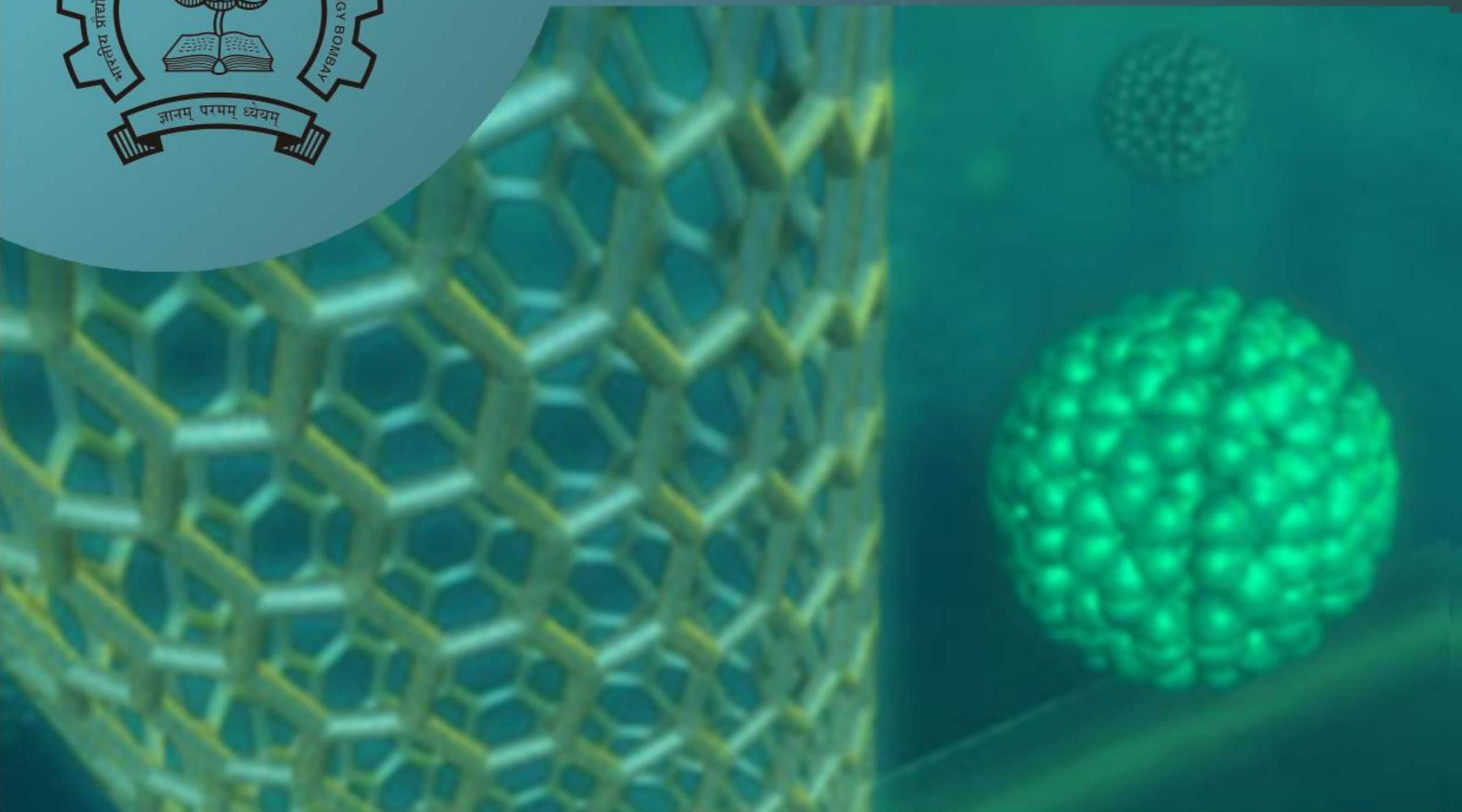
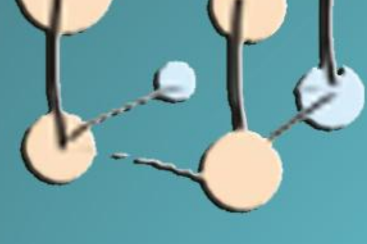
Metallurgical Engineering

& Materials Science



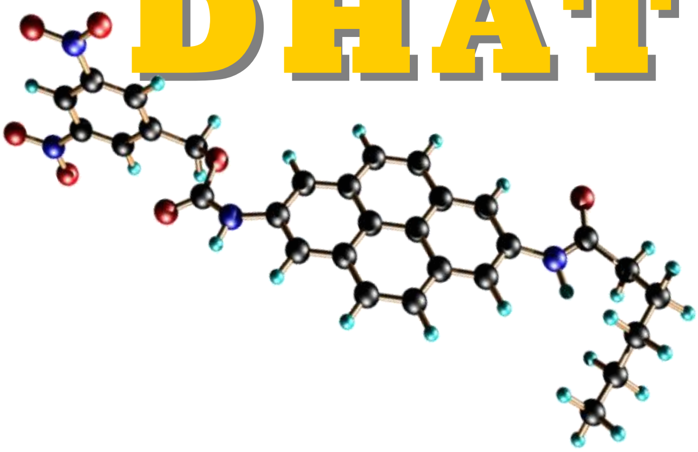
Dhatuki

Issue 4, Oct 2008



And much more inside...

DHATUKI



From The Director's desk

Dear Readers,

I am delighted and feel proud of the efforts taken by the Dhatuki Team of the Metallurgical Engineering & Materials Science (ME&MS) to deliver to you a very informative and interesting issue of Dhatuki as the first in the Golden Jubilee year of IIT Bombay. This is the fourth issue of Dhatuki and I have no doubt that this activity now will continue in the years to come. I may mention that this activity is now getting support from the department's alumni as well for the various expenses required. The impact of Materials Engineering and Science on the development of society has never been less and needs no additional mention. As the two imaginative articles in the issue clearly bring out, it would be the new materials with their exotic properties that we will see unimaginable applications coming true. The department has evolved very successfully over the last 50 years.

I congratulate the department and the editorial team and wish them success for all their future issues.

—Prof. Ashok Misra

Metallurgical Engineering and Materials Science

From HOD's Desk...

Dear readers,

A Very Happy New Year-2008 and Welcome to an exciting reading of the 4th issue of DHATUKI- first in the Golden Jubilee year of the Institute. In this issue we take you through the evolution of the Metallurgical Engineering and Materials Science Department from its inception in 1958. But before that we have a very lucid conversation with the Dual Degree President's gold medal winner from the department – Shreerang Chatre who has added one more feather in the cap of achievements of the department. The editorial team has packed loads of interesting articles, some on the research being carried out in the department, while some which will take you to unforeseen imagination but who knows- possible through technology! Student's worries about practical training are aired along with the importance of materials engineering for the Samurais. Finally the editors have managed to pull in Prita Pant - the first lady faculty to share her experiences of being with us.

Happy reading!

— Prof. Rajiv O. Dusane

INSIDE THIS ISSUE

From Editors' Desk...

Dear fellas,

We present you the fourth edition of your very own newsletter Dhatuki. This time we have gone thematic with Dhatuki, every issue from now onwards would be based on a materials related theme. As you would have noticed, this time it's the latest buzzword, nanotechnology. We have tried to look at it in various ways. However that is not all that is there to this edition; it has got loads of other cool stuff too. This issue is the result of a lot of work put in by under graduate students from all years as well as from the postgraduate students. Looks like our department spirit is getting better!

We would love to hear your comments/suggestions, and we would love it more if you become a part of the team. All right, we won't keep you away from the articles any more.

Meta rocks!

Cheers!

Eds

Rendezvous With A Gold Medalist

"Simple living simple thinking"- best describes Shreerang Chhatre. In his words "It would be an honor to receive one of the highest award the Institute has to offer. I am not sure how I would feel that day though. I think it's best left for the time when I receive the medal. It's too big a day to plan!" This was what he felt before receiving the honour. The honour which not every one dreams of but actually not many can dare to dream of. After doing his Masters at IIT Bombay, Shreerang is now pursuing his doctorate at Dept. of Chemical Engineering, MIT.

Following are the excerpts from a conversation with him:

When did you realize that you could be gold medalist and started working in direction of IR 1?

I never really realized that I was in line for the Gold Medal until early this year. My attempts until then, and even now, had been to perform to the best of my ability. Ironically, it is perhaps because I wasn't bothered by the medal that I could do so well.

What has being a gold medalist brought to you?

The gold medal has brought a lot of joy and satisfaction. It seems like a fitting end to five remarkable years in IIT Bombay.

How has this medal helped in changing your life and perspective towards future?

It has certainly added a lot of confidence. Although I have always believed in myself and my abilities, there is now an added confidence that I can work and excel amongst the creme-de-la-creme.

In your view how can an IITian impact the present society?

An IITian can impact the society most positively by being an epitome of discipline, hard work and integrity. Through his engineering competence, he is capable of bringing efficiency to the industry and adding to the economic growth of India. Through his intelligence and maturity of thought, he should actively tackle the social and political problems facing India - that's where he is likely to have the most significant impact.

Please say a few words about IIT.

IIT Bombay is one of the few places in India which offer a blend of excellent academic and research facilities, sporting and cultural activities, and a pleasant lifestyle close to nature even in the middle of a bustling metropolis. Individuals have the freedom to hone their qualities and improve their personality in every possible way. One of the unique features of IITB is the accessibility and forthcoming nature of the faculty members. They treat you as equals, respect your opinions, and, in some cases, become very good friends.

Your most memorable events/incidents in last 5 years.

One of my most memorable days during my stay in IIT was when my team won the PAN-IIT competition at the IIT Alumni meet in December 2006. The learning experience goes beyond description in black and white. I had to present a student's honest perspective about the IIT system. I had to review and evaluate my own doings over the last four and half years, and I was also required to look at the system from the point of view of a different student. I had to evaluate the pros and cons of the system and had to suggest remedial actions to improve the system significantly. All of my seniors, who had their own views about the system, wanted to listen to me and contest my views with their own. It was a moment when my self-confidence was put to the test, and I feel I rose to the occasion.

Being I.R. 1 means that you have taken all that this institute had, to offer to you. Is it so?

It is true that I took in all that the Institute had to offer in terms of academics and research. I had an amazing time interacting with several brilliant faculty members and students. But my academic priorities meant having to keep away from the other tempting sporting and cultural activities that the Institute has aplenty. But, at the end of the day, it seems like a worthwhile compromise.

How do your associates receive you now?

My associates have always received me well. Those who knew me for a long time haven't changed their opinion towards me. Those who got to know me only socially now seem to look upon me with greater respect and take my suggestions with an added weight that seems to have more to do with the medal than my real authority on any subject.

Who were your role models, your inspirations in the process?

My advisors in IIT Bombay were my role models, notably my dual degree project advisor. I also had a high regard for some of my senior students and classmates. They all inspired me in their very own way.

Any message for the fellow IITians.

Be disciplined and open-minded, work hard and be honest to yourself and your Institute. The rewards will follow on their own.

Being the first gold medalist of the department, Shreerang Chhatre has brought pride to the same by his meticulous and persevering efforts and we wish him success in whatever he desires and deserves.

- compiled by Akash Agrawal

"Practical" Training

Come November and most of the 3rd year students and sophomores start worrying about internships. One cannot deny that it helps one decide his/her career path and hence deserves all attention. So let's unravel the mysteries of the new Practical Training (PT) policies and also delve into the options available for the present sophomores.

What are the new PT policies

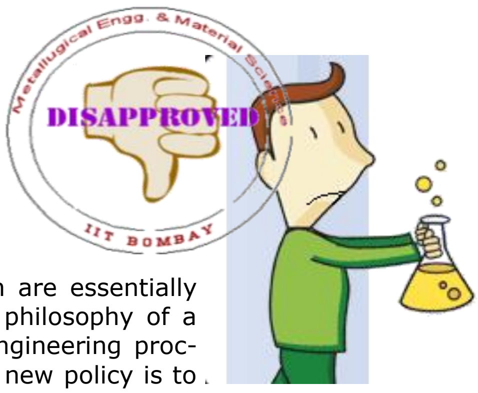
According to the new policies, made under the supervision of Prof. A. S. Khanna (PT Co-ordinator):

- Students can apply for an industrial internship only. It should be a minimum of 8 weeks duration.
- The students are restricted from applying for any kind of research PT, be it in India or abroad.
- This company should necessarily be from the manufacturing sector; service sectors are not allowed. Also the project should be related to metallurgy and material science.
- After the internship, the students are supposed to make a presentation of the same which will be evaluated by the professors under the course MM388 and is then allotted a PP/ NP grade.
- If a student has done a core-industrial PT after his/her 4^{th} or 5th semester, he/she can be waived off a maximum of 4 weeks from the required 8 weeks. However the student would still have to give a presentation of their work to the PT coordinator, if asked for.

How should one apply for it?

Well one way the department is trying to encourage is via the department PT nominee, who would be the interface between students and companies, and would try to convince them to take in as many students as possible for internships. The PT nominee will float the requirements of a particular company and the students will then have to send in their resumes. However if a student can get an industrial PT on his/her own, they are allowed to do so too; although they will have to get the PT sanctioned from the PT Coordinator beforehand.

Why are such policies being brought in?



The previous tradition of applying abroad for a PT needed reconsideration because of two reasons:

1. Firstly, professors wanted to stop the spamming process which floods the mailboxes of professors at universities abroad with long resumes and tall tales which may lead to the extreme step of banning all mails from IITB mail id.
2. Secondly, professors feel that most of these trips which are essentially laboratory apprenticeship are not in line with the basic philosophy of a practical training, which is to get acquainted with the engineering processes related to the department. So the basic aim of the new policy is to instil an industrial sense among students.

Prof. Dusane explains that the department wants to produce Engineers: engineers who have some industrial exposure and who are able to solve industry-related problems. He also said that the department doesn't stop people from taking up research internships at all. One is allowed to do so after their 2nd year and the department will also not object if one wants to take it up in the summer. after the 8th semester. However the formal Practical Training is compulsory and has to be done in core to get an insight into the industry and its working.

What options are available for the sophomores?

With the PT policy enduring its first experimental run this year for the 3rd year students, the options sophomores can look forward to in the coming summer vacation are:

I) A Core Department Industrial PT

This would have all the same requirements as for a third year PT. The benefit is that four weeks of this PT would count towards the third year PT.

II) A Core / Non-Core Research PT

This is the best chance to get the first glimpse of a hands-on experience in research and development. The best places to look for are the top Research Institutes in India or abroad. However students should not spam mailboxes of professors, as this leads to a bad impression later on.

III) A Financial /Non-core/Service Sector PT

If one wants to explore the options available in industry beyond metallurgy and material science, then this is a good option. One can try doing an Internship in stock trading / brokering or consultancy firm or a bank. Some of the basic skills that would come in handy are coding skills, basic finance fundaes (like the NCFM exam conducted by NSE). There's plenty of opportunity here for one to develop numerical skills especially in fields like Quantitative Modelling.

How should sophomores go about applying for internships?

A) For research internships abroad

1. If you are interested in research, make sure you have something specific in mind. If you just want to know about some area of specialization, it will be wise to do a small summer project in the department.
2. Be choosy when you mail to professors. Do not indulge in spam mailing.
3. Send formal mails accompanied by a CV, scanned certificates (if necessary) and a short description of your interests.
4. Send mails between October and April.
5. If the foreign institute provides an online interface for applications, preferably use it.
6. Focus on utility of the project and not splendor of the offer.

B) For Research Internships in India

Doing an internship in one of India's Premier Research Dedicated Facilities like JNCAR, IISc, TIFR, NCL or even private labs like Tata Research Development and Design Centre can also be a fulfilling experience. For this you must be thorough with the faculty interests and have a look at some of their papers as they might want to judge you via a phone interview.

C) For Industrial PTs

The easiest way to get an industrial PT after the 2nd year is via personal contacts. Other way to go about it would be to contact the faculty members. Also if any senior you know has done an industrial PT in some company, then you can ask the senior to back you with a recommendation letter when applying for the same company. You can also contact the PT Nominee for the list of companies being contacted and if he is willing to give you the database and if there is vacancy, then you can apply to these companies. However it should be kept in mind that the Third Year students will be given the first preference for any offer.

— Rajlakshmi Purkayastha, Rahul Wamancharya,
Avinash Prabhu & Aayesha Ghanekar

“The finest steel has to go through the hottest fire

— John N. Mitchell”

“Not only strike while the iron is hot, but make it hot by striking

— Oliver Cromwell”

“If we knew what it was we were doing, it would not be called research, would it?

-Albert Einstein”

Golden Be Thy Spirit

IIT Bombay opened its doors to the very first batch of students in 1958 with 25 faculty members. The Metallurgical, Electrical, Chemical, Civil and Mechanical Departments started off at a temporary location, SASMIRA at Worli, Mumbai along with two pure Science departments, Physics and Mathematics. In 1960-61, the institute moved to its current abode-the majestic Powai Campus, with a variety of flora and fauna from lakes to leopards.

The very first Ph.D. scholar, P.Ramakrishnan was admitted into The Metallurgical Engg. Department in 1962.

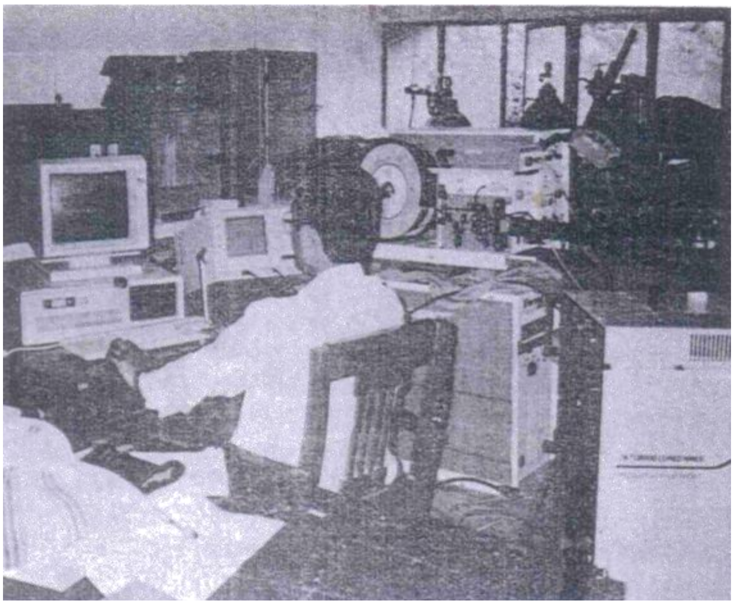
The humble beginnings of this wonderful campus were in two teaching-cum-storage (TCS) sheds, one hostel and three workshops. The TCS 'sheds' were actually strong granite constructions which gained their name from the fact that they were used to store equipment coming from Russia. In the truest sense, the early history of IIT Bombay was hidden in these multi purpose structures which not only housed the various departments but also the Director's Office, Drawing Hall, laboratories, class rooms as well as the State Bank of India. It is also said first Ganpati Festival was held there.

Initially, our department was a part of the Chemical Engg. Department. Prof. G.S.Tendolkar who was associated with UDCT and BARC was invited to set up the Metallurgical Engineering Department of IIT Bombay. By 1962, our Department moved to its current location. It had laboratories for Extractive Metallurgy, Physical Metallurgy, Ferrous Metallurgy, Non-ferrous Metallurgy, Thermodynamics and Electrometallurgy and Powder Metallurgy. It even had a design lab, a drawing section and a workshop section.

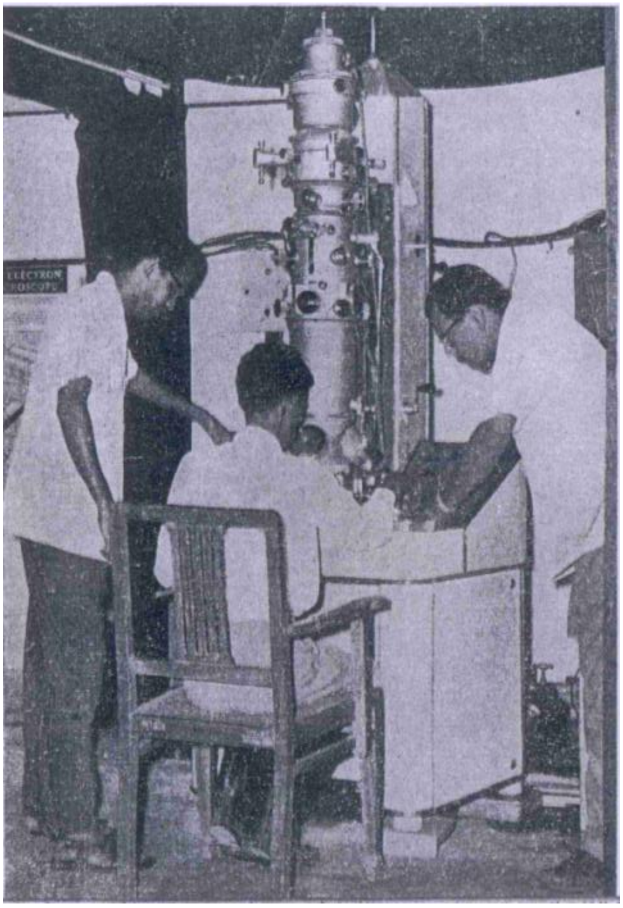
The first batch of 16 B.Tech students passed out in 1962-63 at the first Convocation of the Institute. The grading system for the first decade of IITB's existence was very different from the current relative grading. The successful students were given either a First or a Second Class at the time of graduation.

A significant development around this time was the initiation of the Doctoral programme owing to the improved library and laboratory facilities. An interesting fact is that the first Ph.D. scholar P.Ramakrishnan was admitted into the department in 1962. He submitted his thesis 'An investigation on the influence of oxide films on the Sintering on Metal Powders' in November 1963 which led to the conferring of the Ph.D. degree by IIT Bombay.

The Soviet influence was evident in the fact that many of the faculty members were Russian. Interestingly, most of the equipment in the laboratories had Russian instruction booklets, so the students were made to learn Russian as a compulsory



A still from welding lab (1962)



Electron Microscope

A still from Physical Metallurgy Lab (1963)

language. Prof. T.R.R. Mohan, who retired recently, had fond memories to share with us. He joined IITB as an M.Tech student in 1963. In those times, not only did students have to ace a written examination but also had to hold their own in a grilling personal interview so as to join the M.Tech Programme. Prof. Mohan remembers the Russian Professor V.T.Cherepin (Physical Metallurgy) who conducted his personal interview. Prof. Djakanov taught heat treatment while Prof. Fillipov taught furnace design.

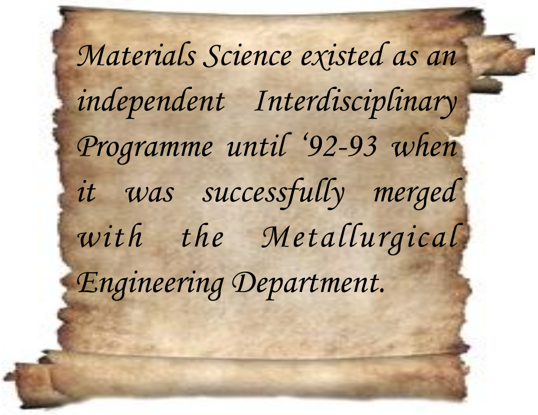
Study Tours formed an interesting part of the education system in those times. The students of our department used to travel every semester to different nooks and corners of the country from north-east to down south visiting places of historic and general importance as well as gaining hands-on experience in industry. Some of the places visited were Bhilai, Rourkela, Kolkata, Jamshedpur etc

What we today know as the MMA started off as early as the 1970s. Two enthusiastic students Prakash Koppar, fondly called Gary Cooper and Suresh Shenoy aka Spoony came up with the novel idea of forming an association under the aegis of the department. This led to the birth of the then MEA (Metallurgical Engineering Association). Making the department more vibrant by ensuring greater people to people interaction was on top of the agenda of the MEA.

An effective step in this direction was the organizing of Department picnics – a tradition that is still alive and kicking. Moonlight picnics to Juhu beach, enjoyable trips to Lonavla, etc became an integral part of the department life. These outings witnessed participation from both the student community and faculty members which gave everyone the opportunity to let their hair down and take a break from the academic rigours. Not very long ago, MEA used to publish a magazine catering to the latest developments in the field of Metallurgical Engineering world-wide.

Prof. Mohan's wife recollects the warmth and candidness of the boys as they'd drop in at her house to savour her delicious meals once in a while or enjoy learning dance sequences from her for the Annual Entertainment Programme (forerunner to today's PAF).

A turning point in the history of department happened in the early 80s. With the arrival of the first female undergraduate, **Mukta Ghate**, the department ceased to be an all-male domain.



IIT Bombay

Main Building (1965)

Since the late seventies, Materials Science existed as an independent Interdisciplinary Programme until 1992-93 when it was merged with the Metallurgical Engineering Department. The successful establishment of the Metallurgical Engineering and Materials Science Department was the first of its kind in India and led the way for other IIT's which followed suit.

Historically 1999-00 was the year that paved the way for the first batch of Dual Degree students in the department. 2001-02 saw the Electronics Classroom come up in the department housing 20 computers.

Being as old as the institute itself, the department has also planned a series of events to celebrate the 50 golden years of the department. The impressive line up includes:

- Golden Jubilee Lecture Series inviting eminent speakers
- Few lectures from eminent scientists and technologists
- A day long national seminar/symposium on "Entrepreneurship in Materials Engineering"
- An international conference largely relating to materials in automotive industry in 2008
- A Golden Jubilee Chair in 'Materials Engineering'
- Installation of a Materials Library— First of its kind
- A Publication depicting the evolution of Materials Technology in the last 50 years
- Contest on materials application on national level
- Two golden jubilee research fellowships for Ph.D. students
- Launch of Continuing Education Programme course on Materials in Automotive Technology
- A cultural event for Alumni and an open day for all

Our department has always been a hub for research and development from the time of its inception. We started off by doing turnkey research in the field of powder metallurgy and eventually broke new grounds by carrying out extensive research various fields. Time and again, our department has not only proved to be a centre of world class education but has also been successful in becoming a second home for the students and faculty members. The strong *guru-shishya* tradition, the quality and quantity of research going on inside the department and the general enthusiasm augur well for a bright future of the department.

— Arunabh Sinha, Aishwarya Ramakrishnan & Upadhi Kabra

Gen X Material

First it was fire, and then the wheel, then Franklin came with electricity and now computers. But what will be the next revolution? It is definitely going to come from materials may be from the latest buzzword, nanotechnology.

Nano materials like carbon nanotubes and fullerenes have shown promise in a variety of applications. Though widely researched for many years, using nano tubes to produce high performance composites has proved to be a difficult feat. However, research has been going on for the past five years at the Florida Advanced Center for Composite Technologies (FACCT) on further development of a novel pure nanotube material, called buckypaper.

Buckypaper is made from carbon nanotubes which are dispersed into a liquid suspension and then filtered through a fine mesh; these nanotubes stick to one another and collect on the filter, forming a thin film disk of pure nanotubes, called buckypaper. Also nanotubes can be magnetically aligned while production to make aligned buckypaper which has enhanced electrical and magnetic properties.

Now let us see some of the amazing things these babies can do!

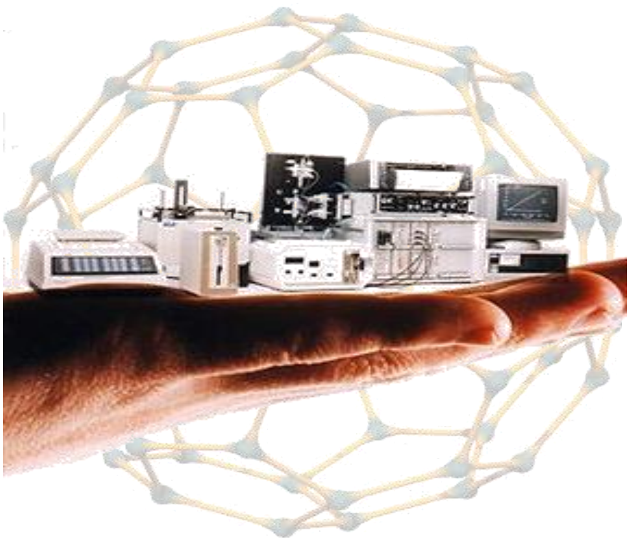
- If exposed to an electric charge, buckypaper could be used to illuminate computer and television screens. It would be more energy-efficient, lighter, and would allow for a more uniform level of brightness than current CRT and LCD technology.
- As one of the most thermally conductive materials known, buckypaper can be used to develop heat sinks that would allow computers and other electronic equipment to disperse heat more efficiently leading to even greater advances in electronic miniaturization. Also, buckypaper can be used to cut thermal signature of a plane by controlling the amount of tell-tale heat pouring from an aircraft engine, guarding them against heat seeking missiles.
- Because it has an unusually high current-carrying capacity, a film made from buckypaper could be applied to the exteriors of airplanes. Lightning strikes then would flow a round the plane and dissipate without causing damage.
- Films also could protect electronic circuits and devices within airplanes from electromagnetic interference, which can damage equipment and alter settings. Similarly, they could allow military aircraft to shield their electromagnetic "signatures," which can be detected via radar. Buckypaper can be used to shield lunar and Mars missions from radiation exposure.

We expect to see commercial use of the buckypapers in composites in about two to three years. To make this commercially feasible, we must be able to scale up production. Also the starting material for the buckypaper can be as simple as acetylene or methane. Even in India people have made it with camphor or kerosene. So once we get a technology for cheap-large scale production it can revolutionize technology across many dimensions. The 'cheap-large scale' part is pretty interesting, mostly because the raw-materials and energy costs of making carbon nanotubes is much less than steel. Currently we have no process for mass-production of carbon nanotubes, but if we did the market for steel as a structural material would collapse, cost and weight of everything from skyscrapers to automobiles would drop like a stone, and the economic effects would be dramatic. And this is leaving aside the fact that carbon nanotube materials like buckypaper are highly conductive and would also find use in consumer electronics, avionics, and computers. That's really like a next generation material.

— Priyank Jain

2063 A.D

On October 21, 2063, as the maglev train shot silently through the tunnel connecting the cities on opposite sides of the chain of hills, there was just a single sound that rang out feebly. A tiny pebble, dislodged from its place at the ceiling of the tunnel by a small rodent, had struck the side of the train. The impact at 450 km/hr had created a nasty gash about an



inch long on the glossy surface of the train. Immediately, there started a silent movement among the meshwork that lay below the surface of the vehicle. The arteries that were exposed by the gash were now sensing an imbalance between the chemical potential within them and outside. The pasty material inside them started diffusing out of the semi-permeable membrane of the mesh. As it came into contact with air, it slowly hardened. The rate of diffusion got slower, but it was never quite zero. As the train emerged out of the kilometer long tunnel, its surface was smooth and flawless to the human eye. To the computer, that is, sensors, the surface was near perfect. There was a recorded log of the outflow of material from the meshwork in the concerned area. A repair schedule had been fixed for when the train would reach its terminal station.

After the passengers had dismounted, the train pulled into its hangar. The repair robot moved to the specified coordinates and measured the depression of a few microns at the site of the accident. The robot extended its arm and sprayed a small quantity of a "pasty stuff" on to the surface of the train. Now the body was flawless to the robot too. The train moved out for another trip.

Though steel was still used for most of the beams and columns of the shell of the mega-city, and also for the supporting rail of the maglev trains, this 'pasty stuff' had revolutionized the world of materials since the late 2010's. It was a lightweight material with adequate strength to endure light impacts. Traffic jams and in general road accidents had dropped to zero after all vehicles became controlled by supercomputers at the traffic department. The only accidents were of the form described at the beginning; the so-called 'natural catastrophes'. Even with these accidents, the self-healing process done by the meshwork below had made this material a universal choice.

Close relatives of our material here were extensively used in hospitals, and to a lesser extent, in common households, where the walls were covered with a germ repelling paint. The more affluent customers had a mesh installed directly on the walls before the painting was done. This gave their walls a self-healing property too.

After dinner, each member of the family put his/her plate into the dishwasher. As the last plate was in, the machine started its task. After the leftover food had been scraped off, the clean plates were dried and elevated out of the machine. A free flowing clear liquid filled the chamber of the dishwasher. This liquid was the new universal solvent. It dissolved almost everything except the inner lining of the dishwasher and the pipes that carried it. As the liquid flushed out of the machine, the chamber was left sparkling clean. The underground pipes from dishwashers, industrial plants, and toilets, among a variety of other places, carried the garbage-saturated fluid to the processing station. Here, by the simple principle of fractional distillation, the low-boiling liquid evaporated first, leaving all other residues behind. This waste was divided between biodegradable and non-biodegradable and sent for recycling or degradation.

After dinner, I proceeded to my favorite couch. It was a new one. It had in its memory, the comfort settings of all the family members. As I sat down on it, the sensors identified me by my weight and posture. Signals were sent to the small nodes at the large number of joints just under the soft surface of the chair. These nodes, on receiving the signals, produced an appropriate temperature at the respective joint. Taking all the joints in conjunction the effect produced was wonderful, the shape of the couch changed to suit me. I felt myself sinking in ever so slightly, yet there was a firm support for my lower back. The small thermal expansions and contractions had molded the couch just for me.

Just then my sister walked in. She had bought one of those new skin patches. She tapped her right temple lightly and a soft glow on the right side of her face indicated that the patch was active. With a very subtle movement of her eyes, cheek and eyebrows, she switched on the television. This patch was synchronized with most of the household electronic devices. The signals through movement of eyes, eyebrows and cheeks were simple and easy to learn. Each gesture produced a different state of stress inside the patch. The material of the patch was inlaid with several million microscopic piezoelectric crystals arranged in a network. As the stress was relieved, all the piezoelectric crystals released a unique, combined electric signal. This signal, within limits of human error, was interpreted by a small processor hanging behind my sister's ear, and sent instructions wirelessly, to the concerned device. Even considering the wide range error for humans, it was still possible for the processor to identify and send several hundred different signals. The TV showed an advertisement for the new skin patch that would allow us to type and navigate computers with subtle gestures of our faces. Of course, learning to use it was an issue.

Suddenly, I thought of my uncle, who worked at a public Laundromat until it closed down nearly thirty years ago; not only that particular Laundromat, but all of them. All clothes today are made of materials having an obtuse angle of contact with all water-based liquids, grease, dirt and most foodstuffs. Washing clothes was a thing of the past. Just a simple jerk to the cloth was enough to remove any loosely adhered dust.

I slept early that night; I had a presentation the following day. The next morning I was up and ready to present my idea for a new line of cars for our company. Reaching the office, I headed directly for the conference room. I pressed my thumb lightly on the small pad on the wall beside the door. The green light confirmed recognition and the doors parted to let me in. After the necessary protocol, I drew up the slides in each of the directors' personal viewing screens from my computer. The new car was to have a whole different type of propulsion. The spherical wheels of the car would fit into a larger cavity on the underside of the car leaving a small section outside to contact the road. The inside of this cavity and one equator of each wheel would be lined with magnets. With the static magnetic field, the repulsion would balance the weight of the car and leave the required gap between the car body and the road, as well as the wheel and the cavity. Superimposed on this field would be another dynamic field, which would cause the wheel to rotate such that the magnets on the wheel remain in a vertical plane. This system would eliminate friction between the car and the wheel and provide acceleration. I had had this idea when I was in college, but it had not proved feasible due to the large mass of high strength magnets. With discovery of the magnetism of carbon, it has now become easy to use this system. The directors loved the idea and sanctioned the required funds.

That evening I had a small party celebrating the success of my presentation with a few relatives and close friends. At night, I sat down to watch a movie recommended by my friends. It was about a young engineer in the decade of 2000-2010 who had drawn up plans of several of the technologies that common people use today.

Truly, today's science fiction is tomorrow's science fact.

— Adhish Majumdar

Thinking Futuristic in Nano

In today's world where there is a never ending race to cramp as many things into as small a space as possible - miniaturization is the buzz word. Pick any material and trace its history over the years; the most noticeable aspect would be the reduction in size. And there simply seems to be no limit to that. Not very long ago, thinking beyond the micro-scale was sacrilegious. It no longer is! The driving force behind this phenomenon is to achieve the same or even better properties using the same materials at much lower costs. By far the biggest step in this direction has been the arrival of the nano materials. Our department leads the way in materials science research with extensive studies in the field of nano-materials as well.

Professor Dusane is presently working to make thin film transistors using silicon nanowires. Also, as an alternative for the costly silicon wafer, innovative ideas to induce crystallization in amorphous silicon are being delved into. Work is also being targeted towards making efficient solar cells with vertical dimensions being limited to few nanometers. Preparation of the thin films is being done by hot wire and plasma enhanced Chemical Vapor Deposition processes. Many researches in the lab have been found to be motivating for industries as well, Applied Materials being one of them.

Prof Bahadur, Prof Om Prakash and Prof. Vitta have been working on exciting areas with nanopowders, where the size ranges from 15 to 100 nm. In Professor Bahadur's lab lots of work pertaining to both magnetic as well as non-magnetic nanopowders has been going on for years and has been recognized by various journals. The research has been targeted towards hyperthermia, treatment of cancer and bio applications of drug delivery. The processes used to manufacture powders range from simple sol-gel techniques to microwave refluxing. Similar work on bio-applications of drug delivery has been a stirring area of research for Professor Om Prakash. The colloidal powders of silver, gold, titanium, zirconium etc might find use in electronics, detergents and catalytic applications. The uniqueness of the work lies in the use of a variety of dispersing agents for deflocculation.

The plethora of prospects in applications like EMI shielding, capacitors, batteries, electronic packaging etc have led to a significant amount of research in Polymer blends and composites at the nano level. Prof. A. Bhattacharya is working towards Polymer and carbon nanotube composites. These composites which exhibit better electrical properties are produced by melt-mixing and injection molding, which are industrial routes as well. This research is being sponsored by Reliance Industries Ltd.

Professor Venkatramani has been working on magnetic materials since 1986. Currently the work is towards production of magnetic thin films with the help of pulsed YAG laser. This technique gives nano-crystalline films with grain sizes as low as 80-90 nm an interesting feature of recrystallization and phase transformations. A remarkable outcome of this research has been the variation of magnetic properties with grain size. These films will find use in high frequency filters in mobiles and spintronic devices.

These researches need a variety of characterization techniques. Just to name a few XRD, Raman Spectroscopy, SEM, TEM and Optical Microscopy. Most of them are available in department itself. Others like Raman Spectroscopy are provided at Centre for Research in Nanotechnology & Sciences (CRNTS). Prof. Bahadur has been affiliated with the CRNTS for quite some time now. He informed us about several proposals and plans to bring high-tech facilities for nano research during the golden jubilee year, including Particle size analyzer, Spray techniques and equipments for the studies of zeta potential and metastability aspects.

-Upadhi Kabra & Aishwarya Ramakrishnan

The Dark Side of Nano-Technology

Nanotechnology has become the buzz word today for every science and technology discipline, be it applied physics, materials science, colloidal science, device physics, and even mechanical and electrical engineering. So one might wonder, what's so special about playing around with atoms and molecules. Well here are some wonders that molecules exhibit at the nano scale

- Copper which is opaque becomes transparent
- Platinum which is inert materials acts as a catalyst (that's added it to every other reaction)
- Stable materials like aluminum turn combustible (who could have thought of that)
- Solids turn into liquids at room temperature (like gold)
- Silicon which is an insulator becomes a conductor (and hence used in our computer chips)

This technology looks extremely promising, so much that fields of structural and mechanical engineering, electrical engineering and even medicine would be completely revolutionized with the advancement in nano. We would be able to get waterproof, tear resistant cloth fibre, stronger and lighter tennis rackets, bike parts, golf clubs. New therapies can be developed which might be useful in treating illnesses like cancer. All of this is just the tip of the iceberg. We can only try to imagine what new application might crop up in future

All said and done, nanotechnology, just like any other modern day discovery, has its own pitfalls. So what makes these seemingly harmless particles dangerous? Its nothing but their size!

The smaller the particle, greater is its surface area to volume ratio, and higher is its chemical reactivity & biological activity. The greater chemical reactivity of nano materials results in increased production of reactive oxygen species (ROS), including free radicals. ROS and free radical production is one of the primary mechanisms of nanoparticles toxicity. The extremely small size of nanomaterials also means that they are much more readily taken up by the human body than larger sized particles. Nanomaterials are able to cross biological membranes and access cells, tissues and organs that larger particles

Beyond the toxicity risks to human health and the environment, nanotechnology poses broader social challenges. Some suggest that nanotechnology will build incrementally, as did the 18-19th century Industrial Revolution, until it gathers pace to drive a nanotechnological revolution (the 'Nano' Age) that will radically reshape our economies, labour markets, social structures, civil liberties, our relationship with the natural world and even what we understand to be human. This could have potential to change the face of the earth completely. Some suggest that nanotechnology could amplify problems like socio-economic inequality through an inevitable 'nano'-divide (the gap between those who control the new nanotechnologies and those whose products, services or labour are displaced by them). Sceptics suggest the possibility that nanotechnology has the potential to destabilize international relations through a nano arms race leading to a scenario similar to the one before the First World War and the Cold War.

Despite the existence of a multi billion dollar market, no regulations anywhere in the world account for the changed character of materials at the nanoscale, which makes things difficult to monitor and predict as well.

NANO: The saviour or the annihilator, only the future knows!

-Edul Patel

Interview

Prof. PRITA PANT

Prof Prita Pant joined the MEMS department of IIT Bombay in January 2006. After graduating from the then Roorkee University in 1997, she took up a marketing job at HCL. Soon after she left the job and completed her PhD from Cornell University in 2004. She did her post doc from Harvard. We had a nice conversation with her about her experiences. Here are some excerpts:

After doing your post doc, what factors motivated you to come and teach here?

After my post doc, I was offered two jobs; one in the R&D department of General Motors in Bangalore and the other of teaching here. I chose teaching because unlike a job in the industry, you are not answerable to anyone for sales, marketing or profits. I have only one professional commitment here, that is teaching, and I can utilize my leisure time for any research I want to do.

How did you find your job at HCL?

I was working in the sales and the marketing department of HCL. I was always more concerned about the technical aspects of the products that I had to market, and that is when I realized that I did not have temperament for the job I was doing, and decided to go for a post graduation.

How has your experience been as being the first and the only lady professor in the department?

Initially I was apprehensive about being the first and the only lady professor but this turned out to be a plus rather than a minus. There were no pre-conceived expectations from me which made me felt at ease in the department and time with the department has been relatively smooth.

How will you compare the under-graduates of IIT Bombay with the under-graduates at Cornell and Harvard?

I would like to compare the under-graduates in two respects. The IIT Bombay under-graduates are better in course-work and writing exams of the courses taught to them. But at the same time, the under-graduates at Cornell were more dedicated and sincere towards the researches they were doing. I didn't have enough interaction with the under-graduates of Harvard to be able to make a comparison.

Many undergraduates and graduates from MEMS finally take up a job in finance/ consultancy. What is your say on it?

Today the choices of students are governed by the pay packages, so even though here are opportunities in core, but they cannot match the pay-scale of a financial/consulting Company. But I think that this phase will eventually pass and student will evolve to realize that there is a limit to the satisfaction you can get by high paying jobs. I hope that this will be the time when students will compromise on packages to take up jobs which are technically more challenging.

What are your research interests?

I am pursuing research in the following areas at present:

- Measuring stress on thin films deposited on surfaces of materials.
- Ni-Ti based shape memory alloys and the shape memory behavior of their thin films.
- Temperature changes phase transformations in alloying Ni-Ti thin films with other alloys.
- Simulation of dislocation interaction.

On an ending note, what message would you want to give to the under-graduates in IIT Bombay?

Many students in our department have made their minds against what they'll be taught in MEMS even before they start the department courses. They have convinced themselves that material science is not what they will be doing after four years. I would like to say to the students to try learning the courses with an open-mind to make a judgment. They should not make decisions about what they'll be doing at such an early stage.

—compiled by Shipra Agarwal

Secrets of the Samurai Swords

13th century, Japan - A Samurai has just returned from practicing his martial arts, to find a messenger waiting for him. The Shogun, a powerful Samurai who has the license to dismember anyone who offends him, has

Japan's coast has been attacked by the Mongols and its time the Samurais lived up to the *bushido* (their way of life), that defined service and conduct appropriate to their status as

The Samurai leaves to get his swords - his most prized possession, in which his soul lives. So Let's walk through a Samurai's soul, his sword:

- **Katana:** The longest type of sword, over 24 inches, generally used for outdoor combats.
- **Wakizashi:** Around a third shorter than Katana, between 12-24 inches, for indoor combats.
- **Tanto:** A small knife used in much the same manner as a Wakizashi.

Katana

Wazikashi

Tanto

These swords, one of the finest expressions of a metal worker's art ever have been engineered to kill !

To make a blade like those used in the Katana, the Japanese sword-smiths had to overcome a problem that had baffled them for years. Sword makers could make steel very hard so that it would hold a sharp edge, but by doing this they would make the blade very brittle. Since the sword was mainly a slicing weapon it would then shatter into pieces upon impact with the enemy. They could make the blade soft, sounds logical, as soft blade was easier to draw from the scabbard, and also, provided a better cutting angle. But then, soft steel would not hold a sharp edge and would quickly dull in battle.

Sword makers found a remarkable solution:

The actual forging of the blade was a complex process. Strips of two, or three different grades of steel, or of iron and steel, were welded together by the smith's hammer. The resulting billet of metal was then folded upon itself and hammered out again to its original length and thickness.

This process was repeated many times, until the final blade consisted of many thin, tightly welded layers of the original metal. When the forging was completed, the sword smith used file and scraping knife to give final shape and finish to the blade and tang.

It was this folding and forging process that 'beat' the impurities out of steel and distributed the carbon uniformly, which is indispensable for a strong blade. (Modern makers use 'Swedish powder steel', the purest form of steel).

Another reason for this labor-intensive process was to eliminate any air pockets that might have developed in the microstructure because that would have weakened the blade.

The most critical phase of the sword making processes was the heat treatment. The smith began by coating the entire blade with a layer of a clay, sand and powdered-charcoal mixture which was thin at the edges and thick at the middle.

Then, the sword smith heated the entire edge over his pine charcoal fire until the proper temperature was reached. Finally, the glowing blade was plunged into a tank of water.

The edges quickly cooled (quenching) making them hard and brittle and the middle portion, because of the thick layer of clay underwent a much slower cooling (tempering) making it a lot softer. Technically speaking, this process renders a martensitic edge, and a pearlitic body to the sword.

No wonder that the weapon in the hands of a Samurai, who is amongst the greatest of warriors to have ever lived, was the deadliest of them all.

Just before the onset of the war, Samurai seeks the blessing of the war god, HACHIMAN and decides to test his sword on a dead deer. The sword rips the deer into two in a flash … and off the warrior goes.

(Fact: Swords were also tested on humans, but it was banned in Japan in 1868)

— Anubhav Agrawal

"Persistence is to the character of man as carbon is to steel

- Napoleon Hill"

"Basic research is what I am doing when I don't know what I am doing

-Wernher von Braun"

Materials de Formula Una!

Auto-racing [*aw-toh-reys-ing*]:

Noun: the ultimate adrenaline rush, magnum opus of racing

Usage: *"Auto racing, bull fighting and mountain climbing are the only real sports, rest all are games"* – ***Ernest Hemingway***

Even if you don't dig Mr. Hemingway's surreal yet blunt words (almost whole of Inter-IIT battalion won't), you'll have to admit these sports do involve unfathomable guts on the part of the players. But apart from the sheer grit, another unavoidable aspect of the sport is the equipment and gear, which have to be equally endearing and strong. But of the 3 picks of ever charming Mr. Hemingway, only auto-racing is a substantial subscriber of materials of interest. So let's take a sneak peek at the mother of all auto-races, Formula 1!

Measuring 4.6m x 1.8m and just 0.96m high approximately, this speed demon goes from 0 to 100 kmph in 2.6 seconds. Weighing merely 605 kgs, it bears the brunt of marvelously designed and engineered circuits and of course, menacing drivers too-be it robust Fangio or skinny Lauda!

But it wasn't always so. Through its avant garde, F1 car has shred its weight but has developed so speaking, muscles and has kept on breaking speed barriers; on ground, of course! It has undergone a metaphorical cosmetic surgery while shifting from an aluminum chassis to a glamorous carbon fibre (whose specific strength is 12 times that of aluminum) chassis. And believe it or not, the enormous fuel tank is shaped out of Kevlar, the same polymer that goes into a bullet-proof vest. It changes shape according to the pressure developed in the tank.

Unlike NASCAR, F1 uses treaded tyres in place of more popular 'slicks'. The tyres in F1 aren't exactly long distance runners, since they just do 200 kms at the most as compared to 16000 kms by a radial car tyre. Structurally, it's a complicated weave pattern of Nylon and polyester enabling it to withstand enormous forces it is subjected to. The key ingredients however are carbon, sulphur, zinc, and oil, which makes the tyres soft. Also low density (nitrogen-rich) gases are used to inflate them.

An avid racing fan would surely agree that races are decided at corners requiring fierce braking, thus putting immense significance to brake material. More so, due to these staggering figures-an F1 car comes to a halt from 300kmph within a mere 4 seconds! Even at 200kmph, it takes 2.9 seconds and a distance of just 65 meters. Under these heavy braking periods, a driver is subjected to a horizontal deceleration of close to 5.2G.

So again, the magic potion the druids at the garages emerged out with is carbon fibre. The carbon fibre disc brakes are light and can bear 1000 degrees of temperature during heavy braking, which so often constitutes the highlights of many a race!

As for what lies beneath, at the heart of the machine is a V8 engine, predominantly made out of forged aluminium alloys. With its innumerous components, it makes F1 cars amongst the fastest on the face of the earth. For the fans and followers, the sound of a V8 engine is music to their ears; it's a symphony at the Belgian circuit Spa-Francorchamps specially at the uphill corner, Eau Rouge.

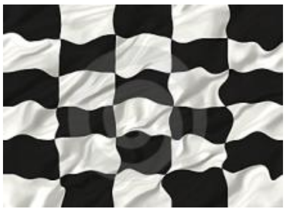
For other parts, the pistons are Al alloys, either Al-Si, Al-Cu or Al-Zn based. Piston pins, camshafts and crankshafts are made of an Fe-based alloy. At full throttle, this modern engineering marvel delivers 750 horse powers and reaches 20000 rpm; but take this with a pinch of salt-it also consumes 60 litres of fuel to run 100 kms.

And it's not just the car alone. Gone are the days when mercurial Farina sped in his Alfa Romeo 158, donning a cotton T-shirt and leather helmet. Today's Schumachers sweat it out in fire resistant Aramid polymer suits and multi-layered carbon fiber helmets, keep their hair gel on at 300 kmph and 4G forces.

The suiting, which may boast to make a 'complete driver', is in reality made of fire resistant Nomex fiber, the same which the gallant fire fighters don! These suits can stand about 8 seconds of fire, thereby allowing a driver safe exit from the car in case of such an emergency. The overalls, as the drivers' clothing is called, are stitched in a very special way, allowing air cushions between the stitches. As air guides warmth far less easily than solids do, this is one of the most important features of an overall. Besides, drivers are protected with a thin Nomex hose, all over their body. It consists of fire protective underwear, pants, a balaclava, etc. They also wear Nomex shoes with a hard sole, which gives grip on the pedals, Nomex gloves with suede on the inside for comfort and extra grip on the steering wheel.

The helmet, weighing a mere 1.25 kgs, has fiber-reinforced resin over carbon fiber sitting tight at its outer layer followed by a layer of strong plastic, mostly Kevlar, and then polystyrene based plastic covered with Aramid plastic fiber. But the fascinating part is the visor, made of special clear polycarbonate, inside of which is coated with anti-fogging chemicals, keeping driver's vision from fogging due to oil and water spray during wet races! It's also said to adjust brightness according to the ambient lighting pretty quickly, especially through the famous tunnel in Monaco!

Leaving the fuel for the chemical engineers to ponder over, let's raise a toast for one of the most exciting sports, which has had a bumpy ride this year but emerged victorious in the end. It was counted amongst the most dangerous sports with an ad infinitum list of fatalities to support the selection; but thanks to advancements in materials science, F1 today is all the more safe and enjoyable as well. I hate to contradict one of the greatest racers of all times, the iconic Ayrton Senna, but his words, *"…Every time I push, I find something more, again and again. But there's a contradiction-the same moment you become the fastest, you are enormously fragile. Because in a split second, it can be gone. All of it."* doesn't bother the drivers anymore. Thanks material science!



— Devasheesh Mathur

"Iron is full of impurities that weaken it; through forging, it becomes steel and is transformed into a razor-sharp sword. Human beings develop in the same fashion

— Morihei Ueshiba"

Alumnus Corner

R.V. Ramanujan, IIT (Bombay, '83, Met.)

Prof. Raju V. Ramanujan is on the faculty of the School of Materials Science and Engineering of Nanyang Technological University (NTU), Singapore. His group's current research activities at NTU include nanomaterials, especially magnetic and thermoelectric nanomaterials for energy, bioengineering, data storage and defense applications. He teaches courses on biomaterials as well as metallic and ceramics materials and he has mentored several students who have won awards at the national and international level. He is a member of the Phase Transformations Committee of both TMS (USA) and ASM (USA), the European Union-India Grid, NSF Review Panel and the Editor or Associate Editor of several international journals and book series. He earned his Bachelor's degree (First Class Honors) from Indian Institute of Technology, Bombay and his Master of Engineering and Ph.D. degrees in Metallurgical Engg. and Materials Science from Carnegie Mellon University, U.S.A. As a staff scientist at Advanced Devices and Materials, U.S.A. he performed consultancy projects on reliability issues in electronic materials and biomaterials. He has received the Excellence in Teaching award from his university and has organized a number of international conferences related to advanced functional materials and is the symposium chair of a symposium series on Materials in Devices and Systems. He has a few words on his stay at IIT.

His Experiences at IIT:

My stay in IIT-B (Met. Engg.) from 1978 to 1983 was a transformational experience. All over the world IIT is recognized as one of the world's best teaching engineering institutions, IIT alumni have done remarkably well in every country and the Metallurgical Engineering Dept. has given India a Chief Minister! IIT should indeed be proud of its achievements. Some of my batchmates and hostelmates like Girish Gaitonde have helped IIT in badly needed infrastructural development. I should also mention the nice guesthouse donated by Nandan Nilekani. My own experience in the dept. began, as I recall, with an orientation visit in which we were shown a cartoon type movie on making steel. For me, my entire professional life has continued in materials science and engineering, so IIT gave me the foundation for my career and I have stayed true to the IIT-B motto (Gyanam Paramam Dhyeyam). In addition, some other ideas that were very important in IIT were those of very high self-confidence (everyone has got through JEE!), strong belief in meritocracy, a pan-Indian, cosmopolitan outlook and the importance of both competition and cooperation. I have made lifelong friends at IIT and the network of IITians around the world is an unparalleled resource. I think the sport of anti-chess was invented in IIT-B as well as the unique IIT slang which sometimes varied from hostel to hostel (e.g., some hostels used the word "janata", while others preferred "punters" or "people"). Frankly, it was only later when I had the opportunity to interact with students of many other Indian engg. colleges that I realized how lucky we were to have studied in IIT. The curriculum both in terms of structure and content was outstanding, but I hope it has been updated for the twenty first century. Of course, 5 years was too long for an engg. degree, so this was subsequently reduced to 4 years. During the first two years, we had core courses (a bit too much engg. drawing), and an excellent chemistry course by Prof Chakrvarty. In the dept., some of our professors were Dixit (M.P. and S.), Malhotra, Kulkarni, Thatte, PK Rao, Gopinathan, TRRM etc. Later, faculty (Prabhu, Vitta, Raja etc.) joined the dept. bringing new areas of expertise and I had a chance to interact with them both as BTech Project external examiner and as a scientist at BARC. New faculty recruitment used to be done in a rather ad-hoc, personalized and really quite unsatisfactory level, I hope that current recruitment processes are more streamlined and professional.

For me, the teachers who influenced my own teaching methodology were Profs. SD Kulkarni, V Gopinathan, Chakravarty and a lecturer from St Xavier's College, Melky Alvarez. Kulkarni was so systematic and clear in his instrumentation course that I still use his method of teaching, Chakaravarty loved to tell stories about famous scientists like Bohr and Gopinathan also taught us the concepts of phase transformations in a lucid fashion. N. Ballal joined the dept. during my stay and introduced for the first time, teaching feedback. At that time there was no formal mechanism for students to feedback about teaching, so we all felt this was a welcome and refreshing approach. We also had our first (and last?) student strike in IIT-B during my stay, I remember a few stalwarts going around urging us not attend classes and an all-night meeting that culminated in a march to the bungalow of the Director (A.K. De).

I took an active interest in the dept. activities through the Met. Engg. Association (MEA), we organized, among other events, a staff-student cricket match. In my final year, I was the secretary of MEA and we brought out a nice issue of the departmental journal called Metallurgical Engineer, I still have a copy and I see that Prof PR Menon has an article in that issue. Vinayak Dravid who was the joint secretary at that time is now involved in alumni activities. I continue to visit IIT and the dept., and talk to old friends like Nithya Prabhu, Vitta, Raja etc., I was the co-chair (with Prof Bahadur) of the Indo-Singapore Symposium on Advanced Functional Materials held at IIT-B in 2006. During my stay, we celebrated the silver jubilee of IIT and I remember that I gave a talk suggesting that the Met. Engg. dept. include more materials science courses. Regarding research, I had access to TIFR DEC computers, so I took the BTech project of AK Mallik, he gave me some very good advice on research methodology, including first developing and fully understanding simple models before moving on to sophisticated models. Ballal also encouraged me by asking me to use the computer to model removal of impurities in molten steel.

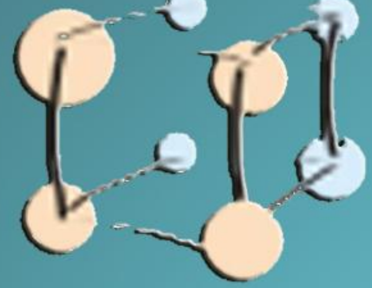
Staying in the hostel (H-3) was always interesting, with the occasional wild animal (panthers!) prowling at night and crazy bulls attacking us by day. Making a phone call was a major achievement, the hostel phone rarely worked and we had to go to a central phone facility near the admin. building, I am sure cell phones have solved this problem. Movies were screened late at night and were considered to be an event where the hostelites would scream "once more" at appropriate points in the movie. Movies in the convo on Friday evenings were boisterous affairs, with the audience shouting "hero, hero,…". The food was terrible, except for Wednesday dry day and the occasional "shrikhand". I should mention that on my recent visits to the hostels, classrooms and admin building, I found that they are in urgent need of repair and maintenance. On the cultural front, Mood Indigo was an exciting cultural event, I listened to Zakir Hussein, Hari Prasad Chaurasia and Jagjit Singh in the Convo, and I had the opportunity to attend a wonderful and influential talk by Alyque Padamsee.

For the good things in my personal and professional life which have been influenced by the Met. Engg. Dept, I am very grateful to all of you. Good luck to IIT and to the Meta Dept. for another golden 50 years!


COLOURFUL
WORLD OF NANO

Team Dhatuki

Contact us @ **dhatuki@gmail.com**
pallav_jhawar@iitb.ac.in
kadama@iitb.ac.in



Metallurgical Engineering

& Materials Science