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From the Editor's Desk

Nurturing Young Innovators

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Chief Editor of Publications

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What should we as a country do to become the real player in the future world? We all would agree that the answer is: Prepare young minds and nurture future innovators. Invention is important. Also very important is adoption of inventions. We not only need exceptional engineers but also persons who are temperamentally innovative and think they could increase country's core values. An innovative country recognises the joys of uncertainty. It knows that the right person who can make a difference is the one not afraid to fail. Innovative countries recognise that bureaucracy is the greatest enemy of innovation. How do we prepare young people to become innovators? What must we do differently as parents, teachers, mentors and employers to produce the 'outliers'? These are some questions that we should address.

The learning cultures that produce innovators are: problem-based multidisciplinary approach to learning, taking risks and learning from mistakes, creating real products for real consumers, and encouraging intrinsic motivation rather than relying on extrinsic motivation. It is heartening to note that young innovators look at things differently. They believe that they can live on less and help produce more. Tony Wagner says, "Those are easy things to say when you're in your 20s. When you're in your 30s — thinking about a family — that picture may change". He adds, "What they may end up doing is some compromising in terms of whom they are willing to work for." This "connected generation" knows how to find support for what they want and need. Wagner's message for the parents: Helicopter parents hovering over their children all the time is certainly not an innovative idea; 'parent', I believe, includes educators.

ACADEMY ACTIVITIES

Creation of Data for INAE Expert Pool

INAE Expert Pool was created with the aim of identifying domain experts in various disciplines of engineering. There has been a good response from the Fellows and Young Associates in uploading their particulars on the INAE Expert Pool website. The INAE Fellows and Young Associates who have not uploaded their particulars are requested to submit their profile details online at the link http://inae.in/expert-search/index.php/inae-members-form

The details of the INAE expert Pool have since been shared with DST, TIFAC, Niti Aayog and Office of PSA. The creation of the website on Expert Pool has been appreciated by all the agencies and the data would be used by them in identifying suitable domain experts and to involve the experts in their activities.

Engineers Conclave 2016

Engineers Conclave 2016 is being held at Indian Institute of Technology Madras during Sep 1-3, 2016. Prof. Bhaskar Ramamurthi, FNAE, Director, IIT Madras and Dr BN Suresh, President, INAE are the Co-Chairs of the Engineers Conclave 2016. The themes of the Conclave are "Engineering Education 2020" being coordinated by IIT Madras and "Smart Cities" being coordinated by INAE. Prof. MS Ananth, FNAE is the Coordinator from IIT Madras for Theme I on "Engineering Education 2020". Theme I

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INAE Annual Convention

This year, the INAE Annual Convention is being held at Space Applications Centre (SAC), Ahmedabad on Dec 8-10, 2016 which will be preceded by Governing Council meeting on 7th Dec 2016. Mr. Tapan Misra, Director, SAC has kindly consented to host the event. The details of the event will be forwarded shortly.

Round Table on "Clean Coal Technologies in India: Current Status, Demands and Aspirations – Pathways to Achievements" held on June 10, 2016 at New Delhi

DST requested INAE to provide engineering interventions required in the field of 'Clean Coal Technologies'. Accordingly, a Round Table meeting on "Clean Coal Technologies in India: Current Status, Demands and Aspirations – Pathways to Achievements" under the chairmanship of Dr. Baldev Raj, Immediate Past President, INAE was conducted on June 10, 2016 wherein about 35 domain experts from Industry, Academia and R&D participated. With this, INAE would be able to provide inputs to the DST on the existing state of technologies in the country, technologies available internationally and the short-term and long-term plans for adoption of technologies in the field of Clean Coal Technologies. The e-proceedings have since been published and may be viewed at the link given below.

http://inae.in/clean-coal-technologies-in-india/#p=

Second Report of INAE Forum on Technology Foresight and Management for Addressing National Challenges

The INAE Forum on Technology, Foresight and Management under the Chairmanship of Mr VK Agarwal, FNAE; has brought out the second Report on addressing national challenges pertaining to Agriculture, Energy and Mass Transit Systems. The Report has been compiled as an e-book and posted on INAE website under the subhead Publications. A copy of the Report can be viewed on the link below.

http://inae.in/inae-forum-on-technology-foresight-and-management-for-addressing-national-challenges/#p=

Global Knowledge Forum 10th Annual Conference on "Technology, Growth and Sustainability"

The e-Proceedings of the Global Knowledge Forum 10th Annual Conference on "Technology, Growth and Sustainability" held in collaboration with INAE and hosted by National Institute for Advanced Studies (NIAS), Bangalore on Nov 27-28, 2015 have since been published. The e-Proceedings have been compiled as an e-book and posted on INAE website under the subhead Publications. A copy of the e-Proceedings can be viewed at the link below.

http://inae.in/knowledge-forum-10th-annual-conferance/#p=

Research Journal -INAE Letters

The website for the Research Journal "INAE Letters" to include facility for submission of papers online has been launched. The first issue of the Research Journal "INAE Letters" will be released on Sep 1, 2016 at IIT Madras, Chennai during the sidelines of the Engineers Conclave 2016. The soft copy of the INAE Letters can be viewed at the link http://www.springer.com/engineering/journal/41403

Opening of Facebook and Twitter Accounts by INAE

The Department of Science and Technology (DST) has recommended enhancing Social Media Optimization through creation of Facebook and Twitter accounts. Accordingly a Facebook page and Twitter Handle for INAE have been created. All INAE Fellows are requested to visit the page and post their comments, if any. The Facebook page of INAE can be viewed at https://www.facebook.com/pages/Indian-National-Academy-of-Engineering/714509531987607?ref=hl and Twitter handle at https://twitter.com/inaehq1

Important Meetings held during August 2016

- INAE Selection Committee Meeting on Innovative Student Projects Awards and INAE Young Engineer Award on Aug 17-18, 2016
- INAE Governing Council Meeting on Aug 26, 2016
- Meeting of Selection Committee for Election of Foreign Fellows on Aug 26, 2016
- Meeting of INAE Forum on Engineering Interventions for Disaster Mitigation on Aug 30, 2016

International Conferences/Seminars being organized by IITs/other Institutions

To view a list of International Conferences/Seminars being held in the month of September 2016 click here.

News of Fellows

1	Prof Mahesh Tandon, FNAE, Managing Director, Tandon Consultants Pvt Ltd, New Delhi has been invited by the Institution of Engineers (India) to deliver the first "Prof Jai Krishna Memorial Lecture" at the National Convention of Civil Engineers to be held at Goa on 21st Oct 2016

2nd International Conference on "Engineering & Technology, Computer, Basic & Applied Sciences" (ECBA- 2016) on Sep 13-14, 2016 at New Delhi
http://www.conferencealerts.com/show-event?id=171162

Second International Symposium on Intelligent Systems Technologies and Applications (ISTA'16) on Sep 21 -24, 2016 at Jaipur
http://www.conferencealerts.com/show-event?id=169799

International Conference on Micro-Electronics and Telecommunication Engineering on Sep 22-23, 2016 at Ghaziabad
http://www.conferencealerts.com/show-event?id=168205

A road map on biohydrogen production from organic wastes

Debabrata Das

Energy crisis is looming the global economy. Our energy requirements are almost fully provided for by carbon-containing fossil sources such as oil, coal and natural gas. The rapid consumption of these fossil resources has caused an accelerated release of the bound carbon as CO_2. The rate at which fossil fuels are depleting, a necessity of alternate fuel has gain importance. The use of fossil fuels for energy is unsustainable and causes build-up of greenhouse gases in the atmosphere leading to global warming. The need of the hour is an efficient fuel with zero carbon footprints and this path can be achieved by using hydrogen. Biofuels store energy chemically that can be harnessed easily. It can also be used in existing combustion engines after blending with petroleum diesel to various degrees. No separate transportation infrastructures would be required for such fuels. Hydrogen having highest energy density (143 kJ/g), is a clean and environment friendly fuel. Fermentative H_2 production using renewable resources (wastes/wastewaters) is a promising way of economical and sustainable energy source as compared to photobiological processes. Dark fermentation of organic wastes may be carried out by mesophilic and thermophilic organisms. The dark fermentation at thermophilic temperatures ($60^{o}C$) has many attractive advantages. Many industrial organic wastewaters are discharged at elevated temperatures such as palm mill effluent, distillery effluent etc. that can be directly used. Moreover, at higher temperature condition leads to pathogenic destruction, lower risk of contamination by

methanogenic archaea, higher rate of hydrolysis and higher H_2 yield. In addition, during fermentation generates excess heat that requires cooling for mesophilic cultures. Bioprocess engineering lab of Indian Institute of Technology Kharagpur is known for accentuating research on various routes of biohydrogen production in India. Over the years, this lab has developed a comprehensive and refined expertise on the field biohydrogen production (Fig.1). All the domains related to hydrogen production through biological routes have been explored.

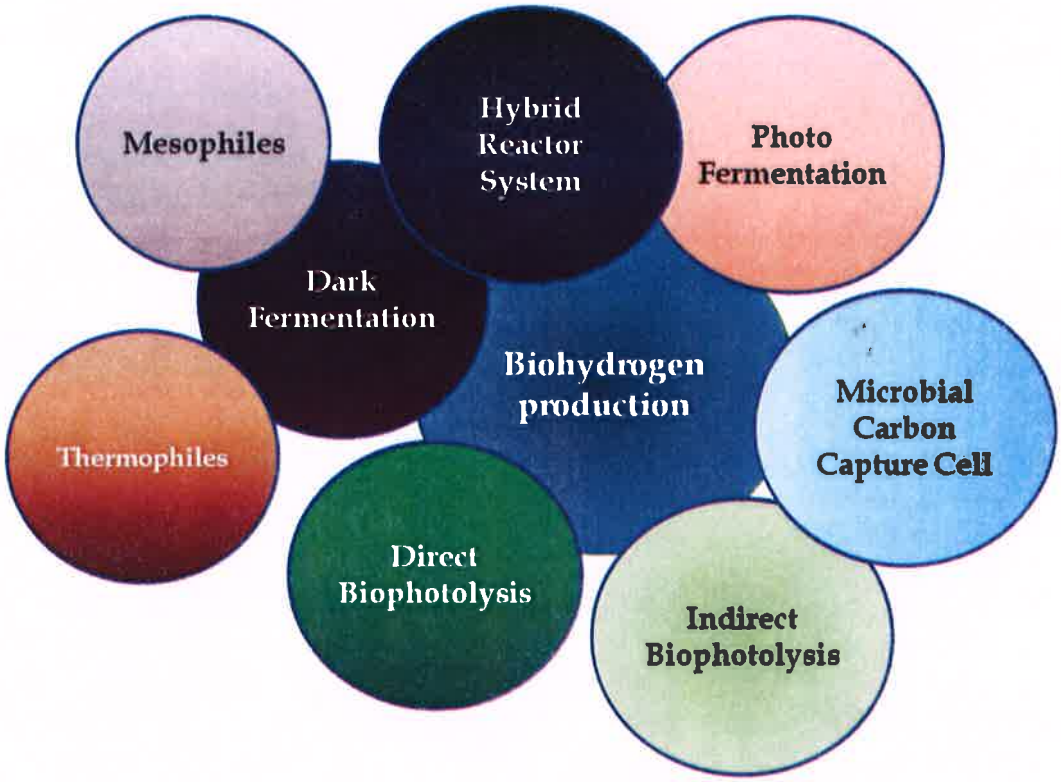


Fig. 1: Biohydrogen production processes

The main objective of the research work is to improve the biohydrogen production process with main emphasis being to increase yields of hydrogen from the existing processes and its generation from organic waste. A wide range of potential H_2 producing microorganisms (which includes thermophiles and mesophiles) have already been identified. One such mesophile potential isolate, *Enterobacter cloacae* IIT BT08 (presently known as *Klebsiela pneumonia*) has been identified. This organism produces hydrogen at high rate as compared

to other mesophilic microbes. Redirection of the biochemical pathways of *K. pneumonia* IIT-BT08 is carried out for the improvement of the hydrogen production. It is done by blocking alcohol and some of the organic acids formation in *K. pneumonia* IIT-BT08 during their metabolism. The principle being that NADH is usually generated by catabolism of glucose to pyruvate through glycolysis. The conversion of pyruvate to ethanol, butanediol, lactic acid and butyric acid involves oxidation of NADH. The concentration of NADH would be increased if the formation of these metabolites could be blocked. Double mutants of *K. pneumonia* IIT-BT08 with defects in both alcohol and organic acid formation pathways are able to enhance H_2 yield as compared to wild type strain (3.8 mol H_2/mol glucose). Recently, acidogenic microbial consortium obtained from the anaerobic digester is also found suitable for hydrogen production.

To make biohydrogen production renewable, its feedstock should be renewable in nature and should be widely available. Suitability of different organic feed stocks for hydrogen production has been studied. Attempts have been made to explore the use of algal biomass, de-oiled cakes, starchy wastewater, lignocellulosic biomass, cane molasses etc. as feedstock. Usually wastewaters have tack of nutrients for the growth of the microorganisms. Effort has been made to identify cost effective nutrient rich supplement for the improvement of hydrogen production using wastewater as substrate. For that purpose, use of de-oiled cakes as nitrogen supplements has been explored. The maximum cumulative hydrogen production and hydrogen yield on using de-oiled cakes are 3.2 L L^{-1} and 11.2 mol H_2/kg $COD_{removed}$, respectively. Groundnut and coconut de-oiled cakes appear most promising as a substrate as well as nutritional supplement in the hydrogen production process. The suitability of cane molasses as substrate for continuous biohydrogen production has been demonstrated using a 20 L bioreactor. The maximum rate of hydrogen production and yield achieved are 67 L h^{-1} and 18.54 mol H_2/ kg $COD_{removed}$, respectively. As H_2 is the product of dark fermentation, its accumulation inhibits the product formation which is in accordance with Le Chatelier's

principle. This increase in partial pressure also contributes towards metabolic shift during fermentation. It leads to formation of reduced end products such as ethanol, propionate, lactate, butanol and acetone. Many strategies are used for the removal of H_2 from the fermentation system. A sophisticated 'Automatic Logic Control System' has been developed for the operation of continuous hydrogen production under reduced partial pressure conditions. Reduced partial pressure always helps in improving the kinetics of hydrogen production. Maintenance of a reduced partial pressure on the overhead space of a reactor has been made automated by implementation this system. This has made the process easy to operate and also helped in improving the overall H_2 yield.

A substantial research has been carried out on development of continuous hydrogen production process especially in customized bioreactors. A prototype 20 L packed bed reactor has also been developed for continuous hydrogen production. Such type of packed bed reactor uses cheaper agro-residues as matrix for whole cell immobilization. The live demonstration of the process has been uploaded in the website: http://www.bioh2iitkgp.in

Pilot plant study has been successfully carried out using an 800 L reactor.

MNRE, Government of India has already prepared a Hydrogen road map in India. IIT Kharagpur is the leading Group in India working on "Hydrogen production through biological routes" under this programme. Our endeavour with large scale biohydrogen production has motivated us to commercialize biohydrogen production process for decentralized energy solution. One of our current major activities is to design 10 m^3 of bioreactor for commercialization of biohydrogen production process from organic wastes.

Mathematical modeling and simulation on the biohydrogen production processes has been carried out. The efficiency of biohydrogen production can be analyzed by defined mathematical models. These models also increase understanding the effect of substrate concentration, feedback inhibition, and effect of different substrate on hydrogen production. The kinetic parameters determined from unstructured mathematical models could help in designing and scaling up of bioreactors. During H_2 production, kinetics of biomass formation and products (hydrogen, VFA, solvents, etc.) are needed to be studied. Our potent microorganism, *K. pneumonia* IITBT08 has been extensively studied for biohydrogen

production. Mathematical modeling using Lineweaver–Burk equation showed that it has maximum specific growth rate, μ_{max} and saturation constant, K_s of 0.28 h^{-1} and 0.98 g L^{-1}, respectively. Biohydrogen production by *K. pneumonia* IITBT08 is growth associated product and this fact has been established by using Luedeking–Piret model. The kinetics of hydrogen production by *K. pneumonia* IITBT08 has been analyzed using modified Gompertz model. It reveals that this organism has maximum hydrogen production potential of 2.6 L/L with lag phase of 45 min.

Recently, thermophilic biohydrogen production process has been explored. *Thermoanaerobacterium thermosaccharolyticum* ST1 has been isolated which yielded a maximum of 2.7 mol H_2/ mol glucose. Use of this organism in continuous hydrogen production in packed bed reactor shows higher hydrogen yield and rates as compared to mesophilic system. A detailed continuous hydrogen production using high temperature effluent such as starchy wastewater has shown that with variation in organic loading rate, the hydrogen production improved. Another interesting observation that has been observed is the inverse relationship between NADH/NAD^+ ratio with rate of hydrogen production. NADH is the reducing equivalent that is required to produce molecular hydrogen via Fe-Fe hydrogenase pathway. Mutants have been developed that have suppressed competing pathways and higher pool of NADH for improvement of hydrogen production.

The spent media generated after completion of dark fermentative hydrogen production is generally rich in short chain fatty acids such as acetate, butyrate, propionate etc. The energy trapped in these metabolized can be used to further improve gaseous energy recovery by integrating it with photofermentation process. Many innovative technologies in the field of photofermentative hydrogen production have been developed. One such innovation is development of a rocking flat panel reactor for photofermentation.

Energy calculation for rocking motion and integration with dark fermentation has been one of the achievements. *Rhodobacter sphaeroides* O.U. 001 is capable of producing biohydrogen

via photofermentation. Maximum hydrogen production rate of 11 mL/L h is observed using spent media.

Recently, research work has also been carried out to explore the possibility of integrating biohydrogen production process with biomethanation under the eponym of Biohythane. This process shows promise in improving gaseous energy recovery through biological routes. By implementation of such two stage process, it is possible to improve gaseous energy recovery up to 56% as compared to single stage hydrogen production process.

In recent years, sequestration of atmospheric CO_2 by cyanobacteria and green algae have been receiving increased attention. Algal cultivation for CO_2 sequestration has many advantages such as faster growth rates and the possibility of cultivation on non-arable land areas or in lakes or the ocean. Finally, an integrated approach using microbial fuel cells (MFCs) for generation of electricity from wastes can be a giant step for mankind into a sustainable future. Green algae and cyanobacteria are the vast group of both facultative photoautotrophic and photoheterotrophic microorganisms. Microalgae can be cultivated under aqueous conditions ranging from freshwater to situations of extreme salinity and from controlled closed system to open system. Algae are generally classified into several taxonomic groups on the basis of their nature and properties, type, number and morphology of flagella, reverse food products chemistry and product of photosynthesis, their chemical and physical properties of cell walls, morphological characteristics of cells and thalli, mode of reproduction etc. Their uniqueness that separates them from other microorganisms is due to presence of chlorophyll and having photosynthetic ability in a single algal cell, therefore, allowing easy operation for biomass generation, and effective genetic and metabolic research in a much shorter time period than conventional plants. The algal biorefinery concept has also been explored. The efforts are concentrated on high rate algal biomass generation in controlled photobioreactors with subsequent use of the obtained biomass as a source of food,

feed, biofuels and bioactive compounds. In continuous mode of operation with *Chlorella sorokiniana,* the maximum biomass productivity of 0.11 g L^{-1} h^{-1} is observed at an optimum dilution rate of 0.05 h^{-1} using 5% air–CO_2 (v/v) gas mixture. Biological fixation of CO_2 has been also studied using industrial flue gas. The flue gas emitted from the oil producing industry contains mostly CO_2 and H_2S (15.6 %v/v and 120 mg L^{-1}, respectively) along with nitrogen, methane, and other hydrocarbons.

The highest reduction in the CO_2 content of inlet flue gas is 4.1% (v/v). Cyanobacteria are also used for CO_2 sequestration study. *Anabaena* sp. PCC 7120 is grown in customized airlift photobioreactors. Higher light utilization efficiency and a higher rate of CO_2 biofixation are observed with maximum biomass concentration of 0.71 g L^{-1} using $BG11_0$ medium under aerated conditions. Another new approach for CO_2 sequestration is microbial carbon capture cells (MCCs). Cyanobacteria have been grown in photo biocathode in dual-chambered flat plate mediator-less MFCs which is separated by an anion exchange membrane. The performance of the MCC with *Anabaena* purged with CO_2–air mixture is compared with that of a conventional cathode purged with air only. It has been established that light can efficiently penetrate up to 3 cm on giving external illumination. Hydrogen production from algal cultivation has been explored via two distinct technologies. Firstly, use of photo biological process of algae for hydrogen production shows maximum hydrogen production rate of 1 mL/L h on using *Chlorella sorokiniana.* Similar studies with cyanobacteria, *Anabena* sp. also showed slower hydrogen production rates. Second strategy of hydrogen production from algal biomass is to use it as feedstock for dark fermentation. . The algal biomass are generally rich in carbohydrates such as starch, cyanophecian starch etc. which can be a potential source of fermentable sugars. Highest hydrogen yield of 2.67 mol/mol of hexose is observed by using *C. sorokiniana* biomass as feedstock.

The advent of Microbial fuel cell (MFC)-based technologies have turned out to be promising technologies for direct energy production from various wastewaters. MFCs can utilize organic substrates and subsequently convert their chemical energy to electricity in a single step using microorganisms. MFC is a bio-electrochemical reactors/device typically consists of anode and cathode chambers physically separated by a proton exchange membrane (PEM). A MFC can be divided into three major components, namely an anaerobic anode chamber, an aerobic cathode chamber and an ion exchanger connecting the two chambers. Anode chamber is the microbial growth compartment, which provides all the necessary condition for the growth and the electron extraction from the microorganism. The chamber is fed with growth media named as anolyte, redox mediator (not required in case of mediator-less MFC), microorganism and an electrode that acts as the anode of the MFC. The bacterial growth in this chamber produces the necessary protons and electrons through metabolic reactions. However, numerous hurdles need to be overcome to make this technology economically feasible and suitable for field applications.

Extensive research work has been carried out on MFC process and focused to improve the performance, reduce the construction cost, and expand the application scopes of MFC based technologies collectively known as bioelectrochemical systems. Low cost materials for the anode, cathode and membrane in MFCs are studied to increase the power performance using complex wastewaters as substrate. Catalytic enhancement with $MnCo_2O_4$ in presence of polypyrrole (PPy) on carbon cloth cathode shows maximum potential reaching power densities of 10.2 W m^{-3} using low cost KOH doped PVA-PDDA anion exchange membrane. The developed MFC system has been explored for hydrogen production under microbial electrochemical system. The developed biofilm on anode during MFC regime would augment towards the poised potential provided to the cathode. At cathode the proton generated during

MFC regime may be converted to molecular hydrogen. The rate of hydrogen production from such system is found to be 10 mL/L h.

Conclusion

Suitability of different biohydrogen production processes has been explored. *K. pneumonia* IIT-BT 08 is found suitable for H_2 production using different carbon sources at 36 ^{o}C and pH 6.5. Double mutant strain of this organism and reduced partial pressure of H_2 improved the gas generation significantly. Scaling up studies has been successfully carried out up to 20 L and 800 L. Acidogenic microflora present in the anaerobic digestion process is found suitable for the H_2 production. The spent medium from dark fermentation is found suitable for H_2 photo-production by *R. sphaeroides* O.U. 001 or microalgae like *Chlorella sorokiniana* or MFC in a two-stage batch fermentation process but H_2 yield is less as compared to dark fermentation process. The possibilities of using different organic residues such as coconut de-oiled cake, sewage sludge, cane molasses, distillery effluents, starch wastes, algal biomass etc. for H_2 production are explored. Continuous hydrogen production is successfully demonstrated using immobilized whole cell system using environmental friendly solid matrix. The present immobilized system may overcome some difficulties like gas hold-up, diffusion problem, etc. due to the improvement of reactor configuration. Modeling and simulation studies are carried out for the different bioH_2 production processes. Biohydrogen production has been established as a prospective alternative and integral component of green sustainable energy. However, two major aspects need indispensable optimization viz. a suitable renewable organic wastes/wastewater and ideal microbial consortia that can convert this biomass efficiently to hydrogen. Biohythane process can improve both COD reduction and gaseous energy recovery significantly indicating its potentiality to overcome the energy scarcity problem in future using organic wastes as substrate.

"NO JOB IS SMALL OR BIG, IT IS THE WAY IN WHICH YOU DO MAKES IT SMALL OR BIG"

B.S.K. Naidu

I was born in a middle-class family. I was schooled in small towns of old Madhya Pradesh. Initially I was admitted to Vidya Mandir, Akola where I was tested and found suitable for 2nd standard and subsequently I secured first position in the class, which proved their judgment right. Thanks to my mother who taught me the basics very early with her meager qualification of just primary education, where of course she was a topper.

My father, in the State Government service, was transferred to Mandla. I have fond memories of my childhood spent there. Once I was given an opportunity to deliver a lecture on *Goswami Tulsidas* representing the Primary school which fetched me a medal. I clearly remember the process of overcoming the stage fear in that big Town Hall packed with elders where I was feeling too small. I little realized then that it would be at the bottom of a long series of invited lectures and standing ovations at international forums in 5-continents including my lead speeches at United Nations, Global Environment Facility (GEF) and the World Bank etc. and a series of 24 awards.

Though I was schooled in district schools of insignificant towns of Madhya Pradesh, my parents somehow dreamt of making me an engineer. I did my engineering from the State's oldest Government Engineering College at Jabalpur. I remember my Russian professor Mr. Tirechev very kindly. His popular catch phrase was "Full work, full marks, No work, no marks". He was in- charge of Project Work in the final year of our 5-Year degree course in Mechanical Engineering. He allotted me a relatively insignificant project on *Calibration of Carburetor's Jet*. Against several IC Engine projects, my project appeared relatively small. However, I did it with full attention and industry. My diligence and attention to minute details impressed him and he not only gave me 100% marks but also got my Project included in the list of Final Year Laboratory Examination of IC Engines. This made me think for the first time in life that "no job is small".

I recall an interesting event of my fourth year studies in the Hostel. A chapter on Redundant Frames in Theory of Structures used to bother us. One day we accidentally evolved a very simple (though time consuming) method of solving the problems by step-by-step resolution of forces in mutually perpendicular directions. I became very enthusiastic and spread the technique in my entire batch. I

happened to visit my college after several years of my passing out and heard one of my junior colleagues say "Naidu's method is still popular and we are sure of getting min. 20 marks in that paper", making me think once again "no innovation is small".

Life continued through a Masters in Hydroelectric Engineering and a Ph.D. in Water Resources Management which I thought was a less significant discipline compared to Aeronautics, Nuclear Engineering or Information Technology. But again sustained efforts in my own field made Americans invite me twice to their country to bestow upon me the highest honors of their respective entities; in 1990 by the CULA, Los Angeles, Californiafor award of D.Eng.(Hon) in Hydro Power Engineering & Technology which I had the privilege to receive along with Hon'ble Nelson Mandela who received D.Lit.(Hon) in the same convocation, and in 2012 by the American Academy of Water Resources Engineers (AAWRE) for award of their highest honor "Honorary Diplomate, Water Resources Engineer", conferred upon me during the AAWRE's Bestowal Ceremony held at the "World Water and Environmental Resources Congress" in Albuquerque. New Mexico *in* 2012 before the august presence of America's who's who of Water Resources Engineering Profession including past and current Presidents of AAWRE, Dr. Jeff Bradley and Dr. Robert G. Traver. The above distinction and designation (Hon. D.WRE) was awarded to only 30 most eminent scientists in the world since inception of AAWRE. This journey from an insignificant Municipal school in Mandla to United States signifies a couple of things when I look back. One, no job (or discipline) is small or big by itself, it is the way in which you pursue, makes it small or big and secondly it is not the institution where you are schooled that matters but the way you position yourself in the school really matters.

In the year 1968, I was earmarked (*not formally selected yet*) by HE(I)L as a Post-Graduate Engineer and in the meanwhile I received a firm offer to join Machine Tools Corporation and deputation to Czechoslovakia for training. I ventured to meet Shri S. Swayambhu, Chairman of HE(I)L Bhopal (later merged with BHEL) to seek his advice. He advised me not to waste my PG qualification and take a chance to wait for HE(I)L's formal selection. Shri S. Swayambhu was a great Power Engineer and used to be our hero. He was the first head of CPRI in Bangalore. Later in the year 2000 when I took over additional charge of CPRI as Director General, my photograph found a place in line with him in the big Conference Hall of the prestigious institution; I felt his blessings coming from heavens and complimenting me for continuing as a Hydro Power Engineer. My 'Research and Testing' strategic initiatives at CPRI took the organization to new heights of distinction in internationally recognized research, testing superiority and peaking revenues. CPRI gave me a great sense of fulfilment where I instituted a Gold Medal in my father's name (*who made me an engineer*) for the best paper published during the year based on testing clues/data.National Perspective Plan for R&D in Indian Power Sector prepared by us in June'2002 gave a tremendous impetus to research activities in the following years.

During my early days in BHEL, I happened to publish a suggestive paper on Scope of research in air-injection techniques with reference to hydraulic turbine operating requirements in the Indian Journal of Power and River Valley Development, June 1975 issue. Later availing Confederation of British Industry (CBI) scholarship 1975-76, I went to UK as a Visiting Engineer and was posted to Boving & Co., London. One day my Chief Manager Mr. Keast came to my desk and congratulated me for having published an article in International Water Power and Dam Construction, London, February 1976 issue. I could not believe it and got a copy from him. I found that my Indian article was abstracted there. My surprise heightened when I was deputed to their collaborator's Laboratory in Kristinehamn, Sweden in the

month of May'1976. I was received by Mr. Gusthavson who took me to his section to show the entire set-up commissioned by him on the lines suggested by me in the above paper which he could source out on his own. I realized that the world was round and very small.

While in BHEL one of the prime assignments given to me was to design a Francis Turbine Runner from the first principles of Hydrodynamicsfor the first time in the country. It was more of a tedious research project with no internal guidance (*runners being totally imported*) and poor computing facilities of 1970's. When my design was model tested, its peak efficiency came out to be 87.5% against 90% + in the international arena. Though this work was later recognized at Hydroturbo'81 in Czechoslovakia and IAHR'90 in Yugoslavia, I was somewhat disappointed with the efficiency level achieved. At that juncture, I got a message from Dr. H. N. Sharan, Director (Engineering) BHEL Corporate Office Delhi that "Even if it was 60%, it would still be our own design". I had not seen him then but he left an unforgettable impression on my mind.

Similarly Dr. V. Krishnamurthy, Chairman, BHEL whom I had not met those days left an indomitable impression on my mind by sponsoring me for the CBI scholarship of one year advanced training in Europe (which I had won in an All India competition) and then historically sponsoring my visit back to India in the middle to present a paper at the World Congress of IWRA at Delhi, being an exclusive paper selected from BHEL. I had submitted this paper before going to UK utilizing an opportunity of hospitalization for my first operation. I was completing the synopsis of my paper when the nurse came to pick me up for the O.T. I remember, she asked me "Are you not afraid of the operation" I just smiled. Rest of the paper on Design and Manufacture of Pumped Storage Power Plants for *Indian* Requirements was completed by me in the post-operative period due to the dead line of submission. This paper only created an opportunity but it was possible to present it only due to an extremely positive outlook of our Chairman which was truly unmatched. It was quite an experience for me to address a World Congress at the age of 30! I may state here that I have undergone several surgical operations in my life and I remember to have always utilized my hospitalization time for some productive writing. When I was admitted to Escorts for my open heart surgery in 2003, I was clearing some important files of National Power Training Institute (NPTI) before going to O.T. It was either my passion for the job or my total faith on doctors, or perhaps a combination of both.

Later in BHEL, I remember once in 1981, Shri B.S. Kochar, Chairman, BBMB walked in requesting us to study the overload margins in Bhakra turbine-generators. It was entrusted to me as a small assignment. I took it rather seriously and expanded the dimensions of the study from signature analysis of the machines to material testing to vibration analysis to design margins to furthering power generating capacity of the machines by opting thinner and effective insulation in the stator slots and even changing the runner profiles to higher specific speed versions; little realizing that it was heading towards a New science of "Uprating & Refurbishment of Hydro Units". It became a pioneering and trend-setting study in Indiafetching me the Willie (a German Scientist) Memorial Award.

I shifted to NHPC in the year 1982. I remember the moment when I informed the General Manager (Electrical) Shri V.K. Sharma (*who was Chairman of the Selection Committee*) on stairs that I submitted my joining consent, he remarked "Yes we know at 1.00 pm today BHEL has become poorer and NHPC richer". I do not know how much richer NHPC could become but for the next decade I worked sincerely pouring my heart and soul. As Chief of Corporate Planning Department for the longest tenure, I was

instrumental in sanctions of projects worth 2265 MW involving an investment of Rs 5400 Cr., authorized share capital growing from Rs 800 to 2500 Cr., Corporation upgraded from "B" to "A" schedule, Five-Year-Plan exercises of NHPC attracting attention of IAS examination papers etc.When I started handling *Hydro-Environment Interface* (having created an environment cell in my department), no one was talking about positive impacts of Hydro, closing one eye of the decision makers. Our sustained efforts brought it on the assessment formats of evaluation matrix.

With the awareness of uprating potential of Hydro spreading across the power sector, during the Power Ministers' Conference held in Jan'1987 a resolution was passed that an All India study of Renovation & Modernization of Hydro Electric Power Plants would be conducted by NHPC and with the background of Bhakra study naturally it was entrusted to me. Assisted by Shri A.K. Tripathi, I did it with full vigor and dedication. Having become one of its kind first national study for a country of continental dimensions, we were invited to the First International Conference on Uprating & Refurbishing Hydro Power Plants" at Strasbourg, France during Oct'1987. I presented the study.This study taking the shape of the first ever made national master plan on Hydro R&M across the globe became a star of the show at the Conference. Mr J. Warnock, Managing Director of Acres International, UK chairing the Conference said in the midst of a standing ovation "Here is the first ever attempted comprehensive study of all the operating plants in a country of India's size dealing with all aspects from Civil Engineering to Electronics, which is going to become a forerunner of such studies by other nations."

I was confronted with another problem of silting in Hydro turbines, damaging their under-water components. I again took the problem seriously and not only worked on solutions in terms of repairs and preventions but also started looking at the design aspects little realizing that it was giving rise to new engineering practices in Renovation & up-gradation of silt prone Hydro Power Stations and a New science was emerging later labelled as *"Design of Hydro Turbines for silt laden flows"*, accepted for post-graduate studies and recognized internationally. I was invited to Europe (United Kingdom, Norway & Austria) and South America (Argentina) to share this specialized knowledge. When I was invited to Argentina by IMPSA for a lecture series on the subject for their design engineers, the Director of the Company, Engr. Roberto Maiorana welcomed me as a person most documented on the subject, once again proving the philosophy underscoring my life.

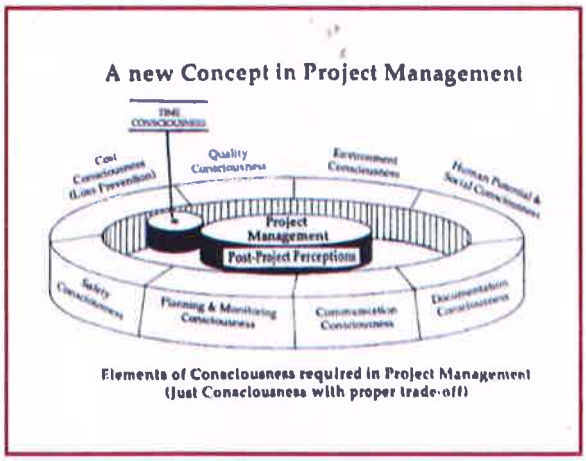
In view of my contributions (some of them stated above) CBIP's highest honor, their Diamond Jubilee award, was bestowed upon me in the year 1989 for my outstanding contribution to Hydropower development in the country. I was happy to get this life time achievement award (as the youngest candidate till then) from the hands of the then Energy Minister of India Shri Arif Mohammad Khan in the august presence of Shri Bahadur Chand,Chairman, CEAin a glittering function in New Delhi, incidentally attended by my mother.

Prof. Pradip N. Khandwalla of IIM, Ahmedabad approached me to contribute to a "*Study on Human Excellence*". The basic idea of this study was to understand why some persons are able to achieve so much, and others with comparable background and intelligence end up doing nothing of any consequence. I did contribute to his interesting study which was later published by him in a book titled "Fourth Eye-Excellence through Creativity". It reinforced my belief that the creativity can flourish in every job, even in seemingly smaller jobs.

Renewable Energy, when I entered the field in early 1990's, was in a nascent stage (kW scale) in India, far from any economies of scale. I took the responsibility for strategic interventions in the India's renewable energy sector by identifying barriers faced at macro & micro levels, exploring remedial options and strategic 'niche' interventions with potential ramifications in terms of replicable models with multiplier effects. Today it has much higher share of nearly 36,000 MW (more than 6 times of Nuclear Power) and is being seen as the energy of the future. I played my modest role as Executive Director, IREDA, Director (Renewable Energy) Winrock International India and Director, MP Windfarms. In 1997, I was declared **"Renewable Energy Man of the Year"** by the National Foundation of Indian Engineers.

As Director, REC (A Navratna Company), I was involved in 1999 with UNDP/GEF project on "Optimizing Development of Small Hydel Resources in the Hilly (Himalayan and Sub-Himalayan) Regions of India". Shri I.M. Sahai, Ex-Chairman, PFC was also a Mission member. When we went to submit our report to the UNDP office in Delhi, they very much liked our format and the findings. Later they informed us that UNDP Headquarters have directed them to keep our report as a Model sample for future projects. At REC, I also evolved a new concept on "Project Management" and presented it as a Key-Note Address at an International Conference at Singapore in November 1999.

Various failures and successes met with in real life projects with the same operating tools like OR/PERT/CPM/OAS/MIS/DSSetc. have time and again pointed towards one basic thing viz. Human mind is crucial to make conscious judgments on optimization of all tangible and even intangible variables influencing a project. The concept of making human being as the hub of management activities should logically lead us to 'Consciousness Concept Model', as it is the man behind the machine who matters. Ten (10) Consciousness Elements were comprehended as crucial ingredients of the 'mind-set' of a successful "Project Manager", pictorially depicted in the diagram shown.



Elements of Consciousness required in Project Management
(Just Consciousness with proper trade-off)

If the Project Management has to succeed on Indian soil, we have to develop the Project Management discipline as a Science of Consciousness. Suitable training packages would have to be evolved for the prospective project managers with exclusive modules aimed at generating 'consciousness elements' itemized above and more importantly the terminal modules aimed at bringing an equilibrium amongst them, appreciating the tradeoffs and inter-linkages involved. An appropriately conditioned mind so trained would possess 'just consciousness' capable of taking judicious decisions during project implementation. This would certainly add a new dimension to the Project Management and if pursued in right earnest, can bring results which would surprise many and Indian consciousness and ethos in Project Management would become a guiding light for the future generations, I believed.

On the above concept, I received appreciation from the then Cabinet Secretary to Govt. of India, Shri S. Rajgopal. Another dose of appreciation I got from Dr APJ Abdul Kalam, the then-Principal Scientific

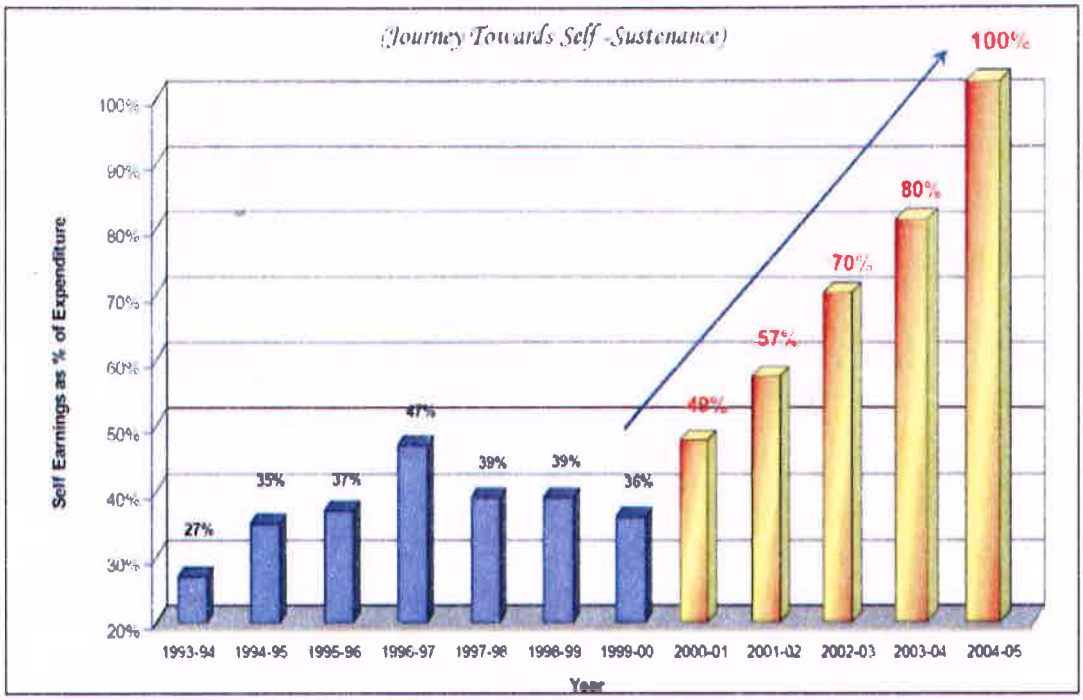
Adviser to GoI on my Institution of Engineers (India) awarded paper on "R&D Vision for 21st Century with special reference to Power Sector in India" in 1999. These are good memories.

When I took over NPTI as its Director General in the year 2000, I found that the performance graphs of this Apex Institution in Training & HRD of Power sector were continuously declining during the previous decade making it a sick organization in the bankrupt power sector. The real challenge was to make it self-sustaining. It needed out-of-the-box thinking for setting the gears right. We resorted to the following strategies:

1) With the permission of the Ministry of Power, we formulated a National Training Policy for the Power Sector (first time in the country) mandating 1-week training/ year compulsory for every one working in the sector and earmarking 1.5 to 5% of salary budget for training. The Policy was passed by the Parliament with theefforts of Shri Suresh P. Prabhu, the-then Union Power Minister. This policy when implemented all over the country in March'2002 generated 10,00,000 trainee-weeks of training load annuallybesides earmarking of funds for the purpose.

2) The above initiated flow of trainees but not the revenue earnings for NPTI on the plea that any cut on the budget is always on the head of training. Then we organized an All India conference of Regulators under the chairmanship of CERC and got a resolution passed that training expenditure would be a part of O&M expenses which are built into the tariff. The moment tariff is realized, cash is available for reimbursement to training.

3) All the processes involved in the steps-1&2 above took two years at the fastest pace but we were committed to self-sustenance from Day-1. We therefore pioneered unique programs viz. B.Tech./ B.E. (Power Engineering) and PGDC in specialized segments like "Power Plant Engineering", "Power Systems Engineering" etc. at NPTI. We offered the Art and Science of Power Management to the Reforming Indian Power Sectorby way of First Ever AICTE/UGC approved MBA Program on the subject, under the auspices of the Centre for Advanced Management & Power Studies (CAMPS) started by me. These programs have unmatched reputation in Power Sector. The product of all these courses not only got absorbed in the industry but also took a premier Training Institute NPTI to new heights of excellence across the globe. During my tenure, we expanded 4-Units of NPTI to 10-Units across 5-Power zones of the country making it the largest Power Training Institute in the world, with total self-sustenance within 5-years. The quantum jumps NPTI experienced in its operational parameters during mytenure (2000-2005) have made an unrepeatable history.



NPTI's Turn around in 5-Years

My professional life provided me a rare combination, 32-years of rich Industry experience in country's premier organizations with subsequent 15-years in Research, Training and Education creating the brains behind the country's power and energy sectors. I also have satisfaction of having documented my experience in 150-technical papers (80 in international fora) ending with 7-books on Renewable Energy including conventional Hydro (whose renewability comes out of nature's hydrological cycle) for PG studies. These are my choicest gifts to the younger generation.

My work at NPTI continued post-retirement through the Institute of Energy Management & Research (IEMR) later rechristened as the Great Lakes Institute of Management (GLIM) Gurgaon (as Founder Chairman) in the field of engineering & management education, providing me great satisfaction and recognition by the Higher Education Forum (HEF) through their First "Outstanding Academic Leadership Award-2014".

When I was elected Fellow of the Indian National Academy of Engineering (INAE) in 1993 I felt happy that I am among the luminaries of the country. My picking up so called small jobs in a conventional field on the way of my career and doing them as perfectly and as innovatively as I could, did not cause any setback against the Missile &Nuclear scientists, Information Technologists, or Industrialists of highest repute.

Lessons from my professional life are simply:

1. No job is small or big by itself, it is the way in which you do, makes it small or big.

2. When you take up a new challenge as an opportunity and proceed, you find so many hidden opportunities unfolding in a cascading manner that astonish and overwhelm you.

3. Self-esteem emerging out of original work motivates you more than any other external stimuli.

4. Anything you succeed in doing for the first time in any domain be it your organization, your sector, your country, your continent or the entire globe, gives you an awesome sense of fulfilment.

5. If you contribute in any sphere, it pays back if not immediately, in some years for sure.

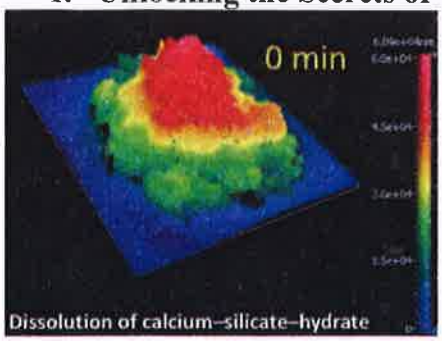
6. Any original ideas and thoughts you generate at your end can be transmitted to the other end of the world, sometimes even without your knowledge, more so in the present digital world.

7. The wind may blow from any direction, but the direction in which you go depends on how you set the sails.

8. Engineering is not just application of science but genuine innovation while applying science and it can be philosophized for its influence on a larger domain.

Civil Engineering

1. Unlocking the Secrets of Creeping Concrete

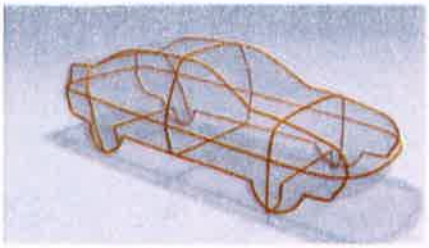


This is a visualization of the dissolution of a C-S-H grain following its repetitive contact with an aqueous solvent. These visualizations which were enabled using vertical scanning interferometry (VSI) provide access to the surface topography at nanoscale resolution.

Concrete is everywhere -- a ubiquity owed to its strength as a building material. Despite its strength, however, it has a tendency to "creep," or deform progressively under mechanical stress, which leads to crumbling bridges and cracked roads. Despite the obvious relevance creep holds for the safety of infrastructure, however, the physical origin of the mechanism has remained poorly understood, and even scientifically contested. "As a result, engineers estimate creep using empirical models, which often poorly predict creep behavior," explained Gaurav Sant, an associate professor in the Department of Civil and Environmental Engineering at UCLA. "By careful unifications of experimental and computational data, we clarified that creep originates from a dissolution-precipitation process that acts at nanoscale contact regions of C-S-H grains." Sant and his colleagues found that calcium-silicate-hydrates, the binding phase that holds cement paste together, tend to dissolve at high-stress regions, and re-precipitate at low-stress regions. This is in correspondence with Le Chatelier's principle, also known as "the equilibrium law." "As a result of such dissolution-precipitation behaviour, a macroscopic, time-dependent 'creep' deformation manifests," said Sant. The idea of a dissolution-precipitation process is familiar to geologists -- its effects lead to deformation in the earth's crust. This the first time it's been shown to be relevant to concrete, explained Sant. The researchers' previous work includes developing vertical scanning interferometry methods to measure the dissolution rates of minerals on the nanometer scale, systematically assessing the viscoelastic behaviour of calcium-silicate-hydrates, and developing methods to simulate long-term relaxation of disordered solids under stress. Taken together and applied to calcium-silicate-hydrate compositions, these contributions have given the researchers the ability to comprehensively examine and isolate the variables at play in concrete creep. The researchers' analysis also uses molecular dynamics simulations to assess how the geometric arrangement of atomic networks influences the volume relaxation of calcium-silicate-hydrate compositions. "Such behaviour shows a dependence on the chemical composition of the calcium-silicate-hydrate, a result which permits identification of 'isostatic' calcium-silicate-hydrate compositions, which feature a minimum in creep and dissolution rates. This data reveals a previously unknown 'compositional route' to minimize creep of concrete," said co-workers. Future work for the researchers will involve putting together a comprehensive description of concrete creep from the atomic to macroscopic scale. This will ultimately help them develop mechanistic models for predicting creep behaviour, and identification of cementation agents with reduced sensitivity to creep.

Source https://www.sciencedaily.com/releases/2016/08/160802125157.htm

2. New Algorithm for Optimized Stability of Planar-Rod Objects



Algorithm corrects connection points of objects fabricated by wire bending machine to optimize stability. Adaptions of design and structure computed. Potential range of application in Rapid Prototyping.

During the annual top conference of the Special Interest Group for Computer Graphics (SIGGRAPH) of the Association for Computing Machinery (ACM), which took place in Anaheim, USA, IST Austria Professor Bernd Bickel and his group present an algorithm that allows improved technical modelling of planar-rod structures consisting of interlocking wires. After designing an aesthetically pleasing structure, e.g. a car or a duck, the contours of the objects are re-calculated with the new algorithm. In this way, necessary adaptions of the structure and its connection points are computed to guarantee optimal stability of the object fabricated by the wire bending machine. The 2D structures are assembled to a 3D object without requiring additional connectors or soldering points. "We were able to find a mathematical formulation for an exciting problem which allowed us to solve this problem in a second step. The software can be a useful tool for designers and engineers," says Bernd Bickel concerning the recently developed algorithm. The software implies applications to art on the one hand, but wire sculptures on the other hand present an extremely efficient and fast alternative for low-fidelity rapid prototyping due to the manufacturing time and required material scaling up linearly with the physical size of objects. The software allows a verification of function and stability resulting in the production of the optimal object only.

Source https://www.sciencedaily.com/releases/2016/08/160810113834.htm

Mechanical Engineering

3. The Miniature Rocket Engine

CubeSats are space age hitchhikers, miniature spacecraft that fly into orbit aboard rockets whose primary payloads are full-size satellites. Measuring about 10 centimeters on each side and weighing less than 1.5 kilograms, CubeSats often ride for free. CubeSats—which could perform tasks as varied as monitoring disasters and repairing orbiting structures—must use their own propulsion systems to get to their destinations; to make the adjustments needed to stay there or go to another location; or even to reach escape velocity and travel to interplanetary space. Paulo Lozano and his team at MIT's Space Propulsion Lab have developed a unique kind of rocket engine for these microsatellites. Dubbed the ion electrospray propulsion system, the electric engine fires tiny streams of ions that push these mini-spacecraft into desired orbits and keep them there. Using semiconductor manufacturing technology, Lozano's team creates chip-sized thruster modules that measure only 10 x 10 x 2.5 mm and could comfortably fit on a dime. An engine that controls yaw or pitch might use four modules, while a main propulsion engine would house many more, depending on the amount of thrust required. The thruster modules themselves consist of an array of hundreds of small volcano-like cones called emitters. Instead of burning chemical fuels, they accelerate ions out of openings so small, their diameters are measured in nanometers and their thrust in nanonewtons. Because a pound of thrust translates into 4.8 billion nanonewtons, it would take about a million billion ion engines to produce the thrust of just one of the five rocket engines on the first stage of the Saturn V moon rocket. Yet, given enough modules firing over a long enough time, an ion engine will vault a CubeSat from a low earth orbit (2,000 km or lower) into a 36,000 km geosynchronous orbit, or even beyond the clutches of Earth's gravitation and onto the moon or other planets. It can do it with only 150 g of fuel and still leave 70-90 percent of the CubeSat free for critical sensors and electronics. No other propulsion system comes close. For conventional space rockets to escape Earth's gravity, they have to generate a lot of thrust and burn a lot of fuel. A rocket that relies on chemical combustion must carry 20 to 40 times more fuel than the weight of the payload. Starting from a launchpad, it will burn through that fuel in minutes to reach escape velocity, just over 40,000 km per hour. Lozano developed his electrospray engines for spacecraft that are already in orbit and that no longer have to do that type of heavy lifting. They can travel and maneuver with far less thrust. In fact, ion engines use fuel so parsimoniously that they can fire for prolonged periods, shut down, and then fire repeatedly without fully depleting their reserves. The thrusters accelerate ions to many times the velocity of a chemical rocket's exhaust, producing more thrust than might be expected from such a small stream of ions. As long as time is not an object, firing long bursts of high-speed ions provides all the thrust needed to accelerate CubeSats into higher orbits and beyond. The cone-shaped emitters accelerate ions through an electrical field generated by the CubeSat's batteries, which are recharged by solar panels. It takes a mere 5 W of electricity—at voltages up 1,000 V—to produce a field at the top of the thruster module's emitters, where the propellant rushes to meet the vacuum of space. The trick to building a successful ion electrospray propulsion system, Lozano explained, is to increase thrust density by jamming together as many emitters as possible. A single 1x1 cm module may contain 400 or more emitters. Add enough modules to a 10 cm x 10 cm CubeSat surface and total thrust approaches the millinewton range. "They produce little force, but because they can fire for a long time, you accelerate the spacecraft to a velocity that would be impossible to get with a chemical engine," Lozano says. "That is a big value." CubeSats, working alone or in groups, could become the maintenance staff of space, inspecting, docking, assembling, and repairing orbiting structures. They could even be used to explore interplanetary space.

Source https://www.asme.org/engineering-topics/articles/aerospace-defense/the-little-rocket-engine-that-could

4. Self-Cleaning, Anti-Reflective, Microorganism-Resistant Coatings

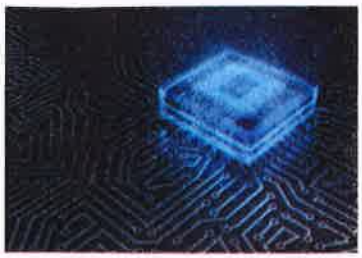
Detail of the phase separation in the copolymer: when the siloxane (areas where yellow predominates) migrates to the surface, it generates greater roughness, and due to its hydrophobic characteristics, prevents the adhesion of organisms.

Alexander Santiago, a researcher in the Department of Polymer Science and Technology at the UPV/EHU's Faculty of Chemistry, has developed three types of functional coatings that are resistant to microorganisms and have self-cleaning and anti-reflective properties. By modifying the surface of paints he has managed to vary their properties or their possible applications at a lower cost in comparison with the materials existing on the market. Coatings or paints are materials applied to different surfaces basically for decorative and protective purposes. Yet today the market for these materials is being subjected to increasingly tougher specifications. In addition to being decorative and protective, today's coatings must have additional properties such as, for example, low microorganism-adherence, ease of cleaning or self-repair properties. The development of materials of this type, known as "functional coatings," calls for the control not only of their physical properties (mainly to do with their morphology); but also of the chemical ones, of the surfaces produced. The research of Alexander Santiago set out to make a contribution towards the development of three types of functional coatings: ones that are resistant to microorganisms (for example for paints for seagoing vessels), and which have self-cleaning (hydrophobic paints) and anti-reflecting properties (for coating mobile phone screens or spectacle lenses). The researcher carried out numerous trials and tests in the three above-mentioned lines to obtain functional materials with the desired properties. The first of the hydrophobic coatings he explored was a type of copolymer that gives rise to spontaneous phase separation between its components. In other words, "one of the components of the copolymer (the polyurethane) gives the substrate adhesion and most of the other component (the siloxane) remains on the surface, which makes it rougher, and as it is also hydrophobic it stops organisms sticking to it," explained Alexander Santiago. Through various measurements they confirmed that the hydrophobicity of the system depended to a greater extent on roughness than on the siloxane concentration on the surface. Protein absorption measurements were used to determine the restriction of the adhesion capacity of the microorganisms on these films. These trials showed that the microorganisms stuck less to the films displaying phase separation. To obtain materials that would display a self-cleaning effect (within the line of hydrophobic coatings), inorganic nanoparticles of a hydrophobic nature were synthesised in advance and inserted into acrylic polymers using various methods. Specifically, they were silicon nanoparticles with an organic coating. The best results were obtained by spraying these nanoparticles onto acrylic films, and that way a super-hydrophobic surface was created offering very good self-cleaning properties in addition to a high level of toughness. The method used "turned out to be a fast and relatively cost-effective one," said the researcher, "as we used silicon that is not as expensive as other substances used on the market." To obtain anti-reflecting properties, the films need to have a refractive index lower than that of the substrate, which can be achieved by inserting porosity into them. But the presence of the pores prevents the anti-reflecting surfaces from having suitable mechanical properties enabling them to be processed. In this respect, he studied the porosity/toughness relation with respect to the refractive index obtained and the results were promising.

Source https://www.sciencedaily.com/releases/2016/08/160808121202.htm

Electrical Engineering

5. Prototype Chip Could Help Make Quantum Computing Practical

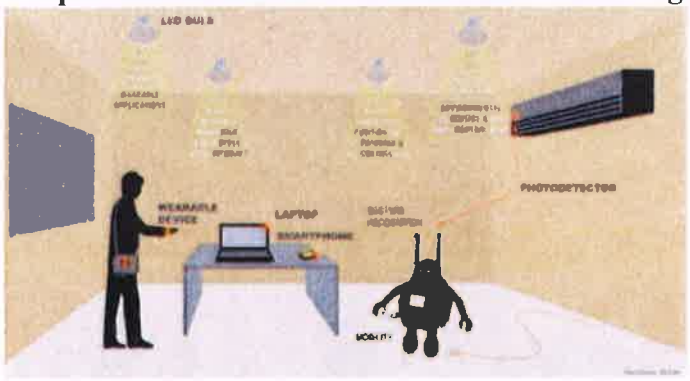


Researchers from MIT and MIT Lincoln Laboratory report an important step toward practical quantum computers, with a paper describing a prototype chip that can trap ions in an electric field and, with built-in optics, direct laser light toward each of them

Quantum computers are largely hypothetical devices that could perform some calculations much more rapidly than conventional computers can. Instead of the bits of classical computation, which can represent 0 or 1, quantum computers consist of quantum bits, or qubits, which can, in some sense, represent 0 and 1 simultaneously. Although quantum systems with as many as 12 qubits have been demonstrated in the lab, building quantum computers complex enough to perform useful computations will require miniaturizing qubit technology, much the way the miniaturization of transistors enabled modern computers. Trapped ions are probably the most widely studied qubit technology, but they've historically required a large and complex hardware apparatus. Researchers from MIT and MIT Lincoln Laboratory report an important step toward practical quantum computers, with a paper describing a prototype chip that can trap ions in an electric field and, with built-in optics, direct laser light toward each of them. "If you look at the traditional assembly, it's a barrel that has a vacuum inside it, and inside that is this cage that's trapping the ions. Then there's basically an entire laboratory of external optics that are guiding the laser beams to the assembly of ions," says Rajeev Ram, an MIT professor of electrical engineering and lead researcher. "Our vision is to take that external laboratory and miniaturize much of it onto a chip." The Quantum Information and Integrated Nanosystems group at Lincoln Laboratory was working to develop simpler, smaller ion traps known as surface traps. A standard ion trap looks like a tiny cage, whose bars are electrodes that produce an electric field. Ions line up in the center of the cage, parallel to the bars. A surface trap, by contrast, is a chip with electrodes embedded in its surface. The ions hover 50 micrometers above the electrodes. Cage traps are intrinsically limited in size, but surface traps could, in principle, be extended indefinitely. With current technology, they would still have to be held in a vacuum chamber, but they would allow many more qubits to be crammed inside. Performing a quantum computation, requires precisely controlling the energy state of every qubit independently, and trapped-ion qubits are controlled with laser beams. In a surface trap, the ions are only about 5 micrometers apart. Hitting a single ion with an external laser, without affecting its neighbors, is incredibly difficult; only a few groups had previously attempted it, and their techniques weren't practical for large-scale systems. Ram's group designed and built a suite of on-chip optical components that can channel laser light toward individual ions. Their associates retooled their surface trap to accommodate the integrated optics without compromising its performance. Together, both groups designed and executed the experiments to test the new system. "Typically, for surface electrode traps, the laser beam is coming from an optical table and entering this system, so there's always this concern about the beam vibrating or moving," Ram says. "With photonic integration, you're not concerned about beam-pointing stability, because it's all on the same chip that the electrodes are on. So now everything is registered against each other, and it's stable." The researchers' new chip is built on a quartz substrate. On top of the quartz is a network of silicon nitride "waveguides," which route laser light across the chip. Above the waveguides is a layer of glass, and on top of that are the niobium electrodes. Beneath the holes in the electrodes, the waveguides break into a series of sequential ridges, a "diffraction grating" precisely engineered to direct light up through the holes and concentrate it into a beam narrow enough that it will target a single ion, 50 micrometers above the surface of the chip. With the prototype chip, the researchers were evaluating the performance of the diffraction gratings and the ion traps, but there was no mechanism for varying the amount of light delivered to each ion. In ongoing work, the researchers are investigating the addition of light modulators to the diffraction gratings, so that different qubits can simultaneously receive light of different, time-varying intensities. That would make programming the qubits more efficient, which is vital in a practical quantum information system, since the number of quantum operations the system can perform is limited by the "coherence time" of the qubits.

Source https://www.sciencedaily.com/releases/2016/08/160808120715.htm

6. OpenVLC Platform for Research in Visible Light Communication Systems



Potential applications of VLC technology.

Visible Light Communication (VLC), sometimes also referred to as "Li-Fi," uses standard off-the-shelf visible light LEDs to transmit data using the visible light spectrum. The idea is very simple: the light emitted by standard LED luminaries is modulated to transmit data at such high speed that the human eye cannot perceive light changes. In other terms, VLC is "like sending Morse code signal with a torch, but a much faster rate and using the alphabet that computers understand". VLC is currently receiving significant attention from the researchers and designers of 5G networks and beyond. Because of the much greater bandwidth available in the visible light spectrum with respect to radio frequency spectrum, VLC can help address the looming spectrum crunch problem. The interplay of this factor with the high-energy efficiency of LEDs will also enable new pervasive wireless systems in the realms of the Internet of Things (IoT) and accelerate the growth rate of connected IoT devices. A research team led by Dr. Domenico Giustiniano, Research Associate Professor at IMDEA Networks Institute is carrying out an important research project called Open VLC. Since VLC is a new technology, as of today there is no open-source reference platform for research in VLC networks. The goal of the project is to overcome this strong limitation and design a solution that is low-cost, flexible and programmable for the research community. The availability of a general-purpose platform would add momentum to VLC research, open up new avenues of VLC research and spark the interest of researchers and engineers. It can be used as a starter kit for embedded VLC research, as well as an education kit for courses aimed at undergraduate students. In order to accomplish these objectives, the initial step taken by the research team is to design and build the OpenVLC platform. In technical terms, the researchers create an open-source VLC platform for fast prototyping of new system protocols and build a Li-Fi network. The software-defined approach of the platform allows easily reconfiguring the system according to the application needs. The platform runs on a cost-effective yet powerful credit-card-sized embedded board. OpenVLC is composed of three parts: An embedded system easily available on the market (BeagleBone Black, BBB); the OpenVLC1.1 hardware, i.e., the VLC transceiver (also called BBB cape), and the OpenVLC1.1 software, a software-defined PHY and MAC layer, implemented as a Linux driver. The OpenVLC1.1 hardware includes three optical components: a low-power LED, a high-power LED, and a photodiode. Several visible light communication channels can be enabled, such as the transmission from a high-power LED to a photodiode and the transmission from a low-power LED to another low-power LED, acting as receiver. The OpenVLC1.1 software is implemented as a Linux driver that can communicate directly with the OpenVLC 1.1 hardware and the Linux networking stack. In OpenVLC, the VLC interface is set up as a new communication interface that can take advantage of the vast range of Linux tools.

Source https://www.sciencedaily.com/releases/2016/08/160809095640.htm

Aerospace Engineering

7. Solar Plane Makes History after Completing Round-The-World Trip


Solar Impulse 2 has completed the first round-the-world flight by a solar-powered aeroplane, after touching down in Abu Dhabi early on July 26, 2016. The final leg of the feat, aimed at showcasing the potential of renewable energy, was a bumpy one, with turbulence driven by hot desert air leaving the solo pilot, Bertrand Piccard, fighting with the controls. The plane, which has a wingspan wider than a Boeing 747 and carries more than 17,000 solar cells on its wings, began the circumnavigation in March 2015 in Abu Dhabi. It has since crossed both the Pacific and Atlantic Oceans using no fossil fuel and has spent more than 23 days in the air. Speaking to the Guardian from the cockpit shortly before landing, Piccard said he was feeling emotional as he neared the end of the journey: "It is a very, very special moment – it has been 15 years that I am working on this goal. "I hope people will understand that it is not just a first in the history of aviation, but also a first in the history of energy," he said. During daylight, the solar panels charged the plane's batteries, which make up a quarter of the craft's 2.3 tonne weight. The pilot also climbed to 29,000 feet during the day and glided down to 5,000 feet at night, to conserve power. The plane flies at about 30mph, although it can go faster if the sun is bright. The plane could fly almost perpetually but the pilots cannot, due to the gruelling conditions aboard. Pilot Borschberg flew the longest leg, 4,000 miles over the Pacific from Japan to Hawaii, smashing the record for the longest uninterrupted journey in aviation history. Bertrand said the final leg from Cairo to Abu Dhabi was particularly tough, because of having to fly at high altitude to avoid the worst of the turbulence. "It is a much more demanding and exhausting flight," he said. "It is so turbulent, there were moments in the last night that I could not rest at all, I just had to fight with my flight controls." The aim of the Solar Impulse adventure was not to develop solar-powered planes for widespread use, but to show the capabilities of renewable energy. "I worked for 15 years to have [this] demonstration of the improvements of these technologies, so now I really want to leverage this demonstration and create a world council for clean technologies," Piccard said. "That will allow all these experts and specialists to advise the governments and big corporations on which types of technology to use to profitably fight climate change and profitably protect the environment." Solar Impulse's journey has not been without difficulties. Crosswinds in China caused weeks of delays in 2015 and overheating batteries during the Pacific crossing forced it to spend the winter inside a Hawaiian hangar.

Source https://www.theguardian.com/environment/2016/jul/26/solar-impulse-plane-makes-history-completing-round-the-world-trip

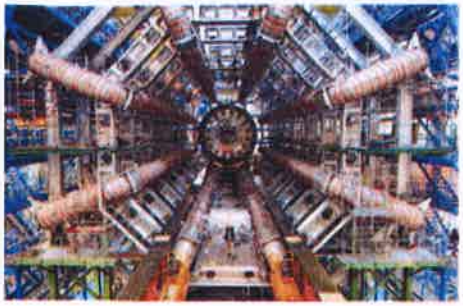
8. Putting the Pressure on Platinum

Researchers synthesize uniquely structured platinum-based superconducting material. Superconductors are materials that, when cooled below a certain temperature, conduct free-flowing electricity without it being impeded by resistance. They are used in magnetic resonance imaging (MRI) machines, magnetic levitation trains and particle accelerators like the Large Hadron Collider. Researchers are constantly on the lookout for materials that can become superconducting at higher-than-currently-possible temperatures and lower costs. A team of researchers from Japan's Hokkaido University along with colleagues at the Kyushu Institute of Technology, NEC Corporation, Keio University and the National Institute for Materials Science have developed a novel superconducting material based on platinum, which was, until recently, thought to be unsuitable as a superconducting material. The material was developed by mixing lanthanum (La), platinum (Pt) and arsenic (As) powders in a ratio of 1:5:1 and compressing them into pellets. These were then heated to 500°C for ten hours. The resultant material was ground and re-pelletized, then heated at 1000°C for an hour at various pressures. The team found that the final product (LaPt5As) was non-superconducting at a pressure of five gigapascals (GPa) (equivalent to 50,000 bars of pressure), but became superconducting at 10 GPa, only to return to a non-superconductive state at 15 GPa. The researchers examined the crystal structure of the superconducting LaPt5As. They revealed that platinum atoms formed multiple layers which piled up as high as 6 nm, the highest among metal superconductor. They also found that lanthanum and arsenic atoms separated platinum layers from each other in a way, they speculate, which weakens the interaction between platinum electrons, allowing them to flow more freely and resulting in the superconducting property. Future research that determines the detailed crystal structure of the non-superconducting phases of LaPt5As will aid in the understanding of the mechanism that causes the material to become superconducting at 10 GPa, the researchers say. High-pressure synthesis (over 10 GPa) is not a commonly used method in the field of materials science, said the researchers. This research shows there is room for further exploration of unknown phases induced by high pressure in a variety of materials, they say.

Source https://www.sciencedaily.com/releases/2016/08/160805085735.htm

Energy Engineering

9. New Results on the Higgs Boson and the Building Blocks of Matter Presented at ICHEP



The ATLAS detector at the LHC.

Physicists conducting research at the Large Hadron Collider (LHC) -- the world's most powerful particle accelerator, located on the border of France and Switzerland -- presented more than 100 new results at the 38th International Conference on High Energy Physics (ICHEP) in Chicago last month. Scientists from the U.S. Department of Energy's Brookhaven National Laboratory helped design and build key components of the LHC, and collaborate on research at the ATLAS detector, one of the LHC's two large high-energy physics experiments that, in 2012, announced the discovery of the Higgs boson. Brookhaven physicists participate in the LHC's Heavy Ion Program at ATLAS, analyzing results from collisions of large nuclei such as lead, much like the gold-gold collisions at Brookhaven's own Relativistic Heavy Ion Collider (RHIC), but at a higher energy. The scientists work in complementary ways to explore details of the quark-gluon plasma (QGP) that existed in the very early universe in an effort to understand its properties over a range of energies and how it evolved to form the visible matter of the universe today. The ICHEP meeting included presentations of heavy-ion data from both colliders. Following last year's first glimpse of physics at an unprecedented energy level -- colliding two beams of protons at an energy of 13 trillion electron volts (TeV) -- the LHC experiments have now amassed significant amounts of data allowing them to "dive in and explore" the physics at this new energy frontier. Recently, the LHC surpassed its design luminosity -- a measure of the number of collisions in a given time interval, reaching a peak luminosity of about 1 billion collisions per second. This means that even the most rare interactions of subatomic particles at the highest effective energy can potentially occur and be detected to reveal new physics. Physicists analyzing the large amounts of 13 TeV collision data have already confirmed the existence of the Higgs boson and they will use the new data to conduct in-depth studies of this particle's properties. They have also made new precision measurements looking for anomalous particle interactions at high mass, a very sensitive but indirect test for potential physics phenomena that cannot be explained by the existing description of subatomic particles and processes -- a.k.a., the Standard Model of particle physics. They are also looking for signs that new particles predicted by Supersymmetry or other exotic theories "beyond" the Standard Model have been produced. The conference also included presentations of new results from research on neutrinos and in cosmology -- additional areas of high-energy physics where Brookhaven scientists make important contributions. Meanwhile, the four LHC experiments (ALICE, ATLAS, CMS, and LHCb) and the two large RHIC experiments (STAR and PHENIX) presented new results on the exploration of the quark-gluon plasma (QGP) -- a state of matter that filled the early universe several millionths of a second after the Big Bang. Both RHIC and the LHC recreate the QGP by smashing together two beams of heavy ions (typically gold at RHIC and lead at the LHC), and explore the heavy ions by colliding them with protons (or deuterons) as well. In the gold-gold and lead-lead collisions, physicists have determined that the high temperatures and densities reached "melt" the protons and neutrons that make up the nuclei to release their constituent quarks and gluons. Careful study has revealed that, even at the higher LHC energy, the QGP flows with extremely low viscosity (relative to its entropy density) -- as it does in the lower-energy, heavy-ion collisions at RHIC. These studies complement other ways physicists are exploring the properties of the hot nuclear matter, including measurements of how high energy quarks lose energy as they traverse the QGP, and the disappearance of particles consisting of bound heavy quarks and antiquarks, many of which are being shown by the experiments at ICHEP. In addition to opening new frontiers in science, the new high-energy collisions at the LHC have also stretched the performance of the Worldwide LHC Computing Grid (WLCG) well beyond previous records, with more than 25 petabytes of data stored and processed since the beginning of the year.

Source https://www.sciencedaily.com/releases/2016/08/160808152039.htm

10. 'GPS in Space': Bringing Autonomous Interplanetary Travel Closer to Reality

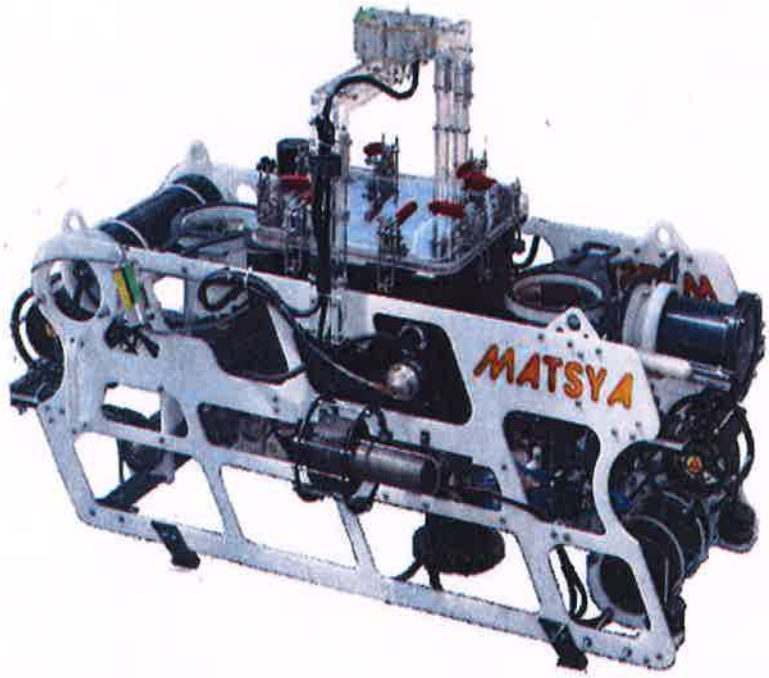
An accurate method for spacecraft navigation took a leap forward recently as the National Physical Laboratory (NPL) and the University of Leicester published a paper that reveals a spacecraft's position in space in the direction of a particular pulsar can be calculated autonomously, using a small X-ray telescope on board the craft, to an accuracy of 2km. The method uses X-rays emitted from pulsars, which can be used to work out the position of a craft in space in 3D to an accuracy of 30 km at the distance of Neptune. Pulsars are dead stars that emit radiation in the form of X-rays and other electromagnetic waves. For a certain type of pulsar, called 'millisecond pulsars', the pulses of radiation occur with the regularity and precision of an atomic clock and could be used much like GPS in space. The paper, published in *Experimental Astronomy*, details simulations undertaken using data, such as the pulsar positions and a craft's distance from the Sun, for a European Space Agency feasibility study of the concept. The simulations took these data and tested the concept of triangulation by pulsars with current technology and position, velocity and timing analysis undertaken by NPL. This generated a list of usable pulsars and measurements of how accurately a small telescope can lock onto these pulsars and calculate a location. Although most X-ray telescopes are large and would allow higher accuracies, the team focused on technology that could be small and light enough to be developed in future as part of a practical spacecraft subsystem. The key findings are: At a distance of 30 astronomical units -- the approximate distance of Neptune from Earth -- an accuracy of 2km or 5km can be calculated in the direction of a particular pulsar, called PSR B1937+21, by locking onto the pulsar for ten or one hours respectively; By locking onto three pulsars, a 3D location with an accuracy of 30km can be calculated; This technique is an improvement on the current navigation methods of the ground-based Deep Space Network (DSN) and European Space Tracking (ESTRACK) network as it: Can be autonomous with no need for Earth contact for months or years, if an advanced atomic clock is also on the craft. ESTRACK and DSN can only track a small number of spacecraft at a time, putting a limit on the number of deep space manoeuvres they can support for different spacecraft at any one time and in some scenarios, can take less time to estimate a location. ESTRACK and DSN are limited by the time delay between the craft and Earth which can be up to several hours for a mission at the outer planets and even longer outside the solar system. Dr Setnam Shemar, Senior Research Scientist, NPL, said: "Our capability to explore the solar system has increased hugely over the past few decades; missions like Rosetta and New Horizons are testament to this. Yet how these craft navigate will in future become a limiting factor to our ambitions. The cost of maintaining current large ground-based communications systems based on radio waves is high and they can only communicate with a small number of craft at a time. Using pulsars as location beacons in space, together with a space atomic clock, allows for autonomy and greater capability in the outer solar system. The use of these dead stars in one form or another has the potential to become a new method for navigating in deep space and, in time, beyond the solar system." Dr John Pye, Space Research Centre Manager, University of Leicester, concludes: "Up until now, the concept of pulsar-based navigation has been seen just as that -- a concept. This simulation uses technology in the real world and proves its capabilities for this task. Our X-ray telescope can be feasibly launched into space due to its low weight and small size; indeed, it will be part of a mission to Mercury in 2018. NPL's timing analysis capability has been developed over many years due to its long heritage in atomic clocks. We are entering a new era of space exploration as we delve deeper into our solar system, and this paper lays the foundations for a potential new technology that will get us there."

Source https://www.sciencedaily.com/releases/2016/08/160804102318.htm

Engineering Innovation in India

IIT Bombay's underwater vehicle 'Matsya' comes second in the AUVSI Robosub 2016

IIT Bombay's autonomous underwater vehicle (AUV) 'Matsya' has secured the second position in AUVSI Robosub 2016. It was adjudged the best performance by an Asian team. The team beat six-time winner Cornell University but lost the first position by a small margin to Caltech University. This year, the Robosub competition was held during July 27-31 in San Diego, California. More than 45 universities from around the world competed to create the most effective autonomous submarine. The teams were judged on their designs, technological innovations and performance in a series of obstacle courses. In this competition, the robots are autonomous, their actions are pre-programmed and they are on their own to complete the objectives without any intervention from the teams. AUV-IITB's Matsya qualified on the first day itself, performed exceptionally in the semi-finals and finals without any retries. Some other tasks that Matsya performed efficiently include identifying colored objects, locating sound sources, dropping markers and shooting torpedoes. Matsya was the only team to attempt all tasks barring one. As a result, Matsya received accolades from the competition organizers.



Source http://economictimes.indiatimes.com/magazines/panache/iit-bombays-underwater-vehicle-matsya-comes-second-in-the-auvsi-robosub-2016/articleshow/53597525.cms