology
8	Dr. Atanu Maity	Engineering Design Group
9	Dr. Tapas Gangopadhyay	Engineering Design Group, Knowledge Resource Centre
10	Dr. Biswajit Ruj	Environmental Engineering Group
11	Dr. Partha Bhattacharjee	Information Technology Group, Robotics & Automation
12	Dr. Nagahanumaiah	Micro System Technology Laboratory, Planning & Performance Division
13	B.N. Singh	NDT & Metallurgy
14	Syd. Salman Mojiz	Planning & Performance Division
15	Dr. Debojyoti Banerji	Robotics & Automation
16	Dr. Sambhunath Nandi	Robotics & Automation
17	Sarbari Datta	Surface and Field Robotics
Principal Scientist		
1	Dr. Palash Kumar Maji	Advanced Design & Analysis Group
2	Dr. Dipankar Chatterjee	Advanced Design & Analysis Group
3	Dr. Sudip Kumar Samanta	Advanced Manufacturing Centre, Near Net Shape Manufacturing Technology Group
4	B.D. Bansal	CoEFM, Ludhiana
5	Rajesh Kumar Chak	CoEFM, Ludhiana

Sl.	Name	Group Affiliation
6	Dr. Pradeep Rajan	CoEFM, Ludhiana
7	G.S. Reddy	CoEFM, Ludhiana
8	Dr. Krishnendu Kundu	CoEFM, Ludhiana
9	Kamalkishor J. Uke	Condition Monitoring and Structural Analysis Group
10	Dr. Biplab Choudhury	Energy Research &Technology, Technology Marketing Group
11	Dr. Amit Ganguly	Energy Research & Technology, Horticulture & Institute House Keeping
12	Ashok Kumar Prasad	Engineering Design Group
13	Dr. Anupam Sinha	Engineering Design Group
14	Dr. Arup Kumar Nandi	Engineering Design Group
15	Bibhuti Bhusan Ghosh	Engineering Design Group
16	Subrata Kumar Mondal	Engineering Design Group
17	Dr. Sudipta De	Engineering Design Group, Publication Group
18	Dr. Asit Kumar Batabyal	Environmental Engineering Group, Intellectual Property Management Group, Quality Management Group
19	Dr. S.R. Debbarma	Environmental Engineering Group, Resource Planning & Business Development Group
20	Dr. Debasish Ghosh	NDT & Metallurgy
21	Dr. Atanu Saha	NDT & Metallurgy
22	Manju Singh	Near Net Shape Manufacturing Technology Group
23	Dr. Aditya Kumar Lohar	Near Net Shape Manufacturing Technology Group
24	Swapan Barman	Precision Engineering & Metrology Group
25	Dr. Soumen Sen	Robotics & Automation
26	Dr. Ranjit Ray	Robotics & Automation
27	Sankar Karmakar	Surface and Field Robotics
28	Dr. Ravi Kant Jain	Surface and Field Robotics
29	Dr. Naresh Chandra Murmu	Surface Engineering & Tribology Group
30	Dilip Kumar Biswas	Technology Innovation Centre
Senior Scientist		
1	Abhijit Mahapatra	Advanced Design & Analysis Group
2	Dr. Nilrudra Mondal	Centre for Advanced Materials Processing, Planning & Performance Division
3	Ajay Yadav	CoEFM, Ludhiana
4	Hanumath Prasad Ikkurti	Drives & Control System Technology Laboratory
5	Dr. Suman Saha	Drives & Control System Technology Laboratory
6	Dr. Arpita Mukherjee	Electronics & Instrumentation
7	Dr. Kalyan Kumar Mistry	Electronics & Instrumentation
8	Dr. Malay Kumar Karmakar	Energy Research & Technology
9	Dr. Chanchal Loha	Energy Research & Technology
10	Dr. T. Murugan	Energy Research & Technology
11	Dr. Lal Gopal Das	Engineering Design Group
12	Dr. Binod Kumar Saha	Engineering Design Group

Sl.	Name	Group Affiliation
13	Dr. Sarita Ghosh	Environmental Engineering Group, Knowledge Resource Centre, Publication Group, Repository Group
14	Rajesh Prasad Barnwal	Information Technology Group
15	Dr. Himadri Roy	International Business Development Group, NDT & Metallurgy
16	Dr. Debashis Das	Material & Structure Evaluation Group
17	Dr. Nripen Chanda	Micro System Technology Laboratory
18	Rajpal Singh	Near Net Shape Manufacturing Technology Group
19	Dr. Samik Dutta	Precision Engineering & Metrology Group
20	Siva Ram Krishna Vadali	Robotics & Automation
21	Virendra Kumar	Robotics & Automation
22	Dibyendu Pal	Robotics & Automation
23	Umesh S. Patkar	Surface and Field Robotics
24	Dr. Dip Narayan Ray	Surface and Field Robotics
25	Dr. Satya Prakash Singh	Surface Engineering & Tribology Group
26	Dr. Rashmi Ranjan Sahoo	Surface Engineering & Tribology Group
27	Dr. Priyabrata Banerjee	Surface Engineering & Tribology Group
28	Santu Kumar Giri	Surface Engineering & Tribology Group
Scientist		
1	Dr. Bittagopal Mondal	Advanced Design & Analysis Group
2	Amit Kumar	Advanced Design & Analysis Group
3	Dr. Ranajit Ghosh	Centre for Advanced Materials Processing
4	Prosenjit Das	Centre for Advanced Materials Processing
5	Dr. Siva Prakash S.	Centre for Advanced Materials Processing
6	Dr. S. Shekhar Chakraborty	Centre for Advanced Materials Processing
7	Jagdish M.	CoEFM, Ludhiana
8	Vivin V.	CoEFM, Ludhiana
9	Dr. Swarup Kumar Laha	Condition Monitoring and Structural Analysis Group
10	Sumit Kumar	Drives & Control System Technology Laboratory
11	Mohd. Afroz Akhtar	Drives & Control System Technology Laboratory
12	Anirudh Kumar	Drives & Control System Technology Laboratory
13	Partha Sarathi Pal	Drives & Control System Technology Laboratory, Resource Planning & Business Development Group
14	Saikat Kumar Shome	Electronics & Instrumentation, Skill & Innovation Promotion Group
15	Partha Das	Energy Research & Technology
16	Subho Samanta	Energy Research & Technology
17	Nitish Kumar	Engineering Design Group
18	Dr. Abhiram Hens	Micro System Technology Laboratory
19	Ravi Kumar Arun	Micro System Technology Laboratory
20	Soumen Mandal	Micro System Technology Laboratory
21	Shikha	Micro System Technology Laboratory
22	Ved Prakash	Near Net Shape Manufacturing Technology Group
23	Amon Arora	Robotics & Automation

Sl.	Name	Group Affiliation
24	S. Reddy	Robotics & Automation
25	Srinivasan Aruchamy	Robotics & Automation
26	Moloy Narayan Das	Surface and Field Robotics
27	Abhijit Das	Surface and Field Robotics
28	Dr. Pranab Samanta	Surface Engineering & Tribology Group
29	P.K. Mallisetty	Surface Engineering & Tribology Group
30	Man Singh Azad	Technology Innovation Centre
31	Rudra Prasad Chatterjee	Technology Innovation Centre
Junior Scientist		
1	Pradyumna Kumar Sahu	Electronics & Instrumentation
2	Priyabrata Chattopadhyay	Energy Research & Technology
Senior Technical Officer, Executive Engineer, RMO		
1	Jiwan Budh	Advanced Manufacturing Centre
2	Rakesh Kumar Padhi	Advanced Manufacturing Centre
3	Viji K.	Advanced Manufacturing Centre
4	Manoja Kumar Biswal	Advanced Manufacturing Centre, Technology Marketing Group
5	Pranabendu Saha	Advanced Manufacturing Centre, International Business Development Group
6	Jagroop Singh Mungra	CoEFM, Ludhiana
7	Prabhu Dutt Sharma	CoEFM, Ludhiana
8	Manoj Verma	CoEFM, Ludhiana
9	Amitava Debnath	Engineering Design Group
10	Arun Baiju V.G.	Engineering Design Group
11	Munshi Amirul Alam	Engineering Design Group
12	Sumit Guha	Engineering Services Division
13	Manick Das	Engineering Services Division
14	Ajay Kumar Gupta	Engineering Services Division
15	Om Prakash Yadav	Engineering Services Division
16	Samir Kumar Das	Engineering Services Division
17	Santu Matia	Engineering Services Division
18	Amitava Mitra	Intellectual Property Management Group, Quality Management Group
19	Dr. Swati Saha	Medical Center
20	Kalyan Kumar Choudhury	NDT & Metallurgy
21	Subrata Ray	NDT & Metallurgy
22	Sanjib Kumar De	NDT & Metallurgy
23	Siddhartha Kumar	Near Net Shape Manufacturing Technology Group
24	Tapan Ray	Near Net Shape Manufacturing Technology Group
25	Somnath Chatterjee	Precision Engineering & Metrology Group
26	Ajoy Kumar Roy	Precision Engineering & Metrology Group, Public Relation Cell, Technology Marketing Group
27	Biswajit Patra	Resource Planning & Business Development Group
28	Banamali Deghoria	Resource Planning & Business Development Group

Sl.	Name	Group Affiliation
29	Jnanendra Prasad Maji	Robotics & Automation
30	Manas Banerjee	Skill & Innovation Promotion Group
31	Sandeep Jain	Surface and Field Robotics
Technical Officer		
1	Anindya Chattopadhyay	Advanced Design & Analysis Group
2	S.Y. Pujar	Advanced Manufacturing Centre
3	Samit Biswas	Advanced Manufacturing Centre
4	Arup Majumder	Advanced Manufacturing Centre
5	Soumyajit Kundu	Advanced Manufacturing Centre
6	Biplab Swarnakar	Condition Monitoring and Structural Analysis Group
7	Siddheswar Sen	Electronics & Instrumentation
8	Vinay P. Tigga	Energy Research & Technology
9	Biplob Roy	Engineering Design Group
10	Sankar Chel	Engineering Design Group
11	Debi Prasad Das	Engineering Services Division
12	Bipradas Karmakar	Engineering Services Division
13	Ansuman Layek	Engineering Services Division, Estate & Welfare Office
14	Bonela Suresh	Engineering Services Division
15	Biswajit Sikdar	Knowledge Resource Centre, Repository Group
16	Sumanta Chatterjee	Material & Structure Evaluation Group
17	Adwaita Maiti	Near Net Shape Manufacturing Technology Group
18	Shantanu Kumar Naskar	Precision Engineering & Metrology Group
19	Pratik Saha	Robotics & Automation
20	Chandan Har	Robotics & Automation
21	Suman Kumar Char	Surface and Field Robotics
22	Deepak Kumar Bhakta	Surface Engineering & Tribology Group
23	Santosh Kumar Das	Technology Innovation Centre
Technical Assistant		
1	Sourav Nandan	CoEFM, Ludhiana
2	Nasir Hussain	Condition Monitoring and Structural Analysis Group
3	Sourav Kansabanik	Condition Monitoring and Structural Analysis Group
4	Md. Musraph Hussain	Drives & Control System Technology Laboratory
5	Sushil Murmu	Electronics & Instrumentation
6	Pratap Karmakar	Electronics & Instrumentation
7	Ram Pyare Singh	Energy Research & Technology
8	Dilip Garain	Engineering Design Group
9	Garibdas Garai	Engineering Design Group
10	Sudeshna Das	Engineering Design Group
11	Rajib Khatua	Engineering Services Division, ERP Cell
12	Arup Saha	Environmental Engineering Group
13	Ranaditya Haldar	ERP Cell
14	Pratyush Kumar Pal	Information Technology Group
15	Ajoy Kuchlyan	Information Technology Group

Sl.	Name	Group Affiliation
16	Dayamay Bouri	Material & Structure Evaluation Group
17	Sumanta Banerjee	Material & Structure Evaluation Group
18	Saurav Halder	Micro System Technology Laboratory
19	Kalyan Chatterjee	Micro System Technology Laboratory
20	Abhijit Mondal	NDT & Metallurgy
21	Bimal Hansda	NDT & Metallurgy
22	Jiten Mandal	NDT & Metallurgy
23	Anup Rajak	Near Net Shape Manufacturing Technology Group
24	Anmol Khalkho	Near Net Shape Manufacturing Technology Group
25	Prasanta Adhikary	Planning & Performance Division
26	Rabisankar Mondal	Precision Engineering & Metrology Group
27	Soma Banerjee	Robotics & Automation
28	Debasish Das	Robotics & Automation
29	Jyotirmoy Karmakar	Robotics & Automation
30	Imtiaz Alam	Surface and Field Robotics
31	Arijit Chowdhury	Surface and Field Robotics
32	Tripty Maity	Surface Engineering & Tribology Group
33	Subhasis Biswas	Surface Engineering & Tribology Group
Senior Technician		
1	Debasish Dutta	Advanced Manufacturing Centre
2	Abhijeet Singh	Advanced Manufacturing Centre
3	Subhas Chandra Halder	Advanced Manufacturing Centre
4	Swapan Singh Patar	Advanced Manufacturing Centre
5	Ramnath Mandi	Advanced Manufacturing Centre
6	Harakripa Singh Sardar	Advanced Manufacturing Centre
7	Tarapada Hembram	Advanced Manufacturing Centre
8	P.N. Pathak	CoEFM, Ludhiana
9	Hardeep Singh	CoEFM, Ludhiana
10	Amarjit Singh	CoEFM, Ludhiana
11	Bodh Raj Sharma	CoEFM, Ludhiana
12	Balvir Singh	CoEFM, Ludhiana
13	Kiran Bala Lekhi	CoEFM, Ludhiana
14	Jai Ram	CoEFM, Ludhiana
15	Ranjit Singh	CoEFM, Ludhiana
16	Inderjit Singh	CoEFM, Ludhiana
17	Bidhan Chandra Bouri	Engineering Services Division
18	Suresh Ram	Engineering Services Division
19	Hari Lal Ram	Knowledge Resource Centre, Repository Group
20	Diponkar Sarkar	NDT & Metallurgy
21	Aswini Kumar Singh Sardar	Precision Engineering & Metrology Group
22	Chandra Sengupta	Resource Planning & Business Development Group
23	Asit Kumar Sau	Resource Planning & Business Development Group, Public Relation Cell

Sl.	Name	Group Affiliation
24	Gopal Biswas	Store & Purchase
25	Chittaranjan Kundu	Transport & Garage
Technician		
1	Tanmoy Kumar Das	Advanced Design & Analysis Group
2	Dipak Mondal	Advanced Manufacturing Centre
3	Tanmoy Mondal	Advanced Manufacturing Centre
4	Nilaksha Swarnakar	Advanced Manufacturing Centre
5	Sanjib Mukherjee	Advanced Manufacturing Centre
6	Pradip Kumar Dutta	Advanced Manufacturing Centre
7	Ratan Chandra Dolai	Advanced Manufacturing Centre
8	Ranjan Kumar Sahoo	Advanced Manufacturing Centre
9	Ranjan Kumar Halder	Advanced Manufacturing Centre
10	Amar Kumar Sharma	Advanced Manufacturing Centre
11	Palash Chowdhury	Centre for Advanced Materials Processing
12	Kamaljit Singh Pannu	CoEFM, Ludhiana
13	Bharat Saini	CoEFM, Ludhiana
14	Tapas Naskar	Drives & Control System Technology Laboratory
15	Bipul Kumar	Electronics & Instrumentation
16	Biswajit Chakraborty	Energy Research & Technology
17	Sabyasachi Mosan	Engineering Design Group
18	Chanchal Das	Engineering Design Group
19	Pallab Chatterjee	Engineering Design Group
20	Chiranjit Pal	Establishment
21	Amit Chandra	Material & Structure Evaluation Group
22	Sujata Pachhal	Medical Centre
23	Sukanta Maji	Medical Centre
24	Jagannath Bindhani	Near Net Shape Manufacturing Technology Group
25	Meraz Ansari	Robotics & Automation
26	Surajit Santra	Skill & Innovation Promotion Group, Technology Marketing Group
27	Anjan Lakra	Surface and Field Robotics
28	Sukanta Bhattacharjee	Surface and Field Robotics
29	Nalin Paul	Surface and Field Robotics
30	Arabinda Sarkar	Surface Engineering & Tribology Group
Lab Assistant		
1	Jaladhar Das	Advanced Manufacturing Centre
2	Monoj Kumar Barui	Advanced Manufacturing Centre
3	Krishna Prasad Singh	AO'S Secretariat
4	Jiwan Lal	CoEFM, Ludhiana
5	R.N. Naskar	Director's Secretariat
6	Dipak Ghosh	Engineering Services Division
7	Ashoke Bouri	General Section
8	Ava Rani Majhi	Medical Centre

Sl.	Name	Group Affiliation
9	Jyotsna Chowdhury	Resource Planning & Business Development Group
10	K.P. Mondal	Security Section
11	T.D. Karmakar	Store & Purchase
12	Indravir Singh	Transport & Garage
Lab Attendent		
1	Kanailal Soren	Near Net Shape Manufacturing Technology Group
DST INSPIRE Fellow		
1	Dr. Kalisadhan Mukherjee	Centre for Advanced Materials Processing
2	Dr. Tapas Kuila	Surface Engineering & Tribology

Administrative, Finance, Store & Purchase and Isolated Cader

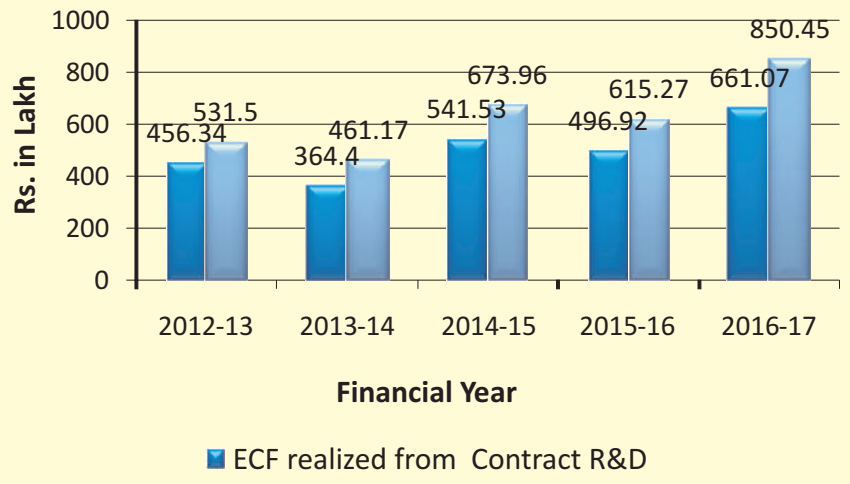
Jay Shankar Sharan — **Administrative Office**
Ratnakar Behera — **Finance & Accounts Officer**
Asim Kumar Jha — **Finance & Accounts Officer**
Bodhisattwa Dhar — **Store & Purchase Officer**

Sl.	Name	Group Affiliation
Section Officer		
1	Prabhat Bhushan	Bill Section, Cash Section, Official Language (Rajbhasa) Section
2	Subhajit Banerjee	CR Cell, Director's Secretariat, Vigilance Cell
3	Munmun Gupta	ERP Cell, Establishment, Public Relation Cell
4	Dayakant Kumar	Finance & Accounts
5	A.K. Bhuyan	Finance & Accounts
6	Pankaj Kumar	Finance & Accounts
7	Rama Kanta Dash	General Section
8	Chandan Kumar	Medical
9	Kaushal Kumar	Recruitment Section
10	D.K. Dhar	Store & Purchase
Personal Secretary		
1	Jhuma Dutta	AO'S Secretariat
2	J. Thandar	Resource Planning & Business Development Group
Assistant, Grade I		
1	Sanat Kumar Mondal	Bill Section
2	Tarun Halder	Bill Section
3	Siuli Pramanick	Bill Section
4	Dhananjoy Rajak	Cash Section, General Section
5	Kuldeep Kaur	CoEFM, Ludhiana
6	Shyam Lal	CoEFM, Ludhiana
7	Swapan Kumar Chakraborty	CR Cell
8	Subudhan Soren	Engineering Services Division
9	Ashis Dutta	Establishment
10	Binod Kumar	Establishment

Sl.	Name	Group Affiliation
11	Sumitry Kumari	Establishment
12	Rajshekar Ghosh	Finance & Accounts
13	Ashesh Kanti Dey	Finance & Accounts
14	Rakesh Sen	Finance & Accounts
15	Bikash Das	Finance & Accounts
16	Humayun Kabir	General Section
17	Surya Kant Swaran	General Section
18	Sukanta Samanta	Legal Cell, Recruitment Section, Vigilance Cell
19	Kajal Saha Talukdar	Recruitment Section
20	Subrata Mandal	Recruitment Section
21	Shailendra Kumar	Recruitment Section
22	Rajendra Nath Mondal	Store & Purchase
23	Samit Boot	Store & Purchase
24	Manish Kumar Pandey	Store & Purchase
25	Chandresh Kumar	Store & Purchase
26	Biswajit Bhowmik	Store & Purchase
27	Malay Mukhopadhyay	Store & Purchase
Assistant, Grade II		
1	Kamlesh Kumar	CoEFM, Ludhiana
2	T.B. Sonari	CoEFM, Ludhiana
3	Amit Kumar Mondal	Finance & Accounts
4	Arun Kumar Mahato	Store & Purchase
5	Ashish Kumar Paul	Store & Purchase
Senior Stenographer		
1	Vornajit Das	Director's Secretariat
2	Shardanand Kumar	Establishment
3	Bikash Kumar Bhakta	Finance & Accounts
4	Sanjeet Kumar	Planning & Performance Division
5	Amrit Kumar	Recruitment Section
Receptionist		
	Rimjhim Bose	Resource Planning & Business Development Group
Security Officr		
	Rajendra Singh Kanwal	Security Section
Junior Hindi Translator		
	Sanjay Kr. Mishra	Official Language (Rajbhasa) Section
Clerk		
	Satnam Singh	CoEFM, Ludhiana
MTS		
1	Raju Pundi	Advanced Manufacturing Centre
2	Sushila Rani Sharma	AO'S Secretariat
3	Basudeb Ruidas	Bill Section
4	Ranjit Kumar Sapui	Canteen
5	Ananda Lal Dey	Canteen

Sl.	Name	Group Affiliation
6	Nathu Ram	CoEFM, Ludhiana
7	Subhash Chander Yadav	CoEFM, Ludhiana
8	Rajinder Singh	CoEFM, Ludhiana
9	Subash Chandra Tewari	Director's Secretariat
10	Bhagwan Das Balmiki	Director's Secretariat
11	Bijendra Balmiki	Estate & Welfare Office
12	Atanu Chakraborty	Finance & Accounts
13	Ranjit Kumar Sil	General Section
14	Mita Samanta	General Section
15	Jealal Ram	Recruitment Section
16	Pabitra Mudikora	Recruitment Section
17	Raj Kumar Mandal	Robotics & Automation
18	S. Banerjee	Security Section
19	Ainul Haque	Security Section
20	Sanjoy Bouri	Security Section
21	Narayan Nayak	Transport & Garage
22	Harkishan Balmiki	Transport & Garage

External Cash Flow



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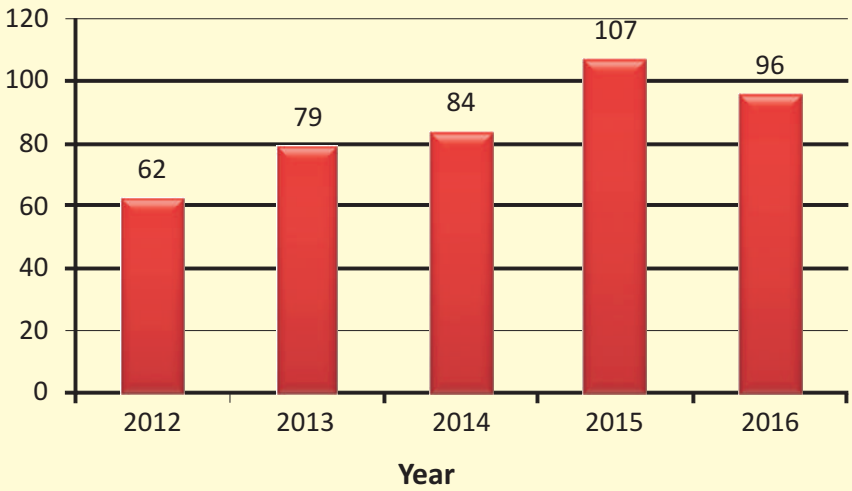

Total LRF Generated