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From the Editor's Desk

AN ACADEMIC

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Desired to see beyond the self

Fate brought him closer to the people

A blue-eyed academic became the darling of the people in no time

But no Read more...

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Chief Editor of Publications

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My friend lost his voice and identity

His theories remained theories

Bound in plans meant for a faraway future

An uneasy realization gripped him

'Mainstream is not for me'

Filled with the discontent of failure

My friend decides to return to the world he once belonged

No longer was he an academic in the world he once belonged

Felt the academe

How can one loose his shine so soon

My friend wondered and suffered
And quietly one day he went away

No one knows where

How the world immersed in myriad things can remember

A forlorn and faded academic

'Wise are not academic, and academic are not wise'

A wise said aeons ago

Don't be sad, my friend, come back

A wise always remains a wise

Academic or otherwise

ACADEMY ACTIVITIES

Engineers Conclave 2017

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Dr VK Saraswat, FNAE delivering the Inaugural Address

Dr BN Suresh, President, INAE lighting the lamp

The themes of the Conclave focused on cutting edge solutions and specific recommendations for development by the concerned organizations. Eminent experts and senior functionaries from National and State Centres/ Departments/ Units, Academia, Industry and INAE participated in the conclave to deliberate on the important themes of the EC-2017. There were about 350 participants including 80 INAE Fellows and Young Associates in the Engineers Conclave 2017. The Technical Sessions on Theme -I were on "Regional air Connectivity: Policy/Regulatory Issues/Operators View Points"; "Airports/No frill Airports"; "Market and Top-Level requirements for new Gen Regional Aircraft"; "Technologies for A New Gen Regional Aircraft" and "Design for Maintenance". The Technical Sessions on Theme -II were on "Infrastructure and Integration"; "Financial Technologies"; "User Interfaces and Services"; "Cyber Security" and "Human Resources: Development, Employment and Empowerment".

Release of Souvenir on Engineers Conclave 2017

The highlights of the Conclave were the five Plenary Talks delivered by Mr VVR Sastry, Ex-Director, C-DOT on " Digital Economy- Challenges, Opportunities, Initiatives and way Forward"; on " IAF's Requirements for Transport Aircraft" by AVM BR Krishna; on "Evolution of Digital Space" by Dr Gulshan Rai, DG-CERT-IN & National Cyber Security Coordinator; on "GST System Project: The Engineering Challenges" by Mr Prakash Kumar, CEO, GST, New Delhi and on " Air Transportation in India- Challenges" by Prof G Raghuram. Director, IIM, Bangalore.

A sideline meeting Chaired by Dr VK Sarawat, FNAE, Member, Niti Aayog on "Development & Production of Commuter & Regional Aircraft in India: Way Forward" was held with all stakeholders and policy makers. Some of the stakeholders who participated in the meeting were delegates from Spicejet, Air India, Indian Air Force, Hindustan Aeronautics Ltd, Pratt & Whitney and Airbus, besides other dignitaries.

Parallel Panel Discussion Sessions on the two themes on Way Forward were held which were Chaired by Dr Kota Harinaryana, FNAE and Prof Veni Madhavan respectively to arrive at the recommendations on proposed course of action. During the Valedictory Session Chaired by Prof Roddam Nanrasimha, FNAE the summing up of the Technical Sessions of the two themes was carried out by the respective Coordinators. The Conclave ended with the Valedictory Address by the Chairman, Prof Roddam Narasimha. Actionable recommendations based on the deliberations of the two themes are under compilation which will be forwarded to the concerned Government Departments/Agencies for consideration.

Dr. Abdul Kalam Technology Innovation National Fellowship

INAE and DST have taken an initiative to institute "Abdul Kalam Technology Innovation National Fellowships" to outstanding engineers to recognize, encourage and support translational research by individuals to achieve excellence in engineering, innovation and technology development. All areas of engineering, innovation and technology are covered by this fellowship. A Maximum of 10 Fellowships will be awarded per year. A meeting of the search -cum-Selection Expert Committee was held on Sept 25, 2017 at INAE Office, Gurgaon to select the first cut of nominations received for the subject Fellowship.

Annals of INAE

The soft copy of the Annals of the INAE Volume XIV, April 2017 containing the text of the lectures delivered by Life Time Contribution Awardees; newly elected Fellows of the Academy and INAE Young Engineer Awardees 2016 has been uploaded on INAE website under the Publications sub-head. The same can be downloaded from the link given below

http://inae.in/ebook/inae-annals-2017/

INAE on Facebook and Twitter

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

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

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

All INAE Fellows are requested to visit and follow the above to increase the visibility of INAE in Social media.

Important Meetings held during September 2017

- **Meeting of Dr BN Suresh, President, INAE with Chairman, AICTE held on Sept 19, 2017** at AICTE Office, New Delhi to discuss the promotion and operation of the current AICTE –INAE Joint Schemes, viz., AICTE-INAE Travel Grant (TG) Scheme, AICTE-INAE Teachers Research Fellowship (TRF) Scheme and AICTE-INAE Distinguished Visiting Professorship Scheme

- **Meeting of Dr BN Suresh, President, INAE with Dr. R Chidambaram, PSA to GOI held on Sept 19, 2017** to discuss Modalities of periodic interactions with the office of PSA for undertaking the joint activities by INAE

- **Meeting of Search-cum-Selection Expert Committee to select first cut of nominations for Abdul Kalam Technology Innovation National fellowship held on Sept 25, 2017** at INAE Office, Gurgaon

- **Meeting of INAE Forum on Technology Foresight and Management** held **at Sept 28, 2017** at INAE Office, Gurgaon

Academia Industry Interaction

AICTE-INAE Distinguished Visiting Professorship Scheme

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

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

Mr S Madivaanan, Formerly Additional Director, CVRDE	Velammal Engineering College, Chennai August 7, 2017	Delivered lecture on "Defence weapon platforms based on Electro Magnetic Waves". As per the feedback from college the industry expert has guided a project and the scheme provides an opportunity to faculty members and students to interact with industry experts.
Dr. Vithal Narasinha Kamat Managing Director, Baroda Electric Meters Ltd.	Sarvajanik College of Engineering and Technology, Surat August 22, 2017	Delivered lecture on "Project Development Methodologies", "Project Management" and "Structured System Analysis and Design Method". According to the feedback from the engineering college, the scheme is a highly beneficial scheme as interaction with industry expert can help enhance practical expertise of both the students and faculty members.
Dr Jayanta Kumar Saha Deputy General Manager (Applications) Institute for Steel Development & Growth	Indian Institute of Engineering Sciences and Technology, Shibpur August 29-30, 2017	Delivered lectures on "Conventional & Alternate Iron & Steel Making Part I and Part II", " Understanding Corrosion Protections" and "Drawing Coating Specifications wrt Codes & Standards" and guided projects. As per the feedback from the engineering college, the lectures by industry expert helped the students to co- relate the applications with theoretical knowledge.

International Conferences/Seminars being organized by IITs/other Institutions

To view a list of International Conferences/Seminars being held in the month of October 2017 click here

Honours and Awards

1.	Mr Rakesh Bakshi, FNAE, CMD, RRB Energy Limited, New Delhi was conferred with "Cross of the Order of Merit of the Federal Republic of Germany" by the Hon'ble President of the Federal Republic of Germany, Mr. Frank-Walter Steinmeier on 17 July 2017. The Award was bestowed upon him on 20 September 2017 at New Delhi by His Excellency, Dr. Martin Ney, Ambassador of the Federal Republic of Germany to India.

2nd International Conference on Advanced Production and Industrial Engineering (ICAPIE-2017) on Oct 6-7, 2017 at Delhi
https://conferencealerts.com/show-event?id=187754

International Conference on Remote Sensing for Disaster Management (ICRSDM-2017) on Oct 11-13, 2017 at Visakhapatnam,
https://conferencealerts.com/show-event?id=185607

International Conference on Chemical, Environmental, Bioprocess, Textile, Mining, Material and Metallurgical Engineering (CEBTME-2017) on Oct 14, 2017 at New Delhi
https://conferencealerts.com/show-event?id=189226

International Conference On "Mechanical, Civil, Engineering, Civil, Engineering, Computer Science (MECIT-2017) on Oct 14, 2017 at New Delhi
https://conferencealerts.com/show-event?id=189223

An Academic's Journey of Life Long Learning

K.P. Madhavan

As I reflect on various phases in my personal and professional life, I have come to realize how I have benefitted from diverse learning opportunities that came my way from time to time. My early life in a village in Kanjani, Trichur (Kerala) was an exciting learning experience of the unstructured kind. I learnt how villagers without access to modern tools could innovate and carry out their farming activities many of which are now done by machines. Watching village craftsmen at work, we learned to make our own toys and sports goods like nets, balls etc. I had my first lesson in Physics watching my eldest brother construct an automatic water dispensing system for the poultry he was rearing. Perhaps one of the most exciting learning experience was the unintentional demonstration of principle of applied mechanics by a team of coconut climbers in bringing down the heavy top of a coconut tree, which was hovering ominously over our house, along a safe trajectory away from the house. These early experiences underscored the importance of learning through such unstructured events and making judicious use of available resources to achieve desired goals

Though my early school education was in Government Schools near Kanjany, for higher secondary education I had to move to the mining town of Kolar Gold Fields (KGF) and get enrolled as a student in St. Mary's High School. Moving from the secure joint family in Kanjany and settling down to an urban life in Kolar required a good amount of learning and adaptation. I had to overcome the immediate challenge of acquiring proficiency in Tamil within a year. I could also develop progressively reasonable command of English under the tutelage of our Principal, Father Rajappa. Access to quality reading material in English comprising of newspapers, magazines and tabloids had also helped in this effort. St. Mary's School had a well-structured academic programme, which did provide the base for us to go ahead in our academic career.

I was singularly lucky to get a chance to pursue my college education at the prestigious St. Joseph's College, Bangalore. True to its reputation, the college had an array of excellent teachers in Mathematics and Chemistry and good lab infrastructure. Learning was an exciting experience at this hallowed institution. On the personal side, this was the beginning of my hostel life. Despite the disciplinary constraints prevalent in such institutions, hostel life was a lesson in living harmoniously among a cosmopolitan student group.

I developed some fascination for Electronics as three of my brothers had chosen Electronics as their specialized area of profession. After completing my intermediate (12th) at St. Joseph's, my attempt to enter Government Engineering College in Bangalore proved abortive. This did not bother me, as pursuing BSc at St. Joseph's Bangalore was always a good option.

Post BSc there was a dilemma as to what could be the road ahead as the job prospects for BSc graduates were not very bright at that time. As my yearning to pursue Engineering did persist, I went on an application spree targeting all possible entry avenues to Engineering. Persistence did ultimately pay when I got admission to the Chemical Engineering programme of AC Tech, Madras under the quota reserved for Kerala students. The irony of the situation was that I had no idea of what Chemical Engineering stood for. Since it was an engineering programme at the prestigious AC Tech, I decided to plunge into the area trusting my erstwhile learning and scholastic capability to help me embrace this unknown discipline. Since it was a two year post BSc programme there was imperative need to absorb the essentials of Chemical Engineering within the limited span of two years. We had the advantage of learning from Prof. G.S. Laddha (Director) who was one of the leading academics in Chemical Engineering of that era. Prof. A.P. Madhavan Nair and Prof. Murugamanickam were the other two faculty members whose lectures were very informative. Prof. Murugamanickam had also marveled us with the display of a remote controlled car that he built in his garage. We found laboratory experiments in Engineering very interesting. Doing a B.Tech. project on Design of Multicomponent Reactive distillation for production of Butyl Acetate was one of the toughest assignments we had to handle. In 1958 when the only computational aid was the ubiquitous sliding rule, the plate to plate calculations we had to do were very arduous and time consuming. This initial tryst with distillation was the forerunner for many of other investigative work I could do on the topic in later years.

The first exposure to working in an industrial setting came when I had to do a three month compulsory training as a part of the curricular requirement for the BSc Tech degree. My training stint was with Travancore Cochin Chemicals, Alwaye (Kerala) making Caustic Soda, Chlorine and Hydrochloric Acid as its primary products. It was with lot of excitement and anticipation that I went for the training. After languishing for a few weeks with no definite assignment to work on, I was asked to take on a project of extracting mercury from the electrolytic cell mud waste. I started work on the project with a good bit of enthusiasm and had started getting some good results. The project had to be terminated abruptly due to safety concerns of working with mercury without proper fume hoods. This was an early lesson about the paramount importance of safety in the plant and in the laboratory.

With no immediate prospects of a job after graduation, I took advantage of the Practical Training Scheme offered by Government of India and joined Travancore Titanium Products Ltd, Trivandrum for a one year training stint. This stint was a rich learning experience from an industrial perspective. The plant had a good amount of unit operations like crushing, grinding, size separation, sequence of reactors, precipitators, rotary drum filters, calciners, dryers and powder mills. The most interesting among these were the huge RCC reactors, in which the Ilmenite digestion with Sulfuric acid was being carried out. The intensity of this exothermic reaction would make the reactor go into a sustained vibration mode, which propagated to the supporting structures also. There was much to be learnt by studying the operation of each of the unit operations in the plant. As I was a paid trainee I was given various tasks. The first task was development of material and energy balance for the Titanium Dioxide plant, a task more demanding than the simple material and energy balance problems we solved in the classroom. I had to learn the art of extracting reliable information from myriad sources, which included plant operating personnel, laboratory technicians and plant records. Closely on the heels of this was the knowledge I gained by associating myself with the team involved in installation of a Sulfuric Acid plant and its commissioning .The startup sequence used in commissioning the plant was an interesting eye opener as such practical issues were seldom discussed in the class rooms. I was also impressed by the excellent quality and completeness of technical documentation provided by the German licensor of the Sulfuric Acid plant.

While the industrial training did bring knowledge about the practical aspects of chemical industry, the urge to continue my higher studies persisted in my mind. During the industrial training, the area, which caught my fancy, was Instrumentation and control, as I saw a large number of instruments being deployed in the plant with only a few of them being operational on a continual basis. I had the good fortune to get admission to IIT Bombay for pursuing Master's Degree programme in Chemical Engineering with specialization in Automation in Chemical Industries. I felt that postgraduate education at IITB would indeed be a turning point in my career. As I was among the first batch of students admitted to this specialization, there was considerable amount of self-learning to be done as there were no peers to reach out to. Most challenging was setting up the experimental system for my Master's Degree project on a pH control problem. After graduation, the limited job offers that came in the area of Instrumentation and Control were not attractive. The enriching academic environment and the social life at IIT campus did entice me to continue for my PhD. During the early phase of my research I had the good fortune to receive guidance from the Russian expert, Prof. Ivanov. He encouraged adoption of a research methodology, which required us to plan our own research independently. For researchers, there were several constraints with respect to the infrastructure, facilities and resources. Here again, the earlier lesson about judicious use of the available resources came into play. A typical instance of this was the development of a simpler Q meter equivalent to the Marconi Ecko Q meter for my PhD work using the available Russian metering instruments and signal generators. Completing PhD under these conditions was truly a lesson in endurance, optimism and self-belief to stay the course.

The academic ambience of IIT Bombay did provide a strong incentive for me to take up academic career as my best option. Since IITB itself was in its growth phase, this could provide an opportunity for me to be part of its development programmes. As a faculty joining the Chemical Engineering department in 1964, I was lucky to have Prof. Kamath as its astute Head who could play the role of a mentor, philosopher and guide. Besides his stature as a leading academic, he was also known for his prowess as an inspiring teacher with a mastery of the subject and excellent communication skills. These became the guiding factors for many of us privileged to work with him. While planning my own approach to teaching, I chose the option of reading as many of the books as I could on the subject and develop a course plan culled out of the material from these sources. This, I thought, would provide a richer source of information and also make me better prepared to approach the class with a fair degree of confidence. Implied in this approach was also the need for continuous learning and preparation rather than the discrete approach of preparing learning material lecture to lecture. The first two subjects I got to teach were Instrumentation and Process Control. As things turned out, Process Control became the flagship course, which I could teach with relish to four generations of undergraduate students. The material for the course was very analytical. The challenge was to develop easy to understand interpretation of the theory of some of the topics like stability and dynamics related controllability issues. These exercises became useful when control had to be taught to professionals later in some of the continuing education programmes for the industry. Optimization was another course I enjoyed teaching at the Postgraduate level. In the initial years this course had attracted a good number of students from other departments also. The course material had to be carefully designed to give equal attention to theory and applications. A broad range of problems drawn from various domains had to be drawn up to meet the learning needs of the diverse student groups in the class. I had also diversified my teaching to take up courses like Process Dynamics, Chemical Plant Simulation and Advanced Process control. Towards the fag end of my academic career, I was requested to take a new course on Artificial Intelligence in Process Engineering. Though I had some familiarity with the subject, I had to do lot of reading on the topic to negotiate the course successfully. The AI techniques I learnt in this process could help me later when I had to handle certain problems from the industry. This lesson I learnt from this is "never lose an opportunity to learn new skills and knowledge even if it takes you out of your comfort zone ". Besides teaching, I was also deeply involved in most of the exercises undertaken by the department in curriculum revision of existing programmmes and curriculum formulation for a Five Year Master's degree programme with specialization in Process Systems Engineering. Converging on the final curriculum, in the face of divergent views, was often a delicate exercise needing patience and persuasive skills.

The development of teaching and research labs was a challenging task especially in a department in its growth phase. While the Russian aid had left the department with an impressive array of equipment and instruments and the Russian Technician had set up a functional Instrumentation and Controls lab, complete utilization of all these was hampered by inadequate documentation in English. In addition, much work had to be done to adapt them to teaching. Using a working knowledge of Russian to study the original Russian manuals and resorting to theoretical analysis, it was possible to get many of the instruments working which included controllers, a wide range of measuring systems and an Analog Computer. Having acquired total familiarity with a wide range of Russian instruments, it was possible to modify the features of some of these to devise some new innovative experiments. A few examples were the use of the 1:1 relay module of a stack diaphragm controller as a low flow control valve, adapting a position balance controller for sampled data control and converting an Analog computer to simulate sampled data control .The laboratories needed to be continuously updated to cope up with the transition pathway from pneumatic, analog, digital to microprocessor based systems. With the assistance of my PhD student, Dr. Sachin Patwardhan (who later joined the department as a faculty) I was able to set up a versatile PC based pressure control system using the resources available in the lab. This was augmented with additional electronic and microprocessor based control systems procured from MHRD modernization grants. There was much learning to be done to transcend from the analog to the digital world

While the initial phase of my academic career was devoted to teaching, in subsequent years research became another equally engaging activity. The choice of modeling, simulation, optimization and control as the broad area of research did help in getting motivated MTech and PhD students to work with me. Guiding research is always a learning experience especially when one has bright students who have the spirit of enquiry working under you. I had PhD students from various backgrounds. This included IIT research scholars, teachers under QIP programme and scholars sponsored by R&D Organizations. I realized that besides providing guidance on technical issues, I needed to play the role of a mentor and a motivator rather than assuming the role of a relentless taskmaster. This approach of building of capability in them to do independent work seemed to work well with the assorted collection of students who had worked with me. It was necessary to acknowledge that each student would come to you with specific talents and certain weaknesses. Recognizing these and shaping their career had been an enriching experience. My research topics for PhD covered modeling and control issues of batch, azeotropic, divided wall distillation columns, exothermic semi-batch and laser photochemical reactors, hydrodynamics of jet type contactors, developing an integrated approach to design and control of chemical processes, model based control of nonlinear systems and heterogeneous and reconfigurable control structures. Two PhD projects which had great industrial significance in the Heavy Water manufacturing practice, related to Modeling of Heavy Water Cascade and Analysis of Jet loop reactors.

A new learning opportunity opened up for me when I got involved with setting up of a CAD Centre as part of an UNDP-DOE initiative for promoting computer applications in Chemical and Metallurgical industries. CAD Centre provided a good platform for me to engage in teaching and research in the emerging area of Computer Aided Process Systems Engineering. Another dimension to the learning was to develop the Centre to act as a window to the industry with a mandate different from that of the academic departments. With proper planning and proactive activities of those associated with the CAD Centre, it could emerge as a unique model of a self supporting Centre in the campus. Process Systems Engineering has also emerged as a dominant research area of the Chemical Engineering department

A change in working environment can provide abundant opportunities for learning and understanding the professional world outside your habitual work place. My first opportunity to interact with my peers in academic universities in USA and UK came in 1985 when I had had spent time with leading research groups working in the area of Computer Aided Process Systems Engineering at universities of Purdue, Washington, Wisconsin, Carnegie Mellon and Imperial College, London. This visit as an UNDP fellow was an excellent experience for me. I could get to know the state of art and the software tools available in the academic and professional domain to engage in teaching and research in the area of Process Systems Engineering. During my second visit to Purdue as a visiting faculty in 1987, I could get to play a more active role in the academic activities of the department which included running a hands-on course on Computer Process Control for the undergraduate students of the department using the real time IBM ACS control software and supervising laboratory courses. The material for the Computer Process Control course was subsequently modified by me to include advance control topics like multivariable control, process identification and self-tuning control. I could also do some developmental work, which included developing an integrated platform for fault diagnosis using IBM ACS with an IBM Expert system and developing computer based experimental systems for three units in the lab namely a distillation column, absorption column and a CSTR using the Camille Control System donated by DOW Chemicals to the department. My third visit to USA in 1993 was to Mobil's Research Centre at Princeton, New Jersey, to work on developing interface packages for integrating Mobil's Custom process packages with SIMSCI's Pro II simulation software. The work had to conform to the software structure standards and protocols prescribed by Mobil for all their future software development activities. Through this association, I could get a first hand experience of the working style and professionalism of a global R&D organization.

As a faculty I felt that interaction with industry would provide an opportunity for me to work on real life problems. As the focus of industry consultancy and sponsored research assignments was on deliverables, I had soon learnt to chalk out a distinctive line of research which would explore not only intellectually stimulating ideas but would also meet the project expectations. I found by experience that successful industry targeted projects were those where there had been close interaction between the academia and industry. One such illustrative case was the long term R&D programme which IITB CAD Centre had with Honeywell Technology Solutions Ltd, Bangalore (HTSL). The collaborative project with HTSL had a high degree of complexity and an artful decomposition of the large scale problem was required to generate a tractable solution strategy. The close involvement of the industry ensured that the solution developed could be readily incorporated into its industrial practice. Another project, which had considerable success, was the development of a simulator for a Sulfuric Acid plant undertaken by the CAD Centre for a leading Sulfuric Acid manufacturer near Mumbai. Here again, the active involvement of the CAD Centre team with the industry team at every phase of the development had led to the development of a simulator which could be relate to the actual operating scenario of the plant. Another challenging industry sponsored project, where there was close industry involvement, was the development of integrated software environment for control system development for a process plant using the resources of a dynamic process simulator, control system design software and an Expert systems package. A unique learning experience opened up for me when I had the opportunity to sit on the Boards of Heavy Water (BARC) and Jopasana Software, Pune. The first organization functioned in a strategic area with assigned targets and growth plans while the second one operated in a competitive business environment. I could get to understand the subtle differences in the way the respective boards looked at operational performance and future plans.

While the prime activity of a faculty is teaching and research, opportunities often come by faculty's way to participate in institutional developmental programmes. Though pursuit of these activities may take time away from research, I found that there were some administrative positions in the institute which could enrich your background and vision. One such was the Dean R&D role where I could get a closer look at the spectrum of research done in various disciplines but also understand fully the ethos of academia –industry interaction. My experience as Dean R &D did help me to tackle a number of institutional developmental programmes that I was entrusted with. The first was to work on a plan to start a Management School with focus on Technology and Manufacturing Management. Since this area was not the prime focus of many of the existing management schools, the first challenge was to put up a curriculum, which will embed these focus areas without compromising the essential facets of a general management education. The second was to mobilize funding from sources other than the Government for setting up the school. Prof. Nag, the then Director and Dr. D.V. Kapoor, Chairman of the Board in position at that time , were the driving forces behind starting of the Management School. Dr. Mashelkar, who was on the Board of Governors of IITB and Prof. A.P. Kudchadkar (in his position as Deputy Director, IITB) had also lent their active support to the cause. They were able to evince the interest of Mr. Nagul, Chairman of ICICI at that time, in the unique character of the IITB Management School in the pipeline. I was entrusted with the onerous task of preparing a credible proposal for financial support to be placed before the ICICI Board. With active co-operation of all concerned persons I was able to prepare of a comprehensive document which was not only academically sound but had also realistic estimates of infrastructural and funding requirements. I found this task a little more intimidating than writing up of a research proposal. The report got acceptance by the ICICI Board and IITB was able to get a sizeable financial assistance from ICICI for its Management School. This exercise was a unique learning experience for me as I could get an idea about the manner in which financial institutions addressed appraisement of developmental proposals. A few years after this exercise, I was again called upon called upon by the institute to explore options of integrating the Biotech and Biomedical academic divisions of the institute into a larger Bioschool, which could have a broader canvass for research. This required extensive efforts to bridge the engineering and science dichotomy and come up with a School which could provide a synergetic growth of the two disciplines. The concept of such a school could only be evolved after protracted discussions with all the stakeholders. The lesson I had learnt from this exercise was that with frank and open discussions one could come up with a solution that could enable people with divergent views to work together in a harmonious manner. Another interesting assignment that I had to undertake for IITB was to co-ordinate the research of a multidisciplinary team working on the Mission Mode project on Integrated Design for Competitive Manufacturing. This required tactical handing of various research groups in the team and adopting a rational approach to resource allocation.

I consider myself lucky to have worked in an institution like IIT Bombay, which provided me opportunities and freedom to pursue my professional interests in an unfettered manner. Chemical Engineering department provided me a warm and friendly atmosphere with my faculty colleagues and departmental staff supporting me in all the ventures I had undertaken. I am happy to see the emergence of the department as one of the leading departments in the country. It has been a privilege to work in such a dynamic department. While being at IIT Bombay, I had also the good fortune to come under the influence of many who have helped shape my professional career. Prof. Kamath was the ideal mentor who inculcated in me many qualities, which helped me to counter the highs and lows in my career. Prof. Kudchadkar pushed me to undertake assignments, which helped me, broaden my spectrum of activities beyond the narrow confines of teaching and academic research. I had the good fortune to work closely with a succession of Directors holding the reins at IITB. Prof. De has been a great source of support to me both during his tenure as Director and thereafter. Prof. Nag gave me freedom to function as the Dean R&D. He had also entrusted me with some important institutional developmental activities. Prof. Sukhatme and Prof. Ashok Misra had also some interesting assignments for me to work on. I have learnt a lot interacting with them and these experiences have helped me become a more mature and complete professional. As resident of the Campus, I had realized the important position that students occupy at such a place. In my several roles of interaction with the students as faculty, supervisor, Head of the department and Chairman of Sports, I had always found excellent support and endorsement from the student community. I would cherish this as the greatest reward that I can get in my academic career.

After having worked for a long period in academic environment, a time had come for me to retire from the active service of the institute in 2002. Fortunately this did not signal premature retirement from professional activity for me. The professional engagements that came my way post retirement were as exciting as my earlier assignments. I could work with the R&D of some of the leading industrial organizations on a range of problems drawn from various domains. This called for extensive learning effort to understand the domain and develop solutions appropriate for the problems from the respective domain. A greater satisfaction that came out of these engagements was the mentor role I could play in nurturing the talents of the young engineers and scientists working on these projects.

As I conclude this narrative, I have come realize how the life of an academic can be an exciting journey of expedition with freedom to explore chartered and unchartered pathways providing abundant learning opportunities and professional challenges.

There is Knowledge in Failure- If Followed by Root Cause Analysis

K. K. Vaze

Introduction

I obtained my B.Tech. degree in Mechanical Engineering from I.I.T. Mumbai in 1973 and joined the 17th batch of Bhabha Atomic Research Centre (BARC) Training School immediately thereafter. After completing the training, I joined Indira Gandhi Centre for Atomic Research (erstwhile Reactor Research Centre). After working for 15 years in the area of structural analysis and design of fast reactor components, I joined the Reactor Engineering Division of BARC in 1989. Subsequently I assumed the charge of Head, Reactor Safety Division and later Director, Reactor Design & Development Group. I retired in Sep 2014 after 40 years of service.

During my tenure at BARC I carried out extensive work in the areas of Nuclear Reactor Safety, Earthquake Engineering, Structural Integrity Assessment, Leak-before-break, Structural Analysis and Design, Fatigue, Fracture and Failure Analysis.

It so happened that around the time I joined BARC, there were quite a few failures in Indian Industry. For Root Cause Analysis as well as corrective actions, these were referred to BARC because of its eminence in structural analysis.

In this article I am going to talk about this single aspect of my work viz. Failure Analysis. This article is prompted by my reading of the book "The Mind of an Engineer" [1] in which many authors have pondered on the question whether the mind of engineer is different.

Dr. P.S. Goel in "Is an Engineer's Mind Different?" brings out that Engineer's mind ought to be different but most of our engineers do not possess that. Prof. Indranil Manna reflects on the dilemma "An Engineer or a Scientist?"

What better way than to learn from the Nobel Laureate Dr. Richard Feynman? After reading his memoirs *"Surely You're Joking, Mr. Feynman!": Adventures of a Curious Character"[2] and "What Do You Care What Other People Think? Further Adventures of a Curious Character"[3],* one comes to an inescapable conclusion that he was a Scientist with the mind of an engineer. One area where the mind of an engineer distinguishes itself is the aftermath of a failure. The question that bothers him is "What is the Root Cause of the failure?"

The two stories in the memoires "He fixes radios by *thinking!" and* "Mr. Feynman Goes To Washington: Investigating the Space Shuttle Challenger Disaster" are masterpieces of Failure Analysis.

Another aspect that assisted us in our Failure Analyses was our assimilation of the ASME Boiler and Pressure Vessel Code, Section III [4] "Rules for Construction of Nuclear Facility Components" where the guiding principles are "Design by Analysis" and "Failure Mode Orientation" as opposed to the conventional approach of "Design by Rule" which provides design formulas, curves, charts and design procedures, which set the minimum required thickness and once this major parameter is fixed, the designer simply follows the rules for detailing of components such as flanges, heads, nozzles etc.

The rational approach for design adopted in Sec. III consists of -

(i) Identifying various failure modes,

(ii) Identifying the parameter causing the failure mode and its critical value and

(iii) Separating the operating value of the parameter from its critical value by appropriate factor of safety

The key to the success in identifying the root causes in the case studies presented here lay in following the first two steps of this approach.

Case Study 1: Investigation of the Accident at a Gas Cracker Complex

Indian Petrochemicals Corporation Limited (IPCL) operated a gas based petrochemical complex at Nagothane near Mumbai, designed to produce 2.75 lakh tones of polymers. In Nov. 1990 there was an accident involving hydrocarbon leak followed by fire and explosion. A high powered Committee, headed by Dr. Mashelkar, constituted to investigate the accident, sought BARC's assistance in performing stress analysis of piping.

Process: A portion of the Ethane-Propane (C2-C3) feed to the cracker complex is diverted to Outside Battery limit (OSBL) plant where it is chilled and stored. Simultaneously the chilled liquid is sent back to main feed, exchanging heat with the incoming stream and getting preheated in the process. See Fig. 1 for Flow Sheet.

Incident: OSBL plant was being commissioned. First two stages of the four-stage chilling were commissioned successfully with chilling to -35 deg C. Ethylene refrigeration system was valved in for further chilling. Temperature dropped to -100 deg C. At that instant, massive leakage was observed forming a vapour cloud. There was an explosion followed by fire, extensive damage and loss of life. From the nature and spread of damage the source of initial leak could be pinpointed to one of the heat exchangers (HX 4 in Fig. 1).

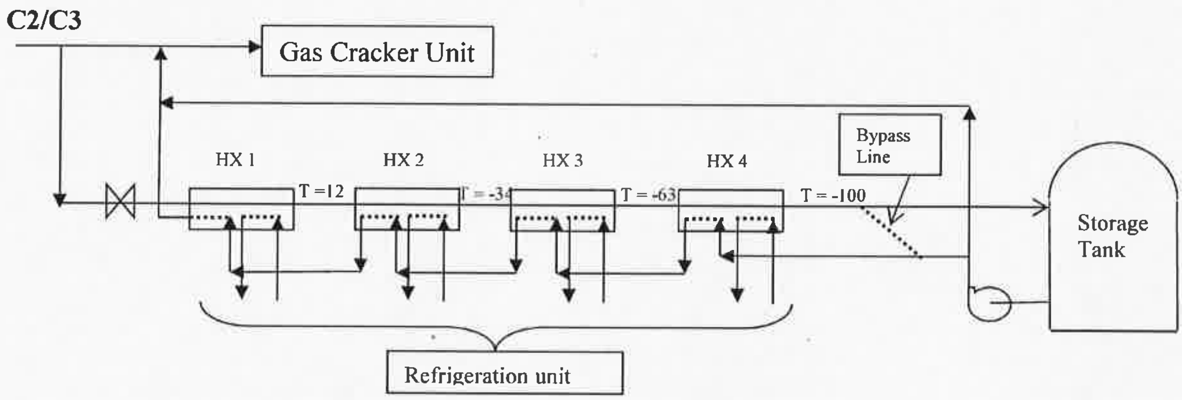

Fig. 1 Partial Flow Sheet

Investigation

While commissioning, a need was felt to isolate the Storage Tank and for this purpose a bypass line was provided across the tank. A doubt was raised about the effect of bypass line on the overall stress picture of the pipeline. However, a detailed stress analysis showed only a marginal change in the stresses.

Two probable causes were investigated.

Weld failure hypothesis

The weld joining the aluminium flange to the nozzle at the suspected leakage location was found to be ruptured and metallurgical examination showed poor quality weld with extensive interpass porosity. However stress and fracture analyses showed that even the poor quality weld should have survived the operating stress once it passed the hydrotest because the operating stress is lower.

Alternate hypothesis

The piping uses low alloy steel studs for joining an aluminium flange to a carbon steel flange. The studs were tightened at room temperature and temperature was then lowered. The differential contraction between the flanges and studs, caused by the large difference in thermal expansion coefficient of aluminium and carbon steel, led to reduction in the gasket compression which in turn caused leakage. In support for this hypothesis, the following extract from Appendix XII of ASME Code Sec. III [5] can be cited:

"DESIGN CONSIDERATIONS FOR BOLTED FLANGE CONNECTIONS

A decrease in bolt stress, below any that may be due to internal pressure, might occur in service during startup or other transient conditions, or perhaps even under normal operation. This can happen when there is an appreciable differential in temperature between the flanges and the bolts, or when the bolt material has a different coefficient of thermal expansion than the flange material. Any pronounced decrease due to such effects can result in such a loss of bolt load as to be a direct cause of leakage. In this case, retightening of the bolts may be necessary."

The retightening or "Cold Bolting" was not followed in IPCL. In order to demonstrate that such a situation can indeed lead to leakage some tests were carried out in BARC.

Leakage Tests

Similar flange assembly containing air at pressure was immersed in methanol and leaktightness was demonstrated. Methanol was then cooled to -90 deg C by liquid nitrogen. Extensive bubbling of air observed demonstrating possibility of leakage.

Root Cause

In view of the two facts: i) The leakage quantity in the tests was not substantial and ii) Whether the failed weld was the cause of the accident or the effect could not be established; it was concluded that the root cause was probably a combination of both.

Corrective Actions

- Use studs made of stainless steel whose coefficient of thermal expansion is between those of aluminium and low alloy steel. This reduces the differential contraction.
- Follow 'cold bolting' practice strictly i.e. tighten the studs after temperature change
- Tighten the specifications for non-destructive examination of nozzle weld

With these modifications, the plant was rebuilt and has been operating satisfactorily.

Case Study 2: Failure Analysis of Methanol Converter Vessel

Deepak Fertilizers and Petro Chemicals Ltd is one of the largest producers of Methanol in India with an installed capacity of 1,00,000 MTPA at Taloja, near Mumbai.

Deepak's low pressure methanol plant was built with know-how derived from ICI via one of ICI's licensees, Davy. The plant was built between January 1988 and September 1991. It was commissioned in October 1991.

Process

- Synthesis gas ($CO + CO_2 + H_2$) enters the vessel through the bottom head (See Fig. 2)
- Rises through the tubes acting as a cooling medium and getting preheated in the process
- Descends through the catalyst bed with following reactions

$$CO + 2H_2 \Rightarrow CH_3OH + 91 \text{ kJ/mole}$$

$$CO_2 + 2H_2 \Rightarrow CH_3OH + H_2O + 50 \text{ kJ/mole}$$

- Other possible reactions

$CO + 3H_2 \Rightarrow CH_4 + H_2O +$ 209 kJ/mole

$2CO + 2H_2 \Rightarrow CH_4 + CO_2 +$ 252 kJ/mole

Design Data

• Diameter	2270 mm
• Thickness	39 mm
• Thickness of hemispherical ends	39 mm
• Design pressure	90 kg/sq.cm
• Operating Pressure	78 kg/sq.cm
• Design temperature	325 deg C
• Operating Temperature	325 deg C
• Material	2.25 Cr- 1 Mo steel

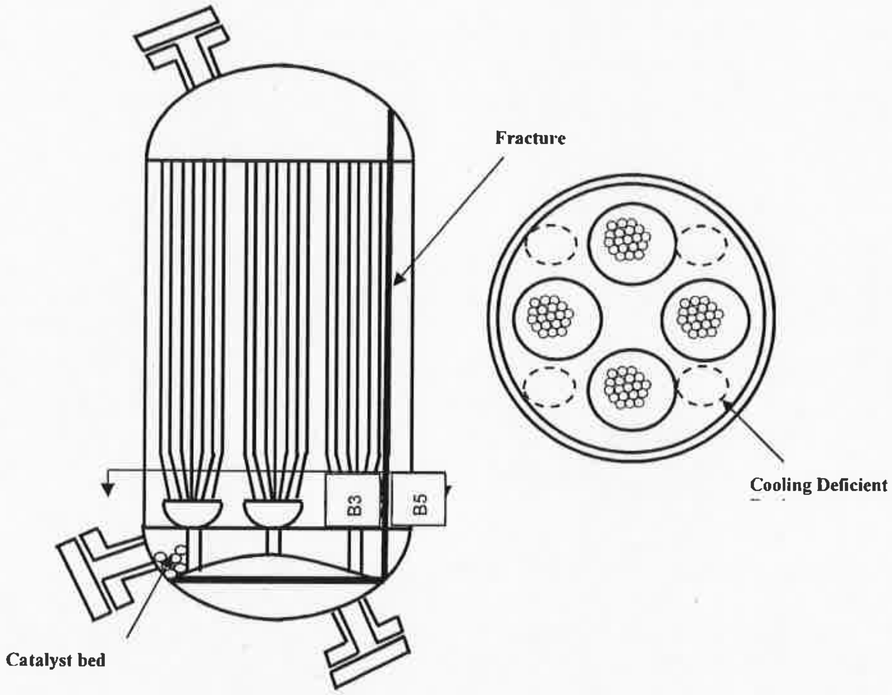

Fig. 2 – Schematic View of Methanol Converter Pressure Vessel

Incident

After about one year of operation, the 2.27 m diameter methanol converter vessel, designed for 90 Kg/sq.cm internal pressure and operating at 325 C, failed catastrophically. The vessel had split open and after flinging its contents, was catapulted to a distance of 80 meters.

Investigation

- The failure was investigated from the following angles:
  - Stress Analysis
  - Fracture Mechanics evaluation
  - Metallurgical studies
  - Process Analysis
- Various hypotheses were postulated and examined in detail

Different hypotheses examined

Postulate	Investigation	Result
Gross material error	Chemical analysis	Ruled out
Error in heat treatment	Tensile tests	Tests show low strength near B3, B5 (See Fig. 2) but not low enough to fail at op. pr.
Gross design error	Stress analysis	Ruled out as Codal limits were satisfied
Material defect	Fracture mechanics evaluation	Critical crack size depth = 19 mm, length = 130 mm, Too large to escape detection
Overpressure	Burst pressure calculation	Burst pressure = 259 kg/sq.cm against design pressure of 90 kg/sq.cm Pressure record does not show any increase
Internal explosion	Examination of fracture edges	Occurrence of bulge and extensive thinning suggests slow deformation
External overheating	Burst pressure vs. temp. calculation	Temp. required for burst at operating pr. is ~ 700 deg C. Requires sustained fire
Internal overheating	Burst pressure vs. temp. calculation	Temp. required for burst at operating pr. is ~ 700 deg C. Possibility of local temperature rise due to methanation reaction

Findings – Accident Progression

- Due to the degraded catalyst, a part of the vessel was operating at a higher temperature
- This portion of the vessel was supporting methanation
- Sustained high temperature resulted in lowering of strength
- The temperature reached the threshold for a runaway methanation reaction.
- Local temperature rose to a value at which the UTS of the material was exceeded.
- Bulging and thinning followed by rupture near B3, B5
- Unstable crack propagation through the length of the vessel

Root Cause

- The failure was due to a local temperature excursion due to methanation reaction.

Lessons learnt

- Consider worst case scenario i.e. runaway methanation reaction and guard against the same
- Detect onset of instability by measurement of temperature at proper locations
- Provide adequate margin between design and operating parameters

Corrective actions

- Avoid areas of cooling deficiency
- Temperature measurement at more locations
- Change the catalyst bed if it results in higher temp.

The plant has been rebuilt with these changes and has been operating satisfactorily.

Case Study 3: FAILURE ANALYSIS OF A NAPHTHA STORAGE TANK

Incident

In November 1988, a fire occurred on a naphtha storage tank (11 m dia x 8 m height, Fig. 3) of BPCL Refinery at Mumbai. The tank roof ruptured releasing a large amount of hydrocarbon vapour spread over an extended area and ignited; causing considerable damage and loss of life.

Design inadequacy was suspected to be the cause and in order to check this possibility, M/s BPCL had asked BARC to perform stress analysis of the tank and also carry out strain gauge instrumentation during a burst test they had planned to carry out.

Investigation

- Theoretical stress analysis was carried out using finite element method. [Fig. 4]

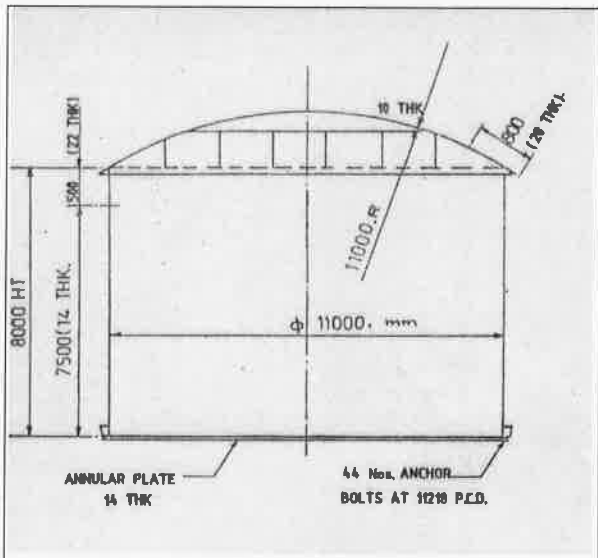

Fig. 3 – BPCL Tank Geometry

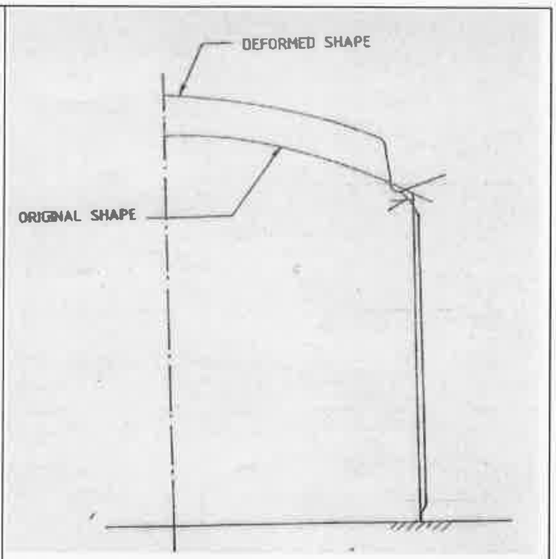

Fig. 4 - Deformed shape

The results showed significant deformation at the shell-roof junction and consequent localized yielding, which commenced at a pressure of 0.6 kg/sq.cm. However, this is permitted by the codes and the tank, as designed, was safe for the design pressure of 1.0 kg/sq.cm.

BPCL carried out a burst test on a similar tank. The tank and the roof were instrumented with strain gauges. The tank was gradually pressurized and the strain gauge readings were taken at regular intervals. The measured and the calculated strains compared very well. Strain Gauges showed non-linearity at 0.6 kg/sq.cm pressure indicating initiation of yielding.

The tank actually failed at a pressure of 3.2 kg/sq.cm, indicating a factor of safety of 3.2 over the design pressure.

Root Cause

- Failure was not due to any inadequacy in design
- Further investigation revealed that the tank was overfilled and consequentially over pressurized because of the faulty indication by tank level gauge.

Lessons Learnt and Corrective Action

- Follow code rules for pressure relief
- Avoid overpressurization during filling

Case Study 4: Damage to Internal Shells of Exchange Tower in Heavy Water Plant

Heavy Water Plant at Baroda is based on monothermal hydrogen ammonia exchange. The synthesis gas which contains about 115 PPM of Deuterium is passed through isotopic exchange tower 12T1, operating at 640 kg/sg.cm. pressure and -20 deg.C temperature In the presence of catalyst, potassium amide, deuterium from feed gas is transferred to liquid ammonia which is further enriched and processed for heavy water production. Exchange Tower-12T1 is a multiwall construction having outside dia 2660 mm and length 3122 mm and a thickness of 329 mm and weighing around 530 MT. Tower has 12 exchange stages

Incident

During the annual shut-down in April-May 1991, tower was opened for maintenance; after it was depressurised purged and made ready for opening as per the procedure laid down for the purpose. Accordingly, the cover of the tower was lifted, kept aside and cable stage removed. When tower stages were removed one by one, stages 6th, 7th and 8th were found to be damaged. The damage was in the form of a 75 mm deep dent in each of the three shells. [6] (Fig. 5)

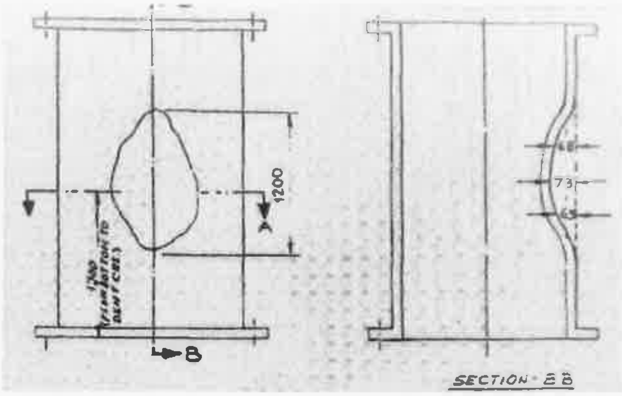

Fig. 5 - Dent on Stage No.6

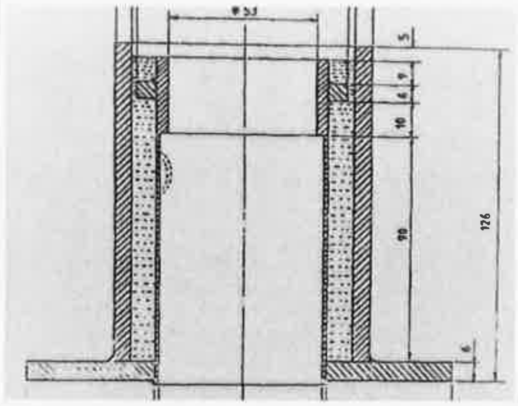

Fig. 6 - Model for Simulation of Denting

Investigation

Causes such as explosion in the annular space, high differential pressure, mechanical damage due to impact during handling, explosion etc. were investigated but were found to be untenable.

During investigation it was discovered that a lot of water was sprayed inside the tower to wash residual ammonia. A postulate that the dents occurred because of freezing of water in the annular space was investigated analytically as well as experimentally. Although it could be verified that the quantity of water sprayed was sufficient to fill the annular space and had in fact frozen (the temperature was below zero deg C); it was difficult to believe that a 30 mm thick shell could be damaged by this mechanism. To verify this, a scaled model of the tower-shell assembly (Fig. 6) was filled with water and put in a refrigerator. Next day, when the water in the annular space had frozen, the same dent appeared in the model. Thus it was conclusively demonstrated that this was indeed the cause.

A fitness-for-purpose evaluation was also performed using finite element method. It was found that for the intended service, the shells could be used without repair. The tower has since been put back into service and has been operating satisfactorily.

Lessons learnt

This is a textbook case. We have read about bursting of water-carrying pipes during winter. The lesson has been relearnt.

Case Study 5: Collapse of Dome of Kaiga Atomic Power Station during Construction

The containment building of a nuclear reactor houses the reactor, primary coolant and moderator systems, and other systems related to steam generation. Its function is to contain the radioactivity release in the event of a postulated Design Basis Accident so that the radiation level in the environment is within acceptable limits.

The reactor building of the Kaiga Atomic Power Project, Unit-1 (Kaiga-1) has full double containment with an annular gap of 2.0m between inner (primary) and outer (secondary) containment structures (Fig. 7).

The inner containment (IC) structure was designed as a prestressed concrete cylindrical shell (42.56m diameter and 610mm thick) capped with a pre-stressed concrete dome having 340mm thickness.

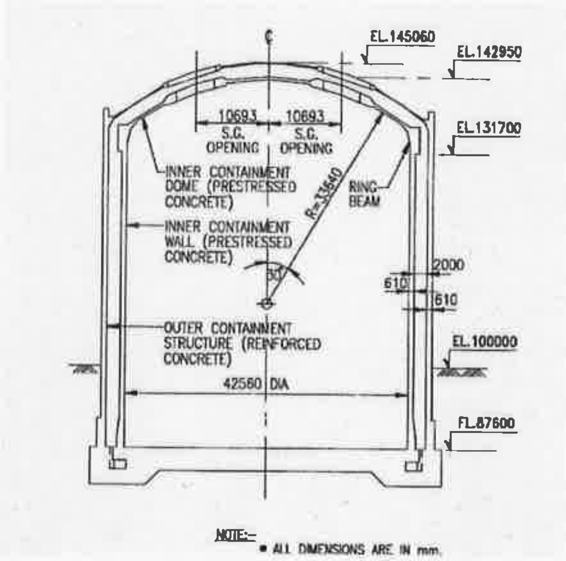

Fig. 7 – Cross Section of Containment Structure

Incident

On 13 May 1994, the inner containment dome of unit 1 of the Kaiga nuclear power plant collapsed during reactor construction. The dome itself had been completed but cabling and other tasks were being carried out. The failure was in the form of delamination. The under surface of the dome in the central portion delaminated and fell down completely. However, the upper portion had sufficient strength to hold itself in position under the action of its self-weight and whatever super-imposed load it had on it [7, 8].

Investigation

The nature of the delamination indicated that it occurred due to the action of radial tensile stress. For the normal operating condition involving dead weight and prestress, there is no external load which will cause net radial tensile stress; which is also the reason for not providing any radial reinforcement.

However, presence of local radial tensile stresses could not be ruled out; one of the sources being the stress concentration effect near an opening, Fig. 8.

Since these radial tensile stresses are localized in nature, there was hesitation in concluding that delamination was caused by them. In order to demonstrate that the radial stresses due to the stress concentration can indeed lead to delamination; an experiment was conducted using a Perspex sheet with two holes drilled into it (Fig. 9). The sheet can be visualized as a slice of the containment dome with the two holes simulating the sheath holes. The compressive load generated by the cables running transverse to the holes was simulated by clamping the sheet in a vice. On application of compressive load the ligaments between the holes and between the holes and the edges cracked, demonstrating the ability of the radial stress to cause cracking. The sheet however, remained as a single piece showing the secondary nature of the radial stress which disappeared on cracking.

Notwithstanding the difference between the two materials viz. concrete and Perspex, the experiment did show the possibility of delamination, in principle. The process of delamination is aided by short spacing between the two openings, which was the case at the location of delamination.

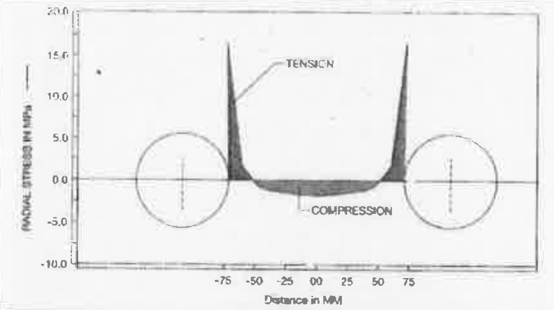

Fig. 8 – Radial Stress Distribution Near Penetrations

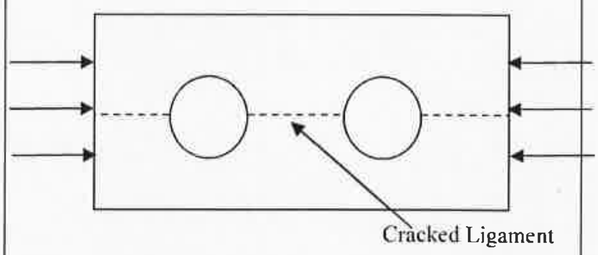

Fig. 9 – Simple Experiment to Demonstrate Delamination Phenomenon

The fact that the sheet remained as a single piece showed that delamination alone may not lead to falling of the delaminated portion. That requires application of external load which will cause radial stress. In case of Kaiga dome, the hooks embedded in the dome were being used to lower the shuttering members. This created the radial stress which tended to separate the delaminated layers.

Root Cause

A detailed stress analysis which included the local changes in thickness and the openings for prestressing cables indicated occurrence of local radial tensile stresses because of some additional phenomena:

1. The in-plane compressive membrane stresses also generate radial stress near the hollow sheath in the thickness of shell due to stress concentration effect, as brought out earlier
2. The curved prestressing cables exert pressure towards centre leading to development of radial stress
3. The radial stress is also generated where the shell thickness changes within a short distance

   These radial stresses coupled with congestion caused by large quantity of reinforcement and closely spaced prestressing cables were identified as root causes of the failure.

Follow up

As a result of the investigation, a number of recommendations had been made for re-engineering of the delaminated dome [7]. Some of the major recommendations were:

(1) The intact portion of the dome to be demolished; extent depending on detailed examination

(2) Measures to be taken in design:

- a) increase of general thickness of dome from 340 to 470 mm;
- b) to minimize the induced radial tension in the transition zones, the dome thickness to be increased gradually to the higher value of the thickened portion around the SG openings;
- c) introduce radial reinforcement;
- d) increase in minimum cable spacing from 108 to 225 mm to avoid congestion

After incorporating the above, the dome was reconstructed and the inner containment structure was accepted after successful pre-commissioning proof test for structural integrity and leakage rate tests.

Epilogue

At this point, I revisit "Mind of an Engineer" [1] and refer to Dr. P. Ghosh who has aptly said "Engineers have a mind of a polymath: someone who knows something about everything and everything about something". The failure analyses described herein required exactly that kind of mind with *some* knowledge about many things and *expertise* in the core domain of structural analysis.

I hope I have been able to provide a glimpse into the mind of an engineer. The journey, though prompted by some unfortunate incidents, has been fruitful in the sense of providing answers. To borrow from Dr. Ghosh [1] again, "Mistakes strengthen engineers' self-confidence". It is hoped that the Root Cause Analyses and follow up recommendations did achieve that purpose.

There are many quotations on failure, especially ones pointing out how it is the path to success. But that hinges on Root Cause Analysis and the follow up. That is why I have named this article "There is Knowledge in Failure – If Followed by Root Cause Analysis"

In a Root Cause Analysis one can ponder over the question "How far should one go in finding the Root Cause"?

In engineering terms, it would suffice to identify "use of improper material" as root cause. But one can go deeper and identify "Lack of Quality Control in Design" or "Inadequate Knowledge" or "Improper Education/training" as the root cause.

That reminds me of a lecture on Failure Investigation which I attended. The excellent lecture was followed by a Question & Answer session. When I asked this question about where to stop in Root Cause Analysis, the lecturer admitted that the chain may indeed become too long to be meaningful. He cited the example of Challenger Disaster where the chain led to White House because of the instructions to fly the shuttle by certain date!

Acknowledgment

In all of these failure investigations the investigating team was necessarily a multi-disciplinary one and consisted of: K.K. Vaze, V. Bhasin, K.M. Prabhakaran, D. Munshi, L.M. Gantayet, H.S. Kushwaha, A.R. Biswas, B.K. Shah, P.R. Vaidya, P.G. Kulkarni, S.C. Mahajan and Dr. A. Kakodkar

As a postscript, I would also like to acknowledge the role played by the BARC work culture in my career. The complete absence of adherence to hierarchy was exemplified by the panel on the door of our boss Dr. Kakodkar, which proclaimed "Disturb". One could walk in with your problems and be sure to get a patient hearing or walk in with suggestions and be sure to get an enthusiastic audience. The willingness of others to share the knowledge/expertise was also contagious and if I were to summarize my innings in one sentence, it would be a quotation: "Choose a job you love, and you will never have to work a day in your life." I loved everything I did during those 40 years, it was done in the most congenial atmosphere and I did not have to *work* for even a day.

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2. "Surely You're Joking, Mr. Feynman!" Adventures of a Curious Character by Richard P. Feynman As told to Ralph Leighton
3. "What Do You Care What Other People Think? *Further Adventures of a Curious Character";* Richard P. Feynman *as told to Ralph Leighton*
4. ASME Boiler and Pressure Vessel Code, Section III "Rules for Construction of Nuclear Facility Components"; The American Society of Mechanical Engineers, New York
5. ASME Boiler and Pressure Vessel Code, Section III, Appendix XII, "Design Considerations for Bolted Flange Connections", The American Society of Mechanical Engineers, New York
6. "Deformation of Stages of Exchange Tower- 12T1 - A Case Study; B.S. Gulati; National Symposium on Commissioning and Operating Experience in Heavy Water Plants; 1992
7. "Safety Evaluation of Rehabilitation of Delaminated Containment Dome"; Prabir C. Basu, Vijay N. Gupchup; Nuclear Engineering and Design 228 (2004) 195–205
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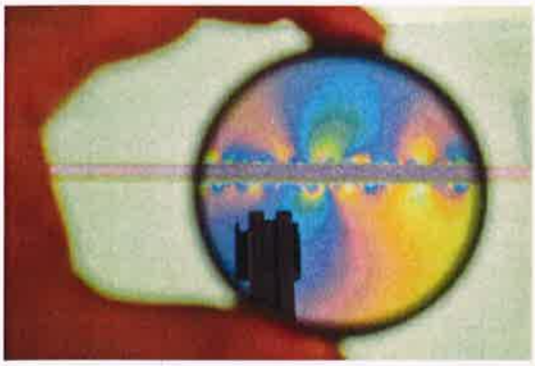
INAE e-Newsletter Engineering and Technology Updates, Vol. VIII, Issue 10, October 1, 2017

Civil Engineering

1.Machine-Learning Earthquake Prediction in Lab Shows Promise



Researchers at Los Alamos National Laboratory have developed a two-dimensional tabletop simulator that models the buildup and release of stress along an artificial fault. In this image, the simulator is viewed through a polarized camera lens, photo-elastic plates reveal discrete points of stress buildup along both sides of the modeled fault as the far (upper) plate is moved laterally along the fault.

By listening to the acoustic signal emitted by a laboratory-created earthquake, a computer science approach using machine learning can predict the time remaining before the fault fails."At any given instant, the noise coming from the lab fault zone provides quantitative information on when the fault will slip," said Paul Johnson, a Los Alamos National Laboratory fellow and lead investigator on the research."The novelty of our work is the use of machine learning to discover and understand new physics of failure, through examination of the recorded auditory signal from the experimental setup. I think the future of earthquake physics will rely heavily on machine learning to process massive amounts of raw seismic data. Our work represents an important step in this direction," he said. Not only does the work have potential significance to earthquake forecasting, Johnson said, but the approach is far-reaching, applicable to potentially all failure scenarios including non-destructive testing of industrial materials brittle failure of all kinds, avalanches and other events. Machine learning is an artificial intelligence approach to allowing the computer to learn from new data, updating its own results to reflect the implications of new information. The machine learning technique used in this project also identifies new signals, previously thought to be low-amplitude noise, that provide forecasting information throughout the earthquake cycle. "These signals resemble Earth tremor that occurs in association with slow earthquakes on tectonic faults in the lower crust," Johnson said. "There is reason to expect such signals from Earth faults in the seismogenic zone for slowly slipping faults."Machine learning algorithms can predict failure times of laboratory quakes with remarkable accuracy. The acoustic emission (AE) signal, which characterizes the instantaneous physical state of the system, reliably predicts failure far into the future. This is a surprise, Johnson pointed out, as all prior work had assumed that only the catalogue of large events is relevant, and that small fluctuations in the AE signal could be neglected. To study the phenomena, the team analyzed data from a laboratory fault system that contains fault gouge, the ground-up material created by the stone blocks sliding past one another. An accelerometer recorded the acoustic emission emanating from the shearing layers. Following a frictional failure in the labquake, the shearing block moves or displaces, while the gouge material simultaneously dilates and strengthens, as shown by measurably increasing shear stress and friction. "As the material approaches failure, it begins to show the characteristics of a critical stress regime, including many small shear failures that emit impulsive acoustic emissions," Johnson described."This unstable state concludes with an actual labquake, in which the shearing block rapidly displaces, the friction and shear stress decrease precipitously, and the gouge layers simultaneously compact," he said. Under a broad range of conditions, the apparatus slide-slips fairly regularly for hundreds of stress cycles during a single experiment. And importantly, the signal (due to the gouge grinding and creaking that ultimately leads to the impulsive precursors) allows prediction in the laboratory, and we hope will lead to advances in prediction in Earth, Johnson said.

Source https://www.sciencedaily.com/releases/2017/08/170830122545.htm

Computer Engineering and Information Technology

2. Caching System Could Make Data Centers More Energy Efficient

Researchers from CSAIL have devised a new system for data center caching that uses flash memory. In addition to costing less and consuming less power, a flash caching system could dramatically reduce the number of cache servers required by a data center.

Most modern websites store data in databases, and since database queries are relatively slow, most sites also maintain so-called cache servers, which list the results of common queries for faster access. A data centre for a major web service such as Google or Facebook might have as many as 1,000 servers dedicated just to caching. Cache servers generally use random-access memory (RAM), which is fast but expensive and power-hungry. Recently at the International Conference on Very Large Databases, researchers from MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) presented a new system for data centre caching that instead uses flash memory, the kind of memory used in most smartphones. Per gigabyte of memory, flash consumes about 5 percent as much energy as RAM and costs about one-tenth as much. It also has about 100 times the storage density, meaning that more data can be crammed into a smaller space. In addition to costing less and consuming less power, a flash caching system could dramatically reduce the number of cache servers required by a data Centre. The drawback to flash is that it's much slower than RAM. "That's where the disbelief comes in," says Arvind, the Charles and Jennifer Johnson Professor in Computer Science Engineering. "People say, 'Really? You can do this with flash memory?' Access time in flash is 10,000 times longer than in DRAM [dynamic RAM]."But slow as it is relative to DRAM, flash access is still much faster than human reactions to new sensory stimuli. Users won't notice the difference between a request that takes .0002 seconds to process -- a typical round-trip travel time over the internet -- and one that takes .0004 seconds because it involves a flash query. The more important concern is keeping up with the requests flooding the data centre. The CSAIL researchers' system, dubbed BlueCache, does that by using the common computer science technique of "pipelining." Before a flash-based cache server returns the result of the first query to reach it, it can begin executing the next 10,000 queries. The first query might take 200 microseconds to process, but the responses to the succeeding ones will emerge at .02-microsecond intervals. Even using pipelining, however, the CSAIL researchers had to deploy some clever engineering tricks to make flash caching competitive with DRAM caching. In tests, they compared BlueCache to what might be called the default implementation of a flash-based cache server, which is simply a data-center database server configured for caching. (Although slow compared to DRAM, flash is much faster than magnetic hard drives, which it has all but replaced in data centers.) BlueCache was 4.2 times as fast as the default implementation. The researchers' first trick is to add a little DRAM to every BlueCache flash cache -- a few megabytes per million megabytes of flash. The DRAM stores a table which pairs a database query with the flash-memory address of the corresponding query result. That doesn't make cache lookups any faster, but it makes the detection of cache misses -- the identification of data not yet imported into the cache -- much more efficient. That little bit of DRAM doesn't compromise the system's energy savings. Indeed, because of all of its added efficiencies, BlueCache consumes only 4 percent as much power as the default implementation. Ordinarily, a cache system has only three operations: reading a value from the cache, writing a new value to the cache, and deleting a value from the cache. Rather than rely on software to execute these operations, as the default implementation does, Xu developed a special-purpose hardware circuit for each of them, increasing speed and lowering power consumption. Inside a BlueCache server, the flash memory is connected to the central processor by a wire known as a "bus," which, like any data connection, has a maximum capacity. BlueCache amasses enough queries to exhaust that capacity before sending them to memory, ensuring that the system is always using communication bandwidth as efficiently as possible.With all these optimizations, BlueCache is able to perform write operations as efficiently as a DRAM-based system. Provided that each of the query results it's retrieving is at least eight kilobytes, it's as efficient at read operations, as well. (Because flash memory returns at least eight kilobytes of data for any request, its efficiency falls off for really small query results.)BlueCache, like most data-centre caching systems, is a so-called key-value store, or KV store. In this case, the key is the database query and the value is the response.

Source https://www.sciencedaily.com/releases/2017/08/170831115210.htm

3. New Robot Rolls with the Rules of Pedestrian Conduct

Engineers at MIT have designed an autonomous robot with "socially aware navigation," that can keep pace with foot traffic while observing these general codes of pedestrian conduct.

Just as drivers observe the rules of the road, most pedestrians follow certain social codes when navigating a hallway or a crowded thoroughfare: Keep to the right, pass on the left, maintain a respectable berth, and be ready to weave or change course to avoid oncoming obstacles while keeping up a steady walking pace. Now engineers at MIT have designed an autonomous robot with "socially aware navigation," that can keep pace with foot traffic while observing these general codes of pedestrian conduct. In drive tests performed inside MIT's Stata Centre, the robot, which resembles a knee-high kiosk on wheels, successfully avoided collisions while keeping up with the average flow of pedestrians. "Socially aware navigation is a central capability for mobile robots operating in environments that require frequent interactions with pedestrians," says Yu Fan "Steven" Chen, who led the work. "For instance, small robots could operate on sidewalks for package and food delivery. Similarly, personal mobility devices could transport people in large, crowded spaces, such as shopping malls, airports, and hospitals." In order for a robot to make its way autonomously through a heavily trafficked environment, it must solve four main challenges: localization, perception, motion planning, and control. The researchers used standard approaches to solve the problems of localization and perception. For the latter, they outfitted the robot with off-the-shelf sensors, such as webcams, a depth sensor, and a high-resolution lidar sensor. For the problem of localization, they used open-source algorithms to map the robot's environment and determine its position. To control the robot, they employed standard methods used to drive autonomous ground vehicles. The tricky problem is particularly in pedestrian-heavy environments, where individual paths are often difficult to predict. As a solution, roboticists sometimes take a trajectory-based approach, in which they program a robot to compute an optimal path that accounts for everyone's desired trajectories. These trajectories must be inferred from sensor data, because people don't explicitly tell the robot where they are trying to go. But this takes forever to compute. Others have used faster, "reactive-based" approaches, in which a robot is programmed with a simple model, using geometry or physics, to quickly compute a path that avoids collisions. The problem with reactive-based approaches, a researcher says, is the unpredictability of human nature -- people rarely stick to a straight, geometric path, but rather weave and wander, veering off. In such an unpredictable environment, such robots tend to collide with people or look like they are being pushed around by avoiding people excessively. The team found a way around such limitations, enabling the robot to adapt to unpredictable pedestrian behaviour while continuously moving with the flow and following typical social codes of pedestrian conduct. They used reinforcement learning, a type of machine learning approach, in which they performed computer simulations to train a robot to take certain paths, given the speed and trajectory of other objects in the environment. The team also incorporated social norms into this offline training phase, in which they encouraged the robot in simulations to pass on the right, and penalized the robot when it passed on the left. The advantage to reinforcement learning is that the researchers can perform these training scenarios, which take extensive time and computing power, offline. Once the robot is trained in simulation, the researchers can program it to carry out the optimal paths, identified in the simulations, when the robot recognizes a similar scenario in the real world. The researchers enabled the robot to assess its environment and adjust its path, every one-tenth of a second. In this way, the robot can continue rolling through a hallway at a typical walking speed of 1.2 meters per second, without pausing to reprogram its route. The researchers test-drove the robot in the busy, winding halls of MIT's Stata Building, where the robot was able to drive autonomously for 20 minutes at a time. It rolled smoothly with the pedestrian flow, generally keeping to the right of hallways, occasionally passing people on the left, and avoiding any collisions. The research team says going forward; they plan to explore how robots might handle crowds in a pedestrian environment.

Source https://www.sciencedaily.com/releases/2017/08/170830103446.htm

4. Reusable Ruthenium-Based Catalyst could be a Game-Changer for the Biomass Industry

The weak electron-donating capability of ruthenium (Ru) nanoparticles supported on niobium pentoxide (Nb_2O_5) is thought to promote reductive amination while preventing the formation of undesirable by-products.

Known for their outstanding versatility, primary amines are industrially important compounds used in the preparation of a wide range of dyes, detergents and medicines. Although many attempts have been made to improve their synthesis using catalysts containing nickel, palladium and platinum, for example, few have succeeded in reducing the formation of secondary and tertiary amines and other undesired by-products. Now, researchers at Tokyo Institute of Technology have developed a highly selective catalyst consisting of ruthenium nanoparticles supported on niobium pentoxide (Ru/Nb_2O_5). In a study the team demonstrated that Ru/Nb_2O_5 is capable of producing primary amines from carbonyl compounds with ammonia (NH_3) and dihydrogen (H_2), with negligible formation of by-products. The study compared the extent to which different catalysts could convert furfural to furfurylamine in a process known as reductive amination1. This reaction is one of the most useful methods for producing primary amines on an industrial scale. The Ru/Nb_2O_5catalyst outperformed all other types tested -- remarkably, a yield of 99% was attained when ammonia was used in excess quantity. Even after three recycles, the Ru/Nb_2O_5 catalyst achieved consistent results, with consecutive yields of over 90%. The superior catalytic efficiency is thought to be due to ruthenium's weak electron-donating properties on the Nb_2O_5 surface. Michikazu Hara of Tokyo Tech's Laboratory for Materials and Structures and his co-workers then explored how effectively the new catalyst could break down biomass (in the form of glucose) into 2,5-bis(aminomethyl)furan, a monomer for aramid production. Previous experiments using a nickel-based catalyst led to a yield of around 50% from glucose-derived feedstock (5-hydroxymethylfurfural). The new catalyst used in combination with a so-called ruthenium-xantphos complex produced a yield of 93%. With little to no by-products observed, Ru/Nb_2O_5 represents a major breakthrough in the clean, large-scale production of biomass-derived materials. Further studies to expand on these initial findings are already underway. By pushing the boundaries of material design, the researchers say that Ru/Nb_2O_5 may accelerate the production of environmentally friendly plastics, rubber and heat-resistant aramid fibers2. In future, the Ru/Nb_2O_5 catalyst may also impact the development of novel anti-cancer drugs, anti-bacterials, pesticides, agrochemicals, fertilizers, bio-oils and biofuels.

Source https://www.sciencedaily.com/releases/2017/09/170901104658.htm

5. Highly Flexible, Wearable Displays

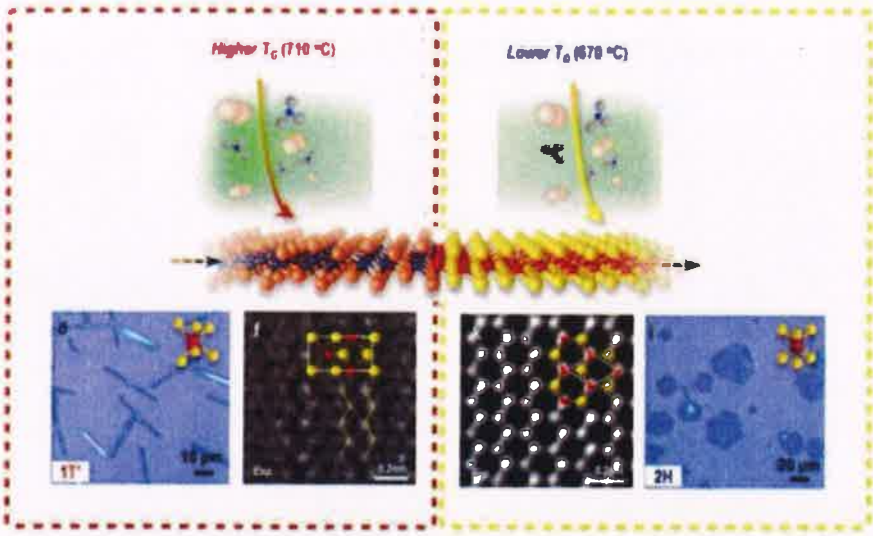
OLEDs operating in fabrics.

How do you feel when technology you saw in a movie is made into reality? Collaboration between the electrical engineering and textile industries has made TVs or smartphone screens displaying on clothing a reality. A research team led by Professor Kyung Cheol Choi at the School of Electrical Engineering presented wearable displays for various applications including fashion, IT, and healthcare. Integrating OLED (organic light-emitting diode) into fabrics, the team developed some of the most highly flexible and reliable technology for wearable displays in the world. Recently, information displays have become increasingly important as they construct the external part of smart devices for the next generation. As world trends are focusing on the Internet of Things (IoTs) and wearable technology, the team drew a lot of attention by making great progress towards commercializing clothing-shaped 'wearable displays'. The research for realizing displays on clothing gained considerable attention from academia as well as industry when research on luminescence formed in fabrics was introduced in 2011; however, there was no technology for commercializing it due to its surface roughness and flexibility. Because of this technical limitation, clothing-shaped wearable displays were thought to be unreachable technology. However, the KAIST team recently succeeded in developing the world's most highly efficient, light-emitting clothes that can be commercialized.
The research team used two different approaches, fabric-type and fibre-type, in order to realize clothing-shaped wearable displays. In 2015, the team successfully laminated a thin planarization sheet thermally onto fabric to form a surface that is compatible with the OLEDs approximately 200 hundred nanometers thick. Also, the team reported their research outcomes on enhancing the reliability of operating fibre-based OLEDs. In 2016, the team introduced a dip-coating method, capable of uniformly depositing layers, to develop polymer light-emitting diodes, which show high luminance even on thin fabric. Based on the previous research performance, the research team succeeded in realizing fabric-based OLEDs, showing high luminance and efficiency while maintaining the flexibility of the fabric. The long-term reliability of this wearable device that has the world's best electrical and optical characteristics was verified through their self-developed, organic and inorganic encapsulation technology. According to the team, their wearable device facilitates the operation of OLEDs even at a bending radius of 2mm. According to the researchers, "Having wavy structures and empty spaces, fibre plays a significant role in lowering the mechanical stress on the OLEDs." "Screen displayed on our daily clothing is no longer a future technology," said the lead researcher. "Light-emitting clothes will have considerable influence on not only the e-textile industry but also the automobile and healthcare industries." Moreover, the research team remarked, "It means a lot to realize clothing-shaped OLEDs that have the world's best luminance and efficiency. It is the most flexible fabric-based light-emitting device among those reported. Moreover, noting that this research carried out an in-depth analysis of the mechanical characteristics of the clothing-spared, light-emitting device, the research performance will become a guideline for developing the fabric-based electronics industry."

Source https://www.sciencedaily.com/releases/2017/08/170824094022.htm

Electronics and Communication Engineering

6. 2-D Electronics' metal or semiconductor? Both



Metallic (right) and semiconducting (left) $MoTe_2$ crystals are obtained side by side on the same plane. Rectangular crystals represent metal $MoTe_2$, while hexagonal crystals are the characteristic feature of semiconducting $MoTe_2$.

Researchers produced the first 2D field-effect transistor (FET) made of a single material. Modern life will be almost unthinkable without transistors. They are the ubiquitous building blocks of all electronic devices: each computer chip contains billions of them. However, as the chips become smaller and smaller, the current 3D field-electronic transistors (FETs) are reaching their efficiency limit. A research team at the Centre for Artificial Low Dimensional Electronic Systems, within the Institute for Basic Science (IBS), has developed the first 2D electronic circuit (FET) made of a single material. This study shows a new method to make metal and semiconductor from the same material in order to manufacture 2D FETs. In simple terms, FETs can be thought as high-speed switches, composed of two metal electrodes and a semiconducting channel in between. Electrons (or holes) move from the source electrode to the drain electrode, flowing through the channel. While 3D FETs have been scaled down to nanoscale dimensions successfully, their physical limitations are starting to emerge. Short semiconductor channel lengths lead to a decrease in performance: some electrons (or holes) are able to flow between the electrodes even when they should not, causing heat and efficiency reduction. To overcome this performance degradation, transistor channels have to be made with nanometer-scale thin materials. However, even thin 3D materials are not good enough, as unpaired electrons, part of the so-called "dangling bonds" at the surface interfere with the flowing electrons, leading to scattering. Passing from thin 3D FETs to 2D FETs can overcome these problems and bring in new attractive properties. "FETs made from 2D semiconductors are free from short-channel effects because all electrons are confined in naturally atomically thin channels, free of dangling bonds at the surface," explains Ji Ho Sung, first author of the study. Moreover, single- and few-layer form of layered 2D materials have a wide range of electrical and tunable optical properties, atomic-scale thickness, mechanical flexibility and large bandgaps (1~2 eV). The major issue for 2D FET transistors is the existence of a large contact resistance at the interface between the 2D semiconductor and any bulk metal. To address this, the team devised a new technique to produce 2D transistors with semiconductor and metal made of the same chemical compound, molybdenum telluride ($MoTe_2$). It is a polymorphic material, meaning that it can be used both as metal and as semiconductor. Contact resistance at the interface between the semiconductor and metallic $MoTe_2$ is shown to be very low. Barrier height was lowered by a factor of 7, from 150meV to 22meV.IBS scientists used the chemical vapour deposition (CVD) technique to build high quality metallic or semiconducting $MoTe_2$ crystals. The polymorphism is controlled by the temperature inside a hot-walled quartz-tube furnace filled with NaCl vapour: 710°C to obtain metal and 670°C for a semiconductor. The scientists also manufactured larger scale structures using stripes of tungsten diselenide (WSe_2) alternated with tungsten ditelluride (WTe_2). They first created a thin layer of semiconducting WSe_2 with chemical vapour deposition, then scraped out some stripes and grew metallic WTe2 on its place. It is anticipated that in the future, it would be possible to realize an even smaller contact resistance, reaching the theoretical quantum limit, which is regarded as a major issue in the study of 2D materials, including graphene and other transition metal dichalcogenide materials.

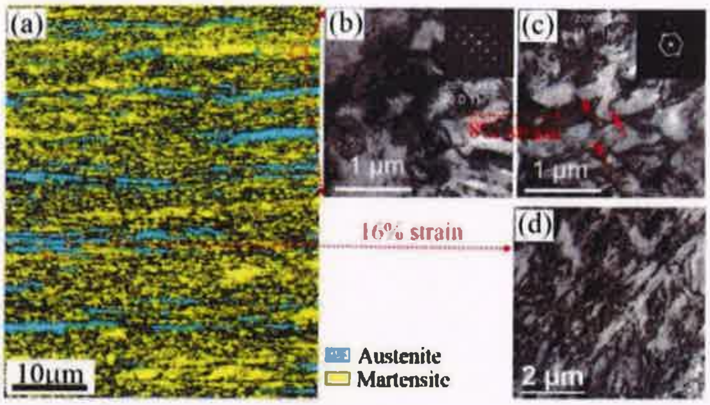
Source https://www.sciencedaily.com/releases/2017/09/170918161531.htm

7. Airline Industry Could Fly Thousands of Miles on Biofuel from a New Promising Feedstock

A Boeing 747 burns one gallon of jet fuel each second. A recent analysis from researchers at the University of Illinois estimate that this aircraft could fly for 10 hours on bio-jet fuel produced on 54 acres of specially engineered sugarcane. Plants Engineered to Replace Oil in Sugarcane and Sweet Sorghum (PETROSS), funded by the Advanced Research Projects Agency -- Energy (ARPA-E), has developed sugarcane that produces oil, called lipidcane, that can be converted into biodiesel or jet fuel in place of sugar that is currently used for ethanol production. With 20% oil -- the theoretical limit -- all of the sugar in the plant would be replaced by oil. "Oil-to-Jet is one of the direct and efficient routes to convert bio-based feedstocks to jet fuel," said Vijay Singh, Director of the Integrated Bioprocessing Research Laboratory. "Reducing the feedstock cost is critical to improving process economics of producing bio-jet fuel. Lipidcane allows us to reduce feedstock cost." This research analyzed the economic viability of crops with different levels of oil. Lipidcane with 5% oil produces four times more jet fuel (1,577 liters, or 416 gallons) per hectare than soybeans. Sugarcane with 20% oil produces more than 15 times more jet fuel (6,307 liters, or 1,666 gallons) per hectare than soybeans. "PETROSS sugarcane is also being engineered to be more cold tolerant, potentially enabling it to be grown on an estimated 23 million acres of marginal land in the Southeastern U.S.," said PETROSS Director Stephen Long, Gutgsell Endowed Professor of Plant Biology and Crop Sciences at the Carl R. Woese Institute for Genomic Biology at the University of Illinois. "If all of this acreage was used to produce renewable jet fuel from lipid-cane, it could replace about 65% of U.S. jet fuel consumption." "We estimate that this biofuel would cost the airline industry $5.31/gallon, which is less than most of the reported prices of renewable jet fuel produced from other oil crops or algae," said Deepak Kumar, a postdoctoral researcher at Illinois, who led the analysis. This crop also produces profitable co-products: A hydrocarbon fuel is produced along with bio-jet fuel or biodiesel that can be used to produce various bioproducts. The remaining sugar (for plants with less than 20% oil) could be sold or used to produce ethanol. In addition, biorefineries could use lipidcane bagasse to produce steam and electricity to become self-sustainable for their energy needs and provide surplus electricity, providing environmental benefits by displacing electricity produced with fossil fuels. PETROSS (Plants Engineered to Replace Oil in Sugarcane and Sorghum) is a research project transforming sugarcane and sweet sorghum to naturally produce large amounts of oil, a sustainable source of biofuel. PETROSS is supported by the Advanced Research Projects Agency-Energy (ARPA-E), which funds initial research for high-impact energy technologies to show proof of concept before private-sector investment.

Source https://www.sciencedaily.com/releases/2017/09/170911125953.htm

8. New Steel Beats the Strength-Ductility Trade-Off



(a) Electron backscatter diffraction (EBSD) phase image showing the lamella microstructure of layered austenite grains embedded in tempered martensite matrix. (b) The dislocation structures in martensite as enlarged in transmission electron microscopy (TEM) image. (c) TEM image showing the elongation of dislocation cell structure after the 8% tensile strain. (d) TEM image confirming the transformation of metastable austenite to martensite after 16% tensile strain.

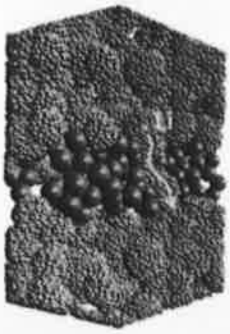
Automotive, aerospace and defence applications require metallic materials with ultra-high strength. However, in some particular high-loading structural applications, metallic materials shall also have large ductility and high toughness to facilitate the precise forming of structural components and to avoid the catastrophic failure of components during service. Unfortunately, increasing strength often leads to the decrease in ductility, which is known as the strength-ductility trade-off. For example, ceramics and amorphous materials have negligible ductility, although they have great hardness and ultra-high strength. To simultaneously increase both strength and ductility of metallic materials using conventional industrial processing routes is both of great scientific and technological importance and is yet quite challenging in both the materials science community and industry sectors. A Hong Kong-Beijing-Taiwan mechanical engineering team led by Dr Huang Mingxin from the University of Hong Kong (HKU) has recently developed a Super Steel (also called D&P Steel as it adopted a new deformed and partitioned (D&P) strategy) which addressed the strength-ductility trade-off. Its material cost is just one-fifth of that of the steel used in the current aerospace and defence applications. Steel has been the most widely used metal in the history of humankind and can be produced with much higher efficiency than any other metallic materials. A strong and ductile steel has been sought since the beginning of Iron Age. It is very difficult to further improve the ductility of metallic materials when their yield strength is beyond 2 Gigapascal (GPa). A breakthrough steel -- the Super Steel -- which has been developed by an HKU-led HK-Beijing-Taiwan team, achieves a high ductility, above the yield strength of 2 GPa. In addition to the substantial improvement of tensile properties, this breakthrough steel has achieved the unprecedented yield strength of 2.2 GPa and uniform elongation of 16%. Additionally, this breakthrough steel has two advantages:

1. **Low raw-materials cost:** The raw materials cost of the D&P steel is only 20% of the maraging steel used in aerospace and defence applications. The chemical composition of this breakthrough steel belongs to the system of medium manganese (Mn) steel, containing 10% manganese, 0.47% carbon, 2% aluminium, 0.7% vanadium (mass percent), and the balance is iron. No expensive alloying elements have been used exhaustively but just some common alloying compositions that can be widely seen in the commercialized steels.
2. **Simple industrial processing:** The second advantage is that this breakthrough steel can be developed using conventional industrial processing routes, including warm rolling, cold rolling and annealing. This is different from the development of other metallic materials where the fabrication processes involve complex routes and special equipment, which are difficult to scale-up. Therefore, it is expected that the present breakthrough steel has a great potential for industrial mass production.

Compared with the widely used automotive steels as well as the steel used in aerospace and defence (maraging steel), the D&P steel demonstrated a much higher yield strength but maintaining a much better ductility (uniform elongation). The D&P steel also outperformed the nanotwinned (NT) steel which was also developed by the same HKU research team. Additionally, the developed D&P steel demonstrated the best combination of yield strength and uniform elongation among all existing high-strength metallic materials. In particular, the uniform elongation of the developed D&P steel is much higher than that of metallic materials with yield strength beyond 2.0 GPa. In this research, the group firstly proposed a new deformation mechanism that the high dislocation density can improve both strength and ductility simultaneously. It is worth mentioning that a general belief in textbooks is that increasing dislocation density will elevate the strength but undesirably deteriorate the ductility.

Source https://www.sciencedaily.com/releases/2017/08/170825124908.htm

9. Supercharging Silicon Batteries



The porosity of the nanostructured Tantalum (in black) enables the formation of silicon channels (in blue) allowing lithium ions to travel faster within the battery. The rigidity of the tantalum scaffold also limits the expansion of the silicon and preserve structural integrity.

As the world shifts towards renewable energy, moving on from fossil fuels, but at the same time relying on ever more energy-consuming devices, there is a fast-growing need for larger high-performance batteries. Lithium-ion batteries (LIBs) power most of our portable electronics, but they are flammable and can even explode, as it happened to a recent model of smartphone. To prevent such accidents, the current solution is to encapsulate the anode -- which is the negative (-) electrode of the battery, opposite to the cathode (+) -- into a graphite frame, thus insulating the lithium ions. However, such casing is limited to a small scale to avoid physical collapse, therefore restraining the capacity -- the amount of energy you can store -- of the battery. Looking for better materials, silicon offers great advantages over carbon graphite for lithium batteries in terms of capacity. Six atoms of carbon are required to bind a single atom of lithium, but an atom of silicon can bind four atoms of lithium at the same time, multiplying the battery capacity by more than 10-fold. However, being able to capture that many lithium ions means that the volume of the anode swells by 300% to 400%; leading to fracturing and loss of structural integrity. To overcome this issue, OIST researchers have now developed a design of an anode built on nanostructured layers of silicon -- not unlike a multi-layered cake -- to preserve the advantages of silicon while preventing physical collapse. This new battery is also aiming to improve power, which is the ability to charge and deliver energy over time. "The goal in battery technology right now is to increase charging speed and power output," explained Dr. Marta Haro Remon, first author of the study. "While it is fine to charge your phone or your laptop over a long period of time, you would not wait by your electric car for three hours at the charging station." And when it comes to providing energy, you would want your car to start off quickly at a traffic light or a stop sign, requiring a high spike in power, rather than slowly creeping forward. A well-thought design of a silicone-based anode might be a solution and answer these expectations. The idea behind the new anode in the Nanoparticles by Design Unit at the Okinawa Institute of Science and Technology Graduate University is the ability to precisely control the synthesis and the corresponding physical structure of the nanoparticles. Layers of unstructured silicon films are deposited alternatively with tantalum metal nanoparticle scaffolds, resulting in the silicon being sandwiched in a tantalum frame. "We used a technique called Cluster Beam Deposition," continued Dr. Haro. "The required materials are directly deposited on the surface with great control. This is a purely physical method, there are no need for chemicals, catalysts or other binders." The outcome of this research, led by Prof. Sowwan at OIST, is an anode with higher power but restrained swelling, and excellent cyclability -- the amount of cycles in which a battery can be charged and discharged before losing efficiency. By looking closer into the nanostructured layers of silicon, the scientists realized the silicon shows important porosity with a grain-like structure in which lithium ions could travel at higher speeds compared to unstructured, amorphous silicon, explaining the increase in power. At the same time, the presence of silicon channels along the Ta nanoparticle scaffolds allows the lithium ions to diffuse in the entire structure. On the other hand, the tantalum metal casing, while restraining swelling and improving structural integrity, also limited the overall capacity -- for now. However, this design is currently only at the stage of proof-of-concept, opening the door to numerous opportunities to improve capacity along with the increased power. "It is a very open synthesis approach, there are many parameters you can play around," commented Dr. Haro. "For example, we want to optimize the numbers of layers, their thickness, and replace tantalum metal with other materials." With this technique paving the way, it might very well be that the solution for future batteries, forecast to be omnipresent in our lives, will be found in nanoparticles.

Source https://www.sciencedaily.com/releases/2017/09/170906103638.htm

10. Icebergs: Mathematical Model Calculates the Collapse of Shelf Ice

*Julia Christmann in front of the icebreakter "Polarstern" in the*Antarctica.

Shelf ice, as found in Antarctica, refers to giant floating ice sheets that can span thousands of square kilometres. Pieces break off at their edges which form icebergs in the ocean. In order to more effectively predict these break-offs, in a process known as calving, Julia Christmann from the University of Kaiserslautern (TU) has developed mathematical models in cooperation with the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI). On the basis of physical factors, it is claimed that these models can be used to predict when and where the ice may collapse. This is important particularly for research teams situated on the ice shelf. The ice rises up like a sheer cliff face -- shelf ice is not only several thousand square kilometres large, it is also more than a hundred metres high in many places. From time to time, pieces break off the edge and crash into the sea below, where they float away in the ocean as icebergs. This was also recently the case with the Larsen C ice shelf. Science is unable to accurately predict when and where the ice shelf will break. "Assumptions were always previously based on observations by glaciologists and other researchers. Concrete calculations with physical parameters did not exist," says Julia Christmann, who is researching technical mechanics at the University of Kaiserslautern with Professor Dr Ralf Müller. As a rule of thumb, she explains, the ice tends to break where it is thinner than 200 metres; in reality, however, there are also many ice shelves that are even thinner. The calving of ice sheets is a continuous process that is influenced by a number of different factors. Satellite data was also used in order to observe this natural spectacle. "However, they only offer snapshots of the process," Christmann adds. As part of her doctorate research, she has developed mathematical models to calculate when and where the ice shelf may collapse. A range of different physical factors are germane here. "The thickness and density of ice can play an important role, for example," Christmann continues. "The material parameters are also critical, including elastic factors. These mainly influence where the iceberg is calved. There is also the viscosity, which affects the time between break-off events." The doctoral student at Kaiserslautern was also supported in her work by Professor Dr Angelika Humbert from the AWI. Humbert is an expert in the field of glaciology. She is also occupied with the properties and motion of giant ice sheets on the Antarctic continent, which constitute 70 percent of the entire supply of freshwater on the planet. "The ice shelf generally breaks at points that are between a half and full thickness of the ice sheet from the edge," summarises Christmann. This data may be particularly important for the scientific community, since numerous research stations are located on ice shelves in Antarctica. This includes the German Neumayer Station III or the British station, Halley VI, which was closed for winter this year due to a crack in the ice. Christmann recently is continuing her research on the properties of ice. She is now focusing on grounding lines in Greenland. This refers to the area in which the ice still touches the ground and merges into floating shelf ice. The researcher intends to find out how these lines change over the course of time.

Source https://www.sciencedaily.com/releases/2017/08/170824093632.htm

Engineering Innovation in India

IIT-Kanpur Students Design International Award Winning Unmanned Helicopter Prototype

A team of postgraduate students of Aerospace department of IIT-Kanpur have been successful in developing a prototype of an 'unmanned helicopter' named "Vibhram" which can fly continuously for 24 hours while carrying a payload of 80 kg. The novel design of this helicopter helped the students bag the third place in the graduate category of 34th Annual Student Design Competition organized by the American Helicopter Society (AHS). IIT-Kanpur students beat teams from University of Liverpool, a second team from Georgia Tech, Nanjing University of Aeronautics and Astronautics (China) and some other prestigious institutions of world fame. The team developed 'Vibhram' helicopter under the guidance of Assistant Professor Abhishek of Aerospace engineering department and Prof C. Venkatesan (Emeritus Fellow Professor in Aerospace Department. Dr Abhishek said, "The design of Vibhram is very innovative. It has novel dissimilar coaxial rotor concept which was conceived for this competition by a PhD student. This rotor concept has been predicted to be more efficient than any existing helicopter concept such as conventional (single main rotor and tail rotor) and regular coaxial helicopters by 15-30%. This revolutionary new design is expected to have a strong impact on the future of helicopter technology. He said that such a type of a helicopter design does not exist anywhere in the world and its prototype has been developed by the students in only six months starting in January this year. "We were required to submit a 100 page report, an executive summary of the project and a video of the operational helicopter which we had provided to AHS for taking part in the competition. The hardwork by the students bore fruits and they won the third prize", he added. He further mentioned that this is for the first time in 34 years that a team from Asia has finished on the podium of this competition in the graduate category. "The objective of this year's competition was to carry out conceptual system level design of an unmanned helicopter that can fly continuously for 24 hours while carrying a payload of 80 kg", he said. The professor said that he and his team of students are now working on scaling up the version of this helicopter.

Source http://timesofindia.indiatimes.com/home/science/iit-kanpur-students-design-unmanned-helicopter-prototype-bag-award-in-international-competition/articleshow/60148666.cms