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 Mission

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 Announcements

- **Last date for submission of Nominations for Fellowship extended.** Fellows may submit nominations though log-in facility provided by INAE Digital Platform. Last date of receipt of nominations has been extended to **April 10, 2021.** For details click on the link given below.

  Link for Fellowship

- **Last date for submission of Nominations for INAE Young Engineer Award Extended.** Last date of receipt of nominations has been extended **to April 10, 2021.** For details click on the link given below.

  Link for Young Engineer Award

- **Nominations invited for Life Time Contribution Award in Engineering 2021**. Last date of receipt of nominations is **May 15, 2021.** For details click on the link given below.

  https://www.inae.in/life-time-contribution-award-in-engineering/

- **Nominations invited for Prof Jai Krishna and Prof SN Mitra Memorial Awards 2021.** Last date of receipt of nominations is **May 15, 2021.** For details click on the link given below.

  https://www.inae.in/professor-jai-krishna-and-professor-sn-mitra-memorial-awards/

- **Nominations invited for INAE Outstanding Teachers Award 2021.** Last date of receipt of nominations is **May 15, 2021.** For details click on the link given below.

  https://www.inae.in/inae-outstanding-teachers-award-awards/

- **Nominations invited for INAE Woman Engineer of the Year Award 2021.** Last date of receipt of nominations is **May 15, 2021.** For details click on the link given below.

  https://www.inae.in/women-engineer-of-year-award/

Special Cover on the Occasion of DST Golden Jubilee Commemoration

Prof Ashutosh Sharma, FNAE, Secretary DST forwarded a Message and a Special Cover released by Dr. Harsh Vardhan, Union Minister for Science & Technology, Earth Sciences and Health & Family Welfare and Shri Sanjay Dhotre, Union Minister of State for Posts on the occasion of DST Golden Jubilee commemoration. Prof Indranil Manna, President, INAE wrote a letter to Prof Ashutosh Sharma, Secretary, DST congratulating him and his colleagues for the same. A copy of the Message and Special Cover can be viewed by clicking here

Celebrations at the behest of DST on *Azadi ka Amrut Mohotsav*

A meeting of Prof Ashutosh Sharma, Secretary, DST with all Autonomous Professional Bodies under DST was held on 12th March 2021 regarding celebration of India's 75th Year of Independence (*Aazadi ka Amrut Mahotsava*) from 12th March 2021 to 15th Aug 2022. Subsequently, a meeting of INAE Apex Committee with Dr. BN Suresh and Dr. PS Goel as special invitees was held 13th March 2021 to discuss the events to be organized by INAE in the next 75 weeks until 15th August 2022.

Accordingly, a 10-member Task Force has been constituted to design and monitor the specific programs that INAE would pursue in the next 75 weeks in different locations and occasions. The composition of the said Task Force is as under.

1. Dr. Sanak Mishra, Immediate Past-President, INAE (Chairman)
2. Prof. Indranil Manna, President, INAE
3. Dr. BN Suresh, Past-President, INAE
4. Dr. PS Goel, Past-President, INAE
5. Dr. Purnendu Ghosh, Vice-President, INAE
6. Prof. Sivaji Chakravorti, Vice-President, INAE
7. Prof. S Gopalakrishnan, FNAE, Governing Council Member and Secretary, INAE Bangalore Local Chapter
8. Prof. Debatosh Guha, FNAE and Secretary-cum-Treasurer, INAE Kolkata Local Chapter
9. Prof. K Muralidhar, FNAE, Chairman, INAE Kanpur Local Chapter
10. Dr. Ram Kumar Singh, FNAE, Visiting Professor, Indian Institute of Technology-Bombay

In addition, the following three INAE Young Associates have also volunteered themselves to contribute to the DST's initiative on Aazadi ka Amrut Mohotsav and have been invited to form part of the sub-committee to function under direction of the Task Force.

1. Dr. Raghvendra Kumar Chaudhary, Department of Electronics Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad.
2. Dr. Mudrika Khandelwal, Dept of Materials Science and Metallurgical Engg., Indian Institute of Technology Hyderabad.
3. Dr. Sathesh Mariappan, Department of Aerospace Engineering, Indian Institute of Technology Kanpur.

All INAE Local Chapters have been requested to forward proposals regarding suitable Chapter activities/events to commemorate **India's 75th Year of Independence (*Aazadi ka Amrut Mahotsava*).** The 1st meeting of the INAE Task Force for "Aazadi ka Amrut Mohotsav" was held on 31st March 2021 to discuss the way forward.

National Frontiers of Engineering (NatFOE 2021)

The National Frontiers of Engineering (NatFOE) Symposium is a flagship event of INAE being held since 2006. The 15th NatFOE 2021 is being organized from July 9-10, 2021 at Indian Institute of Technology, Hyderabad in hybrid mode with partial participation online and rest in physical mode. Prof BS Murty, Director, IIT Hyderabad and Prof Sivaji Chakravarti, Vice-President, INAE are the coordinators of the event. Prof Chandrasekhar Sharma, IIT Hyderabad is the Convener of the event. The four themes of the Symposium are (i) ***Artificial Intelligence and Machine Learning; (ii) Advances in Materials and Manufacturing Technology; (iii) Infrastructure & Unconventional Energy; and (iv) Rural Technology & Entrepreneurship.*** Two Coordinators have been identified for each of the Themes. The first announcement can be viewed at https://www.iith.ac.in/natfoe2021/

An “Innovation in Manufacturing Practices (IMP)” event is being organized on sidelines of NatFOE 2021. IMP is a manufacturing design competition to provide the bright minds a platform to display and exuberate their talent in design and manufacturing. In this event, the participants (students) are expected to design, fabricate and demonstrate a hardware prototype using an innovative manufacturing process not limited to any engineering discipline. A pamphlet on the IMP 2021 can be viewed by clicking here

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INAE Webinar Series

INAE Mumbai Chapter

Indian Nuclear Society (INS) and INAE Mumbai Chapter jointly organized a Webinar on **“Outlook for Nuclear Power in India – Utility Perspective” on Wednesday, 31st March 2021** through WebEx Platform to commemorate celebration of India's 75th Year of Independence (*Aazadi ka Amrut Mahotsava*). The Lecture was delivered by **Mr S K Sharma, Chairman and Managing Director, Nuclear Power Corporation of India Limited**. The Introductory Remarks for the Webinar were by Mr SK Mehta, FNAE, President, INS and moderated by Dr R B Grover, FNAE, Co-Convenor, INAE Mumbai Chapter, Emeritus Professor, Homi Bhabha National Institute, Mumbai.

INAE Hyderabad Chapter

INAE Hyderabad Local Chapter organized a National Workshop on Hypersonic Air-Breathing Vehicle held jointly with National Centre for Combustion R&D, Combustion Institute on **26th March 2021 (Friday) over WebEx.**

INAE Kolkata Chapter

INAE Science Day Celebration

National Science Day in India is celebrated on 28 February every year to commemorate the invention of the Raman Effect by Bharatratna Sir C. V. Raman. On this occasion, the Indian National Academy of Engineering (INAE) organized the *Science Day Lecture* delivered by **Professor David J. Wineland**, Nobel Laureate in Physics 2012, University of Oregon. Prof. Wineland talked on “**Individual Atoms as Clocks and Bits**”. Owing to the restrictions due to the worldwide pandemic, the event was organised online on WebEx platform on Sunday, 28 Feb. 2021 at 9:45 AM. INAE Kolkata Chapter was the host. Prof. Indranil Manna, President, INAE presided over the function which was moderated by Prof. Debatosh Guha, Secretary, INAE Kolkata Chapter. Padmashri Prof. Sankar Kumar Pal, former Director, ISI, Kolkata and Dr. Amitava Sengupta, former Outstanding Scientist, NPL-New Delhi, were present in the panel.

Apart from the scientific innovations made by him and his contemporary scientist, Prof. Wineland also shared his personal life which was truly motivating and inspiring to the young minds. This Science Day event was attended by more than 100 young researchers, engineers and Fellows from different Colleges, Institutes, and Universities all over India.

A few snapshots of this online event are given below:

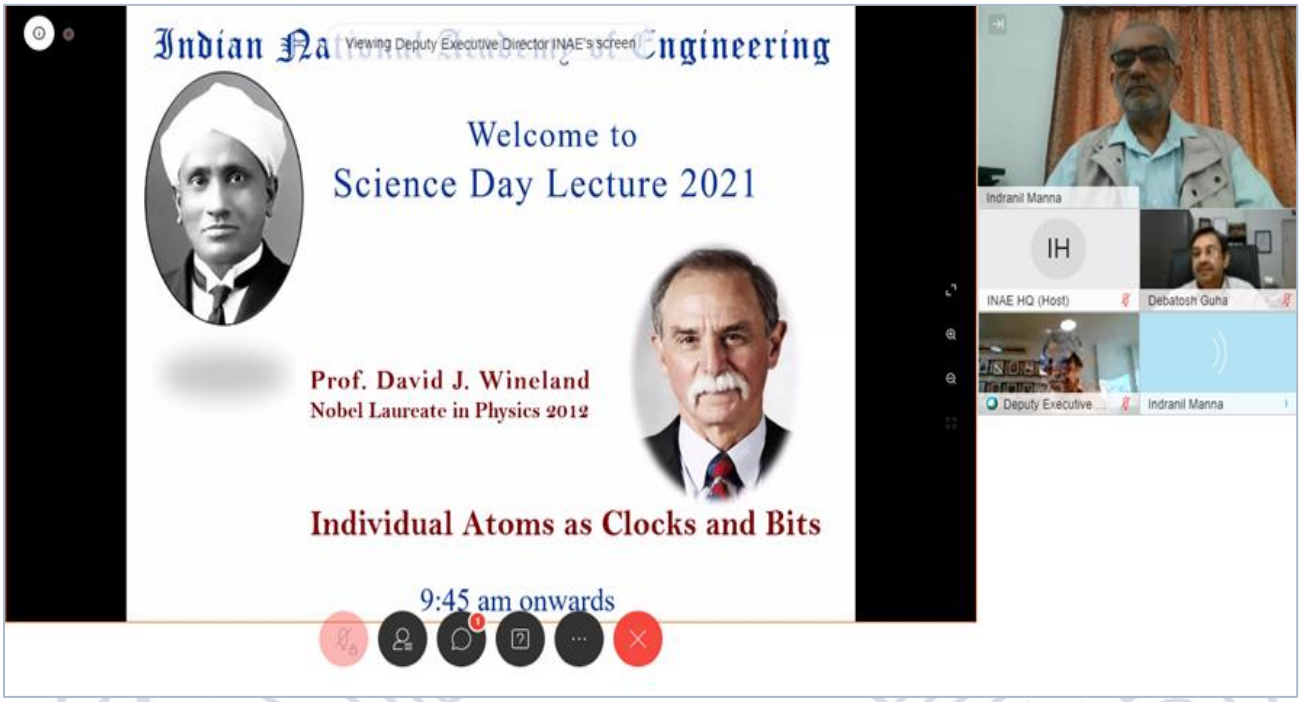

Fig. 1. Prof. Indranil Manna, President INAE giving the welcome address.

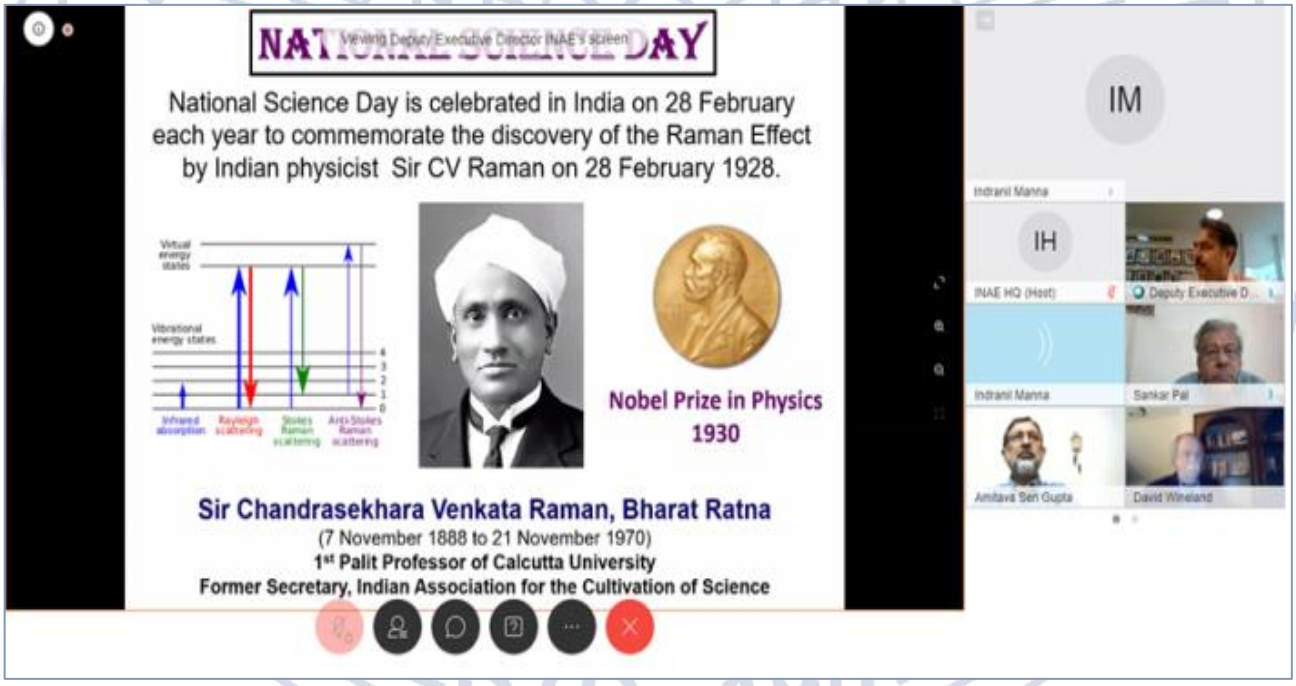

Fig. 2. Prof. Wineland and other panelists during the welcome speech by the President

Fig. 3. Prof. David J. Wineland delivering his lecture.

INAE Mumbai Chapter

INAE Mumbai Chapter organized a webinar on "**Implications of NEP-2020 for Engineering Education in India**" on 16th February 2021**.** The Session was Moderated by Prof A K Suresh, FNAE, Co-Convener - INAE Mumbai Chapter, and Professor - Department of Chemical Engineering, IIT Bombay and the **S**peaker for the session was Prof Raghunath K Shevgaonkar, FNAE, Emeritus Professor, IIT Bombay

Brief report on the webinar

After 34 years, Indian Government approved the new National Education Policy, NEP-2020. Broadly, the policy has received appreciation from all sectors of education. The policy has evolved through a consultative process from political leaders and educationists. The first part of the talk highlights the general features of NEP-2020. Expectations from the future engineers are put forward and the implications of the NEP-2020 for engineering education, and the implementations issues are discussed in the later part of the talk.

The NEP-2020 first discusses the problems faced by the current education system and then proposes many radical reforms at academic, institutional and governance level. The first and the foremost is the GER target that needs to be achieved by 2035. At academic level, a multi-disciplinary, more flexible, student-centric structure has been proposed. A special thrust has been provided on (i) integrating vocational component in the main stream for better employability and (ii) enhancing liberal arts component for holistic developments of the students. Under institutional reforms, three types of HEIs namely research-centric HEIs, teaching-centric HEIs and degree-granting HEIs, have been proposed. It has been proposed that the affiliation system would be phased out in next fifteen years and the HEIs would be granted graded autonomy. The policy also has proposed single regulator, and evolution of the solitary discipline HEIs into comprehensive institutions. Use of technology has been amply emphasized for building inclusivity in the system.

Before discussing at the implications of NEP-2020 for engineering education, it is worthwhile to look into the kind of knowledge and skills the future engineers are expected to possess. It is clear that the future world is going to be technology dominated and the life span of technology will get shorter. The world will also be stressed for natural resources. The future engineers therefore will have to be prepared for addressing the so called 'grand challenges' like adequate energy, water, sanitation, food, etc., for making the development sustainable. The future engineers will need multi-disciplinary, systemic approach with innovative ideas. Global mindset with better understanding of the society, politics and economics will be the need of the hour.

In this light, although there is no special treatment for engineering education in NEP-2020, many of the proposed general reforms may impact engineering education in India. In fact, the NEP-2020 can help in removing obsolescence in technical education, and can facilitate many of the changes that the current engineering education aspires to have. Engineering institutions in India should use this opportunity to restructure their programs and departments to develop tomorrow's engineers who are quality conscious, understand societal needs, and develop technology products that make the world sustainable.

The talk has critically looked at various aspects of NEP-2020 and its impact on technical education as a whole. The NEP-2020 is forward looking but the real challenge lies in its implementation. The most important aspect will be granting autonomy to HEIs with accountability mechanism in place. Development of quality faculty and educational leaders and their unbiased deployment will be an important aspect of implementation. Engineering institutions will have to restructure their departments and programs with less rigid boundaries to inculcate multi-disciplinary culture. More hands-on training in laboratories and industries, and exposure to the real-life problems will have to be emphasized. The regulatory bodies will have to facilitate strengthening of Industry-academia partnership through movement of engineering faculty and industry professionals beyond their territories. Industry will also have to help in providing vocational training to enhance the employability of the graduates.

All this will need a robust financial model. NEP-2020 has not provided any sustainable financial model. For engineering education, which is cost intensive, a financial model that is inclusive and sustainable will be the greatest challenge in implementation of the NEP-2020 for engineering education.

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:

Prof. Bidyut Baran Chaudhuri, FNAE HAG Professor, ISI, Kolkata	Jalpaiguri Government Engineering College, Jalpaiguri Feb 1-3, 2021	Delivered online lectures on "Project Preparation and Research paper writing", "Automatic detection of struck-out text in document images" and "Constrained optimization problems in Engineering". According to the feedback received from the college, they are grateful to INAE for the scheme and approval for online classes during the pandemic situation. The DVP had chosen topics which are beneficial for all students and his interactions have encouraged students and faculty members for higher education.
Prof. V Radhakrishnan, FNAE Professor, Department of Mechanical Engineering, IIT Madras & Emeritus Professor of Indian Institute of Space Science and Technology	College of Engineering Pune Feb 9-11, 2021	Delivered lectures on broad topics "Interferometry", "Measuring Machines" and "Advances in Metrology". According to the feedback received from College Prof Radhakrishnan had given inputs to improve the MTech, SY and TY BTech curriculum to be implemented in 2021-22. He has helped the department to strengthen the research activity of MTech students, PhD scholars and Faculty members. His guidance will help improve quality of work and publication in referred journals.
Dr. SL Mannan, FNAE Former Outstanding Scientist and Director Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam	Government College of Engineering, Salem Feb 11-13, 2021 Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai Feb 27- Mar 1, 2021	Delivered lectures on "Dislocation Theory-I", "Dislocation Theory-II" and "Strengthening Mechanisms- Strain Hardening and Grain Boundary Strengthening". As per the feedback received from the engineering Colleges, the DVP had discussion with faculty members and students regarding UG projects and has also suggested modification in UG syllabus. The intense interactions with the DVP were very beneficial for both the faculty members and the students. Delivered lectures on " Crystal Defects and Strengthening Mechanisms-Strain Hardening and Grain Boundary Strengthening", "Strengthening Mechanisms-Solid Solution, Precipitation& Dispersion Hardening, Ni based super alloys" and " Fracture Mechanics". As per the feedback received from the faculty coordinator of the associated engineering college, the DVP has also guided BTech and MTech students on ongoing projects. The BTech Mechanical Engineering Regulation and syllabi were discussed, and suggestion given on the same by DVP. The interactions with the students were very beneficial and the Dean academics was very happy and appreciated the scheme.

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International/National Conferences/Seminars being Organized By IITs/other Institutions

International Conference on Sustainable materials, Manufacturing and Renewable Technologies (i-SMaRT) online Conference on 22nd to 23rd April 2021
https://conferencealerts.com/show-event?id=231807

4th International Conference on Computer Networks and Inventive Communication Technologies (ICCNCT - 2021) on 23rd to 24th April 2021 at Coimbatore, Tamilnadu, India
https://conferencealerts.com/show-event?id=230740

International Conference on Nanoelectronics, Nanophotonics, Nanomaterials, Nanobioscience & Nanotechnology on 29th to 30th April 2021 at Kottayam, Kerala, India
https://conferencealerts.com/show-event?id=229058

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	A paper by Prof. Saptarshi Basu, FNAE, DRDO Chair Professor in Mechanical Engineering, Indian Institute of Science, Bangalore titled “On secondary atomization and blockage of surrogate cough droplets in single- and multilayer face masks " is now online in SCIENCE ADVANCE. The paper can be viewed at the link given below https://advances.sciencemag.org/content/7/10/eabf0452/tab-pdf The Press Release can be viewed at the link given below. https://www.iisc.ac.in/events/multilayer-masks-most-effective-at-preventing-aerosol-generation/
2	Prof SN Mukhopadhyay, FNAE, Adjunct Professor, Department of Biological Sciences, BITS, Pilani and Former Professor, DBEB, IIT Delhi; Former Professor & Head, BERC, IIT Delhi; Former Professor SOBT, GBU, Greater Noida, was invited to submit abstract in ICSWTM 2021 Conference held on of March 14-16, 2021. The abstract on “Waste Heat and Waste Sources for Renewable Energy in Prevention of Pollution" was accepted and he was invited to deliver on line talk in this Virtual Conference of Widener University, Washington DC, USA.

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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/inaehq1

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

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Engineering And Technology Updates

Civil Engineering

1. Standard digital camera and AI to monitor soil moisture for affordable smart irrigation

Researchers at UniSA have developed a cost-effective new technique to monitor soil moisture using a standard digital camera and machine learning technology. The United Nations predicts that by 2050 many areas of the planet may not have enough fresh water to meet the demands of agriculture if we continue our current patterns of use. One solution to this global dilemma is the development of more efficient irrigation, central to which is precision monitoring of soil moisture, allowing sensors to guide 'smart' irrigation systems to ensure water is applied at the optimum time and rate. Current methods for sensing soil moisture are problematic -- buried sensors are susceptible to salts in the substrate and require specialised hardware for connections, while thermal imaging cameras are expensive and can be compromised by climatic conditions such as sunlight intensity, fog, and clouds. Researchers from The University of South Australia and Baghdad's Middle Technical University have developed a cost-effective alternative that may make precision soil monitoring simple and affordable in almost any circumstance. A team including UniSA engineers Dr Ali Al-Naji and Professor Javaan Chahl has successfully tested a system that uses a standard RGB digital camera to accurately monitor soil moisture under a wide range of conditions. "The system we trialled is simple, robust and affordable, making it promising technology to support precision agriculture," Dr Al-Naji says. "It is based on a standard video camera which analyses the differences in soil colour to determine moisture content. We tested it at different distances, times and illumination levels, and the system was very accurate." The camera was connected to an artificial neural network (ANN) a form of machine learning software that the researchers trained to recognise different soil moisture levels under different sky conditions. Using this ANN, the monitoring system could potentially be trained to recognise the specific soil conditions of any location, allowing it to be customised for each user and updated for changing climatic circumstances, ensuing maximum accuracy. "Once the network has been trained it should be possible to achieve controlled irrigation by maintaining the appearance of the soil at the desired state," Prof Chahl says. "Now that we know the monitoring method is accurate, we are planning to design a cost-effective smart-irrigation system based on our algorithm using a microcontroller, USB camera and water pump that can work with different types of soils. "This system holds promise as a tool for improved irrigation technologies in agriculture in terms of cost, availability and accuracy under changing climatic conditions."

Source Source https://www.sciencedaily.com/releases/2021/03/210315110210.htm

2. Facial recognition ID with a twist: Smiles, winks and other facial movements for access

Using your face to unlock your phone is a pretty genius security protocol. But like any advanced technology, hackers and thieves are always up to the challenge, whether that's unlocking your phone with your face while you sleep or using a photo from social media to do the same. Like every other human biometric identification system before it (fingerprints, retina scans) there are still significant security flaws in some of the most advanced identity verification technology. Brigham Young University electrical and computer engineering professor D.J. Lee has decided there is a better and more secure way to use your face for restricted access. It's called Concurrent Two-Factor Identity Verification (C2FIV) and it requires both one's facial identity and a specific facial motion to gain access. To set it up, a user faces a camera and records a short 1-2 second video of either a unique facial motion or a lip movement from reading a secret phrase. The video is then input into the device, which extracts facial features and the features of the facial motion, storing them for later ID verification. "The biggest problem we are trying to solve is to make sure the identity verification process is intentional," said Lee, a professor of electrical and computer engineering at BYU. "If someone is unconscious, you can still use their finger to unlock a phone and get access to their device or you can scan their retina. You see this a lot in the movies -- think of Ethan Hunt in Mission Impossible even using masks to replicate someone else's face." To get technical, C2FIV relies on an integrated neural network framework to learn facial features and actions concurrently. This framework models dynamic, sequential data like facial motions, where all the frames in a recording have to be considered (unlike a static photo with a figure that can be outlined). Using this integrated neural network framework, the user's facial features and movements are embedded and stored on a server or in an embedded device and when they later attempt to gain access, the computer compares the newly generated embedding to the stored one. That user's ID is verified if the new and stored embeddings match at a certain threshold. In their preliminary study, Lee and his Ph.D. student Zheng Sun recorded 8,000 video clips from 50 subjects making facial movements such as blinking, dropping their jaw, smiling or raising their eyebrows as well as many random facial motions to train the neural network. They then created a dataset of positive and negative pairs of facial motions and inputted higher scores for the positive pairs (those that matched). Currently, with the small dataset, the trained neural network verifies identities with over 90% accuracy. They are confident the accuracy can be much higher with a larger dataset and improvements on the network. Lee, who has filed a patent on the tech already, said the idea is not to compete with Apple or have the application be all about smartphone access. In his opinion, C2FIV has broader application, including accessing restricted areas at a workplace, online banking, ATM use, safe deposit box access or even hotel room entry or keyless entry/access to your vehicle.

Source https://www.sciencedaily.com/releases/2021/03/210318085552.htm

Mechanical Engineering

3. **Engineers combine AI and wearable cameras in self-walking robotic exoskeletons**

Robotics researchers are developing exoskeletons and prosthetic legs capable of thinking and making control decisions on their own using sophisticated artificial intelligence (AI) technology. The system combines computer vision and deep-learning AI to mimic how able-bodied people walk by seeing their surroundings and adjusting their movements. "We're giving robotic exoskeletons vision so they can control themselves," said Brokoslaw Laschowski, a PhD candidate in systems design engineering who leads a University of Waterloo research project called ExoNet. Exoskeletons legs operated by motors already exist, but users must manually control them via smartphone applications or joysticks. "That can be inconvenient and cognitively demanding," said Laschowski, also a student member of the Waterloo Artificial Intelligence Institute. "Every time you want to perform a new locomotor activity, you have to stop, take out your smartphone and select the desired mode." To address that limitation, the researchers fitted exoskeleton users with wearable cameras and are now optimizing AI computer software to process the video feed to accurately recognize stairs, doors and other features of the surrounding environment. The next phase of the ExoNet research project will involve sending instructions to motors so that robotic exoskeletons can climb stairs, avoid obstacles or take other appropriate actions based on analysis of the user's current movement and the upcoming terrain. "Our control approach wouldn't necessarily require human thought," said Laschowski, who is supervised by engineering professor John McPhee, the Canada Research Chair in Biomechatronic System Dynamics. "Similar to autonomous cars that drive themselves, we're designing autonomous exoskeletons and prosthetic legs that walk for themselves." The researchers are also working to improve the energy efficiency of motors for robotic exoskeletons and prostheses by using human motion to self-charge the batteries.

Source https://www.sciencedaily.com/releases/2021/03/210315110140.htm

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4. Double-duty catalyst generates hydrogen fuel while cleaning up wastewater

Hydrogen is a pollution-free energy source when it's extracted from water using sunlight instead of fossil fuels. But current strategies for "splitting" or breaking apart water molecules with catalysts and light require the introduction of chemical additives to expedite the process. Now, researchers have developed a catalyst that destroys medications and other compounds already present in wastewater to generate hydrogen fuel, getting rid of a contaminant while producing something useful. Harnessing the sun's energy to split water to make hydrogen fuel is a promising renewable resource, but it is a slow process even when catalysts are used to speed it along. In some cases, alcohols or sugars are added to boost the rate of hydrogen production, but these chemicals are destroyed as hydrogen is generated, meaning the approach is not renewable. In a separate strategy, researchers have tried using contaminants in wastewater to enhance hydrogen fuel generation. While titanium-based catalysts worked for both removing contaminants and generating hydrogen, the efficiencies were lower than expected for both steps because of their overlapping reaction sites. One way to reduce such interferences is to make catalysts by fusing together different conductive metals, thus creating separate places for reactions to occur. So, Chuanhao Li and colleagues wanted to combine cobalt oxide and titanium dioxide to create a dual-functioning catalyst that would break down common drugs in wastewater while also efficiently converting water into hydrogen for fuel. To make the catalyst, the researchers coated nanoscale titanium dioxide crystals with a thin layer of cobalt oxide. Initial tests showed that this material didn't produce much hydrogen, so as a next step, the team spiked this dual catalyst with 1% by weight of platinum nanoparticles -- an efficient though expensive catalyst for generating hydrogen. In the presence of simulated sunlight, the platinum-impregnated catalyst degraded two antibiotics and produced substantial amounts of hydrogen. Finally, the team tested their product on real wastewater, water from a river in China and deionized water samples. Under simulated sunlight, the catalyst stimulated hydrogen production in all three samples. The greatest amount of hydrogen was obtained from the wastewater sample. The researchers say their catalyst could be a sustainable wastewater treatment option by generating hydrogen fuel at the same time.

Source https://www.sciencedaily.com/releases/2021/03/210317141722.htm

Electrical Engineering

5. New perovskite LED emits a circularly polarized glow

Light-emitting diodes (LEDs) have revolutionized the displays industry. LEDs use electric current to produce visible light without the excess heat found in traditional light bulbs, a glow called electroluminescence. This breakthrough led to the eye-popping, high-definition viewing experience we've come to expect from our screens. Now, a group of physicists and chemists have developed a new type of LED that utilizes spintronics without needing a magnetic field, magnetic materials or cryogenic temperatures; a "quantum leap" that could take displays to the next level. "The companies that make LEDs or TV and computer displays don't want to deal with magnetic fields and magnetic materials. It's heavy and expensive to do it," said Valy Vardeny, distinguished professor of physics and astronomy at the University of Utah. "Here, chiral molecules are self-assembled into standing arrays, like soldiers, that actively spin polarize the injected electrons, which subsequently lead to circularly polarized light emission. With no magnetic field, expensive ferromagnets and with no need for extremely low temperatures. Those are no-nos for the industry." Most opto-electronic devices, such as LEDs, only control charge and light and not the spin of the electrons. The electrons possess tiny magnetic fields that, like the Earth, have magnetic poles on opposite sides. Its spin may be viewed as the orientation of the poles and can be assigned binary information -- an "up" spin is a "1," a "down" is a "0." In contrast, conventional electronics only transmit information through bursts of electrons along a conductive wire to convey messages in "1s" and "0s." Spintronic devices, however, could utilize both methods, promising to process exponentially more information than traditional electronics. One barrier to commercial spintronics is setting the electron spin. Presently, one needs to produce a magnetic field to orient the electron spin direction. Researchers from the University of Utah and the National Renewable Energy Laboratory (NREL) developed technology that acts as an active spin filter made of two layers of material called chiral two-dimension metal-halide perovskites. The first layer blocks electrons having spin in the wrong direction, a layer that the authors call a chiral-induced spin filter. Then when the remaining electrons pass through the second light-emitting perovskite layer, they cause the layer to produce photons that move in unison along a spiral path, rather than a conventional wave pattern, to produce circular polarized electroluminescence. The scientists exploited a property called chirality that describes a particular type of geometry. Human hands are a classic example; the right and left hands are arranged as mirrors of one another, but they will never perfectly align, no matter the orientation. Some compounds, such as DNA, sugar and chiral metal-halide perovskites, have their atoms arranged in a chiral symmetry. A "left-handed" oriented chiral system may allow transport of electrons with "up" spins but block electrons with "down" spins, and vice versa. "If you try to transport electrons through these compounds, then the electron spin becomes aligned with the chirality of the material," Vardeny said. Other spin filters do exist, but they either require some kind of magnetic field, or they can only manipulate electrons in a small area. "The beauty of the perovskite material that we used is that it's two-dimensional -- you can prepare many planes of 1 cm2 area that contain one million of a billion (1015) standing molecules with the same chirality." Metal-halide perovskite semiconductors are mostly used for solar cells these days, as they are highly efficient at converting sunlight to electricity. Since a solar cell is one of the most demanding applications of any semiconductor, scientists are discovering other uses exist as well, including spin-LEDs. Although metal-halide perovskites are the first to prove the chiral-hybrid devices are feasible, they are not the only candidates for spin-LEDs. The general formula for the active spin filter is one layer of an organic, chiral material, another layer of an inorganic metal halide, such as lead iodine, another organic layer, inorganic layer and so on. The concept proves that using these two dimensional chiral-hybrid systems gain control over spin without magnets and has "broad implications for applications such as quantum-based optical computing, bioencoding and tomography," according to Matthew Beard, a senior research fellow and director of Center for Hybrid Organic Inorganic Semiconductors for Energy.

Source https://www.sciencedaily.com/releases/2021/03/210312121330.htm

6. Unique Ag-hydrogel composite for soft bioelectronics created

In the field of robotics, metals offer advantages like strength, durability, and electrical conductivity. But, they are heavy and rigid -- properties that are undesirable in soft and flexible systems for wearable computing and human-machine interfaces. Hydrogels, on the other hand, are lightweight, stretchable, and biocompatible, making them excellent materials for contact lenses and tissue engineering scaffolding. They are, however, poor at conducting electricity, which is needed for digital circuits and bioelectronics applications. Researchers in Carnegie Mellon University's Soft Machines Lab have developed a unique silver-hydrogel composite that has high electrical conductivity and is capable of delivering direct current while maintaining soft compliance and deformability. The team suspended micrometer-sized silver flakes in a polyacrylamide-alginate hydrogel matrix. After going through a partial dehydration process, the flakes formed percolating networks that were electrically conductive and robust to mechanical deformations. By manipulating this dehydration and hydration process, the flakes can be made to stick together or break apart, forming reversible electrical connections. Previous attempts to combine metals and hydrogels revealed a trade-off between improved electrical conductivity and lowered compliance and deformability. Majidi and his team sought to tackle this challenge, building on their expertise in developing stretchable, conductive elastomers with liquid metal. "With its high electrical conductivity and high compliance or 'squishiness,' this new composite can have many applications in bioelectronics and beyond," explained Carmel Majidi, professor of mechanical engineering. "Examples include a sticker for the brain that has sensors for signal processing, a wearable energy generation device to power electronics, and stretchable displays." The silver-hydrogel composite can be printed by standard methods like stencil lithography, similar to screen printing. The researchers used this technique to develop skin-mounted electrodes for neuromuscular electrical stimulation. According to Majidi, the composite could cover a large area of the human body, "like a second layer of nervous tissue over your skin." Future applications could include treating muscular disorders and motor disabilities, such as assisting someone with tremors from Parkinson's disease or difficulty grasping something with their fingers after a stroke.

Source https://www.sciencedaily.com/releases/2021/03/210311185948.htm

Aerospace Engineering

7. ISRO launches DRDO's Sindhu Netra satellite in space, will help in monitoring Indian Ocean

ISRO launched 'Sindhu Netra', on February 28, 2021, a satellite developed by the DRDO to monitor the activities of military and merchant navy ships in the Indian Ocean Region critical to India's strategic and commercial interest. ISRO Chief K Sivan told PTI the satellite was part of the PSLV-51 launch. In the first dedicated mission of its commercial arm NSIL (NewSpace India Limited), the ISRO successfully launched Brazil's earth observation satellite Amazonia-1 and 18 co-passengers, including five built by students, onboard a Polar rocket from the spaceport at Sriharikota. India and France have signed an agreement to build constellations of satellites for maritime surveillance intended to identify and track ships in the Indian Ocean.

Source: https://zeenews.india.com/technology/isro-launches-drdos-sindhu-netra-satellite-in-space-will-help-in-monitoring-indian-ocean-2344913.html

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8. Could we recycle plastic bags into fabrics of the future?

In considering materials that could become the fabrics of the future, scientists have largely dismissed one widely available option: polyethylene. The stuff of plastic wrap and grocery bags, polyethylene is thin and lightweight, and could keep you cooler than most textiles because it lets heat through rather than trapping it in. But polyethylene would also lock in water and sweat, as it's unable to draw away and evaporate moisture. This anti-wicking property has been a major deterrent to polyethylene's adoption as a wearable textile. Now, MIT engineers have spun polyethylene into fibers and yarns designed to wick away moisture. They wove the yarns into silky, lightweight fabrics that absorb and evaporate water more quickly than common textiles such as cotton, nylon, and polyester. They have also calculated the ecological footprint that polyethylene would have if it were produced and used as a textile. Counter to most assumptions, they estimate that polyethylene fabrics may have a smaller environmental impact over their life cycle than cotton and nylon textiles.

The researchers hope that fabrics made from polyethylene could provide an incentive to recycle plastic bags and other polyethylene products into wearable textiles, adding to the material's sustainability. A molecule of polyethylene has a backbone of carbon atoms, each with a hydrogen atom attached. The simple structure, repeated many times over, forms a Teflon-like architecture that resists sticking to water and other molecules. She and her colleagues tried to make weavable fibers from polyethylene. They started with polyethylene in its raw powder form and used standard textile manufacturing equipment to melt and extrude polyethylene into thin fibers, similar to turning out strands of spaghetti. Surprisingly, they found that this extrusion process slightly oxidized the material, changing the fiber's surface energy so that polyethylene became weakly hydrophilic, and able to attract water molecules to its surface. The team used a second standard extruder to bunch multiple polyethylene fibers together to make a weavable yarn. They found that, within a strand of yarn, the spaces between fibers formed capillaries through which water molecules could be passively absorbed once attracted to a fiber's surface. To optimize this new wicking ability, the researchers modeled the properties of the fibers and found that fibers of a certain diameter, aligned in specific directions throughout yarn, improved the fibers' wicking ability. Based on their modeling, the researchers made polyethylene yarn with more optimized fiber arrangements and dimensions, then used an industrial loom to weave the yarn into fabrics. They then tested the wicking ability of polyethylene fabric over cotton, nylon, and polyester by dipping strips of the fabrics in water and measuring the time it took for the liquid to wick, or climb up each strip. They also placed each fabric on a scale over a single water droplet and measured its weight over time as the water was wicked through the fabric and evaporated. In every test, polyethylene fabrics wicked away and evaporated the water faster than other common textiles. The researchers did observe that polyethylene lost some of its water-attracting ability with repeated wetting, but by simply applying some friction, or exposing it to ultraviolet light, they induced the material to become hydrophilic again. The team also found a way to incorporate colour into the polyethylene fabrics, which has been a challenge, again due to the material's resistance to binding with other molecules, including traditional inks and dyes. The researchers added coloured particles into the powdered polyethylene before extruding the material into fiber form. In this way, particles were encapsulated within the fibers, successfully imparting colour to them. The team's dry-colouring process contributes to the relatively small ecological footprint that polyethylene would have if it were used to make textiles, the researchers say. The team calculated this footprint by using a life cycle assessment tool commonly used by the textile industry. Taking into account polyethylene's physical properties and the processes required to make and colour the fabrics, the researchers found it would require less energy to produce polyethylene textiles, compared to polyester and cotton. In its use phase, polyethylene fabric could also have a smaller environmental impact, she says, as it would require less energy to wash and dry the material compared with cotton and other textiles.

Source https://www.sciencedaily.com/releases/2021/03/210315132138.htm

Energy Engineering

9. Novel system sequesters CO2 and generates electricity

A recent study, affiliated with UNIST has unveiled a novel system, capable of producing hydrogen and electricity quickly and effectively while cutting carbon dioxide (CO2) emissions significantly. This breakthrough has been carried out by Professor GunTae Kim and his research team in the School of Energy and Chemical Engineering at UNIST. In this study, the research team succeeded in developing a membrane-free aqueous metal-CO2 battery. Unlike the existing aqueous metal-CO2 systems, the new battery is not only easier to manufacture, but also allows continuous operation with one type of electrolyte. The research team designed a membrane-free (MF) Mg-CO2 battery, as an advanced approach to sequester CO2 emissions by generating electricity and value-added chemicals without any harmful by-products. According to the research team, their MF Mg-CO2 battery operates based on the indirect utilization of CO2 with facile hydrogen generation process. It has been also found that the new battery exhibits high faradaic efficiency of 92.0%. "In order to translate the newly-developed laboratory-scale MF Mg-CO2 battery technology into a commercial reality, we have envisioned an operational prototype system that produces electricity and value-added chemicals, as a cornerstone to better support sustainable human life from CO2 and earth-abundant renewable power (e.g., wind, solar, seawater)," noted the research team. The MF Mg-CO2 battery system has a structure similar to that of hydrogen fuel cells for use in cars, since it only requires a Mg-metal negative electrode, an aqueous electrolyte, and a positive-electrode catalyst. However, unlike the existing fuel cells, they are based on aqueous electrolytes. As a result, the newly-developed MF Mg-CO2 battery had successfully sequestered CO2 emissions by generating electricity and value-added chemicals without any harmful by-products. "Our findings indicate great benefits for the newly-developed MF Mg-CO2 battery technology to produce various value-added chemicals of practical significance and electricity from CO2 without any wasted by-products," noted the research team. "Through this we have opened the door to electrochemical utilization of CO2 with indirect circulation for future alternative technologies."

Source https://www.sciencedaily.com/releases/2021/03/210317094711.htm

10. Wearable devices can detect COVID-19 symptoms and predict diagnosis, study finds

Wearable devices can identify COVID-19 cases earlier than traditional diagnostic methods and can help track and improve management of the disease, Mount Sinai researchers report in one of the first studies on the topic. The Warrior Watch Study found that subtle changes in a participant's heart rate variability (HRV) measured by an Apple Watch were able to signal the onset of COVID-19 up to seven days before the individual was diagnosed with the infection via nasal swab, and also to identify those who have symptoms. "This study highlights the future of digital health," says the study's corresponding author Robert P. Hirten, MD, Assistant Professor of Medicine (Gastroenterology) at the Icahn School of Medicine at Mount Sinai, and member of the Hasso Plattner Institute for Digital Health at Mount Sinai and the Mount Sinai Clinical Intelligence Center (MSCIC). "It shows that we can use these technologies to better address evolving health needs, which will hopefully help us improve the management of disease. Our goal is to operationalize these platforms to improve the health of our patients and this study is a significant step in that direction. Developing a way to identify people who might be sick even before they know they are infected would be a breakthrough in the management of COVID-19." The researchers enrolled several hundred health care workers throughout the Mount Sinai Health System in an ongoing digital study between April and September 2020. The participants wore Apple Watches and answered daily questions through a customized app. Changes in their HRV -- a measure of nervous system function detected by the wearable device -- were used to identify and predict whether the workers were infected with COVID-19 or had symptoms. Other daily symptoms that were collected included fever or chills, tiredness or weakness, body aches, dry cough, sneezing, runny nose, diarrhea, sore throat, headache, shortness of breath, loss of smell or taste, and itchy eyes. Additionally, the researchers found that 7 to 14 days after diagnosis with COVID-19, the HRV pattern began to normalize and was no longer statistically different from the patterns of those who were not infected. "This technology allows us not only to track and predict health outcomes, but also to intervene in a timely and remote manner, which is essential during a pandemic that requires people to stay apart," says the study's co-author Zahi Fayad, PhD, Director of the BioMedical Engineering and Imaging Institute, Co-Founder of the MSCIC, and the Lucy G. Moses Professor of Medical Imaging and Bioengineering at the Icahn School of Medicine at Mount Sinai.

Source https://www.sciencedaily.com/releases/2021/02/210208185112.htm

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Engineering Innovation in India

New Inventions by DRDO

During the past 3 years, 79 projects amounting to Rs.8201 Crores directly pertaining to development of new defence equipments i.e. Cruise Missile, Anti-Ship Missile, Surface-to-Air Missile, Air-to-Air Missile, Extended Range Anti-Submarine Rocket, Mounted Gun System, Ammunitions, Electronic Warfare System, Radars, Torpedoes, High Endurance Autonomous Underwater Vehicle etc. have been undertaken. Some of the DRDO developed systems which are likely to be available to our defence personnel during 2021-23 are as follows:

Sl. No.	System	Timelines
1	ASTRA Missile	2021
2	Anti Drone System	2021
3	SATCOM Devices	2021
4	QRSAM	2022
5	ADFCR	2022
6	Helina	2022
7	ADTCR	2022
8	Guided Bomb	2022
9	NAG	2022
10	NGARM	2023
11	SAAW	2023

Many DRDO developed technologies such as Battle Field Surveillance Rader (BFSR), Joint Venture Protective Carbine (JVPC) Jammers, 5.56 mm Rifle, 40 mm Under Barrel Grenade Launcher (UBRL), Oleo Resin (OR) Grenade etc are being utilized by the State Police.

Upgrades to some of the systems have been developed by DRDO. Details of the same are as follows:-

- Arjun Mk-1A
- Akash-NG
- Light Combat Aircraft Mk-1A
- Medium Power Radar-Extended Range
- PINAKA- Extended Range, Guided
- Electronics & Communication System: Unified Mission Computer for SU-30 MKI aircraft, Internal EW System for MIG-29 Upgrade Aircraft, EW systems for Naval platforms.

Source https://pib.gov.in/PressReleasePage.aspx?PRID=1706596

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