2017-18

वार्षिक प्रतिवेदन
ANNUAL REPORT

सीएसआईआर-केन्द्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान, दुर्गापुर
CSIR-Central Mechanical Engineering Research Institute, Durgapur

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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 licenses. The institute is also the recipients 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.

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 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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DIRECTOR'S MESSAGE FOR ANNUAL REPORT

It gives me great pleasure in presenting the Annual Report of the year 2017-18 of CSIR-CMERI Durgapur, which is a pioneer Engineering Research Institute in the country.

CSIR-CMERI, Durgapur is a Mechanical Engineering Research Institute and being a member of the prestigious Council of Scientific and Industrial Research of National Importance, we are incessantly striving to make significant progress to serve the nation through development of novel and affordable technologies and products. In our effort to do so we try to imbibe the principles of 'Sustainable Development', so that the Environmental and Ecological concerns of the Society are also taken care of.

The activities of CSIR-CMERI, Durgapur, are mainly focussed upon the four primary thrust areas i.e. Industrial Services, Agricultural Machinery, Socio-Technological Applications and Strategic Applications. While focussing upon these thrust areas we also try to include Advance Technological Analysis, which helps us in plugging the technology performance loopholes.

At CSIR-CMERI, initiatives have been taken to make the institute a state-of-the art in-house Manufacturing Hub, which would ensure a smooth transition from conceptualization to materialization. This will also promote transformation of imaginative ideas to reality and give the necessary scientific and technical support to the budding entrepreneurs. Our mission is to innovate and design products which really eases the lives of the millions of Indians and promote "Make in India".

In the year 2017, CSIR-CMERI also received the CSIR Technology Award (Innovation Category) for development of the community level improved Iron Removal Plants.

During the year a number of technologies have been transferred which include Rotating Solar Tree, Plasma Disposal of Plastic Waste and Generation of Syngas, Metal Detector using Magnetic Field Splitting, Solar Artefact, Krishi Shakti Tractor, Plastic Waste Gasification Process, Salivary Fluoride Detection kit, Extraction of Ethanol from Waste Starchy Biomass, Safe disposal of Municipal Solid Waste, Large Scale Production of Graphene Oxide (200 g/ batch), Improved Iron Removal Plant (community level), Domestic Iron Filter, Multi-Fab Micro Fabrication Machine etc. We have now taken it as a mission to give impetus to develop technologies at CSIR-CMERI for societal benefit to help ease the daily life of the common Indians.

This Annual report summarizes in all aspects, the achievements and progress of the institute during the year. I take this opportunity to acknowledge the contributions made by our Scientists, staffs, councils and stakeholders. I also extend my sincere thanks to DG-CSIR and staff of CSIR headquarters for their constant support and confidence in us.

Prof. (Dr.) Harish Hirani

Director, CSIR-CMERI, Durgapur

वार्षिक रिपोर्ट हेतु निदेशक का संदेश

सीएसआईआर-सीएमईआरआई दुर्गापुर जो देश में एक अग्रणी अभियांत्रिक अनुसंधान संस्थान है के वर्ष 2017-18 का वार्षिक रिपोर्ट प्रस्तुत करते हुए मुझे अत्यंत हर्ष हो रहा है।

सीएसआईआर-सीएमईआरआई, दुर्गापुर एक यांत्रिक अभियांत्रिकी अनुसंधान संस्थान है और राष्ट्रीय महत्व के वैज्ञानिक और औद्योगिक अनुसंधान परिषद के प्रतिष्ठित सदस्य होने के नाते हम लगातार नई व सस्ती प्रौद्योगिकियों और उत्पादों के विकास के जरिए राष्ट्र-सेवा कार्य में उल्लेखनीय प्रगति करने का प्रयास कर रहे हैं। ऐसे कार्य हेतु हम अपने प्रयास में 'सतत विकास' के सिद्धांतों को अपनाने की कोशिश करते हैं, ताकि समाज के पर्यावरणीय और पारिस्थितिक मामलों का भी ध्यान रखा जाए।

सीएसआईआर-सीएमईआरआई, दुर्गापुर की गतिविधियां मुख्य रूप से चार प्राथमिक/महत्वपूर्ण क्षेत्रों अर्थात औद्योगिक सेवाएं, कृषि मशीनरी, सामाजिक-तकनीकी अनुप्रयोग और रणनीतिक अनुप्रयोग पर केंद्रित हैं। इन महत्वपूर्ण क्षेत्रों पर ध्यान केंद्रित करते हुए हम उन्नत प्रौद्योगिक विश्लेषण को भी इसमें शामिल करने का प्रयास करते हैं, जो हमें प्रौद्योगिकी प्रदर्शन में निहित खामियों को दूर करने में मदद करता है।

सीएसआईआर-सीएमईआरआई में इस संस्थान को अत्याधुनिक इन-हाउस मैन्युफैक्चरिंग हब बनाने की पहल की गई है। जिससे अवधारणाओं को एक मूर्त रूप देने तक का एक निर्बाध परिवर्तन सुनिश्चित होगा। यह कल्पनाशील विचारों का हकीकत में परिवर्तन को भी बढ़ावा देगा और नवोदित उद्यमियों को आवश्यक वैज्ञानिक और तकनीकी सहायता देगा। हमारा मिशन उत्पादों का नवोन्मेष करना और डिजाइन करना है जिससे वस्तुतः लाखों भारतीयों की जिंदगी और अधिक आसान हो जाती है और "मेक इन इंडिया" को बढ़ावा मिलता है।

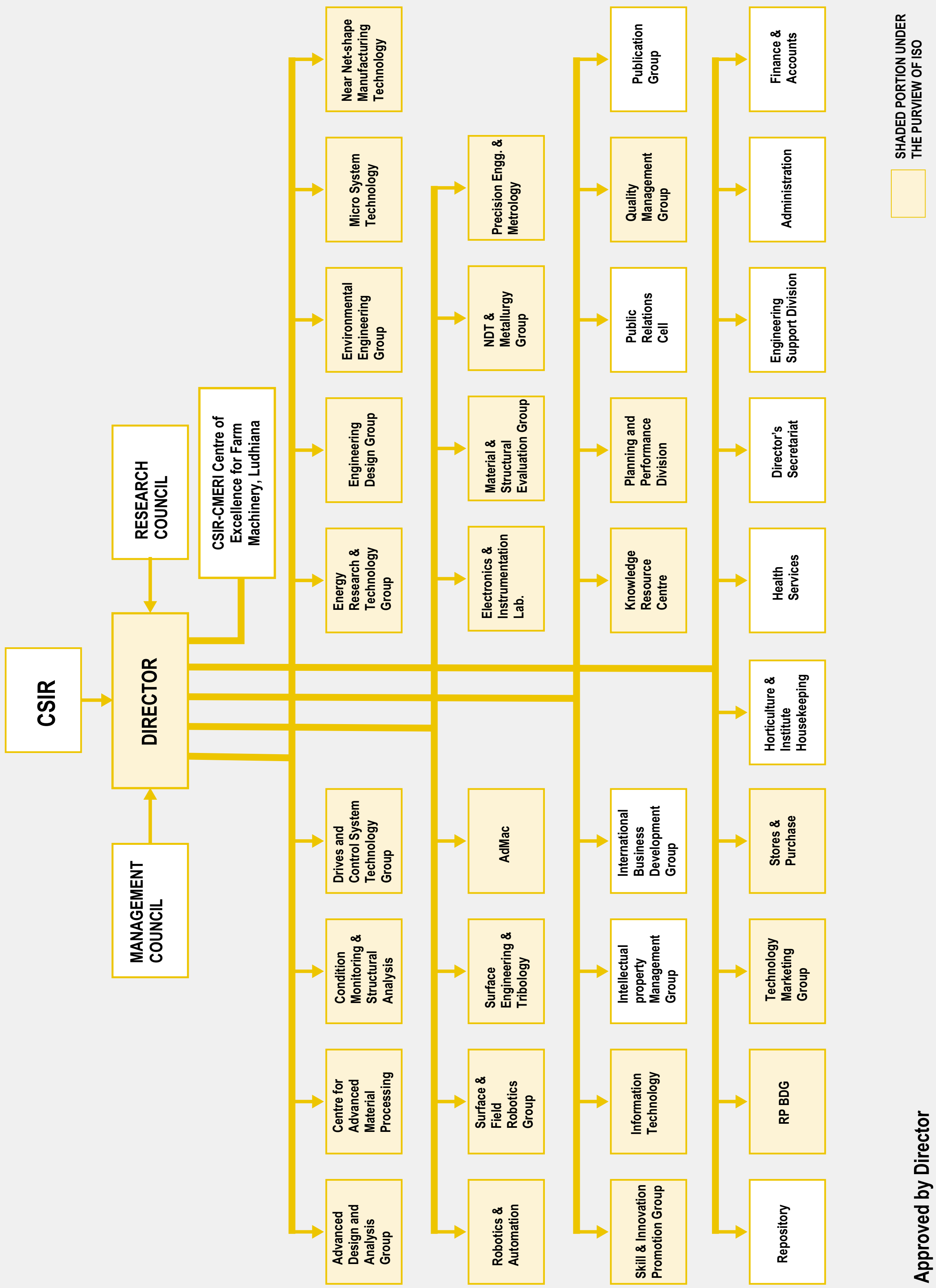
सीएसआईआर-सीएमईआरआई ने वर्ष 2017 में सुधारित लौह निष्कासन संयंत्र के सामुदायिक स्तर पर विकास के लिए सीएसआईआर प्रौद्योगिकी पुरस्कार (नवोन्मेष श्रेणी) भी प्राप्त किया है।

वर्ष के दौरान अनेक प्रौद्योगिकियों को स्थानांतरित किया गया है, जिसमें घूर्णन सौर वृक्ष, प्लास्टिक अपशिष्ट का प्लाज़्मा निपटान और सिनगैस का उत्पन्न होना, मैग्नेटिक फील्ड विभाजन, सोलर अश्मोपकरण (आर्टिफैक्ट), कृषि शक्ति ट्रेक्टर, प्लास्टिक अपशिष्ट गैसीकरण प्रक्रिया, साल्वरी फ्लूराइड संसूचन किट, अवशिष्ट स्टार्च बायोमास से इथनॉल की निकासी, धातु संसूचक का उपयोग नगरपालिका ठोस अवशिष्ट का सुरक्षित निपटान, ग्रेफीन ऑक्साइड का बड़ा पैमाने पर उत्पादन (200 ग्राम/बैच), बेहतर लौह निष्कासन संयंत्र (सामुदायिक स्तर), घरेलू लौह फिल्टर, मल्टी-फैब माइक्रो फैब्रिकेशन मशीन आदि शामिल है। हमने अब आम भारतीयों के दैनिक जीवन को सहज बनाने में मदद करने के उद्देश्य से सीएसआईआर-सीएमईआरआई में प्रौद्योगिकियों को विकसित करने हेतु प्रोत्साहित करने का कार्य एक मिशन के रूप में लिया है।

यह वार्षिक रिपोर्ट संस्थान के सभी पहलुओं, वर्ष के दौरान उपलब्धियों और प्रगति का सारांश प्रस्तुत करती है। मुझे इसके जरिए मुझे अपने वैज्ञानिकों, कर्मचारियों, परिषदों और हितधारकों द्वारा दिए गए योगदानों को स्वीकार करने का एक अवसर मिल जाता है। मैं महानिदेशक, सीएसआईआर और सीएसआईआर मुख्यालय के कर्मचारियों को उनके निरंतर समर्थन और हम पर विश्वास बनाए रखने के लिए तहे दिल से धन्यवाद देता हूँ।

प्रो (डॉ) हरीश हिरानी
निदेशक, सीएसआईआर-
सीएमईआरआई, दुर्गापुर

ORGANIZATION CHART



RESEARCH COUNCIL

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Former Secretary, Defence R&D
Chairman

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Director
Indian Institute of Technology, Dharwad, Karnataka
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Prof. S.G. Dhande
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Indian Institute of Technology, Kanpur
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Member

Shri Ravi Prakash Tripathy
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Member

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Former Director
Variable Energy Cyclotron Centre Kolkata
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Member

Prof. Harish Hirani
Director
CSIR-CMERI, Durgapur
Member

Dr. N.C.Murmu
CSIR-CMERI, Durgapur
Secretary

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Chairman

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Member

Dr. Priyabrata Banerjee
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Member

Dr. T. Murugan
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Shri Sumit Guha
Senior Technical Officer (3)
Member

Mr. Ashok Kujur
Finance & Accounts Officer
Member

Mr. Jayshankar Saran
Administrative Officer
Member-Secretary

Research & Development

1

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). 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.

The Group has the following recent activities:

- Design of Beam Stoppers for Super-FRS in FAIR project
- Design and Development of Mob Control Vehicle
- Design and Development of Tractor Mounted Mentha Reaper
- Battery thermal management through use of PCM based materials
- CSIR-MIDI (Metal Industry Development Institute, Ethiopia) Twinning Program
- Optimization of Friction Stir Welding process parameters for butt joining of 2024 Aluminum alloy plates

Activities in Detail:

1. Design of Beam Stoppers for Super-FRS in FAIR Project (GAP098212)

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

Facility for Antiproton and Ion Research (FAIR), an international accelerator and experiment facility of nuclear physics, is being built at GSI Helmholtzzentrum für Schwerionenforschung Darmstadt, Germany, and is set to be one of the largest accelerator research facilities for basic research in physics worldwide. FAIR GmbH was founded by an International treaty on 4th October 2010 and is anticipated to be operational by 2025. It will deliver beams for research in nuclear physics, hadron physics, high energy heavy ion collisions, atomic and plasma physics.

India is a founder member (Figure 1) and the third largest shareholder in FAIR science project with Bose Institute (BI) as the shareholding institute. India's participation is in the area of design and development of magnets, detectors and beam catchers. Indo Fair Coordination Centre (BI-IFCC) situated at Bose Institute facilitates the coordination of India's participation. An MOU was signed between CSIR-CMERI and BI-IFCC on 22nd July 2014 for design of beam stoppers as one the critical in-kind contribution from India [*http://www.fair-center.eu/partners/in-india.html*].

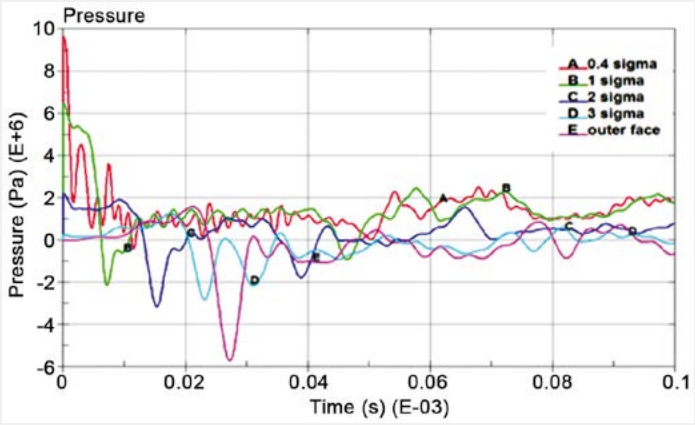
Beam dumps (synonymously used for beam stoppers or beam catchers) are primarily energy intercepting and dissipating devices. At FAIR, a wide range of ions with energies up to 1.5 GeV/nucleon are anticipated to be used for the production of

Figure 1: Indian representation at Foundation ceremony of the FAIR GmbH

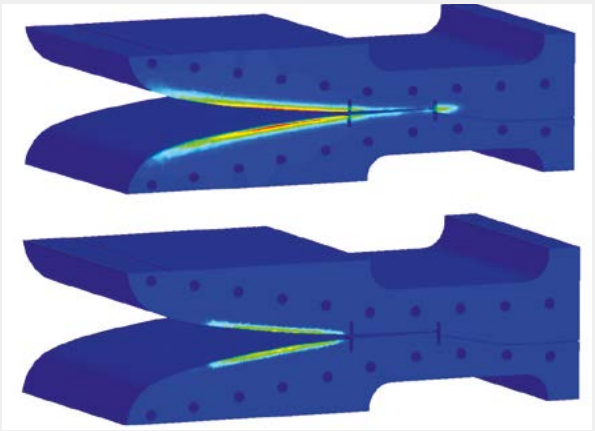
fragments by projectile fragmentation/fission at the superconducting fragment separator (Super-FRS). Rare isotopes of all elements up to uranium will be produced and spatially separated within a few hundred nanoseconds, enabling the study of very short-lived nuclei. The three units of beam catchers (namely BC1, BC2 and BC3) are to be employed in the Super-FRS beamline and have the primary function of safely stopping unwanted fragments and the primary beam and also to protect down stream components.

Each beam catcher employs absorbers of copper and graphite for slow extraction and fast extraction mode of operation, respectively. In the fast extraction mode of operation, series of pulses of high velocity particle beam deposit 29 kJ of energy within 50 – 100 ns duration at an interval of 1.67 s. In the slow extraction mode of operation, the beam is more of a quasi-DC form. The beam profile is a two dimensional Gaussian with varying spread according to the position along the ion-optical system, and the energy deposition is calculated by the stopping power for fast heavy ions in matter. The localized energy deposition density in the absorber (Bragg peak) causes the peak energy density to be as high as 300 J/g per pulse. This is expected to induce thermal shock waves in the absorbers and is one of the major challenges in design of beam catchers for this facility. Further, the removal of heat quickly and efficiently from the absorber is challenged by the huge thermal gradient compounded by material irradiation damage.

The transient coupled thermo-mechanical analysis of the pulsed form deposition of the beam is carried out using non-linear finite element code LS-DYNA® to study the generation and propagation of pressure waves within the absorber medium. The simulation results, wherein the pressure wave propagating from the core to the boundary and subsequent reflection can be observed in Figure 2 (a) which plots time history of pressure at five locations from core to the boundary. The failure of brittle material like graphite is usually in the form of cracking and spalling, and is determined by the maximum and minimum principal stresses present, and the ultimate tensile and compression strengths using Coulomb-Mohr failure criterion.



(a)



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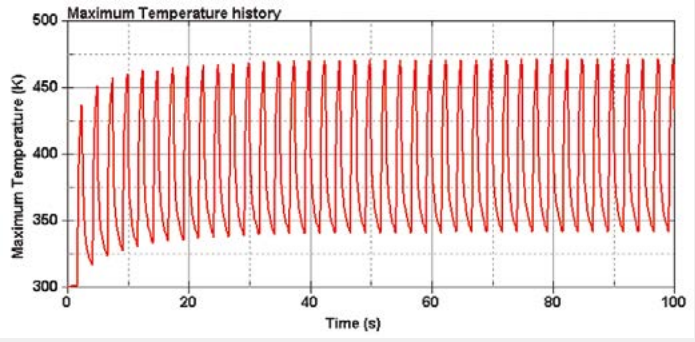
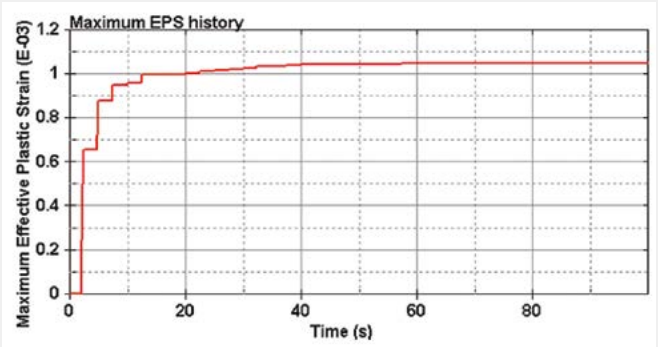


(c)



(d)

Figure 2: (a) Time history of pressure at five locations from core to the boundary for fast extraction. (b) Distribution of Temperature and Effective plastic strain (EPS) in slow extraction absorber, (c) Time history plot of Peak Temperature and (d) EPS in the pulsed slow extraction deposition.

The heat removal performance is studied through quasi static thermo-mechanical study for 17.1 kW average power deposition. The absorber, which is in the form of a segmented graphite block, is water cooled through copper heat sinks joined at the top and bottom. The entry shape of the absorber is optimized to enable maximum distribution of energy along beam direction, reducing steady state temperature reached from 2200K to 1500K. In the pulse form slow extraction case, the temperature and effective plastic strain (EPS) reached in the copper absorber are shown in Figures 2(b), (c) and (d). An algorithm is developed to obtain optimized profile for different Gaussian heights of the beams. As the height of beam spots vary for different absorber (12 different absorbers), this algorithm is used to obtain different profiles of the absorbers.

An important milestone for the project, namely, conceptual design review (CDR) of the Beam stoppers BC1, BC2 and BC3 has been completed in March 2018. The detail design and drafting of engineering drawings of Beam Catchers 1, 2 and 3 are currently on-going in consultation with the FAIR Super-FRS Group at GSI, Darmstadt, Germany. Commencement of Final Design Review (FDR) has been scheduled in Sept 2018.

2. Design and Development of Mob Control Vehicle (MCV)

[CSIR Funded Major Lab Project, Status: Ongoing]

The global riot control system market is projected to grow from USD 9.05 Billion in 2016 to USD 11.78 Billion by 2021. This report forecasts the riot control system market and its dynamics over the next five years, while also recognizing market application gaps, evolving technologies, recent developments in the market, and high potential geographic regions and countries. This growth can be attributed to the increase in ethnic unrest, religious riots, political disputes, and violence against governments globally.

Design and Development of Mob Control Vehicle (MCV) has been initiated from Nov 2017 with the aim of better control and dispersion of aggressive mob in riotous situations under the inspiration of Hon'ble PMO. The design and development team comprising members from various R&D research groups of the Institute and CoEFM Ludhiana is working in close coordination with Ministry of Home Affairs (MHA), Govt. of India, Ministry of Defence and various stakeholders like CRPF-RAF, BSF and Ordinance Factory Board (OFB) for getting their valuable inputs in deriving the system specifications. The MCV under development have been conceived in Fast Tract Translational (FTT) project mode on the high priority areas to address the unmet need. The attainments so far have been very encouraging. Under 1st phase of the project CSIR-CMERI has developed two proof of the concept MCV prototypes and demonstrated in August 2018.

The first prototype MCV is built on a bus (Figure 3), augmented with advanced electronics and control system and suitable for CRPF/RAF for mob control. The vehicle is augmented with dash board integrated display of GPS tracker and Navigator, stitched image display from front cameras, Rear View Camera, Joystick operated Pan Tilt MBL (Multi Barrel Launcher), Multi-channel video transmission system to command and control centre along with Multi-copter surveillance system and irritant spraying system to disperse mob surrounding the vehicle.

Figure 3: MCV-Bus Type

The second prototype MCV is built on a tractor (Figure 4) fitted with hydraulically operated retractable shields and suitable for Police and BSF. Other significant features include hydraulically operated platform; IR Bullet front view, rear view and side view cameras; PTZ camera with 360-degree view mounted on a hydraulic operated platform with controller.

The 2nd phase of the project deals with detail design and development of the vehicle with features integrated in Phase-I and users feedback received through demonstration of "Proof of the Concept" prototype. In this regard a National level Committee has been was constituted by Ministry of Home Affairs, Govt. of India to assess and propose specifications of MCV. Design and testing of various modules in the second phase has already been commenced.

The retractable shields have been designed and tested (Figure 5) considering different types of concepts for shield and its actuation for better applicability, manufacturability and ease of implementation. The shields are operated through numbers of translational and rotational motions using hydraulic actuation systems.

The front adjustable hydraulically operated shovel to remove obstacles in the front is also tested and integrated to the vehicle chassis.

Figure 4: MCV-Tractor Type

Currently detail specifications for two types of MCV have been are under consideration by the National Level Committee considering the spectrum of operations undertaken by CRPF-RAF on various terrain & density profile regions.

Figure 5: Testing of Retractable Shield

Integration and testing of electronics & communication systems inside MCV Prototype – Bus Type (Robotics and Automation Group)

Multi-copter take-off from MCV Prototype

3. Design and Development of Tractor Mounted Mentha Reaper

[CSIR Funded Project, Status: Ongoing]

Currently, a decreasing trend in acreage and interest of farmers in mentha cultivation has been observed due to improper post harvesting management. This is primarily due to shortage of labour required for harvesting the crop during its harvesting period along with comparatively higher labour cost (approx. 10 labourers are required per acre for harvesting (in one day) with an average wage of Rs. 250 per man-day). Hence, harvesting cost per acre is around Rs. 2500 with its associated risk (e.g., snake bites) during manual harvesting. Moreover, the harvesting of the mentha generally coincides with monsoon. Non-availability of labourers sometimes causes excessive delay in growing the crop. This creates a demand for mechanization so that higher acreage can be harvested offsetting manpower non-availability and associated cost.

Glimpses of the Mentha Reaper in operation

The main objectives of the ongoing project are (a) improvement in existing CSIR-CIMAP Mentha reaper and (b) design and development of an improved version of tractor-mounted reaper for mentha and similar crops.

Current Status

The necessary design modifications of existing CSIR-CIMAP Mentha reaper are incorporated and field trials have been conducted satisfactorily on Mentha fields at Barabanki, Lucknow during 1st week of June 2018. Simultaneously, modeling work is going on for design and development of next improved version of the Mentha reaper.

4. Feasibility study of Graphene based PCM cooling for battery thermal management system

[Institute project, Status: Completed]

Thermal issues associated with the 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.

The idea of using phase change materials (PCM) for passive thermal management of devices is to make use of the latent heat of a phase change, usually between the solid and the liquid state. A phase change involves a large amount of latent energy at small temperature changes, so PCMs can be used for storing

heat with large energy densities in combination with small temperature changes. Passive thermal management using PCMs is suitable for applications where heat dissipation is intermittent or transient. PCMs such as paraffin wax typically have low thermal conductivity, so the applications of PCMs are limited to environments with a low heat transfer rate. During last few years, several researches have showed that thermal conductivity of paraffin wax can be improved by incorporating EG into the wax matrix. The results show that thermal conductivities of composite PCMs (paraffin wax) with mass fraction of 2%, 4%, 7%, and 10% EG increases up to 81.2%, 136.3%, 209.1%, and 272.7%, respectively. The present project was a feasibility study of graphene-based PCM cooling for BTMS.

Project Contribution

Thermal energy can be stored mainly in the form of latent heat, sensible heat and chemical energy. The first two forms of energy storage are the most common and, of these, latent heat can store higher quantities of energy per unit storage volume. PCMs are also used to store the heat in various applications like heat pumps, solar engineering, battery thermal management system and spacecraft thermal control. In electric vehicles and hybrid electric vehicles, to maintain the temperature inside the battery within operational limits and maintain temperature uniformity across the cell, PCM can be used. Since the phase change process is isothermal, one of the most important characteristics for a given application of a PCM is its melting point at a certain temperature. The PCM in the PCM tank is able to absorb a significant amount of heat dissipated from the battery pack. That heat is transferred from the PCM to atmosphere by convection. From the comparative analysis, it was shown that PCM can be an advantageous option for the thermal management relative to the other available options. One limitation of using PCMs as a thermal storage material is that they are application specific. Their suitability varies with application, e.g. the phase change temperature must be suitable for the heat source and heat sink, and additional weight is not favorable for vehicles but is much less problematic in stationary applications. Also PCMs sometimes have higher initial costs, volume expansion issues during melting and other issues, relative to sensible thermal storages, that need to be considered and managed.

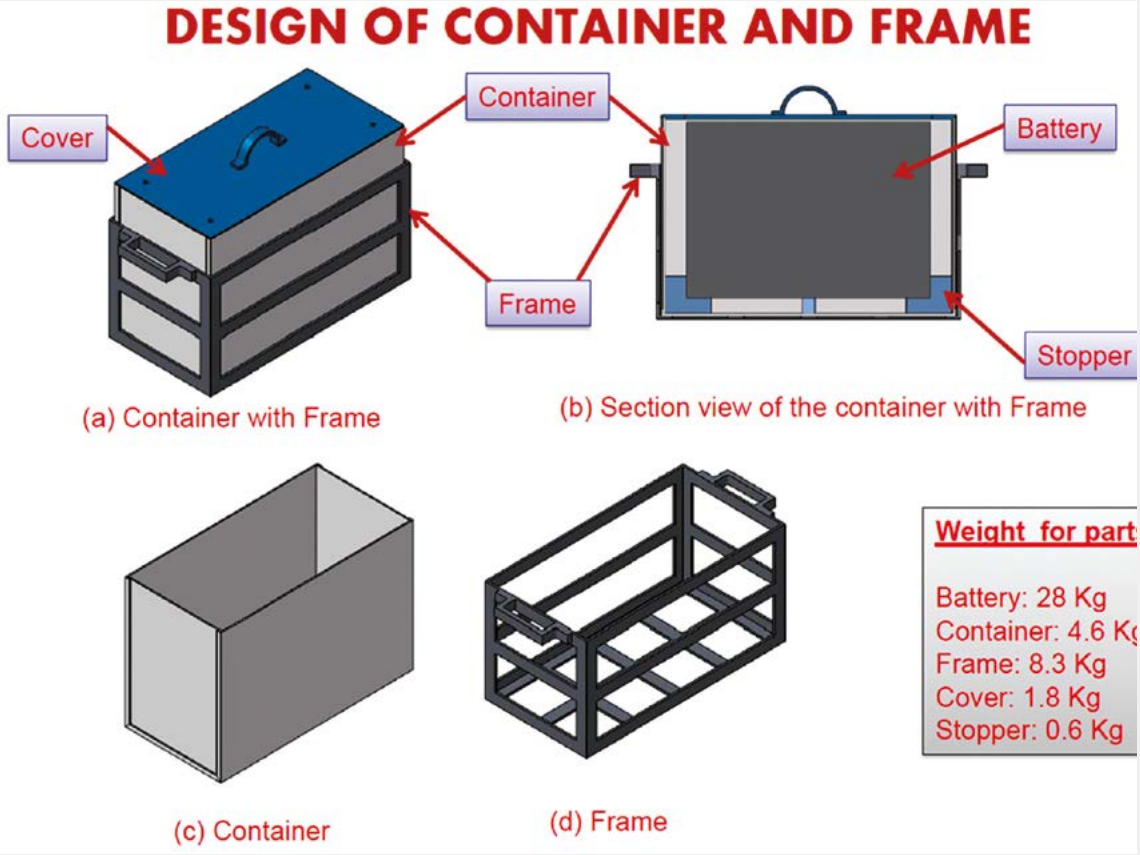


Figure 6: Design of PCM container for KIRAN-100 Battery

Some Representative Results

Figure 7 shows the maximum temperature rise and maximum temperature difference for different discharge rates without PCM, with PCM and with graphene embedded PCM. The melting temperature of PCM is 31.6^{0}C. Hence a maximum temperature of about 33^{0}C is obtained for high discharge rate. During high discharge rate, it is necessary to remove the generated heat very quickly. For this purpose, only a phase change material is used to keep the battery surface temperature low. Since the thermal conductivity of the PCM is very less, the heat is not diffused very quickly. Hence, to increase the thermal conductivity of PCM, graphene is embedded within PCM and used for very quick diffusion of heat from the battery surface. Using PCM, this maximum temperature difference reached is about 4.5^{0}C. On the other hand, this maximum temperature difference goes down to about 2.5^{0}C using the graphene embedded PCM. Due to presence of graphene, the thermal conductivity of the PCM increases and temperature diffuses very fast compared to other two cases.

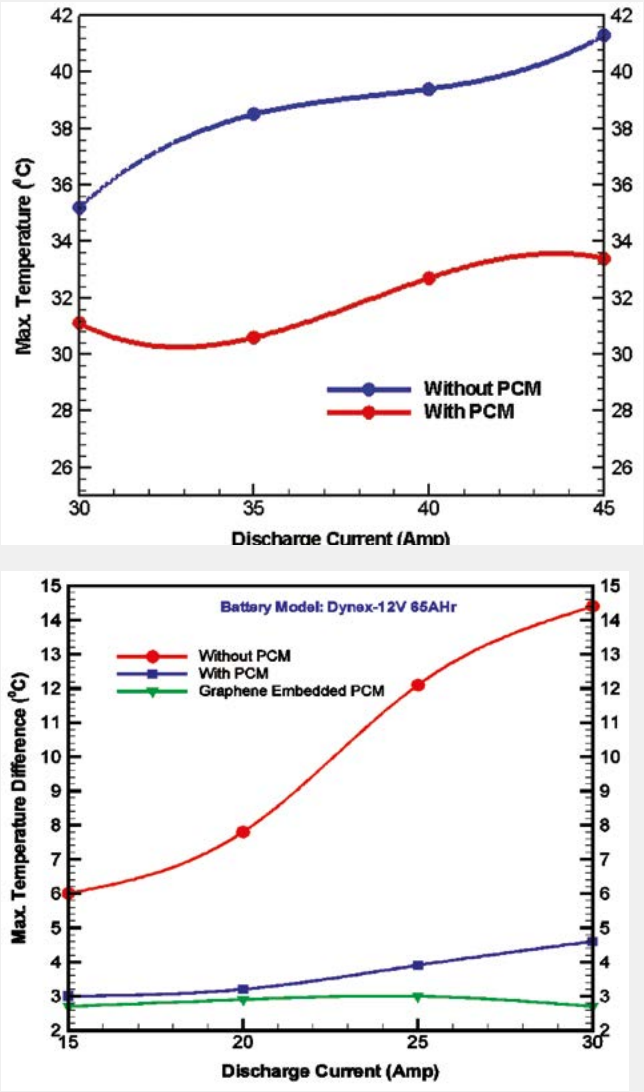


Figure 7: Maximum temperature rise during discharge process.

Conclusions

To check the feasibility of graphene embedded PCM cooling for thermal management system, an extensive experiment is carried out using the standard two types of lead acid batteries used for solar tree application. First of all, a survey on rise of battery surface temperature during day time is carried out for consecutive three days. It is observed that the temperature rise due to operation of charging and discharging is very less (about 2-3^{0}C). Internal heat generation is very low during very slow charging and discharging process; hence the battery surface temperature rise is also found to be very low. In experiment, the temperature rise depends upon the discharging rate. It is found that the temperature rise is less for low discharge rate and high for high discharge rate. Also, the maximum temperature difference obtained is about 14^{0}C without any cooling medium. This maximum temperature goes down to 2.5^{0}C using graphene embedded PCM. Hence, it can be concluded that the graphene embedded PCM can be used for specific applications.

5. CSIR-MIDI (Metal Industry Development Institute, Ethiopia) Twinning Program

[Sponsored by: MIDI, Status: Ongoing]

The Council of Scientific and Industrial Research (CSIR) has recently entered into an agreement with the Metal Industries Development Institute (MIDI), Ethiopia to implement a twinning programme. The same is aimed at R&D capacity building of MIDI. CSIR has clinched approx. 7.0 million US dollar assignment through a process where many international organisations were considered. The twinning is one of the largest programs (in terms of contractual amount) between a CSIR institute and a foreign entity. It should also facilitate CSIR's future collaborations with African Organizations.

The agreement was signed on 7th June, 2017 at Addis Ababa in the gracious presence of H.E. Dr. Alemu Sime, State Minister of Industry, Federal Democratic Republic of Ethiopia, H.E. Mr. Teshome Lemma, State Minister of Education, Federal Democratic Republic of Ethiopia, Dr. Girish Sahni, Director General, CSIR and H.E. Mr. Anurag Srivastava, Ambassador of India to Ethiopia, Djibouti and African Union.

The agreement was signed by the Director of National Metallurgical Laboratory, Jamshedpur (CSIR-NML) on behalf of the participating CSIR Laboratories, and the Director General of Metals Industry Development Institute (MIDI), Addis Ababa, Ethiopia. CSIR will enhance the capacity and capability of MIDI under the twinning arrangement and thereby enable it to contribute more efficiently towards the development of Metals and Engineering sectors in Ethiopia and thus enhance their competitiveness. The MIDI will be positioned to emerge as a globally competitive center of excellence in the field of Metals and Engineering, through the twinning program.

This agreement signing is the follow-up action of the creation of a Letter of Intent (LoI) between Metal Industry Development Institute (MIDI), Ethiopia and the Council of Scientific and Industrial Research (CSIR), India. The assessment of the requirements of MIDI and GAP analysis of MIDI were major initial activities which a CSIR team carried out as a prelude to Twinning with MIDI. The constituent laboratories of CSIR, namely CSIR-NML, Jamshedpur, CSIR-CMERI, Durgapur, CSIR-CEERI, Pilani, CSIR-CSIO, Chandigarh and CSIR-CLRI, Chennai, through a common collaboration platform, will execute the twinning arrangement. These laboratories have demonstrated expertise in minerals and metals extraction, casting, forming and shaping of metals, manufacturing processes and process controls, electronics and instrumentations, soft skills and quality management systems.

The 1st installment of 0.25 million US$ for CSIR-CMERI has been released in May 2018 by MIDI, Addis Ababa, Ethiopia.

6. Optimization of Friction Stir Welding process parameters for butt joining of 2024 Aluminum alloy plates [OLP 221412]

Aluminum alloys in particular 2024 alloy are quite popular in aerospace and automotive sector because of its excellent strength to weight ratio. But difficulties in welding 2024 aluminum alloys, have narrowed down their use in structural applications. Fusion welding of 2024 alloy give rise to various microstructural defects like porosity, voids, distortion and shrinkage which lead to the poor mechanical properties. On the other hand use of fasteners such as rivets, screws, and bolts increase the weight of the mechanical joint. To overcome all these problems, Friction stir welding which is a solid state welding process can be a promising alternative. During Friction stir welding process rotating tool is forced into the workpiece under axial force. The tool pin continues rotating and moves forward at predefined welding speed. Due to the rotary motion of the tool pin, friction heats the surrounding material and rapidly produces a softened "plasticized" area around the pin. As the tool move forward in the welding direction, the material behind the tool pin is forged under axial force from the

shoulder of the tool and consolidates to form a bond. The important parameters involve during the friction stir welding process are welding speed, rotational speed of tool, axial force and tilt angle.

The objective of the present study is to optimize Friction Stir Welding process parameters for butt joining of 2024 Aluminum alloy and similar related grade Aluminum alloy plates. In this report we are addressing the experimental work on hot compression test for understanding the material behavior and mechanical property of 2024 alloy at elevated temperature and FEM simulation is carried out for predicting the temperature distribution during FSW process.

Experimentation

To understand the material response at elevated temperature, hot compression tests were conducted at strain rates ranging from $0.001s^{-1}$ to $10s^{-1}$ and temperature range of 573 K to 773 K (300°C-500°C) with the help of a computer controlled servohydraullic testing machine (DARTEC) of 100 kN capacity. Specimens were made in the cylindrical shape from 2024-T3 Aluminum alloy with a height of 15mm and diameter of 10mm as shown in Figure 8. In order to measure temperature during deformation using thermocouple, a hole of 0.5 mm diameter is drilled at center of the specimen. The specimen was deformed to half of its height. The load stroke curve obtained from compression test was converted to the engineering stress – strain curve and subsequently to the true stress – strain curve using the standard equation shown below. Figure 9 show the flow stress curve.

True stress $$\sigma_T = \sigma_E (1 - \varepsilon_E) \quad (1)$$

True strain $$\varepsilon_T = \log_e (1 - \varepsilon_E) \quad (2)$$

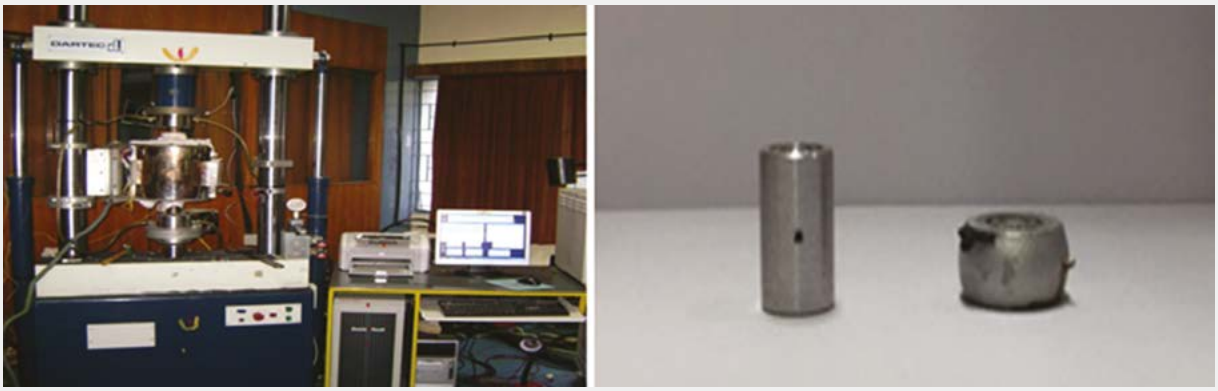


Figure 8: Servohydraullic compression testing (DARTEC) and cylindrical specimen deformed shape after hot compression test

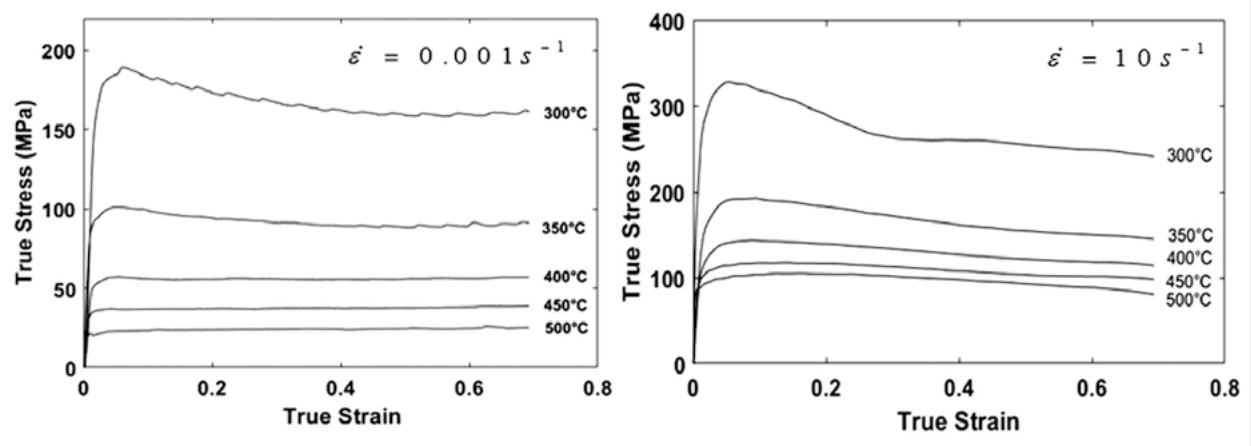


Figure 9: True stress–true strain curves of 2024 aluminum alloy during hot compression deformation at low and high strain rate

Thermal Analysis

The necessity of developing thermal model is to determine temperature variation in the work piece during friction stir welding. Temperature dependent thermo-physical properties of 2024 aluminum alloy such as thermal conductivity, specific heat, and density were used. Understanding heat generation phenomena is the first step in the direction of predicting the temperature variation taking place during the friction stir welding process. Heat generation during friction stir welding process is determined from the contact condition between tool and workpieces. The transition take place in contact condition from sliding to sticking with progress of deformation. In the beginning phase of friction stir welding, the temperature is quite low, and friction shear stress is less than shear yield stress. In this phase, the sliding phenomena takes place and friction condition is governed by Coulomb law of friction. As temperature increases frictional stress exceed shear yield stress and in this condition Coulomb law of friction is not applicable. This phase is described through sticking condition. The present thermal analysis, incorporate both sliding and sticking conditions for heat generation.

The temperature that evolves during friction stir welding is the most important parameter as it directly has an impact on the weld microstructure and quality. Figure 10 shows the FEM simulation results of temperature distribution in plunging phase and welding phase. It is observed that rise in temperature is noticed from the plugging to welding stage. The maximum temperature reached during the welding phase is 449°C which is well below the melting temperature of 2024 aluminum alloy.

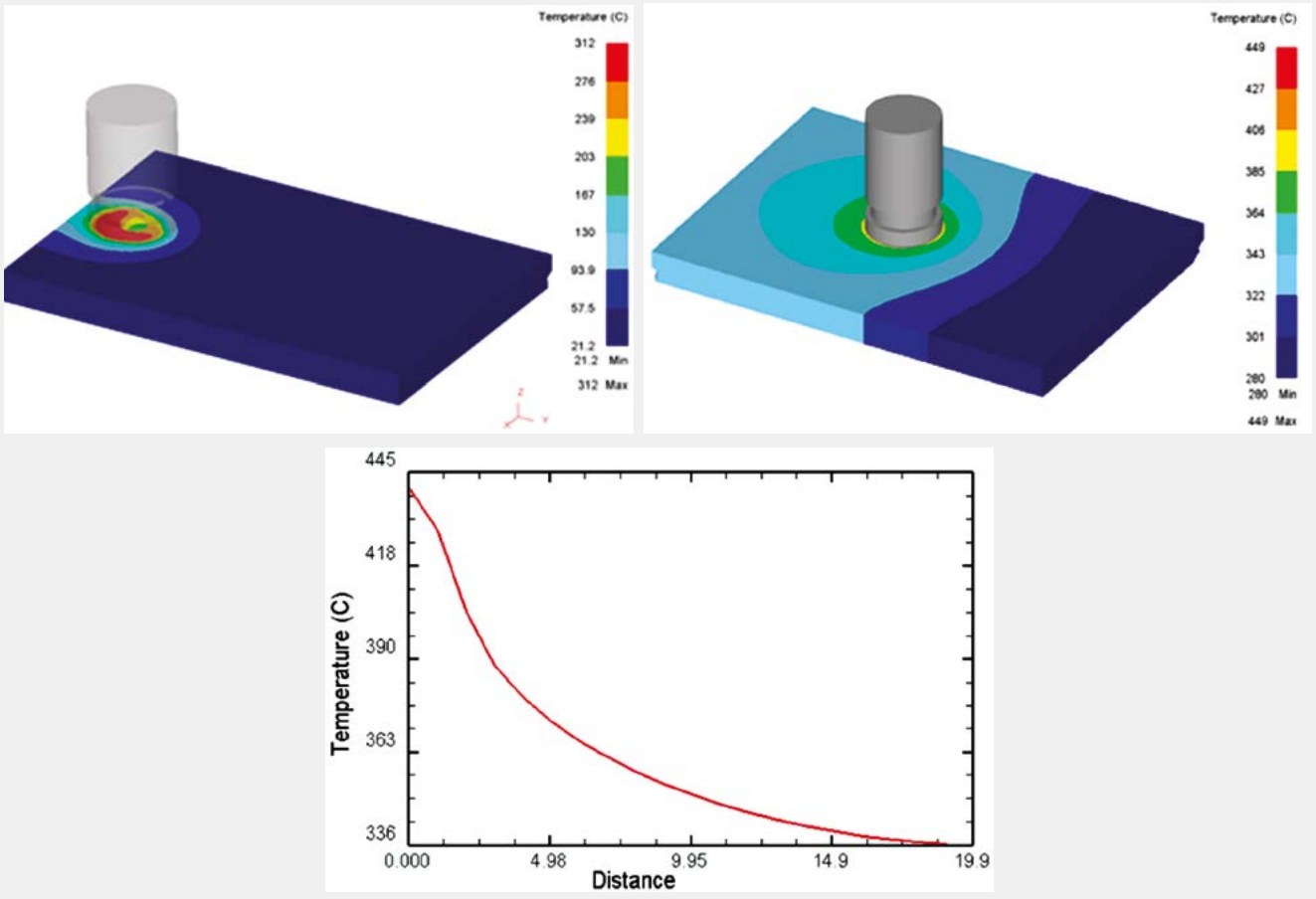


Figure 10: (a) Interfacial temperature distribution (b) Temperature at various location (center, mid-surface, surface) and (c) Transient Temperature variation at the interface

2

CENTRE FOR ADVANCED MATERIALS PROCESSING

1. Tribological influences of CuO in 3YTZP ceramic matrix

CuO is a well-known solid lubricant which imparts low friction coefficient as well as low wear rate while incorporated into the ceramic matrix. 2wt% CuO (<50nm) has been added into the 3mol% yittria stabilized zirconia (3YTZP) ceramic. The samples are compacted and sintered at 5ton/cm^2 and 1500°C respectively. The friction coefficient and wear rate have been evaluated using pin-on-disc tribometer where the pin samples are sliding against alumina disc. 20N load, 0.4m/s sliding velocity and a total of 1000m sliding distance are considered as the tribological operating conditions. All the samples are tested in the normal environmental temperature.

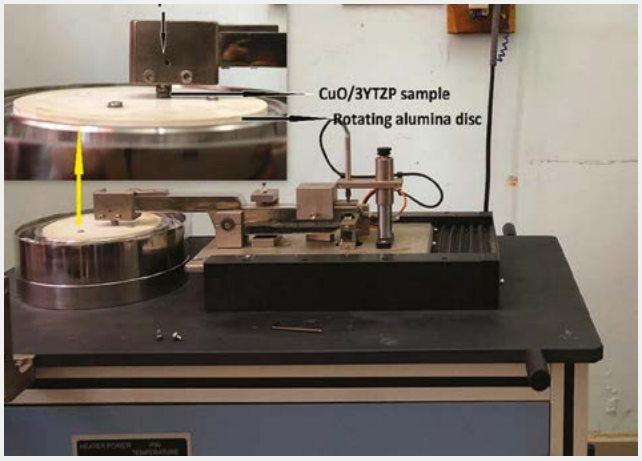
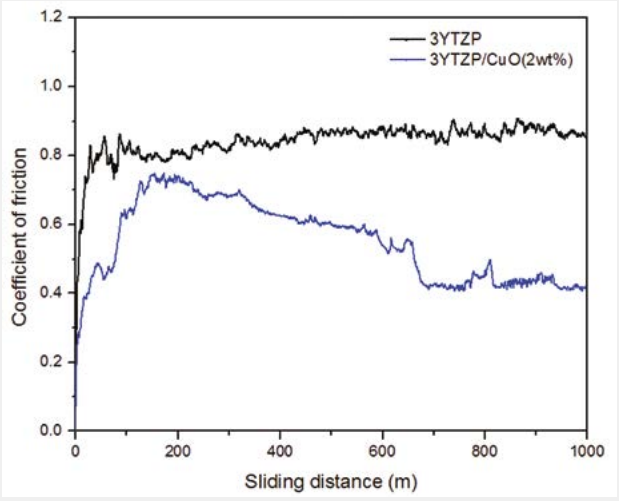


Figure 1: Pin-on-disc tribometer arrangement



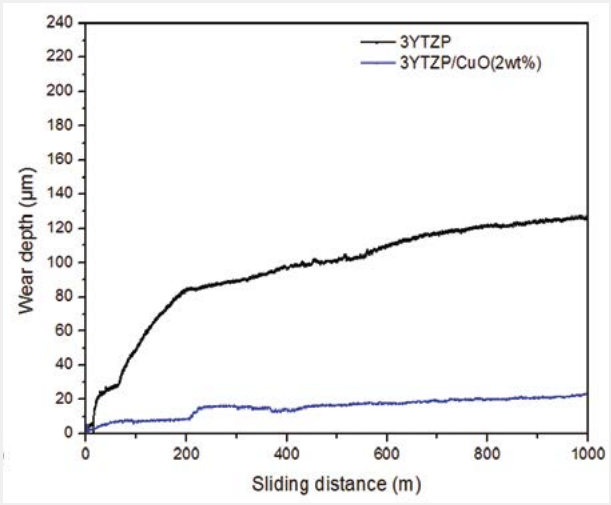


Figure 2: COF and wear depth variation with the addition of CuO over 1000m of sliding against alumina

The COF has been reduced from 0.82 to 0.52 with the addition of 2wt% CuO and the corresponding wear rate also decreases from 2.42×10^{-4} mm^3/Nm to 0.7×10^{-4} mm^3/Nm as well, though severe wear is dominant in all the cases. There is clear evidence that CuO imposes the protecting lubricating film which ultimately reduces the COF and wear by a significant level (Figure 2).

The worn surface characterization by FESEM evidences the film formation phenomena which is given in Figure 3. The patchy layer which is formed due to presence of CuO in-between the interface is responsible for reducing the COF. The patchy layers which wear off due to fatigue may result in a high COF.

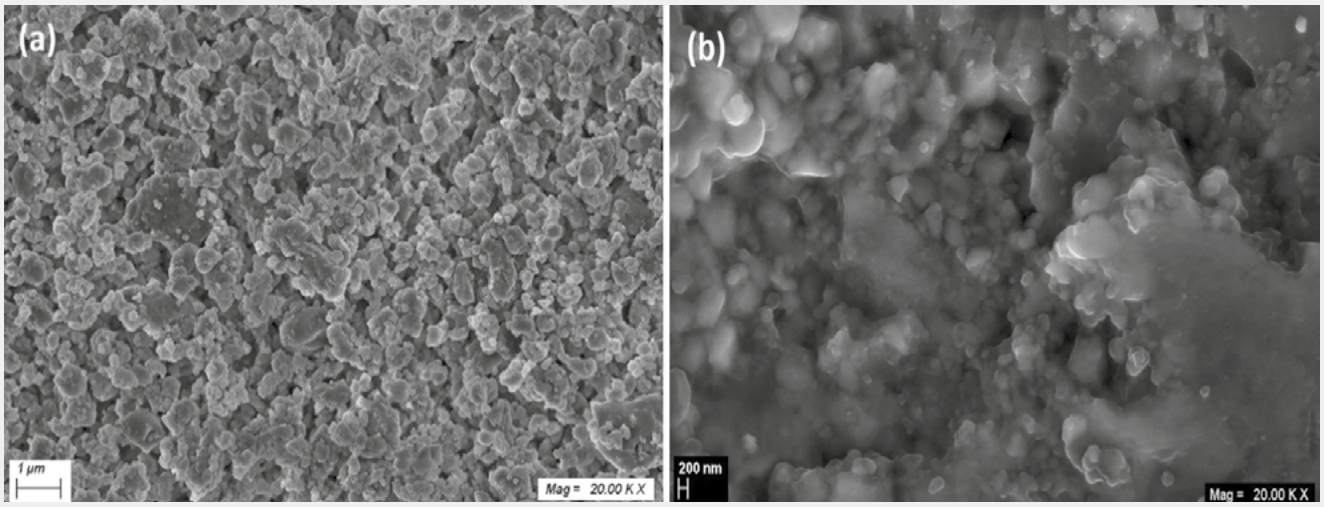


Figure 3: FESEM of the worn surfaces for (a) 3YTZP and (b) CuO/3YTZP

Therefore, it has been proved from the above research that small amount of CuO into 3YTZP ceramics influences the COF and wear rate to a great extent while sliding against alumina counter surface. Further investigation is needed to explore whether the COF and wear rate can be minimized by varying the tribological conditions and modifying the other processing parameters of the sample. Homogeneity of the microstructure can be improved by enhancing the ball-milling technique which may again lead to better tribological property as well. Of course, the size of additive particles into the contact interface plays a key role while forming a tribo-film and it should be further investigated.

2. Performance evaluation of in-house developed tooth coloured dental brackets towards possible societal deployment

Dental brackets, scientifically known as orthodontic brackets, are used for correction of irregular and deformable teeth of 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. At present, different types of dental brackets are available in the world such as metallic, gold-plated, sliver coated, plastic, translucent plastic and ceramic. Stainless steel brackets find mass usage in our country owing to its cost effectiveness over bio compatible ceramic brackets. Ceramic brackets offer significantly better mechanical properties, increased transparency and decreased reactivity with the oral environment compared to their metallic and plastic counterparts. Ceramic brackets are similar in colour to human teeth and offer solution to most of the problems associated with the metallic and plastic brackets. So, ceramic brackets offer an unbeatable combination of performance and beauty. However, ceramic brackets are imported to our country and available for a cost of approximately 5 times than its metallic counterparts, which sets the stage for indigenous development of the tooth coloured brackets at a comparable cost to metallic ones.

In the present work, affordable tooth coloured alumina dental brackets have been developed for a comparable cost with their metallic counterparts for the first time in the country. The tooth coloured brackets have been developed employing Micro Ceramic Injection Moulding (μ-CIM) process technology, alleviating the need of precision machining operations involved in case of other process technology of bracket manufacturing followed worldwide, such as press moulding, slip casting, conventional CIM etc. Design modifications have been incorporated within the prototype brackets, compared to other imported ceramic brackets available in the market, keeping in view of the manufacturing ease and cost effectiveness. Multi cavity micro injection mould has been designed and developed, wherefrom eight brackets of similar or different dimensional details can be manufactured from one injection shot. Alpha alumina powder having average particle size of 0.3-0.4 μm and polymeric inorganic/ organic binder system is used for the preparation of alumina feedstock, having powder loading of 58 vol%. Afterwards, injection moulded green compacts

were debonded using solvent and thermal debonding techniques and then finally sintered at 1600°C to develop tooth coloured alumina dental brackets with average density of approximately 3.8gm/cc (98% of theoretical density of alumina). In the present work, low cost, tooth coloured, polycrystalline alumina dental brackets have been developed with a bimodal grain structure having grain sizes ranging between 0.8-2 µm, minimum presence of microporosity, micro hardness of approx. 2400 VHN, and indentation fracture toughness of approx. 4.2. The brackets are found to possess sufficient debonding strength while tested in-vitro with the help of extracted human teeth. Subsequently, bio compatibility evaluation of the developed brackets were performed with the help of cytotoxicity analysis, using MTT assay technique. The biological cells cultured over the tooth coloured bracket samples were found to be living even after 72 hours of observation, which strongly establishes compatibility of the developed dental brackets with the oral atmosphere and confirms their suitability for possible societal deployment. Graphical abstract of the performance evaluation is shown below.

Acknowledgements

Author thankfully acknowledges the funding received from DST-SEED (Science and Society division), New Delhi via grant no. SP/YO/008/2015, under "Scheme for Young Scientists and Technologists" program.

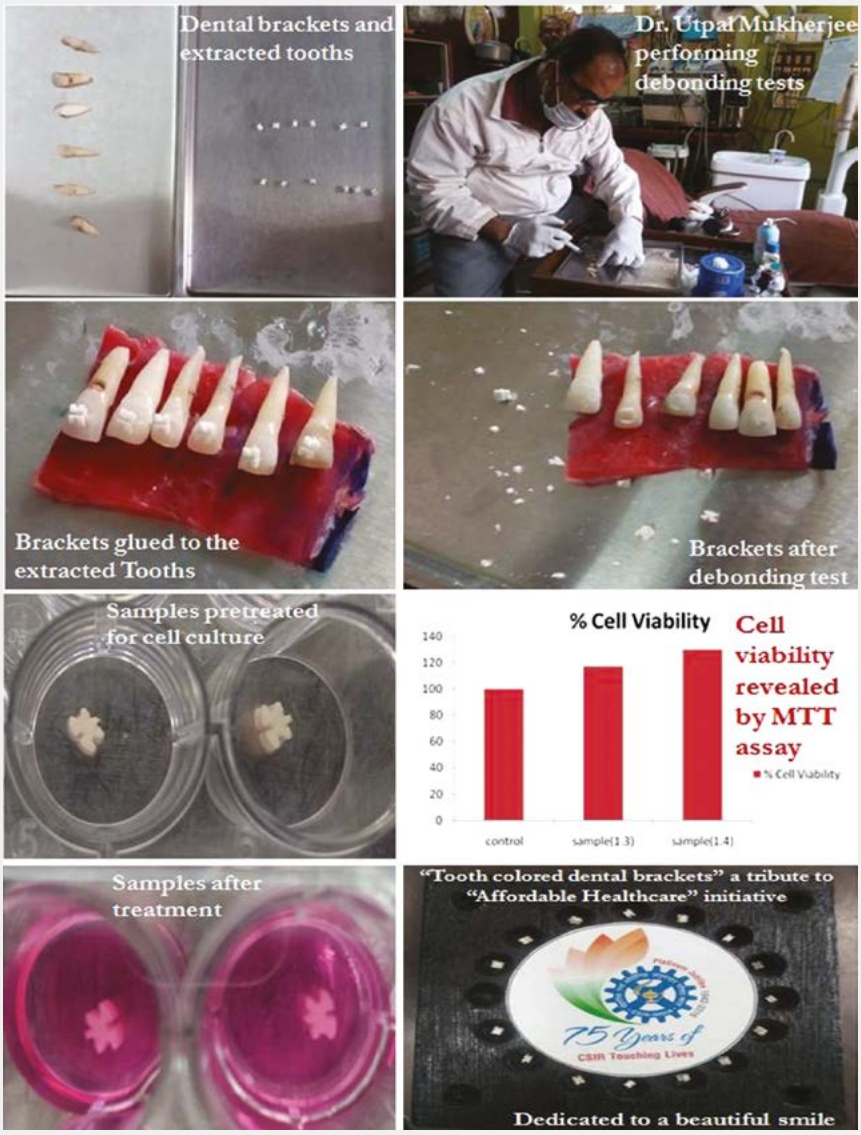


Figure 4: Graphical abstract of performance evaluation of "Tooth coloured dental brackets"

3. Design and development of prototype automobile brake disc and connecting rod, using novel Al-15Mg_2Si-4.5Si-0.2Sr-0.5B composite

According to Geneva Motor Show dated 9-19th March 2017 (http://aluminiuminsider.com/increased-aluminium-content-drives-geneva-motor-show/), the automobile industry continues to design their vehicles with an ever-increasing focus on efficiency and sustainability. Intensive use of aluminium helps manufacturers meet global greenhouse gas requirements and fuel standards. A 10% reduction in mass is usually accompanied by a 6.5% reduction in fuel consumption, a clear advantage over Advanced High Strength Steels (AHSS).

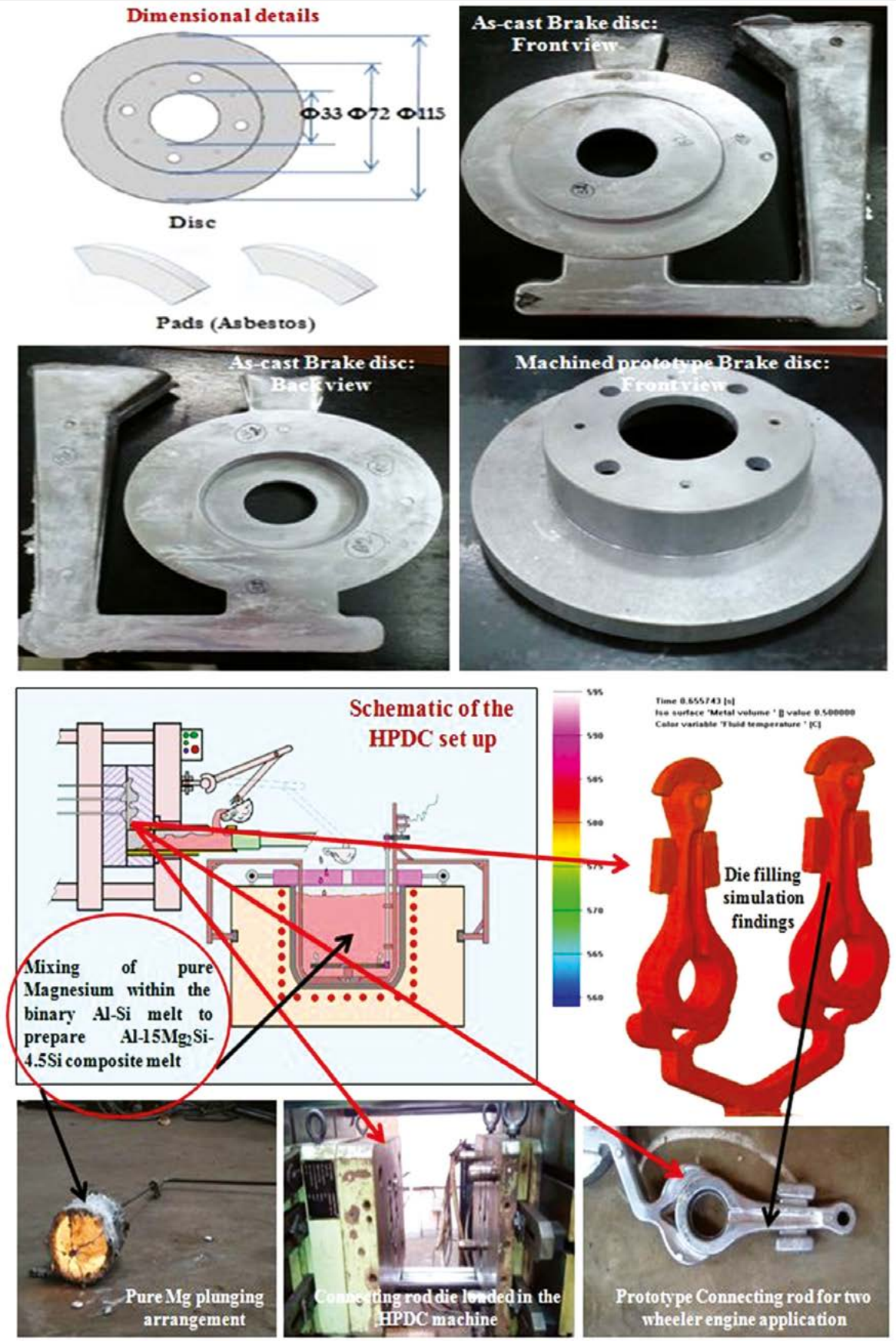
The present work discusses development of prototype automobile brake disc out of novel Al-15Mg_2Si-4.5Si-0.2Sr-0.5B composite. It should be mentioned here that the brake is an integral part of a vehicle which is used to retard or stop the vehicle from moving. From the safety aspect, the brake is an important and crucial component. So the brake rotor should be strong enough to withstand the thermal effect and dissipate the generated heat quickly. In recent times, disc brakes have gained popularity owing to their better heat dissipation ability—a direct result of the exposed friction surface. Commonly used material for disc brakes is cast iron. Density of cast iron is high and leads to more fuel consumption and emissions. Whereas, advanced light weight Al based composites offer notably improved mechanical properties and enhanced strength to weight ratio, which opens up the window for using them to develop wear resistant, lightweight automotive vehicle components such as brake drums, disc brake, brake calipers, engine blocks, cylinder heads, transmission casings, and engine components such as pistons, connecting rods, oil pumps etc.

Ex-situ composites like Al-SiC is well researched as a promising brake disc material due to its excellent mechanical properties and friction behaviour. However, in comparison to iron and steel, Al-SiC composite has larger linear expansion coefficient and lower strength at high temperature, which increases the thermal damage tendency and limits the speed range of Al-SiC brake disks. Moreover, being an ex-situ composite, Al-SiC offers a series of manufacturing difficulties such as (i) poor wettability and (ii) anisotropic mechanical properties in the cast parts due to their segregation tendency. On the contrary, in-house developed novel Al-15Mg_2Si-4.5Si-0.2Sr-0.5B composite offers solution to the wettability issues and yields isotropic mechanical properties within the cast parts due to the in-situ formation of Mg_2Si particles within the melt. Mg_2Si particles exhibit high melting temperature, low density, high hardness, low thermal expansion coefficient and reasonably high elastic modulus, which makes the present composite an ideal candidate for braking applications.

In view of the above, it can be concluded with confidence that the developed in-situ Al-15Mg_2Si-4.5Si-0.2Sr-0.5B composite being a low cost, light weight and superior alternative to commercially available cast Al-Si-Mg alloys, can be used for development of engine and body components related to automobile, aerospace and spacecraft manufacturing industry. In this study, an automobile brake disc (Tata Indica) has been developed as a prototype component out of the above mentioned composite, with notably improved mechanical, friction properties. Furthermore, the developed composite is processed using a high pressure die casting machine at liquid and semi solid state to develop a prototype connecting rod, targeting two wheeler engine applications. Graphical abstract of the above discussed developments is shown below.

Acknowledgements

Author thankfully acknowledges the funding received from SERB (DST), New Delhi via grant no. SB/EMEQ-449/2014.


Dimensional details
Φ33 Φ72 Φ115
Disc
Pads (Asbestos)
As-cast Brake disc: Front view
As-cast Brake disc: Back view
Machined prototype Brake disc: Front view
Schematic of the HPDC set up
Mixing of pure Magnesium within the binary Al-Si melt to prepare Al-15Mg2Si-4.5Si composite melt
Die filling simulation findings
Pure Mg plunging arrangement
Connecting rod die loaded in the HPDC machine
Prototype Connecting rod for two wheeler engine application

4. Development of advanced nanomaterials for volatile organics (VOCs) sensor

Gas sensors have attracted intensive research interest due to the demand of sensitive, fast response, and stable sensors for industry, environmental monitoring, biomedicine, and so forth. The development of nanotechnology has created huge potential to build highly sensitive, low cost, portable sensors with low power consumption. The extremely high surface-to-volume ratio of nanomaterials is ideal for the adsorption of gas molecules.

Gas sensors are devices that can convert the concentration of an analyte gas into an electronic signal. Zinc oxide (ZnO) is an important n-type metal oxide semiconductor which has been utilized as sensor for several decades. In recent years, there have been extensive investigations of nanoscale semiconductor gas sensors. The size reduction of ZnO sensors to nanometer scale provides a good opportunity to dramatically increase their sensing properties in comparison with their macroscale counterparts.

Two kinds of very high-quality ZnO nanostructures (nanowires and nanorods) were developed. ZnO nanowires and nanorods were synthesized by a low-cost hydrothermal technique with different concentration of solution. A schematic of the structure is shown in Figure 5(b). Nanowires were grown using 0.01M solution concentration and nanorods were grown using 0.1M solution concentration. Figure 5(a) shows the FE-SEM image of ZnO nanowires on ZnO thin films, which act as a seed layer (Figure 5(c)). However, the average diameter of ZnO nanowires is in the range of 30 to 110 nm with a length of about 1.2 µm. ZnO micro rods with diameter 300-600 nm was synthesized using 0.1M solution concentration at a low temperature of 95°C using a hydrothermal method.

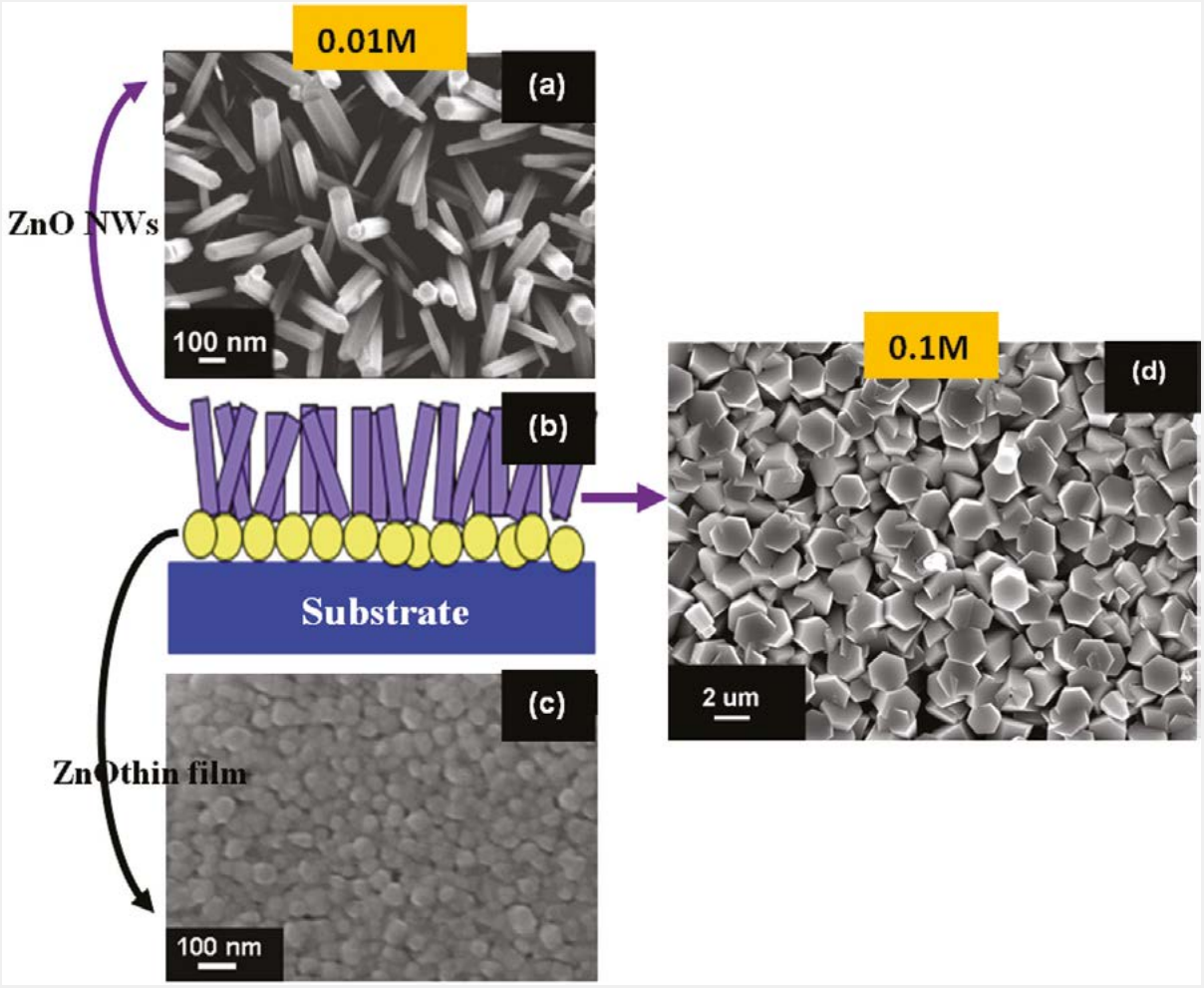


Figure 5: Hydrothermally synthesized ZnO nanowire and nanorods

The digital photograph of the gas sensing setup is shown in Figure 6(a), which was indigenously developed in our laboratory. The schematic structure with electrical connection of the gas sensor is shown in Figure 6(b).

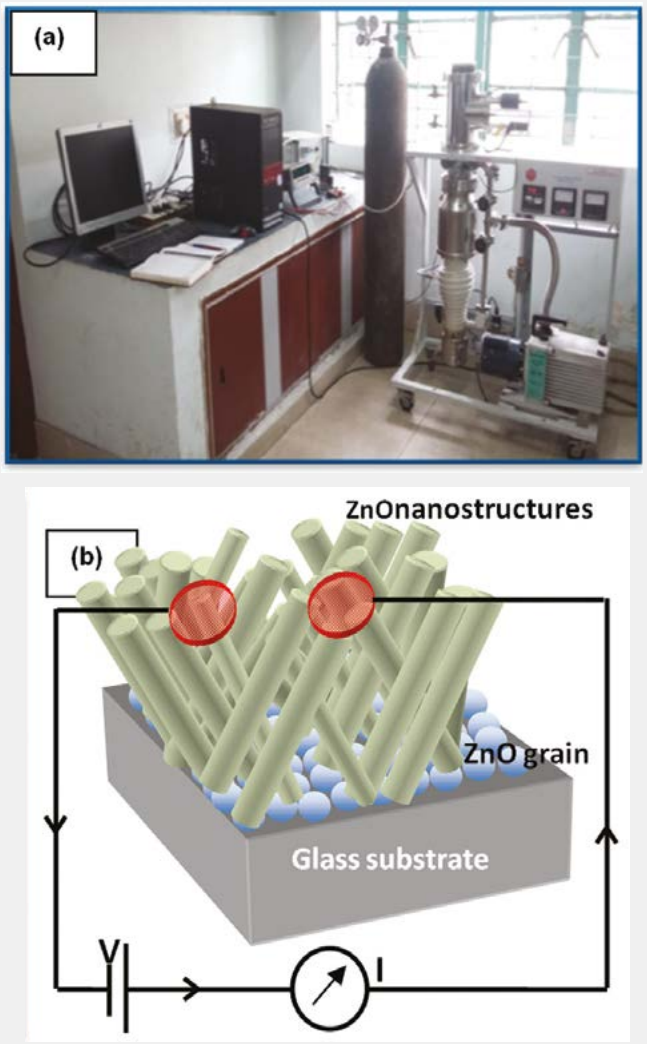


Figure 6: The digital photograph of the sensor measurement set up and the schematic architecture of sensor with electrical connection.

The sensing performances of the synthetic ZnO nanostructures were investigated using different volatile organic (VOC) vapours like methanol, acetone, and formaldehyde. Both ZnO nanostructures showed good sensitivity and selectivity to VOCs. Ultra-high sensitivity of 4.41×104% [gas sensitivity, Sg= (Ig–Ia)/Ia× 100%] and 5.11×102% to 100 ppm methanol gas at a temperature of 300°C and 100°C, respectively, has been observed from Figure 7. A fast response time of 200 ms and 270 ms as well as a recovery time of 120 ms and 1330 ms to methanol gas have also been found at an operating temperature of 300°C and 100°C, respectively.

Due to the size dependence, ZnO nanowires with the smallest diameter is considered the best sensor candidate compared to ZnO nanorods.

Acknowledgement

Author thankfully acknowledges the funding received from SERB (DST), New Delhi via grant no. EMR/2017/000058.

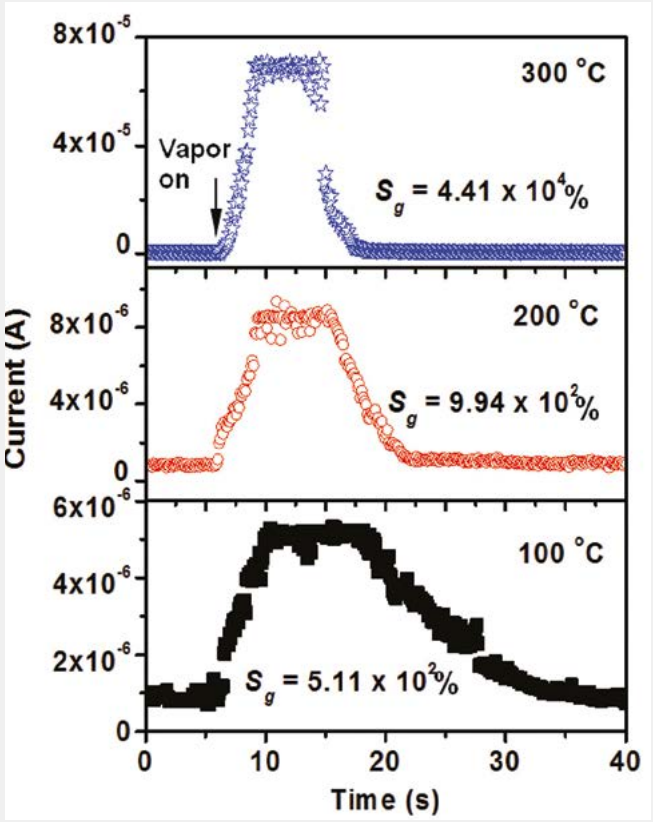


Figure 7: Methanol sensing performance

5. Design and development of a versatile welding fixture for manufacturing of prototypes

The developed welding fixture has two stainless steel (magnetic) breadboards, each of 900×900×10 mm size, having M10 taps at 50 mm pitch all along their faces. This would facilitate clamping varying size of plates on either of the breadboards for welding. One of the breadboards can be held at an acute angle (range: 45° - 90°) or obtuse angle (range: 90° - 135°) relative to the other. This is to hold the plates at

different angles within the mentioned ranges during welding. The fixture contains a manually operated hydraulic cylinder that can be bolted to its structure at two alternate positions. When bolted at one of the positions, it helps to rotate one of the breadboards, in the range: 45° - 90°, in both forward and reverse directions. When clamped at the alternate position, it helps to rotate the same breadboard in the range: 90° - 135°, again in both directions. A digital inclinometer, is attached to the rotating breadboard, with the help of its magnetic attachment to show the relative angle between the breadboards and hence the plates clamped onto them for welding.

Acknowledgement

This work was finically supported by CSIR—CMERI Institutional project (OLP-214412)

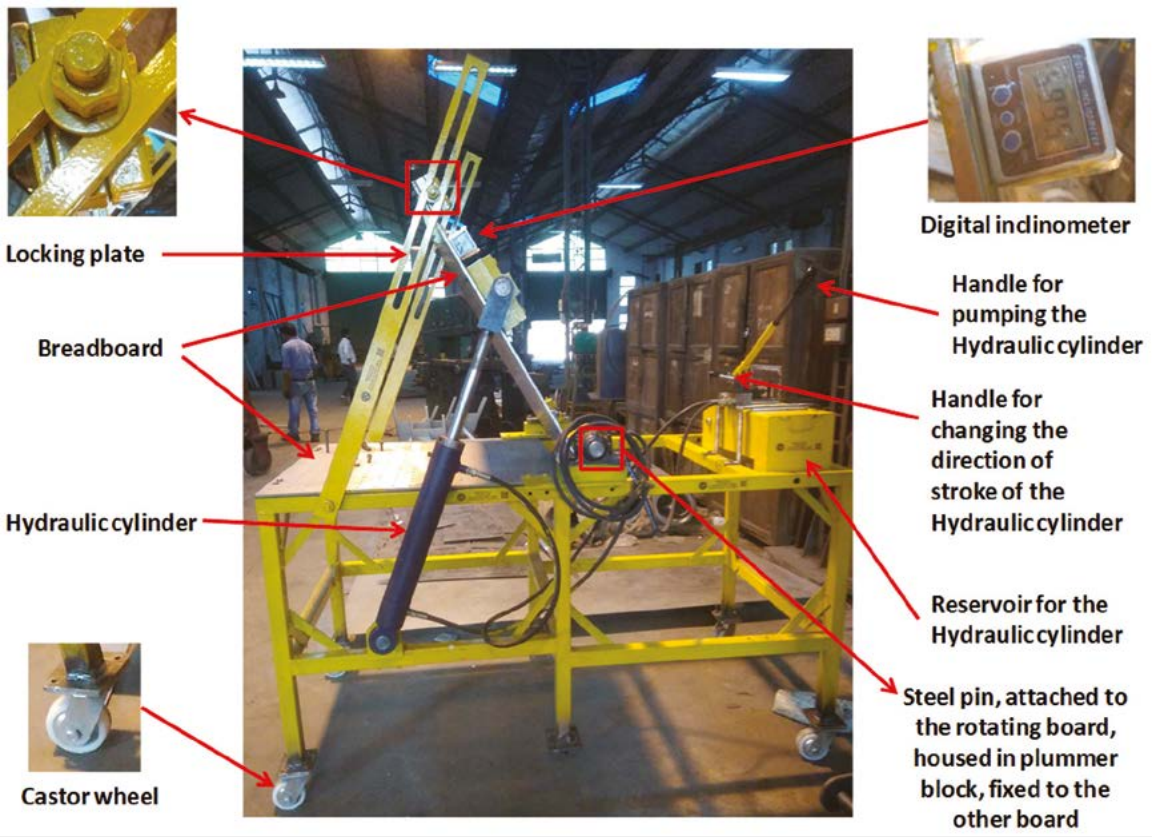


Figure 8: The welding fixture developed

3

CSIR-CMERI CENTRE OF EXCELLENCE FOR FARM MACHINERY, LUDHIANA

CSIR-CMERI-CoEFM, Ludhiana, since its inception has been pursuing research and development in various fields of mechanical engineering and collaborating with allied fields that include strategic, agricultural, bio-fuels, automobile and societal sectors. The infrastructural and research facilities are being upgraded along with more infusion of scientific staff for conducting research at world level and creating next generation products for the most crucial societal sector which includes the agricultural sector. The two major facilities are:

Technical and Industrial Services Centre (TISC)

A Technical and Industrial Services Centre (TISC) is being setup, by strengthening the existing manufacturing facilities, with the main purpose of providing direct interface between Industries and CoEFM, Ludhiana. Keeping in view with Prime Minister's vision of "Make in India", "Skill India" and "Start-up India", TSIC's aim is to promote technology transfer, establishing start-ups and other domestic industries. An in-house facility for development of assembly line for the agriculture and industrial machines in multiple numbers for deployment in the society and end users is also envisaged under TISC. Another objective is to impart technical skills to personnel from industry, (Recognition of Prior Learning) and graduates under CSIR Skill India Initiative.

It is formulated as an institutional mechanism to develop an atmosphere for innovation and entrepreneurship. Furthermore, TISC leads to active interaction between academics and industries which will help in sharing ideas, knowledge, experience and facilities for the development of new technologies and its rapid transfer to industries through setting up of start-up companies in the emerging areas of technology.

The scope of TISC:

- Nucleation of new business by creating the environment and opportunities for the technology providers and entrepreneurs. DDC-AC Single Phase Inverter
- Nurturing business during initial phase of new industries by offering them not only space but also access to technology support, business mentoring, networks, scientific and information resources and a generally conducive and supportive environment.
- Providing common facilities such as infrastructure and instrumental/manufacturing facilities to emerging industries.
- Arranging awareness programs for orientation of entrepreneurs towards technology basics/ management approach.

Precision Agricultural Laboratory

Precision Agriculture (PA) technologies, such as tractor guidance systems using a Global Positioning System (GPS), soil nutrient and yield mapping, and Variable-Rate input applications (VRT), are playing an increasing role in farm production by helping farmers gather information on changing field conditions to adjust production practices in the developed countries. This work methodology allows small producers to improve sustainability with maximising the yield potential. However, there are many obstacles for adoption of precision farming in developing countries in general and India in particular like small farm size, culture and perception of users, lack of success stories, lack of local technical expertise, data availability, quality and costs etc.

The development and mainstreaming of PA technologies needs multidisciplinary approach and requires experts and scientists from different fields such as agriculture, mechanical, mechatronics and

electrical background. An effort has been made in this focus area by developing different advanced agricultural machinery with the establishment of Centre for Precision & Conservation Farming Machinery (CPCFM) at CoEFM, Ludhiana and majority of the developed technologies are transferred to Industry for commercialization. CSIR-CMERI, have dedicated R&D groups like Centre of excellence of Farm Machinery, Robotics and Automation, Surface and Field Robotics, consisting of scientists of varied engineering backgrounds to address current opportunities, limitations and transferable innovative solutions on the topic of Precision Agriculture.

Under the PAg lab, key PA solutions which are already a success are being identified and field trials of such technologies be conducted for developing case studies to find the suitability of PA technologies in real Indian farm situations. Technical solutions such as data capture, processing and integrating this data to user friendly farm management system needs to be developed to mainstream the application and adoption of PA for resource conservation. Training and awareness programmes along with the demonstration of these technologies are formulated by identifying the stake holders and ambassador farmers and making them aware of benefits of PA technologies in different scenarios.

The objectives of PAg Lab are:

- Field trials of PA equipment and technologies in different real farm situations.
- Identify barriers to adoption of these technologies and improve their usefulness.
- Imparting advanced training on PA technologies to researchers.
- Demonstrating Precision Ag technologies to the farmers.

1. Design and development of kitchen waste biogas plant

A substantial portion of food waste is biodegradable (38-40%), which can be used to generate methane and environment friendly disposal of waste is a necessity considering mass pollution everywhere. Generation of fairly good amount of fuel gas is possible through solid fermentation of these food waste, which can augment the dwindling energy resources and provide self-reliance to the households for cooking. Generation of high quality manure, which would be odourless can act as an excellent soil conditioner for kitchen gardens. One kg kitchen waste produces approximately 0.5 m^3 biogas. For a typical urban household, biogas (having CV of almost 6600 kCal/kg) saves about 100 kg of LPG or 250 litres of kerosene per year, which is equivalent to 300 kg to 600 kg of carbon dioxide (CO_2) per year.

Advantages

- Combined advantages of fixed dome type and floating drum type biogas plant
- Online and offline use of gas
- Movable
- Protected Storage
- Solid state fermentation
- Manual slurry churning system
- Specially designed slurry outlet
- Slurry drying not required
- In built scrubbing system for methane enrichment
- Zero electrical power requirement
- Equipped with manual feed stock shredding system

Figure 1: Kitchen Waste Biogas Plant

2. Automatic Biomass Briquetting Plant

Punjab produces approximately 19-20 million ton of paddy straw and about 20 million ton of wheat straw. About 85-90% of this paddy straw is burnt in the field, and increasingly, wheat straw is also being burnt during the Rabi harvesting season. In Haryana, the problem of paddy straw burning also exists, although the scale is smaller than in Punjab. Burning of agricultural biomass residue, or Crop Residue Burning (CRB) has been identified as a major health hazard. In addition to causing exposure to extremely high levels of Particulate Matter concentration to people in the immediate vicinity, it is also a major regional source of pollution, contributing between 12 and 60% of PM concentrations as per various source apportionment studies. Other biomass wastes like dry leaves, grass, saw dust, rice husk also have little or no utility. A practical, cost effective solution for the disposal/use of agricultural and agro-industrial waste is making biomass fuel/briquettes for power generation. In CSIR–CMERI, a multi feedstock automatic briquetting machine has been designed and developed which can produce briquettes off-site from wheat/paddy straw, dry leaves, rice husk, grass, saw dust etc. A binder is prepared by mixing starch, paper pulp or animal fat. The briquettes can be sun dried or can be dried in conventional/solar dryer up to a moisture content of 4 to 8% for final use in household and dhabas for cooking purpose as well as in boiler & furnaces for generation of heat. The briquettes produced through an optimized process have been found to be having calorific value as high as 6000 kCal/kg, fast ignition and prolonged burning time of almost 2 hrs , low ash content and fixed carbon (~5%), lesser chloride (~0.02%) and sulphur content (~0.3%).

Advantages

- Use of multi-feed stock
- Density of briquettes can be modified as per requirement
- Use of locally available waste material as binder
- 5000 briquettes per day (8h)
- Same machine can be used for production of briquettes for domestic as well as industrial purpose
- Combination of mechanical, hydraulic and electrical systems

Figure 2: Prototype of automatic biomass briquetting plant

3. Offset Rotavator for Orchards

Mechanization of orchards in India need urgent attention and appropriate machinery for farm operations like tilling, inter-culture etc. are required to be developed. Side shifting capability of the rotavator can be used for inter-cultural applications in the orchards even under the canopy. Using this option, the tractor operator will be able to till the soil under the tree canopy where tilling cannot be done with present designs of rotavators or any other equipment. With suitable design features the rotavator can be effectively used for operation like seed bed preparation, orchard tilling etc.

For the first time in India, automatic hydraulic side shift rotavator for orchards is developed by CSIR-CMERI Centre of Excellence for farm machinery, Ludhiana in collaboration with PAU, Ludhiana and GBPUA&T, Pantnagar, sponsored by DST (GoI). A prototype developed has undergone preliminary testing. Extensive field trials are going on at the Punjab Agricultural University, Ludhiana and GB Pant University of Agriculture & Technology, Pantnagar.

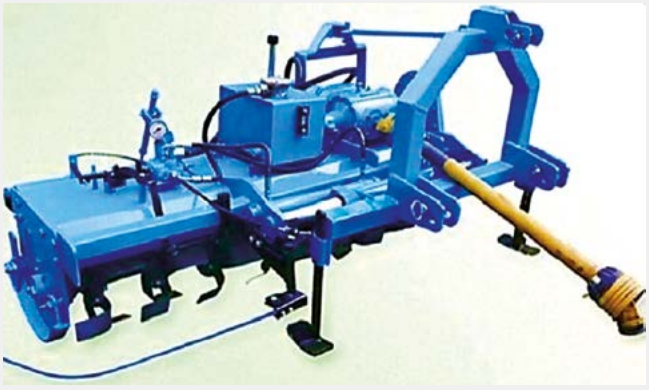


Figure 4: Intercultural operation using Offset Rotavator in Kinnow and Pear orchard

Specifications

- Effective working width: 1800mm
- Side shift: 400mm
- Offset of machine: 500 mm
- Power, HP: 35 to 50
- Actuation time of side shift: 0.5 sec

Features

- Automatic Hydraulic side shift
- Suitable for Indian conditions
- With side shift lock work as rotavator
- Maximum working width
- Easy to operate

Field Evaluation results

The machine was tested in Pear Orchards for a total area of 10.5 acres. The different blocks of Pears were of age 15-25 years (8 acres) except one block of soft pear of area 2.5 acres of age 6-7 years. Row to row spacing of Pear crop was 20 feet and plant to plant spacing 10 feet and 20 feet.

1	Working width of operation, cm	180
2	Depth of operation, cm	12.0 - 13.5
3	Weeding index, %	84.0 - 98.2
4	Response time (side shift), s	1.0
5	field efficiency, %	65.3
6	Plant damage, %	3.5
7	Fuel consumption, litre/hour	7.25

The results are shown on the right side and the field evaluation images in Figure 4.

4. Automated Seed Drill Calibration Test Rig

Wheat sowing in India is about 80-90% mechanized with the use of seed-cum-fertilizer drills, no-till drills and other variants with majority of them uses fluted roller as the seed metering mechanism. Infrequent calibration and lack of data on the variation in seed rate necessitates a correct assessment with respect to the distance travelled by the seed drill. This will be useful information for the use of seed drills in precision agriculture scenario. An automated calibration test rig has been developed to determine the variation in seed rate at different operating speeds and seed rate settings. The test rig is capable of determining:

(a) The variation in dropping of seeds in different seed tubes.

(b) The variation in quantity dropped per hectare and quantity specified to be dropped at particular setting.

(c) The variations due to seed hopper filling at ¼, ½, and ¾ of rated capacity.

(d) The variation in quantity of seed dropping due to change in speed.

(e) The variation in quantity of seed per meter of row length.

The preliminary tests showed that only 70 – 80% seed rate values are in the permissible range of ±7%

of the mean value obtained during the calibration process and this significantly impacts the productivity and profitability of the farmer. Also, results indicated that operating speed of seed drill and seed levels in the hopper have a direct impact on the variation in a random manner which may be due to the seed flow over the bottom plate. The assessment of seed rate revealed that a new mechanism or modification in fluted roller is essential for reducing the variation. The test rig is shown in Figure 5 and the variation of seed rate at different operating speeds and with respect to the distance travelled are shown in Figure 6 and Figure 7.

Figure 5: Automated Seed Drill Calibration Test Rig

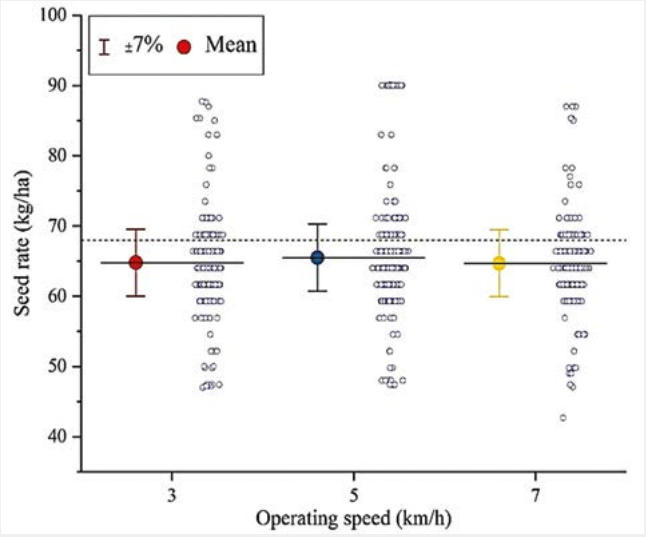


Figure 6: Interval jitter plot of seed rate distribution at 6.3 mm active length of fluted roller

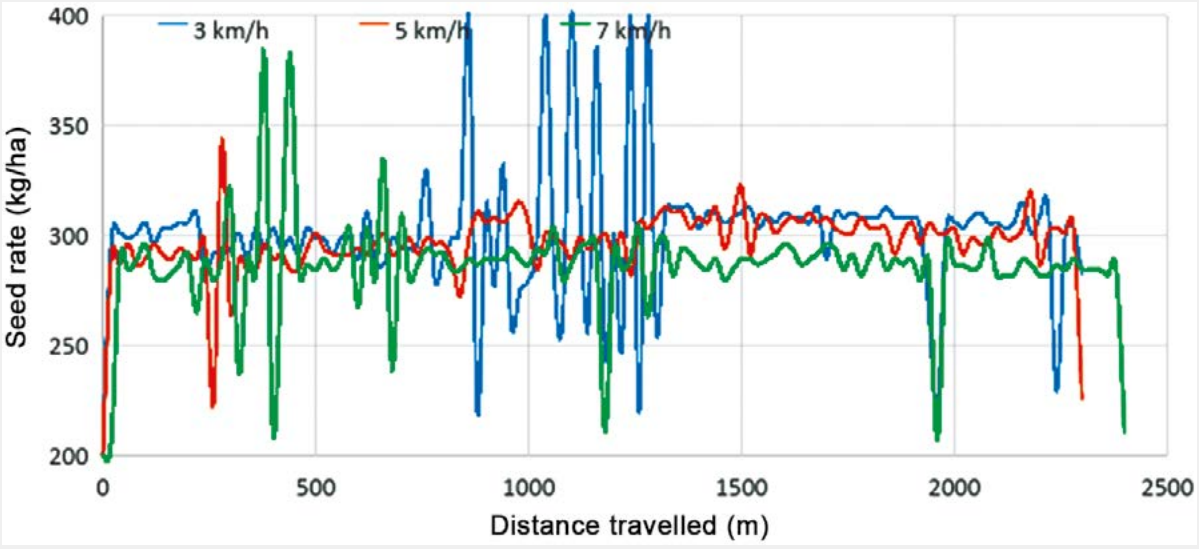


Figure 7: Seed rate variation with distance travelled at 20.9 mm active length of fluted roller

4

DRIVES & CONTROL SYSTEM TECHNOLOGY GROUP

Power Electronics is the field which deals with conversion of electrical energy from one form to another in an efficient, clean, compact and robust manner for convenient utilization. Its relevance in modern times is increasing with a plethora of applications like automobiles, distributed energy generation, information technology, consumer electronics etc. These products help in improving industrial productivity and competitiveness of the nation, providing better quality of life. Variable speed drives are also becoming increasingly important to address the modern day industrial needs of automation. Electric Motors are the main consumers of electrical energy and Power electronic converter based drives can increase the efficiency of their operation by 30% leading to huge savings in electricity costs, and contributing directly/indirectly to reduction in pollution through conventional fossil fuels. According to an estimate, 15% of grid energy can be saved through widespread applications of Power Electronics. As an enabling technology for tapping renewable energy, especially solar and wind, it has huge potential in mitigating the energy problems of mankind. In addition, the automobile sector which is the biggest contributor to green house gas emission can have fleets of vehicles running on electrical energy, and power electronics has a huge role to play in that transformation, through efficient control of propulsion systems, as well as providing interfaces for battery charging.

Research focus of the Drives & Control System Technology group includes power electronics for renewable energy and electric vehicles, electric drives, control systems, special electric machines etc. The activity of the Group is nucleated around a Power Electronics & Machine Drives Laboratory developed to attract the best technology students for continuation of research pursuits and serve as a hub for innovative R&D, product development and simulation services. Its mandate is to enable CSIR-CMERI develop knowledge alliances between traditional mechanical engineering and electrical & electronics engineering in the design of "intelligent" products, systems and processes. In addition, the group is undertaking technical services for design, installation & commissioning of solar photovoltaic systems in different configurations like roof top solar, solar tree etc.

1. Technology Development for On Grid Solar Inverter

Drives & Control System Technology Group (D&CST Group) has been working on design & development of Solar Inverter technologies which are critical for efficient utilization of solar energy either for running any conventional electrical appliance or feeding the solar energy to an AC utility grid. M/s Micromax Energy Limited (MEL), New Delhi is an Indian company dealing with products in the solar energy domain who showed interest in collaborating with CSIR-CMERI after demonstration of prototypes developed by the D&CST Group. After a few rounds of technical discussion, a Memorandum of Understanding (MoU) was signed on 26th February, 2017 between the two parties to undertake joint collaborative efforts for "Development of Solar ON grid inverters with or without storage which will be used to convert Direct Current (DC) power from solar array into Alternating Current (AC) to meet the domestic, commercial and industrial electricity requirements". On the basis of this understanding an agreement was reached and a sponsored collaborative project was initiated on 15th May, 2017.

It was decided that initial work would start for a 1kW Single Phase On Grid Solar Inverter as it would provide major understanding of various subsystems comprising the product. The major activities undertaken for development of a 1kW Single Phase ON Grid Solar Inverter are mentioned below.

(a) Design Review, Preparation of Detailed Circuit Schematics & Bill Of Materials

Design of 1kW solar inverter was initiated and the complete system has been divided into five subsystems, mentioned below, for better understanding of system operation:

- DC-DC MPPT Boost Converter
- DC-AC Single Phase Inverter
- Gate Driver & Signal Conditioning Circuits
- Auxiliary Power Supply
- Digital Signal Processor (DSP) based Controller Card

Detailed design of each subsection and selection of its associated Bill of Materials (BoM) was carried out and the design outputs in the form of detailed circuit schematics & BoM were also shared with M/s Micromax Energy Limted.

(b) Simulation Study of Circuits & Associated Control Algorithms

The operation of power circuit and associated control algorithms of 1kW solar inverter was simulated in the PSIM environment. The parameters of components used in simulation were as per the designed BoM and the switching frequency of the IGBT switches were 20kHz. The control scheme of DC-DC section comprised of Perturb & Observe based MPPT algorithm giving reference MPPT current and an inner current loop which generates switching signal of boost IGBT, to make the boost inductor current track the reference MPPT current. The control scheme of DC-AC single phase inverter had a Phase Locked Loop (PLL) logic to track grid phase & frequency, outer DC Bus voltage control loop giving reference inverter current and an inner current loop which generated switching signals for six IGBTs of inverter such that inductor current tracked the reference sinusoidal current as shown in Figure 1.

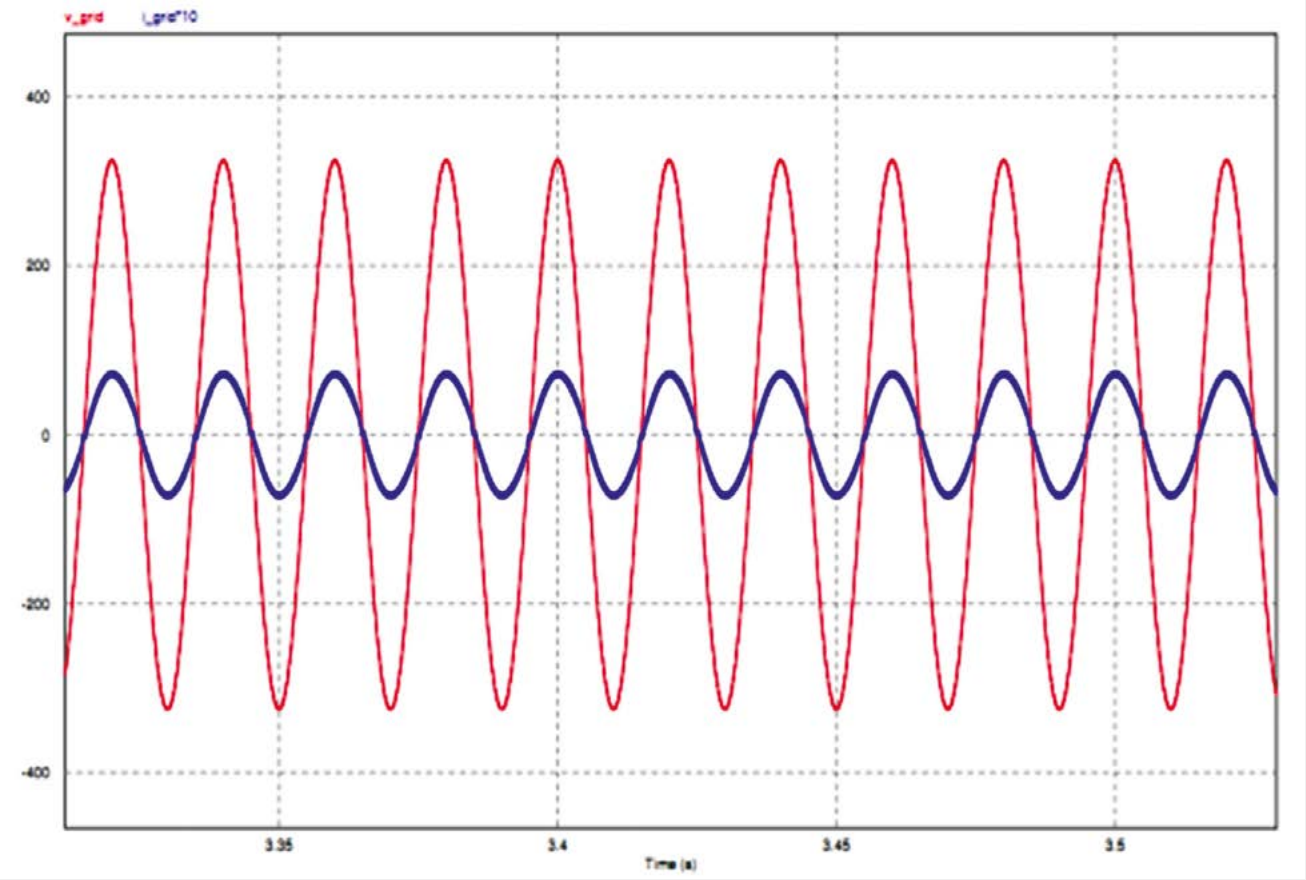


Figure 1: Grid voltage and grid current during current feeding into grid during power transfer to Grid

(c) Design of PCB layouts for Power Board and DSP Controller Card

The complete system of 1kW solar inverter will consist of two Printed Circuit Boards; the first one is Power Board which houses the four subsections namely DC-DC MPPT Boost Converter, DC-AC Single Phase Inverter, Gate Driver & Signal Conditioning Circuits and Auxiliary Power Supply. The second board will be for DSP based Controller card and this card will have appropriate connection ports for interaction with the power board. The PCB layout design of Power Board has been completed and the board is currently under fabrication. The composite figure of the four layered PCB for power board is shown in Figure 2. The PCB layout design for DSP based Controller Card is in progress and will be completed soon. Figure 3 shows the dimensions and placement of components for controller card. Procurement for Bill of Materials for both boards have been completed and after fabrication of boards, assembly of components will be carried out leading to exercise of lab level testing of developed boards.

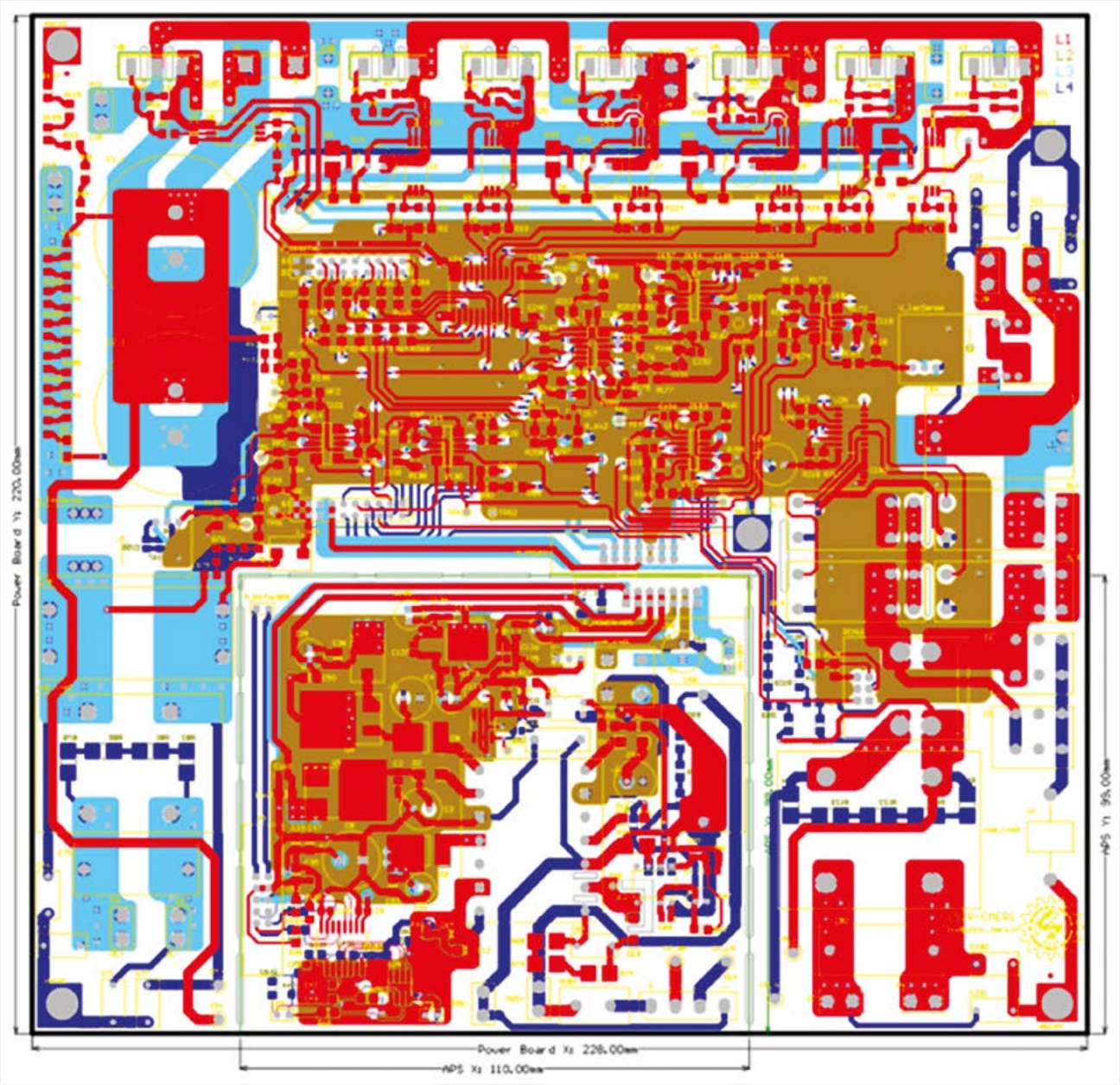


Figure 2: Composite PCB layout design for power board

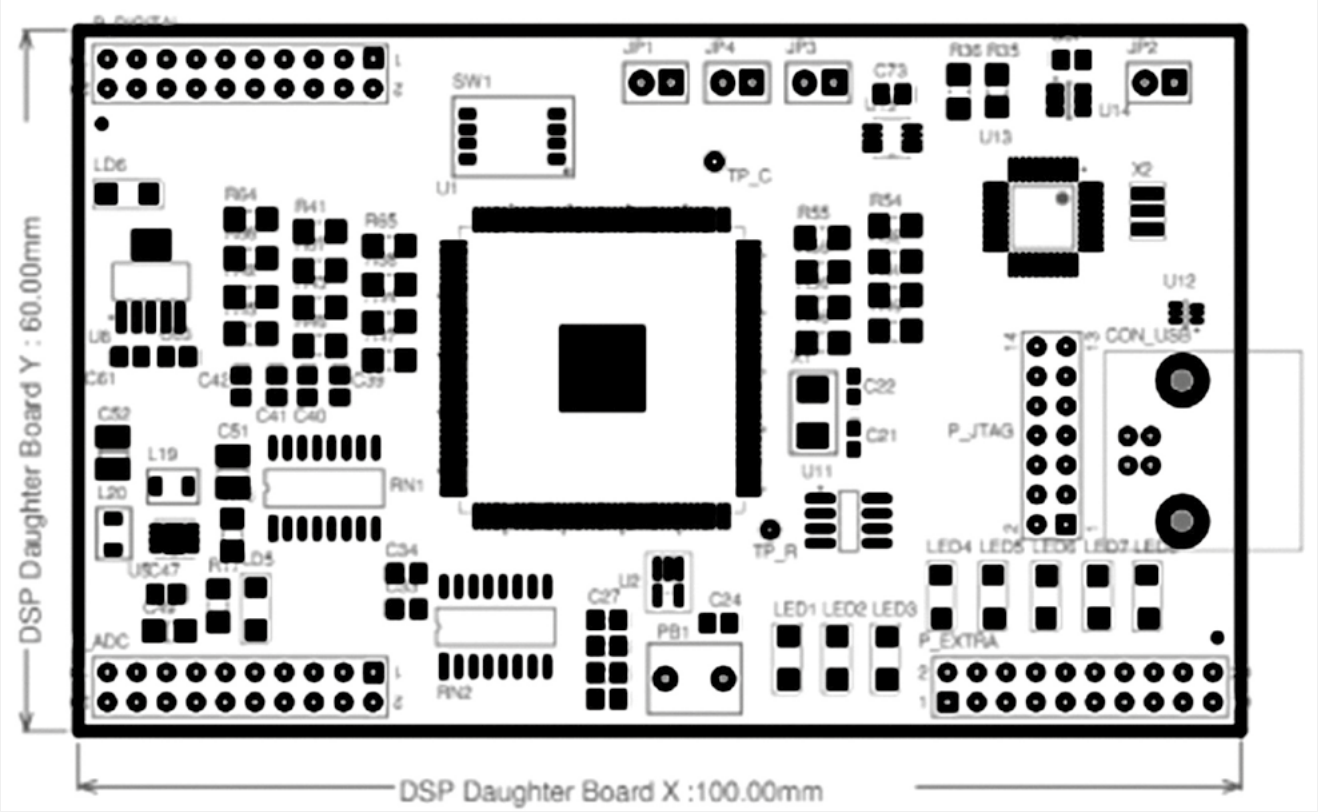


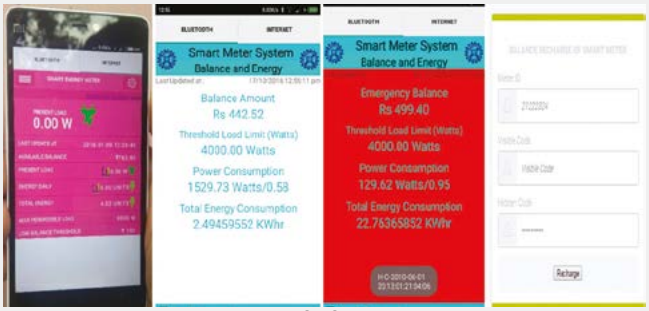
Figure 3: Dimensions and component placement (top layer) for controller card

2. SMART Energy Monitoring

The Smart Energy Monitoring Device (SEMD) is an energy monitoring device capable of registering consumption of energy delivered through its output. For proper functioning, SEMD has to be given an input of 220V/50 Hz AC signal and it can supply a maximum output current of 30A. SEMD has the capability to communicate to a server using Wi-Fi communication or to nearby devices using Bluetooth. SEMD maintains a prepaid balance in its memory and allows its user to consume energy till a positive prepaid balance is available in SEMD. Dedicated android application has also been developed for SEMD, using which users of SEMD will have facility to recharge its prepaid balance using their mobile phone.

It has two components: hardware and software. The hardware component is an energy meter installed at user's premise having internet connection. The software component is installed in user's Android device. The software in user's Android device enables him to monitor the electrical energy consumed together with providing an aggregate control through its programmable load control feature.

(a)



(b)

Figure 4: (a) Field testing of smart energy meter
(b) Screenshot of android application of smart meters

3. SMART AC Controller (SMACON)

It has all the functionality of the smart energy meter in addition to internet enabled remote control of air conditioners. It has a hardware unit installed at individual homes or other desired places (office) together with an android application in mobile phone which enables individuals to control and monitor room air-conditioner remotely through internet.

Figure 5: SMACON unit

4. Solar PV Installations

This group has undertaken installation & commissioning of Solar PV systems at different locations and with different configurations, as shown below

(a) Installation & commissioning of Solar Rooftop PV System at Asansol Braile Academy, Asansol

Type of PV Installation	Solar Rooftop
Peak Capacity	9kWp
No. of PV Panels	28
Rating of each PV Panel	330Wp
Rating of Inverter	10kW
Type of Connection	ON Grid

(a)

(b)

Figure 6: Photograph of the Installed Systems at ABA, Asansol; (a) Site before Installation, (b) Site After Installation

(b) Installation & commissioning of Solar Artifacts at WBPDCL office premises, Salt Lake, Kolkata

Configuration of PV Installation	Solar Artifacts (2 Nos)
Peak Capacity	6kWp (2X3kWp)
No. of PV Panels	20 (2X10)
Rating of each PV Panel	320Wp
Rating of Inverter	5.8kW
Type of Connection	ON Grid

Figure 7: Photograph of the Installed Systems at WBPDCL Premises, Salt lake, Kolkata

(c) Installation & commissioning of solar rooftop PV System at Durgapur Sub Divisional Hospital, Bidhannagar, Durgapur

Type of PV Installation	Solar Rooftop
Peak Capacity	50kWp
No. of PV Panels	152
Rating of each PV Panel	330Wp
Rating of Inverter	2X30kW
Type of Connection	ON Grid

Figure 8: Photograph of the Installed Systems at Durgapur Sub Divisional Hospital, Bidhannagar, Durgapur

(d) Installation & commissioning of Solar Artifacts at CSIR-CIMFR Dhanbad

Type of PV Installation	Solar Artifacts (3+2 Nos)
Total Peak Capacity	11kWp (3X3kWp+2X1kWp)
No. of PV Panels	(3X10+2X100)
Rating of each PV Panel	320Wp/10Wp
Rating of Inverter	3kW/1kW
Type of Connection	Hybrid without grid export

(a) (b) (c)

Figure 9: Photograph of the Installed Systems at CIMFR, Dhanbad

5. BLDC Motor Development

The group is also working in the field of Motor development from last few years. The JMAG software is used for designing and evaluating the performance analysis of motor prior to development of prototypes. MATLAB is used for motor drives simulation and control algorithm development and testing. An in-house 350W BLDC motor prototype is designed using motor design software JMAG with the following specifications:

Power Rating	350 W
No. of Slots and Poles	12 Slot/ 8 Pole
Voltage	48 V
Speed	3000 rpm
Magnet	N35, Coating Ni-Cu-Ni
Sensor	In built Hall Sensor

Motor prototype is developed using institute's Electrical Discharge Machining-Wire cut machine facility for cutting the stamping of stator and rotor for the designed motor. Other standard components were used for the fabrication of the motor prototype. The rotor and stator templates after wire cutting are shown in Figure 10.

Figure 10: Stator and Rotor after wire cutting

The process of fabrication of motor is shown in Figure 11 and finally complete motor prototype is shown in Figure 12.

Figure 11: Photograph of fabrication of BLDC Motor

(a) (b)

Figure 12: Photograph of complete BLDC Motor (a) 1st version (b) Improvement in 1st version with incorporation of flange type fitting arrangement

The operation of developed motor was evaluated using an in-house developed 3 phase inverter test bench wherein the controller was embedded on dSPACE Controller platform integrated with MATLAB. The developed test bench is shown in Figure 13. The motor performance evaluation for its characterization is under progress.

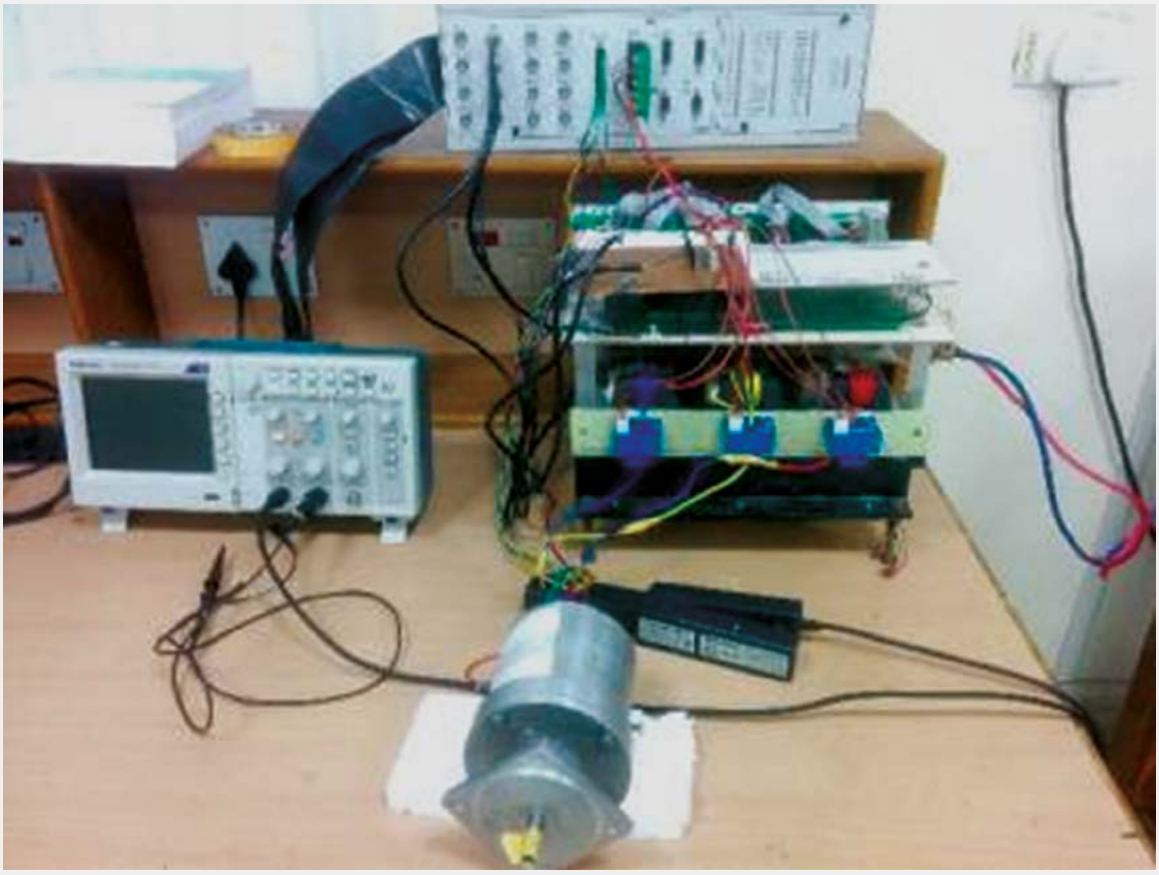


Figure 13: Photograph of test bench for motor operation testing

5

ENERGY RESEARCH & TECHNOLOGY GROUP

1. Biohydrogen production by co-digestion of cheese whey and fruit vegetables wastes

Introduction

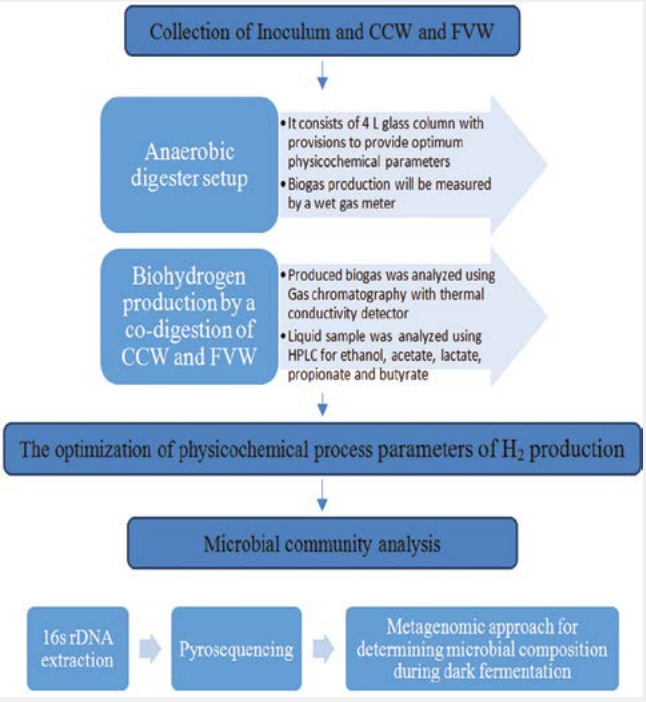
Hydrogen has been proposed as a clean energy carrier and as potential replacement to fossil fuels, since it has the highest energy content and generates no other product than water when burned. For hydrogen to be considered a sustainable alternative fuel, it should be generated from cheap and readily available feedstocks that are renewable or potentially renewable. Biohydrogen production by dark fermentation has received broad attention, since this process can utilize renewable feedstock sources (complex wastewaters, agro-industrial wastes). In particular, biohydrogen production from agricultural waste is very advantageous since agro-wastes are abundant, cheap, renewable and highly biodegradable. In the present research, efforts are being made to determine the effects of co-substrates like Crude Cheese Whey (CCW) and Fruit-Vegetable Wastes (FVW) in codigestion process to better understand and elucidate the mechanisms to enhance biohydrogen production. The biohydrogen producing microbial community structure identification and substrate pretreatment to generate fermentable sugars are critical steps toward improvement of biohydrogen production.

Specific Objectives

In view of the above facts, the following objectives were undertaken to enhance biohydrogen yield through fermentation of fruit-vegetable wastes and cheese whey:

1. Investigating the effect of different carbon to nitrogen ratios (C/N) obtained by mixing different amounts of CCW and FVW on hydrogen production.
2. Evaluating the effect of CCW acclimation on the microbial distribution of the inoculum.
3. Optimization of various physicochemical parameters of dark fermentation process in hydrogen production by use of statistical approach.
4. Analyzing the microbial community structure and diversity during dark fermentation of the CCW and FVW mixtures.
5. Investigating the effect of co-substrates in the co-digestion process on the metabolic profile evolution and over the buffer capacity of the CCW and FVW mixtures.

Methodology



Salient Research Achievements

1. Evaluation of the pretreatment of inoculum on H_2 production: The maximum H_2 production of 113.12±0.51 mMol/L was obtained with 2-bromoethane sulfonate treatment, while heat pretreatment of anaerobic sludge inoculum yielded 83.28±0.727 mMol/L. COD removal, total carbohydrate utilization, and pH profile of the dark fermentation by 2-BES and heat pretreated inocula were also analyzed.

2. Effects of initial pH, substrate to inoculum ratio and C/N ratio on H_2 production: The H_2 production kinetics were analyzed for determining the possible effects of different initial pH, substrate to inoculum ratio and C/N ratio on the bio H_2 yield. Maximum cumulative H_2 production (CHP) was observed at pH 7 (113.2±2.8 mMol/L) whereas highest H_2 yield was obtained at pH 7.5 (159.32±11.7 ml/$gCOD_{removed}$). On the other hand, maximum COD removal was observed at pH 7.

3. H_2 production kinetics were also analyzed for determining the effects of different substrate (S_0) to inoculum (X_0) ratio on the bio H_2 yield. The results obtained indicated that increasing S_0/X_0 ratio from 3.2 gCOD/gVS to 10.6 gCOD/gVSS significantly increased the CHP from 4.69 mMol/L to 113.12±0.51 mMol/L. Maximum CHP (113.12±0.51) as well as highest H_2 yield(115.82±7.43) was achieved at S_0/X_0= 10.6 beyond which increase in S_0/X_0 ratio diminished CHP and H_2 yield.

4. Total 10 clones were selected through screening for further identification. Among them, 6 amplified 16srRNA gene sequences were determined using ABI 3500 XL Genetic Analyzer and deposited onto NCBIGenBank under accession number: MF806593.1; MF806596.1; MF806605.1; MF806609.1; MF806610.1 and MF966377.1. Comparison with the 16S rRNA genes in the GenBank showed that all the selected isolates had sequence similarities ≥98% with known strains.

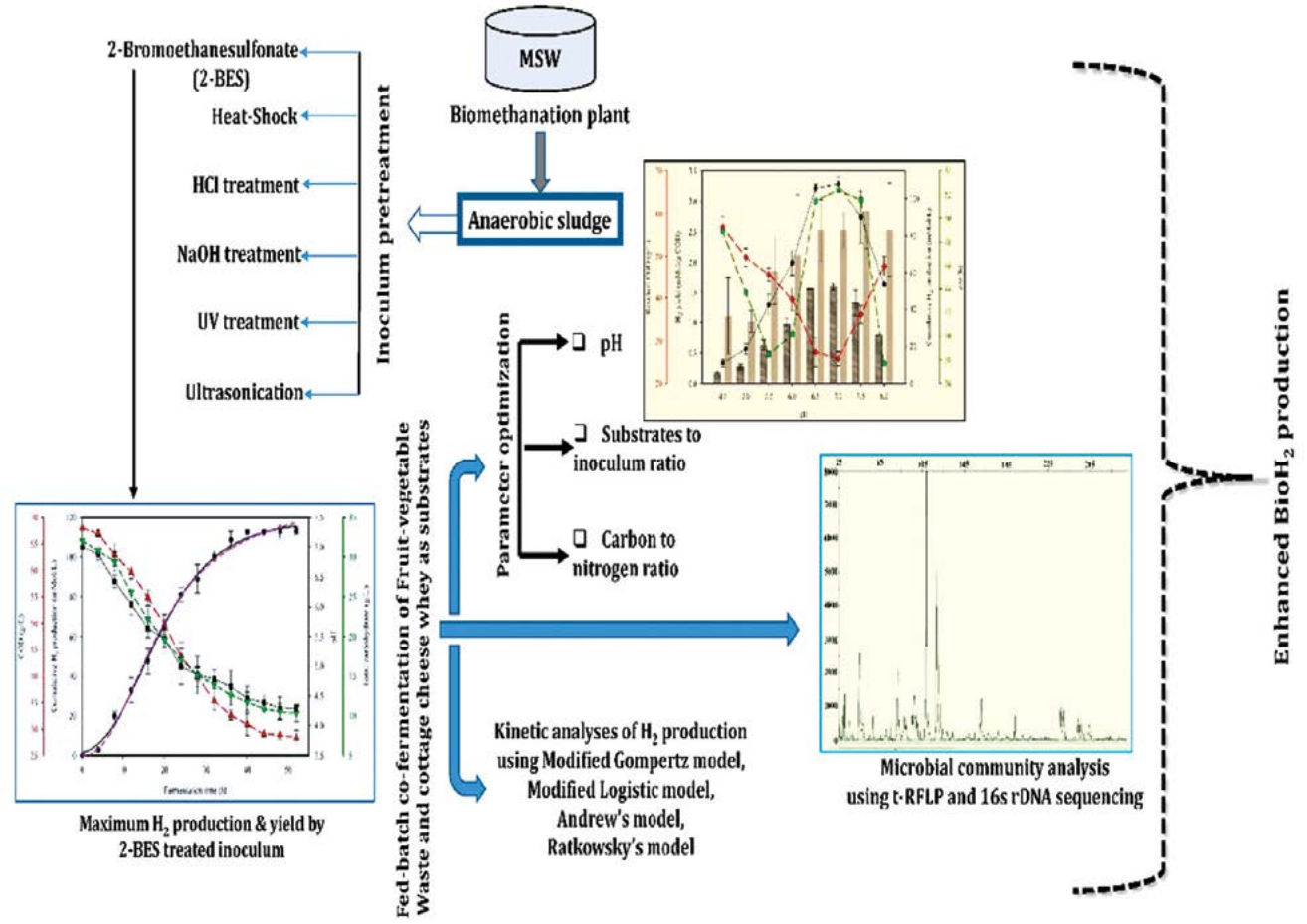


Figure 1: Graphical Abstract of the work done and results obtained so far

Publication

Basak B., Fatima A., Ganguly A., Jeon B-H, Chatterjee P. K., Dey A. (2018). Effects of inoculum pretreatment on biohydrogen production from fruit-vegetable waste and cheese whey: A kinetic study. Waste & Biomass Valorization (in revision).

2. Biodiesel Production from food waste using enzymatic transesterification

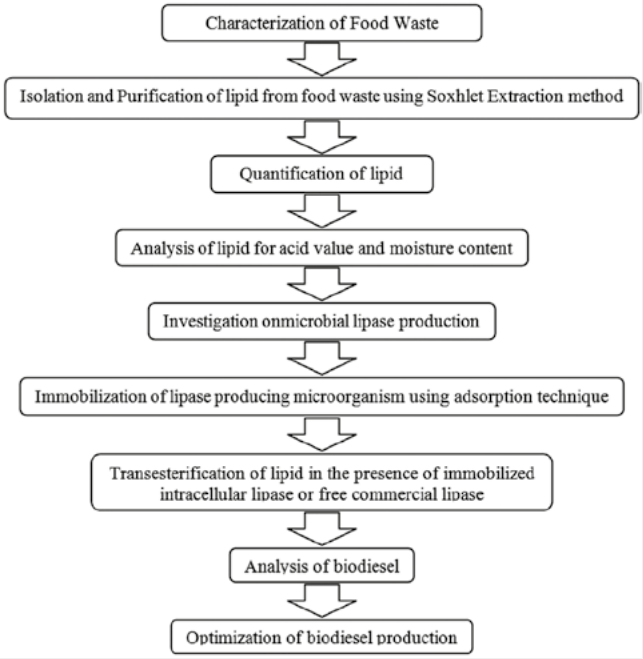
Introduction

Rationale of the research: Biodiesel has been considered as one of the substitutes for fossil fuels in recent years, and alsoa type of renewable energy source. Biodiesel reduces most emissions (CO_2, CO, particulate, except NOx) while burning. Chemically, biodiesel consists of Fatty Acid Methyl Esters (FAMEs) that can be produced from various lipid sources by transesterification reaction with alcohol in the presence of a base, acid, enzyme or solid catalyst. Biodiesel has been strongly criticized because vegetable oils require cultivation of crops like rapeseed, palm, sunflower, jatropha and soybean, which involves long extension of lands. In that context food waste is a great choice for biodiesel production. According to reports by Food and Agricultural Organization of the United Nations, approximately 1.3 billion tons of food waste is discarded globally without any further use. Food waste generated in developing Asian countries is expected to rise further in the upcoming years because of rapid economic expansion and continuous population growth. Usually food waste is disposed in landfills. This is causing world's mounting food waste disposal problem. This practice of disposing food waste in landfills is creating many problems in public life such as bad odour, air pollution, and leaching. Landfills are known to generate carbon dioxide, methane and other toxic gaseous substances. Therefore, biofuels such as biodiesel can be produced in alternative ways by using food wastes as non-edible resources without using land available for growing food crops.

Objectives:

1. Survey on biodiesel production throughout the world
2. Development of a comprehensive model for biodiesel production
3. To develop an optimization model for transesterification for biodiesel production
4. To study the effect of various parameters (effect of different alcohols, lipase amount, oil to alcohol molar ratio and reaction time) on biodiesel production from foodwaste.
5 Study of techno-economics of biodiesel production.

Main Experiments To Be Carried Out



Expected output and outcome of the proposal

Biodiesel will be produced from food waste which is considered as the largest category of municipal solid waste that is disposed in landfills and monofactorial as well as statistical optimization will be carried out to optimize various factors of transesterification process such as effect of different alcohols, lipase amount, oil to alcohol molar ratio and reaction time. Therefore expected output of the proposal is to develop a comprehensive model for biodiesel production and the outcome of the proposal is utilization of waste for valuable biodiesel which will reduce pollution while burning by less emission of greenhouse gas.

3. Development of Solar PV systems

(a) 3.6 kWp Capacity Solar Lotus With Surveillance System

The solar lotus of maximum capacity 3.6 kWp has been conceptualized, designed and developed by

CSIR-CMERI, Durgapur. The mechanical structure of the system has been designed on varying load conditions considering self weight, live weight and wind loads. The shading analysis, one of the most essential steps in solar energy system design, has been done to check the shading effect. In addition, the panels are arranged in a particular orientation to receive maximum solar insolation to generate maximum power.

Figure 2: 3.6 kWp Solar Lotus installed at Children Park, CMERI Colony

Specification of the Solar Lotus

- Maximum installed capacity: 3.6 kWp
- Polycrystalline solar panel capacity/nos: 12 nos. 300 Wp panels
- Size of solar inverter: 3 kVa/single phase
- Solar batteries (compatible with inverter) as per back-up requirement

(b) 5.4 kWp Solar Tree

A solar tree of maximum capacity 5.4 kWp has been designed and developed by Energy Research & Technology team of CSIR-CMERI, Durgapur.

Figure 3: 5.4 kWp Solar Tree installed at the Guesthouse Complex, CMERI Colony

Specification of the Solar Tree:

- Maximum capacity: 5.4 kWp
- Each polycrystalline solar panel capacity/ nos: 300 Wp / 18 nos. 300 Wp panels
- Size of solar inverter: 5kVa/single phase
- Solar batteries (compatible with inverter) as per back-up requirement

(c) Solar Roof of Capacity 7.5 kW

7.5 kWp capacity solar roof has been conceptualized and developed by a team of CSIR-CMERI, Durgapur. The roof is arranged in a decorative structure using solar panels for producing solar energy. Special care is taken to make it leak-proof. It uses multiple numbers of solar panels arranged together. Attention is given to avoid shades on the panels from nearby building or any other physical obstructions. The advantages of using Solar Tree are as follows:

- Replacement of conventional roof with solar roof to produce power
- No water requirement (other than occasional cleaning) for power generation
- Very less air pollution, no fossil fuels, ecologically friendly, Carbon credit
- Off grid and On grid power generation
- Low maintenance cost

Figure 4: 7.5 kWp Solar Roof installed at MSW Complex, CMERI Colony

Specification of the Solar Roof

- Maximum capacity: 7.5 kWp
- Each polycrystalline solar panel capacity/ nos: 300 Wp / 25 nos. 300 Wp panels
- Size of solar inverter: 7-8 kVa / single phase
- Solar batteries (compatible with inverter) as per back-up requirement

4. Online moisture measurement in ginger drying system

Measurement of moisture content in ginger during drying is very important in the process of ginger post processing. CSIR-CMERI already developed ginger post processing technology, which consists of ginger washer, ginger slicer and dryer to remove moisture content for long time preservation. India's north east region produces huge quantity of ginger but due to lack of technology, bad humid weather condition, tough geographical position, it is difficult to store the raw ginger. As a result, rural farmers do not get actual profit from it. CSIR-CMERI has developed ginger post processing technology and demonstrated for the direct benefit of the rural tribal farmers, particularly from the North East Region. The system has been installed and it is operational at Mizoram and Arunachal Pradesh.

The present technology still needs lot of modification and automation. Among these, online moisture measurement and moisture control for drying system benefit the drying system further. Present drying system has temperature control to be maintained at 60°C, at continued air flow condition for dry up. The present dryer needs to run for about 4-5 hours for drying up to the moisture level of 10-12%, which is investigated by offline moisture measurement. The present work will develop/modernize the existing dryer with a moisture sensor placed into the ginger tray and sensor output will be fed to moisture controller for monitoring the actual moisture content for production of quality product.

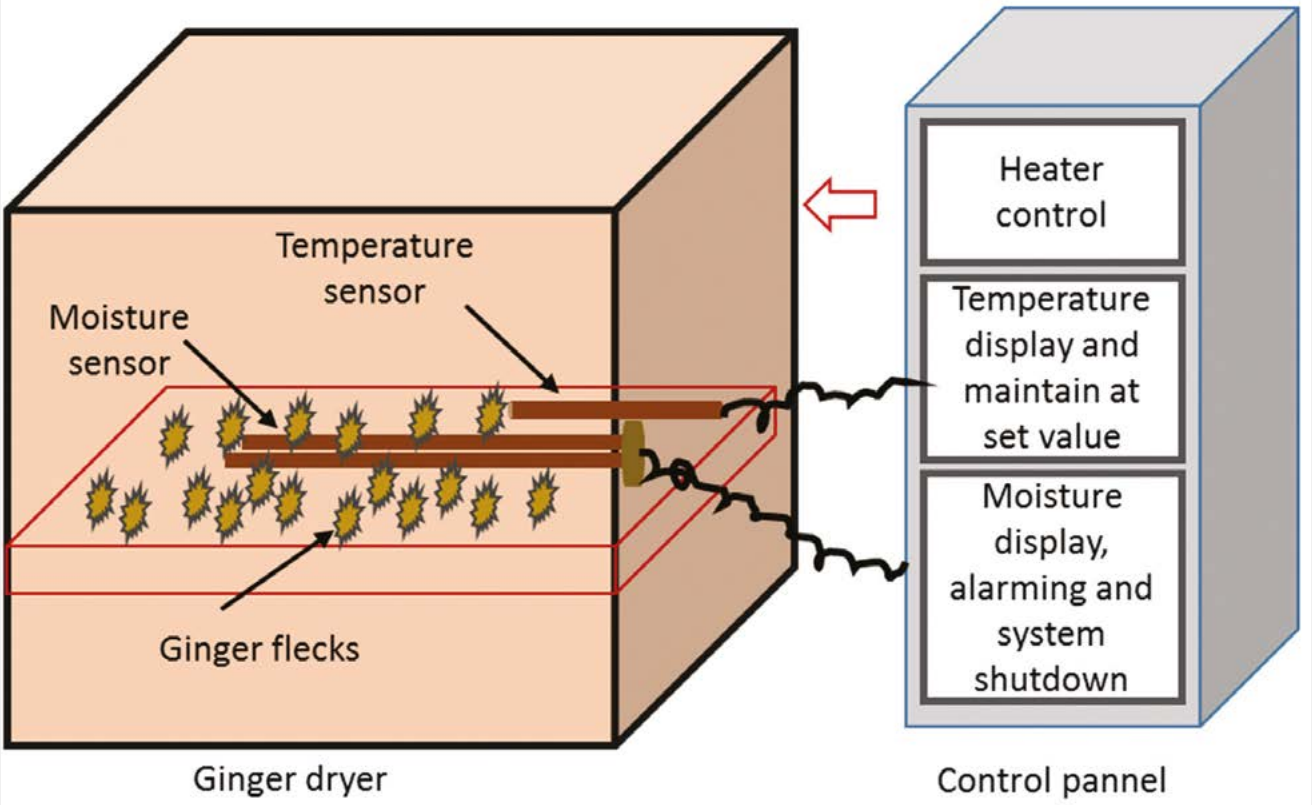


Figure 5: Schematic diagram of online moisture measurement system

5. Aerodynamic measurements

Circular cylinders experiencing different upstream flow conditions were studied for low Reynolds numbers (Re) using hot-wire anemometry and smoke flow visualizations. The upstream condition of the cylinder was varied using a wire mesh placed at the entrance of the test section. The Re was varied by changing the diameter of the cylinders from 1.25 to 25 mm, and the mean velocity in the test section. The sectional views of the wake behind the cylinder are obtained using a 4 MP CCD camera, 200 mJ pulsed laser and a fog generator. The effect of free stream turbulence amplitude and their frequencies on wake structures and the shedding frequencies of circular cylinders were studied in detail. It has been observed that the alteration in wake structure and the shedding frequency depend strongly on the frequencies and the amplitudes of upstream disturbances.

External aerodynamics plays a vital role in designing high-speed vehicles to ensure superior performance, comfort, and vehicle stability. The effect of added surfaces such as NACA 2412 wings and wedge type spoiler at the rear end of a sports car were examined in detail using 3D numerical simulations substantiated with lab scale experiments. The simulations were performed by solving RANS equations with a realizable k-ε turbulence model using ANSYS Fluent software. The results obtained from simulations were validated with the experiments performed on a scale down model at the low-speed wind tunnel using a six component external pyramidal balance. The variation in the wake flow field of the vehicles with different added surfaces was demonstrated using pressure and velocity contours, velocity vectors at the rear end, and the turbulent kinetic energy distribution plots. It was observed that the positive lift coefficient of the base model is reduced drastically by incorporating a single wing at the rear end of the vehicle. The aerodynamics coefficients obtained from different configurations suggest that the two wing configuration has a lesser drag than the wedge type spoiler, though the negative lift is higher with a wedge than the two-wing configuration.

The effects of a semi-ellipsoidal structure placed ahead of a rider on the HONDA CBR 600 RR bike was also studied for Reynolds number varying from 1.24 to 3.72 million. 3-D numerical simulations were performed by solving the RANS equations with the SST k-ω turbulence model and validated with the wind tunnel testing performed on a 1:12 scale down model. It was observed that the wake pattern behind the vehicle, pressure and velocity distribution over the vehicle were modified remarkably by the inclusion of Semi-Ellipsoidal Structure (SES) compared to the model with the rider. The drag coefficient of the bike was decreased substantially and reached close to the base model value when the semi-ellipsoidal structure was placed ahead of the rider. Further, the inclusion of SES produced a negative lift which improves the traction on the road compared to the base model.

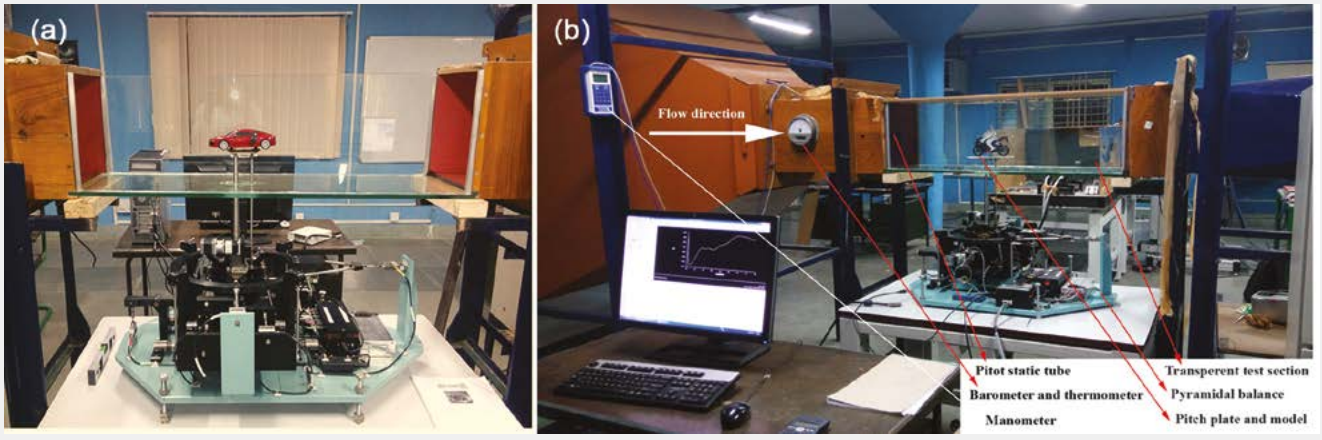


Figure 6: (a) 1:24 scale down model of Audi R8 car (b) 1:12 scale down bike model mounted on the pitch plate of the external pyramidal balance inside the test section

ENGINEERING DESIGN GROUP

1. Tele-operated Bomb Detection Robot (TeleRo)

Handling crude bombs

Crude bombs are very common in the countryside due to availability of low cost explosives. It does not use any external trigger or timing device and uses very low-grade explosives, such as gun powder. Often accidents happen due to negligence and lack of seriousness of the policemen to handle such bombs.

TeleRo can be used for handling such crude bombs easily for correct detection and defusing with appropriate instruments.

Distance means safety

Such crude bombs contain a lot of potential energy that can be very rapidly liberated. Even low-grade explosives can deflagrate — which means that the chemical energy travels more quickly than the percussive force, as fast as several hundred meters per second. Someone standing within, say, 20 feet of a small device can have his leg torn off by shrapnel from the container of the device.

First step towards handling such crude bombs is right identification/detection as this will lead to proper defusing methods/arrangements. If enough distance is maintained during the identification/detection, it is safe for the policemen and other people who are in a hurry to defuse the bomb without waiting for the arrival of experts of bomb squad.

TeleRo is ideal for detection of crude bombs from a safe distance. The good quality wireless night-vision camera provides clear image of the subject, even in lower illumination at a safe distance from the robot.

Portability

Often the bombs are made by countrymen at abandoned buildings, agricultural fields, small bushes etc. which are difficult to approach as well as dangerous.

Due to light weight and easily detachable parts, ***TeleRo*** can be taken easily to such unapproachable locations as close as possible and operated from a safe distance.

Fast charging batteries

Batteries are the heart of any robotic vehicle and battery life determines the mission time for any operation. Often, in disturbed areas there are continuous calls for detection and there will be no scope for charging the batteries. ***TeleRo*** uses fast charging batteries with 1C to meet such urgent requirements in time.

Easy deployment

Sometimes the state/district headquarter does not allow anybody except the trained operator to operate such costly vehicles to safeguard people and property. Usually there would be a number of knobs, switches, indicators with complex instructions to operate such a system. On the contrary, the portable, light weight and simple command control console for ***TeleRo*** can be easily understood by anyone competent technically (knowledge of operating mobile phones) without any prior training.

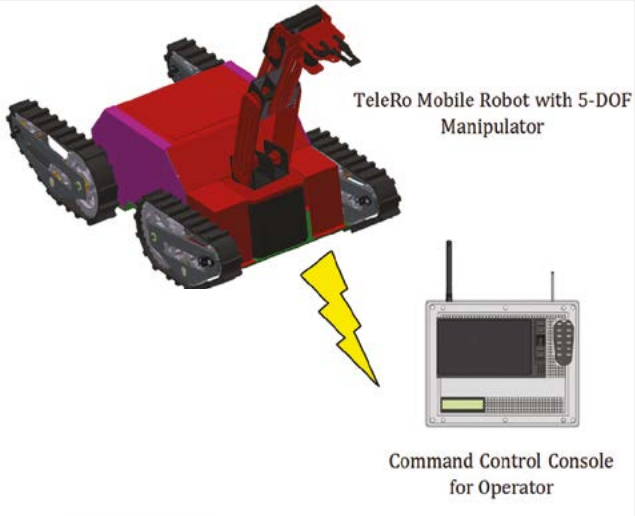
Tentative specifications:

Vehicle:

Designation:	Differentially driven tracked mobile robot
Dimension:	1000 X 630 X 320 mm (without manipulator)
Weight:	50 Kg (Vehicle: 30 Kg, Manipulator: 20 Kg)
Drive:	2 Nos. of 200 W DC Motors
Battery:	2 Nos. of 29V 20Ah fast charging Li-Ion battery
Features:	Obstacle avoidance using Infrared (IR) sensors, emergency stop, safety fuses for over-current protection, automatic LED lights for low illuminations
Camera:	2 Nos. of Night-vision Wireless cameras
Operation:	Through Tele-operation mode day and night using a hand-held, portable command control console
Range:	100 - 200 mtr. (with line-of-sight)

5-DOF Manipulator

Payload:	3 Kg (approx.)
Max. Reach:	1000 mm (approx.)
Camera:	Night-vision wireless camera for manipulator



Salient Features of TeleRo

- Terrain adaptive tracks
- Fast charging Li-Ion battery
- Powerful motors
- Night vision cameras
- Easy maintenance
- Several safety features
- Tele-operation mode from safe distance
- Simple & easy hand-held command control console

2. Capability Building in Mob Mitigation

Mob control or Riot control refers to the measures used by police, military or other security forces to control, disperse, and arrest people who are involved in a riot, demonstration, or protest. During these activities, sometimes policemen or army personnel become injured. To protect themselves during riot control, police uses different types of devices. For better control, an improved armoured vehicle may be necessary to handle riots and mobs in the streets and urbanized areas. The system may be implemented for both protecting the law-enforcement units in action and controlling the situation whenever peace maintenance is required. Since this kind of system is complicated in nature and very large in size, a scaled down model of MCV (Mob Control Vehicle) was developed for functional demonstration of the concept. The desktop model was built based on a scaled down standard backhoe model. A miniaturized scaled down horizontally expandable front shield was fitted in the front. This scaled down model along with the concept of different variants of probable full scale system were presented at the PMO on 7th September, 2017.

Figure 1: Demonstrable desktop model of MCV

3. Countrywide installation of Solar Flora

CSIR-CMERI, Durgapur has recently developed several Artifact Solar Power Trees (ASPT) to harness solar energy at levels of 1, 3 and 5KWp utilizing a relatively small measure of land. Apart from power generation, they offer better aesthetic view for beautification of the place where they are installed. The uniqueness of the development lies in the limited use of ground for accommodating the foundation for the pole which serves 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 elevation. This, however, is not the case with ground-deployed solar panels, where much larger ground area is required for equivalent power generation. In case of the 3 KW Solar flora variant of the Solar Power Tree, which uses twelve 250Wp Solar Photovoltaic panels, 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 99sq.ft.

Structurally the arms act as a cantilever and they are the most critical components as far as design is concerned of Solar flora. To reduce self weight of such structures they are made up of hollow tubes and thin plates. To optimize its design several rounds of design modification and stress analysis have been carried out. Consider a case where a monkey or several monkeys are playing on the solar panels. The panel support arms are most vulnerable components of the solar tree. In addition to their self weight, each support arm has to carry extra load caused by the monkeys. Moreover, a monkey jumping on a panel is more harmful than a monkey sitting idle. This will cause excessive stress on the base of the support arm. Without digging into intricate details of such situations an extra load of 150kg has been considered for this analysis.

Wind load plays a serious threat to such slender structures and needs special care while designing. For example, in May 2009 a cyclonic storm in this region named 'Aila' measured wind speed as high as 90kmph. The model was analyzed for wind speed of 180kmph. Subsequently the load was transferred to the model of ASPT to estimate developed stresses at various locations, such as, at the base of the tree as well as at the base of the branches.

Although various variants of the solar tree has been developed by CSIR-CMERI, the 3 KW Solar flora has been gaining popularity day-by-day. In past one year this solar tree has been installed at various places, as shown below.

MANAS, Vizianagaram, A.P

Durgapur Steel Plant

Srijani, Durgapur

CSIR-CMERI's CoEFM Ludhiana Campus

WEBREDA, Kolkata

CIMFR, Dhanbad

4. Drop Test Rig

A test of the strength of an object, in which it is dropped under standard conditions or a set weight is dropped on it from a given height is call drop test. During 2017-18, the Design Management and System Engineering group developed a drop test facility at CSIR-CMERI premises. This is a 5m drop test facility and equipped with highly sensitive industrial sensor for online recording of test data. Setup for high speed photography is also available for minute inspection of the test procedure as well as image analysis. The Drop Test Facility is quite flexible in its capabilities. The drop load and the drop height can be adjusted as per the requirement of the test. Because of its design, it is capable of lifting large weights to great heights; this feature permits the testing of packages under conditions more severe than customers/regulations require. Often these tests have been carried out on full-scale packages in order to obtain technical information on package behaviour under specific conditions.

This facility can test and qualify items such as:

- Shipping packages used for carrying protective equipment and sensitive items/ materials
- Building and construction equipment
- Pit buffer cylinders used in mines and building elevators for safety purposes.

Recently the facility has been used to test pit buffer cylinder (A safety device which is required to be mounted at the base of an elevator shaft. As with any safety device, the elevator buffer has to meet with a variety of specifications but probably the most important of these is the manner in which the buffer must bring an impacting elevator car to rest.) of capacity 1 tonne.

Figure 2: CMERI Drop Test Facility

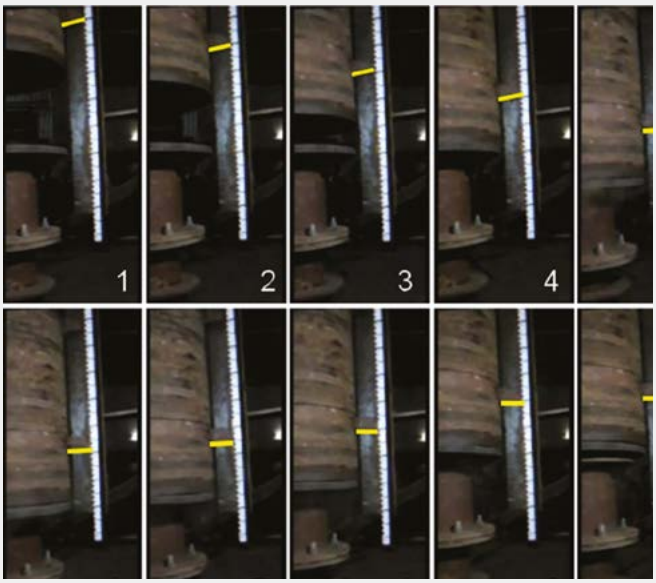


Figure 3: Sequence of deadweight impact on buffer

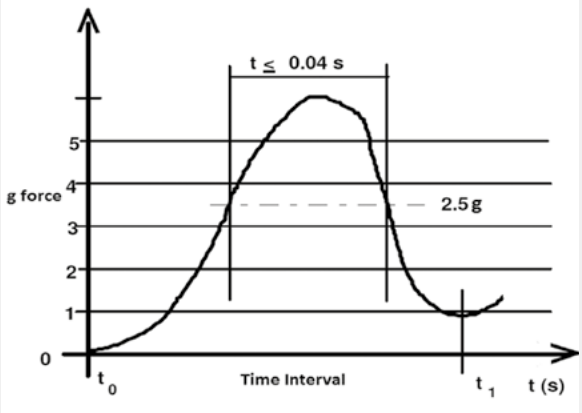


Figure 4: Deceleration graph

Salient Features

- Height of the facility: 5m
- Drop load adjustment arrangement
- Drop height adjustment arrangement
- Arrangement for weight in free fall for minimizing the friction
- Arrangement of retardation measurement
- Arrangement for high speed photography
- Arrangement for lifting large weights to great heights
- Time measuring arrangement

5. Milk Curdling Machine

The milk casein (colloquially called as Chhana) is used for making many kinds of sweets and dishes. Still the process of making chhana in local sweet/ food industries is manual and a lot of human effort is also involved. Moreover, the intervention of humans in the process of making chhana causes bacterial contamination. Shri B. N. Das, Bangalore and his firm is a pioneer in the field of milk based sweet industry. Shri B. N. Das, Bangalore approached CSIR-CMERI to make chhana making plant so that the making process rate could be increased and the contamination is decreased. CSIR-CMERI has taken up a project on this regard as Design and Development of Milk Curdling Machine. CSIR-CMERI has designed a plant for 100Liter milk /batch for chhana making.

Process Description

The plant is equipped with tanks, pumps, plate heat exchanger, filtering system, solenoid operated valves, sensors, tubing system, kneading/packaging/sealing machines and centralized control panel etc. The solenoid operated valves are placed in between tanks, pumps and milk, water and whey tubing as per the operation control system. The milk is filtered and stored in the storage tank (1000L) after the quality check on the required parameters such as fat, snf, total solids & acidity etc. Then 100Litre milk is pumped to a heating tank through the Plate Heat Exchanger (PHE) by a centrifugal pump. The milk is re-circulated continuously through the plate heat exchanger and tank until the required temperature is achieved in heating tank by the help of pump. The heated milk is then pumped to the curdling tank by the help of same pump. There the milk is allowed to cool by a circulating water jacket system. Sufficient amount of whey water is supplied to the cooled milk from a whey storage tank. As soon as the curdling starts, the flow of whey water is to be stopped. The curdled milk with whey water is pumped to a centrifugal filtering and washing system with the help of a screw pump. The centrifugal filtering and washing system can be operated at different speeds. The chhana and whey water are separated by the help of centrifugal filtering and washing system. Required whey water is collected and stored in a whey tank with the help of a centrifugal pump for next batch production. The chhana is transferred to a standard kneading machine where it is extracted as a smooth soft paste. Then the kneaded chhana is packed and sealed in required quantities in a standard packaging and sealing machine.

Model of the Milk Curdling Plant

7

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 and waste management research activities, particularly plastic waste, tyre waste disposal and option for energy recovery etc.

For development and implementation of community level improved iron removal plants in groundwater iron affected villages, this group has won the CSIR-Technology Award-2017 (Innovation Category) and the same has been received from the Hon'ble President of India Sri Ramnath Kovind on 26th. September, 2017 in New Delhi.

The major ongoing projects/activities undertaken by the group are as follows.

1. CSIR-CMERI developed improved iron removal plant installation at M/s. Satyam Iron & Smelters Pvt. Ltd. Mangalpur, Raniganj & Jamuria, Paschim Bardhaman

-under Market Seeding Project Mode

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 fulfil 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 & attached with a submersible pump and successfully installed (1no. IIRP) at M/s Satyam Iron & Steel Co. Ltd, Mangalpur Industrial Estate, Raniganj, Paschim Bardhaman and (1 no.) at M/s Satyam Smelters Pvt. Ltd., Jamuria Industrial Area, Paschim Bardhaman for the benefit of factory workers. After installation of such iron removal plants, around four hundred factory workers are now being benefited by getting safe drinking water.

Iron removal plant installed at M/s Satyam Smelters Pvt. Ltd, Jamuria (attached with submersible pump)

Technology on Improved Iron Removal Plant is being transferred to a Nagpur base Private company

2. Development of Domestic Iron Removal Filter

-Fast Track Translation (FTT) Project of CSIR

Under CSIR-FTT project scheme iron removal filter for domestic purpose use with a capacity of ~ 3 L/Hr. for removal of iron from groundwater has been developed to provide the iron free water to the rural people. Domestic iron filter is cheap and operates chemical-free without any need for electrical power. Back washing facility is also available. 20 Nos. of such filters have been deployed in different organizations, like Gram Panchayat, Block Hospital, reputed NGOs (Ram Krishna Mission, Narendrapur) etc.

Features of Domestic Iron Filter

- Estimated cost of the iron filter unit: Rs 1500-2000 /- (approx.)
- No replacement of adsorbent
- Backwashing facility is available
- Estimated filtration ability of filter medium (backwashing time) is around 40 days (for 7 ppm iron conc.) assuming consumption of 8L of water per day for a family.
- Removes iron to the desired permissible limit (0.3ppm) of drinking water.
- No electricity
- No chemicals required
- No running water required
- Completely green technology
- Flow rate: ~3 L/hour(approx.)
- Storage capacity: ~10 L
- The filtration unit can also remove foul odour, bad taste of iron-water.

Domestic Iron Filter

Domestic Iron filter is in use in a Rural Hospital

Technology on Domestic Iron filter is being transferred to a private company

3. Thermal treatment & solidification of arsenic & iron sludge generated from arsenic & iron removal plant: Their safe disposal & value added products

-sponsored by Department of Science & Technology, New Delhi (Under Water Technology Initiative programme of DST)

No proper disposal method for the highly toxic arsenic sludge waste has been developed yet. So, there is a strong demand for environmentally safe reuse of and effective disposal methods for arsenic contaminated sludge out of water treatment plants due to the increasing amount of sludge generated by the water treatment plants. Uncontrolled disposal of the arsenic sludge may lead to the pollution of the surface water and ground water system and create serious problem for the environment. 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 rivers or low laying areas, which is likely to pollute surface and groundwater. As environmental regulations become more stringent and volume of sludge generated continues to increase, traditional sludge disposal methods are coming under increasing pressure to change. 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 and can be shown to leach toxic pollutants within acceptable limits.

The objectives of the research proposal are as follows:

- Thermal treatment of arsenic sludge for its safe disposal and exploration for extraction of value added product from the same.
- Solidification/Stabilization of arsenic sludge by integration with materials like cement, clay, fly-ash, hydrated lime, $CaCl_2$ etc. for its safe disposal by producing a value added commercial product such as tiles, bricks etc.

To fulfil the above objectives, experimental studies are in process.

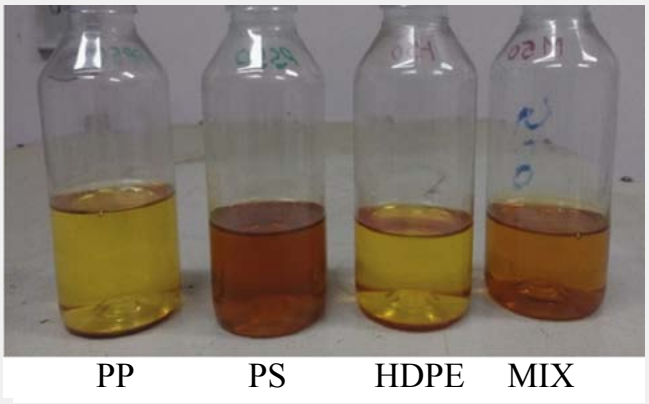
4. Thermal Treatment of Plastic waste for Recovery of Fuel oil & gas

-sponsored by PCRA, Ministry of Petroleum & Natural gases, New Delhi

In general, pyrolysis represents a procedure of thermal degradation of the waste (carbonaceous material) in an oxygen starved 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 (> C50) are thermally broken down into shorter hydrocarbon chains (C1–C12) which can be used as a petrochemical or chemical feedstock.

A prototype with a capacity of 15 kg/batch plastic waste disposal reactor has been developed with recovery of fuel oil and gas.

Plastic waste



Pyrolytic oil from individual plastics

Joint collaborative project Lecture programme on plastic waste to fuel oil & gas recovery between CSIR-CMERI and PCRA-Ministry of Petroleum & Natural Gases, New Delhi

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 objective of this research proposal is the development of processes to improve safe management of arsenic-rich waste generated from arsenic removal plants. Main activities will focus on assessing environmental risks posed by arsenic (As) contaminated sludge disposal in landfill under simulated real conditions and possible safe recycle of exhausted filter materials.

Different sub-objectives are proposed by each unit that contributes to the overall development of suitable management options both in Europe and in India.

In details:

1. to review current regulations in As-sludge management both in India and Italy and highlight possible improvements 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 converting it into a beneficial item like bricks, concrete blocks, pavement tiles etc. having commercial values used for different construction and development 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.

Under bilateral exchange project research activities are being demonstrated to the Scientists of Water Research Institute, Rome, Italy

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 several countries spread throughout the world as ingestion of excess fluoride, most commonly, through drinking contaminated groundwater causes fluorosis. Long term ingestion of fluoride in high doses can lead to severe skeletal fluorosis. In India the groundwater of several states contains high concentration of fluoride. There are several methods for removal of fluoride from groundwater. Thus, although there have been several attempts with different techniques on defluoridation of groundwater, the area still remains quite topical in view 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 effective in long term has yet to be definitely proven. So, there is a strong demand for removal of fluoride from groundwater. The proposed research proposal describes the removal of fluoride from groundwater by using naturally available/low cost materials as adsorbent. The laboratory research results are encouraging.

7. Facility Creation for Water Testing

-A project of CSIR-CMERI

Due to deterioration of groundwater and surface water quality, it is expected that people will more and more need to test the quality of their drinking and other sources of water. World Health Organization (WHO) and Bureau of Indian Standards (BIS) have set drinking water quality standards in India to provide safe drinking water to the common people whereas industry gets a safe effluent limit to get a "No Objection Certificate" from Environment Pollution Board. It is essential that drinking water and surface water (wastewater) sources should be monitored regularly to know whether water is meeting the maximum prescribed limit for drinking or not and, if not, then, the level of contamination and the follow-up required. There are about 60 lakh reported and unreported public drinking water sources in the country. As the tests are to be performed twice a year, 120 lakh water

samples have to be tested in the country in a year. As per reports by the states, approximately 1,869 district and sub-district water testing laboratories exist now in the country but many of them are still defunct. If all such laboratories are made fully functional and considering a capacity of 3,000 samples to be tested in a year per laboratory, the number of sources that could be tested in a year would be 3,000x1869 = 56 lakh samples i.e. about 50%. Therefore, provision for setting up new water testing laboratories has been made to bridge the gap. Initially different common water quality parameters (which includes physical, chemical and bacteriological parameters) have been selected to serve for the benefit of industries and the society.

8. Hydrographic Survey of River to determine average discharge, river bed profile and velocity of water

Hydrographic Survey across River Gumani at BewaMouza (JL No. 031) under Farakka Block, Murshidabad District was carried out to determine average discharge and velocity of water. The project was sponsored by P.H.E Dept., Govt. of West Bengal.

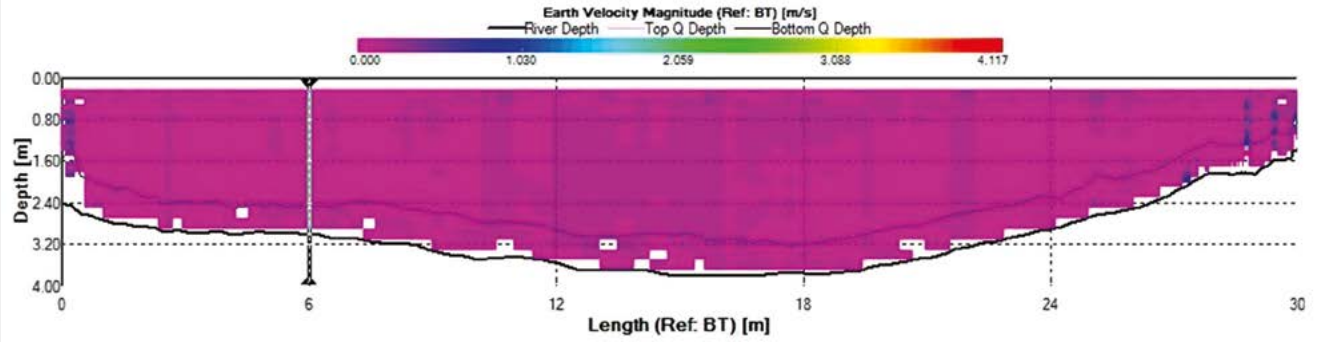
River Gumani originates from Rajmahal Hills in Sahibganj District of Jharkhand State and flows from west to east and passes near the Ganga river at the Farakka Barrage in Murshidabad district of West Bengal. In order to understand the behaviour of river Gumani in terms of its flow quantity and velocity in the vicinity of Bewa Mouza, a hydrographic survey was conducted. The survey was carried out using Acoustic Doppler Current Profiler (ADCP) including topographic survey of slopes and banks to generate Hydro-geological information like width of water flow, maximum depth of water, mean depth of water, area of water flow, velocity and discharge of flow at this particular cross section of the river.

Horizontal controls were established by connecting to nearby G.T.S and vertical controls from Farakka Barrage which have been established by NHPC. Hydrographic Survey was done using ADCP instrument by transmiting sound bursts into the water column. Suspended particles carried by water current produce echoes which were heard by the ADCP. Echoes arriving later, from deeper in the water column, are assigned greater depths in the echo-record. This allows the ADCP to form vertical profiles of current velocity. The ADCP senses in four orthogonal directions simultaneously. Particles within the current flow moving towards the instrument exhibit different frequencies from those moving away. This enables precise measurement of current speed and direction.

Monitoring of the river bed echo–sounding technology of the river bottom in combination with the determination of position using GPS instruments was performed. Single beam Sounding System, which provides data of sufficient density and accuracy was used. Measurements were performed in transverse profile with necessary density measure data and reduced to reference level through 3D models.

Hydrographic Survey in progress

Recorded points of the riverbed are transformed into national coordinate system (x, y, z). Data are loaded into MS-Inroads and then DTM of the river bed is created for regulation of low water level. By intersection of these models isolines are generated and reduced to regulation of low water level. The result of the processing and evaluation of data is isoline plan of the measured section of the river.



Transect-1: Left to Right

Multi-beam data was automatically filtered. Hydrographic software Hypack/Hydaspro was used for correction of single-beam soundings. Hydrographic Information Processing System HIPS (CARIS) was used to process the large quantities of multi-beam sounding data. Bathymetric charts in different scales with the mapping software Surfer (Golden Software) were used. It was observed that the average quantity of water discharge on 4 July 2017 was 100.6 MGD.

9. Workshop on "Emerging Technologies on Water Purification for Rural Applications"

A workshop on "Emerging Technologies on Water Purification for Rural Applications" was organized at the M. M. Suri Hall of CSIR-CMERI, Durgapur on 27 March 2018. Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI and Sri Sankha Santra, SDM, Durgapur inaugurated the programme. Block Development Officers of Paschim Bardhaman, representatives from Gram Panchayat, Administrative Personnel of ADDA, Executive Engineers of Public Health Engineering Department and Members of ECL and DVC attended the Workshop. Technologies developed in CSIR-CMERI on water purification for rural applications like improved iron removal plant and domestic arsenic, fluoride and iron filters were presented in this workshop.

8

MICRO SYSTEMS TECHNOLOGY LABORATORY

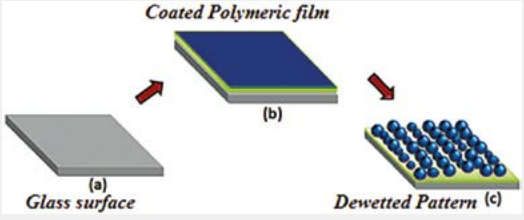
Research at Micro Systems Technology (MST) Laboratory involves engineering of micro/nano systems with novel and unique functions by integrating different domains such as mechanical engineering, electronics, chemistry, and biotechnology. The facilities related to micromachining, micro-mechatronics, microfluidics, nanomaterials processing and bio-engineering have made the laboratory unique and interdisciplinary in India. This group has successfully executed several projects funded by CSIR, DST, DBT, DRDO, Baruirpur Surgical Cluster and Indo-EU-FP7, Indo-US, Indo-Japan bilateral programs. The important highlights of the MST laboratory during 2017-18 include:

- *Research Projects: Two FTT projects and one DST funded project*
  - Micro-Fuel Cell
  - 4-axis controller and desktop micro milling machine
  - SMART Foundry 2020 – Sustainable Metal Casting using Advanced Research and Technology (GAP213212)
- *Sanction of externally funded project*
  - An Aqueous Rechargeable Battery Using Zinc Anode & RGO-V2O5-SiO2 hybrid as Cathode Material (DST)
  - Inkjet printed electrodes of Graphene oxide-Metal oxide hierarchical nanostructured nanocomposites for thin flexible supercapacitors (DST) with improved energy density and power density.
- *Product/Technology developed/demonstrated in 2016-17*
  - Metal-graphene nanocomposite as electrochemical sensor material for malaria parasite infected RBC detection
- *Publications and Patents*
  - SCI Publications: 05; Patents filed: 01
- *HRD/Skill Development*
  - PhD: Awarded (01); Submitted (01); Ongoing (06)
  - M.Tech: 01 (NIT, Durgapur); Project staff trained: 10

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

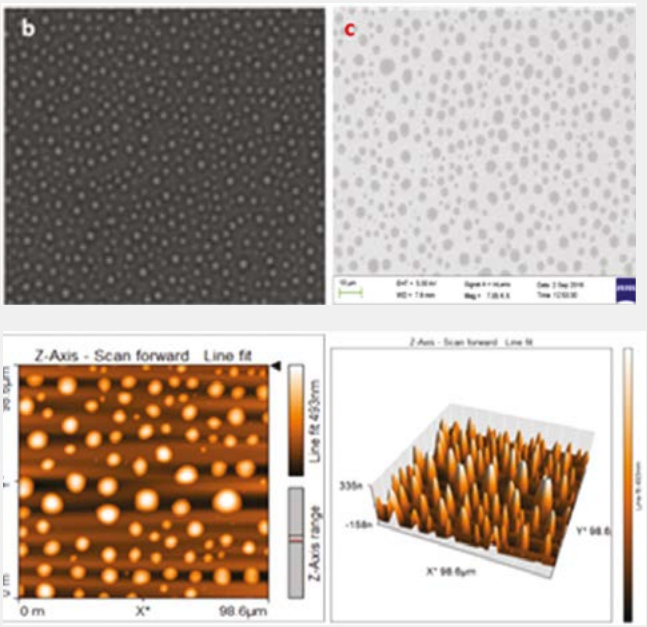
1. Micro/Nano Scale patterning of soft materials

Polymeric patterned surfaces are finding significant importance in various biomedical applications such as screening and diagnostic assays, tissue engineering, biosensors and in the study of fundamental cell biology. There exists a number of sophisticated techniques for creating polymeric patterns such as photolithography, inkjet printing, soft lithography, and dip-pen lithography etc. Most of these methods use expensive facilities to create such a pattern. In order to generate polymeric patterned surface in a simple and low-cost manner, a thin film dewetting based method was followed. The dewetting of a thin polymeric film is a spontaneous and self-organized process that forms an array of micro- and nano-scale droplets on a substrate. This is a facile approach of patterning polymer on glass surface providing a reliable surface for specific, dense, and uniform immobilization of desired molecules to pre-designed patterns. Such type of polymeric patterned surfaces are being used to develop bio-sensor for detecting important bio-molecules, biological cells etc. All these sensing platforms form the basis for the development of lab-on-chip devices which is one of the major objectives of this laboratory.



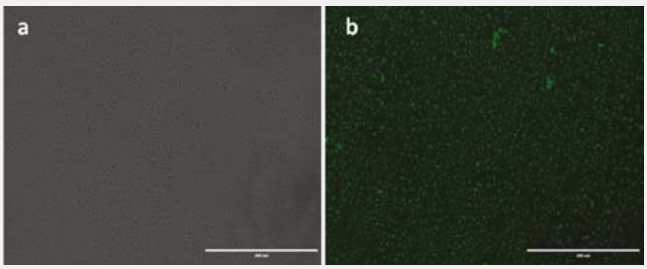
Schematic of dewetting based patterning process

In the dewetting based technique, a thin film of polymeric material is spin coated on a solid substrate which is later kept under solvent vapour for dewetting to take place. During dewetting, self-organization of the thin film takes place which produces an array of micro-/nano-droplets over the base substrate. Once the patterned surface is developed it can be further treated chemically for necessary functionalization. This functionalization will help to create biologically active surfaces where different important bio-molecules, cancer cells can be isolated efficiently.



Microscopic views of the polymeric patterned surface obtained from thin film dwetting. From left to right, optical microscopic view, FESEM view, AFM view and AFM 3D view of the patterned surface is shown.

Using such polymeric patterned surface, research related to the development of microfluidic lab-on-chip devices are being carried out. Successful protein patterning was achieved on such patterned surfaces. A study related to efficient cancer cell isolation has also been completed recently.



(a) Microscopic image of dewetted polystyrene micropatterns after incubation with Antibody in normal mode at 20X magnification, (b) Image in fluorescence mode at the same position as in (a) where protein patterning is indicated by green fluorescent colour.

2. Micro/Nano structures for environmental/ biomedical/energy applications

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

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

Real-time detection of the heavy metals such as arsenic is an important goal for water controlling and food processes. In this aspect, europium-functionalized gold nanoparticle (GNP-MMT@Eu) is developed as a sensor for highly sensitive and specific detection of very low concentration of As^{III} and As^{V} ions in water using paper strips. The nanosensor is synthesized by step-wise chemical conjugations of gold nanoparticle (GNP) with 2-mercapto-4-methyl-5-thiazoleacetic acid (MMT) followed by europium chloride ($EuCl_3$) in DI water. The characterization of the nanosensor is done by size and charge analysis, UV-vis, fluorescence, Fourier transformed infra-red (FT-IR), x-ray photoelectron spectroscopy (XPS) and transmission electron microscopy (TEM) techniques (Figure 1). The nanosensor shows colorimetric detection capabilities for both As^{III} and As^{V} ions in water up to the limit of ≤10 ppb. The performance is monitored by observing the characteristic change in colour from red (λmax ~525 nm at pH~6.5) to blue (λmax ~650 nm) in presence of As^{V} and As^{III}. As^{V} exhibits quicker response due to the effects of electrostatic and covalent type interactions in comparison to As^{III} ion which is bonded only through covalent type interaction taking more time during sensing process. The nanosensor is highly selective for As^{III} and As^{V} ions against other common ions present in water. Moreover, the nanosensor has regeneration ability after treatment of GNP-MMT@Eu-$As^{III/V}$ complex with a strong chelating agent EDTA. Since fluorescent Eu^{III} is present in the nanosensor, the detection ability of GNP-MMT@Eu is also checked through fluorometric approach but a successful result could not be achieved as Eu^{III} ion showed low-intensity luminescence in an aqueous environment due to the presence of –OH group vibration causing non-radiative decay. Another reason for quenching luminescence property of GNP-MMT@Eu may be due to efficient

energy transfer from the excited state of Eu^{III} to the excited state of MMT attached to gold nanoparticle. The analytical performance is checked with real arsenic water sample collected from Malda district, West Bengal, India. The nanosensor displays excellent recoveries of spiked samples up to a range of 96-100.8 %. Thus GNP-MMT@Eu shows excellent capabilities for regeneration and quantitative estimation of total dissolved arsenic in real water sample, signifying the usefulness of the developed nanosensor for field-test applications such as arsenic level screening during the water quality monitoring process.

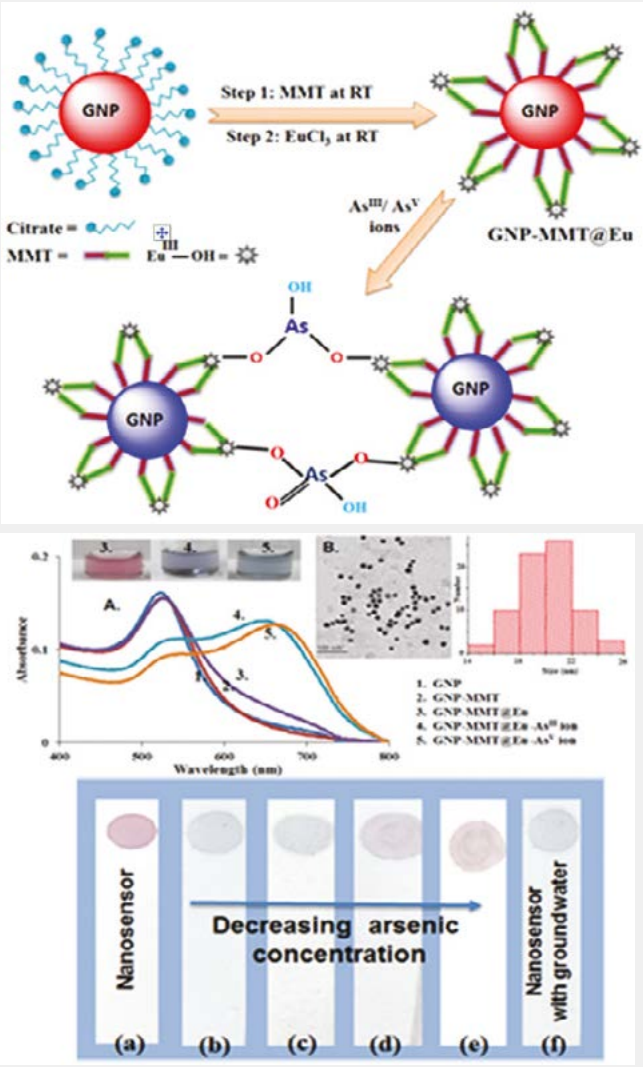


Figure 1: Schematic of fabrication of gold nanosensor, GNP-MMT@Eu and its interaction with arsenic ions (As^{III}/As^{V}) in water. Image showing colour change of GNP-MMT@Eu upon interaction with various concentrations of a solution containing As^{III} and As^{V} mixture on straight paper strips. Extreme left strip shows colour of the nanosensor only (control) while right one exhibits colorimetric response in presence of arsenic contaminated real ground water sample.

(b) Polymeric micro/nano-scale materials for drug delivery applications

In this work, a biocompatible polymer PLGA is used two develop two batches of particles of size range 50 - 100 nm and 1.0 - 3.0 µm respectively. In this process, PLGA is mixed with rhodamine B dye as a mimic of drug molecules and dewetting method is carried out to demonstrate the effectiveness of external molecule loading capability by this technique. Since rhodamine B, a potential dye is encapsulated in PLGA matrix, an in-vitro study on A549 cell line is carried out to demonstrate the PLGA mediated delivery of external species inside cells by fluorescence imaging (Figure 2).

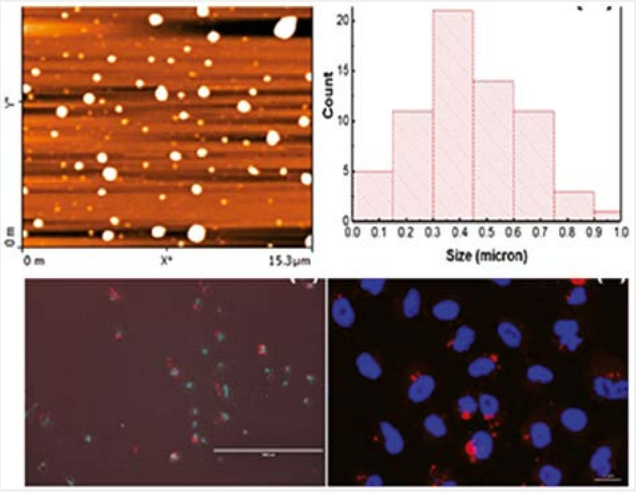


Figure 2: AFM image of the mixture of PLGA micro-/ nanoparticles after extraction (1st row, left); histogram of the particle size distribution (1st row, right); superimposed microscopic image of A549 cell line after treated with PLGA-rhodamine nanoparticles (2nd row, left); image of the same using confocal microscopy (2nd row, right)

This method does not require any sophisticated instrument and complicated process technologies. Other benefits of this process are that, a wide variety of polymers can be used in this method to generate their respective micro-/nanoparticles. Moreover, a wide range of external molecules like drugs or imaging agents can be effectively encapsulated within those particles with minimum loss. In most of the cases, polymeric structures have been made by emulsification and suspension technique which has limitation especially when loss of encapsulated expensive species is considered. We, for the first time, used PLGA, a biocompatible polymer in the dewetting process to generate patterned structures followed by micro-/nanoparticles synthesis and demonstrated the efficient encapsulation of external

molecules (e.g. rhodamine B) by this method. To illustrate the effectiveness of such particles in biomedical applications, in vitro delivery capabilities of the produced PLGA-rhodamine nanoparticles are shown using A549 cell line. Although the size distribution of the particles obtained by the present method is wide ranging from micro to nano-dimension, the use of dewetting based technique as a route of micro/nanoparticle synthesis is completely new. Controlling the wide particle size distribution may be achieved by tuning the thickness of the polymeric films which is kept as a scope of our future research.

(c) Development of indigenous CNC Micromachines and controllers

A multi-process CNC micromachine "Mμlti-Fab" is developed for 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 developed CNC machine is licensed at a licensing fee of Rs 15.00 lacs. Five similar systems are deployed at various client locations. Three skill development programs on micro-CNC are conducted with assistance from SIP Group, CMERI to enhance necessary skills among the students related to CNC machine operations.

Technology licensing of Multi-Fab machine

Field deployment of the developed system at various locations

(d) Development of sensor system for measurement of spark gap across multiple electrodes in Micro EDM

Electrical Discharge Machining (EDM) is a process used to remove metal through the action of an electrical discharge of short duration and high current density between the tool (or electrode) and the work-piece. Micro EDM is a derived form of EDM, which is used for Micro-Manufacturing Processes for production of micro and miniature parts or components. The process is based on electro-thermal energy, i.e., the electric energy conversion into heat energy during the generation of spark that results in erosion of materials from the work-piece forming a crater. It is a non-contact type machining process as the electrode never touches the work-piece; instead it discharges its current through an insulating dielectric fluid across the small gap between the conducting work-piece and tool, where the spark takes place. The spark is hot plasma at an average temperature of 1000°C; it vapourizes and melts the materials from the work-piece. Materials removed are of micron size which helps in producing a desirable finishing part to the desired contour.

Micro EDM has distinct features compared to conventional EDM. It is highly adaptable to hard materials. The discharge energy is very low (around 150µJ) with the short pulse duration less than 5µsec to the orders of nanoseconds. The Material Removal Rate (MRR) yields are very low and result in high Tool Wear Rate (TWR), which is very undesirable for micro manufacturing. So for better performance and precise micro machining, there are few challenges that are needed to be addressed. One of the major issues is control of the Spark Gap. Secondly, integration of the electro mechanical system, and finally, a need for increased rate of MRR.

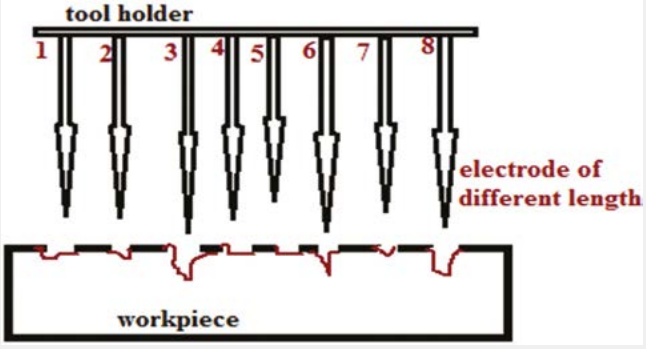


Figure 3: Multi-Electrode system forming non-uniform contour on work-piece

To address these challenges, implementation of Parallel Spark Micro-EDM has been conceptualized, a system that adopts engagement of multiple electrodes to the Micro-EDM setup with a common work-piece and machining is done simultaneously across all the electrodes forming an array of craters on the work-piece. As the spark gap plays a critical role in Micro-EDM for the desired contour formation, in case of parallel spark Micro-EDM, spark gap measurement is vital. Also, individual electrode control in a multi-electrode Micro-EDM system is a challenging job.

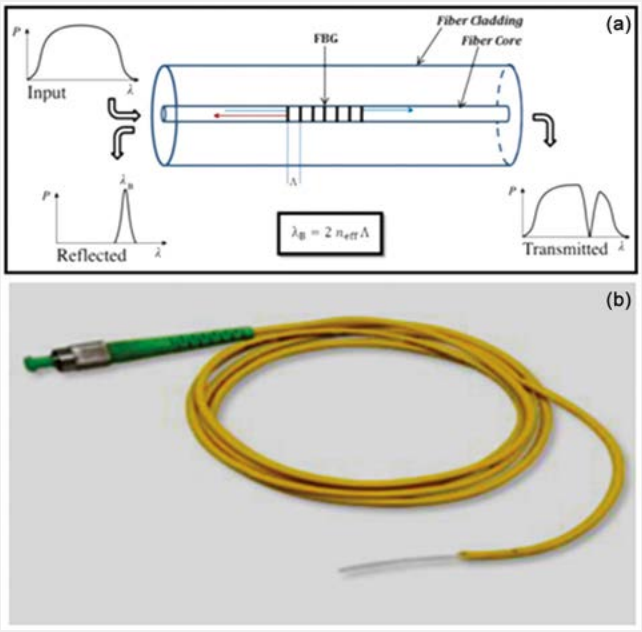


Figure 4: (a) FBG Principle and (b) A bare FBG sensor with communication fiber

A feasibility study for spark gap measurement on a micro-EDM system using sensing device based on a Fiber Bragg Grating (FBG) sensor is under exploration. An FBG is a periodic modulation in the refractive index of the core of a photosensitive optical fiber. It is fabricated by exposing the core of the optical fiber to an ultraviolet (UV) laser beam. It is such that when a broadband light is launched in the optical fiber inscribed with FBG, one particular wavelength (center wavelength, λB) that satisfies the Bragg's condition reflects back and the remaining wavelengths are transmitted. This reflected back wavelength shifts from the center wavelength as a property of strain or temperature effect on the sensor. Thus interrogating the reflected back wavelength, the shift in the wavelength from the center wavelength of the sensor can be determined, which helps in determination of amount of strain or temperature effect on the sensor.

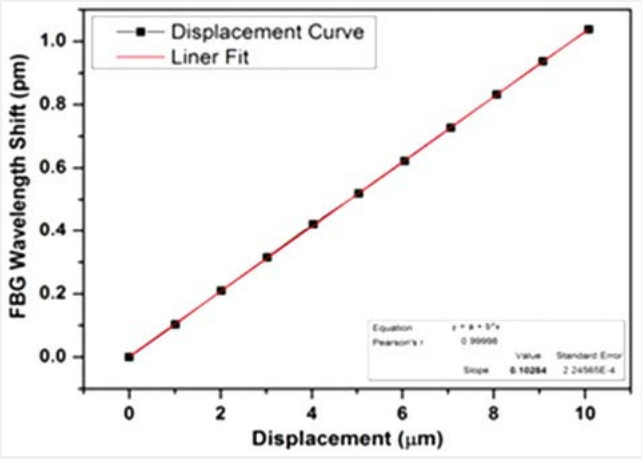


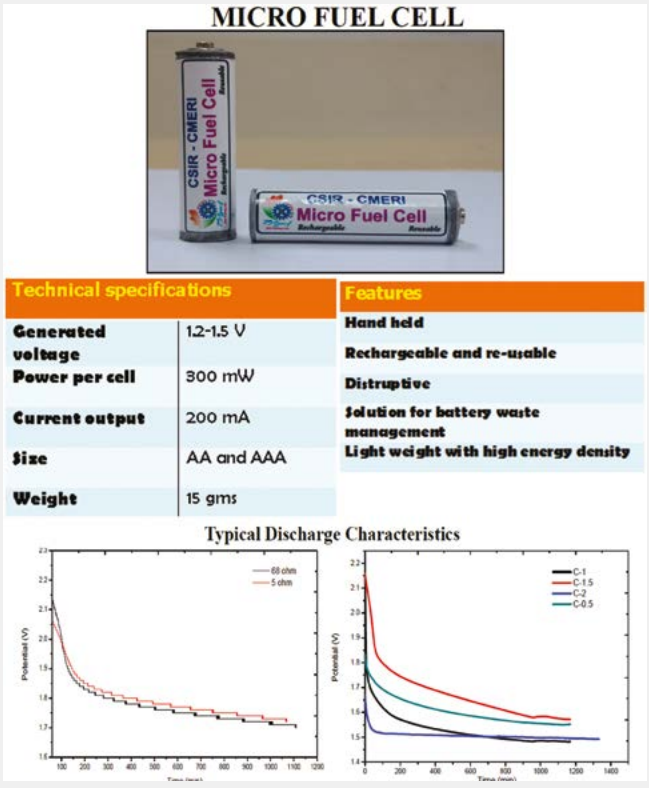
Figure 5: FBG Calibration Plot

The distinct advantages of FBG like its small size, ultra-fast response, immunity to electromagnetic interferences, chemical inertness, semi-active in nature, etc. makes it an ideal sensor for wide application areas. In view of the system requirement for the present work and the features of the FBG sensor, it has been adopted for use in spark gap measurement. In addition, multichannel interrogators can facilitate integration of multi devices developed based on FBG sensors for measurements across multi-electrodes. FBG based displacement sensing device has been designed and developed for measurement of spark gap in micro-EDM. In the present work, considering the mechanical design, the FBG sensor's strain sensing property is used to measure the spark gap of micro EDM. The sensor has been integrated with a cantilever mechanism attached to electrode system for gap measurement between electrode and work-piece during movement of the electrode. The system has been designed as per system requirement and calibrated for displacement measurement with a resolution of 1pm/10μm i.e., for every 10 micrometer displacement of the electrode an FBG wavelength shift of 1pm is observed.

Further, work has been planned for implementation of the developed FBG based displacement sensing device for real-time monitoring of the movement of the electrode and thus monitoring the electrode-work-piece gap during generation of spark gap. This is to be executed with a single electrode system first, on the successful implementation of which a system with multi FBG is to be designed and developed for multi-electrode spark gap measurement.

(e) Micro Fuel Cell

In this project, a micro fuel cell (1.5 V, 300-1000 mAh) is developed that can be made in the size of AA and AAA for applications where batteries are being used. The micro fuel cell is a power source for electronic devices that converts chemical energy into electrical energy. The scaled down fuel cells can be developed for use in electronic devices such as digital cameras, radios, toys and other low power applications. The developed micro fuel cell can generate 1.5 V, 300-1000 mAh per cell which can be stacked upon to extract more energy (~1W). The developed liquid based fuel cell can undergo in-situ charging-discharging process like batteries, eliminates the complexities associated with previous micro fuel cells and can contribute in the development of affordable and novel rechargeable batteries. The novel and cost effective rechargeable fuel cell can contribute significantly to the growing energy market of low power electronics.



9

NORTH EAST TECHNOLOGY DEVELOPMENT GROUP

1. Solid Waste Disposal Techniques Developed by CSIR-CMERI

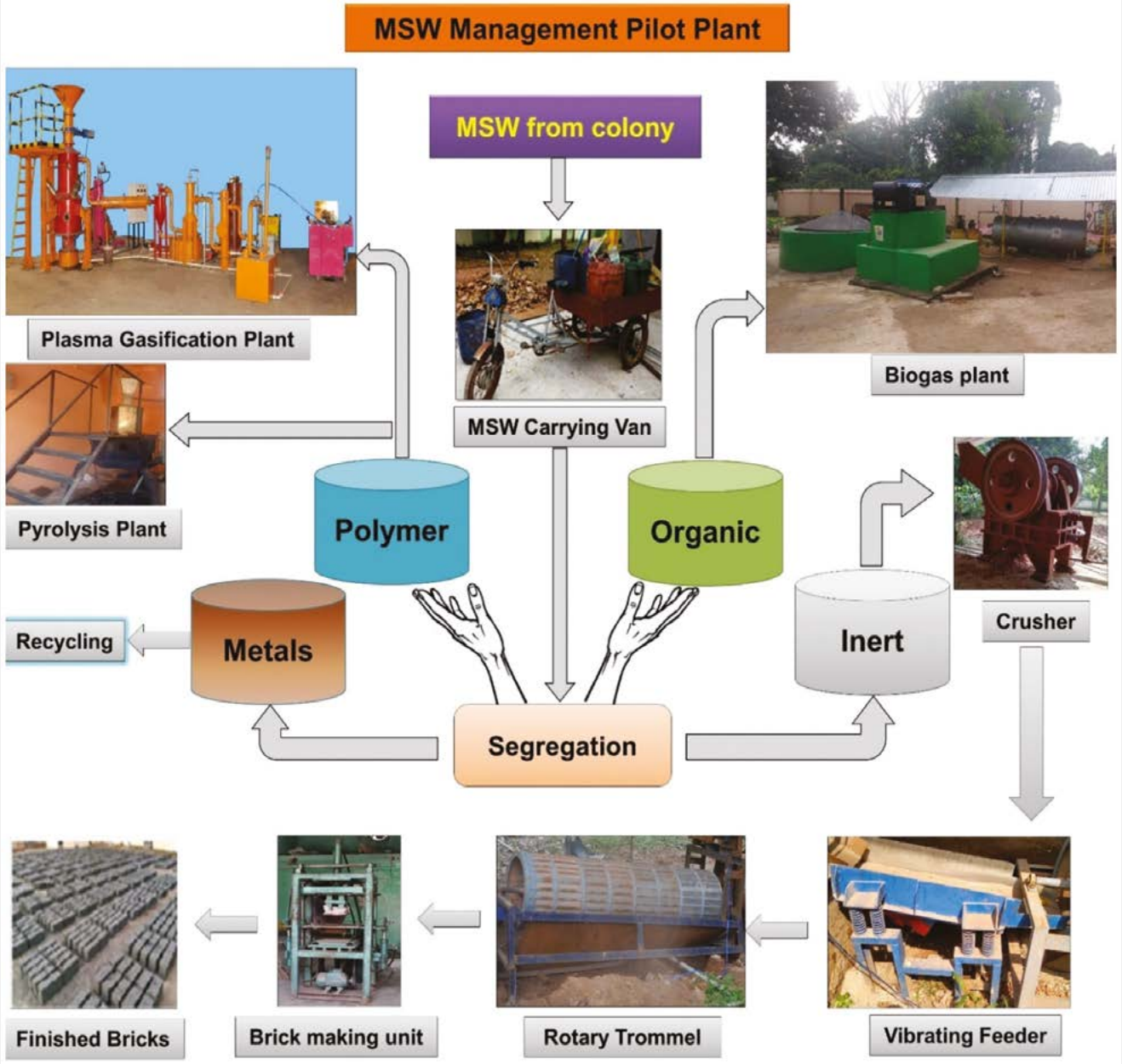


Figure 1: Zero Waste Colony Model developed by CSIR-CMERI

2. Mechanized Segregation of Live Municipal Solid Waste

The waste is being classified into two categories a) live waste and b) dead waste. The classification is based on collection of waste. The wastes which are being collected daily by the municipalities are termed "Live Waste". The wastes which have been dumped over the years at the landfill site are being termed as "Dead Waste". CSIR-CMERI has developed mechanized segregation system for both live and dead waste into different components.

The segregation process starts with dumping of solid waste material into a bin directly from the dumper carrying the materials. The segregation system should be capable of segregating metallic waste (metal body, metal container etc.), biodegradable waste (foods, vegetables, fruits, grass etc.), non-biodegradable (plastics, packaging material, pouches, bottles etc.) & inert (glass, stones etc.) wastes.

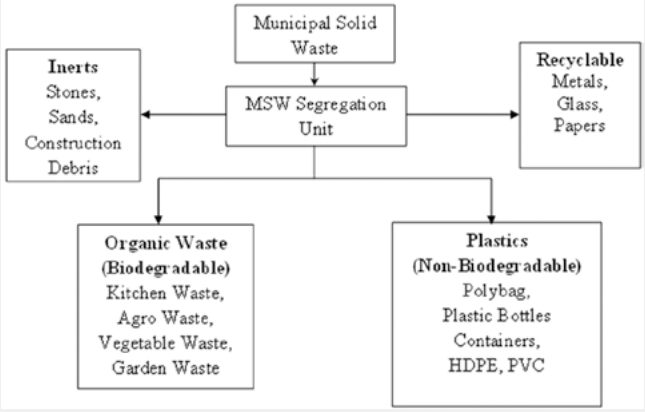


Figure 2: Process layout of Segregation System for Live Waste

The Municipal Solid Waste contains a high amount of moisture. The high moisture content reduces the efficiency of mechanical sorting, consequently making it unfavourable for beneficial utilization. Hence, a pre-treatment is required before mechanized segregation of waste. The MSW is passed over a horizontal roller conveyor where it is exposed to hot air (55-60°C). The dried material is passed over a rotary magnetic drum separator where the iron components (Fe) separate out which are collected in a hopper for reuse. The rest of the material are passed over an Eddy Current Separator where non-ferrous metallic parts (Al, Cu) are separated out. The remaining waste are sent to the Air Separation Unit where the lighter particles (Plastics, paper) and heavy mass (biomass) are being separated. The lighter objects (Plastics, paper) can be directly fed into the shredder. The shredded material is sent to polymer waste pyrolysis unit using a vibratory chute for pyrolysis. The segregated biomass can be utilized for production of biogas in the bio-methanation unit through a waste grinder. A mechanized segregation unit of capacity 50 kg/h developed at CSIR-CMERI is shown in Figure 3.

Figure 3: Mechanized Segregation Unit for Live Waste at CSIR-CMERI (Capacity: 50 kg/h)

3. Mechanized Segregation of Dead Municipal Solid Waste

The segregation system should be capable of segregating metallic waste (metal body, metal container etc.), fines (degraded organic waste), non-biodegradable (plastics, packaging material, pouches, bottles etc.) & inert (construction debris, stones etc.) wastes.The process flow of mechanized segregation unit for dead waste developed at CSIR-CMERI is shown in Figure 4.

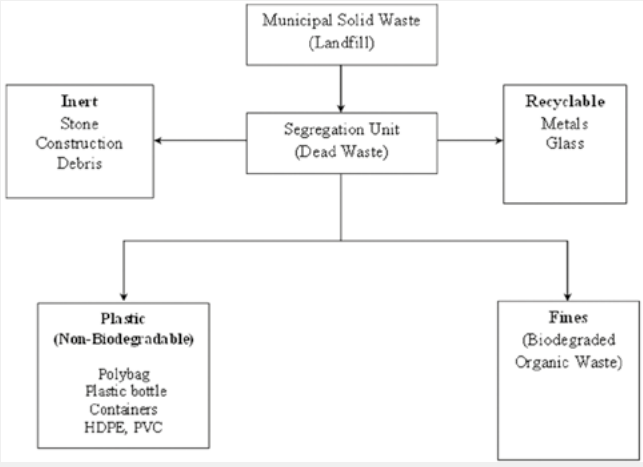


Figure 4: Process layout of Segregation System for Dead Waste

A mechanized segregation unit of capacity 50 kg/h developed at CSIR-CMERI is as shown in Figure 5.

Figure 5: Mechanized Segregation Unit for Dead Waste at CSIR-CMERI (Capacity: 100 kg/h)

4. Disposal of Plastic Waste Utilizing High Temperature Plasma

Plasma arc technology is effective, eco-friendly, most efficient and less explored technology for proper disposal of mountains of solid waste material generated on daily basis. In this method electrical ionization between cathode and anode at low voltage and high current is being used to treat the waste at a temperature as high as ~3000°C. The electric ionization is carried out through low voltage (30-50V) & high current (300-400A) between two electrodes. The temperature shall be raised to as high as ~3000°C during the ionization process. The chances of generation of carcinogenic gases at such elevated temperature are remote. The output gas will be mainly CO, H_2, hydrocarbons and CO_2. This CO & H_2 enriched sys-gas has high calorific value. The product gas after passing through the plasma treatment is made to pass through the carbon sieves (REDOX reactor). This helps to convert carbon from the sieve and oxygen to form CO. Catalytic converter shall be used to convert any traces of hydrocarbon into CO and H_2. Catalyst like Nickel can be used for this purpose. The gas is then cleaned in cyclone separator and scrubber and cooled in the condenser. This CO & H_2 enriched sys-gas has high calorific value. This gas will be primarily stored into a gas holder and will be used for generation of electricity after combustion into gas engine. The layout of the proposed plant is as follows: The process layout is shown in Figure 6 and the Plastic disposal unit of 25 kg/h capacity developed at CSIR-CMERI is shown in Figure 7.

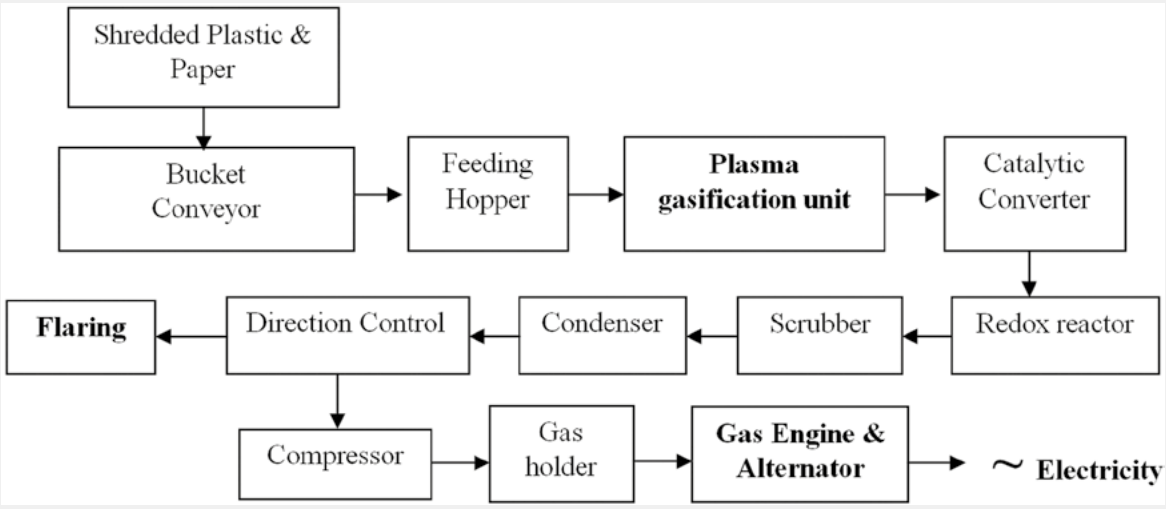


Figure 6: The process layout of Plasma Gasification Unit

Figure 7: Plastic Disposal Unit at CSIR-CMERI (Capacity: 25 kg/hr)

5. Disposal of Plastic Waste Through Pyrolysis

Pyrolysis is the thermal degradation of waste in the absence of air to generate gas (often termed syngas), liquid (bio oil) and solid (char, mainly ash and carbon). The plastic wastes are heated at a temperature of about 450˚ to 600˚C in the absence of oxygen and broken down to simpler substances forming oils and carbon after condensation. The pyrolysis oil is termed Petro Alternate Fuel (PAF), which can be used in industrial boilers, generators, or can be further refined into diesel. The process of pyrolysis has been shown in Figure 8 and the 20kg/batch pyrolysis plant developed by CSIR-CMERI has been shown in Figure 9.

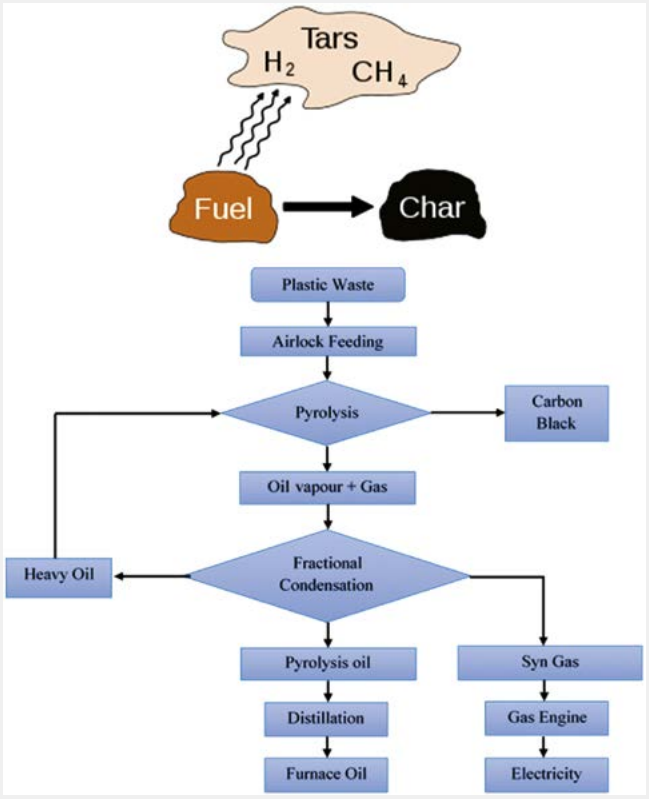


Figure 8: Schematic Process Layout for Plastic

Figure 9: Polymer Waste Pyrolysis Unit at CSIR-CMERI (Capacity: 20kg/batch)

The major components of the polymer waste pyrolysis plant include the following:

(i) Reactor

The reactor is the heart of the pyrolysis system. It consists of a reaction vessel and a furnace which is insulated on the outside with ceramic wool and cladded. The heating system consists of an oil purification unit, oil pumping unit and monoblock burners for oil and gas.

The reactor is fed with raw material and catalyst mixed in a certain proportion.

The furnace is heated so that the temperature inside the reactor is in a temperature range where catalytic decomposition takes place depending on various feedstocks. The reactor also has the provision for nitrogen purging to create inert environment to allow the process to happen in the absence of oxygen.

(ii) Gas Receiver

The syngas from the catalytic degradation comes out of the reactor and is cleaned using a receiver where the heavier carbon particles and long chain hydrocarbons condense and flow back to the reactor and the lighter fraction is taken to the multi-layer catalytic tower. The syngas velocity also decreases in the cyclone due to which the gas gets more residence time in the catalytic tower and subsequent line.

(iii) Catalytic Tower

The catalytic tower is used to purify the syngas using catalyst in the vapour phase. Unwanted components like H_2S, SO_x, NO_x etc. can be removed using appropriate catalyst, if required.

(iv) Condenser

Shell and tube condenser is used to cool the syngas from the reactor to liquid petro alternate fuel.

(v) Anti-Flashback Device

The uncondensed clean gas is then passed through a tank that is partially filled with water. The gas bubbles out to the next line of components. The water ensures that the gas that bubbles out cannot go back to the previous line of components.

(vi) Scrubber

The gas and oil after getting fired in the furnace is cleaned by passing it through a wet alkali packed bed scrubber. The flue gas is cleaned, cooled and filtered to remove the particulate matter from the flue gas.

(vii) Chimney

The cooled flue gas is vented to the atmosphere through the chimney.

(viii) Flaring System

It is dangerous to vent exhaust gas (C1 to C4) without any safety measures. In this process, it is transferred first through the safety device and then burnt in the burner or Flare system.

(ix) Distillation

The same machine can be used to distil the Petro Alternate Fuel (PAF) to high quality diesel with some changes.

Advantages of polymer waste pyrolysis process:

The pyrolysis system demonstrates:

- stable operation for a broad range of waste quality
- emissions from the system well below the limit values
- flexibility in design and operation achieved by a modular design
- effective initial waste volume reducing
- efficient recovery of the materials and energy from the process
- low operational costs; no supplementary external fuel supply for the normal operation, i.e. significant reduction of running costs

The pyrolysis system is designed for treatment of variety of different wastes such as Municipal Solid Waste (MSW), sewage and oil sludge, Automotive Shredder Residuals (ASR or car fluff), e-waste, rubber and tyres, medical waste, plastics, agricultural waste, as well as cleaning of the contaminated soil. Dozens of the commercial pyrolysis facilities for treatment of different feedstocks have been designed and built so far.

The pyrolysis facility can operate as stand-alone waste-to-energy plant as well as a part of big power plants. In the last case the pyrolysis process thermally treats the waste and generates fuel, namely pyrolysis gas and pyrolysis char. These fuels are then co-fired in the power plant boiler unit. Pyrolysis process in this configuration disposes waste, simultaneously replacing part of the fossil fuels, consumed by the power plant.

6. Bio-Methanation for Biodegradable Waste

The potential of kitchen wastes to be used as substrates for biogas production can achieve the goals of developing a sustainable technology for waste management, producing renewable energy and reducing greenhouse gas emissions. A complex microbiological process lies behind the efficient production of biogas. The organic waste treated in the biogas process represents the substrate for various microorganisms. The more varied the composition of the organic material, the more components are available for growth, and thus the greater diversity of organisms that can grow. The various microbial groups are involved in the flow of carbon from complex polymers to methane-based model. Biogas is a mixture of methane, carbon dioxide, water vapour, ammonia etc. generated from the anaerobic digestion of biomass. The methane will be enriched through scrubbing the dust, CO_2. The enriched methane gas will be used as fuel gas for cooking purpose in the kitchen and also in fuel cell for generation of electricity. Moreover, after anaerobic digestion, the spent slurry becomes excellent organic manure which is highly rich in N P K content. This manure can be used in cultivation after drying. The process flow has been described in Figures. 10 & 11 and the 10 cum capacity biogas plant developed at CSIR-CMERI has been shown in Figure 12

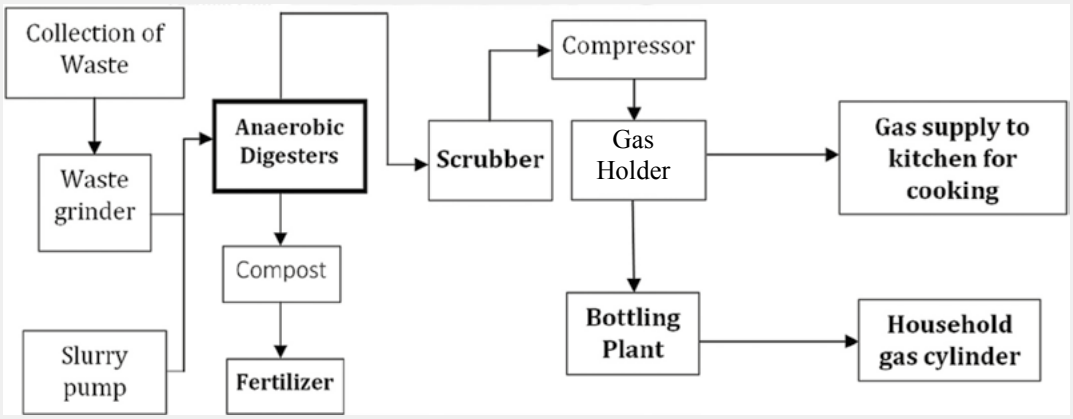


Figure 10: The Process Layout of Bio-methanation Unit

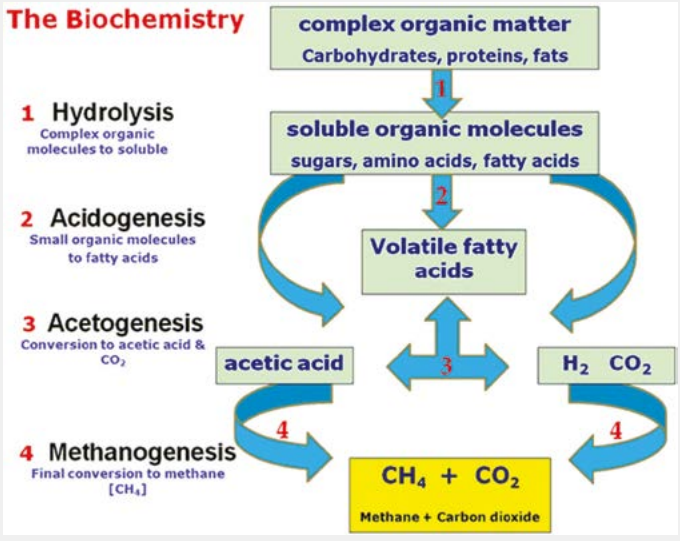


Figure 11: The Anaerobic Digestion Process of Bio-Degradable Waste

Figure 12: Bio-methanation Unit of 10 cum capacity at CSIR-CMERI

7. Utilization of Construction & Demolition Waste

Safe and effective disposal of solid waste is the greatest challenge of the era. The management of MSW is going through a critical phase, due to non-availability of suitable facilities to treat and dispose larger amount of MSW, generated daily in metropolitan cities. The major portion of the waste generated is the construction debris (C&D). The composition of C&D waste can vary depending on age of building being demolished /renovated or the type of buildings being constructed. C&D waste generation figures for any region fluctuate as it depends largely on the type and nature of construction/demolition activities.

The construction debris is collected and crushed into a crusher. Then different sized gravels which are coming out from the segregation unit are mixed with this slag. Then 10-15% cement is mixed with the materials for punning. Now, these materials are mixed thoroughly in a dry state for proper mixing. Water is added to the dry mixture in a suitable proportion. The prepared mixture is then filled in the die of a mould cavity followed by pressing. Moulding gives a definite shape to the mixture. Finally, the prepared bricks are tested for engineering properties. The ready bricks are being used as construction materials. The process of brick making has been shown in Figure 13 and the plant at CSIR-CMERI has been shown in Figure 14.

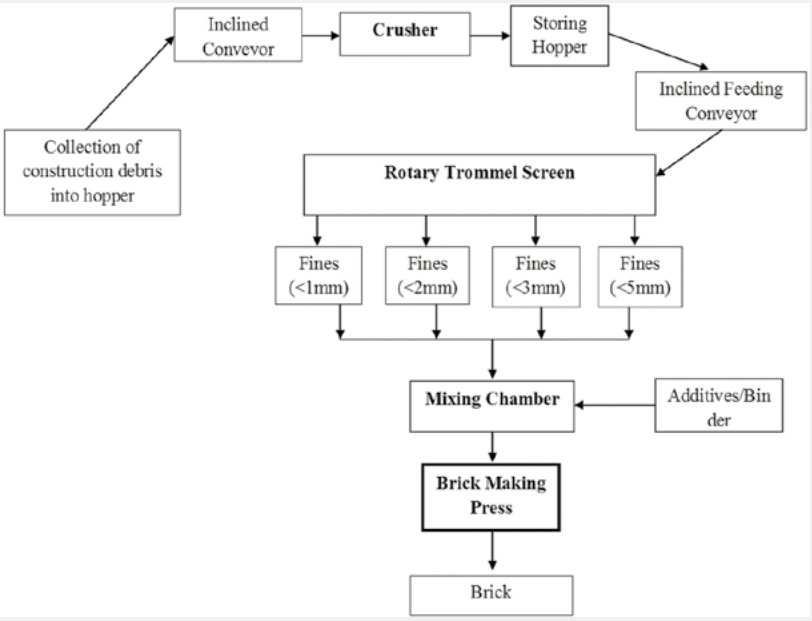


Figure 13: Brick Making Process from Construction & Demolition Waste

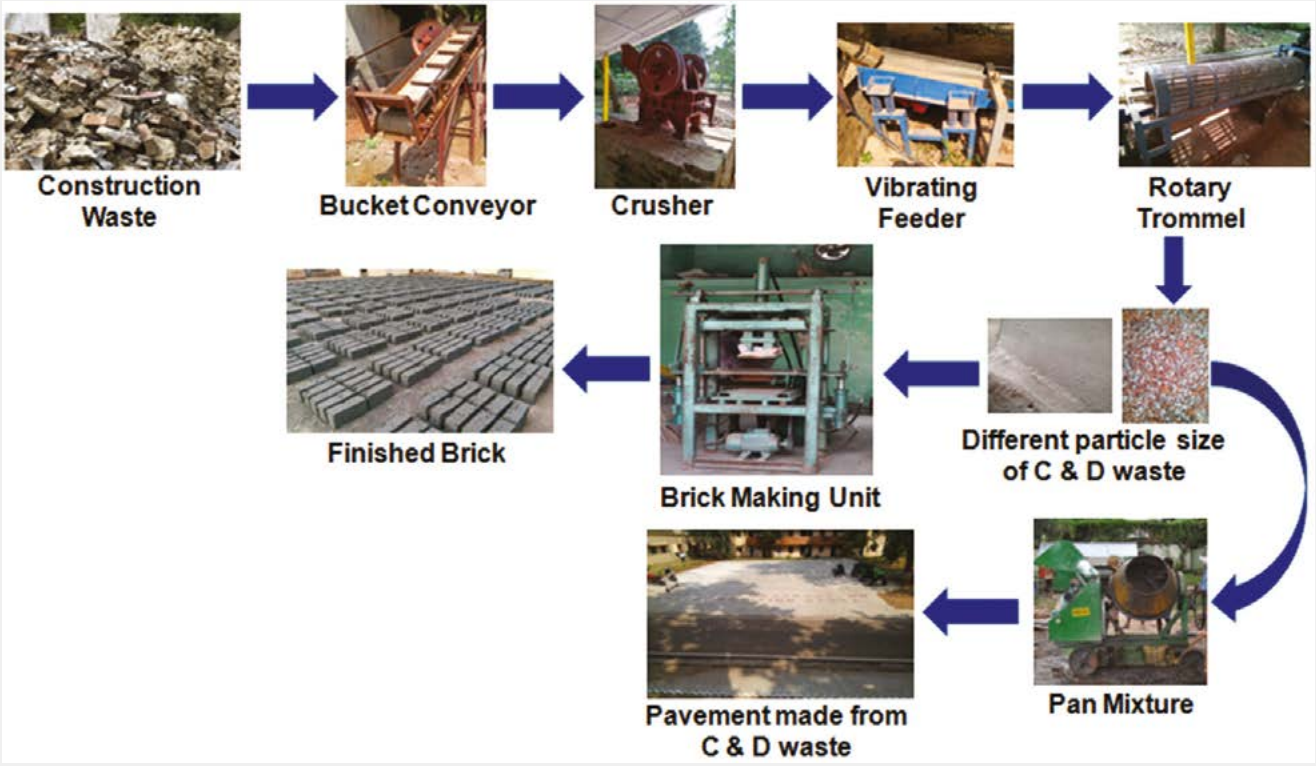


Figure 14: Utilization of Construction & Demolition Waste at CSIR-CMERI

Advantages:

The advantages of the system are as follows:

- Integrated & mechanized system for disposal of both bio-degradable & non-biodegradable waste
- Eco-friendly disposal of municipal solid waste with zero level toxin emission
- Utilization of generated bio-gas for household purpose in an economic way
- Utilization of organic manure generated from bio-methanation plant for agricultural purposes
- Utilization of construction debris for generation of value added products

10

ROBOTICS AND AUTOMATION GROUP

Robotics and Automation Group undertakes research projects and developmental work related to the robotics and mechatronics for various application domains addressing the need of civilian and strategic sectors. During 2017-18, this group completed a couple of projects (externally and internally funded), published research papers and applied for copyright of developed technologies. Besides, the group has been awarded one high value externally funded R & D project from JCBCAT, DRDO and a high-priority developmental project funded by CSIR.

Brief overview of the completed as well as ongoing projects is provided in a chronological manner:

1. Toward Developing Biomimetic Underwater Swimming Robot for Autonomous Surveillance (DST Sponsored Project, Completed)

Brief Background

In the field of underwater robotics, there are clear and distinct advantages of use of small and simpler robots in groups or swarms over a single big vehicle, especially in applications of surveillances and monitoring. Swimming by fish/aquatic animals is inspirational for the underwater propulsion systems research community. Biomimetic propulsion mechanisms can achieve significant gain in efficiency over conventional actuators used in large AUVs, and possess advantages specific to surveillance, viz. agility, less visibility, less turbulent and quiet operation. In this project, investigations are carried out for deeper understanding of fin actuation in swimming by fish through extensive experiments, followed by development of bio-robotic fin device; these are complemented by mathematical modelling, analyses and hydrodynamic simulations.

Objective

The primary objective is to develop energy efficient, less noise and reduced turbulence producing biomimetic propulsion mechanism for applications in small/miniature underwater autonomous vehicles meant for surveillance and monitoring operations of aquatic life and environment.

Major Activities

1. Dynamic and hydrodynamic modeling of the flapping fins (rigid and flexible) is done through multibody dynamics approach utilizing blade element method for estimation of the hydrodynamic forces.
2. Experiments are carried out with rigid and flexible flat plate trapezoidal fins to validate the developed model. Few glimpses of the experimental setups are shown below.
3. Instigations are carried out with flexible joint fin model for analysing the effect of joint flexibility on propulsion performance.
4. A numerical optimization study is carried out for determining the optimal flexural stiffness distribution of a fin that maximizes propulsive force.
5. Few primary motion primitives are identified for a caudal fin fish swimming actions and CFD simulations are carried out to identify the nature of hydrodynamic forces.
6. A prototype of anatomically approximate bio-robotic caudal fin of a bluegill sunfish is designed, developed, and tested for its capability to reproduce the identified motion primitives and load characteristics.

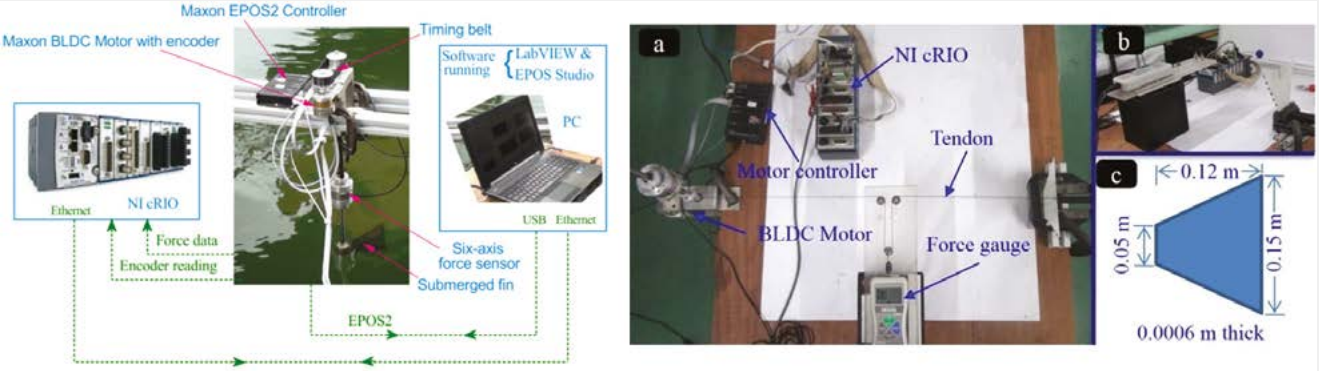


Figure 1: Experimental setup of rigid fin for measuring hydrodynamic forces and measurement of physical properties (stiffness and damping) of GFRC fin material

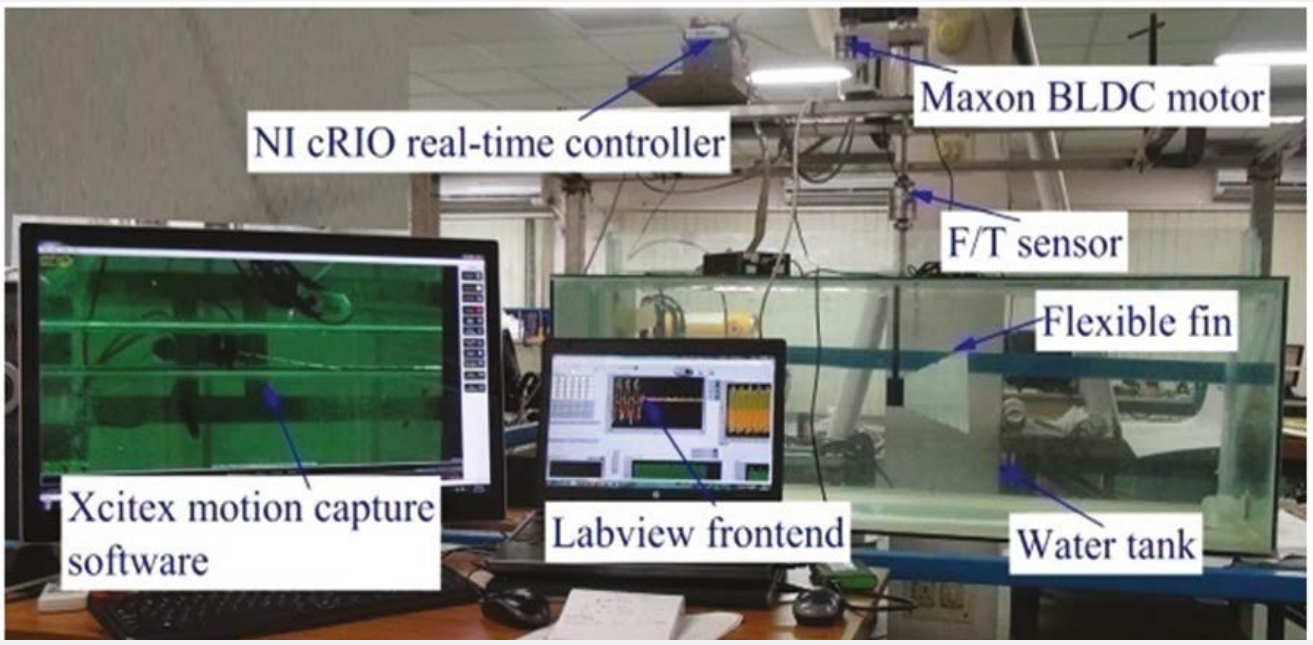


Figure 2: Experimental setup for measurement of hydrodynamic forces and deformation of a flexible fin while flapping underwater

Key results and findings

1. The model estimated hydrodynamic forces of a flapping fin (rigid and flexible) reasonably match with the experimental results.
2. It is found that joint compliance influences the propulsion performance of a fin and best performance is achieved by tuning the joint flexibility to match its natural frequency and motion frequency.
3. The optimal flexural stiffness distribution changes with different motion parameters i.e. motion amplitude and frequency.
4. A conjecture is that biological fishes adjust their fin stiffness to cope up with different living conditions of survival i.e. escaping from predators, catching a prey, and/or cruising with minimal energetic costs.
5. The optimization results resemble the stiffness distributions of biological fish fin rays.
6. A set of flat plate flexible fins with different optimal stiffness distributions are experimented to compare its performance with a normal fin. These results show that optimal stiffness distributions yield higher propulsive forces. Figure 3 shows the fabricated fins with optimal stiffness distributions suitable for different motion parameters.
7. Figure 4 shows the developed multi-ray caudal fin prototype capable of generating propulsive forces required for manoeuvring small underwater vehicles.

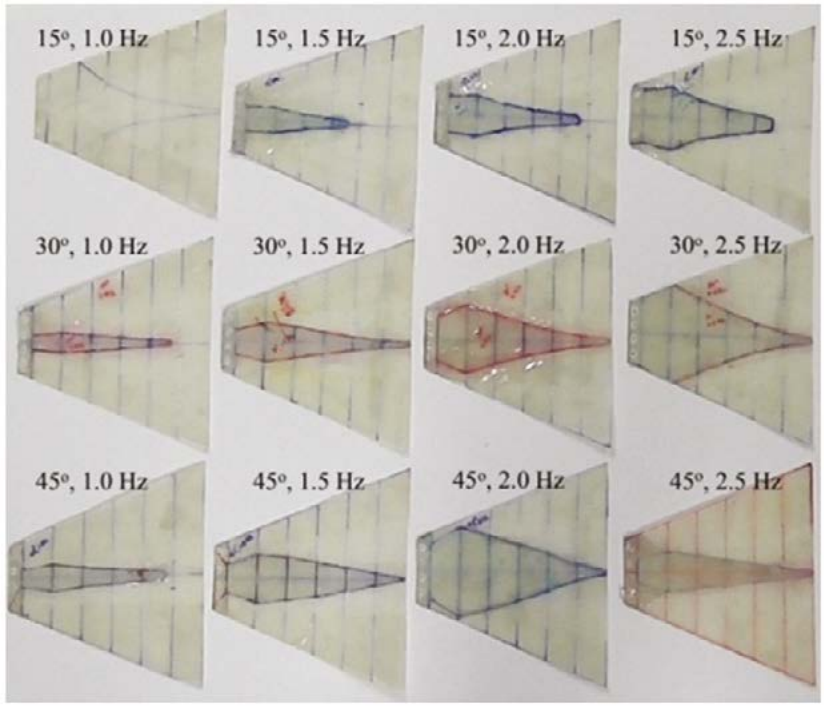


Figure 3: Fabricated fins with optimal flexural stiffness distributions corresponding to different motion parameters

Figure 4: (Left) Multi-ray caudal fin prototype without web, (Right) execution of identified motion primitives in water by the developed caudal fin prototype

2. Surveillance System for Restricted Entry Zones: Detection of Unauthorized Vehicle Parking (OLP Project, Completed)

Introduction

Outdoor surveillance systems are typically meant for monitoring traffic violation, zone or area security, unauthorized parking in restricted areas etc. It is known that the mode of surveillance in restricted areas is unique to the ambience. To cater to such applications, a team of scientists and technical staff developed a system to monitor vehicles parked in unauthorized areas. The developed detection mechanism generates an event at the control room whenever an unauthorized parking is observed by the system. It is expected that necessary measures may be taken to initiate an appropriate action on the receipt of generation of the event under consideration.

Objective of the Project

The basic objective of the project is to develop a surveillance system with features specific to restricted entry areas. Figure 5 shows a block schematic of the developed video surveillance system. As seen in the figure, the primary source of information for the

proposed system is a low cost (2 Mega Pixel, 20-30 meter range) network camera. The network camera (installed on a pole at the site) continuously captures live video from the ambience, in the region of interest. The captured video is handled at two different locations: locally at the surveillance location and at the remote control station. The surveillance location is equipped with an embedded controller which processes real-time video based on a specific requirement (eg. object detection in the present context). Frames are extracted from video data which is processed for the occurrence of a specific event. For example, as envisaged in the present application, video frames are looked for unauthorized parking in a restricted area or the area of interest.

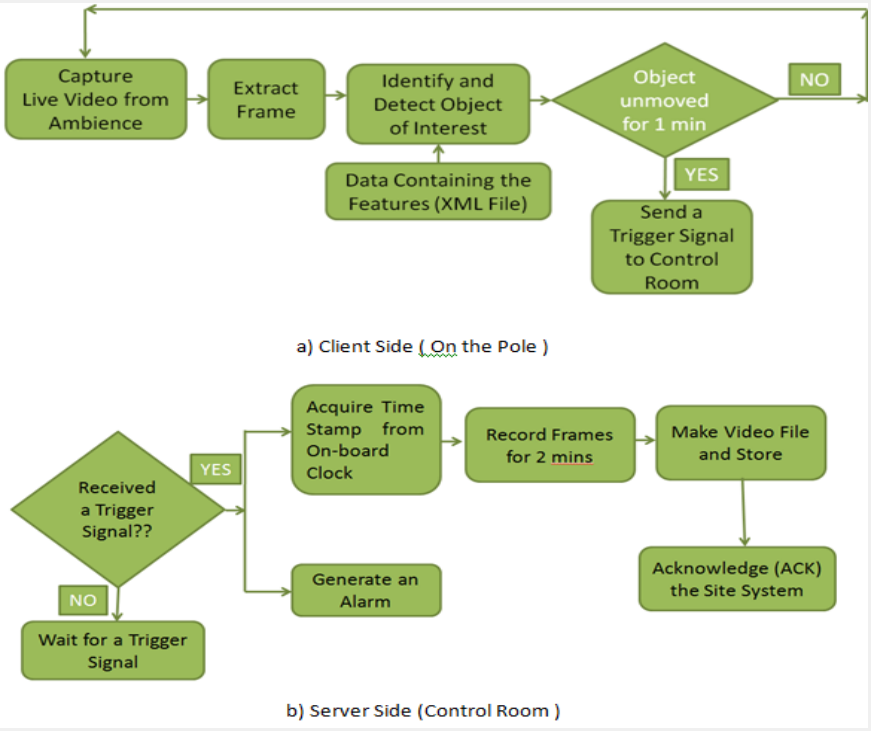


Figure 5: Block Schematic of the Developed Video Surveillance System

Principle of the System

Figure 6 shows the detection of vehicles with the help of in-house developed software. Whenever a change in environment is detected, the next step of object detection is initiated. Next, a suitable method is developed to make an affirmative decision on the detected event (a parked vehicle in the context). As a last step, when the event is decided to have occurred, the local station generates an alarm. More specifically, at this juncture, the Client system sends an event detection signal to Server (i.e. the control room) and an alarm is raised (at the control room), thus rendering the developed system to be an intelligent surveillance system. Figure 7 shows the installation of the developed hardware on the site, which includes the installation of camera, enclosure with hardware alongside onboard software. Finally, the system was demonstrated to the higher authorities in the presence of security officer for its functionality and the operational sequence.

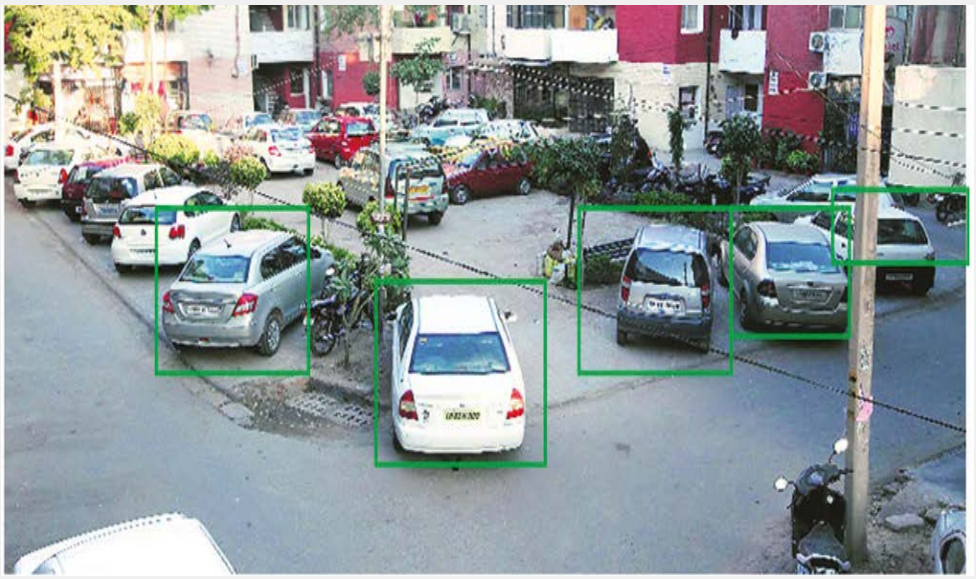


Figure 6: A few results from in-house developed vehicle detection system

Figure 7: Setup for live vehicle detection on-site: Tasks include Installation of camera, enclosure with entire hardware with onboard software

Interesting Features of the Developed Surveillance System

The proposed system is unique in the sense that, the developed video surveillance system is capable of detecting unauthorized vehicle parking with reasonably-low probability of false alarm. Such a feature is expected to play a vital role in security and surveillance of restricted areas on need basis. The other interesting feature of the developed video surveillance system is that the system gets auto-powered even when the power to the entire system is lost and initiated after a while. As a result, the event detection process continues without any human intervention. This is a typical feature required for systems developed for surveillance of areas which are not easy to access.

3. Automation of Bio-Methanation Plant (Completed)

Members of the R & A group actively participated and successfully executed the task related to **Automated Operation of Bio-Methanation Plant** at MSW complex at CMERI colony. The work was executed as an important requirement/task of the project entitled **Development of Technology for Safe Disposal of Municipal Solid Waste Utilizing High Temperature Plasma**, an OLP project.

Safe disposal of municipal solid waste has been an active area of research in recent times and is in high demand for every upcoming society. Under the purview of the above project a pilot plant demonstrating utilization of bio-waste and generation of methane gas, which can be stored and used for cooking, was established. Automation of the plant, in terms of storage and utilization of the gas as and when required, was implemented in a very simplified manner to relieve any manual intervention during the complete process.

The maximum and minimum pressures inside the gas chamber (drum) were mapped to the height of the chamber. An Ultrasonic Range Finder (URF), which continuously measures the height of chamber, was stationed directly above the chamber. A microcontroller continuously monitored this distance

that is captured by URF. A distance of around 300 mm (Figure 8) mapped to a pressure greater than the specified limit. As the chamber reached to this pressure limit, microcontroller commanded the contactor relay to make contact, which switched on a 3-phase compressor motor and the gas was transferred from the chamber (drum) to a storage tank, where methane was stored under high pressure for cooking purposes.

Figure 8: The installed system at MSW Complex in CSIR-CMERI residential complex

4. Design and Development of Mob Control Vehicle (MCV): A CSIR Funded Major Lab Project (Ongoing Project): Start: 17th November 2017, Duration: 2 yrs

CSIR-CMERI has embarked upon execution of a major design and development project on Mob Control Vehicle (MCV). The MCV is developed for effective riot control and protection of law enforcing agencies (police, paramilitary etc.). It is expected to assist in controlling of riots, dispersion or control of crowds and maintenance of law and order in public places in order to protect people or property.

The total work has been broken down in three major Work-Packages (WPs):

- Structural Design including vehicle chassis, hood, shield, Transmission and Traction, Hydraulics, Actuation, Water Jet System etc., Vehicle dynamics, Mechanism Analysis and Synthesis and Prototyping (WP-1)
- Development of light weight frames and bullet resistant shield (WP-2)
- Sensing Instrumentation and Control including Aerial Surveillance System using multi-copters (WP-3)

Scientists and technical staff members of R & A group with other associated team members took part in design, development and field trial of systems to fulfil the envisaged objectives enumerated in WP-3.

WP-3 of MCV is one of the major work-packages and involves challenging tasks such as designing of instrumentation/sensor system for visualization of mob-prone environment with control interface for concept demonstration as well as incorporation of aerial surveillance. Essentially, it involves several activities, namely, design framework with analyses, payload identification, instrumentation, procurement, testing, installation, management, post processing of the payload data etc. In order to achieve the proposed objectives of the work package, necessary sub-modules were envisaged through several brainstorming sessions and discussions. Summary of the envisaged list of activities to accomplish the objectives of the project are provided below:

- ergonomic design of DASH BOARD at driver as well as control cabin
- design of TELESCOPIC system for panoramic camera
- development of multi-channel video transmission system
- feature based value addition by interfacing robust and reliable sensors
- design of stone-proof shielding for all sensors including light etc.
- design of pan tilt system for multi barrel launching system/camera
- demonstration of the MCV with the aforementioned features

It is to be noted that most of these activities have been initiated.

5. Development of Compliant Actuators with Mechanical Impedance Variability (Ongoing Project), Sponsor: JCBCAT, DRDO, Start: 1st December 2017, Duration: 3 yrs

CSIR-CMERI has been awarded a major project by JCBCAT, DRDO. The project aims to carry out research and development of new generation actuators to be used for machines and robots which involve physical interaction with environment and human operators. Conventional design methods of actuators bring in rigidity for accuracy and then use control for compliance in interactive tasks. On the contrary, the envisaged developments claim to introduce a paradigm

change in design methodologies for actuators, and emphasize on use of intrinsic passive compliance to be applied in physically interactive tasks and then employ variability in compliance/mechanical-impedance to enhance performance. In doing so, the proposed activities will bring in principles from biology in mimicking musculoskeletal actuations. Eventually, the project proposes to develop prototype(s) of actuators, where the output motion and impedance can be controlled and varied simultaneously. The design and performance specifications for demonstration will be selected from a chosen task requirement, such as in an application of leg design in a quadruped. Other targeted application areas include human friendly robots, exoskeletons for power augmentation, powered orthoses, rehabilitation and sports training devices. Novelty of the actuation system is in introducing intrinsic variability of output mechanical impedance/stiffness, which mimics the biological musculoskeletal actuation in design principle as well as in implementation.

Extensive literature study has been carried out on actuators with stiffness/impedance variability containing the design principles, engineering realizations, control methods and implementations.

Apart from the literature survey, some preliminary work has been done as briefly described below and delineated through pictorial representations:

- biomimicking biological actuation principles as a viable method for design of actuators and finding the first principle of design
- conceptual design of Non-linear elastic transmission element (essential in the development of the actuators with inherent ability to vary stiffness passively; biomimicking of muscle elastic properties inspires the design principle and shown in Figure 9)
- finding a concept of electromagnetic variable damping
- exploring possible actuator packaging (presented in Figure 10)
- exploration on tendon drive system (presented in Figure 11) with compliant actuation and concept of joint for decoupling of tendon routing

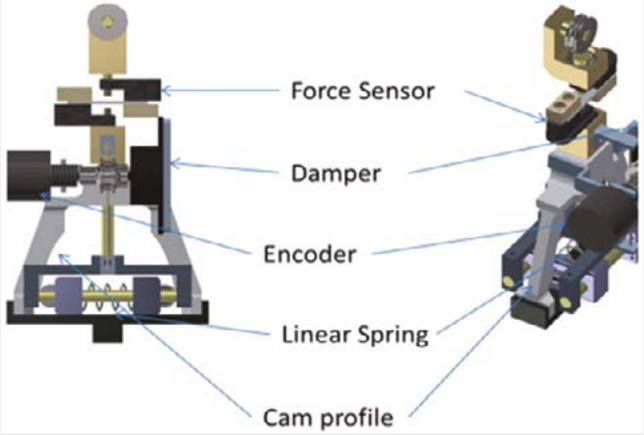


Figure 9: Concept of Non-linear elastic transmission element

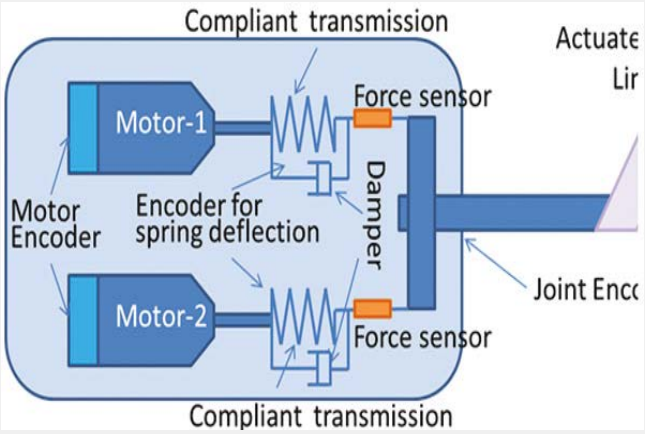


Figure 10: Envisaged compliant actuator within a package

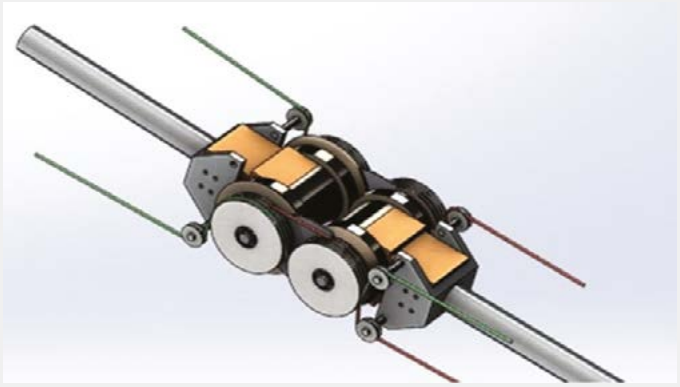


Figure 11: Envisaged tendon driven system with compliant actuation

11

SURFACE AND FIELD ROBOTICS GROUP

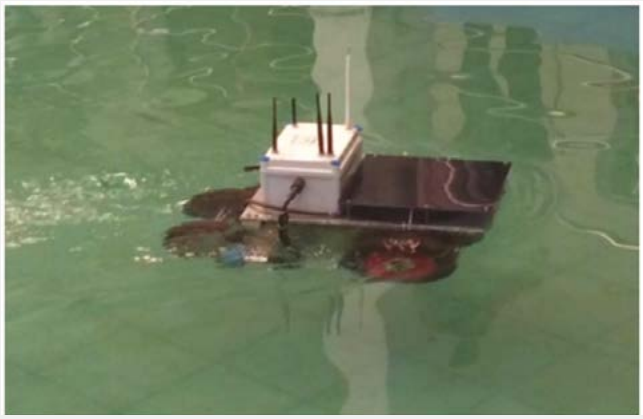
1. Amphibian Robot for post disaster rescue operation in inland shallow water (OLP-212712)

CSIR-CMERI has developed a robotic vehicle which has the unique capability of launching and retrieval without any special arrangement and for its amphibian features, it is called an Amphibian Robot. DVC requested for the services of CSIR-CMERI during water leakage from intake reservoir at DSTPS, DVC, Andal.

Special considerations have been undertaken in its design so that the system can effortlessly move over a variety of terrain surfaces under varying conditions. Another interesting behaviour is that the proposed system exhibits swimming capability against moderate current.

The key issue that influenced the shape and size of the amphibian robot is the equipment that need to be mounted on it, depth of operation, mission time and power requirement. The size of the robot is 550 x 400 x 300 mm and its weight is around 40 kg. A major share of the total power is consumed by the propulsion system, such as the motors and thrusters. Various equipment and sensors are packed within a very limited space which is the hull—a watertight compartment— that houses motors, controllers, on-board battery banks, Single Board Computer (SBC) and necessary electronics and cabling. The system has modular wheel arrangement on both sides, driven by two different motors from within the hull, the shafts of which are extended to two drive-wheels outside the hull. The thrusters are mounted at the back of the hull. The system is capable of moving over fairly rough terrain when exploring over dry land, whereas, the thrusters come into action when it is in water. The system is positively buoyant so it floats on water without any buoyancy pack.

In addition, an underwater camera and an acoustic echo sounder are mounted for safe navigation, inspection and for measuring the depth of turbid water along with INS, GPS, compass for kinematic updates and location of the robot during operation.



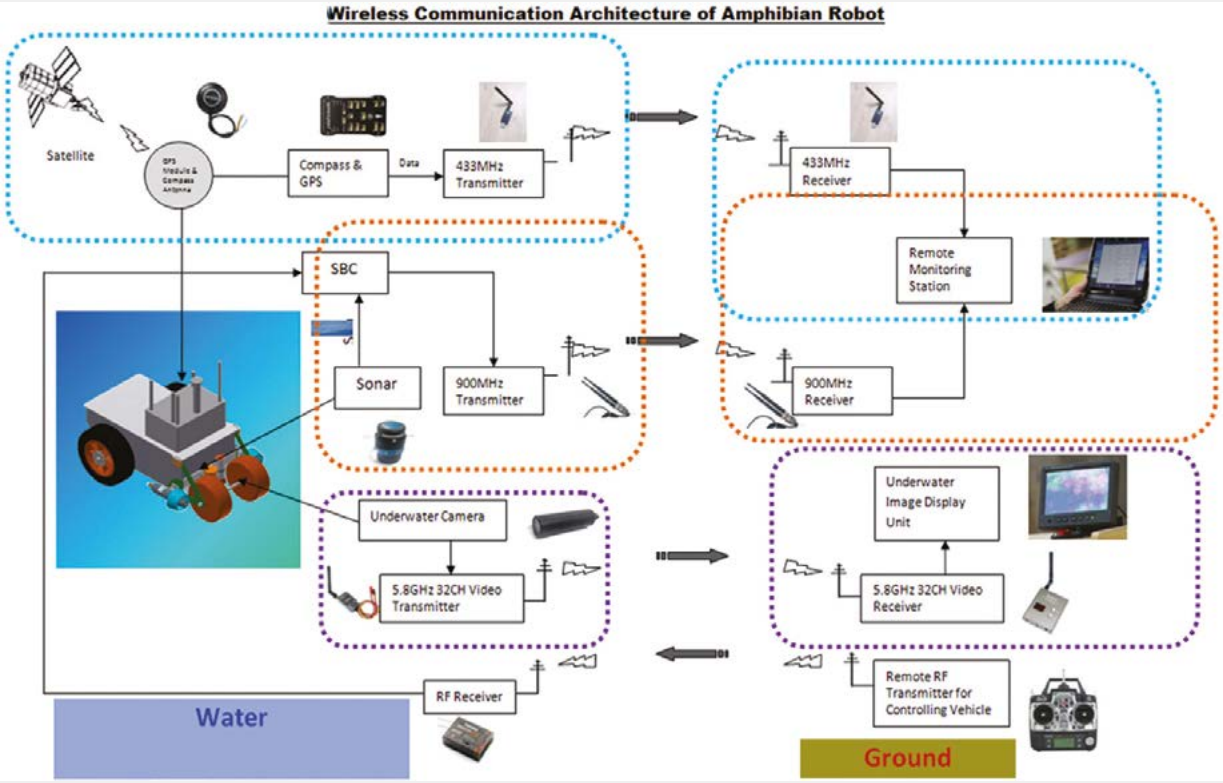
Amphibian robot for shallow water surveying

Launching and retrieval of amphibian robot

Amphibian robot during testing at site DSTPS, DVC, Andal

Amphibian Robot Communication

The robot communicates with the command station, stationed on the shore, in wireless tele-operation mode. Analog data from the camera and navigational and payload sensor data are transmitted over wireless link to the command control station as shown below.

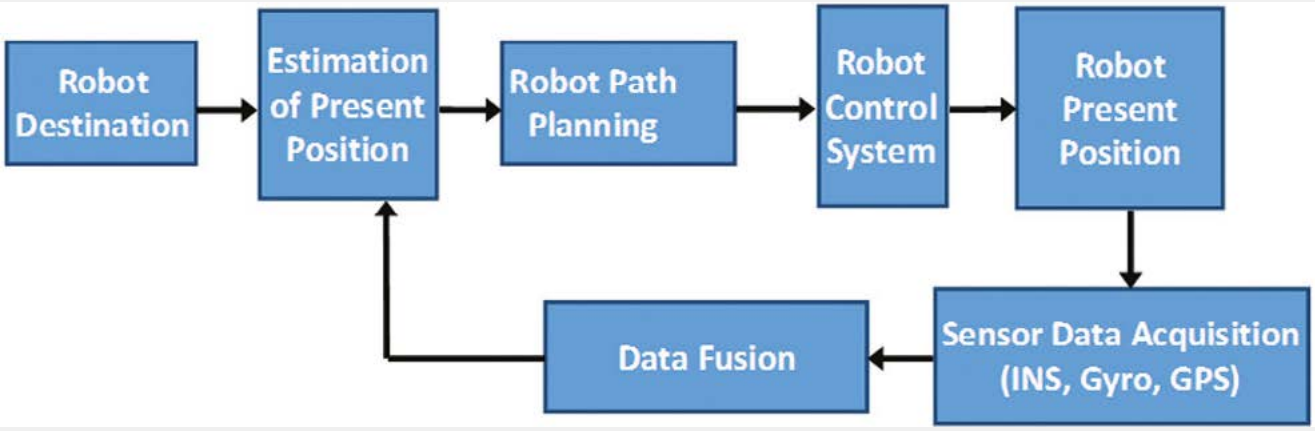


Amphibian Robot Navigation

As Amphibian Robot moves from the higher ground to the water body, it gathers information of its surrounding with camera and acoustic echo sounder. It requires accurate estimation of position for guidance and control. The reliability of the estimated data is increased by using different types of sensors. The path tracking algorithm of an amphibian robot is developed using multi sensor fusion algorithm, a process of combining observations from a number of different sensors to provide an accurate estimation of state of the robot. Data fusion algorithm is used for fusing the data from Global Positioning System (GPS), accelerometer, compass and gyro. Accelerometer and gyro for translational and rotational information respectively are fused with positional information from GPS and rotational information from compass for accurate estimation of state and navigation including path tracking. The block diagram of robot navigation is given below.

After accurate estimation of the current position, the path planner enables identification of an optimal path for the robot to traverse on the water surface. After that the mission planner controls robot motion by sending appropriate commands to robot's wheels or thrusters to navigate the robot in desired direction towards destination.

Post project activities include submission of two project proposals to DST and CSIR Mission project on Ecology, Environment Earth Science and Water.



Schematic layout of amphibian robot path tracking

12

SURFACE ENGINEERING & TRIBOLOGY GROUP

Tribological understanding of surfaces in contact results in superior performance of the products which are significant for scientific progress. The research projects at surface engineering & tribology group are led by eight scientists and assisted by a technical officer and a few technical assistants.

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. In addition, the group is actively involved in developing some products for societal use. Thrust research areas of the group include "material synthesis and characterization, novel lubricants and coatings, corrosion resistant materials, thrust pad bearing design and numerical investigations, theoretical analysis, micro/nano scale manufacturing systems, sensor development, hospital & municipal waste management, smart LED street lighting system". These research activities are augmented by the state of art and well equipped experimental facilities, mostly designed and developed by CSIR-CMERI.

1. Material Synthesis and characterization

- Controlled synthesis of nickel/iron multimetal oxide with different stoichiometry and particle size is carried out by varying the pH of the reaction medium.
- An asymmetric supercapacitor (ASC) cell was fabricated with electrodeposited samples which showed large potential window of ~1.6 V along with high energy and power density of ~91W h Kg-1 and 7200 W Kg-1, respectively. The ASC exhibited very low relaxation time constant (~1.3 ms) and long stability ~83% after 10,000 CD cycles.
- Reduced graphene oxide (rGO) was synthesized via chemical reduction of GO by using hydrazine. The synthesized rGO was incorporated in carbon fiber (CF)/epoxy composites to investigate the mechanical properties of the CF/epoxy composites.
- At 0.2 wt% of rGO loading, the CF/epoxy composites showed best load carrying capacity among the developed laminates and correspondingly interlaminar shear strength, impact strength and fracture toughness enhanced by 84, 100, and 33%, respectively.
- Cobalt sulfide-molybdenum sulfide core-shell ($CoS_x@MoS_2$) and cobalt sulfide anchored nickel sulfide (CoS_x/Ni_3S_2) was prepared hydrothermally. $CoS_x@MoS_2$ was deposited by means of drop casting on conducting substrate nickel foam (NF) and CoS_x/Ni_3S_2 was directly grown on NF.
- CoS_x/Ni_3S_2@NF II CoS_x/Ni_3S_2@NFand $CoS_x@MoS_2$ II $CoS_x@MoS_2$ achieved benchmarking current density of 10 mA cm^{-2} at 1.572 and 1.668 V, respectively. The values achieved were found to be comparable with the state-of-the-art existing electrolyzer device (consisting of ruthenium oxide, RuO_2 as anode and platinum on carbon, Pt/C as cathode material).
- Synthesised Cu_2O-graphene nano platelet composite through two step electrodeposition method for selective detection of hydrogen peroxide. The composite achieved the sensitivity and detection limit of 52.8595 µA $µM^{-1}$ cm^{-2} and 34.32 nM, respectively along with better selectivity.

- Synthesised Cu_2O-graphene layer-by-layer composite through SILAR method for quantification of H_2O_2. The composite displayed a sensitivity of 74.99 µA $µM^{-1}$ cm^{-2} and LoD of 1.05 nM. The interference test suggested superior selectivity of the composite for H_2O_2 against various other analytes.
- The fracture toughness of the composites (critical stress intensity factor, KIC) achieved from single edge notched bending (SENB) testing is improved by ~111% against pure epoxy at 0.1 wt% loading of TZG. Thermal stability of the composites as investigated by TGA showed 29 °C rise in onset degradation temperature for 0.1 wt% TZG incorporated composite.

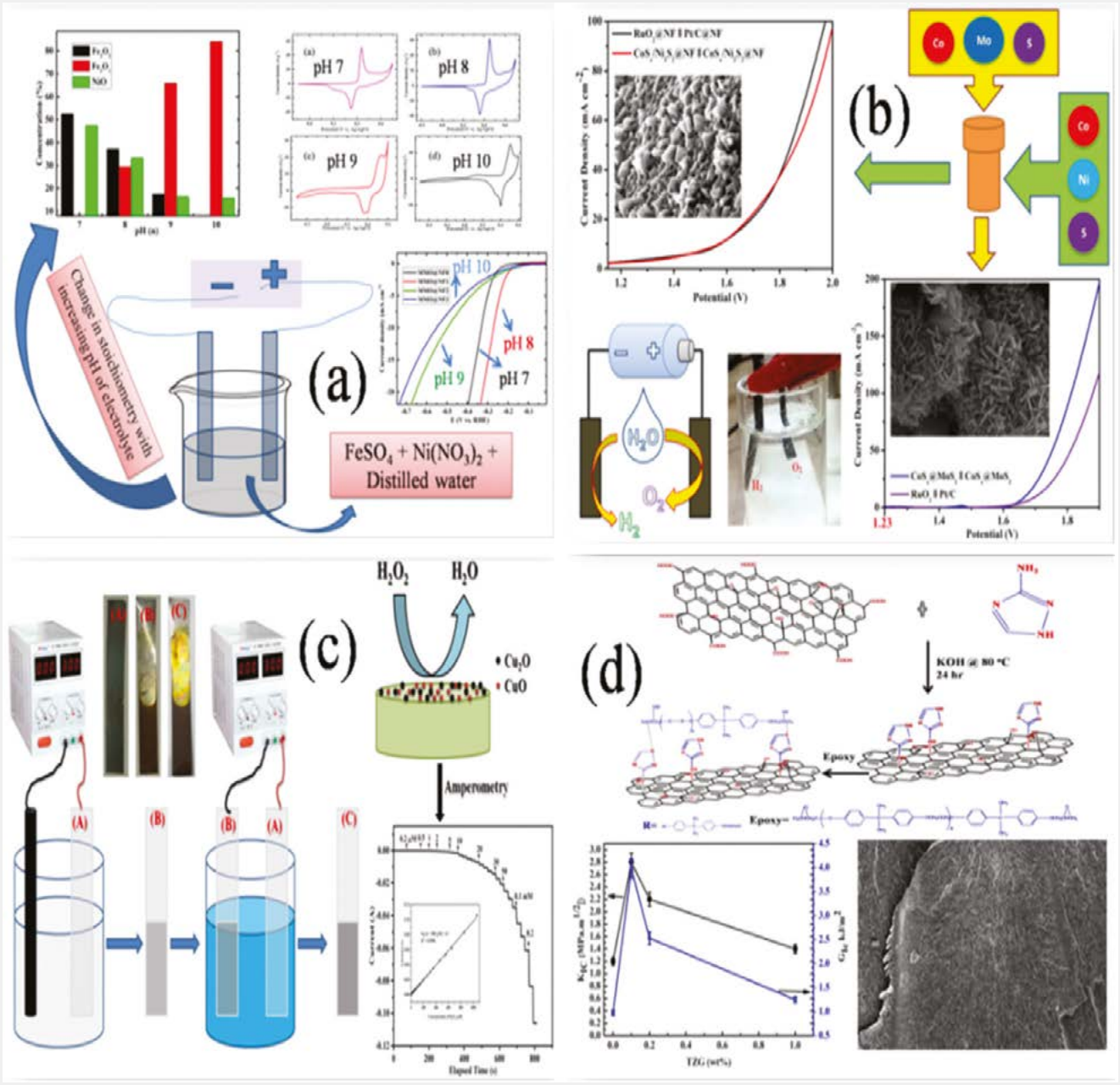


Figure 1: Schematic for (a) electrodeposition and electrochemical performances of nickel/iron multimetal oxide with different stoichiometry and particle size, (b) Synthesis and overall water splitting activity of CoS_x@MoS_2 and CoS_x/Ni_3S_2, (c) Synthesis and sensing behaviour of Cu_2O-graphene platelet composite, and (d) preparation of rGO/epoxy composite

2. Novel lubricants and coatings

The use of traditional additives for lubrication in the mechanical systems creates many problems of toxicity, pollution and slow degradation of additives hinder the tribological performance. Therefore, new lubrication concepts need to be taken into account. Initiatives are taken to develop a new generation of lubricants based on the development of additives for lubrication using nanoparticles. The lubrication of surfaces at nanoscale will have to be accomplished by tenacious particles dispersed in a medium which will form long-lasting surface bound films to reduce friction. Over the last few years, the main research focus was to develop functionalized particle lubricants for dry and lubricated contacts and friction and wear resistant composite coatings through electro and electroless deposition.

Nanofluids are a new class of fluids engineered by dispersing functionalized nanolubricant particles in a liquid medium. To act as a superior lubricant, the transport of these nanoparticles randomly dispersed in the liquid, to the region of contact between the asperities of mating surfaces is of prime importance. Figure 2 depicts one such kind of Nanofluids. The solid particles adhere to the asperities and supports the normal load. Thin films of these particulate materials grow on mating surfaces as material is transferred and back transferred to develop a regime of low friction steady state tribology. Functionalized graphitic nanoparticles were prepared, with various amine containing organic functionalities and polyelectrolytes, as the load bearing candidates for efficient lubrication of dry and oil/water lubricated mechanical contact. The prepared particles were analyzed for their structural and physico-chemical evaluation for successful functionalization. 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 show prospect of obtaining comparable tribological behaviour with functionalized nanoparticles in both oil and water medium.

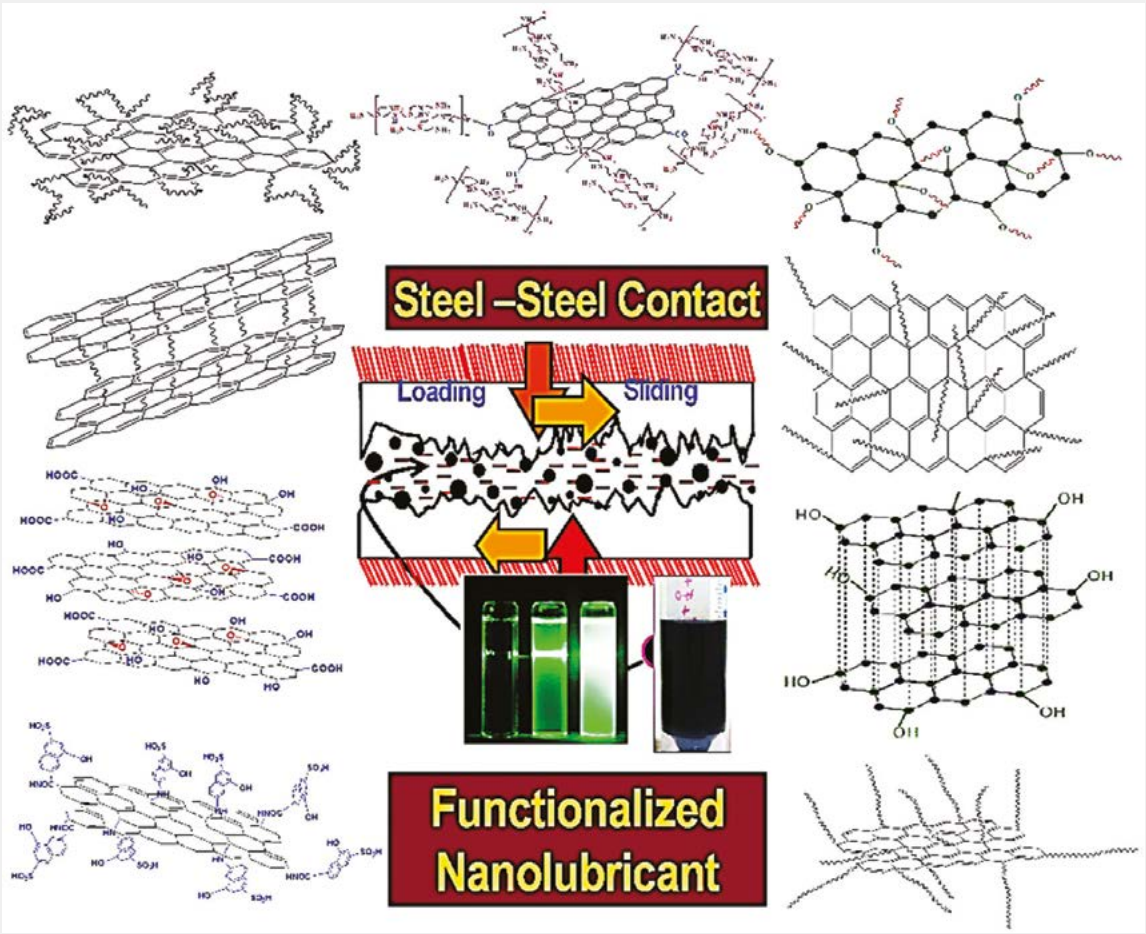


Figure 2: Functionalized Graphitic Nanolubricants

3. 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. The method is commonly used for the electrodeposition of thin metallic films. The electrochemical deposition of nanostructured metals is possible if a large number of grain nuclei on the electrode surface is created and if the growth of nuclei and crystallites is strongly impeded. Electroless Nickel (EN) plating is used in applications where corrosion resistance is desirable and when plating intricate surfaces or small or deep bores, for a uniform thickness and medium to high hardness. The process is limited to certain types of metals and it requires a strict, high level of quality control. Electroless Ni coatings have been extensively applied in numerous fields because of their excellent quality, uniform deposition, excellent wear and corrosion resistance, good weldability, and electrical conductivity. EN 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. Electroless coatings find their use in almost every domain. From simple knitting needles to the mighty aerospace applications, their range of applications is continuously broadened. The main applications of electroless nickel coatings are based on its properties viz. wear resistance and corrosion resistance. Low friction nanostructured coatings consisting of a hard transition metal carbide or nitride in combination with a solid lubricant embedded in a Ni matrix. 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.

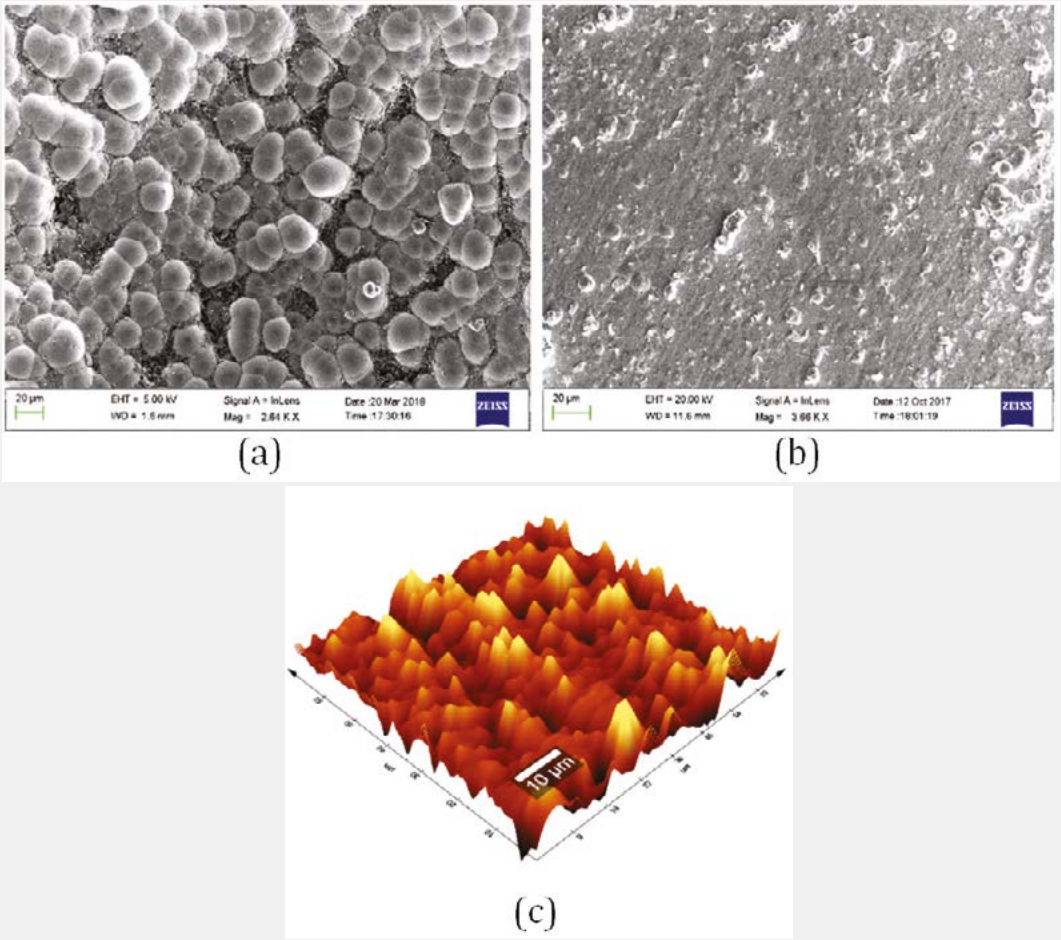


Figure 3: (a) FE-SEM image of electroless Ni-P-B coating, (b) FE-SEM image and (c) AFM topographic image of functionalized hydrophobic Ni-GO-ODA composite coating prepared by PED

4. Thrust pad bearing design

It is observed that the thrust pad bearings' load capacity can be enhanced by maintaining the clearance values of single digit microns, which are very difficult in practical applications. So to improve the bearing load capacity it was suggested to use surface texturing features on the bearing thrust pad surface. A thorough investigation on different textured parameters like dimple depth, texture extent and aspect ratio was carried out. It was also observed that for the plain pad with increase in tilt the load capacity increases and for textured pad the load capacity decreases. This shows that with the textured features a high load capacity can be achieved even with the parallel sliding surfaces. Several surface texturing features like linearly varying rectangular profiles, stepped profiles with various texture depths were analyzed. CFD analysis was carried to understand the effect of various texture shapes and sizes. A 2D profile was modelled and FLUENT was used to conduct the CFD analysis. A comparison of hydrodynamic pressure generated due to various surface texture features are depicted in the following figure.

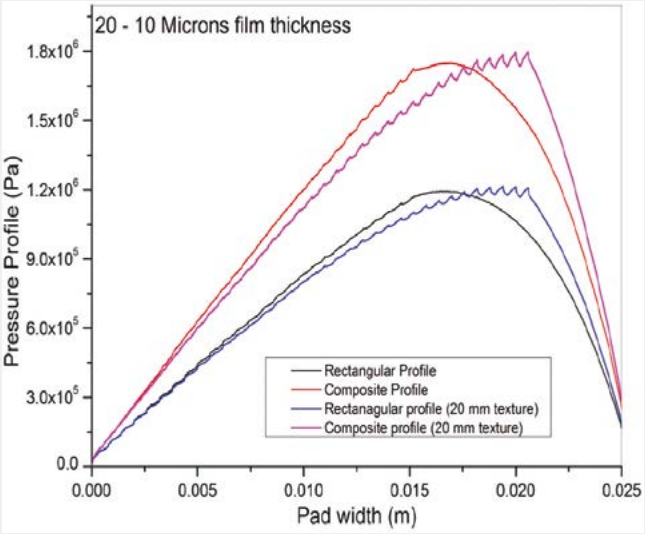


Figure 4: Pressure profiles generated with different texture profiles

From Figure 4 it is observed that a composite texture profile results in better hydrodynamic pressure profile when compared to other surface texture features. Implementation of the composite textured features on the thrust pad bearing surface is advised to achieve the desired bearing load capacity.

5. Numerical Investigations

The analysis of thermoelastic instability using the perturbation technique for an incompressible flow is well established but the same is not available for a compressible flow. Therefore, thermoelastic instability (TEI) model for foil bearings has to be developed from scratch. The analysis has three components: a) determination of amplitude of the perturbed heat wave, b) development of an expression for surface deformation due to thermal expansion, and c) calculations of the elastic deformation of bearing surface due to resulting pressure from perturbed film profile. The derivation of expressions that incorporates all the important operational parameters as well as closed-form expression of pressure for compressible flow is a challenging task. In the proposed analysis, the solution of Reynolds equation with the short bearing approximation is obtained using a first order perturbation method and with the application of the Stokes' theorem.

Table 1: Comparison of obtained results with experimental findings

References	Experimental Value[m/s]	Theoretical Value[m/s]	
Lee et al.		91.75	90.21
Dykas and Howard	30 µm	159.59	162.0
	35 µm		160.629

Table 1 shows the close agreement of critical speed values obtained from the present theoretical model with those obtained experimentally for two different cases. The developed model can be used for the prediction of critical speed of foil bearings that can cause TEI.

6. Theoretical Analysis

Several theoretical analyses are being carried in this research laboratory using commercial software like ANSYS, FLUENT, ABAQUS etc. These analyses are used to validate the experimental findings.

7. Simulation of ink-jet printing process

A CFD (Computational Fluid Dynamics) simulation has been carried out to study the behaviour of droplets under various operating conditions. The landing of the droplet formed from the nozzle has been carried

out by simulation. According to the different wetting parameters, hydrophobic (contact angle > 90˚) and hydrophilic (contact angle < 90˚) surfaces are considered. The landing on surfaces with different contact angles (35˚ and 175˚) is reported using Ansys-Fluent software. The CLSVOF model is used and it captures the interface between the ink droplet and air precisely and satisfies the mass conservation equations. The droplet is generated by using a cosinusoidal velocity profile at the nozzle inlet. The velocity profile is such that the velocity of flow of ink decreases following a cosine curve from its maximum value to zero within the injection time. Here in this simulation, the maximum velocity is 5 ms^{-1}. Average flow rate is 1000 pico-liter per second through the inlet and micron sized bubbles are produced.

Bouncing of droplets from the super-hydrophobic surface has been observed for the contact angle is 175°. The time sequence of droplets is shown in Figure 5 and 6 for contact angles 35˚ and 175˚ respectively. In Figure 6, bouncing back of the droplet is observed clearly at time instant 115 µs. This work is output of the GAP project Design and Development of Electro-hydro dynamic Ink Jet Printing System (GAP211412).

Ultra-hydrophobic surfaces have been developed recently which are capable of obtaining contact angles with water as high as 177°. It is inspired originally by the unique water repellent properties of the lotus leaf. The extremely large contact angles result in almost spherical water droplets.

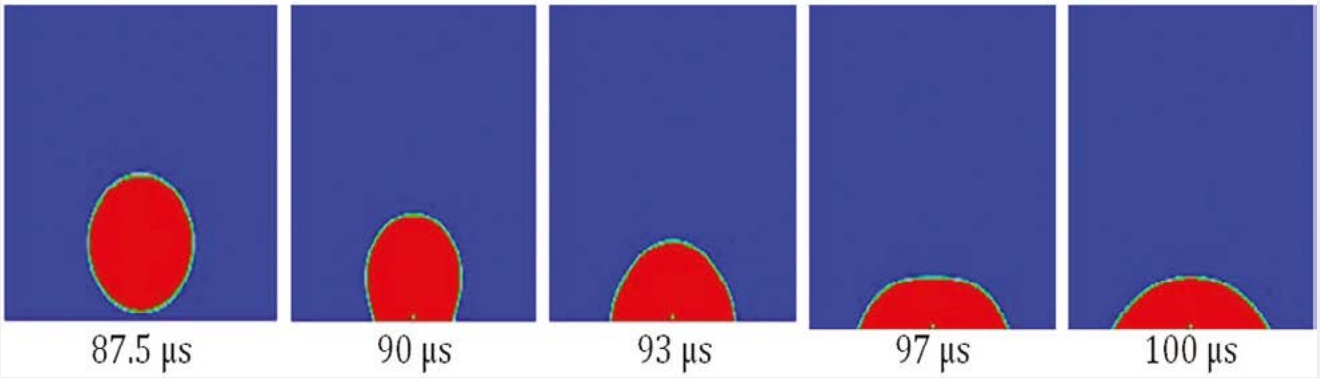


Figure 5: Landing of droplet on surface with contact angle 35

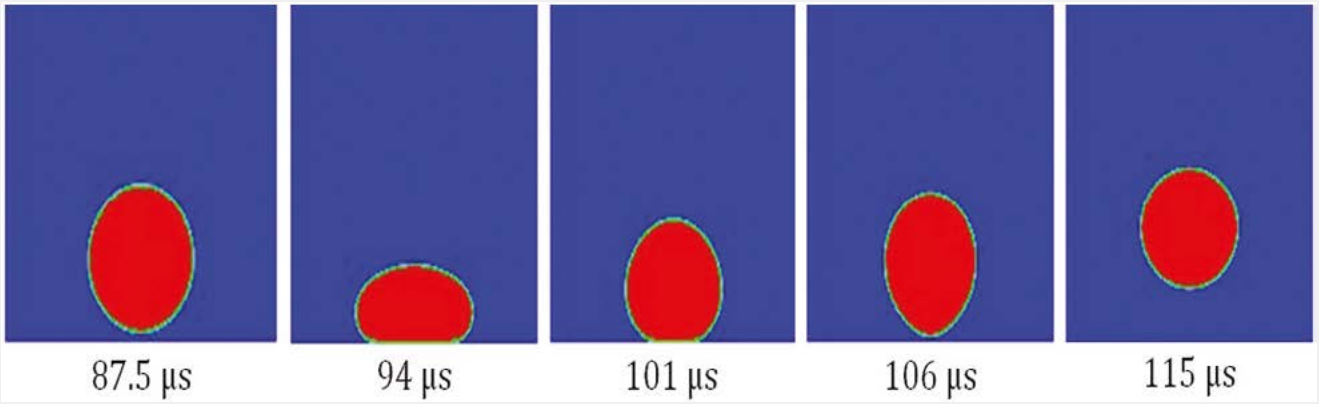


Figure 6: Landing of droplet on surface with contact angle 175˚

8. Micro/Nano scale manufacturing systems

Extensive experiments were carried on the developed electrohydrodynamic inkjet printing system to study the inkjet behaviour under various operating conditions. Effect of several operating parameters like applied voltage, stand-off height and printing speed on the droplet dimensions were studied using commercially available ink. The following figure shows the developed experimental set up. Design of experiments are used to carry out sufficient number of experiments to study the influence of parameters which affect the droplet diameter. Table 2 below shows the ANOVA table for finding the significant process parameters that impact the droplet diameter.

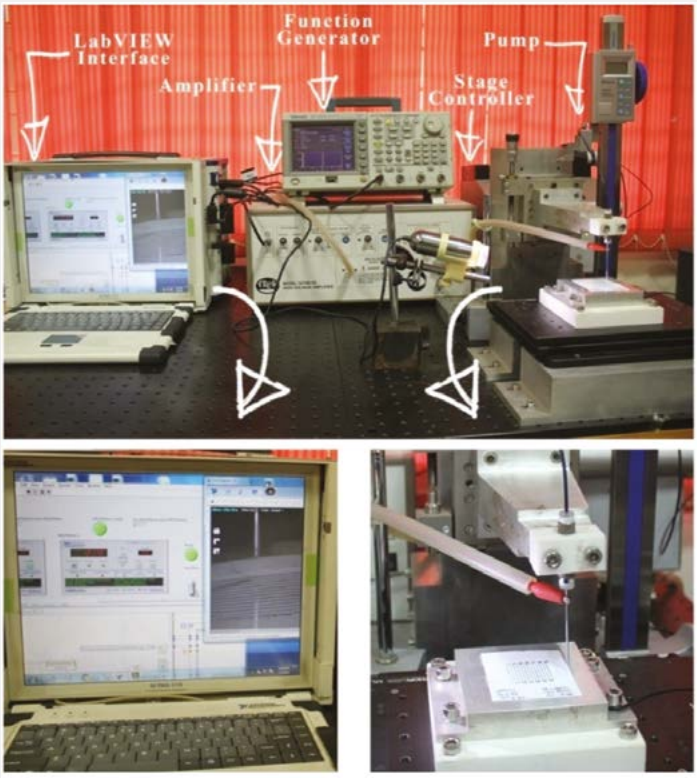


Figure 7: EHD Inkjet printing Experimental setup

Table 2: ANOVA table for finding significant Process parameter onto output droplet diameter

Factors	Degree of freedom (DOF)	Sum of Square (SS)	Variance	F value	P value	Percent of contribution (%)
A	2	249057	124529	82.43	0.000	26.56132
B	2	1032	516	0.34	0.720	0.11006
C	2	604549	302274	200.08	0.000	64.47367
AB	4	12764	3191	2.11	0.171	1.361249
AC	4	36083	9021	5.97	0.016	3.848164
BC	4	22097	5524	3.66	0.056	2.356591
Error	8	12086	1511			1.288942
Total	26	937668				100

Where

A->Standoff Height
B-> Applied Voltage
C-> Flow Rate
AB-> Interaction between Standoff Height and Applied Voltage
AC-> Interaction between Standoff Height and Flow Rate
BC-> Interaction between Applied Voltage and Flow Rate

9. Sensor Development

In the past decade the application of supramolecular chemistry in the domain of chemical sciences has attained immense significance on account of its diversity in the field of sensors, drug delivery, catalysis etc. This branch of chemistry particularly deals with the non-conventional mode of interaction towards selective identification of a targeted analyte in organic to aqueous medium by the host chemoreceptor. A very significant role is exhibited by the tailored host molecule towards the detection of the guest species. The development of a chemical sensor seems to be predestined in order to improvise the potentialities of chemical analysis.

Emphasis has been given towards detection of biologically ubiquitous and toxic analytes. Dr. Banerjee has successfully developed a sensor molecule that could detect salivary fluoride level with distinct colorimetric changes, i.e.; the diagnosis of dental fluorosis could be performed. The invention is unique. The technology has been patented and also transferred to a small scale industry unit. The sensor kit has already been deployed for common people in several fluorosis affected areas. Several NGOs from Northern India and southern India (Naandiwater, Hyderabad) has shown their interest to deploy the kit in their working area for quick prediction of dental fluorosis. This application would be of enormous impact for common people for getting fluoride free drinking water and would better the livelihood of our rural Indians.

In addition, the scientist is also engaged in detection of organic pollutant 2,4,6-trinitrophenol by chromogenic and fluorogenic pathway with the help of newly developed SOC (Schiff base organic chemosensor). The intracellular detection has also been performed in order to detect the contamination of this sort of mutagenic pollutant. A few interesting and novel organic molecular probes have also been synthesized at very low cost for detection of heavy & toxic cations such as Cu^{2+}, Hg^{2+}, As^{3+}, lethal anions like CN-, OAc- as well as neutral analytes like m-xylene (detected by luminescent MOF). Reversible spectroscopic responses of the sensor molecule towards different analytes have been monitored by fluorescence and UV-Vis spectroscopy. The outcome has been used for preparation of next generation molecular switch applicable in molecular electronics. Several urea, amide or Schiff base type molecules have been prepared for this purpose. Different logic function based circuitry have been designed.

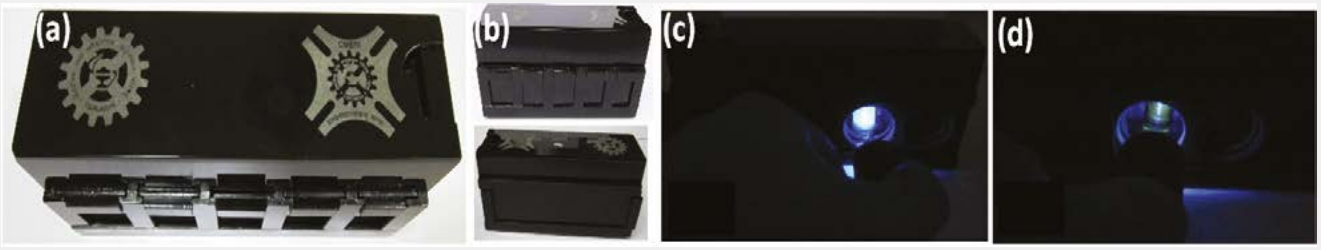


Figure 8: TNP detection prototype (a) top view and (b) front view (top) and rear view, (c) emission turn on for chemosensor and (d) emission turn off with TNP

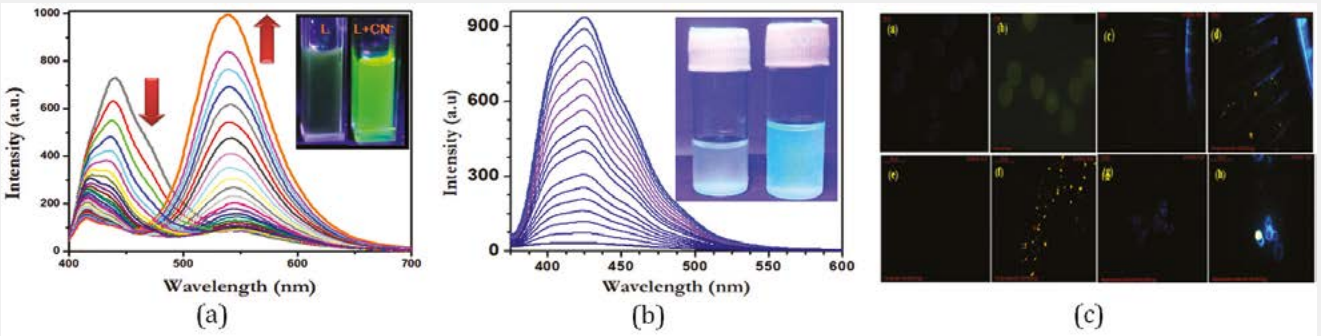


Figure 9: Fluorescence detection of (a) CN- by sensor molecule (b) m-xylene by luminescent MOF; (c) Intracellular detection of As(III) employing varying cell lines

10. Anticorrosive Coating Materials

In order to protect the metallic surfaces from the adverse environmental effects, various types of chromates, bisphenol based coating materials are widely used. Nevertheless, these coating materials leach out to the environment and cause adverse effects to 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.

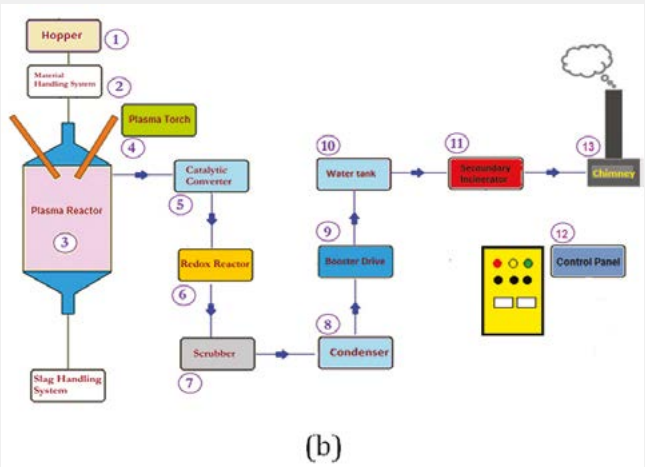
In view of the above, our intention is to develop an alternative path from where epoxy resin can be prepared from the non-toxic or less toxic starting precursors. Epoxy resin obtained from Schiff bases is non-toxic in nature. The presence of the –CH=N–Ar azomethine group in a resin macromolecule improves adhesion of the coating on a metal substrate and also increases its thermal stability.

Figure 10: Synthesis of Schiff base epoxy (SBE) from Schiff base (SB)

11. Safe disposal of Hospital waste by electric arc plasma

Amount of waste generated is increasing very significantly and spreading its adverse effect on environment and human health. Also, improper waste management methods are adding to this harmful effect. In this respect an eco-friendly and efficient technology is a bare minimum necessity. 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 by around 99% and produces less toxic residues within the standard values of central pollution control board. A mini plant with a capacity of 15kg/hr has been developed by CSIR-CMERI where three plasma torches are placed in the plasma reactor to crack these wastes and convert them to gas which goes through a closed system containing 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, following standard practices mentioned in Bio-Medical Waste Management Rules, 2016.

(a)



(b)

Figure 11: (a) A mini-plant for Hospital Waste Management developed by CSIR-CMERI (Capacity: 15kg/hr); (b) Schematic Diagram of HWM plant at CSIR-CMERI

12. Development of Technology for Safe Disposal of Municipal Solid Waste utilizing high temperature plasma

In the modern age environmental safety and concern regarding human health should be our chief priority. The generation and efficient management of solid

waste is unambiguously a prime concern. Therefore it is the urge of the century to create awareness among the people regarding the disposal of the solid waste generated and the necessity for its minimization. Ample methods are available for proper disposal and management of solid wastes. A mini-plant for Municipal Solid Waste Management has been developed by CSIR-CMERI (Capacity: 25 kg/hr).

13. Spilled oil cleaning material

Oil spill due accidents shades a major toxic impact over the environment. It is necessary clean up spilled oils and oil like toxic solvents using some adsorbents. Organic polymers are very useful as adsorbent material due to their hydrophobicity, non-toxicity, robust nature and eco-friendliness. Organic polymers can be synthesized easily and could be useful for oil or toxic solvents adsorption. There are several bio materials available in nature, generally treated as wastes, which can be used together with organic polymers in order to prepare composite materials. These adsorbent materials will be highly beneficial for adsorption of oils.

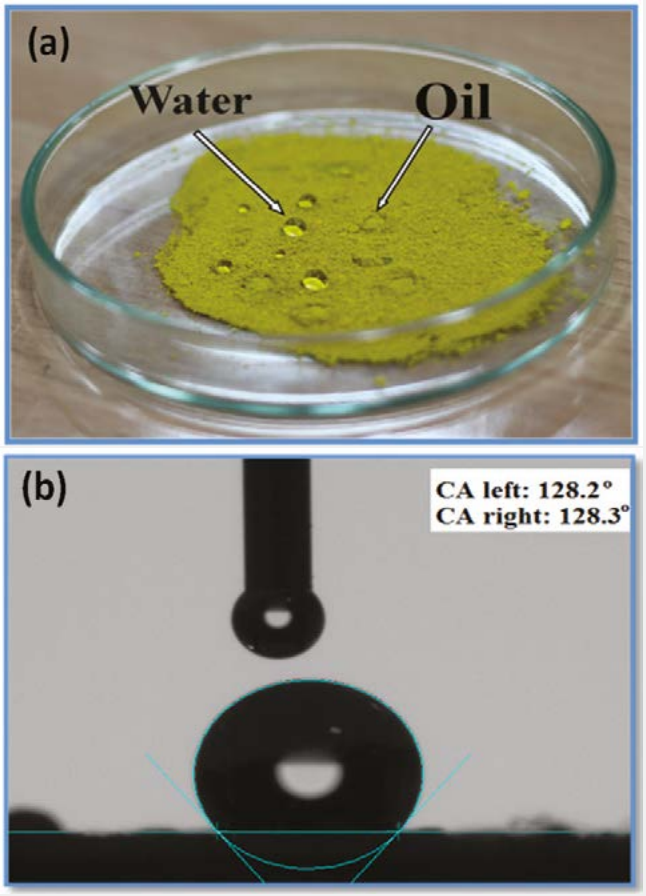


Figure 12: (a) Water and oil droplets over polymer (b) Contact angle of water over polymer coated glass surface

14. Design, Development and Implementation of Smart LED Street Lighting System

Presently, most of the cities, urban places and municipality areas in India use constant illumination lighting system (mostly vapour lamps) where all the street lights remain fully operational during the entire night. Due to inadequate dimming control technology and low efficiency, current street lighting is wasteful in terms of energy usage. This also lowers the lamps' life, causes significant light pollution and also accounts for a major part of governmental electricity costs.

Forecasts show that the energy spending for street lights is likely to increase over the next few years as the demand and price for electricity increase. Considering the above problems of conventional lighting methods, it has become desirable and of great importance to design a smart street lighting system which is efficient, cost effective and environmentally friendly. The Smart Street Lights Solution is considered to be an integral part of the government's recent initiatives of "Smart Cities Solutions". The deliverables include cost effective and energy efficient Smart Street lighting system that turns on the LEDs only when needed and remains in a dim state otherwise. The development consists of following major elements which are: motion detection sensors, wireless communication/networking and power control for the LEDs. The smart street lighting system has the following main features:

- automatic switch ON and OFF of the LEDs based on ambient light conditions
- identify the presence of pedestrians or vehicles to switch ON lights when they approach
- illumination control (dimming) of individual street lights during different time zones during night to attain maximum efficiency
- monitor and display additional parameters like temperature, humidity, light intensity level, ambient air quality etc.

Figure 13: Smart LED street lighting system

Technical Support & Services

1

ADVANCED MANUFACTURING CENTRE

CSIR-CMERI since its inception has been pursuing research in various fields of mechanical engineering and allied fields that include strategic, agricultural, mining, automobile, medical and societal sectors. Accordingly, various prototype machines, components and process plants are being developed at its Advanced Manufacturing Centre (AdMaC) and demonstrated. In many cases multiple prototypes are being manufactured for translational research and market seeding of the developed technologies. Besides the prototype manufacturing for in-house R&D activities, researchers have been pursuing research in the area of manufacturing technologies. The manufacturing facilities of AdMaC are being augmented and extended to outside agencies to fulfil their manufacturing needs.

Prototype manufacturing for in-house R&D activities

Efforts are made by the researchers to replace the conventionally steel cast digger teeth with that of cast Austempered Ductile Iron (ADI) digger teeth for their use in earth digging machines owing to the better wear resistance property and cheaper production cost of ADI material. Accordingly, around 14 nos of ADI digger teeth (Figure 1) manufactured at AdMaC have been fitted in the machines for field trials. Results of field trials are very encouraging. Finally, the technology of ADI digger teeth has been transferred to industry.

Mob Control Vehicle (MCV) is being developed in the institute. As per the design developed by the researchers, various components of different assemblies of the vehicle like, protective shields, mechanisms and frames etc. are manufactured/ fabricated and assembled to carry out testing of desired movements of front and back side protective shields using hydraulic force.

For effective communication between the competent authority and people, especially in rural areas, e-Kiosks (Figure 2) have been developed. Twelve such e-kiosks have been manufactured at AdMaC for deployment at various locations.

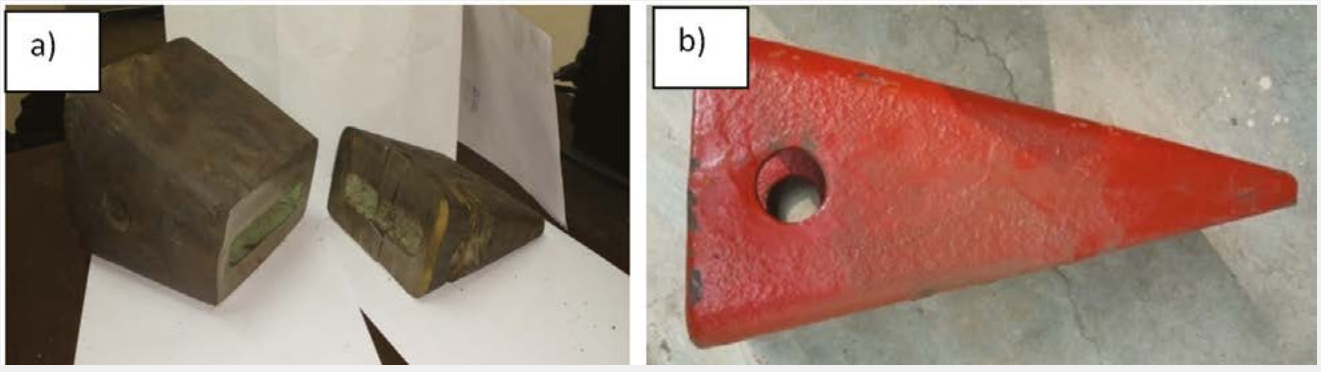


Figure 1: a) Cast digger teeth without any flaw, b) ADI digger teeth

Figure 2: e-Kiosk

To address the disposal of Municipal solid Waste (MSW), a system has been designed and developed consisting of segregation (bio-degradable and plastics) and handling unit, cleaning units, biomass generation and storage unit etc. by the researchers of the institute. Various components and subsystems of the above units such as cyclone separator, scrubber system, roller conveyors, hoppers etc. are manufactured at AdMaC (Figure 3).

Figure 3: a) Cyclone separator b) Scrubber

CSIR-CMERI has been continuously working for upliftment of the local economy of north-eastern states of India through technological intervention. Ginger is cultivated in large scale in the north-eastern region and therefore, washer, slicer and special dryers are developed for its processing in a mechanized way, so that farmers can be benefitted. Five sets of washers, slicers and dryers were manufactured in the previous years and six such dryers with improved design were also manufactured this year for north eastern states (Figure 4). Plywood is used as insulating material in manufacturing the dryers for maintaining proper temperature and other required parameters for ginger processing.

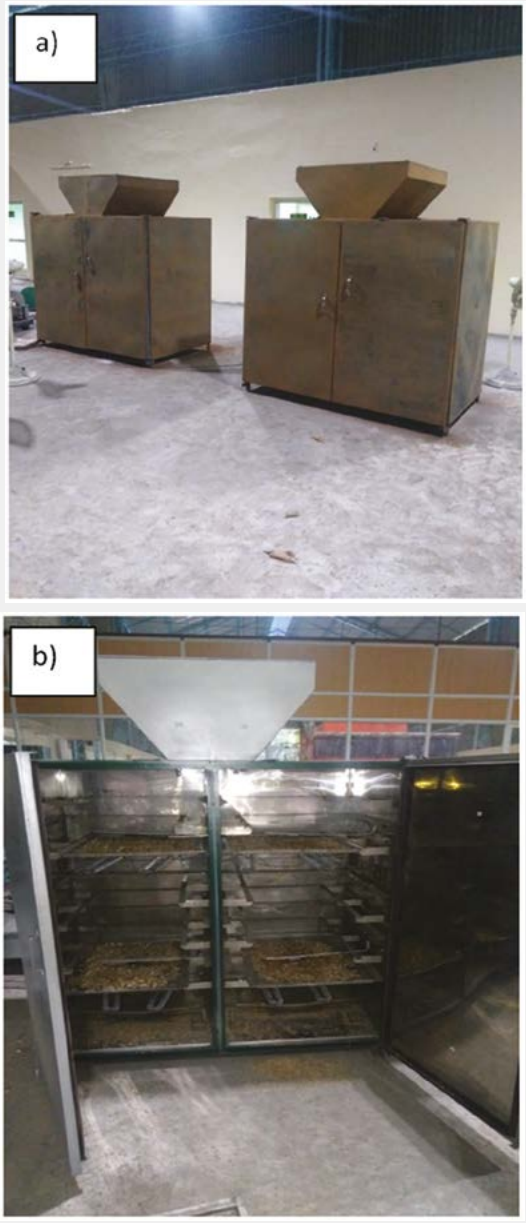


Figure 4: a) Ginger dryers b) Interior of the ginger dryer

R&D activities

Apart from prototype manufacturing, R&D activities related to manufacturing, especially near net-shape manufacturing are being carried out at AdMaC. These include melting-solidification, additive manufacturing, powder injection moulding and solar energy harvesting.

In the area of melting and casting, researchers at AdMaC have developed semi solid casting technology i.e. Rheo Pressure Die Casting (RPDC) for casting of aluminium alloy components with better mechanical properties by engineering its microstructure (globular instead of dendritic). With the sponsored project from Sona Koyo Steerings Ltd., Gurgaon, a valve housing of power steering system has been developed out of ADC12 aluminium alloy through the developed rheo pressure die casting process. The developed rheo pressure die cast valve housing is shown in Figure 5.

Similarly, in the project sponsored by Gas Turbine Research Establishment, Bangalore (A constituent lab of DRDO) the "Fuel Housing system" (of radiography Level-I) consisting of gear pump and metering unit is being developed out of A356 aluminium alloy which will be used to supply meter quantity of fuel in gas turbine engine. The project involves analysis of solidification using CFD, manufacturing of permanent mould, development of water soluble core to create intricate interconnected channels inside the casting and development of a low vacuum casting system. The Simulation of gear pump unit is shown in Figure 6. CAD model of the designed mould and core based on simulation results are shown in Figure 7.

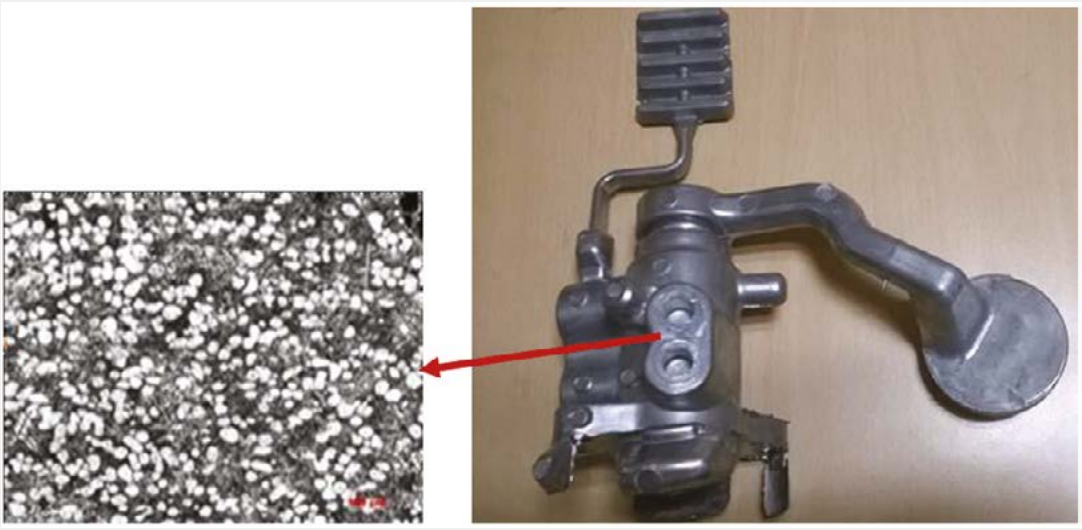


Figure 5: Rheo pressure die cast ADC12 valve housing

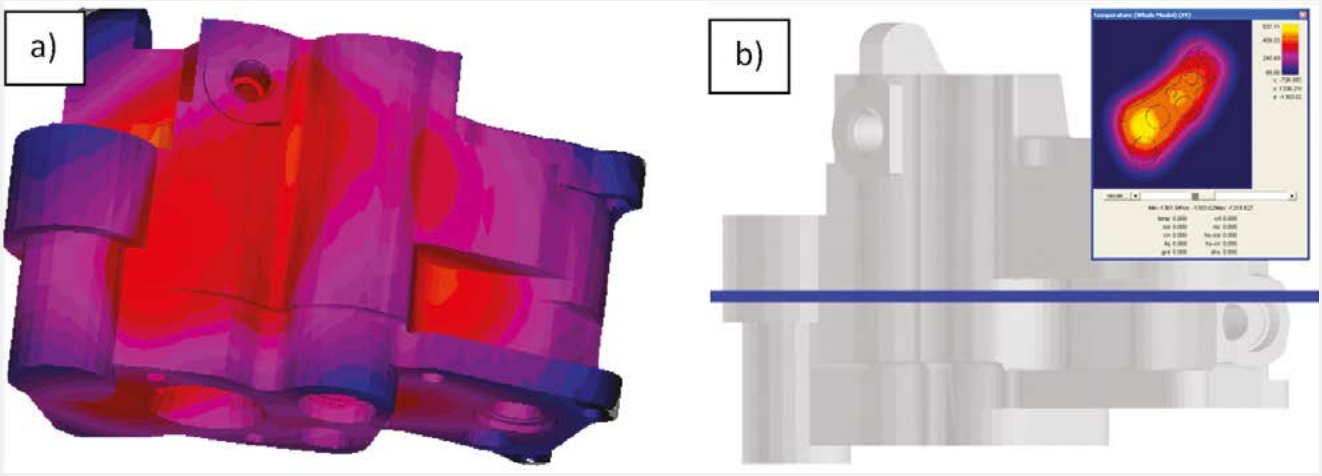


Figure 6: Temperature distribution (a) of the whole gear pump unit and (b) Sectional View

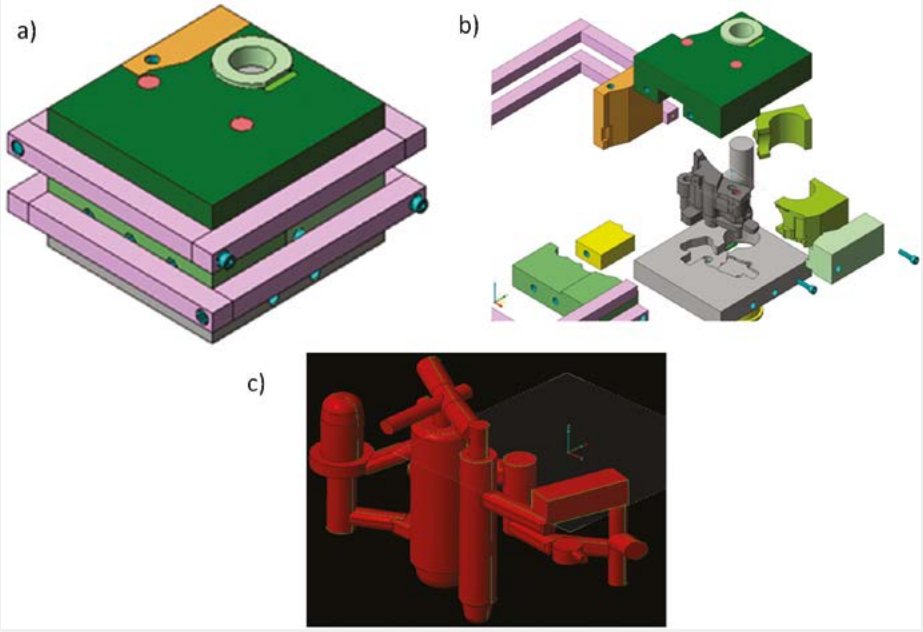


Figure 7: a) CAD model of the mould of gear pump unit, b) CAD model of various parts of the mould and c) CAD model of the core

In CSIR 12th Five Year Plan project, micro-Powder Injection Moulding (micro-PIM) laboratory was created and the micro-PIM process has been developed for economical manufacturing of micro components in large quantities out of metals and ceramics. The hard micro patterned (0.45 mm patterned height) tip of surgical forceps has been developed out of WC-Co alloy through micro-PIM to avoid the damage of the tip during repetitive use. The developed tip will be brazed with the stainless steel shank of the forceps. The developed micro patterned tip along with its mould is shown in Figure 8.

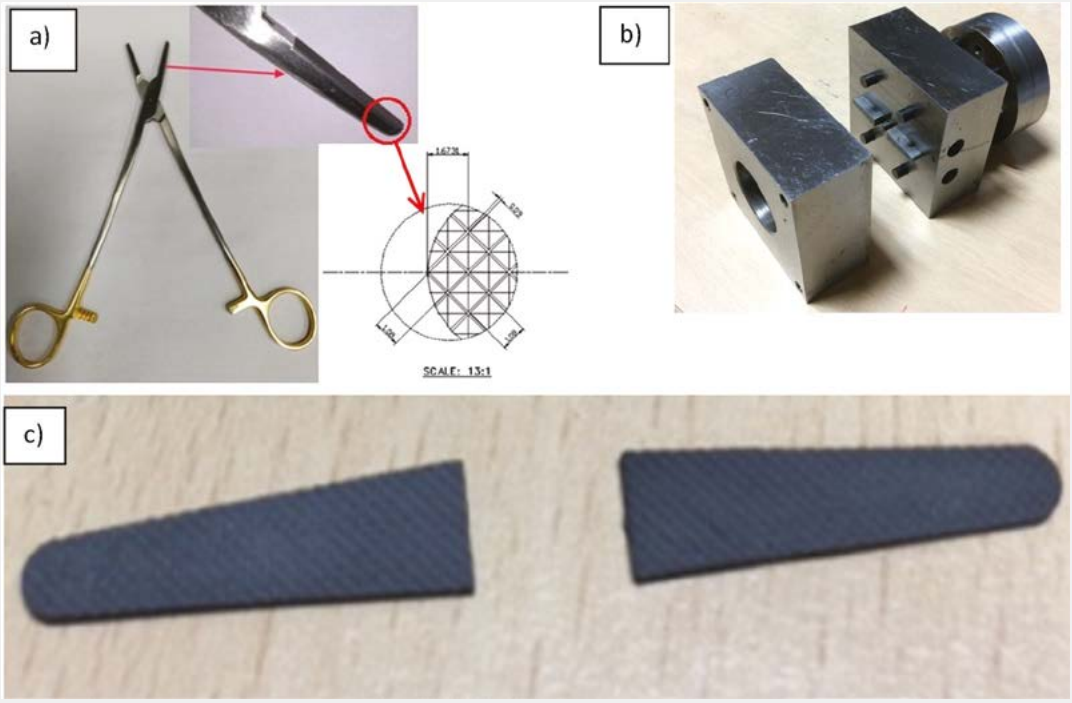


Figure 8: a) Surgical forceps with brazed tip, b) mould for micro patterned tip and c) Developed WC-Co micro patterned tip

In the area of additive manufacturing, a multi-metal deposition system was developed in the previous years under the CSIR 12th Five Year Plan project and DST sponsored project. Currently, components developed with various materials such as stainless steel, nickel etc. using the developed multi-metal deposition system are being characterized in regard to their dimensional accuracy, surface finish and mechanical properties.

In regard to solar energy harvesting, various designs of solar artifacts are being manufactured at AdMaC. As a value addition, a surveilance system (camera) has been added with the solar artifacts for effective surveillance of the area. The solar artifacts installed at CSIR-CIMFR, Dhanbad with surveillance system has been shown in Figure 9a. A novel rain water proof solar roof has also been developed and installed in the MSW site of the CSIR-CMERI colony which is shown in Figure 9b. The solar roof can be used as a normal roof which generates electricity from solar energy.

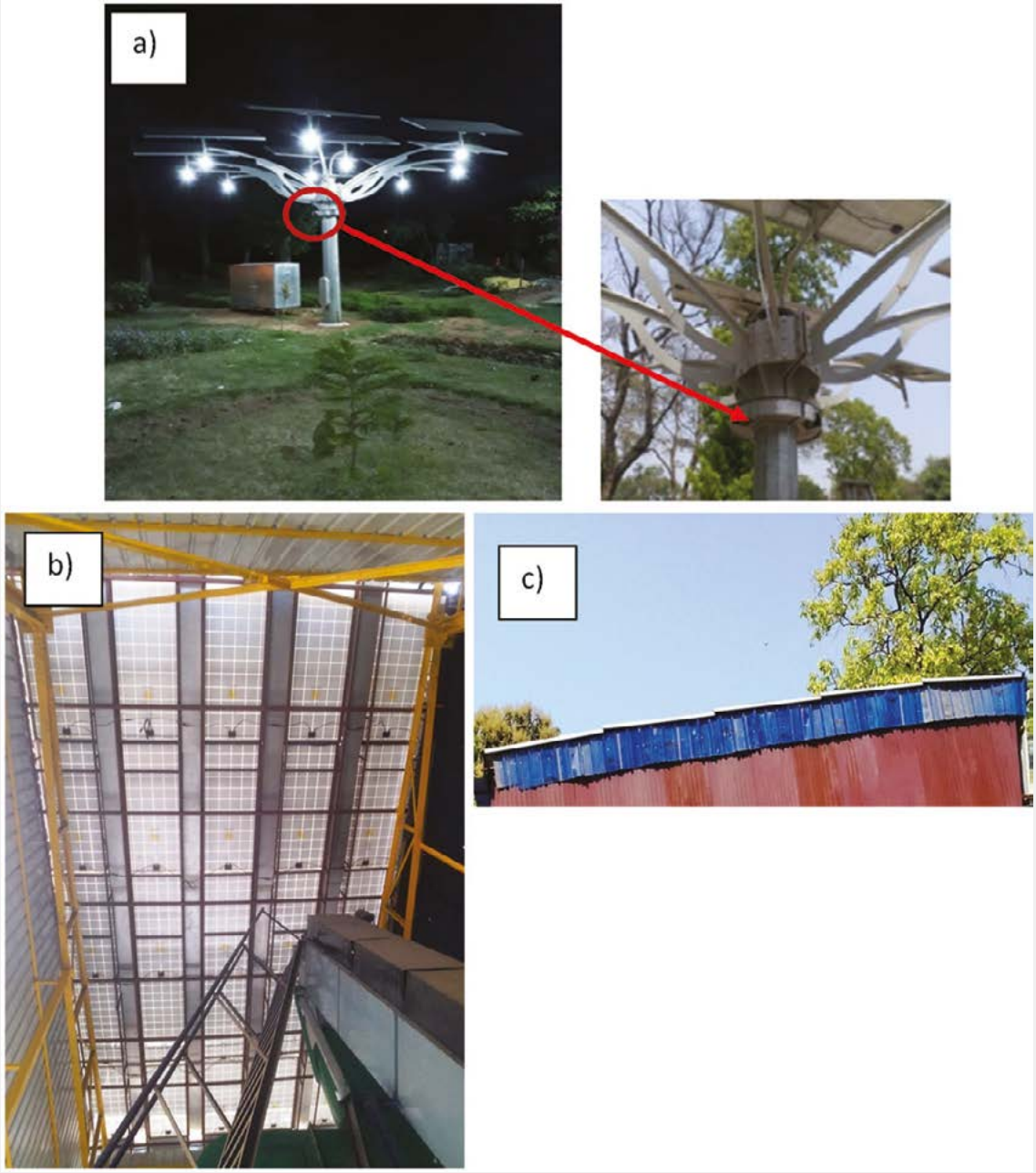


Figure 9: a) Solar artifact with surveillance system, b) Solar roof (view from ground floor) and c) solar roof (side view)

New equipment added to the existing manufacturing facility

To expedite the prototype manufacturing activities, the facility of AdMaC is being augmented in the area of sheet metal fabrication, machining, melting and casting. This year, the CNC Plasma Arc cutting machine, CNC EDM and Powder coating facilities have been commissioned as shown in Figure 10.

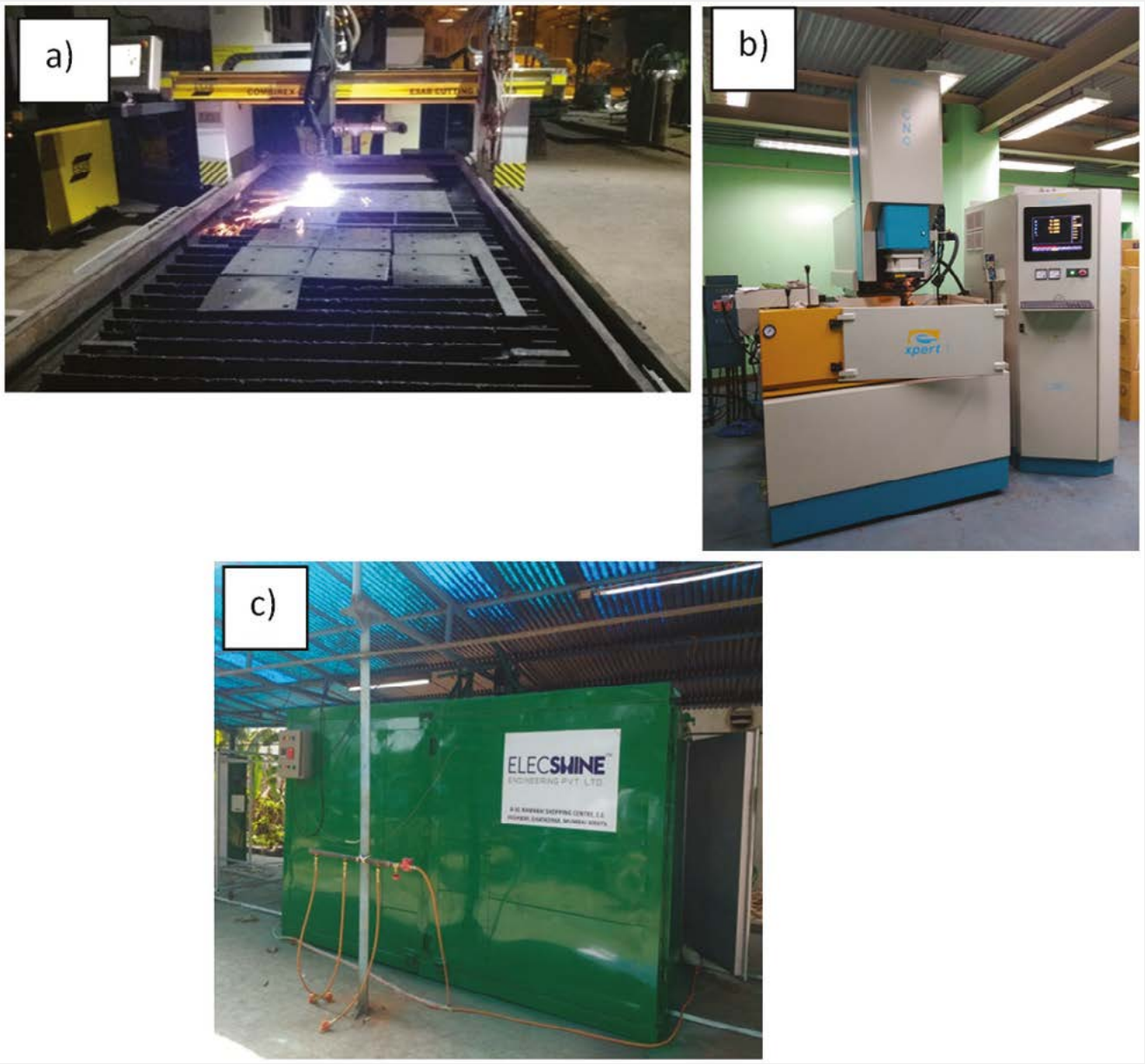


Figure 10: a) CNC Plasma Arc Cutting machine, b) CNC EDM and c) Powder coating facility

2

CENTRAL CAD FACILITY

The Central CAD Facility (CCADF) is one of the technical service groups of CSIR-CMERI. The group serves the following technical activities for various R&D departments of CSIR-CMERI and outside agencies.

1. Solid modeling & dimension, tolerance and functional analysis for any kind of mechanical systems.
2. Design and preparation of manufacturing drawing.
3. Development of drawing of any physical component/part.
4. Delivering technical training under skill development programme.

Besides serving the above technical activities, the group is also implementing various industrial and research projects, conducting academic projects for MTech and PhD students.

The group has the following recent activities:

- development of manufacturing drawings and CAD modelling for solar tree, fuel housing system of gas turbine engine, plasma Gasifier, different nozzles, welding fixture, multi-material deposition system, scrubber, cover for biomethanation etc.
- design and development of small tractor operated hay baler machine.
- design and development of semi-mechanized prototype for makhana processing machine.

R&D Projects:

1. Design and development of small tractor operated hay baler machine (OLP 211512)

A laboratory level working prototype of a small round hay baler of the following specification is developed under this project

Baler Specifications:

Diameter: 400 mm

Length: 450mm

Weight: 10-15 Kgs

Power source: Tractor Driven (12 HP and above)

Operation: Fully mechanical

The machine is operating under the working principle demonstrated in Figure 1. The photograph of the prototype and baled hay produced by this machine are presented in Figure 2 and Figure 3, respectively.

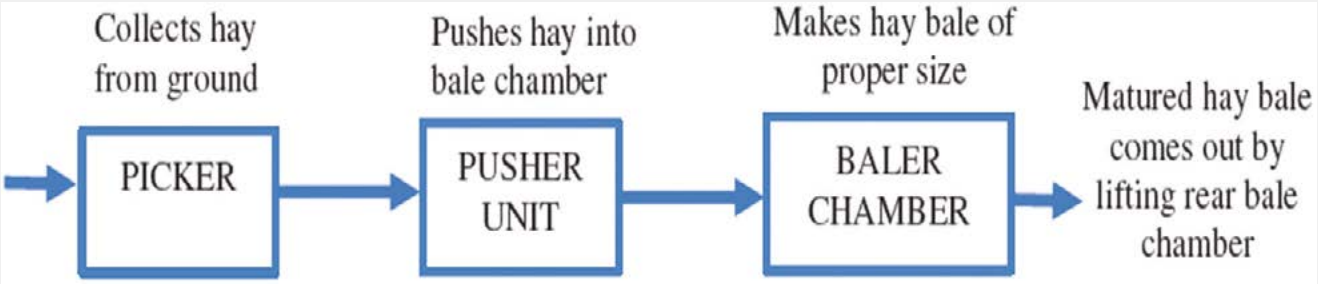


Figure 1: Flow diagram of hay baler working principle

Figure 2: Photograph of hay baler prototype

Figure 3: Photograph of baled hay

This machine is useful for the farmers who normally burn the crop residues in order to cultivate the next crops in the same field within a short time. Burning of hay causes enormous air pollution with particles and poisonous gases. Such scenario of air pollution has been observed often in Punjab, Hariyana and Delhi. In addition to causing air pollution, it may cause a significant shortage of forage. Instead of burning, agricultural waste material can be used for production of bio-gas.

2. Design and development of semi-mechanized prototype for makhana processing machine (SS221312)

This project is sponsored by Directorate of Micro, Small & Medium Enterprises, Malda, Government of West Bengal. In this project a small semi-mechanized machined is going to be developed for popping makhanna. Figure 4 presents a solid model of the proposed machine.

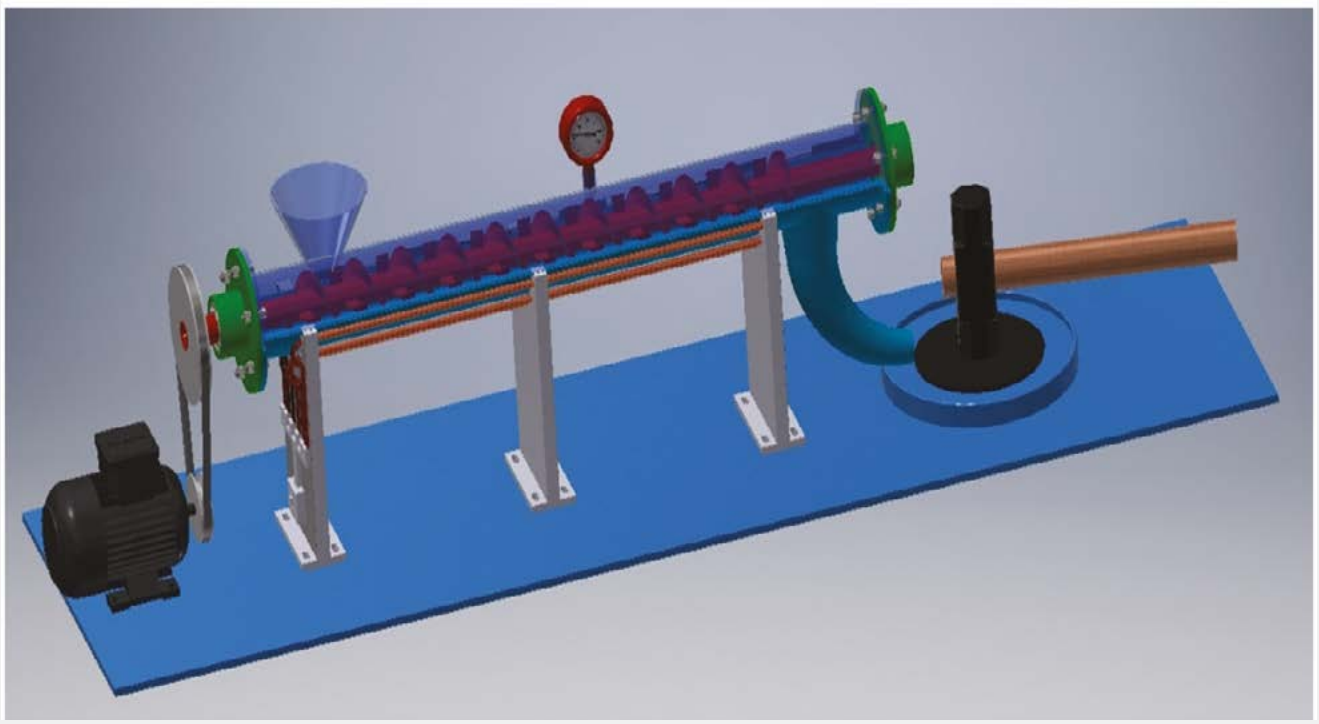


Figure 4: Solid model of semi-mechanized makhana processing machine

Training

The group has an excellent classroom for training. Presently the group is offering a short term training course on "Understanding and preparation of manufacturing drawing using CAD system".

Photograph of classroom

Course objectives

- Develop the ability to communicate with others through the language of technical drawing and sketching
- Develop the ability to read and interpret engineering drawings
- Use of international standards for drafting
- Develop an understanding of 2D and 3D computer aided drafting

Key learning of the course

- Concepts of Engineering Drawings (basic concept, projection methods, sectioning, dimensioning, etc.)
- Understanding of various drawing symbols, fits and tolerances, drawing features etc. required for mechanical system design
- Understanding and selection of various standard mechanical items such as fasteners, bearings, gears, sprocket-chain, belt-pulley, etc.
- Conventional practices for preparation of assembly and part drawings for mechanical systems as per Indian Standard
- Geometric dimension and tolerance
- Use of conventional measuring instruments for engineering metrology
- A basic learning of computer for operating CAD software
- Preparation of drawing using CAD software with hands-on practices

Academic projects

Various recent academic projects conducted in this group are as follows:

- Formulation of a generic methodology for rock mass classification: Analytical & ANN approaches (MTech thesis, Completed)
- Multi-objective based Energy management in electrical vehicle: Design of an optimal driving strategy using Evolutionary Algorithms (PhD thesis, AcSIR Enrollment No.- 20EE13A12007, Thesis submitted)
- Optimal driving based trip planning of electric vehicles using evolutionary algorithms: A driver assistance system (PhD thesis, AcSIR Enrollment Number: 20EE17J12001, Ongoing)
- Machine Learning Inspired Methodology for Assessment of Grasp Ability of Stroke Survivors (PhD thesis, AcSIR Enrollment No: 20EE16A12001, Ongoing)

3

CONDITION MONITORING & STRUCTURAL ANALYSIS GROUP

In an ever increasing global competition involving fast technological changes and customer awareness towards quality, reliability and safety, managing industries in the 21st century is a challenging task. With its four-decade experience, the Condition Monitoring & Structural Analysis (CMSA) Group of CSIR-CMERI extends its expert services to the Indian industry to solve its various problems in the field of mechanical vibration, noise and structural analysis.

Ever since its inception, CMSA Group has been providing commendable services to the nation by identifying the origins and locations of faults in industrial machinery and structural components and eliminating them by appropriate engineering procedures. It has also developed innovative abilities to provide appropriate solutions for a range of industrial problems (including those of the strategic and power sectors). Some of the details of the ongoing activities in technical services and research for sponsored projects in fulfilling the need of the industries are presented here.

1. Condition Monitoring Services

Plant and machinery are expensive assets, designed to operate under harsh conditions. A failure can be catastrophic both in terms of safety and economic aspects. A great amount of savings in energy and production cost can be achieved by applying Condition Monitoring methods for safe and satisfactory operation and performance of industrial machinery.

Two options may be considered in operating plant and machinery.

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

Both techniques have been adopted by the CMSA Group of CSIR-CMERI to provide its services to the industries. 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.

(i) Achieving maximum reliability of a Cooling Water (C.W.) pump by proper condition Monitoring (sponsored by MTPS, DVC, Mejia and by CTPS, DVC, Chandrapura)

The Cooling Water (CW) pump, a critical component of thermal power stations, needs regular monitoring and occasional balancing for smooth, reliable and safe performance of the entire plant. Severe vibration problems in these pumps, that could lead to catastrophic failures (due to breakage/crack of impeller, pump shaft, ratchet pinion, etc.) need to be rectified, often on an emergency basis.

The CMSA Group had taken up condition monitoring of seventeen such CW Pumps (Figure 1) at MTPS, DVC, Mejia and five CW Pumps at CTPS, DVC, Chandrapura. Through vibration monitoring (diagnosing misalignment, unbalance, looseness, cracks etc. in running condition) and mass balancing techniques, these pumps were made to run smoothly and safely, thereby preventing catastrophic failures of such expensive industrial equipment.

Figure 1: Condition Monitoring of C.W. Pumps at MTPS & CTPS, DVC

(ii) Vibration Analysis and Dynamic Balancing of MMV Fan (sponsored by M/s. Eastern Coalfield Limited (ECL)

Ventilation Fans are important equipment in coal mines, providing continuous air flow to the underground mines to remove dust, noxious gases (typically NO_x, SO_2, methane, CO_2 and CO) and to regulate the ambient temperature and humidity. Proper functioning and maintenance are essential for smooth production of coal. Periodic monitoring and necessary in-position balancing may reduce the overall down time and increase the production.

The methodologies of the work adopted by the CMSA Group involve:

- Collection of vibration data at various bearing points.
- Fault diagnosis by vibration analysis and suggestions for preventive action.
- Balancing mass preparation, fixation & calculation during in-position dynamic balancing, whenever required.
- Test report preparation after completion of site work.

The equipment components employed for the purpose are shown in Figure 2.

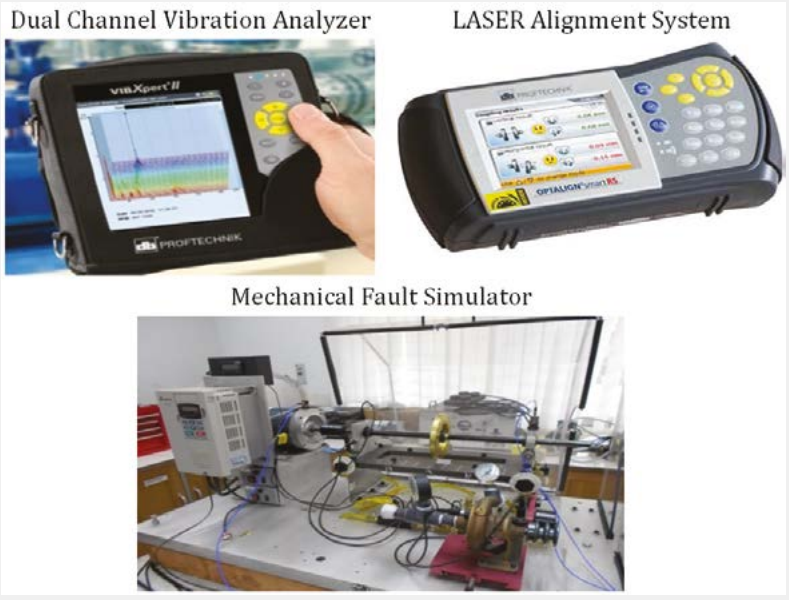


Figure 2: Equipment and facilities of the CMSA Group

2. Sponsored Projects from Industry

(i) Investigation of large amplitude vibration observed in Nose Landing Gear of LCA-TEJAS and Similar Aircraft

ADA scientists and pilots of the indigenously developed LCA-Tejas aircraft have observed sudden bouts of uncomfortable, large amplitude oscillations of its Nose Landing Gear (NLG) during take-off, landing and taxiing at subcritical velocities (Figure 3).

In January 2016, the CMSA Group had taken up the project for performing an investigative study of the dynamics of the NLG of LCA-Tejas. Linear dynamic analysis with low order models (of 3 and 5 DOF) showed that the nose landing gear structure is stable at the actual taxiing speeds.

An improved mathematical model (6DOF) for the NLG, with nonlinear dynamics formulation was developed by the CMSA Group scientists. Improved analysis with the sophisticated mathematical model revealed that nonlinear effects (from free-play and nonlinear damping) are primarily responsible for the observed large amplitude oscillations in a certain range of subcritical taxiing speeds. This project was successfully completed in May 2017. A project completion report along with the MATLAB code developed for the analysis was submitted to ADA in January 2018.

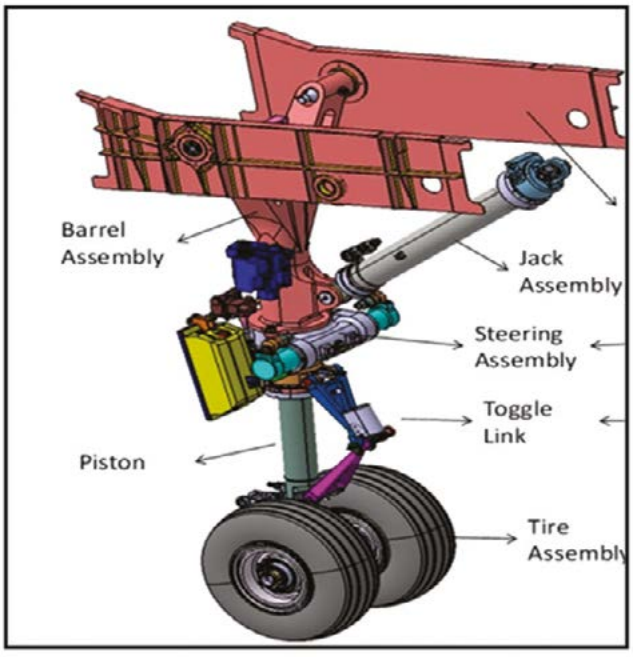


Figure 3: The LCA-TEJAS aircraft and its nose landing gear

(ii) Finite Element Analysis Based Design of Lightweight High Pressure Hydrogen Storage Composite Cylinder for Vehicular Applications

Hydrogen storage within a given space on-board a vehicle under high operating pressure for vehicular applications is a challenging task. To obtain efficient storage capacity and to reduce fuel consumption, efforts are being developed to manufacture composite cylinders or tanks made of much lighter weight materials than steel, and which allow us to store hydrogen up to a pressure of 700 bar.

Sponsored by MNRE, New Delhi, the project has successfully performed analysis-based designs of light-weight hydrogen storage composite cylinders (Type-III as well as Type-IV) of specified capacities for vehicular applications using fully-wrapped carbon or glass fiber reinforced composites. An object-oriented computer code in C++ was also developed for calculation of design data using analytical model based on composite shell theory and optimal fiber path algorithm. Structural design and finite element stress analysis of the overwrapped composite cylinders were performed using both shell and 3D finite element formulations. The formulations involved correct modeling of the mechanical properties of composite materials, non-linear material behavior of metal liner, calculation of autofrettage pressure and stress levels at working pressure, test pressure and minimum burst pressure conditions. A typical Type IV cylinder of internal volume as 60 litres, working pressure 700 bar and inner diameter 320 mm is depicted in Figure 4. Hydrogen storage density of this cylinder was calculated to be 5.3 (wt%) which meets the 2015 target of 5.2 (wt%) specified by DOE, US.

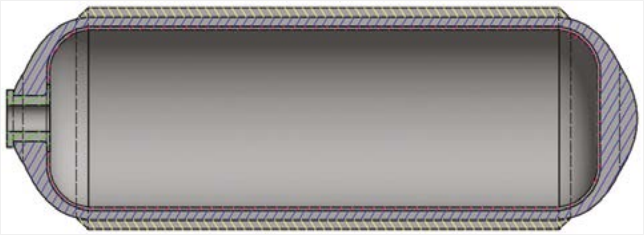


Figure 4: A typical CAD drawing for a Type IV cylinder

(iii) Condition Assessment, Study and Suggesting Remedial Measures to Minimize Vibration at Structure CF6 of Paper Manufacturing Unit

Mechanical equipment associated with structural supports, building systems and industrial processes is often the major source of noise and vibration in a building or a plant. In several cases, it is necessary to undertake assessment of such excessive vibration levels and to recommend remedial measures for their reduction during the useful life of the building or the plant. This project (sponsored by M/s. Bagalamukhi Industries Pvt. Ltd., ADDA Industrial Plot, Durgapur) investigated the use of external steel bracing for a reinforced concrete machine support structure of a paper manufacturing plant as a remedial measure to avoid severe vibration (of resonance type) occurring during a particular range of paper speed. Vibration measurement of the machinery was undertaken and natural frequency of the concrete structure was estimated using finite element modeling. This was followed by selection of proper configuration of external steel bracing (Figure 5) in order to strengthen and stiffen the structure for lateral forces. This measure had resulted in a shift of the natural frequency away from the operating range of excitation, so that resonance could be avoided. The increase in natural frequency (from 10 Hz to 20 Hz approximately) of the strengthened structure was also assessed using finite element modeling.

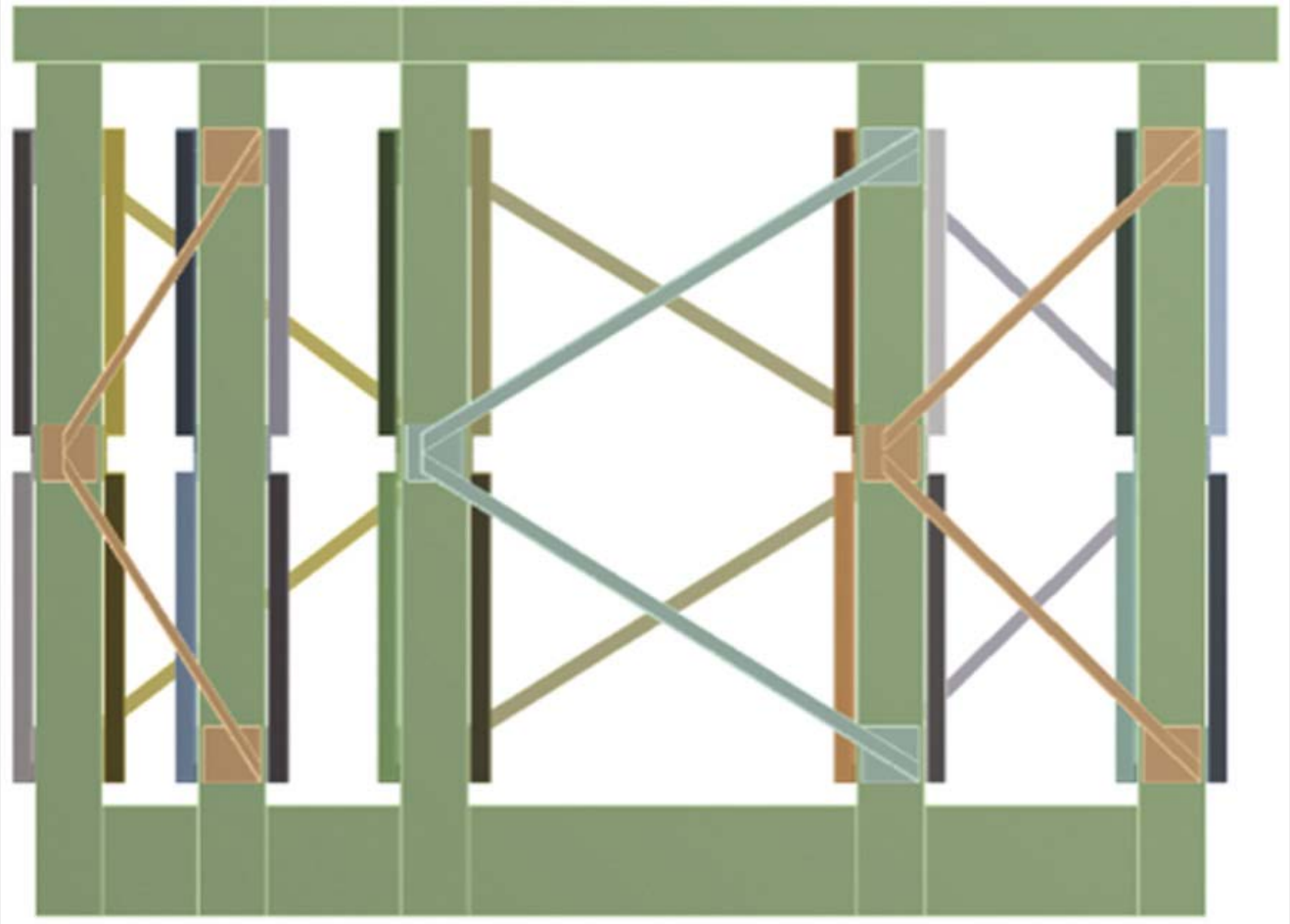


Figure 5: Modified structure with K-type external bracing

(iv) Stress Analysis and Fatigue Life Estimation of Railway Wheel Under Combined Mechanical and Thermal Loads Using Finite Element Method

The current move towards higher train speeds has created a demand for a deeper knowledge in the field of wheel design. The stresses experienced by railway wheels during service are due to mechanical and thermal loads. Mechanical stress fields are created by rolling contact loads in rail-wheel contact region. Thermal stresses are usually created as a result of frictional heating produced between wheel and brake block during braking process (in case of drag braking) and also as a result of the occurrence of slip between wheel and rail at the braking stage. An accurate assessment of mechanical and thermomechanical behaviour of wheel is necessary in order to determine the stress fields (von-Mises stress) created by mechanical and thermal loads during operating conditions.

This project (sponsored by Durgapur Steel Plant) dealt with Finite Element (FE) analysis for assessment of mechanical behavior and thermomechanical behavior of LHB solid forged railway wheel designed for an axle load of 18T provided with disc brakes for a maximum speed of 200 kmph. Assessment of Mechanical behavior was performed on both new and worn conditions of the subject wheel under different loading conditions as per EN and UIC specifications and stress results (von Mises stress, range of dynamic stress, etc.) were obtained. 3D FE analysis was also carried out for temperature distribution assessment in disc brake system as well as at the rail wheel interface during braking. A few results are depicted in Figures 6 and 7.

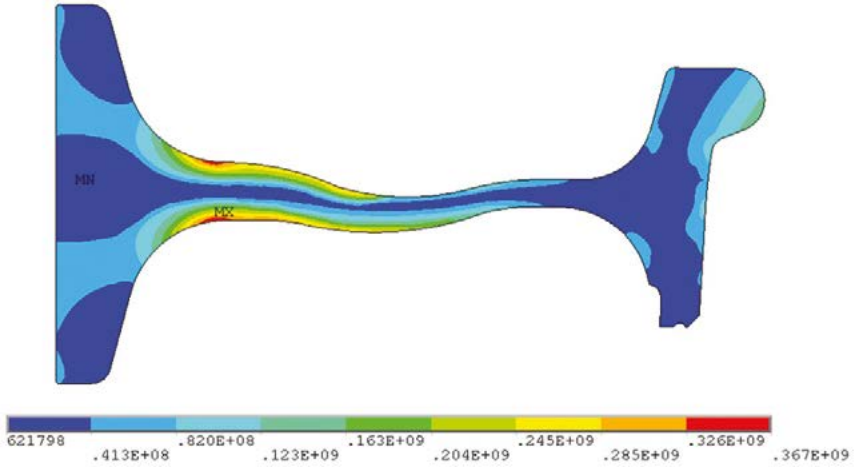


Figure 6: Dynamic stress for fatigue analysis of a worn-out wheel

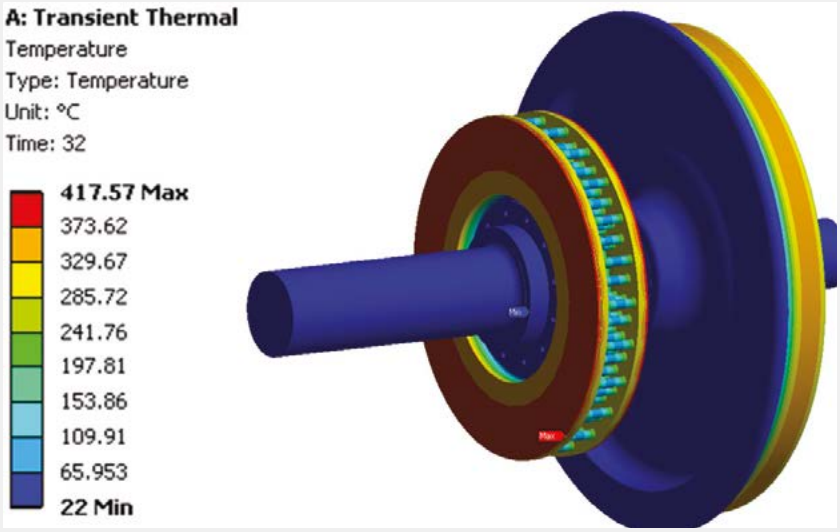


Figure 7: Temperature distribution at the time of maximum disc temperature (at time 32 s) in the disc-axle-wheel assembly incorporating disc made of cast iron

4

INFORMATION TECHNOLOGY GROUP

1. Piezoelectric Actuator System for Automotive Translation Systems (PASATS)

Sponsored by: Indo French Centre for The Promotion of Advanced Research, DST

Indian Collaborator: CSIR-Central Mechanical Engineering Research Institute

French Collaborator: Group of electrical engineering, Paris, GeePs

Industrial Collaborator: Faurecia Automotive Seatings, FAS

Introduction

Inchworms are one of the good examples of animals that present an exceptional functional locomotion system. The project involves operating an Inchworm Motor (IM) in order to realize Automotive Seat Motion. The technology is inspired from a real inchworm motion and is based on Piezoelectric Actuators (PAs). The motor consists of an Extending Mechanism (EM) and two Clamping Mechanisms (CMs). The CM is designed in order to obtain high clamping forces between rotor and stator, while the EM is designed for a large displacement and high force using multi-stack PAs.

The objective of this work is to develop an IM that can provide high clamping forces, large loads and displacement with high resolution. In addition, the IM must ensure full clamping abilities when not activated (self-locking at rest). The proposed IM design is given in Figure 1. The motor contains a stator (fixed part) and a rotor (moving part). The rotor includes two CMs and an extender. The clamps apply a force on the rail through a screw equipped with a clamping washer and a spring. Three PAs are implemented in the IM, w hose pre-tightening elements consist of two pre-tightening blocks for each actuator and screw. The connection between CM and EM is provided by screws. The stator has a T-shape that prevents the rotor from derailing.

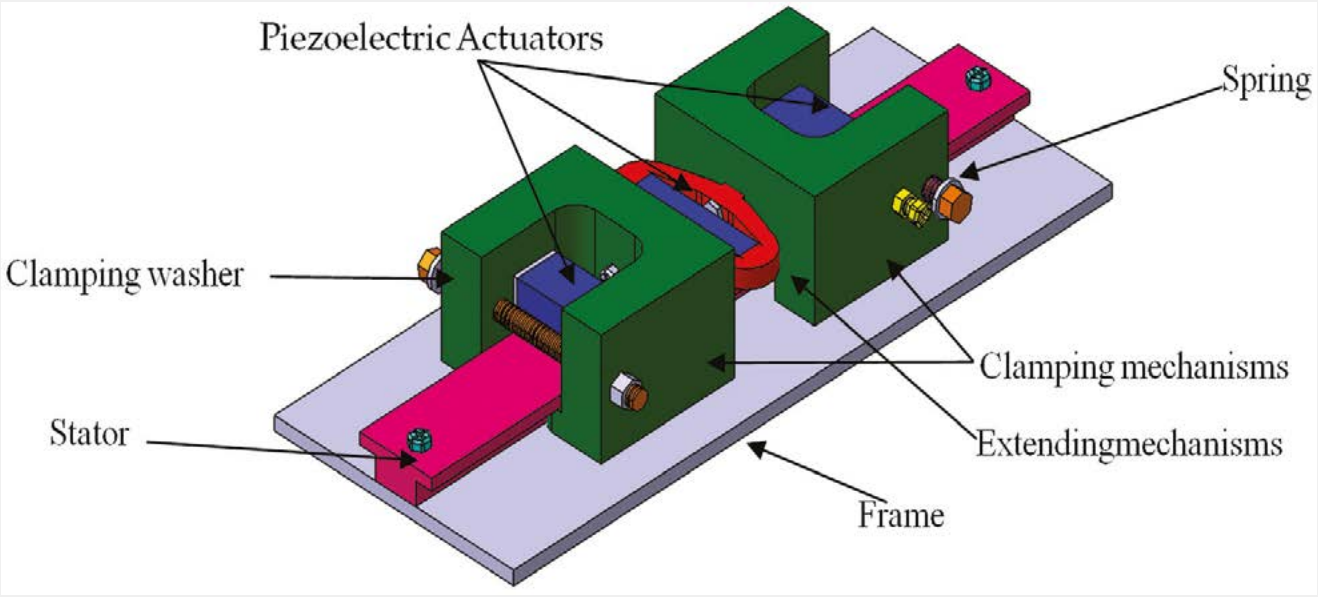


Figure 1: Schematic design of proposed inchworm motor

Operating principle

The inchworm technique is based on the concept of incrementally summing the relatively small displacements produced by piezoceramic elements to generate large displacements. As shown in Figure 2, a typical inchworm type linear motor has three major components, two clamping mechanisms (referred to as clamp A and clamp B) and an extending mechanism. During the part of a typical inchworm cycle, only one clamping device is to be activated at a time, this allows the extender to extend and retract freely. The clamping mechanisms are normally designed for the purpose of creating a frictional force that can withstand static forces produced by a constant load and dynamic forces produced by the extending mechanism. The purpose of the extending mechanism is to generate the small displacements in which the inchworm technique sums to produce a large displacement. Figure 2 demonstrates one full cycle of a typical incremental motor in the forward direction. At the beginning of the motion, both clamps (clamp A and clamp B) are clamped and no signal has been sent to the extender mechanism. This scenario describes a stopped motor that could possibly be holding a load stationary.

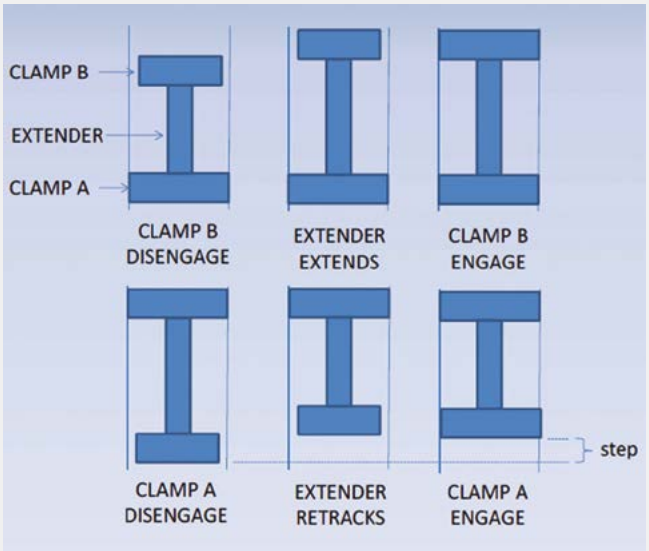


Figure 2: Schematic of inchworm concept

Extending Mechanism

The EM controls the speed and the driving force of the motor. For applications requiring longer step motions in extending or contracting mode an amplified PA is required. Figure 3 shows simulation results of displacement distribution in response to a PA force of 1150 N along X-axis. When one of the two clamps is blocked on the stator, a displacement of ±10 µm along X-axis induces a displacement of 30 µm according to Y-axis. As a result, a driving force of 515 N is produced (i.e. peak to peak amplitude of 1030 N).

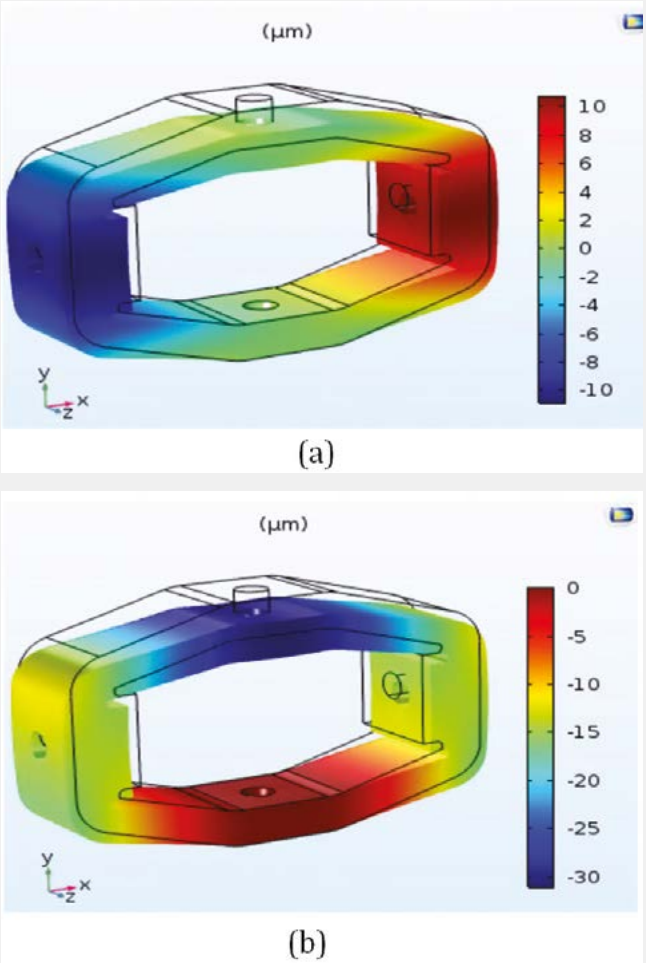


Figure 3: Deformation distribution in the extending mode according to : (a) X-axis, (b) Y-axis

Mathematical Modelling of the Inchworm Motor

The inchworm technique is based on the simple concept of incrementally summing the relatively small displacements produced by piezoceramic elements to generate large displacements as reported above (Operating principle).

The equations of motions of the Inchworm motor have been finalised, stated below:

$$M1\ddot{X1} = -\left(\frac{K_{comp}\cdot K_{e_{pzt}}\cdot L1^2}{2K_{e_{pzt}}\cdot L1^2+K_{comp}\cdot L2^2}\right)(X1-X2)-C_{act}\left(\dot{X1}-\dot{X2}\right)+F_{break1}-\left(\frac{K_{comp}\cdot K_{v_{pzt}}\cdot L1\cdot L2}{2K_{e_{pzt}}\cdot L1^2+K_{comp}\cdot L2^2}\right)V_{max\_act} \quad (1)$$

$$M2\ddot{X2} = \left(\frac{K_{comp}\cdot K_{e_{pzt}}\cdot L1^2}{2K_{e_{pzt}}\cdot L1^2+K_{comp}\cdot L2^2}\right)(X1-X2)+C_{act}\left(\dot{X1}-\dot{X2}\right)+F_{break2}+\left(\frac{K_{comp}\cdot K_{v_{pzt}}\cdot L1\cdot L2}{2K_{e_{pzt}}\cdot L1^2+K_{comp}\cdot L2^2}\right)V_{max\_act}-m.g \quad (2)$$

$$k_{e_{pzt}} = \frac{F_{block\_act}\cdot L2}{(D_{max\ act}/L2)} \quad (3)$$

$$k_{v_{pzt}} = \frac{F_{block\_act}\cdot L2}{V_{max\ act}} \quad (4)$$

$$K_{comp} = \frac{2}{\left(\frac{1}{k_{act}}-\frac{L2^2}{k_{e_{pzt}}}\right)} \quad (5)$$

The following parameter values have been assumed to verify the motion principality

Parameters	Value
Static coefficient of friction (mus)	0.8
Dynamic coefficient of friction (mud)	0.4
Load (m)	22.679 Kg (50 pound)
Blocking force of brake actuators (F_{block_brake})	3500 N
Blocking force of compliant amplifier (F_{block_act})	1400 N
Maximum input voltage of brake actuator (V_{max_Brake})	150 Volt
Maximum input voltage of compliant amplifier (V_{max_act})	180 Volt
Maximum displacement of brake actuator	79 x 10^{-6} meter
Maximum displacement of compliant amplifier (D_{max_act})	150 x 10^{-6} meter
Stiffness of compliant amplifier (K_{act})	11.7 x 10^{-6} N/meter
Damping co-efficient of compliant amplifier (C_{act})	90 Kg/Sec
Mass of brake1 (M1)	0.4705 Kg
Mass of brake2 (M2)	0.4855 Kg
Gain of complaint structure (L2/L1)	3

Controller of Inchworm Motor

Inchworm motor (IWM) consists of three mechanisms working together to produce the inchworm motion. It requires three electrical signals to drive each of the three mechanisms. The phases between these signals are very important to produce inch worm motion as described below. Typical signals are shown in figure 4 which shows the relative timing between them. Each of the control signals requires conditioning and amplification to drive the piezo actuators. Application of appropriate control strategy plays an important role on the performance of IWM.

Voltage control strategies are mostly used to operate piezo actuators. In open loop operation, piezo actuators show a hysteresis nonlinearity between displacement and voltage applied to the actuator and this effect increases with increase in applied voltage as well as frequency of operation. The hysteresis effect can be minimized by designing appropriate control system. Present application needs to develop a close loop control system of IWM to check on its accuracy for a particular desired distance.

Another control challenge of IWM is the impact-induced vibrations that result from each clamping step (piezoelectric actuators A and B). Therefore, suitable control techniques and associated algorithms have to be designed and developed to mitigate the adverse effects of impact forces and vibration during rapid positioning with inchworm motors.

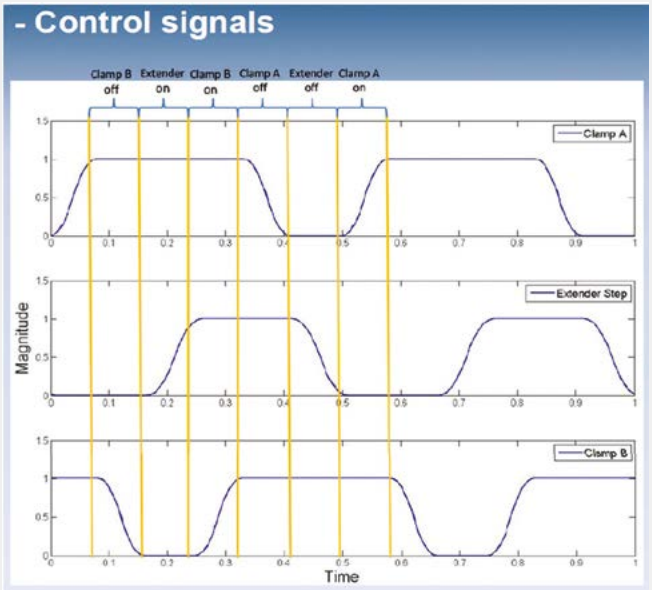


Figure 4: Typical signals required for each of the three actuators

2. Solar Assisted Robot for Surveillance Application

Project No.: OLP 215912

Funding: CSIR-CMERI, Durgapur

Duration: June 2017- Dec 2017

Summary of project

Under this project, a security and surveillance system along with a mobile robot is developed. A four wheeled pioneer mobile robot is used where a differential wheel drive is used for moving in forward, reverse, right & left directions. This is used for defining the trajectory which is set by the user. For developing the security and surveillance system robot, various sensors are interfaced with the mobile robot. A Pi camera is integrated with the robot for image sensing, capturing and recognition purposes as shown in Figure 5. Also for object sensing purposes four ultrasonic and four IR sensors are mounted perpendicular to each other on the mobile robot. For sending the captured images, a GSM module is also mounted at the top section of the robot. The two speakers are connected for raising an alarm when an object comes within its defined range. For controlling the security system, a Raspberry Pi3 based micro controller is mounted on the top of the robot which controls the sensors, camera and GSM module. A user defined program is developed in Raspberry Pi3 and this is interfaced with the mobile robot. Afterward, the mobile robot can perform continuous surveillance within its defined periphery and senses any object within its range. The picture can be sent to the user through MMS as well as the output sound created by the speaker.

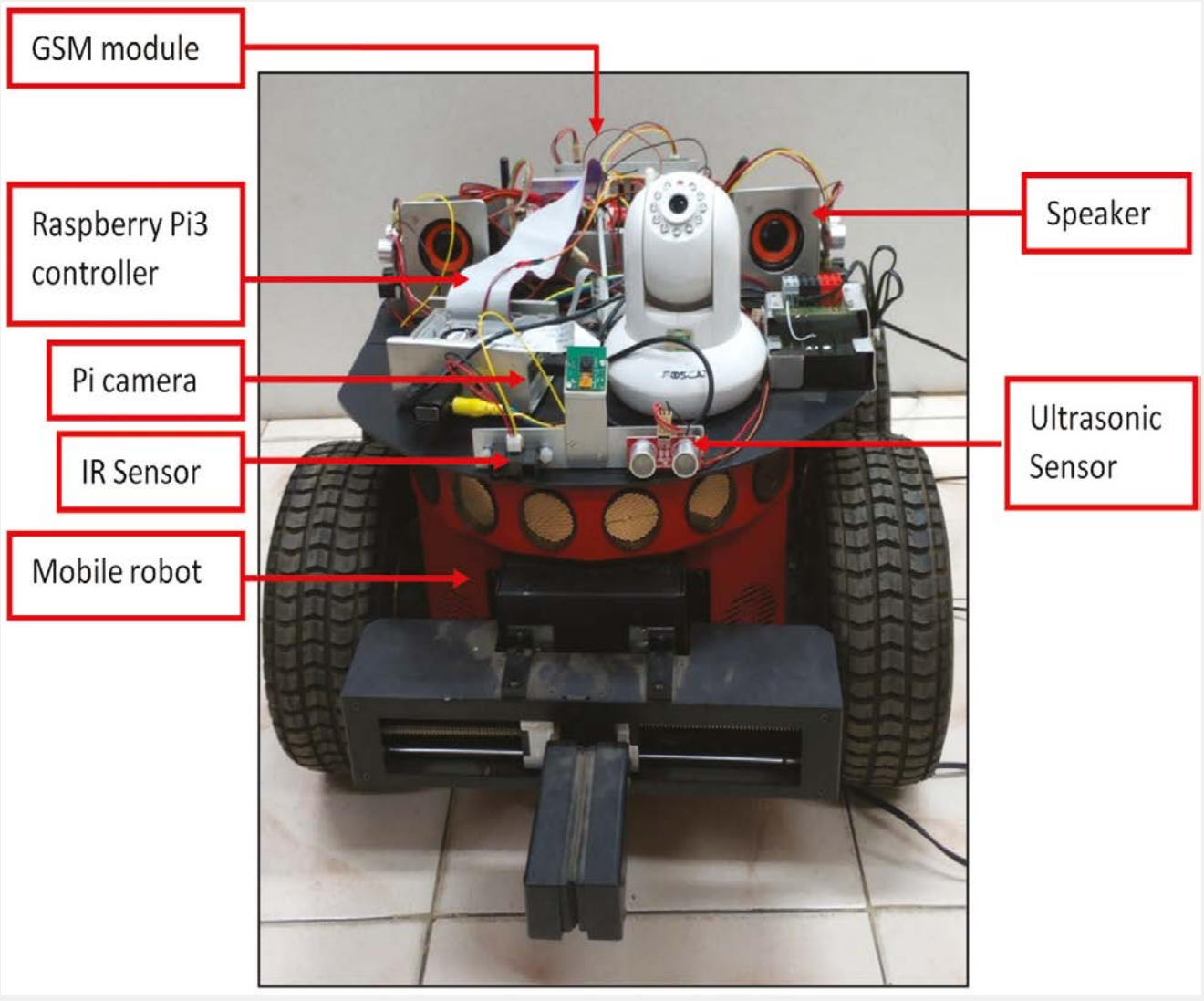


Figure 5: Development of security and surveillance system with a mobile robot

3. Advanced Ionic Polymer Composite Sensors and Actuator for Artificial Muscles and Robotic Applications

Project No. :GAP: 216112

Funding :DST, New Delhi

Duration: April 2017- March 2019

Summary of project

Under this project, a novel flexible link manipulator using SPVA/IL/Pt based IPMC membrane is developed as shown in Figure 6. An IPMC is considered as a flexible joint link and a two-IPMC finger based micro gripper is also integrated at the end of a flexible plastic link. The flexible IPMC joint provides the bi-directional bending of link manipulator for manipulating the object of different shapes and sizes from one position to another. The IPMC micro gripper holds the object by providing the applied voltage (0-4 VDC). This can hold objects of different shapes and sizes. The object weight is ranging from 20-117 mg. During assembly it is also demonstrated that this kind of manipulator provides the more flexible nature as compared to a rigid type manipulator because in this manipulator the IPMC is used as an active joint during manipulation. The IPMC based micro gripper is also used for handling objects with any shape. These are major advantages of this kind of flexible manipulator for robotic assembly. This shows the potential of dexterous handling of the object.

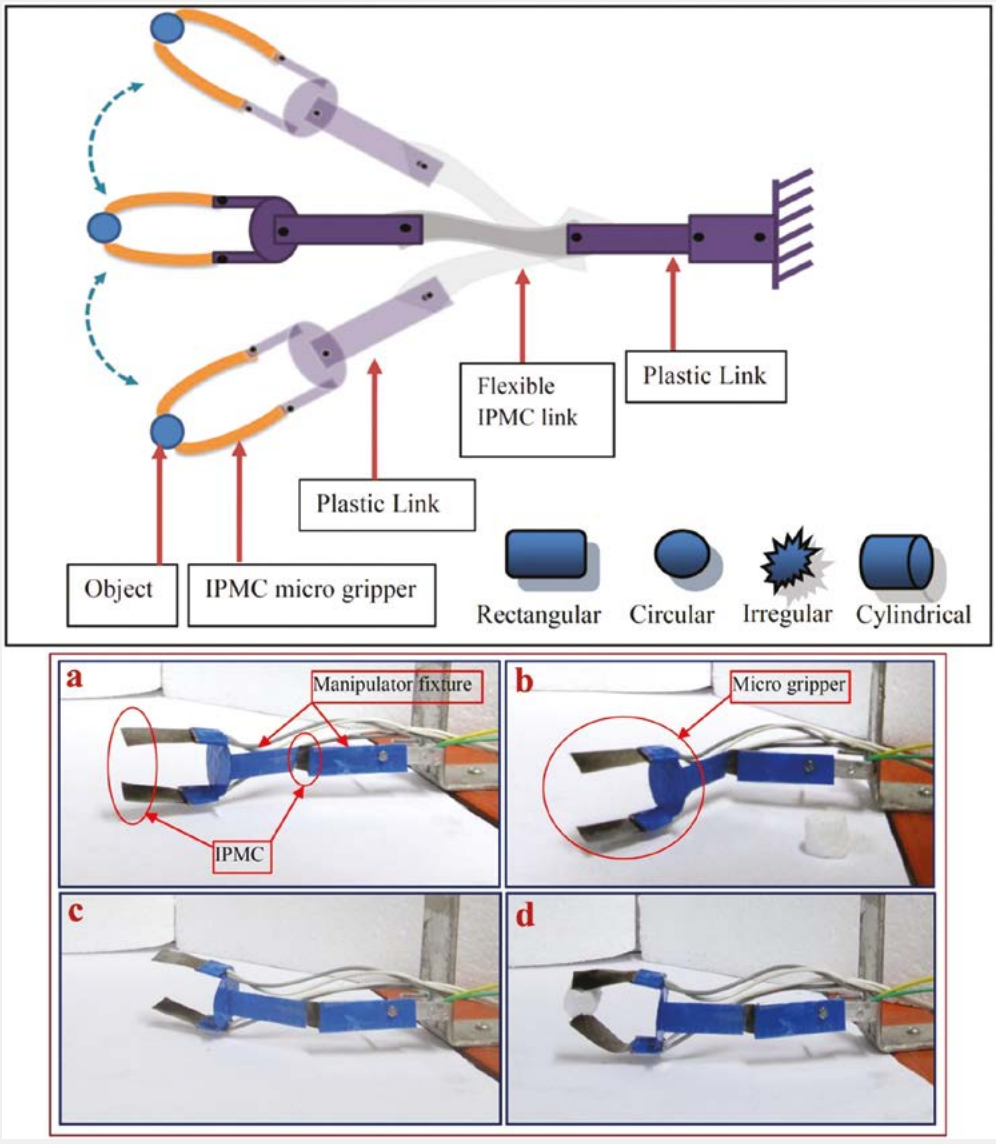


Figure 6: Flexible link manipulator using SPVA/IL/Pt based IPMC membrane

5

MATERIALS & STRUCTURAL EVALUATION GROUP

MSEG department carried out following activities in 2017-18

1. Solutions for Residual Life Assessment of Industrial structures

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

- OIL Guwahati- Study and Testing of oil storage tank.
- NCL Jayant and Dudhichua- study and testing of coal handling plant.

2. 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.

Project work:

Performed Technical service projects and generated ECF.

Publication: 1no (SCI) IF 1.44

6

NDT & METALLURGY GROUP

Residual life assessment, NDT based Health/Condition Assessment and Failure analysis of Different Industrial 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 the 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 aged thermal power stations. Many of the power plants in India are old and require major renovation programme for future operation, which need in-depth assessment of the present component damage. The beneficiaries of the studies include several industries like DVC, WBPDCL, HZL, DSP(SAIL),CESC, BHEL, Hindustan Unilever and Haldia Petrochem. 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 had strong interaction with various power plants all over India for the last 30 years regarding various technical services for the industries. 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, Govt. 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 plant 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, which brings into notice the mandatory replacement/modifications necessary to guarantee minimum 75% plant load factor and 85% plant availability.

The in-service failure of Engineering components has also become a major issue to the plant owners. The post mortem analysis is very often needed to predict the root cause of the 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 part of its 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 images-copy, Ultrasonic Test (UT), in-situ metallography and in-situ surface hardness measurements are employed in critical industrial components, mainly in power and process plants. The tests are carried out to detect surface/near surface, internal discontinuity/flaw, creep damage in microscopic level and thermal softening due to creep damage. Figure 1a and 1b depicts 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 Figure 1c and 1d, respectively.

Figure 1a & 1b: Non-Destructive Examination of the critical components on site

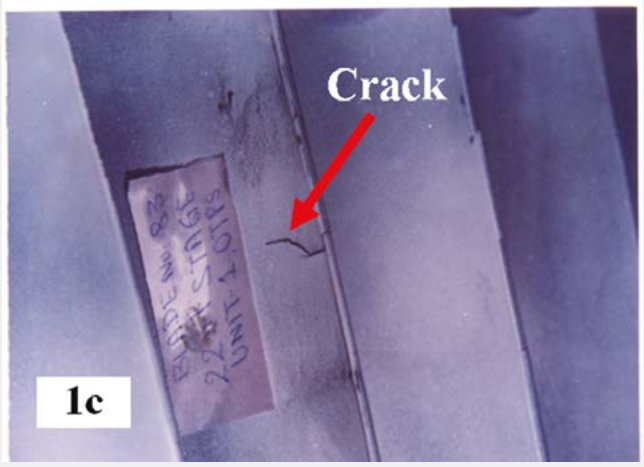


Figure 1c: Crack on Turbine Blade

Figure 1d: Crack on Boiler Superheater

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. Figure 2a and 2b shows the oriented creep cavities and microcrack in the grain boundaries.

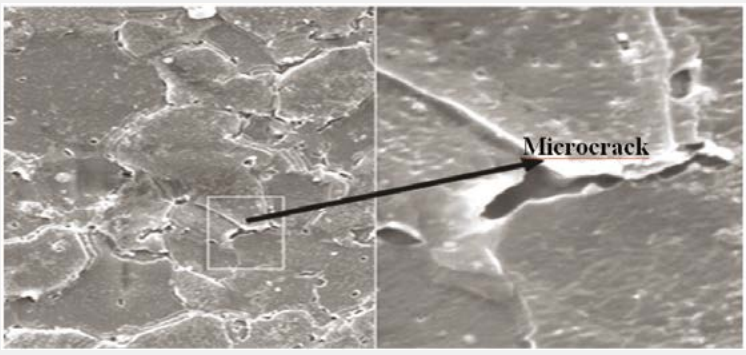


Figure 2a: The microstructure at in-situ condition shows oriented creep cavities and microcracks at the grain boundaries

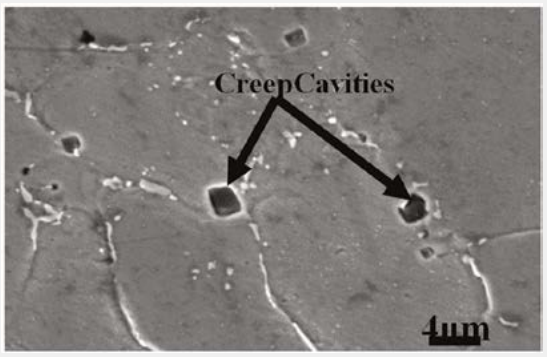


Figure 2b: The microstructure at in-situ condition shows isolated creep cavities at the grain boundaries

The post mortem failure analysis of different failed components is also carried out mostly for the power plant components. One of the important failure analysis done in Hindustan Zinc Limited, Udaipur, Rajasthan, addressed premature failure of a 225T crane during operation in construction of a mineral beneficiation plant in S K Mines Site, where casualties happened due to sudden failure of the crane boom. The NDT & Metallurgy Group of CSIR-CMERI officials took up the work on urgent basis to find out the probable reasons of the failure with possible recommendations to avoid similar kind of failure in near future. The technical report containing the possible causes of untimely failure was highly appreciated by HZL authorities along with the Director General of Mines Safety (DGMS). Visual inspection, metallographic examination, mechanical testing and stress analysis were among wide range of tests conducted to ascertain the probable cause of the failure.

Figure 3: Catastrophic failure of the crane boom of 225 ton crane at Hindustan Zinc Limited, Udaipur, Rajasthan Site

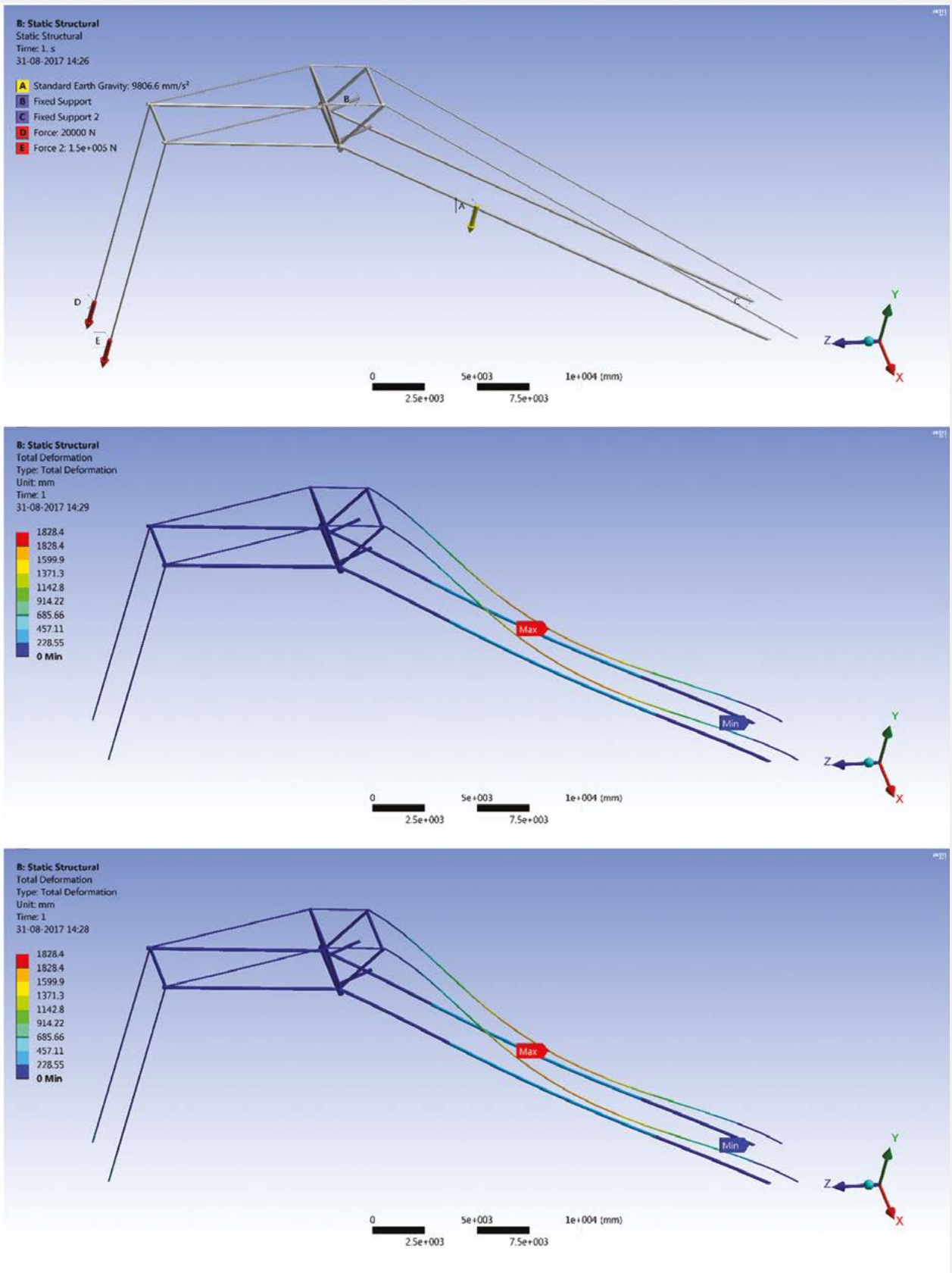


Figure 4: Stress analysis showing equivalent stress and total deformation on the crane with maximum load on outside rope of failed crane boom

Apart from the various RLA and failure investigative works, NDT & Metallurgy Group of CSIR-CMERI also conducts considerable research on material characterizations and evaluation in connection with different projects with other groups.

The scientists from NDT & Metallurgy group are also exploring for the new research areas on Health Monitoring of Tall Structures using Unmanned Aerial Vehicle(Drone). The main advantage of this project is faster inspection technique in inaccessible area. The main objective of the project is to develop multicopters for health monitoring of tall structures. Depending on the type of camera and other sensors which will be loaded in the developed drones, the payload is unlikely to exceed 5 kg, and a flight time of no less than 15 minutes is expected. The developed multicopter will have high resolution cameras to detect external defects like cracks/spallations, leaks, holes etc. along with appropriate displacement sensors and thermal imaging camera which will precisely detect cracks and other structural features from a distance close to the structure. The defects thus identified will be quantified.

The group is also actively engaged in spreading awareness among college students/working professionals about the importance of NDT and inspection. Quite often, workshops/ training programs are conducted to take initiative in this regard. A two day training program was organised with this objective in mind for industry officials and different engineering college students.

7

PRECISION ENGINEERING AND METROLOGY GROUP

Precision engineering and metrology have both gained an important role in not just current, but also in future technologies. It covers a wide range of scope, starting from design to development, manufacturing to measurement of parts of a system. It is the basic to the economic and social development of a country as it provides precision machining and accurate measurement, which impact our economy, health, safety and general well-being. Precision Engineering and Metrology (PE & M) group has a wide capability and extensive expertise in the field of high accuracy measurements, in-situ calibration of high precision gauges and measuring equipment, manufacturing machine tools, reverse engineering, 3D surface characterization, quality systems (NABL) and management systems (ISO), research on vision based surface inspection and geometry and size effects in micro EDM and skill development for SMEs. PE. & M Group has NABL accreditation in 68 in-lab and 16 in-situ parameters.

PE & M Group rendered following R&D activities and services to industries during 2017-18:

1. In-situ Calibration of Machine Tools and Measuring Equipment

Quality assurance programme is very essential to review an ongoing machining performance. Comprehensive performance assessment and calibration are usually performed on a regular basis in accordance with national and international standards which minimize downtime on the basis of comprehensive view of all the geometric and dynamic characteristics of the machine. It is ideal to supplement annual calibration of the machine with regular performance check. The linear measurement is the most common form of measurement for quality check of the machine. Quality check for high precision measuring equipment is carried out by the laser interferometer or other suitable equipment following national/international standards.

Following are the in-situ calibration service undertaken by the group for machine tools/measuring equipment:

a) Slip Gauge Measuring Machine, Steel Tape Calibrating Unit at M/s. ERTL (East), Kolkata

b) Bridge Type CMM, at Adityapur Auto Cluster, Jamshedpur

c) CMM, Profile Project, Universal Measuring Machine, at M/s. CMERI-CoEFM, Ludhiana

d) Scale & Tape Measuring Machine, at M/s. Sibali Instrument Works, Howrah

Figure 1: Setup of calibration for block gauge comparator (Reference EAL-G21)

Figure 2: CMM being calibrated by Step Gauge

2. Quality Checking of Machine Tools

Quality checking of newly procured machine tools at AdMaC of CSIR-CMERI has been provided for

a) CNC Surface Grinding Machine,

b) PLC Surface Grinding Machine,

c) CNC Cylindrical Grinding Machine,

d) Universal Grinding Machine, Conventional Lathe and

e) Universal CNC Milling Machine.

Test samples prepared as per national / international standards by those machines have been measured for dimensions (linear & angular), 2D and 3D surface roughness parameters, straightness, squareness, circularity, cylindricity, concentricity and coaxiality etc. by Profile Projector, UMM, ULM, CMM, Perthometer, 3D Optical Surface Profiler. Axis errors for CNL and PLC Surface Grinding Machines have been quantified by LASER Interferometer.

Figure 3: Test sample of Universal CNC Milling Machine being measured by CMM

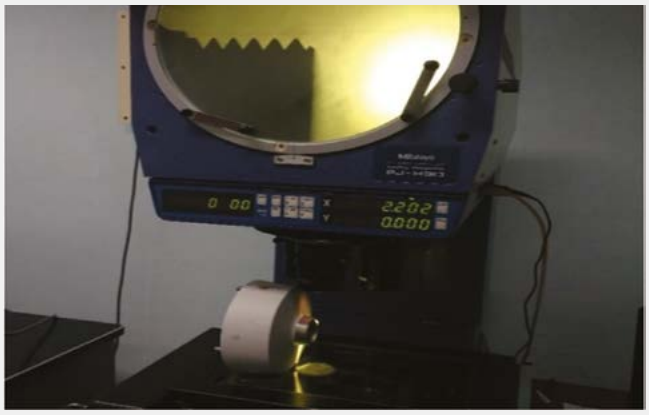


Figure 4: Camera Mounting Assembly of Mob Control Vehicle under inspection

3. In-house Developed Products/ Samples of R& D Projects

High precision measurement services rendered by measuring different features and surface characteristics of several components of different on-going R&D projects for their successful and timely completion. Some major important services provided are :

a) Detail dimensions of Camera Mounting Assembly of Mob Control Vehicle (MLP 218112)

b) Surface roughness of thrust pad and bearing collars (MLP 210812)

c) Surface roughness of laser metal deposited surface (GAP 121512)

d) Failure investigation of bolt sample of BHEL (TSP-1076, BDG AID/1639)

e) Detail dimensions of 2 nozzles (GAP 214612)

f) Detail dimensions of 3 components and attachment (MLP 218112/WP-2)

g) 3D profile and depth of 6 slots (MLP 218112)

h) 3D topography and 2D sectional profile of worn surface with width and depth coated with different materials and different coating thickness (MLP 216212) – 15 samples

i) 3D topography and 2D sectional profile with width and depth of worn surface machined at different load (MLP 216212) – 8 samples

j) Dimensioning of 3 nozzles for engineering drawing for manufacturing (MLP 214612)

k) Measurement of peak height & pitch of sintered alumina samples (GAP 218212)

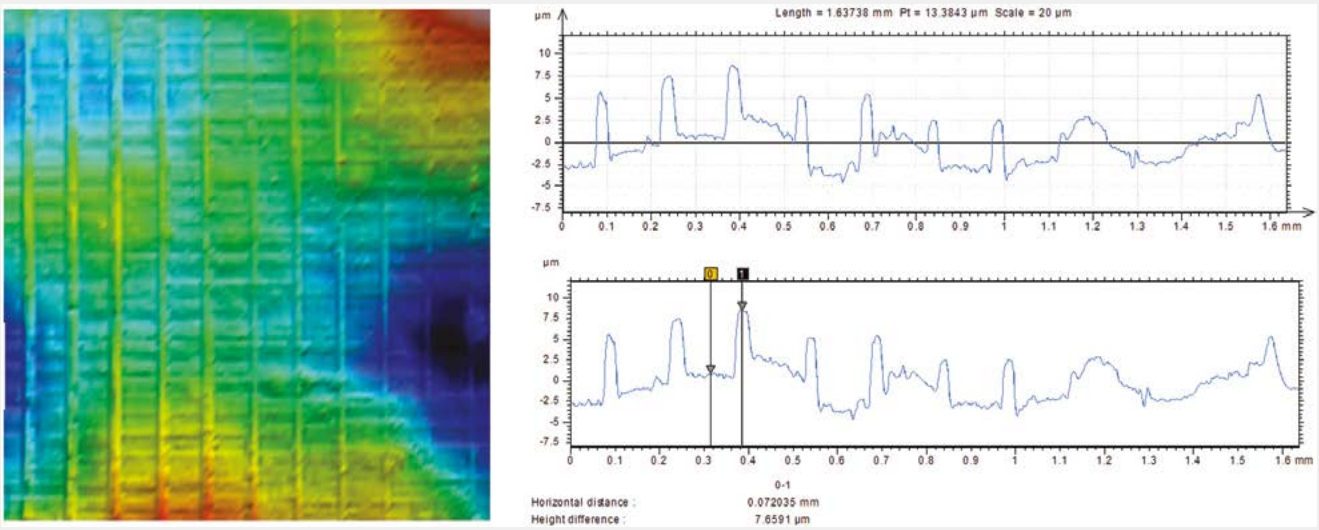


Figure 5: Peak height & pitch measurement of alumina sample sintered at 1540°C (GAP 218212)

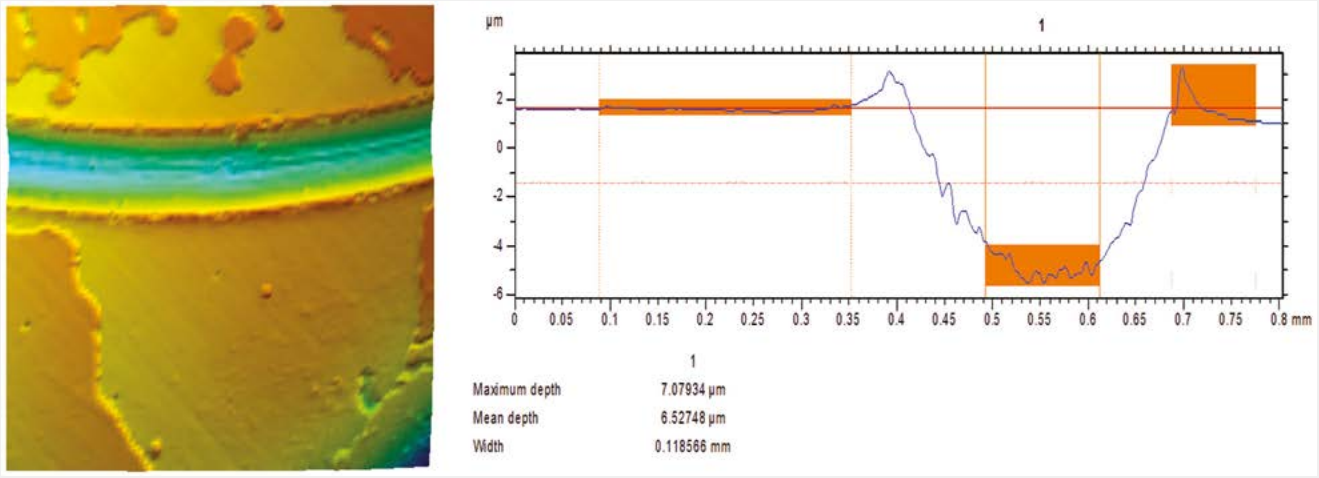


Figure 6: Wear depth measurement of 3 µm TiSiBCN coating with load 500 g (MLP 216212)

4. External Calibration Services

Accurate measuring devices improve product quality which is the ultimate requirement. The accuracy of all measuring devices degrade over time due to normal wear and tear. Sometimes, changes in accuracy of measuring equipment are caused by electric or mechanical shock or a hazardous measuring environment. Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period. To access accuracy of measuring gauges/equipment, it is mandatory to calibrate them periodically following national/international standards. Calibration improves the accuracy of the measuring device. Calibration services were provided to the follow major industries and calibration labs for getting and retaining NABL accreditation.

a) M/s. IOCL, Begusarai
b) M/s. Damodar Valley Corporation, Andal
c) M/s. CMERI-CoEFM, Ludhiana
d) M/s. SAIL, DSP, ASP, Durgapur
e) M/s. MSME Testing Centre, Kolkata
f) M/s. G.E. Power India, Burdwan
g) M/s. Quality Solutions (India), Faridabad
h) M/s. Electronics Regional Test laboratory (East), Kolkata
i) M/s.Alca Lab Pvt Ltd., Jamshedpur
j) M/s.Adityapur Auto Cluster, Jamshedpur
k) M/s. R S safety & Calibration, Jamshedpur
l) M/s.Jaganaths Slip Gauges & Company, Kolkata
m) M/s.Sibali Instrument Works, Howrah
n) M/s. Durgapur Chemicals Limited, Durgapur

5. Internal Calibration Services

To maintain NABL accreditation and ISO certification for the Institute, performance verification of different measuring equipment and measuring gauges of CMERI-CoEFM, P.E & Metrology Group, AdMac and other groups have been carried out throughout the year. This saved a good amount of Institute money.

6. Manpower Development

Hands on training on 'Dimensional Metrology & Pressure Metrology' for 3 participants from R.S. Safety, Jamshedpur was provided. Regular theoretical as well as hands on practical classes for 4 students of PGDAMT course have been provided. Hands on training was provided to participants from different engineering colleges under skill development program of the SIP Group. Personnel from other groups of CSIR-CMERI, CMERI-CoEFM, Ludhiana as well as from industries and academic institutes visited with specific problems. They have been provided expertized solutions.

7. Organization of Conference

Successful development of any product requires synergy of proper materials, optimum manufacturing processes and suitable metrology. Therefore, motivated by the 'Make in India' call, a fruitful interaction among researchers working in the advanced areas of materials, manufacturing and metrology, at a national level, was targeted by arranging a conference. As a part of 'Diamond Jubilee Celebration' of CSIR-CMERI, a National Conference on Advance Materials, Manufacturing and Metrology (NCAMM-2018) was organized during 16-17 Feb., 2018 at CSIR-CMERI, jointly with the CAMP group. 70 technical papers were accepted for publication in the proceedings and 107 participants from various industries, academic institutions and research laboratories participated. Distinguished dignitaries like Bhatnagar awardee Prof. Kamanio Chattopadhyay (Honorary Professor, IISc.), Dr. R. N. Das, GM, Corporate R&D, BHEL Hyderabad; Mr. U. Thanu, Director General, National Test House; Prof. A. K. Nath, IIT Kharagpur; Prof. S. K. Pal, IIT Kharagpur; Prof. S. Das, Kalyani Govt. Engg. College enlightened the participants on the recent trends of the theme chosen for the conference. The platform of NCAMMM-2018 created an opportunity to discuss and to start collaborative work between the industries and academia in the field of new materials development, characterization techniques, advanced manufacturing and quality engineering.

8. Determination of stiffness parameters for the mathematical model of the LCA nose landing

(Proj. title: 'Studies on Non-Linear Dynamics (LCO) of Shimmy Phenomenon in Aircraft Nose Landing Gear', sponsored by Aeronautical Development Agency (ADA)).

One of the primary structural components of the airframe, the landing gear assembly enables the airplane to take off and land on the ground. For the purpose of modelling the nose landing gear of the Light Combat Aircraft (LCA) using discrete multi-degree of freedom dynamic system, the values of the effective torsional, lateral and rolling stiffness of the assembly at chosen positions are necessary. Therefore, in this effort, a precise estimation of the above mentioned stiffness values were estimated by reducing the original landing gear assembly to a simpler version in CATIA.

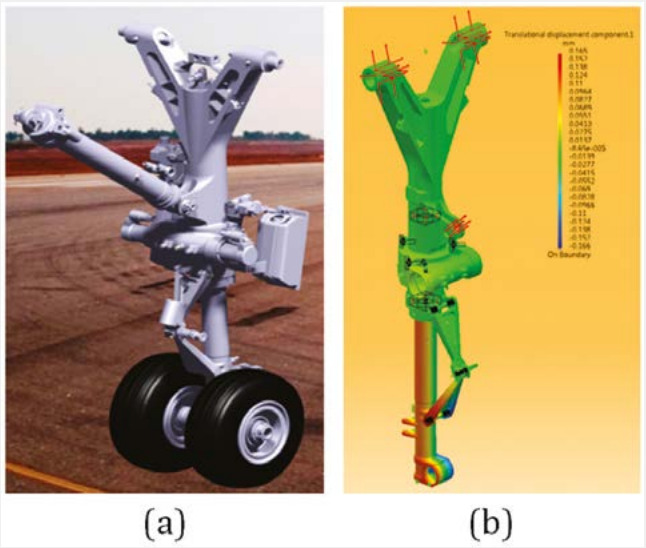


Figure 7: (a) Solid model of original landing gear assembly, (b) Stiffness (torsional) analysis of the reduced model using Finite Element Modelling (FEM)

Figure 8: Release of the proceedings of NCAMM-2018

9. Publication and Review of Project Proposals

Publications :

In '9th International Congress on Precision Machining (ICPM -2017), Athens, Greece : 01

In 'Solid State Phenomena' : 01

In 'Proceedings of Institution of Mechanical Engineers, Part B : Journal of Engineering Manufacture' : 01

Two project proposals (Proj. No. 22/6948/NS/17/EMR-II and Proj. No. 22/7599/18/EMR-II) from CSIR-HRD Group (Extra Mural Research Division) have been reviewed for suitability of funding from CSIR-HRDG.

Skill Development Programmes

SKILL AND INNOVATION PROMOTION GROUP

CSIR-CMERI was actively involved in imparting training for last three decades to various sectors of industry. However, with the fresh paradigm emerging out of the Skill India initiative of the Central Government, CSIR-CMERI is focusing and coordinating activities directed towards skill development for the youth of India at every scale with speed and standards. CSIR-CMERI is further in the process of streamlining the institutional mechanism and leveraging public infrastructure for value addition to the skill development schedules, thereby leading to better employability.

The skill development activities at CSIR-CMERI are now being carried out through the Skill & Innovation Promotion Group which, in its turn, is being promoted and coordinated through the CSIR Integrated Skill Initiative.

Prior to the initiation of the Skill Development Programmes (SDP), the Skill & Innovation Promotion Group of CSIR-CMERI, Durgapur had undertaken a thorough survey of the ITIs and polytechnic institutions in the within a radius of 70 km. A number of Institutions were contacted and their requirements were assessed and wherever possible, the SDPs were aligned with specific Qualification Packs of associated Skill Development Councils at its core, while keeping in mind the specific requirement of the trainees. The programmes undertaken by CSIR-CMERI straddles both the higher and lower ends of the skill development spectrum, thereby bringing about interventions at all levels. Similar activities are being undertaken at Ludhiana at the Centre of Excellence for Farm Machinery (CSIR-CMERI-CoEFM, formerly known as MERADO), an extension of CSIR-CMERI, Durgapur.

In this manner, a number of SDPS could be designed and offered to students and MSME workers, which has created a cascading effect in terms of their popularity. Keeping in mind the institutional facilities - both human resources and equipment considered - the group size has been optimized to 30 students per batch, which affords imparting of hands-on SDPs most effective.

Skill Development Programmes

Sl.	Skill Development Programme on	Duration		Number of participants
		From	To	
1	Understanding Engineering Drawings at MSME, Bargachhia, Howrah	April 21, 2017	April 23, 2017	32
2	Advanced Apprenticeship in Multidisciplinary Engineering	May 08, 2017	June 30, 2017	44
3	Industrial cum CAD/CAM/CAE Training Programme	June 20, 2017	July 28, 2017	19
4	Design Integration and Interfacing using PIC 16F Series & 8051 Microcontroller	June 27, 2017	July 17, 2017	43
5	Project work of Post Graduate Students (for One Year)	July 2017	June 2018	05
6	PCB Design and Fabrication	August 07, 2017	August 14, 2017	30
7	Technical drawing Skills	August 28, 2017	September 08, 2017	30

8	PCB Design and Fabrication	October 05, 2017	October 10, 2017	30
9	Conventional and CNC Operations including Micro CNC	November 13, 2017	November 22, 2017	17
10	Design Integration and Interfacing using PIC 16F Series & 8051 Microcontroller	December 27, 2017	January 15, 2018	30
11	Design and Manufacturing Techniques of Engineering Components at CSIR-CMERI CoEFM, Ludhiana	January 01, 2018	April 20, 2018	14
12	Understanding and preparation of Engineering Drawing	January 03, 2018	January 12, 2018	39
13	Conventional and CNC Operations including Micro CNC			34
14	Foundry Technology			27
15	Design Engineering Installation and commissioning of Solar PV system			30
16	Understanding and preparation of Engineering Drawing	January 16, 2018	January 25, 2018	27
17	Metal Injection Moulding	February 14, 2018	February 18, 2018	14

Glimpses of Skill Development Programmes




Events

EVENTS

World Autism Awareness Day

World Autism day was observed on April 02, 2017 in the Institute. Dr. Swati Saha, Senior Medical officer of CSIR-CMERI Dispensary delivered a lecture on Autism: A challenge, not merely a disease.

Dr. Swati Saha, Senior Medical officer of CSIR-CMERI Dispensary

Plantation Programme & Blood Donation Camp

To commemorate the 126th Birth Anniversary of Dr. Bhim Rao Ambedkar as well as an event of the CSIR-CMERI Diamond Jubilee Celebrations a Plantation Programme on April 14, 2017 and a Blood Donation Camp on April 29, 2017 was organized by CSIR-CMERI, Durgapur.

Two Day Training Program

Almost 60 Final Year Civil Engineering students from Asansol Engineering College visited NDT & Metallurgy Group on 27-28 April 2017 to get acquainted with the various activities of the Group. The details of the group activities were explained to them by the Staff members of NDT & Metallurgy Group. In addition, the importance of NDT in Industrial Maintenance was highlighted. The students were curious to learn about various NDT techniques, Failure Investigation and Material Characterization using Electron Microscopes. The students visited in two batches, each batch comprised of almost 30 students. In addition, few faculty staff also accompanied them.

Demonstration at the laboratories

National Technology Day

The National Technology Day was observed on May 11, 2017 at the Institute Auditorium. Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, inaugurated the program along with Prof. Asok De, Director, National Institute of Technology, Durgapur, and other invited dignitaries. Citing the recent example of launching of the SAARC satellite as a testimony, Prof. Hirani contended that if the concentration of scientific know-how is channeled in right direction, the nation can perform wonders. Under the leadership of the Director, CSIR-CMERI would continue to improve its outreach capability towards the suffering masses. Prof.Hirani mentioned the Green Battery, 3D printing (metal deposition) machine and a Zero-Waste Colony as few amongst the technological solutions offered by the Institute.

Prof. Harish Hirani, Director CSIR-CMERI, delivering his lecture

Prof. Asok De, Director, NIT, Durgapur lighting the lamp

International Yoga Day celebration

CSIR-CMERI, Durgapur, organized a one-day Yoga workshop in the CSIR-CMERI Staff Club premises to celebrate the '3rd International Yoga Day' on June 21, 2017. The workshop programme was inaugurated by Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, Durgapur, in the august presence of Dr. Asis Goswami, Ex-Chair holder, UNESCO Chair in Adapted Physical Education and Yoga, Academic Coordinator, Department of Sports Sciences, Ramakrishna Mission Vivekananda University, Belur Math, Howrah and Shri Subhash Chandra Kesarwani, Post Graduate Diploma in Yoga Studies, Ramkrishna Mission Vivekananda University, Belur Math, Howrah. Dr. Hirani on this auspicious day made an announcement that henceforth Yoga would be practiced every day in the CSIR-CMERI Staff Club Premises and urged all to come and participate in this endeavor.

Prof. Harish Hirani, Director CSIR-CMERI, at the inaugural session

Participants of the Yoga Workshop

Visit of Ethiopian Delegates at CSIR-CMERI Durgapur Regarding CSIR-MIDI Twinning Program

Council of Scientific and Industrial Research (CSIR) has signed an agreement to implement a twinning programme with the Metals Industry Development Institute (MIDI), Ethiopia on June 07, 2017. Mr. Teshome Lemma Hon'ble State Minister, Ministry of Education, Federal Democratic Republic of Ethiopia and his team visited CSIR-CMERI on June 16, 2017.

Ethiopian Delegates at Director's Office

Delegates visiting Laboratory

Delegates at MSW Complex

Delegates at Solar Park

Workshop on Science Pedagogy in Schools

To promote interest, excitement and excellence in science education among the students and to Introduce the new and emerging areas of science to the science faculty, the Council of Scientific & Industrial Research (CSIR) has started a scheme on Faculty Training and adoption of schools and colleges by CSIR Laboratories. Towards this objective and commemorating the birthday of Acharya Prafulla Chandra Ray, CSIR-CMERI, Durgapur organized a two-day workshop on Science Pedagogy in schools during August 02-03, 2017. Science faculties from Kendriya Vidyalaya, CMERI, Hem Sheela Model School, Guru Teg Bahadur Public School, Manisha International School, DAV Model School, Bidhan Chandra Institution (For Girls), Surenchandra Modern School, RamkrishnaPally Vivekananda Vidyapith, Amrita Vidyalayam, Durgapur R.E. College Model School and JawaharNavodayaVidyalaya attended the workshop. Eminent Professors Prof. Subhash C. Bhattacharya and Prof. Bhupati Chakrabarty, Dr. Somenath Mukherjee, Senior Principal Scientist and Dr. Soumen Sen, Principal Scientist of CSIR-CMERI addressed the gathering.

Participants of the Workshop

Workshop-cum-Training Programme on Advanced Materials Processing & Characterization (WAMPC-2017)

In the aegis of CSIR-CMERI diamond jubilee celebration a Workshop-cum-Training Programme on Advanced Materials Processing & Characterization (WAMPC-2017) was successfully organized during September 7-8, 2017 at CSIR-CMERI, Durgapur. The basic objective of this two days training programme is to bring together participants from industries, R&D organizations and academic institutions to offer an overview of different functional materials and their processing methods. The workshop will also provide hands on training about the characterization of materials using a variety of high-end and sophisticated equipments e.g. Universal Testing Machine (UTM), Micro-hardness Tester, UV-VIS, FTIR, DTA/ TGA, Surface Analyzer, FE-SEM etc.

Inauguration of WAMPC

Dignitaries at the dias

Jubilee Outreach Programmes

CSIR Platinum Jubilee 'Technofest' was organized at CSIR-CMERI during September 16-18, 2017 as a part of CSIR Platinum Jubilee Celebrations encompassing important CSIR technologies developed at various CSIR laboratories throughout India. To make this endeavour a grand success, CSIR-CMERI has also organized Diamond Jubilee Technology Demonstration to showcase activities of CSIR-CMERI in the societal arena and technology intensive domains. Special functions towards Outreach Programme of IISF-2017 and JIGYASA (CSIR-KV Sangathan) were also organised on September 16, 2017 and September 18, 2017 respectively. Several dignitaries graced the occasion and several hundreds of visitors from mainly schools and colleges, industrial partners and general public have visited the exhibition site.

Inauguration of Jubilee Outreach Programme

Dignitaries at the exhibition

Students at the outreach programme

Transfer of Technology

Celebration of Hindi Pakkhada 2017

This year Hindi Pakkhada was celebrated in CSIR-CMERI during September 14-25, 2017. Dr Manjurani Singh,Visva-Bharati University, Santiniketan and Chief Guest of the inauguration ceremony, addressed our Institute personnel and motivated them to increase interest towards Hindi. In their speech Prof. (Dr.) Harish Hirani, Director and Dr. Ranjan Sen, Chief Scientist also emphasized on the Hindi implementation. During the programme, recitation, noting and drafting, quiz and essay competitions were organized among the staff members of the Institute. On the closing ceremony on September 25, 2017, Mr. Vinit Agrawal, Chief Financial Officer of Indian Oil Corporation Ltd., Rajbandh, Durgapur, was present as the Chief Guest.

Inaugural session of Hindi Pakkhada

Observance of 'Swachchata hi Seva' Programme

CSIR-CMERI observed "SWACHCHHATA HI SEWA" programme at the Institute premises on September 29, 2017 and at CSIR-CMERI Colony premises on September 30, 2017. Prof. Harish Hirani, Director of the Institute led the initiative and a good number of enthusiastic participant joined hands to clean the Campus.

Observation of 'Swachchata hi Seva' programme

Industry-R&D-Academia Meet

CSIR-CMERI, Durgapur, organized an Industry-R&D-Academia Meet on October 08, 2017. The theme of this interactive assembly was "Opportunities to be Technology Partner". The Meet was attended by Industry participants from various clusters belonging to multifarious domains. In his Welcome Address, Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, Durgapur, stated that there are manifold domains where CSIR-CMERI can positively intervene as a technology solutions provider and numerous areas where it can seek the cooperation and assistance of other technology players. Prof. N. Ramesh Babu from IIT Madras shared his experiences of getting projects through the Industrial-R&D-Academia Partnership.

Director, CSIR-CMERI and Prof. N. Ramesh Babu from IIT Madras on the Dias

Participants of Industry-R&D-Academia Meet

CSIR Platinum Jubilee Foundation Day Celebration

The closing ceremony of the CSIR Platinum Jubilee Foundation Day was celebrated at CSIR-CMERI on October 09, 2017. Shri Shankha Santra, Sub-Div. Magistrate, Durgapur & Additional District Magistrate (Development), Paschim-Bardhamangarced the programme with his presence. Prof. N. Ramesh Babu from IIT Madras was present as the Guest of Honour of the programme. The foundation day lecture was delivered by Prof. D. C. Panigrahi, Director, IIT, Dhanbad.

Director, CSIR-CMERI inaugurating CSIR Platinum Jubilee Foundation Day Celebration

Director, CSIR-CMERI felicitating Prof. D.C. Panigrahi, Director, IIT, Dhanbad

National Workshop on Shock and Blast Wave Research in India: The Past, Present and Future [NWSBRI-2017]

A National Workshop on Shock and Blast Wave Research in India: The Past, Present and Future (NWSBRI)- 2017 was organised by CSIR-CMERI during October 12-13, 2017. The theme of the workshop was to create awareness among researchers and academicians for the need based research for strategic sector. Eminent academicians and researchers like Prof. K. Ramamurthi, Chairman ARMREB Panel of DRDO, Dr. L. Venkatakrishnan, Head, Experimental Aerodynamics, CSIR-NAL, Shri K. Srinivasan, Engineer, VSSC / ISRO, Shri Inderpal Singh Sandhu, Divisional Head BDS, TBRL Chandigarh graced the occasion. In his inaugural address, Prof. (Dr.) Harish Hirani, Director, CSIRCMERI, stated that learning science comprehensively should be one of the fundamental aspects of Mechanical Engineering. He encouraged the Scientists and the young minds of the nation to explore the numerous application possibilities of shock and blast wave research in India.

Inauguration of NWSBRI-2017

Participants of NWSBRI-2017

Vigilance Awareness Week

CSIR-CMERI, Durgapur observed the Vigilance Awareness Week, 2017 during October 30 – November 04, 2017. The week long programme started with administration of "Pledge" by Prof. Harish Hirani, Director, CSIR-CMERI. Prof.Hirani, Dr. P. K. Chatterjee, Chief Scientist & Chairman, Vigilance Awareness Week committee 2017 and Mr. J.S .Sharan, Administrative Officer talked on the theme 'My vision-Corruption free India'. An Essay competition for the Employees was organised on October 30, 2017. On October 31, 2017 an Inter school Essay competition was organised and heads of Administration, Finance and Stores & Purchase apprised the employees about the basics of the Rules and Regulations being followed in CSIR relating to their respective fields. In connection with the programme a online Integrity Pledge was also taken by the employees.

Inauguration of Vigilance Awareness Week

A play was organised on the occasion

Visit of Shri Keshari Nath Tripathi, Honorable Governor of West Bengal

Hon'ble Governor Shri Keshari Nath Tripathi visited CSIR-CMERI, Durgapur, on November 03, 2017 as a part of the Institute's year-long Diamond Jubilee Celebrations. During his visit the Hon'ble Governor visited the CSIR-CMERI Institute and Residential Campus and later inaugurated the Municipal Solid Waste Pilot Plant—a Zero Waste Colony initiative and inaugurated the new CSIR-CMERI Guest House. Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, Durgapur, in his welcome address expressed his elation and gratitude to the Hon'ble Governor for gracing the occasion and sought his blessings for achieving success in all the societal intervention initiatives of the Institute. Prof. Hirani expressed that being government servants we are duty-bound to serve the society at large and therefore the primary mandate of this Institute is to inculcate a benevolent mindset towards the society. Hon'ble Governor, Shri Keshari Nath Tripathi, congratulated Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, for the outstanding accolades that this Institute has received in the recent past. Shri Tripathi gave special emphasis to the development of indigenous technologies so that India can espouse Import-Substitution and Export Promotion.

Honorable Governor of West Bengal at CSIR-CMERI

Honorable Governor addressing the CSIR-CMERI

Inauguration of Executive MSW Pilot Plant—a Zero Waste Colony

Inauguration of Executive Guest House

Visit by Japanese Delegation

CSIR-CMERI, Durgapur, hosted Prof. Idaku Ishii & Prof. Takeshi Takaki of Hiroshima University, Japan, during November 20-21, 2017. The delegation was shown the potent array of facilities available at the various groups of the Institute, such as Robotics and Automation, Surface & Field Robotics and Advance Design & Analysis. Prof. Hirani stressed that India with its immense academic potential can calibrate the growth momentum of the nation, only if the potential knowledge-base gets the right ambience to nourish its skills and give shape to its ideas. Prof. Ishii stated that the R&D policy of CSIR-CMERI has a very strong ambience for nurturing and boosting professional growth. He stated that Robotics and Nano-Technology are the future of the Global Economy and as the flag bearer of these disciplines CSIR-CMERI is to play critical technological intervention roles for the nation. According to Prof. Takeshi Takaki, Hiroshima University, CSIR-CMERI can be the pivotal point for catalyzing a Scientific and Technological Renaissance in India.

Japanese Delegates visiting robotics Laboratories of CSIR-CMERI

International Conference on Sustainable Manufacturing, Automation and Robotics Technologies (IC-SMART)

In the aegis of CSIR-CMERI diamond jubilee celebration an International Conference on Sustainable Manufacturing, Automation and Robotics Technologies (IC-SMART) was successfully organized during December 15-16, 2017. The focused theme for this two day ICSMART conference is on Enabling Technologies for Smart and Sustainable Manufacturing towards achieving improved quality, productivity and reliability. Prof. V. Radhakrishnana, Former Professor, IITM graced the occasion as Chief Guest. Prof Surya Pratap Vanka, Emeritus Professor, University of Illinois, USA, Prof. D. Banerjee, Texas A&M University, USA, Prof. Pradip Majumdar, USA, Prof. J. Ramkumar, IIT Kanpur, Prof. Sathyan Subbiah, IIT Madras, Prof. Gautam Sutradhar, Jadavpur University and Dr. S. Majumdar, Former Chief Scientist, CSIR-CMERI delivered keynote lectures during the conference.

A Pre-Conference (IC-SMART) Workshop was successfully organized on December 14, 2017. The workshop on Additive Manufacturing was focussed on various technologies being used in prototyping as well as in rapid manufacturing. The aim of Micro-Nano Systems Engineering Workshop was to give a comprehensive overview on scientific principles and techniques associated with design, manufacturing protocols, materials and system integration at nano, micro, meso scale. The workshops provided better insight to the students and young engineers through interactions with international experts via classroom and live demonstrations.

Director, CSIR-CMERI inaugurating IC-SMART

Participants of IC-SMART

National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM –2018)

Motivated by the 'Make in India' call, a fruitful interaction among researchers working in the advanced areas of materials, manufacturing and metrology, at a national level, was targeted by organizing a National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM–2018) at CSIR-CMERI, during February 16-17, 2018. Bhatnagar awardee Prof. Kamanio Chattopadhyay (Honorary Professor, IISc) delivered his lecture as the chief guest. Dr. R.N. Das, GM, Corporate R&D, BHEL Hyderabad, and, Mr. U. Thanu, Director General, National Test House addressed the audience as guests of honour. The list of keynote speakers included Prof. A.K. Nath & Prof. S.K. Pal, IIT Kharagpur; Prof. S. Das, Kalyani Government Engineering College; Dr. S.S. Roy, NIT Durgapur and Dr. Tapas Kuila, CSIR-CMERI. The Director, CSIR-CMERI, in his welcome address, emphasized the importance of initiating innovative manufacturing in India by sharing knowledge between the delegates from industries, academia and R&D laboratories.

Inauguration of NCAMMM-2018

Opening of the conference proceeding of NCAMMM-2018

National Conference on Graphene and Functional Materials (NCGFM-2018)

A National Conference on Graphene and Functional Materials (NCGFM-2018) was held during February 23-24, 2018. The main objective of the conference was to highlight the practical applications of graphene and functional materials in the area of coating, lubrication, energy storage, corrosion, composite materials, etc. Prof. N.R. Bandyopadhyay from IIEST Shibpur was the chief guest of NCGFM-2018. Plenary speech was delivered by Prof. N.R. Bandyopadhyay, Prof.Amitava Ghosh (IACS, Kolkata) and Prof. Pradyut Ghosh (IACS, Kolkata). About 10 invited speakers and 45 participants across the country joined the conference.

Inauguration of NCGFM-2018

Poster session of NCGFM-2018

CSIR-CMERI Diamond Jubilee Culminating Programme

The Culminating Programme of the year long CSIR-CMERI Diamond Jubilee Celebration was held on February 26, 2018. Prof. Harish Hirani, Director CSIR-CMERI in his welcome address gave a glimpse of present activities of CSIR-CMERI. Prof. Gautam Biswas, J.C. Bose National Fellow and Director, IIT, Guwahati graced the occasion as the Chief Guest and delivered the CSIR-CMERI foundation day lecture: Mechanical Engineering Quo Vadis. Diamond Jubilee commemorative volume was released during the programme. A presentation on six decades of CSIR-CMERI was delivered by Dr. Sankar Nath Shome, Chairman of CSIR-CMERI Diamond Jubilee Celebration committee. On this momentous occasion, a get-together of past and present employees was also arranged. Many ex-employees attended the programme and shared their experiences. In the evening, a cultural programme was organized by the CSIR-CMERI Diamond Jubilee Celebration committee. A Drama titled 'Premkatha' and directed by Shri Meghnad Bhattacharya was staged by the SAYAK Group.

Inauguration of CSIR-CMERI Diamond Jubilee Culminating Programme

Prof. Gautam Biswas, Director, IIT, Guwahati delivering the foundation day lecture

Get-together of of past and present employees

Drama performed by the SAYAK Group

Workshop on 'Emerging Technologies on Water Purification for rural application'

A Workshop on "Emerging Technologies on Water Purification for Rural Application" was organized at M.M. Suri Hall of CSIR-CMERI, Durgapur on March 27, 2018. Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI and Shri SankhaSantra, SDM, Durgapur inaugurated the programme. Block Development Officers of Paschim Bardhaman, Representatives from Gram Panchayats, Administrative Personnel of ADDA, Executive Engineers of PHE and members of ECL and DVC attended the Workshop. Prof. (Dr.) Harish Hirani, Director, CSIR-CMERI, Durgapur, in his welcome address elaborated his Vision Project of 'Smart Village'. A detailed Model Smart Village Map was showcased by Dr. Hirani to help comprehend the Concepts and Execution Plan. He also stated that when there is a confluence of Smart Technologies and Smart Decision Makers, it can lead to a Win-Win situation for eradication of all pressing societal issues. Technologies developed in CSIR-CMERI on water purification for rural application have also been presented in this workshop. Shri Sankha Santra, SDM, appreciated such a wonderful social endeavour. Shri Santra thanked Dr. Hirani and his team for organizing the program and expressed his pride in CSIR-CMERI's activities and Vision. He urged all the participants to espouse the technologies of CSIR-CMERI, Durgapur and utilize them. Shri Santra committed to organize field workshop for local level implementers by arranging the visit of team of CSIR-CMERI Scientists.

Prof. Harish Hirani, Director CSIR-CMERI and Shri Sankha Santra, SDM, Durgapur

Participants of the Workshop

Hindi 'Kavita Path Pratiyogita'

A Hindi 'Kavita Path Pratiyogita' (Hindi Recitation Competition) had been organised on March 14, 2018 by the Hindi Cell at the M.M. Suri Hall of the Institute under the annual activities of TOLIC Durgapur. The participants from different Central Government Offices under TOLIC participated in the programme. Shri HeeraVallabh Sharma, AGM, DSP and Member Secretary of TOLIC, Mr. Vineet Aggarawal, CRM, Indian Oil Corporation, and Mrs. MeeraHirani were the guests of honour of the programme. Other Officials of TOLIC DSP attended the programme. Shri Viswajit Majumder, Hindi Teacher, HTS, Shri Arvind Kumar Singh, Senior Hindi Officer, MTPS, DVC and Smt. Manju RaniSharan, Assistant Teacher, Dhanbad were the juries of the competition. The winners of the competition wereawarded by the guests. The overall programme ended with a grand success.

Inauguration of Hindi 'Kavita Path Pratiyogita'Participants of Hindi ' Kavita Path Pratiyogita'

Key Performance Indices

KEY PERFORMANCE INDICES

Erudite Lectures by Eminent Faculty & Scientists

Sl.	Name	Topic	Date	Programme
1	**Prof. D. C. Panigrahi** Director, IIT, Dhanbad	Foundation Day Lecture	October 09, 2017	CSIR Platinum Jubilee Foundation Day Celebration
2	**Prof. (Dr.) Samir Kumar Pal** Department of Chemical, Biological & Macromolecular Sciences, S.N Bose National Centre for Basic Sciences, Kolkata	Development of Indigenous Scientific Devices and Nanomedicines	October 17, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
3	**Prof. (Dr.) Atul Sharma** Department of Mechanical Engineering, IIT, Bombay	Computational Fluid Dynamics (CFD): A more Physical Approach	October 30, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
4	**Prof. (Dr.) Kalyan Kumar Chattopadhyay** Professor in the Department of Physics, Director of the School of Materials Science and Nanotechnology, Jadavpur University, Kolkata	Graphene and Graphene Quantum Dots for Some Exotic Applications	November 06, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
5	**Dr. Barbara Casentini** Inorganic Contaminants in aquatic environment and remediation technologies, Water Research Institute (IRSA), National Research Council of Italy (CNR)	Current Knowledge on Arsenic Groundwater Contamination: From Source to Remediation	November 08, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
6	**Shri Sanjeev S. Afzulpurkar** Chief Scientist & Head Marine Instrumentation Division, CSIR-NIO, Goa	Research and Technology at CSIR-National Institute of Oceanography	November 08, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
7	**Dr. Prasad Patnaik B.S.V.** Professor, Fluid Mechanics Laboratory, Department of Applied Mechanics, Indian Institute of Technology Madras, Chennai	DPD Simulations in Micro Flow Systems	November 17, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration

8	**Dr. Idaku Ishii** Professor, Robotics Laboratory, Department of System Cybernetics, Graduate School of Engineering, Hiroshima University, Japan	The Future of Mechanical Engineering and Allied Disciplines	November 20, 2017	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
9	**Dr. N.R. Bandyopadhyay** Professor & Head Dr. M.N. Dastur School of Materials Science and Engineering, Indian Institute of Engineering Science and Technology, Shibpur, Howrah	Impending Paradigm Shift in Engineering Sciences & Technology: Future Challenges	January 10, 2018	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
10	**Prof. Ajoy Kumar Mishra,** Department of Chemistry & Chemical Technology, Vidyasagar University	Low Dimensional Fluorescent Organic Materials and their Potential Use as Sensor	January 30, 2018	Invited Lecture
11	**Dr. Deepak N. Badodkar** Distinguished Scientist Director, Reactor Design & Development Group, Head, Division of Remote Handling & Robotic, BARC, Mumbai	Automation, Remote Handling and Robotics at BARC: Some of the Recent Achievements	February 02, 2018	CSIR-CMERI Diamond Jubilee Foundation Day Celebration
12	**Prof. Gautam Biswas,** J. C. Bose National Fellow and Director, IIT Guwahati	CSIR-CMERI Foundation Day Lecture: Mechanical Engineering Quo Vadis	February 26, 2018	CSIR-CMERI Diamond Jubilee Foundation Day Celebration

Higher Qualification Attained

Sl.	Awardees	Qualification
1	**Dr. Abhiram Hens** Scientist	**Ph.D.** from AcSIR **A study on phase change and Instabilities using continuum and molecular dynamics simulations**
2	**Dr. Prosenjit Das** Scientist	**Ph.D.** from IISC, Bangalore **Rheo processing of Al alloys using cooling slope technique**
3	**Dr. B.B. Ghosh** Principal Scientist	**Ph.D.** from Jadavpur University **Design and real-time control of a 2 DOF electro-hydraulic motion simulator**
4	**Shri Santu Matia** Technical officer (1)	**M.Tech.** from NIT, Durgapur on **Structure analysis**
5	**Shri Rakesh Sen** Assistant Section Officer (F&A)	**MBA**
6	**Shri Sanjeet Kumar** Senior Stenographer	**MBA**

Awards and Accomplishments

- **CSIR-CMERI's** nomination titled "Development of Community Level Iron Removal Plant & Their Implementation in Rural Areas to Supply Iron Free Drinking Water" was selected jointly with CSIR-CLRI's nomination for the "Innovation" category of the **CSIR Technology Awards- 2017**.
- **Dr. Prosenjit Das**, Scientist has been selected for receiving prestigious **'CSIR Young Scientist Award'** in Engineering Science category for the year-2017.
- **Dr. R.K. Jain**, Principal Scientist has bagged **Eminent Engineer Award** from Institution of Engineers (India) in recognition and contribution to the profession of Mechanical Engineering on the occasion of the 3rd National Convention of Mechanical Engineers at Udaipur Local Centre, Udaipur during September 1-2, 2017.
- The Intuition of Engineers (India) has presented the **Production Engineering Division Prize** to **Dr. Nilrudra Mandal** and **Dr. Biswanath Mondal** along with **Dr. Biswanath Doloi** for their paper titled Surface Roughness Prediction Model using Zirconia Toughened Alumina (ZTA) Turning Inserts: Taguchi Method and Regression Analysis.
- **Dr. Priyabrata Banerjee** has been awarded **'Outstanding Contribution in Reviewing'** in recognition of the contributions made to the quality of the journal by the Editors of the Elsevier Journals namely Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, Inorg anica Chimica Acta and Journal of Solid State Chemistry.
- **Dr. Biswaji Ruj**, Senior Principal Scientist has been awarded **"Environment Excellence Award 2017"** by Scientific and Environmental Research Institute, Kolkata. The award is based on the contribution in the field of environmental education and research.
- The board of management of the Venus International Foundation has conferred the **Distinguished Scientist award** to **Ms. Manju Singh**, Principal Scientist for her contribution and achievement in the field of Metallurgical Engineering.
- **Dr. Krishnendu Kundu** delivered Expert Lecture on March 23, 2018 in a Short Term Course on "Sustainable Renewable Energy: Science, Technology and Development" sponsored by MHRD under TEQIP-III and organized by Mechanical Engineering Department, University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra.
- **Shri Debi Prasad Das**, Assistant Engineer has got the **Chartered Engineer Certificate** from the Institution of Engineers (India).
- Papers entitled "Novel tritopic chemosensor for selection detection of Al3-, F- and TNP" presented by **Mr. Debanjan Dey** at the 2nd National Seminar on Nanoscience and Nanotechnology (NSNN-2017) have been awarded as one of the **best posters**.
- Papers entitled "A target specific Schiff base epoxy coating on mild steel surface: synthesis characterisation and exploration of its anticorrosion properties in a diluted NaCl medium" presented by **Mr. Manilal Murmu** at the 2nd National Seminar on Nanoscience and Nanotechnology (NSNN-2017) have been awarded as one of the **best posters**.
- **Ms. Suparna Paul**, JRF (DST Inspire Fellow) of Surface Engineering & Tribology Group, CSIR-CMERI has been awarded for 'Best Poster' in 22 CRSI National Symposium in Chemistry held at Pt. Ravishankar Shukla University, Raipur, Chhattisgarh during February 2-4, 2018.

Foreign Deputation of CSIR-CMERI Personnel

Sl.	Name	Deputation to	Duration
1	Dr. Pranab Samanta, Scientist	USA	March 29 - August 28, 2017
2	Prof. (Dr.) harish Hirani, Director	Ethiopia	May 28 - June 7, 2017
3	Dr. Avik Chatterjee, Senior Principal Scientist	Ethiopia	May 28 - June 7, 2017
4	Shri Saikat Kumar Shome, Scientist	France	October 01 - 15, 2017
5	Dr. S.R. Debbarma, Principal Scientist	Italy	October 01 - 10, 2017
6	Prof. (Dr.) harish Hirani, Director	Japan	October 03 - 06, 2017
7	Dr. Avik Chatterjee, Senior Principal Scientist	Germany	November 01 – 08, 2017
8	Shri Amit Kumar, Scientist	Germany	November 01 – 08, 2017
9	Dr. Soumen Sen, Principal Scientist	Japan	January 07 – 20, 2018
10	Shri Amon Arora, Scientist	Japan	January 07 – 20, 2018
11	Prof. (Dr.) harish Hirani, Director	Japan	January 15 – 19, 2018
12	Dr. Avik Chatterjee, Senior Principal Scientist	Ethiopia	March 06 – 16, 2018
13	Dr. Krishendu Kundu, Principal Scientist	Ethiopia	March 06 – 16, 2018

Technologies Deployed by CSIR-CMERI

Sl.	Technology	Transferred to
1	Solar Tree 5 kWp	M/s Gybes Solar India Ltd., 167, Jessore Road, South B.T. College, Kolkata, West Bengal
2	Small Tractor “KrishiShakti”	M/s Singha Components (P) Ltd., Dhulagarh Industrial Park, Kanduah, Howrah, West Bengal
		M/s K.N. Bioscience Pvt. Ltd., Hyderabad, Telangana (through NRDC)
3	Screen Printed Electrode	M/s ANTS Innovations Pvt. Ltd., Thane, Maharashtra
4	Plasma disposal of plastic waste & generation of Syngas	M/s Projwala BioEnergy, Bangirinagar, BSK-III Stage, Bangalore, Karnataka
5	“Inter Row Rotary Cultivator” Technology	M/s NASCENT Agrimach, Ludhiana, Punjab
		M/s Raftaar Processional Engg. Co., Ludhiana, Punjab
6	Irrigation Scheduler- Programmable System” Technology	M/s Raftaar Processional Engg. Co., Ludhiana, Punjab
7	Extraction of Ethanol from waste starchy biomass	M/s Bio-Technical Resources, Kanchrapara, 24 PGN(N), West Bengal
8	Safe Disposal of Municipal Solid Waste (MSW)	M/s Positronics Innovation Pvt. Ltd., Suren Sarkar Road, Kolkata, West Bengal
9	Large Scale Production of Graphene Oxide (200 g/batch)	M/s Auropol India Pvt. Ltd., Kolkata, West Bengal
10	Domestic Type Filtration Unit of Defluoridation of water	M/s Ants Ceramics Pvt. Ltd., Vasai (East), Maharashtra
11	Prismatic Solar Tree 1 kWp	M/s HINDS Machineries, Plot No.139, Sector-8, IMT Manesar, Gurgaon, Haryana

12	Solar Tree 3 kWp	M/s Baby Engineering Pvt. Ltd., Trichy, Tamil Nadu (through NRDC)
		M/s Just In Pinnacle Technology (P) Ltd., Chennai, Tamil Nadu (through NRDC)
		M/s Surya Power Tree, Chinna Waltair, Visakhapatnam, Andhra Pradesh (through NRDC)
13	Jal Kavach	M/s KSR Industrial Development (OPC) Private Limited, Vadodara, Gujrat
14	Improved Iron Removal Plant	M/s HES Water Engineers (India) Pvt. Ltd., Nagpur, Maharashtra
15	Multi-Fab Micro Fabrication Machine	The New Horizons Institute of Technology, Durgapur & The Manbhum Private ITI, Raghunathpur, Purulia, West Bengal
16	20 HP Tractor	ITL, Hoshiarpur, Punjab (through NRDC & CSIR HQ)
17	Intelligent & Powered Wheel Chair	M/s S. S. Udyog, Kanchrapara, Kolkata, West Bengal
18	Domestic Iron Water Filter	M/s Bargachiya Cluster of Metal Product, Bargachiya, Howrah, West Bengal
19	3 kWp Solar Flora	M/s Meeco Solar And Infrastructure Associates, Gouri Bhaban, Sagarbhanga, Durgapur, West Bengal
20	Salivary Fluoride Detection Kit	M/s Marcopolo, Ambuja, City Centre, Durgapur, West Bengal

MoU/ Agreement Signed by CSIR-CMERI

Sl.	Subject	Other Party	Signed on
1	Co-Development Agreement on project entitled "Piezoelectric Actuator System for Automotive Translation Systems (PASATS), Project No.GAP210312	Faurecia Sieges d'automobile, France & Centrale Supelec, Group of Electrical Engg., Paris	17.04.2017 (Effective Date : 27.03.2017)
2	Agreement for development of 'On-Grid Solar Inverter'.	M/s M icromax Energy Ltd. Nariana Indl. Area, New Delhi	22.05.2017
3	MoU for Skill Development Programme under CSIR Integrated Skill Initiative	The New Horizon Institute of Technology, Durgapur, West Bengal	02.06.2017
4	MoU for Skill Development Programme under CSIR Integrated Skill Initiative	Manbhum Private Industrial Training Institute, Raghunathpur, Purulia, West Bengal	02.06.2017
5	MoU on collaborative R&D activities.	Guru Nanak Dev Engineering College, Ludhiana, Punjab	17.08.2017
6	MoU on rendering Technical Services for Transportation, Installation & Commissioning of a Ginger Processing Unit in the state of Mizoram to achieve economic sustainability	Mizoram Food Processing Industry (Mifproy), A-97, Hmar Veng, Sihphir Venghlun, Aiwawl, Mizoram	18.08.2017
7	MoU on Joint Research Collaborative Project	Indian Institute of Technology, Kanpur (IITK)	23.11.2017
8	MoU on Implementation of the exchange of undergraduate and graduate students under the "International Linkage Degree Program for developing Innovators Transforming Advanced Technology to Social Goals.	Hiroshima University, Japan	18.01.2018

New Industries added to the CSIR-CMERI

	Sl.	Name of the Industries
a.	**R&D Projects**	
	1	Micromax Energy Ltd., Naraina Industrial Area, New Delhi
	2	Suman Engg., Raniganj, Paschim Bardhaman, West Bengal
	3	West Bengal State Electricity Distribution Co. Ltd., Purulia, West Bengal
	4	GTRE, DRDO, C.V. Raman Nagar, Bangalore
	Sl.	**Name of the Industries**
b.	**Licensees**	
	1	M/s Gybes Solar India Ltd.
	2	M/s ANTS Innovations Pvt. Ltd.
	3	M/s Projwala BioEnergy
	4	M/s NASCENT Agrimach
	5	M/s Raftaar Processional Engg. Co.
	6	M/s Bio-Technical Resources
	7	M/s Auropol India Pvt. Ltd.
	8	M/s Ants Ceramics Pvt. Ltd.
	9	M/s HINDS Machineries
	10	M/s Baby Engineering Pvt. Ltd.
	11	M/s Just In Pinnacle Technology (P) Ltd.
	12	M/s K.N.Bioscience Pvt. Ltd., Hyderabad
	13	M/s HES Water Engineers (India) Pvt. Ltd.
	14	The New Horizons Institute of Technology
	15	M/s Surya Power Tree
	16	M/s S.S. Udyog
	17	M/s Bargachiya Cluster of Metal Product
	19	M/s Marcopolo
	20	M/s Meeco Solar And Infrastructure Associates
c.	**Technical Services**	
	1	Public Health Engineering Directorate, Murshidabad Div.,Berhumpur, Murshidabad, West Bengal
	2	Andhra Pradesh Heavy Machinery & Engg. Ltd., Konda Pally, AP
	3	Hindustan Zinc Ltd., Udaypur, Rajasthan
	4	Bagalamukhi Industries Pvt.Ltd., ADDA Industrial Plot, Durgapur, West Bengal
	5	Takshi Infra Pvt. Ltd., AJC Bose Road, Kolkata, West Bengal
	6	Housing Directorate, Govt. of WB, Kolkata, West Bengal, West Bengal
	7	Mizoram Food Processing Industries (MIFPROY), Aizawl, Mizoram
	8	Manbhum Private ITI, Raghunathpur, Purulia, West Bengal
	9	NHIT, City Centre, Durgapur, West Bengal
	10	Luthfa Polytechnic Institute, Molandighi, Shibpur, West Bengal

	11	Mallabhum Institute of Polytechnic, Mallabhum, West Bengal
	12	Purulia Polytechnic, Purulia, West Bengal
	13	Satyam Smelters Pvt. Ltd., Paschim Bardhaman, West Bengal
	14	Satyam Iron & Steel Co. Pvt. LTd., Mangalpur, Paschim Bhardhaman, West Bengal
	15	BHEL, Bokaro Thermal Power
	16	Sriram Vinyl & Chemicals Industries, Kota, Rajasthan
d.	**Testing & Calibration Services:**	
	1	Multitech Technofab Pvt. Ltd., Adityapur, Jamshedpur
	2	Indian Rare Earth Ltd., Orissa
	3	Testing Concern, Howrah, West Bengal
	4	Mangalpur Cement Pvt. Ltd., Raniganj, Burdwan, West Bengal
	5	R&D Associates, Mumbai
	6	Quality Solutions (India), Faridabad, Haryana
	7	Chemtex Speciality Ltd., Kolkata, West Bengal
	8	Jeseph Cement Bricks, Mangalpur, Burdwan, West Bengal
	9	BDG Metal & Power Limited, Bankura, West Bengal

Glimpses of Technology Transfer 2017-2018

Austempered Ductile Iron (ADI)

Domestic IIRP

Fluoride Detection Kit

Improved Iron Removal Plant

Improved Iron Removal Plant

Micro Fab Machine

Solar Tree

Wheel Chair

Five technologies transferred on CSIR Platinum Jubilee

Journal paper published 2017

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 High-Sensitivity Gas Sensor Toward Methanol Using ZnO Microrods: Effect of Operating Temperature	M. Sinha, R. Mahapatra, B. Mondal, R. Ghosh	Journal of Electronic Materials	2017, 46 (4), pp. 2476–2482
3	A novel approach to fabricate dye-encapsulated polymeric micro- and nanoparticles by thin film dewetting technique	Manosree Chatterjee, Abhiram Hens, Kuldeep Mahato, Namita Jaiswal, Nivedita Mahato, Nagahanumaiah, Nripen Chanda	Journal of Colloid and Interface Science	2017, 506, pp. 126-134
4	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
5	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
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12	An overview of modelling techniques employed for performance simulation of low–grade heat operated adsorption cooling systems	Ramesh P. Saha, Biplab Choudhury, Ranadip K. Das, Anirban Sur	Renewable and Sustainable Energy Reviews	2017, 74, pp. 364-376
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1	A generic method for rock mass classification	Vitthal M.Khatika, Arup Kr. Nandi	Journal of Rock Mechanics and Geotechnical Engineering	2018, 10 (1), pp. 102-116
2	Chelator Probe with Exceptionally High Stokes Shift for Selective Detection of OAc– with Red Emission: Application as a Biosensor	Koushik Pramanik, Pritam Ghosh, Debanjan Dey, Pijush Malpaharia, Swapan K. Chandra, Subhra Kanti Mukhopadhyay, Priyabrata Banerjee	ChemistrySelect	2018, 3 (4), pp. 1151-1156
3	Comparative study between different optimisation techniques for finding precise switching angle for SHE-PWM of three-phase seven-level cascaded H-bridge inverter	Sourabh Kundu, Arka Deb Burman, Santu K. Giri, Sarbani Mukherjee, Subrata Banerjee	IET Power Electronics	2018, 11 (3), pp. 600-609
4	Design of Innovative Pulse Thresher	B.K. Saha, S.K. Mandal	Journal of Scientific and Industrial Research (JSIR)	2018, 77 (1), pp. 50-54
5	Effect of Thermally Reduced Graphene Oxide on Mechanical Properties of Woven Carbon Fiber/ Epoxy Composite	Nitai Chandra Adak, Suman Chhetri, Naresh Chandra Murmu, Pranab Samanta, Tapas Kuila	Crystals	2018, 8 (3), article no. 111
6	Electrochemical behaviour of uncoated and phosphatidylcholine coated copper in hydrochloric acid medium	Dipankar Sukul, Aparesh Pal, Shipra Mukhopadhyay, Sourav Kr. Saha, Priyabrata Banerjee	Journal of Molecular Liquids	2018, 249, pp. 930-940
7	Hybrid $NiCo_2O_4$-$NiCo_2S_4$ Nanoflakes as High-Performance Anode Materials for Lithium-Ion Batteries	Shipra Raj, Yifan Dong, Pradip Kar, Liqiang Mai, Song Jin, Poulomi Roy	Chemistry Select	2018, 3 (8), pp. 2315-2320
8	Improved efficiency of ZnO hierarchical particle based dye sensitized solar cell by incorporating thin passivation layer in photo-anode	Priyanka Das, Biswanath Mondal, Kalisadhan Mukherjee	Applied Physics A	2018, 124, article no. 80
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14	Production of biodiesel from unused algal biomass in Punjab, India	Rachan Karmakar, Anita Rajor, Krishnendu Kundu, Nitin Kumar	Petroleum Science	2018, 15 (1), pp. 164–175
15	Progressive tool condition monitoring of end milling from machined surface images	Samik Dutta, Surjya K. Pal, Ranjan Sen	Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	2018, 232 (2), pp. 251-266
16	Soft wearable ionic polymer sensors for palpatory pulse-rate extraction	Ritwik Chattaraj, Subhasis Bhaumik, Siladitya Khan, Debabrata Chatterjee	Sensors and Actuators A: Physical	2018, 270, pp. 65-71
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21	Cellulolytic Enzyme Production by Trichoderma reesei MTCC 164 Using Cattle Dung and Cattle Dung Slurry of Biogas as a Substrate	Ajit Kaur, Urmila Gupta Phutela	International Journal of Pure & Applied Bioscience	2018, 6 (1), pp. 523-531
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Paper presented in Conference (April 2017 – March 2018)

Sl.	Title of the paper	Name of the Author	Conference	Date	Place
1	lawn Mower Trajectory tracking by wheeled mobile robot: Its consequences	Bibekananda Patra, Sambhunath Nandy	International Conference on Electronics, Material Engineering & Nano-Technology	April 28-29, 2017	Science City, Kolkata
2	Task space stiffness analysis of wire driven parallel manipulator	Pratibha Shinde, Soumen Sen, Sankar Nath Shome	International Conference on Electronics, Material Engineering & Nano-Technology	April 28-29, 2017	Science City, Kolkata
3	An approach to differentially flat modeling and control of surface water vehicle with vectored thrust	Manmohan Sharma, Soumen Sen, Sambhunath Nandy	Advances in Robotics, 3rd International Conference of Robotics Society of India	June 28 - July 02, 2017	IIT, Delhi
4	Automatic characterization of Materials using digital image processing	Samik Dutta, Himadri Roy	All India Seminar on 'Damage Assessment and Advanced NDE Techniques for Industrial Application'	July 15-16, 2017	The institute of Engineers (India), Durgapur Local Centre
5	Consideration of sensitization to find parameters for laser forming of AISI 304 steel	Shitanshu Shekhar Chakraborty	All India Seminar on 'Damage Assessment and Advanced NDE Techniques for Industrial Application'	July 15-16, 2017	The institute of Engineers (India), Durgapur Local Centre
6	Non destructive testing - a tool for damage assessment of different industrial components	D. Ghosh, H. Roy, B.N. Singh	All India Seminar on 'Damage Assessment and Advanced NDE Techniques for Industrial Application'	July 15-16, 2017	The institute of Engineers (India), Durgapur Local Centre
7	Non destructive testing - an inspection media for damage assessment	Subrata Roy, B.N. Singh	All India Seminar on 'Damage Assessment and Advanced NDE Techniques for Industrial Application'	July 15-16, 2017	The institute of Engineers (India), Durgapur Local Centre
8	Role of in-situ metallography for damage assessment of critical high temperature thermal power plant components	Abhijit Mondal, Himadri Roy, B.N. Singh	All India Seminar on 'Damage Assessment and Advanced NDE Techniques for Industrial Application'	July 15-16, 2017	The institute of Engineers (India), Durgapur Local Centre
9	Three-dimensional phase field simulation of speroidal grain formation to establish process control during semi solid processing of Al-7Si-0.3Mg alloy	Prosenjit Das, Pradip Dutta	All India Seminar on 'Damage Assessment and Advanced NDE Techniques for Industrial Application'	July 15-16, 2017	The institute of Engineers (India), Durgapur Local Centre

10	Tribilogical investigation of DLC Nanocoating prepared by RF sputtering	Santosh Singh, Amit Banerjee, Debojyoti Das, R.R. Sahoo	4th International Conference on Nano Science & Nano Technology	August 09-11, 2017	Chennai, India
11	Manufacturing of Engineering components with Austempered Ductile Iron - A Review	Suvradip Samaddar, Tishta Das, Ashish Kr. Chowdhury, Manju Singh	International Conference on Advances in Materials & Manufacturing	August 17-19, 2017	Amrita Viswa Vidhya- peetham, Bengaluru
12	Design & Simulation of a limbless climbing robot	Priyabrata Chopadhyay, A.H. Dikshit, Majunder, S. Ghoshal, A. Maity	2nd International Conference in Engineering & Science	August 18-19, 2017	Online Conference
13	Design and control of novel robotic gripper mechanism	Gourab Kumar Bagchi, R.K. Jain, Bhashkar Ghosh, Ajahar Khan	Advances in MEMs and Robotics in Manufacturing Industry	September 01-02, 2017	Udaipur, Rajasthan
14	Development of micro robots using smart actuators	Bhaskar Ghosh, R.K. Jain, Ajahar Khan, S.S. Roy, S. Mukhopadhyay	33rd National Conference on Mechanical Engineering on MEMS and Robotics in Manufacturing, IEI Udaipur	September 01-02, 2017	Udaipur, Rajasthan
15	Smart actuator using polyvinyl chloride/ polyaniline composite materials for robotic applications	Ajahar Khan, R.K. Jain	Advances in MEMs and Robotics in Manufacturing Industry	September 01-02, 2017	Udaipur, Rajasthan
16	Analysis of Surface texture of High aspect ratio blind micro holes on Titanium super alloy (Ti-6Al-4V) in micro electrical discharge drilling	Swapan Barman, Asit Baran Puri, Nagahanumaiah	9th International Congress on precision Machining (ICPM - 2017)	September 06-09, 2017	National Technical University, Athens, Greece
17	A comparative study on arsenic removal technologies and stabilisation of arsenic sludge	Pretam Mondal, Arup Saha, S.R. Debbarma, Biswajit Ruj	National Conference on Environmental Pollution, Biodiversity Conservation and Climate Change: Issues and Challenges	September 08-09, 2017	Nistarini College, Purulia, West Bengal
18	Removal of fluoride from groundwater using naturally available/low cost material	Santanu Nandi, Bhaskar Bishayee, Biswajit Ruj	National Conference on Environmental Pollution, Biodiversity Conservation and Climate Change: Issues and Challenges	September 08-09, 2017	Nistarini College, Purulia, West Bengal
19	Removal technologies of groundwater contaminants: Arsenic, iron, fluoride, nitrate and their effect on health: An overview	Biswajit Ruj	National Conference on Environmental Pollution, Biodiversity Conservation and Climate Change: Issues and Challenges	September 08-09, 2017	Nistarini College, Purulia, West Bengal

20	Walking speed measurement from EMG signal using Kurtosis of approximate coefficient	Habib Masum, Surajit Chattopadhya, Ranjit Ray, Subhasis Bhaumik	International Conference on Advanced Computational and Communication Paradigms	September 08-10, 2017	Sikkim Manipal Institute of Technology, Sikkim
21	In plane fracture toughness of graphene oxide incorporated carbon fibre/epoxy symmetric laminate	Nitai Chandra Adak, Suman Chhetri, N.C. Murmu, J.H. Lee, Pranab Samanta, Tapas Kuila	Processing and Fabrication of Advanced Materials (PFAM-XXVI)	October 16-21, 2017	Chonbuk National University, Republic of South Korea
22	Significantly improved mechanical properties of graphene/epoxy composites at low loading	Suman Chhetri, Nitai Chandra Adak, Pranab Samanta, N.C. Murmu, J.H. Lee	Processing and Fabrication of Advanced Materials (PFAM-XXVI)	October 16-21, 2017	Chonbuk National University, Republic of South Korea
23	Plasma: An ultimate solution in waste management	Priyabrata Banerjee	32nd National Symposium on Plasma Science & Technology	November 07-10, 2017	Institute of Plasma Research, Gandhinagar, Gujarat
24	Interaction of shock tube generated wave with solid obstacles	T. Murugan, I.P.S. Sandhu, Sudipta De, D.R. Saroha, A. Kundu	11th Internation High Energy Materials Conference & Exhibits	November 23-25, 2017	HEMRL, Pune, India
25	PS-Sim: A framework for scalable simulation of 'Big' participatory sensing data	Rajesh P. Barnwal, Nirmoy Ghosh, Soumya K. Ghosh, Sajal K. Das	IEEE Globecom - 2017	December 04-08, 2017	Singapore
26	Life prediction of hydraulic oil in hydraulic power steering	Pranab Samanta, Arabinda Sarkar, Tripty Maity, Naresh Chandra Murmu	9th International Conference on Industrial Tribology	December 06-09, 2017	Kolkata
27	Investigation of the tribological properties of graphene based water lubricant	Nitai Chandra Adak, Tapas Kuila, Naresh Chandra Murmu, Pranab Samanta	9th International Conference on Industrial Tribology	December 06-09, 2017	Kolkata
28	In-situ dry sliding wear monitoring using discrete wavelet transform based acoustic emission signal analysis	M. Phani Kumar, Himadri Roy, N.C. Murmu, P. Samanta, Samik Dutta	9th International Conference on Industrial Tribology	December 06-09, 2017	Kolkata
29	Investigation on deformation mechanism in laser forming of a bowl shaped surface out of a flat circular thin sheet using circular scan	S.S. Chakraborty, V. Racherla, A.K. Nath	Conference on Precision Engineering (COPEN-10)	December 07-09, 2017	IIT, Madras, Chennai

30	Evaluation of mechanical and metallurgical properties of different composition of zirconia toughened alumina	B.K. Singh, N. Mondal, S.S. Chakroborty, S.S. Roy	Conference on Precision Engineering (COPEN-10)	December 07-09, 2017	IIT, Madras, Chennai
31	Effect of thermally reduced graphene oxide on dynamic mechanical properties of carbon fibre/epoxy composite	Nitai C. Adak, Suman Chhetri, N.C. Murmu, Pranab Samanta, Tapas Kuila	The 7th National Conference on Processing and Characterization of Materials	December 08-09, 2017	NIT, Rourkela
32	Newly developed Schiff base molecules having small aliphatic chain, branched aliphatic chain and aromatic moiety for competitive corrosion inhibition study on mild surfaces in 1 M HCL medium: A combined experimental and theoretical approach	Sourav Kr. Saha, Naresh Chandra Murmu, Priyabrata Banerjee	3rd International Conference on Global Trends in Pure & applied Chemical Science	December 08-09, 2017	SRM University, Delhi-NCR Campus, Ghaziabad
33	A bio-inspired climbing robot: design, simulation and experiments	P. Chattopadhyay, A. Majumder, H. Dikshit, S.K. Ghoshal, A. Maity	1st International Conference on Mechanical Materials and Renewable Energy	December 08-10, 2017	Department of Mechanical Engineering, Sikkim Manipal Institute of Technology, Sikkim
34	Influence of pH and inoculum pretreatment on dark fermentative production of biohydrogen from vegetable waste hydrolysate and cheese whey	Bikram Basak, Amit Ganguly, Pradip K. Chatterjee	Bioprocessing India-2017, on 'Recent Trends in Bioprocessing for Health Care, Eenergy & Environment'	December 09-11, 2017	IIT, Guwahati
35	An eight-wire passively driven parallel manipulator: Development and Analysis	Pratibha V. Shinde, Soumen Sen, Pratik Saha, Dheeraj Singhal	3rd International and 18th National Conference on Machines and Mechanisms, 2017 (iNaCOMM-2017)	December 13-15, 2017	Bhabha Atomic Research Centre, Mumbai
36	Effect of whole body flexibility of caudal fin on propulsion performance	Srinivasa Reddy, Soumen Sen, Chandan Har, S.N. Shome	3rd International and 18th National Conference on Machines and Mechanisms, 2017 (iNaCOMM-2017)	December 13-15, 2017	Bhabha Atomic Research Centre, Mumbai

37	An approach to trajectory planning for underwater redundant manipulator considering hydrodynamic effects	Virendra Kumar, Soumen Sen, S.N. Shome, S.S. Roy	3rd International and 18th National Conference on Machines and Mechanisms, 2017 (iNaCOMM-2017)	December 13-15, 2017	Bhabha Atomic Research Centre, Mumbai
38	A modified PWM Scheme for three-level Inverters with Neutral Point Voltage Balancing for EV Applications	Sarbani Mukherjee, Santu Kumar Giri, Sourav Kundu, Subrata Banerjee	International Transportation Electrification Conference (ITEC) India, 2017	December 13-15, 2017	Pune, India
39	An altered PWM stragy for over modulation operation of three-level NPC inverter with capacitor voltage balancing	Santu Kumar Giri, Sarbani Mukherjee, Sourav Kundu, Subrata Banerjee	International Transportation Electrification Conference (ITEC) India, 2017	December 13-15, 2017	Pune, India
40	A carrier-based flexible discontinuous modulation scheme for three-level neutral-point clamped traction inverter	Sarbani Mukherjee, Santu Kumar Giri, Sourav Kundu, Subrata Banerjee	International Transportation Electrification Conference (ITEC) India, 2017	December 13-15, 2017	Pune, India
41	Non Destructive Testing (NDT) and other testing methods for quality assurance of Indian stone products	Debashis Ghosh	Global stone Technology Forum (GSTF-2017)-An International Stone Technology Conference	December 14-15, 2017	Kishengarh, Ajmer, Rajasthan
42	Effect of hydrazine reduced graphene oxide on tensile and flexural properties of carbon fiber/epoxy composite	Nitai Chandra Adak, Suman Chhetri, N.C. Murmu, Tapas Kuila, Pranab Samanta	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
43	Electrochemical behavior of Non-perfluorinated polymer based IPMC actuator for robotic application	Ajahar Khan, Ravi Kant Jain, Bhaskar Ghosh	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
44	Design of security and surveillance system in a mobile robot	R.K. Jain, Kumarika Sahu, Ajahar Khan, Bhashkar Ghosh, Imtiaz Alam, Arijit Chowdhury, Rajesh P. Barnwal	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur

45	Covalent functionlization of hexagonal boron nitride (h-BN) nanoparticles for lubrication of steel-steel tribocontacts	Suprakash Samanta, Deepika M., Rashmi R. Sahoo	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
46	Evaluation of mechanical and metallurgical properties of multiwall CNT reinforced zirconia toughened alumina	B.K. Singh, R. Ghosh, M. Mondal, S.S. Roy	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
47	Design and control of shape Memory Alloy (SMA) wire for micro robotics applications	Bhaskar Ghosh, R.K. Jain, Ajahar Khan	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
48	Optimization of degree of sphericity of ADC12 Al alloy using Taguchi method	Sujeet Kumar Gautam, Himadri Roy, Aditya Kumar Lohar, Sudip Kumar Samanta, Goutam Sutradhar	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
49	A comparative rheological study of alumina feedstock for micro-PIM	Sk Tanbir Islam, Sudip Kumar samanta, Aditya Kumar Lohar, Nagahanumaiah, Asish Bandyopadhyay	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
50	Prediction of droplet diameter in E-jet printing using statistical method	Amit Kumar Ball, Raju Das, Shibedu Shekhar Roy, Dakshina Ranjan Kisku, Naresh Chandra Murmu	International Conference on Sustainable Manufacturing, Automation and Robotics Technology (IC-SMART)	December 15-16, 2017	CSIR-CMERI, Durgapur
51	Elucidation of the reaction mechanism of copper catalyzed water oxidation	Lisa Roy, Alexander Brinkmeier, Frank Neese, Shengfa Ye, Franc Meyer	Asia Pacific Conference in Theoretical and Computational Chemistry	December 15-17, 2017	IIT, Bombay, Mumbai
52	Detection of signals in additive cauchy noise with unknown parameters	Siva Ram Krishna Vadali, Prof. Pyiyadip Ray	14th IEEE India Council International Conference 2017 (IEEE-INDICON-2017)	December 15-17, 2017	IIT, Roorkee
53	Design development and experimental validation of an underwater acoustic pinaer system	Siva Ram Krishna Vadali, Samarjeet Das	14th IEEE India Council International Conference 2017 (IEEE-INDICON-2017)	December 15-17, 2017	IIT, Roorkee

54	An improved learning based multilayer height control strategy in LMD process	Apurba Das, Sarbani Mukherjee, Santu Kumar Giri, Aditya Kumar Lohar	14th IEEE India Council International Conference 2017 (IEEE-INDICON-2017)	December 15-17, 2017	IIT, Roorkee
55	Design and Development of plasma arc driven System for producing energy from Municipal Solid Waste mitigation of Green House Gases (GHGs)	Abhijit Hazra, Saikat Das, Amit Ganguly, Partha Das, Pradip Kumar Chatterjee, Naresh Chandra Murmu, Priyabrata Banerjee	International Conference on Solid Waste Management	December 15-17, 2017	Professor Jayashankar Telangana State Agricultural University (PJTSAU), rajendranagar, Hyderabad, Telengana, India
56	Proportional multi resonant controller based cascaded voltage control scheme of three phase four leg inverter for non-linear loads in OFF Grid solar photovoltaic application	Ikkurti Sai Chaitanya, Hanumanth Prasad Ikkurti	8th National Power Electronics Conference 2017	December 18-20, 2017	College of Engineering, Pune
57	Tuning graphene oxide surface foe high performance epoxy nanocomposites	Suman Chhetri, N.C. Murmu, Pranab Samanta, Tapas Kuila	International Conference on Advanced Nanomaterials and Nanotechnology (ICANN 2017)	December 18-21, 2017	IIT, Guwahati
58	Functionalization and doping of 2D superlattices for high energy supercapacitor application	Sanjit Saha, N.C. Murmu, Tapas Kuila	International Conference on Advanced Nanomaterials and Nanotechnology (ICANN 2017)	December 18-21, 2017	IIT, Guwahati
59	Dynamic analysis of a bio-inspired climbing robot using ADAMS-SIMULINK co-simulation	P. Chattopadhyay, H. Dikshit, A. Majumder, S. Ghosal, A. Maity	International Conference on Electrical, Electronics, Material & Applied Science	December 22-23, 2017	Secunderabad
60	Lubricating performances of covalently stitching and surface modified graphene oxide paraffin oil suspension	Suprakash Samanta, Reshmi Ranjan Sahoo	Indian Chemical Engineering Conference	December 27-30, 2017	Haldia Institute of Technology, Haldia
61	A learning based approach towards closed loop height control of Direct metal deposition process	Apurba Das, Sarbani Mukherjee, Santu Kumar Giri, Aditya Lohar	1st International Conference on Mechanical Engineering (INCOM) 2018	January 04-06, 2018	Jadavpur University, Kolkata

62	A learning based approach towards closed loop height control of Laser metal Deposition	Apurba Das, Sarbani Mukherjee, Santu Kumar Giri, Aditya Kumar Lohar	1st International Conference on Mechanical Engineering (INCOM) 2018	January 04-06, 2018	Jadavpur University, Kolkata
63	Experimental and numerical investigation of flow over 70o/40o double delta wing at low reynold numbers	Biswajit Sharma, Rabindra Nath Barman, Thangadurai Murugan	1st International Conference on Mechanical Engineering (INCOM) 2018	January 04-06, 2018	Jadavpur University, Kolkata
64	Laser beam welding of dissimilar materials - An overview	Manoja Kumar Biswal, Anirban Changdar, Alok K. Das, S. Chattopadhyaya, Sudip K Samanta	1st International Conference on Mechanical Engineering (INCOM) 2018	January 04-06, 2018	Jadavpur University, Kolkata
65	Modeling of overcut and taper angle of high aspect ratio micro holes on bulk metallic glass in MEDD	Swapan Barman, Nagahanumaiah, Asit Baran Puri	1st International Conference on Mechanical Engineering (INCOM) 2018	January 04-06, 2018	Jadavpur University, Kolkata
66	Optimization of process parameters in Laser Metal Deposition	Anirban Changdar, A.K. Lohar, N.C. Murmu, S. Chattopadhyaya	1st International Conference on Mechanical Engineering (INCOM) 2018	January 04-06, 2018	Jadavpur University, Kolkata
67	A study of moisture measurement of transformer oil	Kalyan Kumar Mistry, Ranajit Ghosh	Sensor Technologies & its application in power genaration	January 23-24, 2018	NETRA, NTPC, Noida
68	A combined crystalographic and thermodynamic interaction of explosive TNP with a tritopic receptor	Pritam Ghosh, Suparna Paul, Naresh Chandra Murmu, Priyabrata Banerjee	22nd CRSI National Symposium in Chemistry	February 02-04, 2018	Pt. Ravishankar Shukla University, Raipur, Chattisgarh
69	Evaluation of metallurgical and mechanical properties of CeO2 reinforced zirconia toughened alumina	B.K. Singh, Nitai Chandra Adak, S.S. Chakraborty, Nilrudra Mandal	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
70	Static and dynamic mechanical properties of glass/carbon fiber reinforced epoxy composite	Nitai Chandra Adak, Suman Chhetri, Bipin Kumar Singh, N.C. Murmu, Pranab Samanta, Tapas Kuila	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
71	Effect of Nanostructured 8% partially yttria stabilized zirconia (YSZ) coating in oxidation behaviour of inconel alloy	D. Ghosh, S. das, H. Roy	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur

72	A linear regression model, based on energy balance approach, to estimate dilution in laswer cladding	Shitanshu Shekhar Chakraborty, Samik Dutta	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
73	In-situ monitoring and control of laser cladding : a survey	Samik Dutta, Shitanshu Shekhar Chakraborty, Rajesh Prasad Barnwal	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
74	Brain MR Image analysis using discrete wavelet transform with GLCM feature analysis	Srinivasan Aruchamy, Partha Bhattacharya, Goutam Sanyal	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
75	Realisation of industry 4.0 complaint manufacturing : a brief overview	Rajesh Prasad Barnwal, Samik Dutta	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
76	Effective study of MRR based on different processes parameters in micro-electrical discahrge machining	Arjita Das, Sucharita Saha, Sourav Halder, Kalyan Chatterjee, Nagahanumaiah	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
77	Optimization of micro hardness and fracture toughness of Zirconia Toughened Alumina (ZTA) under different compacting pressures and sintering temperatures using Response Surface Methodology (RSM)	Subhrojyoti Mazumder, Kunal Ghosh, Himadri Roy, Nilrudra Mondal	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
78	Identification of diseased cells using image processing	Puja Mitra, Samik Dutta, Abhiram Hens, Nagahanumaiah	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
79	Microstructure and mechanical properties of rheocast of ADC12 auminium alloy	Sujeet Kumar Gautam, Himadri Roy, Aditya Kumar Lohar, Sudip Kumar Samanta, Goutam Sutradhar	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM - 2018)	February 16-17, 2018	CSIR-CMERI, Durgapur
80	Biohydrogen production by dark fermentation of vegetable waste and cheese whey	Bikram Basak, Amit Ganguly, Pradip Kumar Chatterjee	Recycle-2018, International Conference on Waste Management	February 22-24, 2018	IIT, Guwahati

81	A combined density functional theory and molecular dynamics simulation study of three amine derivativrs for efficient anticorrosion materialk on the ccarbon steel surface in the corrosive medium	Manilal Murmu, Sourav Kumar Saha, N.C. Murmu, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
82	Analytical and finite element solution for vibration characteristics of CNT-reinforced polymer	Surendra Kumar, Shweta Paunikar	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
83	Cobalt sulfide/nickel sulfide composite for electrocatalytic water splitting application	Subhasis Shit, Naresh Chandra Murmu, Tapas Kuila	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
84	Comparative study on the role of functionalisation and doping of 2D superlattices for high energy supercapacitor application	Sanjit Saha, N.C. Murmu, Tapas Kuila	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
85	Dry sliding wear and friction behaviour of Ni-SiC- graphene oxide composite coating prepared bty pulsed electrodeposition	Santosh Singh, Suprakash samanta, Alok Kumar Das, Rashmi R. Sahoo	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
86	Effect of graphene oxide dispersed nanolubricans of steel stee; tribo-pair	Gayatri Paul, Tapas Kuila, N C Murmu	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
87	Effect of wettability on covalent functionalized graphene oxide with variable chain length anine for fluoride lubrication of steel-steel tribocontact	Suprakash samanta, Santosh Singh, Rashmi R. Sahoo	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
88	Evaluation of mechanical and metallurgical properties of graphene reinforced yttria stabilized zirconia	B.K. Singh, Subhrojyoti Mazumder, Nitai Chandra Adak, S.S. Roy, Nilrudra Mondal	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur

89	Experimental and theoretical studies of Schiff base molecules as effective corrosion inhibitors for mild steel in 1 M HCL medium	Sourav Kurmar Saha, N.C. Murmu, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
90	Functionalization of graphene oxide surface for high performance epoxy nanocomposite	Suman Chhetri, Naresh Chandra Murmu, Tapas Kuila	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
91	Lumininescent Metal-Organic frameworks (LMOFs) : a study of selectvity and sensitivity of an explosive and magnetic water pollutant, 2,4,6-Triibtrophenol	Abhijit Hazra, Baharul Islam, Pritam Ghosh, N.C. Murmu, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
92	Performance study of hybrid energy storage system using battery and supercapacitor	H.S. Chatterjee, S. Mukherjee, S. Sen, S.K. Giri, T. Kuila, P. Samanta, N.C. Murmu	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
93	Recognition of biologically ubiquitous fluoride annd heavy transition metal ion (Cd^{2+} and Hg^{2+}) by novel ditopicchemoreceptor	Suparna Paul, Additi Roy Chowdhury, N.C. Murmu, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
94	Red emmisive chelatorprobe fo selective recognirtion of biotic anion Oas-wth exceptionally high stroke shift: an explorationof its biosensing ability	Debanjan Dey, Pritam Ghosh, Khueli Dome, Naresh Chandra Murmu, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
95	Study of tribological behavior of Ti-Si-B-C nanocomposites coating deposited by magnetron sputtering under ball on disc condition	Parikshit Mahato, N C Murmu, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
96	Synthesis of Cu_2O graphene composite by electrochemical deposition for electrochemical determination of H_2O_2	J. Sharath Kumar, Naresh Chandra Murmu, Tapas Kuila	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
97	Synthesis of proficient hydrazine functionalized and fluorimeric sensing of F-	Amita Mondal, Sourav Bej, Additi Roychowdhury, Priyabarata Banerjee	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur

98	Theoretical perspective of BN nanotube/fullerene based hydrogen storage beyond ammonia borane	Lisa Roy	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
99	Tribological characterization of velectroless Ni-P coatings under dry lubricated condition with varying composite phase	Abhilash Jose, Santosh Singh, Dinesh Kumar Kontees, Alok Kumar Das, Rashmi R. Sahoo	National Conference on Graphene and Functional Materials (NCGFM-2018)	February 23-24, 2018	CSIR-CMERI, Durgapur
100	Numerical study of blast wwave generation through shock tube and its comparision with free-field blast wave parameters	Murugan Thangadurai, Naveen Raj, C.L. Dora, Inderpal Singh Sandhu	5th National Symposium on Shock Waves	February 26-28, 2018	TBRL, Chandigarh
101	Detection of Alzhemier's diseases in brain MR images using hybrid local graph structure	Srinivasan Aruchamy, Partha Bhattacharya, Goutam Sanyal	IEEE International Conference on Computing for Sustainable Global Development	March 14-16, 2018	BVICAM, New Delhi
102	Experimental study of blast wave mitigation in open cell foams	Inderpal Singh Sandhu, Meenakshi Bhatt Kala, Murugan Thangadurai, Manpreet Singh, Prashant S Alegaonkar, D.R. Saroha	International Conference on Composite Materials: Manufacturing, Experimental Techniques, Modeling and Simulation	March 15-17, 2018	Jalandhar
103	Design and development of prototype tooth coloured orthodontic brackets targeting mass usage	Prosenjit Das	105th Indian =Science Congress	March 16-20, 2018	Manipur University, Imphal
104	Proportional multi resonant controller based cascaded voltage control schemeof three phase four leg inverter for nonlinear loads in OFF grid solar photovoltaic applications	Sai Chaitanya Ikkurti, Hanumath Prasad Ikkurti	International Conference on Recent Trends in Electrical, Control and Communication RTECC-18	March 20-22, 2018	Crescent University, Chennai
105	Brain MR image analysis using discrete wavelet transform with fractal feature analysis	Srinivasan A., Partha Bhattacharya, Anand Prasad I., Gautam Sanyal	IEEE 2nd International Conference on Electronics communication and Aerospace technology	March 29-31, 2018	RVS technical Campus, Coimbatore

Chapter Contribution to Books

1	Gasifiers: types, operational principle and commercial forms (BOOK CHAPTER), Chanchal Loha, Malay K. Karmakar, Santanu De, Pradip K. Chatterjee in Coal and Biomass Gasification, 2018, pp 63-91, ISBN 978-981-10-7334-2
2	Hydrodynamics of circulating fluidized bed systems (BOOK CHAPTER), Malay K Katmakar, Chanchal Loha, Santanu De, Pradip K. Chatterjee in Coal and Biomass Gasification, 2018, pp 03-114, ISBN 978-981-10-7334-2
3	Polyaniline-nanomaterials composites: structural, optical and electrical properties (BOOK CHAPTER), Mrinmoy Goswami, Ranajit Ghosh, Ajit Kumar Meikap, in Polyaniline Blends, Composites, and Nanocomposites, 2018, Pages 305–325, ISBN: 978-0-12-809551-5
4	Thermochemical Conversion of Biomass to Bioenergy: A Review (BOOK CHAPTER), Krishnendu Kundu, Ayoma Chatterjee, Tamashree Bhattacharyya, Madhuka Roy and Ajit Kaur, in Prospects of Alternative Transportation Fuels, 2018, pp 235-268, ISBN 978-981-10-7517-9
5	Gold Nanostructure in Sensor Technology: Detection and Estimation of Chemical Pollutants (BOOK CHAPTER), P. Nath, N. Priyadarshni, S. Mandal, P. Singh, R.K. Arun in Environmental, Chemical and Medical Sensors, 2018, pp 31-66, ISBN 978-981-10-7750-0
6	Polymeric-Patterned Surface for Biomedical Applications (BOOK CHAPTER), N. Jaiswal, A. Hens, M. Chatterjee, N. Mahata, N. Chanda in Environmental, Chemical and Medical Sensors, 2018, pp 227-25

IP Portfolio

Patent Filed		
Sl.	**Title**	**Inventors**
1	Standalone multi channel-speed & direction controller system for underwater thrusters	Dibyendu Pal, Dheeraj Kumar Singhal, Jyotimoy Karmakar
2	An inverted mini-microscope with imaging capabilities	Abhiram Hens, Nripen Chandra, Nagahanumaiah, Vimlesh Kumar Sharma, Puja Mitra, Saurav Haldar, Kalyan Chatterjee
3	A new process for detection and measurement of fluoride level in water	Priyabrata Banerjee, Additi Roy Chowdhury, Asit Kumar Batabyal, Sourav Bej
4	Gravity cast in-situ Al-15Mg_2Si-4.5Si composite and a process thereof	Prosenjit Das, Adwaita Maiti
5	Automatic transverse moving tilling unit for orchards	Jagdish Manikrao, Pradeep Rajan, Paramjeet Singh, Ajay Yadav
6	Development of technology for safe disposal of Municipal Solid Waste utilizing high temperature plasma	Amit Ganguly, Priyabrata Banerjee, Partha Das, Subho Samanta, Saikat Das, Pradip Kumar Chatterjee, Harish Hirani
7	Safe Disposal of Arsenic Sludge through Microwave treatment and the process thereof	Biswajit Ruj, Swarup Ranjan Debbarma, Prasant Mondal
8	A device for recovery of fuel oil & gas from plastic waste and the process thereof	Biswajit Ruj, Harish Hirani, Rohit Kumar Singh, Surendra Pratap
9	Tooth colored dental brackets and a process thereof.	Prosenjit Das, Pinaki Das, Tapan Ray, Nilrudra Mandal, Manju Singh

Copyright Filed		
Sl.	**Title**	**Authors**
1	Brochure for Multi-Fab Machine and the code for its functioning	Soumen Mandal, Kalyan Chatterjee, Nagahanumaiah, Anirudh Kumar, Manish Kumar Singh
2	An initiative towards environment friendly disposal of inert material in municipal solid waste locally available in Durgapur, West Bengal through development of bricks	Debashis Das, Abhijit Chatterjee, P.K. Chatterjee
3	A method of assessment of corrosion risk of concrete structure through characteristic resistivity values	Debashis Das, Abhijit Chatterjee, P.K. Chatterjee
4	A mix proportion development process for making of bricks from municipal solid waste inert material locally available in Durgapur, West Bengal	Debashis Das, Abhijit Chatterjee, P.K. Chatterjee
5	Printed circuit board designing of the sensor station for detection of salivary fluoride level in batch scale	Priyabrata Banerjee, Pritam Ghosh, Subhasis Biswas, Naresh Chandra Murmu
6	Pedal assisted high power E-Rickshaw	Ashok Kumar Prasad, Atanu Maity, Biplob Roy, Dilip Garain, Sankar Chel
7	Solar Artifact	Atanu Maity, Sabyasachi Mosan
8	Hybrid Controller for Long Travel Range with Sub-Micron Resolution	Arpita Mukherjee, Uma Datta, Pratap Karmakar, Siddheswar Sen, Bipul Kumar, Saikat Kumar Shome, Sushil Murmu, Pradyumna Kumar Sahu
9	Feed forward and Feedback Controller for Piezo Actuator	Arpita Mukherjee, Uma Datta, Pratap Karmakar, Siddheswar Sen, Bipul Kumar, Saikat Kumar Shome, Sushil Murmu, Pradyumna Kumar Sahu
10	Drawings for Amphibian Robot for post disaster rescue operation in inland shallow water	Sarbari Datta, Suman Kumar Char, Arijit Chowdhury, Abhijit Das, Sandeep Jain, Umesh Patkar, Anjan Lakra, Nalin Paul
11	Design of Official Bilingual Website and its Content Management System of CSIR-CMERI, Durgapur	Rajesh P. Barnwal, Pratyush Kumar Pal, Partha Bhattacharya, Harish Hirani
12	Development of technology for safe disposal of municipal solid waste utilizing high temperature plasma	Partha Das, Subrata Kumar Mandal, Subho Samanta, Vinay P Tigga, Priyabrata Banerjee, Amit Ganguly, Pradeep Kumar Chatterjee, Harish Hirani

Design Registration Filed		
Sl.	**Title**	**Inventors**
1	Ginger Slicing Machine	Lal Gopal Das, Chanchal Loha, Pradip K. Chatterjee, Rakesh Kumar Padhi, Sanjib Mukherjee
2	Rectangular Grass Bundling Machine	Dilip Kumar Biswas, Man Singh Azad, Santosh Kumar Das
3	Design and Development of Plasma Torch for Municipal Solid Waste Gasification	Amit Ganguly, Priyabrata Banerjee, Partha Das, Subho Samanta, Priyabrata Chattopadhyay, Pradip Kumar Chatterjee, Harish Hirani
4	Ginger Drying Machine	Chanchal Loha, Anjali Chatterjee, Lal Gopal Das, Biswajit Chakraborty, Pradip K. Chatterjee
5	Solar Artifact	Atanu Maity, Harish Hirani
6	Design and Development of 1.2 Kw Artifact solar Umbrella (SWASTIKA)	Pranabendu Saha, Ravi Kant Jain, Santu Kumar Giri, Chanchal Das, Sudip Kuamr Samanta
7	Biomass grinder cum stirrer for biomethanation of food waste	Partha Das, Subho Samanta, Bittagopal Mondal, Amit Ganguly, Harish Hirani,
8	Amphibian robot for post disaster rescue operation in inland shallow water	Sarbari Datta, Suman Kumar Char, Arijit Chowdhury, Abhijit Das, Umesh Patkar

Dateline

Date	Events
April 02, 2017	World Autism Awareness Day
April 14, 2017	Plantation Programme on the occasion of 126th Birthday of Dr. Bhim Rao Ambedkar
April 29, 2017	Blood Donation Camp to commemorate the 126th Birth Anniversary of Dr. Bhim Rao Ambedkar
May 11, 2017	Observance of National Technology Day
June 07, 2017	Visit of Ethiopian Delegates regarding CSIR-MIDI Twinning Programme
June 21, 2017	International Yoga Day Celebration
July 10, 2017	Management Review Meeting
July 18, 2017	Second Periodic Audit (ISO 9001:2008) by DNV GL
August 2-3, 2017	Workshop on Science Pedagogy in Schools
August 10, 2017	Pledge on the occasion of completion of 75th year of launch of Quit India Movement
August 15, 2017	Independence Day Celebration
August 18, 2017	Observance of "Sadbhavana Diwas"
September 14-25, 2017	Hindi Pakhwada
September 16, 2017	Outreach Programme of IISF-2017
September 16-18, 2017	CSIR Platinum Jubilee 'Technofest'
September 18, 2017	JIGYASA (CSIR-KV Sangathan)
September 29-30, 2017	Observance of 'Swachchata hi Seva'
October 08, 2017	Industry R&D Academia meet
October 09, 2017	CSIR Platinum Jubilee Foundationday Celebration
October 12-13, 2017	National Workshop on Shock and Blast Wave Research in India: The Past, Present and Future
October 30–November 04, 2017	Vigilance Awareness Week
October 31, 2017	Observation of 'Rashtriya Ekta Diwas'
November 01-03, 2017	Workshop on 'Technology Commercialization and Transfer' through Video Conference
November 01-15, 2017	Observance of Swachhta Pakhwda
November 03, 2017	Visit of Shri Keshari Nath Tripathi, Honorable Governor of West Bengal
November 09, 2017	35th Management Council Meeting
November 20-21, 2017	Visit by Jpanese Delegation
November 22, 2017	54th Research Council Meeting
November 27, 2017	Celebration of Constitution Day
November 29–December 13, 2017	All India FIDE rating Open Chess Tournament
December 14, 2017	Pre-Conference (IC-SMART) Workshop on Additive Manufacturing & Micro -Nano Systems Engineering
December 15-16, 2017	International Conference on Sustainable Manufacturing, Automation and Robotics Technologies (IC-SMART)
December 16-17, 2017	Paschim Bardhaman District Under-9, Under-11 & Veteran Badminton Tournament
December 20-26, 2017	West Bengal Sub Jr. & Jr. State Ranking Badminton Tournament
January 25, 2018	Celebration of National Voters Day

January 26, 2018	Republic Day Celebration
January 27-28, 2018	Annual Sports
January 30, 2018	Observance of Silence
February 12-13, 2018	Workshop on Imparting Knowledge on Vigilance and Tendering Process
February 14-16, 2018	Skill Development Training Programme for New Recruits
February 16-17, 2018	National Conference on Advanced Materials, Manufacturing and Metrology (NCAMMM-2018)
February 23-24, 2018	National Conference on Graphene and Functional Materials (NCGFM-2018)
February 26, 2018	CSIR-CMERI Diamond Jubilee Culminating Programme
March 14, 2018	Hindi 'Kavita Path Pratiyogita'
March 27, 2018	Workshop on 'Emerging Technologies on Water Purification for rural application'

Manpower as on March 31, 2018

Dr. Harish Hirani Director, CSIR-CMERI, Durgapur	
Scientist & Technical Staff	
Sl.	**Name**
Chief Scientist	
1	Chatterjee, Abhijit
2	Chatterjee, Dr. Pradip Kumar
3	Maity, Dr. S.N.
4	Sen Sharma, Soumya
5	Sen, Dr. Ranjan
Senior Principal Scientist	
1	Banerjee, Dr. Partha Sarathi
2	Banerji, Dr. Debojyoti
3	Bhattacharjee, Dr. Partha
4	Chatterjee, Dr. Anjali
5	Chatterjee, Dr. Avik
6	Datta, Sarbari
7	Gangopadhyay, Dr. Tapas
8	Kumar, Dr. Surendra
9	Kushwaha, Aswani Kumar
10	Maity, Dr. Atanu
11	Mukherjee, Dr. Somnath
12	Nagahanumaiah, Dr.
13	Nandi, Dr. Sambhunath
14	Ruj, Dr. Biswajit
15	Sarkar, Maw Nandi
16	Singh, B.N.

Principal Scientist	
1	Bansal, B.D.
2	Barman, Swapan
3	Batabyal, Dr. Asit Kumar
4	Biswas, Dilip Kumar
5	Chatterjee, Dr. Dipankar
6	Choudhury, Dr. Biplab
7	De, Dr. Sudipta
8	Debbarma, Dr. S.R.
9	Ganguly, Dr. Amit
10	Ghosh, Dr. Bibhuti Bhusan
11	Ghosh, Dr. Debasish
12	Jain, Dr. Ravi Kant
13	Karmakar, Sankar
14	Kundu, Dr. Krishnendu
15	Lohar, Dr. Aditya Kumar
16	Maji, Dr. Palash Kumar
17	Mondal, Subrata Kumar
18	Murmu, Dr. Naresh Chandra
19	Nandi, Dr. Arup Kumar
20	Prasad, Ashok Kumar
21	Rajan, Dr. Pradeep
22	Ray, Dr. Ranjit
23	Saha, Dr. Atanu
24	Samanta, Dr. Sudip Kumar
25	Sen, Dr. Soumen
26	Singh, Manju
27	Sinha, Dr. Anupam
28	Uke, Kamalkishor J
Senior Scientist	
1	Banerjee Dr. Priyabrata
2	Barnwal Rajesh Prasad
3	Chanda Dr. Nripen
4	Das Dr. Debashis
5	Das Dr. Lal Gopal
6	Dutta Dr. Samik
7	Ghosh Dr. Sarita
8	Giri Santu Kumar
9	Ikkurti Hanumath Prasad
10	Karmakar Dr. Malay Kumar
11	Kuila Dr. Tapas
12	Kumar Virendra

13	Loha Dr. Chanchal
14	Mahapatra Abhijit
15	Mistry Dr. Kalyan Kumar
16	Mondal Dr. Nilrudra
17	Mukherjee Dr. Arpita
18	Murugan Dr. T.
19	Pal Dibyendu
20	Patkar Umesh S.
21	Ray Dr. Dip Narayan
22	Roy Dr. Himadri
23	Roy Dr. Poulomi
24	Saha Dr. Binod Kumar
25	Saha Dr. Suman
26	Sahoo Dr. Rashmi Ranjan
27	Singh Dr. Satya Prakash
28	Singh Dr. Shailesh Kumar
29	Singh Rajpal
30	Vadali Siva Ram Krishna
31	Yadav Ajay
Scientist	
1	Akhtar, Mohd. Afroz
2	Arora, Amon
3	Aruchamy, Srinivasan
4	Arun, Ravi Kumar
5	Azad, Man Singh
6	Chakraborty, Dr. S. Shekhar
7	Chatterjee, Rudra Prasad
8	Chattopadhyay, Priyabrata
9	Das, Abhijit
10	Das, Dr. Prosenjit
11	Das, Moloy Narayan
12	Das, Partha
13	Ghosh, Dr. Ranajit
14	Hens, Dr. Abhiram
15	Kumar, Amit
16	Kumar, Anirudh
17	Kumar, Nitish
18	Kumar, Sumit
19	Laha, Dr. Swarup Kr
20	M., Jagdish
21	Mallisetty, P.K.
22	Mandal, Soumen

23	Mondal, Dr. Bittagopal
24	Mondal, Sourav
25	Pal, Partha Sarathi
26	Prakash, Ved
27	Rasool, Showkat
28	Reddy, S.
29	Samanta, Dr. Pranab
30	Samanta, Subho
31	Shikha
32	Shome, Saikat Kumar
33	Singh, Gurlovleen
34	Sivaprakash, Dr. S.
35	V., Vibin
Junior Scientist	
1	Sahu, Pradyumna Kumar
Senior Technical Officer, Executive Engineer, RMO	
1	Alam, Munshi Amirul
2	Banerjee, Manas
3	Biswal, Manoja Kumar
4	Budh, Jiwan
5	Chatterjee, Somnath
6	Choudhury, Kalyan Kumar
7	Das, Manick
8	Das, Samir Kumar
9	De, Sanjib Kumar
10	Debnath, Amitava
11	Deghoria, Banamali
12	Guha, Sumit
13	Gupta, Ajay Kumar
14	Jain, Sandeep
15	K., Viji
16	Kumar, Siddhartha
17	Maji, Jnanendra Prasad
18	Matia, Santu
19	Mitra, Amitava
20	Mungra, Jagroop Singh
21	Padhi, Rakesh Kumar
22	Patra, Biswajit
23	Ray, Subrata
24	Ray, Tapan
25	Roy, Ajoy Kumar
26	Saha, Dr. Swati

27	Saha, Pranabendu
28	Sharma, Prabhu Dutt
29	V.G., Arun Baiju
30	Verma, Manoj
31	Yadav, Om Prakash
Technical Officer	
1	Bhakta, Deepak Kumar
2	Biswajit, Sikdar
3	Biswas, Samit
4	Char, Suman Kumar
5	Chatterjee, Sumanta
6	Chattopadhyay, Anindya
7	Chel, Sankar
8	Das, Debi Prasad
9	Das, Santosh Kumar
10	Har, Chandan
11	Karmakar, Bipradas
12	Kundu, Soumyajit
13	Layek, Ansuman
14	Maiti, Adwaita
15	Majumder, Arup
16	Naskar, Shantanu Kumar
17	Pujar, S.Y.
18	Roy, Biplob
19	Saha, Pratik
20	Sen, Siddheswar
21	Suresh, Bonela
22	Swarnakar, Biplab
23	Tigga, Vinay P.
Technical Assistant	
1	Adhikary, Prasanta
2	Alam, Imtiaz
3	Banerjee, Soma
4	Banerjee, Sumanta
5	Biswas, Subhasis
6	Bouri, Dayamay
7	Chatterjee, Kalyan
8	Chowdhury, Arijit
9	Das, Debasish
10	Das, Sudeshna
11	Garai, Garibdas
12	Garain, Dilip

13	Haldar, Ranaditya
14	Halder, Saurav
15	Hansda, Bimal
16	Hussain, Md. Musraph
17	Hussain, Nasir
18	Kansabanik, Sourav
19	Karmakar, Jyotirmoy
20	Karmakar, Pratap
21	Khalkho, Anmol
22	Khatua, Rajib
23	Kuchlyan, Ajoy
24	Maity, Tripty
25	Mandal, Jiten
26	Mondal, Abhijit
27	Mondal, Rabisankar
28	Murmu, Sushil
29	Nandan, Sourav
30	Pal, Pratyush Kumar
31	Rajak, Anup
32	Saha, Arup
33	Singh, Ram Pyare
Senior Technician	
1	Bouri, Bidhan Chandra
2	Dutta, Debasish
3	Halder, Subhas Chandra
4	Hembram, Tarapada
5	Lekhi, Kiran Bala
6	Mandi, Ramnath
7	Patar, Swapan Singh
8	Pathak, P.N.
9	Ram, Hari Lal
10	Ram, Jai
11	Ram, Suresh
12	Sardar, Aswini Kumar Singh
13	Sardar, Harakripa Singh
14	Sarkar, Diponkar
15	Sau, Asit Kumar
16	Sharma, Bodh Raj
17	Singh, Abhijeet
18	Singh, Amarjit
19	Singh, Inderjit
20	Singh, Pannu Kamaljit
21	Singh, Ranjit

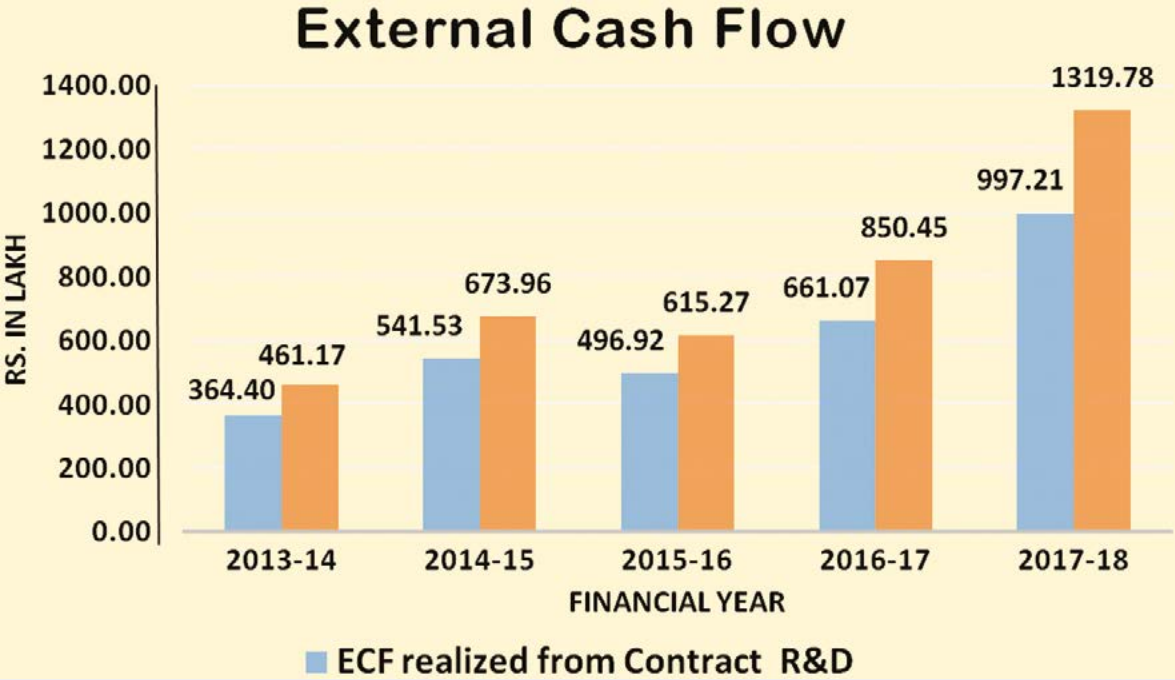
Technician	
1	Ansari, Meraz
2	Bhattacharjee, Sukanta
3	Bindhani, Jagannath
4	Chakraborty, Biswajit
5	Chandra, Amit
6	Chatterjee, Pallab
7	Chowdhury, Palash
8	Das, Chanchal
9	Das, Tanmoy Kumar
10	Dolai, Ratan Chandra
11	Dutta Pradip Kumar
12	Halder, Ranjan Kumar
13	Lakra, Anjan
14	Maji, Sukanta
15	Mondal, Dipak
16	Mondal, Tanmoy
17	Mosan, Sabyasachi
18	Mukherjee,, Sanjib
19	Naskar, Tapas
20	Pachhal, Sujata
21	Pal, Chiranjit
22	Paul, Nalin
23	Sahoo, Ranjan Kumar
24	Saini, Bharat
25	Santra, Surajit
26	Sarkar, Arabinda
27	Sharma, Amar Kumar
28	Swarnakar, Nilaksha
Lab Assistant	
1	Bouri, Ashoke
2	Chowdhury, Jyotsna
3	Ghosh, Dipak
4	Karmakar, T.D.
5	Kumar, Barui Monoj
6	Lal, Jiwan
7	Majhi, Ava Rani
8	Mondal, K.P.
9	Naskar, R.N.
10	Singh, Indravir
11	Singh, Krishna Prasad

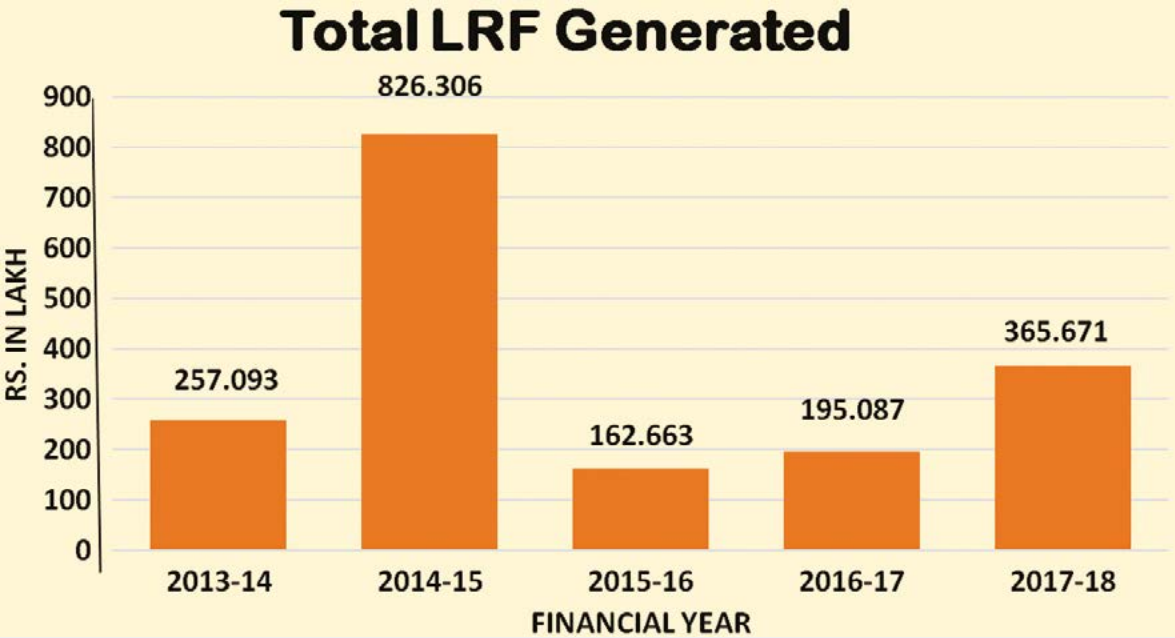
Lab Attendant		
1	Soren, Kanailal	
DST INSPIRE Fellow		
1	Roy, Dr. Lisa	
2	Samanta, Dr. Subhro	
Administrative, Finance, Store & Purchase and Isolated Cadre		
	Jay Shankar Sharan	**Administrative Office**
	Asim Kumar Jha	**Finance & Accounts Officer**
	Bodhisattwa Dhar	**Store & Purchase Officer**
Section Officer		
1	Banerjee, Subhajit	
2	Gupta, Munmun	
3	Kumar, Pankaj	
4	Kumar, Chandan	
5	Kumar, Dayakant	
6	Bhushan, Prabhat	
7	Kumar, Kaushal	
8	Bhuyan, A.K.	
9	Dash, Rama Kanta	
Personal Secretary		
1	Dutta, Jhuma	
2	Bhakta, Bikash Kumar	
Assistant Section Officer		
1	Bhowmik, Biswajit	
2	Boot, Samit	
3	Chakraborty, Swapan Kumar	
4	Das, Bikash	
5	Dey, Ashesh Kanti	
6	Dutta, Ashis	
7	Ghosh, Rajshekar	
8	Halder, Tarun	
9	Kabir, Humayun	
10	Kaur, Kuldeep	
11	Kumar, Binod	
12	Kumar, Chandresh	
13	Kumar, Shailendra	
14	Kumari, Sumitry	
15	Lal, Shyam	
16	Mandal, Subrata	
17	Mondal, Rajendra Nath	
18	Mondal, Sanat Kumar	
19	Mukhopadhyay, Malay	

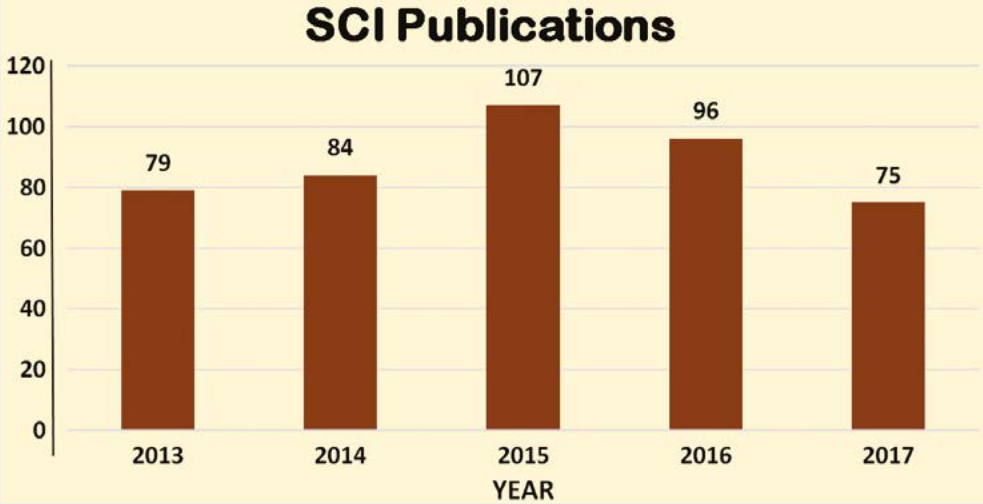
20	Pandey, Manish Kumar
21	Pathak, Dheeraj
22	Pramanick, Siuli
23	Rajak, Dhananjoy
24	Samanta, Sukanta
25	Sen, Rakesh
26	Soren, Subudhan
27	Swaran, Surya Kant
28	Talukdar, Kajal Saha
Senior Secretariat Assistant	
1	Mondal, Amit Kumar
2	Mahato, Arun Kumar
3	Paul, Ashish Kumar
4	Kumar, Kamlesh
5	Sonari, T.B.
Junior Secretariat Assistant	
1	Reshmi, Kumari
2	Singh, Prakash
3	Malo, Swapan
4	Roy, Sourav
5	Rajak, Sangeeta Kumari
6	Shaw, Pooja
7	Thakur, Prakash Kumar
8	Ganga, Nag
9	Chakraborty, Shekhar
10	Kumar, Suman
11	Basu, Tanmoy
12	Kumari, Priyanka
13	Ansari, Md. Salahuddin
Senior Stenographer	
1	Kumar, Amrit
2	Das, Vornajit
3	Kumar, Shardanand
4	Kumar, Sanjeet
Junior Stenographer	
1	Kumar, Bablu
2	Kumar, Goutam
3	Kumar, Navneet
4	Kumar, Ritesh
5	Kumar, Suraj
6	Pal, Sarika
7	Paswan, Nitish

8	Shiv, Balak
9	Singh, Vikash Kumar
Receptionist	
1	Bose, Rimjhim
Security Officer	
1	Kanwal, Rajendra Singh
Junior Hindi Translator	
1	Mishra, Sanjay Kumar
Clerk	
1	Singh, Satnam
MTS	
1	Balmiki, Bijendra
2	Balmiki, Harkishan
3	Banerjee, S.
4	Bouri, Sanjoy
5	Chakraborty, Atanu
6	Das, Balmiki Bhagwan
7	Haque, Ainul
8	Kumar, Sil Ranjit
9	Mandal, Raj Kumar
10	Mudikora, Pabitra
11	Nayak, Narayan
12	Pundi, Raju
13	Ram, Jealal
14	Ram, Nathu
15	Ruidas, Basudeb
16	Samanta, Mita
17	Sapui, Ranjit Kumar
18	Sharma, Sushila Rani
19	Singh, Rajinder
20	Tewari, Subash Chandra
21	Yadav, Subhash Chander

Performance Indices



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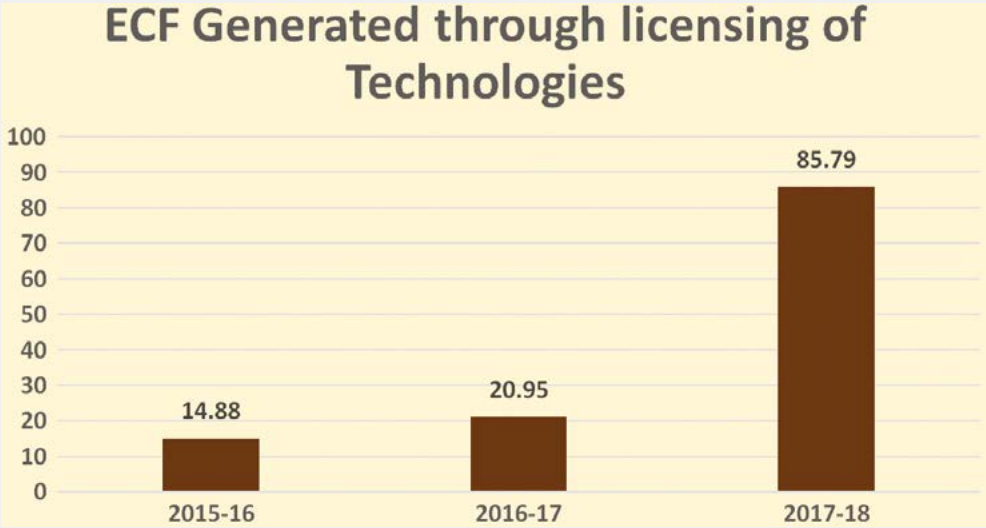
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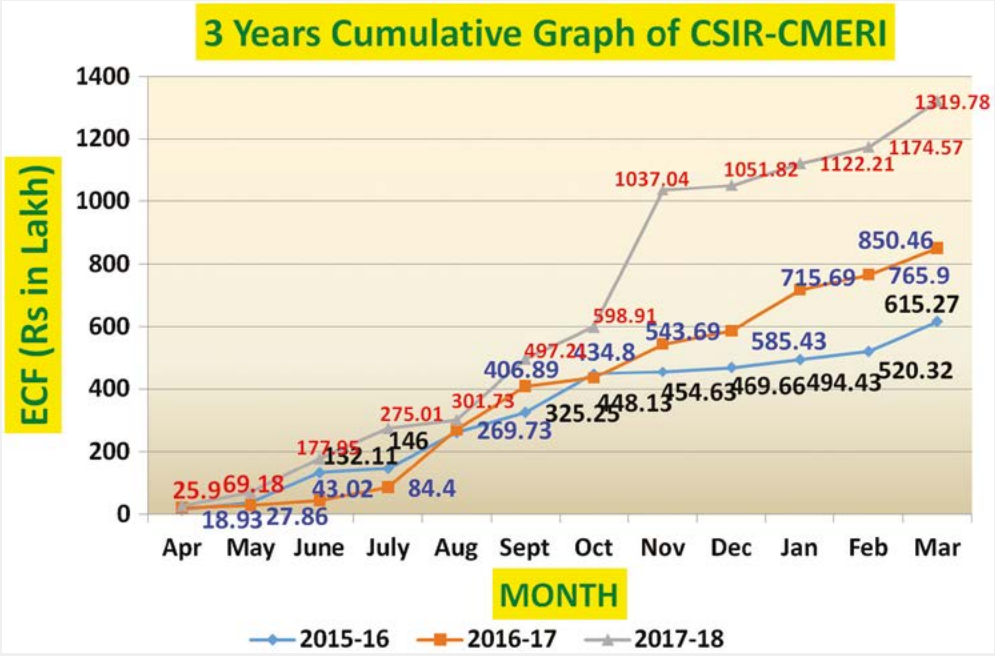
2016-17
2017-18


3 Years Cumulative Graph of CSIR-CMERI
ECF (Rs in Lakh)
1400
1200
1000
800
600
400
200
0
Apr
May
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MONTH
2015-16
2016-17
2017-18
1319.78
1174.57
1122.21
1051.82
1037.04
850.46
765.9
715.69
615.27
598.91
585.43
543.69
520.32
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448.13
434.8
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325.25
301.73
275.01
269.73
177.85
146
132.11
84.4
69.18
43.02
27.86
25.9
18.93

सीएसआईआर-केन्द्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान

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