INDIAN NATIONAL ACADEMY OF ENGINEERING

E-Newsletter

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INAE VISION 2020-2025

INAE VISION

To be the premier Engineering Academy of the World providing timely inputs to the national and international policy makers, and to extend appropriate assistance in developing engineered solutions for the challenging problems facing contemporary societies and the humanity as a whole.

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INAE Vision

To serve professionals in building and institutionalizing engineering and technological excellence in education, research and industry in India and supports advancement of engineering profession globally

Technology Roadmap

We are living in exciting times. We will have to contend with the profound transformation of our society and our industry, because of two revolutions in the making – namely, the digital revolution and the impending transition to fossil fuel free energy globally.

The digital revolution is rapidly transforming the very nature of industrial enterprise today. Many disruptive transformations are maturing rapidly because of the advent of cloud computing and internet of things (IoT) and due to major advances and breakthroughs being made on several fronts such as artificial intelligence (AI) including machine learning (ML) and big data analytics, robotics, autonomy, drones, 3D printing, advance sensors and 5G technologies.

Another revolution in the making is the exciting possibility of fossil fuel-free generation of electricity in the coming decade. The availability of electricity based on renewable sources such as sun, wind and biomass, will cause a major disruption as well as an opportunity for creating a cleaner world, since use of fossil fuels (coal, oil or natural gas) currently, creates deleterious environmental consequences which need urgent attention.

While both these revolutions will cause major disruptions in how we live and work, the transition to the new world in the making is contingent upon the availability of new sources of critical raw materials.

Both digital hardware and generation of electricity from renewables (including the technological challenges associated with energy storage) require a host of new metals and materials for which the new value chains (also the appropriate global supply chains) will have to be established. Innovative processes for extraction of minerals and metals as well as recycling, which are more energy efficient and environment-friendly will have to be developed to produce these critical elements.

To facilitate this global transition, we need to create human resources with high level of domain expertise in different facets of engineering as well as the much needed engineering skill sets needed to deal with the problems of scalability, uncertainty, reliability, complexity, system engineering, ability to deal with variability and yet manufacture products and create solutions of uniform and reproducible quality, capability to design, develop and optimize engineering systems for a given set of inputs and for a desirable set of assured outputs of consistent quality.

Our engineering education has to be appropriately re-engineered so as to equip our future leaders with not only the domain expertise but also the skillsets to innovate continuously and consistently in the face

of constant change and dynamic transformations. The human ingenuity and the preparing the well-trained minds, will be critical ingredients in responding to the challenges ahead.

It in this context, INAE has come up with the following areas for our focused attention in the next five years. We believe that these efforts will assist us in facilitating the smooth transition to the new world in the making.

1. **Accelerated Discovery, Development and Deployment of Novel Materials, particularly for strategic sectors like Defense, Atomic Energy and Space.**

We have an urgent need of materials (metals, alloys as well as composites) development for the following sectors – auto sector (both electric vehicles as well as IC engines based vehicles), aerospace, ultra-supercritical power plants, nuclear power plants, renewable energy sector (novel PV materials, rare earth magnets, battery materials for both large scale energy storage as well as for electric vehicles and other electronic appliances, thermoelectric materials for converting low temperature heat into electricity), novel sensors for healthcare industry, materials for the defense applications and space applications, to name a few.

These materials will have to engineered for India-specific applications. That means one must consider during the process of design & development itself, the kind of natural resources we have and the kind of supply chains we will be able to establish to source the starting raw materials, considering the complex geo-political scenario and vulnerabilities associated with dependence on raw materials from abroad.

The other important consideration is the speed of development. In order to remain globally competitive in this domain, we must leverage the state of the art digital platforms (equipped with advance modeling, simulation, data analytics and knowledge engineering tools) for accelerating the development cycle from conception to deployment in actual applications as well as the entire life cycle (cradle to cradle or cradle to grave in some cases), that is, even for the structural health monitoring of the structures where these materials will be deployed.

Another important consideration is the environmental impact of these materials, that is, we must undertake a life cycle analysis, both with respect to the environmental footprint as well as the energy efficiency (actual consumption as compared to the thermodynamic energy needed to accomplish the particular task), for every developmental effort.

It is now well established that integrated computational materials engineering (ICME) approach can help accelerate the materials development cycle.

INAE will work towards coming up with a national strategy to establish and institutionalize the ICME based approach for all material development efforts. The digital platform, thus created, must be equipped with knowledge engineering capabilities so that it can not only act as a knowledge repository of all past efforts made thus far but also continues to update the knowledge going forward.

2. **Strategies for Energy Transition to Fossil Fuels free Renewable Energy Sources**

It is inevitable that India, like several other nations of the world, will move away from fossil fuels as a source of energy. While we have made some headway in developing renewable energy sources like solar and wind, the necessary infrastructure to support the energy transition does not exist at the present time. INAE plans to create an interdisciplinary expert group to study the whole energy transition comprehensively and holistically, keeping in mind the challenges inherent in such a massive transformation.

INAE will focus on the following important sectors which will be disrupted in the immediate future and/or the areas of concern which we require a strategy for, urgently to facilitate the transition

- Large scale energy storage solutions - Solutions other than Lithium Ion Batteries which do not seem to be appropriate for a country like India for a variety of reasons including the fact that we do not have the basic raw materials - Liquid Metal Flow batteries (for example, Vanadium Flow Batteries) is another attractive option which must be explored.
- Electricity Grid Infrastructure - current grid will not be able to cater to intermittent and distributed electricity inputs; the concept of smart grids which is adequately robust to cater to both supply side challenges (renewable energy sources) as well as demand management (dynamic pricing to take care of its peak loads).
- Transportation (electric mobility, both for people as well as for goods).
- Mining, Mineral Processing and Extractive Metallurgy Industry (which currently depends totally on fossil fuels not only as a source of heat but also as a reductant to convert metal oxides to metals).
- Recycling of waste by-products including municipal waste, tailings and smelter slags including steel slag, red mud and spent pot lining, electronic waste and hospital waste.
- Supply chains for raw materials needed for the transition - sourcing strategies from other geographies, urban mining, deep sea mining and space mining.
- Finding alternative technology options for the manufacture of steel and cement to reduce the environmental foot-print - currently these two materials which will continue to remain the backbone of the Indian economy for the foreseeable future and the consumption is likely to increase by an order of magnitude in the coming decade.
- Waste-water treatment and recycling.
- Water purification technologies including desalination

3. Excellence in Engineering Education

Several groups including other academies globally, are working on the new curricula for engineering education so that our young emerging leaders are adequately equipped with necessary engineering skill sets to face the challenges in the coming decades.

Various deliberations within India as well as abroad have emphasised the need of providing hands-on design experience, problem solving skills and exposure to the systems engineering concepts, tools and technologies to the engineering students. The curricula also need to be updated with the advancements in digital technologies.

All engineers must be familiar with the sustainability paradigm and must be able to do life cycle analysis for every engineering product. They must be equipped with knowledge and the experience with various digital platforms and modelling tools such as computational materials engineering (all the way from atomistic scale to macroscopic scale), computational fluid dynamics, structural analysis tools, life cycle analysis modelling tools, engineering scale up, robust design methodologies to take care of uncertainty and complexity, machine learning and data analytics tools and algorithms, multi-objective and multi-variate optimization tools and technologies.

It is important that the professional ethics is part of the engineering course curricula. A multi-disciplinary systems perspective to all engineers will certainly broaden their horizons – much needed to face the emerging world scenario. Good communication skills and ability to work in teams, are also prerequisites for engineers to succeed in the real life.

All engineers must possess basic IT skillsets and it is a given since digital technologies are transforming every aspect of our lives.

A multidisciplinary INAE Expert Group will critically examine the current status of engineering education, identify gap areas and strive to fill those gaps with appropriate action plans

4. **World Class Infrastructure**

INAE will come up with an action plan in consultation with all stake- holders to upgrade our national infrastructure within next few years. This will include

- Requirements, technology options and the investments needed to create a few smart cities in the country - including mobility, healthcare facilities, e-governance, access to affordable housing, utilities (electricity and water), waste collection, processing and recycle, education, communication, maintenance of infrastructural facilities, disaster management infrastructure including extreme events (for example, excessive rain and floods) etc.
- Requirements, technology options and the investments needed to create a rural infrastructure so that they can enjoy access to certain basic amenities where they are located - digital connectivity for example can provide them with access to healthcare, online education, information dissemination, financial inclusion, logistics warehousing and agriculture and farm productivity with engineering focus etc.

5. **Cyber-physical Systems**

Globally innovations are taking place at the interface of digital technologies and domain expertise. For example, manufacturing is being transformed as a consequence of the following - robotics and automation, Internet of Things (IoT), cloud computing, 3D printing, AI, machine learning and data analytics (Digital Twins), structural health monitoring of built structures and engineered products, drones, autonomy, data analytics based predictive asset maintenance systems, blockchain technology to facilitate complete traceability of the products, digital platforms for integrated design, development, deployment and monitoring of materials and products and knowledge engineering platforms for capturing, retaining and context sensitive retrieval of knowledge to solve challenging problems.

Similarly leveraging the advanced digital technologies, the infrastructure available in a given locality or a city can be upgraded for easy accessibility – for example, healthcare facilities, e-governance, utilities (electricity and water)

It is now possible to make most of healthcare facilities available to the citizens at their place ofresidence (particularly important for senior citizens living alone) through the intervention of digital connectivity, sensors and IoT solutions. Provision of healthcare and affordable Medicare facilities through technological interventions is a key focus area.

INAE will select certain areas for focussed attention during the next five years and develop strategies to create infrastructure to facilitate digital transformation for achieving a set of desirable objectives for example, higher productivity, higher efficiency, better quality of life and better quality of products, reduced cost of services, higher safety of workers, etc.

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ACADEMY ACTIVITIES

ACADEMY NEWS

INAE White Paper on Technological Preparedness for Dealing with National Disruptions

During the Apex Committee deliberations held over Webex on April 30, 2020 it had been expressed that the COVID-19 Pandemic is a serious issue for the welfare, security, economy and sustainability of the nation. The Government of India is engaged like never before in various means, conventional and innovative, in mitigating the impact of the pandemic. One learning point from this adverse situation is that similar situations can and will arise in the future. What is required is a perennial state of preparedness for the unknown perils of unanticipated disruptions. On major dimension of preparedness is unquestionably "technological preparedness". It was unanimously agreed that we should come out urgently with an "INAE White Paper on Technological Preparedness for dealing with National Disruptions". Dr. B.N. Suresh, Immediate Past -President, INAE had prepared a base paper towards this goal. Inputs by Dr. P.S. Goel, former President, INAE and Dr. Bhujanga Rao, and members of the Apex Committee had already been incorporated in the draft material. Besides this the draft White Paper has also been circulated to the Conveners of the Sectional Committees and 22 other selected domain experts from INAE Fellowship. The White Paper on "Technological Preparedness for dealing with National Disruptions" integrating all the inputs was compiled by Dr BN Suresh and forwarded to Shri Amitabh Kant, CEO, NITI Aayog; Dr VK Saraswat, Member, NITI Aayog; Prof K VijayRaghavan, PSA to Govt. of India and Prof Ashutosh Sharma, Secretary, DST, Govt. of India with a request for an opportunity of consulting with them over a WebEx meeting to take this initiative forward. Positive response has been received from DST to take this initiative ahead.

In response to this initiative, Niti Aayog convened a meeting, through 'Video Conferencing' on 10th August 2020 to be chaired by Dr. VK Saraswat, Member, Niti Aayog to discuss the future course of action to implement the recommendations of the White Paper on **'Technological Preparedness for dealing with National Disruptions'**, with a view to take the initiative forward. Accordingly, the said meeting was attended by Dr. Sanak Mishra, President, INAE, Dr. BN Suresh, Immediate Past-President, INAE, Dr. PS Goel, Former President, INAE, Dr. VK Saraswat, Member, Niti Aayog; Shri Neeraj Sinha, Adviser (S&T) and Dr. Ashok A Sonkusare, Jt. Adviser (S&T), Niti Aayog and Lt Col Shobhit Rai (Retd), Deputy Executive Director, INAE . The meeting was successfully concluded to arrive at an action plan to implement the recommendations suggested in the subject White Paper. It was suggested that an Apex Committee be constituted with member experts from INAE and Niti Aayog who would further identify Sub-committees to take up specific task envisaged to take this initiative to its logical conclusion.

Launch of INAE Webinar Series

INAE launched a Webinar Series on topics encompassing all sectors and disciplines of engineering and technology. It has been a long-cherished plan of the Academy to launch the Webinar Series in the year 2020. The INAE Webinar Series is an important new initiative of the INAE Digital Platform. INAE is geared to host events on this platform for the benefit of the Fellowship. It is planned to hold at least one Webinar every month, and if felt necessary, one every fortnight. The first Webinar on May 23, 2020 featured two talks, one on "Launch of INAE Webinar Series" by Mr K Ananth Krishnan, FNAE, EVP and CTO, TCS and a technical talk on "Enterprise Digital Twin" by Mr Vinay Kulkarni, FNAE, Chief Scientist, TCS Research. A total of 58 INAE Fellows/ Foreign Fellows/Young Associates/other invitees participated in the first Webinar held on May 23, 2020, out of 103 registered participants and received

good feedback. The recording of the Webinar has been uploaded in INAE You tube account and an access has been provided on INAE website.

A second Webinar was held on 13th June 2020 on the topic "Does Hydrogen have a role in India's Energy Strategy?" and the four speakers were Dr. SSV Ramkumar, Director R&D, IOCL; Dr. Ashish Lele, Senior VP and Head, Advanced Materials and Alternate Energy, Reliance Industries Limited; Dr. RR Sonde, EVP, Research, Technology and Innovation, Thermax and Dr. P C Maithani, Advisor, MNRE, Govt. of India. Mr MV Kotwal, Ex - Member of L&T Board & President, Heavy Engineering was the Moderator of the second webinar. A Q & A Session was held after the four speakers made their presentations which was coordinated by Mr Sachin Chugh, Chief Research Manager, Indianoil R&D Centre. A total of 151 INAE Fellows/ Foreign Fellows/Young Associates/other invitees participated in the second Webinar. The recording of the second webinar has also been made available in INAE YouTube Channel and link provided on INAE Website.

The third Webinar was held on July 25, 2020 on "Strategy for Accelerated Growth of Renewable Energy Application in India". The webinar commenced with opening statement by Dr. Sanak Mishra, President, INAE and was moderated by Mr. Pradeep Chaturvedi. The Webinar had expert panellists: Dr. Ajay Mathur, Director General, TERI; Mr. Sumant Sinha, CMD, ReNew Power; Mr. K. S. Popli, former CMD, IREDA and Advisor, International Solar Alliance; Dr. P.C. Maithani, Advisor, Ministry of New and Renewable Energy and Dr. B. Bandyopadhyay, former Advisor, MNRE. A total of 102 INAE Fellows and other invitees participated in the second Webinar.

A report on the Webinar prepared by the Moderator of the Webinar -Mr. Pradeep Chaturvedi, Convener, Engineering Section -IX (Energy Engineering) is given below.

REPORT on Webinar on "Strategy for Accelerated Growth of Renewable Energy Application in India"

The Indian National Academy of Engineering, INAE organised a Webinar on **"Strategy for Accelerated Growth of Renewable Energy Application in India"** on 25 July, 2020.The discussion was moderated by Mr. Pradeep Chaturvedi, Coordinator, Energy Sectional Committee, INAE. Dr. Sanak Mishra, President, INAE, presented the Welcome address and opening remarks. The Webinar had expert panellists: Dr. Ajay Mathur, Director General, TERI; Mr. Sumant Sinha, CMD, ReNew Power; Shri K. S. Popli, former CMD, IREDA and Advisor, International Solar Alliance; Dr. P.C. Maithani, Advisor, Ministry of New and Renewable Energy and Dr. B. Bandyopadhyay, former Advisor, MNRE.

Mr. Pradeep Chaturvedi, presented the context to the Webinar being conducted with the aim of evolving a strategy for accelerated growth of renewable energy in India.

Dr. Sanak Mishra, President, INAE in his welcome address described the formation and role of INAE to promote and advance the practice of engineering and technology. He emphasised that energy, specifically the renewable energy applications, is a thrust area of the Academy. Two significant studies on Renewable Energy Applications in India were conducted during last four years have been found extremely relevant by various stakeholders.

Dr. Ajay Mathur, DG, TERI referred to two studies "Engineering Interventions Necessary for Achieving 175 GW of Renewable Power by 2022" and "Clean and Green Energy in Urban Development", and described which of the recommendations were already under implementation and which others were under consideration by government and other stakeholders. He also described that INAE has initiated work on another important study on Energy for Accelerated Economic Growth where renewable energy can make a big difference. This study has been initiated by the Energy Sectional Committee, but in view of wider scope, other committees are also involved.

Mr. Sumant Sinha, CMD, ReNew Power deliberated on the industry view point with regard to implementation of renewable energy projects. He mentioned that we should realise that reaching 450 GW by 2030 requires adding 375 GW in the next ten years, which is equivalent to the present total installed power generation capacity in the country. Major challenges include land acquisition, equipment availability and supply chain, and grid availability and connectivity. The industry will prefer long-term policy and regulatory regime, financial arrangements and quality supply in international and domestic markets.

Mr. K.S. Popli, former CMD, IREDA and Advisor, International Solar Alliance discussed three important aspects: Financing options, Adequacy of funds availability and Export Potential through RE lever to attain higher economy of scale. He emphasised that financing options will ensure for accelerating deployment of renewable energy projects, will depend on how following issues get support and are addressed: Policy and regulation; status of infrastructure with regard to land and power evacuation; and enforceability of long-term contracts and mitigating various risks. Feed-in tariff for smaller projects will open up retail markets.

Dr. Bibek Bandyopadhyay, former Advisor, MNRE emphasised on indigenous manufacturing of equipment for RE projects, especially for solar cells. The manufacturing capacity for solar cell and panel has to be substantially increased. Setting up a modern cell manufacturing facility is a costly affair and industry will need support for investment for land and infrastructure also. The product has to be of high quality and produced at a globally competitive price. For this the government intervention is essential for development of manufacturing ecosystem. The technology route including the storage battery has to be carefully finalised keeping in view the availability of raw materials.

Dr. P. C. Maithani, Advisor, Ministry of New and Renewable Energy gave an overview of Government's Policy Framework in the renewable energy sector where state governments also have their role, energy being a concurrent subject. He mentioned that challenging targets were set to signal country's intentions and diverse policy instruments were also put in place for facilitating the accelerated development and deployment of renewable. He emphasised that renewable energy development cannot be seen in isolation. It is in synergy with other power generation sources. Efforts are being made to allocate financial resources for grid augmentation and balancing of power and incentivising indigenous manufacturing. Efforts are being made for harnessing emerging technology options including hydrogen energy and energy storage.

Following the above presentations, the participants raised a number of issues including policy framework, programme implementation strategy, financing, battery storage development, balance of the equipment availability and regulatory regime. It was decided to develop a Strategy for Accelerated Growth of Renewable Energy Application in India document for consideration of various stakeholders.

Dr. Sanak Mishra, President, INAE profusely thanked the panellists and participants of the Webinar and assured necessary follow-up action by INAE.

Transactions of the Indian National Academy of Engineering, An International Journal of Engineering and Technology

INAE had launched a quarterly journal "INAE Letters" published by M/s Springer in the year 2016. The objective of the journal is to provide a medium for rapid publication of new research results and invited short review articles across different domains of engineering science and technology. In the year 2020 the title of the Journal has been changed to **"Transactions of Indian National Academy of Engineering – International Journal of Engineering and Technology**" and has become a full-fledged journal to include full Research Papers and Review Articles besides short communications.

The Transactions of INAE publishes original research papers, contributed and invited reviews on the topics related to Civil Engineering, Computer Engineering and Information Technology, Mechanical Engineering, Chemical Engineering, Electrical Engineering, Electronics and Communication Engineering, Aerospace Engineering, Mining, Metallurgical and Materials Engineering, Energy Engineering, Industrial Engineering, Interdisciplinary Engineering, Nano Science and Technology, and related fields such as applied Mathematics, Applied Physics, Applied Chemistry and computational Biology.

Special Issue of Transactions of the Indian National Academy of Engineering - Volume 5, Issue 2, June 2020 on "Technologies for Fighting COVID-19"

The Special Issue of Transactions of the Indian National Academy of Engineering - Volume 5, Issue 2, June 2020 on "Technologies for Fighting COVID-19" is now available on INAE website, as well as in open access domain on Springer website. The articles in the issue may be downloaded either through the log in facility provided to INAE Fellows or by copying the link given below in your internet browser.
https://link.springer.com/journal/41403/5/2

The contents of the Special Issue are given below:

1. **Editorial**

Foreword by President of INAE
Sanak Mishra Page 89

2. **PREFACE**

PREFACE on the Special Issue 'Technologies for Fighting COVID-19'
Amit Agrawal, Shiv Govind Singh Pages 91-95

3. **Technical Note**

Opportunities, Challenges and Directions in Science and Technology for Tackling COVID-19
Appa Rao Podile, Anirban Basu Pages 97-101

4. **Original Article**

COVID-19 Pandemic: Power Law Spread and Flattening of the Curve
Mahendra K. Verma, et al Pages 103-108

5. **Original Article**

Temporal Dynamics of COVID-19 Outbreak and Future Projections: A Data-Driven Approach
Rajesh Ranjan Pages 109-115

6. **Original Article**

Epidemiologically and Socio-economically Optimal Policies via Bayesian Optimization
Amit Chandak, Debojyoti Dey, et al Pages 117-127

7. **Original Article**

Optimising Lockdown Policies for Epidemic Control using Reinforcement Learning
Harshad Khadilkar, et al Pages 129-132

8. **Original Article**

A Predictive Model for the Evolution of COVID-19
Rajneesh Bhardwaj Pages 133-140

9. **Original Article**

45.Technical Note
Mechanical Ventilator Using Motorized Bellow
H. Hirani Pages 379-384

46.Original Article
Affordable, Compact and Infection-Free BiPAP Machine
Gaurav Pal Singh et al Pages 385-391

47.Original Article
Leveraging Wettability Engineering to Develop Three-Layer DIY Face Masks From Low-Cost Materials
Sourav Sarkar, Achintya Mukhopadhyay et al Pages 393-398

48.Review Article
Chloroquine: A Potential Drug in the COVID-19 Scenario
Ranjana Singh, Viji Vijayan Pages 399-410

49.Original Article
En route to Peptide Therapeutics for COVID 19: Harnessing Potential Antigenic Mimicry Between Viral and Human Proteins
Maya Madhavan et al Pages 411-415

50.Review Article
An Overview of Coronavirus COVID-19 with their Pathogenesis and Risk Assessment of the Disease Utilizing Positive Predictive Value of the Clinical and Laboratory Data
Tapan Krishna Biswas, Malabika Biswas et al Pages 417-427

51.Original Article
Conceptual Design of a Body Bag for Preventing Infections and Safe Disposal of Deceased from COVID-19 Virus
Mayank Patel, Shubham Khatri et al Pages 429-435

The first Volume of Transactions of the Indian National Academy of Engineering is Volume 5, Issue 1, March 2020, ISSN: 2662-5415 (Print) 2662-5423 (Online) The articles in the issue may be downloaded through the log in facility provided to INAE Fellows.

In this issue there are (10 articles) as given below.

1. **Review Article**

Microstructure–Texture–Mechanical Property Relationship in Alloys Produced by Additive Manufacturing Following Selective Laser Melting (SLM) Technique
Satyam Suwas, Deepak Kumar Pages 1-10

2. **Original Article**

Liquid Metal Corrosion Studies for Fusion Reactor Applications: Facility Development and Basic Research
P. Chakraborty, V. Kain, R. Tewari Pages 11-16

3. **Original Article**

Process Analysis of Chemical Looping Systems for Dimethyl Ether Synthesis from Coal
Fanhe Kong, Qiaochu Zhang, Yan Liu, Jordan Swift, Darryl Tene Youmbi, Andrew Tong & Liang-Shih Fan Pages 17-26

4. **Original Article**

Electrical Properties of Pure NiO and NiO:Ag Thin Films Prepared by Pulsed Laser Deposition
Omar Abdulsada Ali, Mohammed A. Hameed & Qahtan Ghatih Al-Zaidi Pages 27-31

5. **Original Article**

Graphene Flake-Based Electrodes for High-Energy and Power Lithium-Ion Semi-flexible Rechargeable Batteries
Sanjay Kanojia, Mohd. Imamuddin, Subhash Mandal, Debmalya Roy, Kingsuk Mukhopadhyay & N. Eswara Prasad Pages 33-38

6. **Original Article**

Modification of On-Site Velocity Boundary Condition in LBM for D3Q27D3Q27 Lattice Structure
Alankar Agarwal Pages 39-49

7. **Original Article**

Eutrophication Risk Assessment by Estimation of Denitrification Rate in Yamuna River Sediments
Shikha Sharma, Shakeel Ahmad Khan, Amit Kumar, Pawan Kumar Jha & Tanu Jindal Pages 51-60

8. **Original Article**

Multi-phase MPSP Guidance for Lunar Soft Landing
Avijit Banerjee, Radhakant Padhi Pages 61-74

9. **Original Article**

Large-Scale Manufacture of Nickel Alloy Turbine Rotor Forgings for A-USC Power Plants
B. Donth, N. Blaes, A. Diwo, D. Böttcher Pages 75-82

10. **Original Article**

Development of Test Protocol for Accelerated Creep and Transient Thermo-mechanical Testing of AUSC Steam Turbine Rotor in High-Temperature Spin Test Rig

Bishnu Pada Pal, M. Naga Suresh, K. Ramakrishna, A. Narayana Teja, Supak Pore, Prabhat Kr. Hensh, Somnath Nandi & Maneesh Batrani Pages 83-88

Submission of high quality research/review papers are invited from the Fellowship, Young Associates and their colleagues. Guidelines for submission of papers are available on Springer website and through log in facility provided to INAE Fellows.

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TECHNICAL BOOK REVIEWS

"Ultra-High Strength, High Fracture Toughness Low-Alloy Steel: DMR-1700"
(Low Cost High Performance Steel for Defence applications)

A startling prediction has been essayed by Chris Anderson, Chief Editor of the Technology Review Journal "Wired" ((https://www.wired.com/2008/06/pb-theory/). He pronounced *"The End of (Scientific) Theory"* as we know it, and envisaged "a *future in which the long-established way of doing scientific research is replaced by computers that divulge knowledge from data at the press of a button"!* This provocative assertion was based on the perceived dawn of an era of peta-bytes of information

(data), supercomputing capabilities, sophisticated algorithms and novel statistical tools to sift through massive amounts of data.

Important as it may be from an epistemological point of view, the "Big Data- No Theory" thesis has been contested by several commentators (see for example, Fulvio Mazzochi (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4766450/). The emerging consensus is that the data-driven approach constitutes at best a new tool for scientific research, which can complement but not supersede cognitive and methodological procedures - both the strategies are necessary for the progress of science and technology.

The Monograph under review "Ultra High Strength, High Fracture Toughness Low-Alloy Steel: DMR-1700" is an outstanding illustration of how the synergic action of data-driven and methodological procedures can be used to develop a new technological material. This book, authored by Dr G Malakondaiah, FNAE and Dr P Rama Rao FNAE, is published by the Defence Research & Development Organization, Ministry of Defence, Government of India (2019). It describes a long drawn-out research programme (carried out over the past thirty years and counting) anchored at DMRL, Hyderabad, with the support of a multitude of sister organizations and industries. As pointed out by the authors themselves (p.194) *"no such comprehensive effort has ever been undertaken in any Indian academic institution, in any national laboratory or any Indian industry and therefore the work at DMRL can be regarded as truly pioneering".*

It is instructive to follow the sequence of increasingly complex stages in the evolution of this Project.

Stage 1: Identifying a clearly stated objective: in the present case the objective was the development of an ultra-high strength (> 1550 MPa YS) and high fracture toughness (> 85 $MPa.m^{-1/2}$) steel for structural applications in Defence hardware. It should be amenable to easy processing on an industrial scale, and possess good formability, weldability and acceptable resistance to fatigue crack growth and stress corrosion, all at a low cost.

Stage 2: Experimenting with a new idea**:** (a) *Identify one major problem in achieving the objective*: Here the identified problem is that efforts to increase strength generally result in a loss of toughness. (b) *Search for a novel solution:* The authors hit upon the idea of initiating de novo research on the effect of selected alloying elements on toughness of dilute binary solid solutions of iron. (c) *Pay attention to fine details while doing this research:* This hallmark of true excellence is evident at every step of the present effort. (For example, dozens of experiments were conducted just to ensure a reproducible common grain size for all the compositions tested). This work is described in detail in Chapter 3 of the book.

Stage 3: Selecting the best material and generating relevant data: The insights gained from the previous step were used to select the best material - a high strength low alloy steel consisting of Ni, Si, Cr, Co and Mo (total alloy content < 7%) *designated as DMR-1700*. Extensive experimentation on the new steel was carried out to evaluate its mechanical and other properties. This work involved 100s of carefully designed experiments, using a wide variety of sophisticated equipment, followed by intensive analysis of the results (partly aided by innovative computer algorithms).

Stage 4: Scaling up the laboratory effort to industrial level production: In the present case, scaling-up involved optimization of the processes of making, shaping and treating of the new steel. The laboratory-produced DMR-1700 steel successfully achieved the target properties of about 1600 MPa yield strength and 85-90 $MPa.m^{-1/2}$ fracture toughness in the optimum heat-treated condition. Reproducing these properties in industrial melts required the use of premium production processes to give clean inclusion-free material. Two different processing routes were used. The first was Electric Arc Furnace (EAF) melting followed by Vacuum Arc Refining (VAR) / Electro Slag Refining (ESR) for melts of 5 ton size. The second route employed the two-stage process of EAF followed by Ladle

Refining & Vacuum Degassing (LR&VD) for larger melts of 150 tons. The satisfying outcome of both the routes was a steel plate which proved to be a one-to-one replacement for 18Ni1700 maraging steel matching its mechanical properties in the same section thickness. Importantly, it was achieved *at one half to one third the cost of the maraging steel in the first processing route. The cost reduction was even more dramatic at one tenth that of maraging steel in the larger 150 ton melts when melting and refining were followed by continuous casting (a process used for the first time with steels of this type).* Chapter 4 of the monograph gives a detailed description of the work listed in items 3 and 4 above.

Stage 5: Producing components for practical applications: The intended main application of the new steel was for rocket motor casings (for AKASH and AGNI missiles) as a low cost one-to-one replacement for the presently used but expensive 18Ni1700 maraging steel. Extensive work was carried out on the new steel to successfully optimize the conditions during fabrication of missile casings and subsequent heat treatment schedules. Suitability of the steel for other applications such as for reducing the weight of the base plate for 120mm Long Range Mortar (LRM) and as armour plate for India's Main Battle Tank has also been established. Chapter 5 of the monograph gives a captivating step-by-step account of the work carried out in this regard.

Stage 6: Achieving acceptance by the end- user: This is the ultimate requirement before the component can be taken into actual service. The DMR-1700 Project is no doubt a sparkling crown jewel of Defence Research in India. But achieving acceptance by the end-user could be an intractable problem. This has been pointed out by the authors themselves when they pose the rhetorical question *"DMRL has done all that one may possibly envisage for demonstrating large scale utilization of DMR-1700 and for clearly establishing its cost advantage. Adoption of DMR-1700 for rocket motor casings would be in the nature of crowning the DMRL long-drawn out programme. The question is, will it happen?" (*Epilogue, p.194).

The DMR-1700 Monograph should be of immense interest to various categories of readers. On the primary level there are the numerous investigators partly associated with the Project at various stages, who will be able now to get a picture of the entirety of the work. Scientists in metallurgical Institutions engaged in developmental research will find the book to be a highly instructive guide on how to carry out purposeful research. For students of metallurgy at any level including undergraduates, the book in effect is a summary of a substantial part of metallurgy in the guise of a complete case study. In aid of such students, the authors have included at the beginning two chapters dealing with the principles of ultra-high strength steels and ductile fracture of steels respectively. In addition, Appendices at the end of each subsequent Chapter explain in detail some of the concepts / processes mentioned in that Chapter. A comprehensive stand-alone summary at the end of each Chapter is a major highlight of the book. Other value additions that enrich the text include a large number of data tables, appropriately composed illustrations, an alphabetical index of topics and Lists of Symbols, Acronyms and References.

It is a pleasure and an education to read this well- written monograph.

V V Kutumbarao, FNAE
Formerly Professor, Department of Metallurgical Engineering
Indian Institute of Technology, Varanasi
10.07.2020

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NEWS ON INTERNATIONAL FELLOWSHIPS

German Chancellor Fellowships by Humboldt Foundation for Tomorrow's leaders
An email has been received from DST forwarding a communication from Mr S. K. Varshney, Adviser & Head, International Bilateral Cooperation, Department of Science & Technology (DST), Government of India informing about nominations for German Chancellor Fellowships for Tomorrow's leaders, a yearly program handled by the Humboldt Foundation. The Alexander von Humboldt Foundation grants up to 50 German Chancellor Fellowships every year to prospective leaders from Brazil, China, India, Russia and the USA – irrespective of their field of work. Recipients use the Fellowship to conduct together with their German host and mentor a socially-relevant project that they have developed themselves. The Chancellor of the Federal Republic of Germany is the patron of this fellowship programme.

The candidate applying for this Fellowship should be:

- The applicant must be a national of Brazil, China, India, Russia or the United States.
- Bachelor's or equivalent academic degree completed less than twelve years before the beginning of the fellowship.
- A confirmation of supervision by the host in Germany.
- A project plan which candidates must draw up on their own and coordinate with their host.
- Initial proven leadership experience

Fellowship benefits for recipients:

- A monthly fellowship of €2,170, €2,470 or €2,770, depending on your qualifications.
- Individual mentoring during your stay in Germany.
- Additional financial support for items such as family members accompanying you, travel expenses or a German language course.
- A study tour of Germany, an opportunity to meet the German chancellor at the end of your stay and a number of events during which you can make contact with other fellows and representatives of German companies and institutions.
- Extensive alumni sponsorship, particularly to help you sustain contact with collaborative partners in Germany during your entire professional career.

Application deadline: 15 September 2020.
Period of sponsorship: 1 October 2021 – 30 September 2022
Fellows desirous of recommending candidates from their organization may download all relevant information by accessing the links given below.

Further information, a list of all application requirements and a link to the online application form are available at www.humboldt-foundation.de/youngleaders

Advice and contact: If you have any questions regarding the German Chancellor Fellowship Programme or would like individual guidance, please contact at info@avh.de<mailto:info@avh.de>.

You can find **examples of projects conducted** at https://www.humboldt-foundation.de/web/buka-testimonials-en.html

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ACADEMIA INDUSTRY INTERACTION

AICTE-INAE Distinguished Visiting Professorship Scheme

Industry-academia interactions over technological changes have become essential in recent times so that relevant knowledge that would be sustainable in the changing conditions can be imparted to the students in the engineering institutions. While industries could gain by using the academia's knowledge base to improve the industry's cost, quality and global competitive dimensions; thereby reducing dependence on foreign know-how and expenditure on internal R&D, academics benefit by seeing their knowledge and expertise being fruitfully utilized practically and also by strengthening of curricula of educational programs being offered at engineering colleges/institutions. INAE together with All India Council for Technical Education (AICTE) launched "AICTE-INAE Distinguished Visiting Professorship Scheme" in 1999. Under this scheme, Industry experts are encouraged to give a few lectures in engineering institutions. This scheme has become popular among industry experts as well as engineering colleges.

Brief details pertaining to recent visits of industry experts under this scheme are given below.

Mr. S. Krishna Kumar Former Senior Vice President (Retired), Lucas TVS Ltd, Chennai	RMK Engineering College, Kavaraipettai, Tamil Nadu March 13-14, 2020 March 16, 2020	Delivered lectures on Design and Fabrication projects on "Borewell Rescuer", "Design and Fabrication of Drag Racing Motorcycle Modified Braking System", "Cake Decoration Machine", "Utilization of Waste Heat from exhaust gas in automobile using heat pipes in cold regions", "Pneumatic grinding machine", "Variable Compression Ratio in an Engine", "Heat Pipe Solar Collector", "Power Generation using Door Mechanism", "Anti-theft Braking System", "Pneumatic Paper Cup making Machine", "Semi-Automatic Shoe Cleaning Machine", "Piezoelectric wheel", "Composite Fibre using Coconut Coir and Epoxy Resin", "Swing-Hammer Punching Machine", "Hydraulic Pedestrian Crossing set-up", "Modular Hydraulic Jack Mechanism", "Drive-Line Assembly", "Electro Magnetic Suspension System", "Load Carrying Apparatus for Vendors", "Dual Direction Drive Shaft Mechanism", "Magnetic Propulsive System in Bicycle", "Variable Sprocket Mechanism", "Solenoid Engine", "Plastic Waste Recycler", "Motorized Scissor Jack", "Rod Bending Machine", "Auto-Pneumatic Braking System", "Extracting Welding Smoke Fumes using Blower", "Trolley encompassed Pesticide Sprayer" and "Power Generation using Speed Breaker". According to the feedback received from the College, the Scheme helps private engineering institutions to excel in their offering students the appropriate

		knowledge based on the rich experience of industry experts, based on real industrial case studies and by working towards meeting the challenges of Indian automotive industry for e-mobility.
Dr. Pradeep Chatterjee Sr. General Manager & Global Solution, Architect, Cummins Inc.	GH Raisoni Institute of Engineering and Technology, Pune Sept 4, 2019 Feb 22, 2020	Delivered lectures on "Introduction to Advance Natural Language Processing", "Introduction on Advanced Deep Learning". According to the feedback received from the Institute, Scheme provides good opportunity to institute to interact with eminent industry experts. Students and faculty get guidance in research, projects and proposals, besides an opportunity to work on industry sponsored projects. The lectures created the awareness of Deep Learning and its applications among faculties and students. Project session introduction helped students to explore new ideas for implementation and development.

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INTERNATIONAL/NATIONAL CONFERENCES/SEMINARS BEING ORGANIZED BY IITS/OTHER INSTITUTIONS

To view a list of International/ National Conferences/Seminars being held in the month of September 2020, click here….

International Conference on Smart Electronics and Communication (ICOSEC 2020) on 10th to 12th September 2020 at Trichy, Tamilnadu,
https://conferencealerts.com/show-event?id=226825

International Conference on Electrical, Electronics and Communication Technology (ICEECT 2020) on 17th to 19th September 2020 at Coimbatore, Tamilnadu,
https://conferencealerts.com/show-event?id=226386

International Conference on Advances in Computing Communications and Embedded Systems at 18th to 19th September 2020 at Hyderabad, Telangana
https://conferencealerts.com/show-event?id=223180

4th International Conference on Intelligent Computing and Communication (ICICC - 2020) on 18th to 20th September 2020 at Bangalore,
https://conferencealerts.com/show-event?id=226900

Note: Due to Lockdowns imposed by Government in view of Covid-19, schedule of these conferences may be rechecked.

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NEWS OF FELLOWS

1	Dr. Sanak Mishra, FNAE, President, INAE and formerly Managing Director, Rourkela Steel Plant and formerly Director, Steel Authority of India Ltd (SAIL); formerly Vice-President, ArcelorMittal and CEO India Projects; formerly Secretary General, Indian Steel Association and former President, Indian Institute of Metals has recently authored a book "Sanak Mishra - An Autobiography" published by Notion Press. In 294 pages, the book narrates his personal and professional life over 70 years, from the age of four to the age of seventy-four. The review of the book as mentioned in the back cover page of the book is reproduced below. *"This is an autobiography that traces the life of a transformational leader, as narrated by him. It alternates between his personal life and his professional life, his aspirations and his accomplishments as a scientist, as an industry captain and as a communicator. Above, all the book is about people and what makes them what they are. It details how his concept of reducing 'the distance between minds' helped synergise twenty-six thousand employees of one of the largest industrial enterprises in India, leading to its regeneration and sustainability. The narration is full of subtle elements which will be motivational to many, especially the young."* BOOK REVIEW SANAK MISHRA-AN AUTOBIOGRAPHY[1] In the vast expanse of the engineering profession, leaders of the genre of Dr Sanak Mishra are *rara avis*. I find his autobiography highly fascinating and unique in many ways. His academic track record, illustrious professional career, accomplishments, recognitions and awards are well known to the engineering community but they tell only part of the story of his life. After reading his autobiography, readers will also get to see the other, otherwise hidden side of his personality, especially his exemplary human qualities, his principled life, his personal courage, transparency and commitment to the goals he pursued. The book is characterized by lucidity, clarity, and reader friendly expression and easy communication. Dr Mishra, who is currently the President of Indian National Academy of Engineering, climbed up the ladder of success through sheer imagination and hard work. When he took over the affairs of the Rourkela Steel Plant (RSP), it was like mounting a tiger because the Plant was literarily on oxygen. Who could have imagined at that time that the RSP running at a loss of Rupees 3 crore per day would come out of the abyss as a flourishing enterprise netting a profit of Rupees 3 crores per day in a matter of no more than 3 years? Dr Mishra saw the route to success through SAMSKAR as his brain child, set the priorities right and cruised home through turbulent waters riding on the waves of a well-engineered mass contact exercise which eventually resulted in virtually a communication revolution. He met the entire workforce of 26000 employees, 500 at a time, in just about 52 weeks! What was it if not his vision, courage and conviction that before taking the job with a missionary zeal, he insisted on securing unqualified assurance of non-interference in work from the powers that be. According to E.M. Forster, "Failure or success seem to have been allotted to men by their stars. But they retain the power of wriggling, of

	fighting with their stars or against it, and in the whole universe the only really interesting movement is this wriggle! The journey of Dr Mishra's life vindicates Forster. The autobiography reminds me of J.K. Rowling who once said that "If you want to see the true measure of a man, watch how he treats his inferiors, not his equals". Dr Mishra does not even fail to recall all his domestic aids with great admiration for the services rendered to him and to Madam Veena Mishra during their quarter of a century long stay in Ranchi! Likewise, amidst dozens of notable initiatives taken by him upon taking over as President, INAE and the extra load of work which fell on his shoulders because of the untimely demise of INAE's Executive Director, Dr Mishra did not fail to acknowledge each and every INAE employee by name who helped him make things happen! It is said that behind every great man is a great woman. It is inspiring to know that Madam Veena Mishra gave-up a senior level position as a nameless gesture to bolster Dr Mishra's freedom when he joined as the Chief Executive of RSP at a time when the script of Dr Mishra's success was still being written! Best written books are those which are reader friendly and I place the book in that category. The Preface of the book opens with the sentence, "I hope Rohan, our grandson, now about four years old, will read this book as he grows up, or at least look through it. When he does, he will know something about his grandfather, grandmother and about the early life of his own father and uncle. He will get an idea about his lineage". There is a profound message in this for the rest of the world, especially in the present age when joint families are rapidly breaking and losing their identities in the whirlwind of the evolving new ecosystem! My heartiest congratulations to Dr Sanak Mishra for taking time out to write his autobiography. R.K. Bhandari, FNAE Distinguished Visiting Professor, IIT Roorkee and Member, National Advisory Committee to NDMA **Published by Notion Press, Chennai, Tamil Nadu, India (ISBN 978-1-64899-726-6)**
2	Dr Debabrata Das, FNAE, Visiting Professor, Former Head and Renewable Energy Chair Professor, Department of Biotechnology, Former Professor-in-Charge, P K Sinha Centre for Bioenergy, Indian Institute of Technology, Kharagpur has co-authored a new book titled "Biochemical Engineering: A Laboratory Manual" with Dr Debayan Das which will be published by M/s. Jenny Stanford Publishing, Singapore in the winter, 2020. This book will be marketed by M/s. Taylor & Francis. The authors hope that this book will be very useful to the undergraduate/postgraduate students in Biotechnology / Biochemical Engineering / Chemical Engineering / Applied microbiology / Environmental Biotechnology.
3	Prof. SN Upadhyay, FNAE, Department of Chemical Engineering & Technology, IIT (BHU) Varanasi has co-authored a book titled "Industrial Enzymes for Biofuel Production" published by Elsevier Press. The hard copies of the book will be published shortly. He has also written a book on "Fluidization: A General Introduction" (तरलन: एक सामान्य परिचय) for diploma students of Chem Eng./Mech. Eng./Civil Eng./Env. Eng. and Agricultural Engineering studying in polytechnics of Hindi belt states.

4	Dr MD Nair, FNAE, Formerly Vice President, SPIC Pharmaceuticals, Madras has authored a book titled "Fifty Years in The Indian Pharmaceutical Industry" which was released by MOS, GOI Shri Alphons Kannanthanam in Kochi in March 2019.
5	The Digital Twin methodology has been applied for modeling, analysis & projections for the COVID 19 scenario in Pune, by Dr. Vinay Kulkarni, FNAE, Chief Scientist, Tata Research Development and Design Centre, Tata Consultancy Services Research, Hadapsar, Pune along with his team at TRDDC-TCS. It has been successfully used by PMC. INAE had covered the subject of Digital Twins in the first of its webinar series. Dr. Vinay Kulkarni had delivered a talk on the subject. The recording is available on the INAE website (www.inae.in). Given below is a URL for an article which has appeared in Indian Express. https://indianexpress.com/article/cities/pune/pune-peak-load-on-critical-healthcare-to-be-sustained-until-oct-end-6562008/

INAE ON FACEBOOK AND TWITTER

INAE has created a Facebook and Twitter Account to post the news of recent INAE activities in the Social Media. The same can be viewed at the link below.

(a) Facebook -link https://www.facebook.com/pages/Indian-National-Academy-of-Engineering/714509531987607?ref=hl

(b) Twitter handle link https://twitter.com/inaehq1

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OBITUARIES

Prof PN Murthy

Prof PN Murthy, FNAE born on April 23, 1928 passed away on June 23, 2020.

Prof PN Murthy, Formerly Adviser, Tata Consultancy Services, Hyderabad had made significant research contributions in the areas of aircraft structures and sandwich beams. He taught Aeronautical Engineering at Indian Institute of Science, Bangalore and was the head of the Department of Aeronautical Engineering in IIT Kanpur. Later, he moved to Tata Consultancy Services to start and head a research centre in Systems Engineering and Cybernetics at Hyderabad and subsequently assumed the responsibility of Advisor. He was engaged in the system design of projects and cybernetic analyses of decision-making models and was principal initiator in promoting an Adult Literacy Program through a Computer Based Functional Literacy (CBFL) solution.

May God bless his soul to Rest in Peace

Prof DK Dutta Majumder

Prof DK Dutta Majumder, FNAE born on February 10, 1932 passed away on June 27, 2020.

Prof DK Dutta Majumder, Professor Emeritus, Electronics and Communication Sciences, Indian Statistical Institute, Kolkata had made pioneering contributions in computer memory technology, pattern recognition, speech recognition, image processing and fuzzy systems, among others. He played an instrumental role in initiating Computer Science Education and Research in India. The then Department of Electronics, Government of India established one of the nation's Fifth Generation Computer System (FGCS) Research Centres at ISI Kolkata under his leadership in 1986. Prof. Dutta Majumder was conferred the INAE Life Time Contribution Award in Engineering in the year 2004.

May God bless his soul to Rest in Peace

Prof JS Rao

Prof JS Rao, FNAE born on July 1, 1939 passed away on July 4, 2020.

Prof JS Rao, Formerly Science Councellor, Embassy of India, Washington D.C. and Professor, IIT Delhi; Formerly Chief Technology Officer, Quality Engineering and Software Technologies Pvt. Ltd., Bangalore; Former President- Academics, Kumaraguru College of Technology, Coimbatore & Bangalore had made significant research contributions in the areas of vibrations, rotor dynamics and decades and had published more than 300 research papers and books on the subject of vibrations, as an expert in the field.

May God bless his soul to Rest in Peace

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ENGINEERING AND TECHNOLOGY UPDATES

Civil Engineering

1. New research leads to lighter and greener bridges

To accommodate the request for ever longer bridges, the Technical University of Denmark (DTU) and COWI, an international consulting group, studied how to optimise structures to reduce the weight of the bridge deck, in particular increasing the span. "We applied different methods for examining how to better utilise materials, which primarily consist of steel and concrete. Initially, we sought to optimise their use in traditional structures by using transverse diaphragms in the bridge deck, thereby achieving a theoretical weight reduction of up to 14 per cent," says Mads Jacob Baandrup, who carried out the analyses in connection with his PhD project and today works as an engineer in COWI's bridges department. With a view to achieving additional savings, the researchers looked at the possibility of altering the structural design. That was done by using topology optimization, a method known in car and aircraft industries, that had not previously been used for large-scale building structures. "In popular terms, it's about 'emptying' a bridge girder of its existing elements, providing complete freedom for choosing a new design. The inner volume of the bridge girder is then divided into a structure of very small voxels (3D pixels), like small dice. The topology optimisation method is then used for determining whether each individual voxel should consist of air or steel material. The result is a bridge girder design that uses the least possible steel without impairing the strength of the structure," says Associate Professor Niels Aage, DTU Mechanical Engineering. Specifically, a bridge element measuring 30 x 5 x 75 metres was analysed, divided into two billion voxels, each no bigger than a few centimetres. The result was an incredibly extensive calculation performed by a supercomputer, which would have taken an ordinary computer 155 years to do and is the largest structural optimisation ever carried out. The computer calculation presented input for how to best structure the design space of the bridge deck. Among other things, that meant curving part of the currently straight transverse diaphragms, making it possible to shave off 28 per cent of the material that is used for bridge decks and thereby achieve a corresponding reduction of the CO2 emissions generated by the production and transport of concrete and steel. "We interpreted and adjusted calculations so the result became a suggested bridge girder structure with the optimum design that can be carried out without too costly production methods. The economic aspect is important in order for the design to be a realistic option for future bridge projects," says Mads Jacob Baandrup. Naturally, additional analyses will be required before the new design can be used for building bridges, but COWI is confident that the results of the research project add valuable knowledge to tomorrow's suspension bridges. "The new bridge girder design can be converted into a weight and CO_2 reduction of up to 20 per cent for the entire bridge, which of course benefits the climate. COWI is also involved in a wide range of the world's largest bridge projects, so a potential new design will also benefit our customers and society," says Technical Director Henrik Polk, COWI, who participated in the research. DTU is also very excited about the results. "We believe there are huge perspectives to using topology optimisation for ensuring the sustainable design of other large building structures, such as high-rises, stadiums or highway bridges. We want to explore that field, and since the construction industry accounts for 39 per cent of global CO2 emissions, almost any reduction can be of interest," says Professor Ole Sigmund, DTU Mechanical Engineering.

Source https://www.sciencedaily.com/releases/2020/06/200603110240.htm

2. New system combines smartphone videos to create 4D visualizations

Researchers at Carnegie Mellon University have demonstrated that they can combine iPhone videos shot "in the wild" by separate cameras to create 4D visualizations that allow viewers to watch action from various angles, or even erase people or objects that temporarily block sight lines. The videos can be shot independently from variety of vantage points, as might occur at a wedding or birthday celebration, said Aayush Bansal, a Ph.D. student in CMU's Robotics Institute. It also is possible to record actors in one setting and then insert them into another, he added. "We are only limited by the number of cameras," Bansal said, with no upper limit on how many video feeds can be used. Bansal and his colleagues presented their 4D visualization method at the Computer Vision and Pattern Recognition virtual conference last month. "Virtualized reality" is nothing new, but in the past it has been restricted to studio setups, such as CMU's Panoptic Studio, which boasts more than 500 video cameras embedded in its geodesic walls. Fusing visual information of real-world scenes shot from multiple, independent, handheld cameras into a single comprehensive model that can reconstruct a dynamic 3D scene simply hasn't been possible. Bansal and his colleagues worked around that limitation by using convolutional neural nets (CNNs), a type of deep learning program that has proven adept at analyzing visual data. They found that scene-specific CNNs could be used to compose different parts of the scene. The CMU researchers demonstrated their method using up to 15 iPhones to capture a variety of scenes -- dances, martial arts demonstrations and even flamingos at the National Aviary in Pittsburgh. The method also unlocks a host of potential applications in the movie industry and consumer devices, particularly as the popularity of virtual reality headsets continues to grow. Though the method doesn't necessarily capture scenes in full 3D detail, the system can limit playback angles so incompletely reconstructed areas are not visible and the illusion of 3D imagery is not shattered.

Source https://www.sciencedaily.com/releases/2020/07/200701134244.htm

Mechanical Engineering

3. New Automotive Radar Spots Hazards Around Corners

Using radar commonly deployed to track speeders, researchers have developed an automated system that will allow cars to peer around corners and spot oncoming traffic and pedestrians. The system, easily integrated into today's vehicles, uses Doppler radar to bounce radio waves off surfaces such as buildings and parked automobiles. The radar signal hits the surface at an angle, so its reflection rebounds off like a cue ball hitting the wall of a pool table. The signal goes on to strike objects hidden around the corner. Some of the radar signal bounces back to detectors mounted on the car, allowing the system to see objects around the corner and tell whether they are moving or stationary. "This will enable cars to see occluded objects that today's lidar and camera sensors cannot record, for example, allowing a self-driving vehicle to see around a dangerous intersection" said Felix Heide, an assistant professor of computer science at Princeton University and one of researchers. "The radar sensors are also relatively low-cost, especially compared to lidar sensors, and scale to mass production." The researchers described how the system is able to distinguish objects including cars, bicyclists and pedestrians and gauge their direction and oncoming speed. "The proposed approach allows for collision warning for pedestrians and cyclists in real-world autonomous driving scenarios -- before seeing them with exist direct line-of-sight sensors," the authors write. In recent years, engineers have developed a variety of sensor systems that allow cars to detect other objects on the road. Many of them rely on lidar or cameras using visible or near-infrared light, and such sensors preventing collisions are now common on modern cars. But optical sensing is difficult to use to spot items out of the car's line of sight. In earlier research, Heide's team has used light to see objects hidden around corners. But those efforts currently are not practical for use in cars both because they require high-powered lasers and are restricted to short ranges. In conducting that earlier research, Heide and his colleagues wondered whether it would be possible to create a system to detect hazards out of the car's line of sight using imaging radar instead of visible light. The signal loss at smooth surfaces is much lower for radar systems, and radar is a proven technology for tracking objects. The challenge is that radar's spatial resolution -- used for picturing objects around corners such as cars and bikes -- is relatively low. However, the researchers believe that they could create algorithms to interpret the radar data to allow the sensors to function. "The algorithms that we developed are highly efficient and fit on current generation automotive hardware systems," Heide said. "So, you might see this technology already in the next generation of vehicles." To allow the system to distinguish objects, Heide's team processed part of the radar signal that standard radars consider background noise rather than usable information. The team applied artificial intelligence techniques to refine the processing and read the images. The researchers plan to follow the research in a number of directions for applications involving both radar and refinements in signal processing. He said the system has the potential to radically improve automotive safety and it relies on existing radar sensor technology, so readying the radar system for deployment in the next generation of automobiles should be possible.

Source https://www.sciencedaily.com/releases/2020/06/200625140727.htm

4. Carbon-Loving Materials Designed to Reduce Industrial Emissions

Researchers at the Department of Energy's Oak Ridge National Laboratory and the University of Tennessee, Knoxville, are advancing gas membrane materials to expand practical technology options for reducing industrial carbon emissions. Results demonstrate a fabrication method for membrane materials that can overcome current bottlenecks in selectivity and permeability, key variables that drive carbon-capturing performance in real environments. "Often there is a trade-off in how selective or how permeable you can make membranes that filter out carbon dioxide without allowing other gases to pass through. The ideal scenario is to create materials with high permeability and selectivity," said Zhenzhen Yang of UT's Department of Chemistry. Gas membranes are a promising but still developing technology for reducing post-combustion or flue gas emissions produced by fossil-fueled industries. The concept is simple: a thin, porous membrane acts as a filter for exhaust gas mixtures, selectively allowing carbon dioxide, or CO_2, to flow through freely into a collector that is kept under reduced pressure, but preventing oxygen, nitrogen and other gases from tagging along. Unlike existing chemical methods to capture CO_2 from industrial processes, membranes are easy to install and can operate unattended for long periods with no additional steps or added energy costs. The catch is that new, cost-effective materials are needed to scale up the technology for commercial adoption. "Gas membranes need pressure on one side and typically a vacuum on the other to maintain a free-flow environment, which is why materials' selectivity and permeability are so important to developing the technology," said Ilja Popovs of ORNL's Chemical Sciences Division. "Underperforming materials require more energy to push gases through the system, so advanced materials are key to keeping energy costs low." No natural and only a few synthetic materials have exceeded what is called the Robeson upper limit, a known boundary that constrains how selective and permeable most materials can be before these rates start to drop. Materials with sufficiently high selectivity and permeability for efficient gas separations are rare and often made from expensive starting materials whose production requires either long and tedious synthesis or costly transition metal catalysts. "We set out to test a hypothesis that introducing fluorine atoms into membrane materials could improve carbon-capture and separation performance," Yang said. The element fluorine, used to make consumer products such as Teflon and toothpaste, offers carbon dioxide-philic properties that make it attractive for carbon-capture applications. It is also widely available, making it a relatively affordable option for low-cost fabrication methods. Research on fluorinated gas membranes has been limited because of fundamental challenges of incorporating fluorine into materials to realize its carbon-loving functionality. "Our first step was to create a unique fluorine-based polymer using simple chemical methods and commercially available starting materials," Yang said. Next, researchers transformed, or carbonized, the material using heat to give it the porous structure and functionality needed for capturing CO_2. The two-step process preserved the fluorinated groups and boosted CO_2 selectivity in the final material, overcoming a fundamental hurdle encountered in other synthetic methods. "The approach resulted in a carbon dioxide-philic material with high surface area and ultra-micropores that is stable in high-temperature operating conditions," Yang said. "All of these factors make it a promising candidate for carbon-capture and separation membranes." The material's novel design contributes to its exceptional performance, observed in high selectivity and permeability rates that exceed the Robeson upper limit, something only a handful of materials have accomplished. The basic discovery expands the limited library of practical options for carbon-capture membranes and opens new directions for developing fluorinated membranes with other task-specific functionalities. Researchers aim to next investigate the mechanism by which fluorinated membranes absorb and transport CO_2, a fundamental step that will inform the design of better carbon-capture systems with materials purposely tailored to grab CO_2 emissions.

Source https://www.sciencedaily.com/releases/2020/07/200702144731.htm

Electrical Engineering

5. New Method Measures Temperature Within 3D Objects

University of Wisconsin-Madison engineers have made it possible to remotely determine the temperature beneath the surface of certain materials using a new technique they call depth thermography. The method may be useful in applications where traditional temperature probes won't work, like monitoring semiconductor performance or next-generation nuclear reactors. Many temperature sensors measure thermal radiation, most of which is in the infrared spectrum, coming off the surface of an object. The hotter the object, the more radiation it emits, which is the basis for gadgets like thermal imaging cameras. Depth thermography, however, goes beyond the surface and works with a certain class of materials that are partially transparent to infrared radiation. "We can measure the spectrum of thermal radiation emitted from the object and use a sophisticated algorithm to infer the temperature not just on the surface, but also underneath the surface, tens to hundreds of microns in," says Mikhail Kats, a UW-Madison professor of electrical and computer engineering. "We're able to do that precisely and accurately, at least in some instances." For the project, the team heated a piece of fused silica, a type of glass, and analyzed it using a spectrometer. They then measured temperature readings from various depths of the sample using computational tools previously developed by Xiao in which he calculated the thermal radiation given off from objects composed of multiple materials. Working backwards, they used the algorithm to determine the temperature gradient that best fit the experimental results. Kats says this particular effort was a proof of concept. In future work, he hopes to apply the technique to more complicated multilayer materials and hopes to apply machine learning techniques to improve the process. Eventually, Kats wants to use depth thermography to measure semiconductor devices to gain insights into their temperature distributions as they operate. That's not the only potential application of the technique. This type of 3D temperature profiling could also be used to measure and map clouds of high temperature gases and liquids. "For example, we anticipate relevance to molten-salt nuclear reactors, where you want to know what's going on in terms of temperature of the salt throughout the volume," says Kats. "You want to do it without sticking in temperature probes that may not survive at 700 degrees Celsius for very long." He also says the technique could aid in measuring the thermal conductivity and optical properties of materials without the need to attach temperature probes. "This is a completely remote, non-contact way of measuring the thermal properties of materials in a way that you couldn't do before," Kats says.

Source https://www.sciencedaily.com/releases/2020/07/200702144101.htm

6. Spintronics: Faster Data Processing Through Ultrashort Electric Pulses

Physicists at Martin Luther University Halle-Wittenberg (MLU) and Lanzhou University in China developed a simple concept that could improve significantly magnetic-based data processing. Using ultrashort electric pulses in the terahertz range, data can be written, read and erased very quickly. This would make data processing faster, more compact and energy efficient. The researchers confirmed their theory by running complex simulations. Magnetic data storage is indispensable for storing securely the huge amount of data generated every day, for instance through social networks. Once stored, the information can still be retrieved after many years. Charge-based data storage used for example in mobile phones is much more short-lived when there is no energy supply. Traditional magnetic hard drives and components have disadvantages of their own, due to the moving mechanical parts and the need for magnetic fields which makes them more power consuming and relatively slow when reading and writing data. "We were after a fast and energy-efficient alternative," explains Professor Jamal Berakdar from the Institute of Physics at MLU. He and his colleagues from Lanzhou University came up with a simple idea. By using ultrashort pulses in the terahertz range, information could be written in magnetic nano-vortices and retrieved within picoseconds. Theoretically, this renders possible billions of read and write operations per second without the need for magnetic fields. "With the appropriately shaped pulses the data can be processed very quickly at low energy cost," says Berakdar. The new concept is based on existing terahertz and magnetism technologies. "It exploits advances in electric pulse generation and nanomagnetism." So far, the method has been tested in computer simulations. "In recent years there have been fantastic advances in generating and controlling electrical pulses," says Berakdar. Therefore, it makes sense to explore new ways to apply these pulses to data storage. The concept presented by the researchers offers a simple tool for controlling magnetic nano-vortices and can therefore be directly utilised for new storage technologies.

Source https://www.sciencedaily.com/releases/2020/07/200702100556.htm

7. Predicting in-flight air density for more accurate landing

In the final few minutes of a spacecraft landing it is moving at hypersonic speeds through many layers of atmosphere. Knowing the air density outside of the vehicle can have a substantial effect on its angle of descent and ability to hit a specific landing spot. But air density sensors that can withstand the harsh hypersonic conditions are uncommon. A student from The Netherlands, working with an aerospace engineer at the University of Illinois at Urbana-Champaign, developed an algorithm that can run onboard a vehicle, providing important real-time data to aid in steering the craft, particularly during the crucial entry, descent, and landing stage. "The algorithm we created can run in-flight, onboard the vehicle and estimate what the atmosphere outside is like," said Hamza El-Kebir, an undergraduate at Delft University of Technology. "So this is a complete game changer, because now you can use prior knowledge about the vehicle's motion to estimate the air density, inform your decisions in flight, and make minor alterations in your course. This can provide more certainty that you're going to hit that spot, instead of dealing with really conservative guidance." El-Kebir conducted the research with Melkior Ornik, assistant professor in the Dept. of Aerospace Engineering at U of I, during a semester abroad program and will begin graduate school at Illinois in the fall. He said his work is new because it uses data from sensors that weren't intended to provide air density data. "It extracts that density information from it by using really nifty algorithms that don't require any real knowledge of the aerodynamics or the atmosphere." Ornik explained how the algorithm learns the air density. "The algorithm starts from almost nothing. It doesn't know anything about the air density. It gathers data from accelerometers and gyroscopes available on any vehicle to gather data, and combines it with prior knowledge about maximal rate of acceleration to obtain a time-varying estimate of air density. And it gets, in a sense, smarter over time. It changes its estimations onboard, based on the input data it receives." El-Kebir and Ornik used data acquired from the entry, descent, and landing of the Phoenix lander -- a Mars science probe -- representing the last 220 seconds, the ballistic phase, until parachute deployment. "There's no steering at the later portion of that stage, so it's really important to immediately know the air density in the rarified flow regime -- from about 80 kilometers and up. When it enters that later portion, its flight path angle gets fixed and the vehicle just descends, and is barely affected by the direction of the wind," El-Kebir said. What if the Phoenix had the algorithm? "If you know the air density, you can estimate your angle of attack with respect to the wind. You could also predict what the density will be like in the future, so you can make decisions. There was no control on Phoenix during the ballistic stage. If it had the knowledge of air density, it would have had an edge. They could have leveraged the data and landed more accurately." Ornik said there is often an assumption that there exists a fixed model that we know in advance and we figure out control methods that lead the vehicle to land. "That is often a strong assumption. It's often wrong because it's not just about air density. Due to the speed and the impact with air, hypersonic vehicles change shape slightly during the flight and that changes their dynamics during flight." "So we don't have a unified model that describes the whole flight because the dynamics change gradually over time. We know the maximal rate of change, so with this algorithm, we can exploit that knowledge to create an estimate," Ornik said.

Source https://www.sciencedaily.com/releases/2020/04/200402100851.htm

8. World's widest graphene nanoribbon promises the next generation of miniaturized electronics

Standard semiconductor technology is reaching its limit in miniaturization, but the demand for smaller electrical devices with higher performance continues to grow. The research group introduced the widest graphene nanoribbon prepared by the bottom-up approach with electrical properties surpassing those of silicon semiconductors, promising a new generation of miniaturized electronic devices. With literally the thickness of one carbon atom and electrical properties that can surpass those of standard semiconductor technologies, graphene nanoribbons promise a new generation of miniaturized electronic devices. The theory, however, remains far ahead of reality, with current graphene nanoribbons falling short of their potential. A new collaborative study by a project of CREST, JST Japan including Nara Institute of Science and Technology (NAIST), Fujitsu Laboratories Ltd. and Fujitsu Ltd., and the University of Tokyo reports the first ever 17-carbon wide graphene nanoribbon and confirms it has the smallest bandgap seen to date among known graphene nanoribbons prepared by a bottom-up manner. Large-scale integrated circuits (LSIs) that use silicon semiconductors are used in a wide range of electronic devices, anywhere from computers to smartphones. They are actually supporting our lives and almost everything else these days. However, although LSIs have improved device performance by reducing the size of the devices, LSI miniaturization is approaching its limit. At the same time, commercial demand continues to put pressure on companies to make higher performing smartphones at smaller sizes, while industry pressure is demanding large-scale manufacturing with smaller equipment. Other methods and/or materials are definitely needed to solve these problems, says the group leader Dr. Shintaro Sato, Fujitsu Ltd. "Silicon semiconductors are giving us better performance at smaller sizes. However, we are reaching the limit in how small we can make devices. Thus, we have high expectations for the performance of graphene nanoribbons, which have semi-conducting properties that are only one atom thick -- a 2D material," he notes. Graphene nanoribbons are honeycomb-like structures and, compared to graphene and carbon nanotubes, are the lesser known carbon-based semiconductor family member. Graphene nanoribbons exhibit unique electronic and magnetic properties that do not appear in two-dimensional graphene. "Interestingly, the electronic and magnetic properties of graphene nanoribbons are widely tuned as a function of the width and edge structure." says Prof. Hiroko Yamada at NAIST. Armchair-type graphene nanoribbons, which are promising type of nanoribbon for device application, display width-dependent band gap. They can be classified into three subfamilies (3p, 3p + 1, 3p + 2), their band gaps being inversely proportional to the width of those families. Basically, wider armchair-edge graphene nanoribbons belonging to the 3p + 2 subfamily have the smallest bandgaps among different graphene nanoribbons, having considerable potential to be exploited in GNR-based devices. So far, 13-armchair graphene nanoribbons belonging to the 3p + 1 subfamily with a band gap of more than 1 eV have been reported, but Sato, Yamada and colleagues show the synthesis of a 17-graphene nanoribbon belonging to the 3p + 2 subfamily, which have even smaller bandgaps. The graphene nanoribbon synthesis was based on the bottom-up approach, called "on-surface synthesis," and a dibromobenzene-based molecule was used as a precursor for on-surface graphene nanoribbon synthesis. "There are many methods to synthesize graphene nanoribbons, but to produce atomically precise graphene nanoribbons, we decided to use the bottom-up approach. The important point is that the structure of the precursor can define the ultimate structure of graphene nanoribbons if we use the bottom-up approach," explains NAIST's Dr. Hironobu Hayashi, who also contributed to the study. Scanning tunnel microscopy and spectroscopy by Dr. Junichi Yamaguchi at Fujitsu. Ltd. and non-contact atomic force microscopy by Dr. Akitoshi Shiotari and Prof. Yoshiaki Sugimoto at The University of Tokyo confirmed the atomic and electronic structure of the acquired 17-armchair graphene nanoribbons. Additionally, the experimentally obtained bandgap of 17-armchair graphene nanoribbons was found to be 0.6 eV, and this is the first demonstration of the synthesis of graphene nanoribbons having a band gap smaller than 1 eV in a controlled manner. "We expect these 17-carbon wide graphene nanoribbons to pave the way for new GNR-based electronic devices," says Sato.

Source https://www.sciencedaily.com/releases/2020/06/200630111440.htm

Energy Engineering

9. Engineers Develop New Fuel Cells with Twice the Operating Voltage As Hydrogen

Electrification of the transportation sector -- one of the largest consumers of energy in the world -- is critical to future energy and environmental resilience. Electrification of this sector will require high-power fuel cells (either stand alone or in conjunction with batteries) to facilitate the transition to electric vehicles, from cars and trucks to boats and airplanes. Liquid-fueled fuel cells are an attractive alternative to traditional hydrogen fuel cells because they eliminate the need to transport and store hydrogen. They can help to power unmanned underwater vehicles, drones and, eventually, electric aircraft -- all at significantly lower cost. These fuel cells could also serve as range-extenders for current battery-powered electric vehicles, thus advancing their adoption. Now, engineers at the McKelvey School of Engineering at Washington University in St. Louis have developed high-power direct borohydride fuel cells (DBFC) that operate at double the voltage of conventional hydrogen fuel cells. The research team, led by Vijay Ramani, the Roma B. and Raymond H. Wittcoff Distinguished University Professor, has pioneered a reactant: identifying an optimal range of flow rates, flow field architectures and residence times that enable high power operation. This approach addresses key challenges in DBFCs, namely proper fuel and oxidant distribution and the mitigation of parasitic reactions. Importantly, the team has demonstrated a single-cell operating voltage of 1.4 or greater, double that obtained in conventional hydrogen fuel cells, with peak powers approaching 1 watt/cm^2. Doubling the voltage would allow for a smaller, lighter, more efficient fuel cell design, which translates to significant gravimetric and volumetric advantages when assembling multiple cells into a stack for commercial use. Their approach is broadly applicable to other classes of liquid/liquid fuel cells. "The reactant-transport engineering approach provides an elegant and facile way to significantly boost the performance of these fuel cells while still using existing components," Ramani said. "By following our guidelines, even current, commercially deployed liquid fuel cells can see gains in performance." The key to improving any existing fuel cell technology is reducing or eliminating side reactions. The majority of efforts to achieve this goal involve developing new catalysts that face significant hurdles in terms of adoption and field deployment. "Fuel cell manufacturers are typically reluctant to spend significant capital or effort to adopt a new material," said Shrihari Sankarasubramanian, a senior staff research scientist on Ramani's team. "But achieving the same or better improvement with their existing hardware and components is a game changer." "Hydrogen bubbles formed on the surface of the catalyst have long been a problem for direct sodium borohydride fuel cells, and it can be minimized by the rational design of the flow field," said a researcher. "With the development of this reactant-transport approach, we are on the path to scale-up and deployment."

Source https://www.sciencedaily.com/releases/2020/06/200618092445.htm

10. Wearable-tech glove translates sign language into speech in real time

UCLA bioengineers have designed a glove-like device that can translate American Sign Language into English speech in real time though a smartphone app. "Our hope is that this opens up an easy way for people who use sign language to communicate directly with non-signers without needing someone else to translate for them," said Jun Chen, an assistant professor of bioengineering at the UCLA Samueli School of Engineering and the principal investigator on the research. "In addition, we hope it can help more people learn sign language themselves." The system includes a pair of gloves with thin, stretchable sensors that run the length of each of the five fingers. These sensors, made from electrically conducting yarns, pick up hand motions and finger placements that stand for individual letters, numbers, words and phrases. The device then turns the finger movements into electrical signals, which are sent to a dollar-coin-sized circuit board worn on the wrist. The board transmits those signals wirelessly to a smartphone that translates them into spoken words at the rate of about a one word per second. The researchers also added adhesive sensors to testers' faces -- in between their eyebrows and on one side of their mouths -- to capture facial expressions that are a part of American Sign Language. Previous wearable systems that offered translation from American Sign Language were limited by bulky and heavy device designs or were uncomfortable to wear, Chen said. The device developed by the UCLA team is made from lightweight and inexpensive but long-lasting, stretchable polymers. The electronic sensors are also very flexible and inexpensive. In testing the device, the researchers worked with four people who are deaf and use American Sign Language. The wearers repeated each hand gesture 15 times. A custom machine-learning algorithm turned these gestures into the letters, numbers and words they represented. The system recognized 660 signs, including each letter of the alphabet and numbers 0 through 9.

Source https://www.sciencedaily.com/releases/2020/06/200629120201.htm

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ENGINEERING INNOVATION IN INDIA

Role of Nuclear Fuel Complex in First Criticality of KAPP-3

It is a happy and momentous occasion to Department of Atomic Energy (DAE), especially Nuclear Power Corporation India Limited (NPCIL) Team on achieving the "First Criticality" of 3rd Unit of Kakarpar Atomic Power Project (KAPP-3) on 22-07-2020 at 09.36AM. Nuclear Fuel Complex (NFC) congratulates Team-NPCIL on this stupendous achievement. Indeed, it is a proud moment as well to see a congratulatory message from Shri Narendra Modi, The Prime Minister of India saying "development of indigenous reactor as shining example of Make in India and a trailblazer for many such achievements".

It is interesting to note that KAAP-3 finds a special place in Indian Nuclear Power Program as India's First 700MWe and biggest indigenously developed variant of Pressurized Heavy Water Reactor (PHWR). Operationalisation of India's first 700MWe reactor marks significant scale-up in design and economies of existing 540MWe reactor without significant design changes and also addressing the important issue of excess thermal margin. It is also important to note that the mile stone moment has come ahead of its original schedule. Thanks to coordinated efforts of many related agencies including NFC. This has given a tremendous boost and confidence to DAE to handle & ensure the successful completion of such mega projects. Thus, KAPP-3 has become the backbone to new fleet of 10 such reactors sanctioned by government in 2017. This will help DAE in ram-up the nuclear power capacity to 22,480MWe from existing 6780MWe by 2031, where 700MWe reactors find a lion share.

Nuclear Fuel Complex (NFC) has played an important & substantial role in this achievement through the timely supply of several reactor-core components to this indigenous variant and directly contributing to the government stand of self-reliance. The core components includes 125T of natural uranium fuel, 392 channels of pressure tubes, 1568 numbers of garter springs, 30 meter length of 'U-bend' Incoloy800 steam generator tubes, 96numbers of reactivity mechanism assemblies.
In order to have better performance under operating conditions, several new requirements for production of better quality products have come-up for this 700MWe reactor when compared to already exiting 540 or 220MWe reactors. And, NFC faced several challenges while executing this time bound assignment. It demanded development of technologies and their seamlessly implementation to realize the targets. Development or modifications of manufacturing routes for fabrication of critical components like Pressure Tube, Fuel Clad and Garter Springs are among few necessary ones. For example, development of two pass forging route with single pass pillgering in place of extrusion route was carried out to produce 6 meter long pressure tubes with better stability and uniform mechanical properties under reactor conditions. Similarly, blank machining, ID honing and OD turning operations were introduced during fuel clad manufacturing process to reduce wall variations in clad thickness and also to obtain better recovery in UT pass. The design of garter springs was also changed to corrugated & welded spring to improve integrity of griddle wire under dynamic flow of coolant and improved testing capability during ISI. The untiring, dedicated and commendable efforts of its employees were an added advantage to NFC.

It is a matter of privilege to recollect the fruitful association between NFC and NPCIL, which dates back to 1974 soon after Canada's withdrawal from cooperating India in PHWR program due to Pokhran-1 restrictions. Since then NFC has come long way in supporting NPCIL starting from 220MWe at NAPS

to 540MWe at TAPS to present 700MWe at KAPS. Thus, one can confidently say that NFC always sets a new benchmark in **N**ever **F**ails in its **C**ommitments attitude and continue to play a significant role in all NPCIL's ambitious future expansion programs as well.

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