IIT BOMBAY

update

A Newsletter of Industrial Research & Consutancy Centre

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Technology Developed and Transferred to Industry*






- A Silent Revolution: Assessing Output of Women Graduates & Post-graduates from IIT Bombay
- Novel Processes Recently Developed Utilizing Unique Properties of Carbon Dioxide
- Solar Concentrator for Industrial Process Heat
- The Challenges of Adopting Better Corporate Governance Norms

Editorial

Worldwide, it has been found that the active participation of females at all levels of primary, secondary or tertiary education is a consistently good indicator of societal well being. An educated woman appears to considerably increase the appetite for learning within her family and community. This edition's lead article on the silent revolution of increasing enrolment by women in engineering institutions is a testimony to a potentially bright future for technical education in India.

UPDATE also brings to you the exciting new product developments made possible by our engineering faculty. In the field of environmentally cognizant products that also address issues of better quality and safety, we are beginning to see many interesting innovations. *Supercritical Fluid Extraction Technology* promises environment-friendly and non-polluting extracting processes. The *solar concentrator for generating industrial process heat* is another very capable technology that if widely used can save considerably on our huge foreign oil dependence.

UPDATE highlights a perspective on how corporations internally govern themselves so as to minimize losses for their shareholders as well as for the larger societal stakeholders. With the rash of corporate malfeasance in various parts of the world this topic has acquired considerable salience. What lessons can we learn in India on issues of corporate governance? Are they different from other countries?

The IIT Bombay community has been very active these last several months with several awards won, memorandum of understandings signed, projects and consultancies accepted. *Techfest 2006* was a particularly successful event with considerable participation. We give you a comprehensive account of many such events.

Shishir K. Jha, Editor

IRCC Notes

IIT Bombay's focus on teaching and research is coupled with a desire to ensure that the Institute's research output gets disseminated and used by industry and society. The academic environment facilitates open discussion and a free transfer of ideas. However in order to make an impact in the real world, we need funding to shape our ideas. In our interactions with industry the first thing we have learnt is that there is a high commercial value to the 'Intellectual Property or IP' (knowhow, software, technologies or designs) that we develop.

In 2003 IIT Bombay formulated an Intellectual Property (IP) policy. The Institute owns all IP that is generated at IITB by faculty, students and project staff. The revenue that results from the exploitation of this IP is shared by the inventors and the Institute (70:30). When an industry or an external agency sponsors research at IITB we agree to joint ownership of the IP developed. We also provide the industry the first right of commercialising the IP and are willing to transfer the rights to the IP, based on mutually agreeable terms.

At times we find that industry is reluctant to agree to joint ownership of IP. They feel that since they are paying for the development, they should own the rights. However we believe that R&D is not 'work for hire'. We believe that by funding research the industry gets the benefit of using the work internally in their organisation and the option of deciding whether to commercialise it. However if they commercialise the research we think it is only fair that the IP creators get a share of the revenue. One of the key issues in working out the revenue share is assigning a monetary value to the IP generated.

How do we value IP? Unfortunately there is no simple formula or process for arriving at this value. We arrive at it through a process of negotiation. We have tried different models - an upfront one-time payment or an annual royalty based on sales as well a combination of both. Ideally we would like to negotiate the fee at the time after the completion of the project when the IP has been fully developed. Most industries want the IP transfer fee to be decided a priori at the time when the project starts. This normally results in undervaluing IP as it is linked with the project cost.

Is the emphasis on royalty and share of revenues misplaced in an academic institution? We believe that this emphasis is necessary for ensuring commercialisation of IP into products and processes in a competitive business environment. We also have several examples of IP development that is transferred at low cost/free of cost or provided in the open domain (e.g. artificial arm, aAqua - rural web portal) where the benefits directly reach the people. The Institute encourages both models - commercial IP transfer (competition/business environment) and placing IP in the open domain, depending on the faculty's inclination. Industry and business are interested in acquiring ownership of our IP for obtaining a competitive advantage. In order to exploit this advantage they often want exclusive rights and also want to ensure that the IP is protected (patented). In our dealings with business and industry our focus is on revenues generation from IP.

We have built processes to protect the IP developed in the institute. We have an invention disclosure form, a peer review process, patent agent and attorneys and a technical section at IRCC that handles the process of patenting IP (www.ircc.iitb.ac.in). We have also established SINE (Society for Innovation and Entrepreneurship), a Technology Business Incubator that facilitates students, faculty to incubate companies to commercialise IITB IP.

In the process of patenting, negotiating agreements with industry and licensing technology to companies, encouraging and facilitating incubatee companies based on IITB IP we have grappled with several issues related to ownership, revenues, law, conflict of interest and secrecy among others. We have also realised that it is time to review our IP policy and develop appropriate strategies to ensure that our research results in benefits to society.

Rangan Banerjee

Major New Consultancy Projects

Investigator	Department	Project Title
B K Chakravarthy	IDC	Design of New Modular Multi Hose Petrol Pump
S K Gupta	CESE	Development of Action Plan for Environmental Improvement of Mithi River
S Iyer / O Damani	KReSIT	Network Security
A Joshi	IDC	User Studies of the Election Process
D Manjunath	Electrical Engg	Self Tuning of Enterprise Servers and QoS Provisioning
P M Mujumdar	Aerospace Engg	Development of Industry Standard Codes for Aeroelastic and Aerservoelastic Analysis of Aircrafts
D B Phatak	KReSIT	Capacity Enhancement and Migration of Legacy Applications
D B Phatak	KReSIT	Building Large Data Warehouse
Ravi Sinha	Civil Engg	Design of Road Over Bridges in Jharkhand State
M Sohoni	Computer Science & Engg	Algorithms for Class A Surface Design
S A Soman	Electrical Engg	Assessment of Transmission System Adequacy in the EHV Network of Western Region of India

Major New Sponsored Projects

Investigator	Department	Project Title
M Atrey / K G Narayankhedkar	Mechanical Engg	Development of Two Stage Pulse Tube Cryocooler for 20k using Linear Compressor
A N Chandorkar / H Narayanan / Supratik Chakraborty	Electrical Engg / Computer Science & Engg	Special Manpower Development Programme for VLSI Design
B G Fernandes	Electrical Engg	National Mission on Power Electronics Technology
P Gopalan	Met Engg & Mat Science	Development of Thin Film Capacitors Based on Novel Co-doped Titanate Materials
P Mathur	Chemistry	National Single Crystal X-Ray Diffraction Facility Phase II
S K Mitra	Mechanical Engg	Modeling, Flow Visualization and Validation of Fuel Cells
A S Moharir	Chemical Engg	Development of Adsorption-Based Process for Recovery of CO_2 from Power Plant Flue Gases
P M Mujumdar	Aerospace Engg	Vibration Control of Structures using Piezoelectric Stack Actuators
G Naresh Patwari	Chemistry	Spectroscopic Investigations of Reactions in Gas Phase
S Suryanarayanan / K Arya	Mechanical Engg / KReSIT	Low Cost Engine Management Systems for Petrol Powered Small Vehicles
V R Rao / J Vasi A Q Contractor	Electrical Engg / Chemistry	Centre for Research in Nanoelectronics

Select MOUs

Organization	Signed	Scope
Creative Commons	April 2005	Establishing of Creative Commons - India
NTPC	September 2005	Development of Adsorption Based Process for Recovery of CO_2 from Power Plant Gases
Reliance Industries Ltd	September 2005	Specialised Continuing Education Programme in Chemical Engg
Applied Materials Inc	October 2005	Collaboration for Research and Innovation
ONGC	November 2005	Studies for UCG for Indian Coals
IPCL	November 2005/ January 2006	Degree Level Engineering Programme in Electrical & Mechanical Engg
TCS	January 2006	Manpower Development and Research in VLSI Design
Reliance Life Sciences	January 2006	Degree Level Engineering Programme in Biosciences & Biochemical Engg
Tata Consultancy Services	January 2006	Partnership in VLSI Design Research Consortium
National Research Council, Canada	January 2006	General Collaboration Agreement
Washington University at St Louis, USA	February 2006	Partnership for Collaboration in Research & Education

Awards

Prof Rinti Banerjee, School of Biosciences & Bioengineering, has been awarded the AICTE Career Award for Young Teachers for the year 2005-06.

Prof J Bellare, Department of Chemical Engineering, has been selected for the IIChE - Hindustan Lever Biennial Award for the Most Outstanding Chemical Engineer under the age of 45 in recognition of his work of fundamental and applied nature.

Prof S Bhargava, SJMSOM, has been selected for the V K R V Rao prize of Indian Council of Social Science Research for his contributions in Social Science Research.

Prof Supratik Chakraborty, Department of Computer Science and Engineering, and **Prof Pramod Wangikar,** Department of Chemical Engineering, have been selected for the INAE Young Engineer Award for 2005.

Prof D Choudhury, Department of Civil Engineering, has been selected for the BOYSCAST FELLOWSHIP for 2005 by Department of Science and Technology to carry out research in Earthquake Geotechnical Engineering.

Prof D Choudhury, Department of Civil Engineering, has been selected for the INSA Young Scientist Medal 2005.

Prof R O Dusane, Department of Metallurgical Engineering and Materials Science, has been elected as the Fellow of Maharashtra Academy of Sciences, for his significant contributions to Engineering and Technology.

Prof Vikram M Gadre, Department of Electrical Engineering, has been selected for Prof S V C Aiya Award from IETE Pune Centre for the year 2005.

Prof A S Khanna, Corrosion Science and Engineering, has been awarded ASM Fellow 2005 by America Metal Society for his contributions in high temperature oxidation and corrosion research and education.

Prof Nand Kishore, Department of Chemistry, Prof J Bellare, Department of Chemical Engineering and Prof D Panda, School of Biosciences and Bioengineering have been elected as Fellows of the National Academy of Sciences.

Prof S Kotha, Department of Chemistry, has been awarded the Punjab University Bhagyatara National Award for the year 2005 for his research in Organic Chemistry.

Prof Ashok Misra, Director IIT Bombay, was awarded the 2005 "Qimpro Platinum Standard Statesman for Quality-Education" by the Qimpro Foundation for excellence in the quality of education and its management.

Prof M Mukhopadhyay, Department of Chemical Engineering, was awarded the Herdillia Award for Excellence in Basic Research in Chemical Engineering for 2005, by the Indian Institute of Chemical Engineers (IIChE).


Nandan Nilekhani

Mr Nandan Nilekani, Distinguished Alumnus IIT Bombay, CEO and Managing Director of Infosys Technologies Ltd. and a member of the Board of Governors of IIT Bombay, has been honoured with Padma Bhushan by the Government of India.


Prof D Panda

Prof D Panda, School of Biosciences and Bio-engineering has been selected for the Department of Bio-technology instituted National Bioscience Award for Career Development for the year 2005 for his outstanding research contributions.

Mr A Prakash, Dual Degree Student, Department of Metallurgical Engineering And Materials Science, has been awarded the K Suryanarayan Rau Memorial Junior Student Award - 2005 by the Indian Society for Advancement of Materials and Processing Engineering, Bangalore, for his contributions in the development of thin film for various sensor applications.

Prof V Ramgopal Rao, Department of Electrical Engineering, has been elected as a Fellow of the Indian National Academy of Engineering (INAE) in recognition of his distinguished research contributions.

Prof M V Rane, Department of Mechanical Engineering received the Dr P K Patwardhan Technology Development Award 2005 for his innovative work on Matrix Heat Recovery Unit.

Prof T S Rathore, Department of Electrical Engineering, has been selected for the 12th Prof K Sreenivasan Memorial Award and the 3rd B R Batra Memorial Award of IETE in recognition of his contribution to teaching in Electronics and Telecommunication Engineering.

Prof V D Sharma, Department of Mathematics received the Prof S C Bhattacharya Award for Pure Sciences in recognition for his contribution in the area of Partial Differential Equations and Non linear Waves. This award is instituted by IIT Bombay alumni Mr. Rakesh Mathur.

Prof A K Singh, Department of Chemistry has been elected as the President of the Section of Chemical Sciences (2006-2007) by the Indian Science Congress Association, Kolkata.

Prof R Srivastava, School of Biosciences and Bioengineering, has been awarded the DAE-BRNS Young Investigator Award.

Prof M Tirumkudulu, Department of Chemical Engineering, has been selected as a Young Associate of the Indian Academy of Sciences, Bangalore.

Prof J Vasi, Department of Electrical Engineering received the Prof H H Mathur Award in Applied Sciences in recognition for his contribution in the field of Microelectronics. This award is instituted by IIT Bombay alumni Mr Rakesh Mathur.

A US patent 6,890,438 B2 has been granted in respect of "Process for Treatment of Organic Wastes" developed by H S Shankar, B R Pattanaik and U S Bhawalkar of IIT Bombay.

Lifetime Achievement Award

Prof S C Lakkad, former Deputy Director of IIT Bombay and retired faculty member, Department of Aerospace Engineering received the IIT Bombay Life Time Achievement Award in recognition of his contributions over nearly four decades as a great teacher and researcher in the area of fibre reinforced composites.

Prof Lakkad has been associated with IIT Bombay since 1967. In addition to being a Professor in the Department of Aerospace Engineering, he was also Dean of Research and Development and Deputy Director. His contributions to teaching, basic and applied research, industrial consultancy, development work for important national programmes and administration are exceptionally noteworthy and inspiring. He has made landmark contributions in the area of composite structures and is now recognized as the leading authority in India on Composite Structure Design.

His efforts in education and research in the area of composites brought in major funding to the institute. He has made notable contributions in composite structure design in a number of areas, such as Aerospace, BioMedical, Chemical Industry, Fan Industry and Railways. Various prestigious awards conferred on him include Fellow of the Indian Academy of Engineering and Maharashtra Academy of Sciences, Medal of Materials Research Society of India-1990, Eminent Engineer Award of Institution of Engineers (India) on the occasion of Platinum Jubilee in 1998, National Award for Excellence in Consultancy Services-2001, and Distinguished Alumnus Award of IISc Bangalore-2003.

IITB-ONGC Agreement for Collaborative Research in Coal Gasification

An agreement was signed between IIT Bombay and ONGC for taking up collaborative research on "Studies in Underground Coal Gasification for Indian Coals." The three-year project with an outlay of over Rs. 2.6 crores, with Prof A Ganesh, Energy Systems Engineering, as the Principal Investigator and Prof S Mahajani, Prof P Aghalyam and Prof K C Khilar, Department of the Chemical Engineering as the Co-Principal Investigators aims at a comprehensive study of Underground Coal Gasification (UCG) with special emphasis on applicability to selected Indian coal mines. This is the second large project being funded by ONGC under the IITB-ONGC partnership initiative.

Contact: aganesh@me.iitb.ac.in

Release of R&D Spectrum

R&D Spectrum, a comprehensive information brochure of the R&D activities of IIT Bombay, was released by Mr Rahul Bajaj, Chairman, Board of Governers, IIT Bombay, on February 18, 2006.

Mr. Bajaj appreciated the work required to produce such a publication and added that it has the necessary content to attract industry interest. This publication, the first of its kind, reflects the R&D ethos, culture and activities at IIT Bombay and is a walk through of information on the various facilities, expertise, R&D achievements and partners. The main objective of this major initiative is to make it useful for the stakeholders of IIT R&D.

SINE-IITBAA Workshop

The Society for Innovation and Entrepreneurship (SINE) and IIT Bombay Alumni Association (IITBAA) organized a workshop on "Entrepreneurship and Incubation at IIT Bombay: Alumni Linkage" in October 2005.

IIT Bombay is one of the early technology institutes in India to initiate technology business incubation activities on its campus. The inspiration behind this initiative has been to exploit and effectively convert the technology and management expertise at IIT Bombay for the advantage of the entrepreneurial ventures. There has been considerable interest in entrepreneurial activities from student and faculty members on campus in recent times. The success of first generation entrepreneurs from IIT Bombay alumni and success as professionals in the industry and management fields has been a significant inspirational force for entrepreneurial activities at the institute.

The workshop served as a platform for networking and exploring synergy between Student, Faculty and Alumni for promotion of entrepreneurship and incubation at IITB. It covered detailed sessions on the SINE incubation model, possible ways of alumni contribution to the process, an overview on various emerging technologies such as Telecommunication, Networking, Nanoelectronics, Biotechnology and Robotics and presentations by some SINE incubatee companies.

Institute Colloquium

Nobel Laureate Prof David J Gross, Director, Kavli Institute for Theoretical Physics and Frederick W Gluck Chair in Theoretical Physics, University of California at Santa Barbara, delivered an institute colloquium on "The Coming Revolutions In Fundamental Physics" on 24 January 2006. He spoke on the basic structure of string theory and presented the motivation for the ambitious attempt to unify all the forces of nature. He also discussed the coming revolutions in fundamental physics that are suggested by string theory.

IIT Bombay at Global Conference on India R&D

IIT Bombay participated in the Global Conference on "India R&D 2005: The World's Knowledge Hub of the Future" held on November 7-8, 2005 at Vigyan Bhawan, New Delhi. The conference was organised by the Federation of Indian Chambers of Commerce and Industry (FICCI) in partnership with the Department of Science and Technology (DST), Department of Industrial Policy and Promotion (DIPP) and Council of Scientific and Industrial Research (CSIR). In conjunction with the conference an Exhibition showcasing the recent achievements in Science and Technology was organised on November 7-9, 2005.

Dr A P J Abdul Kalam, President of India inaugurated the Exhibition and Conference. Mr Kapil Sibal, Minister of State (Independent Charge) for Science and Technology and Ocean Development, Government of India, Prof V S Ramamurthy, Secretary, Department of Science and Technology, Government of India, Dr R A Mashelkar, Director General, CSIR, Secretaries of Department of Industrial Policy and Promotion, Ministry of Heavy Industries and Public Enterprises, Department of Telecommunications, Ministry of Petroleum and Natural Gas, Department of Space, Prof P Balaram, Director, Indian Institute of Science, Bangalore, Prof Ashok Misra, Director, IIT Bombay, Prof Kartic C Khilar, Dean (R&D), IIT Bombay and several leading scientists / R&D Managers / Directors attended the Conference.

The conference included various plenary and technical sessions such as India - the World's Knowledge Hub of the Future, Nurturing Innovation - Creating the Right Culture, Capacity Building - Infrastructure and Human Resources, Pharmaceutical and Biotechnology - Breakthrough for the Masses, Automotive and Transportation Sectors - The Engineering Design Highway, IT and Communication - Reinventing India, Energy - Alternate Solutions for India's Needs, Space Research, Societal Needs and Nanotechnology.

IIT Bombay was one of the thirty-eight R&D establishments, from both private and public sectors that had participated in the exhibition and the exhibits included various technological developments and R&D achievements at the institute. The exhibition attracted a large number of visitors

Science Expo 2005

IIT Bombay was one of the participating institutions in the Science Expo-2005, held at Nehru Science Centre, Worli, during November 23-27, 2005. As an exposition for science, technology and society interface, it was aimed at high school children and the general public with an endeavour to promote and spread scientific awareness. The Institute displayed a variety of exhibits in the form of working models, demonstrations, posters and film shows that highlighted research and technology development efforts. Some of these included demonstration of Remotely Controlled Airship, Remote Sensing and GRAM++, Polymers on Move and Polysensors, Global Positioning System (GPS) Receivers, Advanced Space Technologies and Global Navigation Satellite Systems, Agro Explorer, Nomad Education for Quality, Clean Water and aAQUA, Molecular Visualisation and Antigen-antibody Reaction. As a part of the Expo, Prof C Amarnath of Mechanical Engineering Department, gave a popular science lecture on Robotics. The IIT Bombay exhibits attracted nearly 10000 visitors.

Maintenance Free Letterbox for Indian Post

The old rusty red letterbox, popularly known as "Lal Dabba" just got a new look. This was due to the new futuristic-looking maintenance free letterbox designed by Prof B K Chakravarthy of Industrial Design Centre and inaugurated in December 2005.

Having maintenance-free post-boxes was the long time requirement by the Indian post and the initiative was taken up as a student project by Mr S Patil of IDC and later as a research project. The new letterbox has an interesting beak shape on the top, which calls for attention as the place where people post the letters. The design is such that the top box caps the stainless steel body from all sides, so that there is no ingress of rainwater. Even the slopes on the top box allow the rainwater to drain out fully. The letterbox is mounted on a base, so that the overhang can be used to put a bag and collect the letters easily. It can be mounted very quickly on the foundation bolts to be placed before hand in concrete. This high quality maintenance free stainless steel letterbox costs a little more than the existing letterbox but lasts five times the number of years. A design registration has been filed for the same recently.

Contact: chakku@idc.iitb.ac.in

Silicon Locket for Cardiac Monitoring

The Microelectronics group of IIT Bombay in collaboration with the School of Biosciences and Bioengineering has developed a Silicon Locket as part of a complete suite for cardiac monitoring and diagnosis. Three versions of the locket have been designed with appropriate hardware and software interfaces for downloading to a PC. The locket, which allows continuous monitoring of various heart parameters, has in-built algorithms for arrhythmia detection. At its occurrence, the locket automatically transmits through SMS the last few seconds of the ECG data to a central server using a mobile phone interface. The locket also has an integrated motion artifact detection software and interference cancellation scheme. An elegant SU8 based accelerometer has been designed, fabricated and tested for detecting motion artifact. A low-power version of the silicon locket is also under development, and a three-lead ECG chip has been designed and tested. Tata Consultancy Services, which has funded this programme, has demonstrated the Silicon Locket at a number of venues; currently field trials are underway at hospitals.

Contact: rlal@iitb.ac.in, dinesh@iitb.ac.in

Carbogen Breathing Apparatus

The Industrial Design Centre, IIT Bombay in association with a DRDO laboratory developed a system of Carbogen delivery for inhalation by persons working under high noise stress. Number of prototypes were developed and tested extensively with Indian Navy by Defence Institute for Physiology and Allied Sciences, Delhi. This system has been approved by Indian Navy for use of Jawans working in severe noise environments.

The system was developed in 3 capacities of 10 lit, 50 lit and 300 lit. The 300 lit unit has 10 stations and can accommodate 10 persons at a time for inhalation of Carbogen gas, which is a mixture containing 95% Oxygen and 5% Carbon Dioxide. Carbogen has a therapeutic role for impaired hearing and relieves the stresses due to noise pollution. If this is inhaled for 5 minutes, 2-3 times a day, the ill effects of working in severe noise environments, or noise stress can be eliminated.

It finds extensive use in Defence related environments such as firing ranges, aircraft hangers, ship engine rooms etc and in civil locations such as oxygen bars, traffic islands, fitness centres, workshops, factories etc.

Contact: munshi@idc.iitb.ac.in

Collaborative Research between IIT Bombay and NTPC

IIT Bombay and National Thermal Power Corporation (NTPC) are jointly undertaking research on the 'Development of Adsorbent based Process for the Capture of Carbon dioxide from Power Plant Flue Gases'. The two organizations will carry out basic collaborative research and technology development over the next four years along with laboratories of the Council of Scientific and Industrial Research (CSIR). The technology, when implemented, will enable NTPC to capture carbon dioxide from flue gases from its coal-based thermal power plants for its subsequent sequestration.

For NTPC, this is a major step in its quest for developing indigenous technologies through Energy Technologies Research Centre, a new initiative expected to enhance and strengthen the indigenous competency in adsorption research in the country.

Contact: amoharir@iitb.ac.in

CTARA to Build Dams in Karjat

Geology Survey in Progress

Preparing the Cut-Off Trench

Karjat Taluka of Raigad district is well known for its green hill stations and trekking spots such as Matheran and Bhimashankar. However, in spite of the heavy rainfall received here, come summer time, many villages and hamlets face a severe shortage of drinking water.

The Centre for Technological Alternatives for Rural Areas (CTARA) along with Civil Engineering Department, Computer Science & Engineering Department, Centre of Studies in Resources Engineering, Earth Sciences Department and Humanities & Social Sciences Department of IIT Bombay in association with the Academy of Development Science (ADS), Kashele, Karjat has initiated work to construct small dams in some of these hamlets. The main objective of these dams is to hold enough water so that drinking water needs for the villagers and their livestock are met for the whole year.

Two sites of Gudwanwadi and Belachiwadi have been selected initially for the current year and next year respectively, along with nearby hamlets of Amberpada, Kathewadi. The dam for Belachiwadi will be roughly 80m in length, with a 20m spillway and a maximum height of 8m with storage of about 30,000 cu. m.

The survey and study of the sites has been done by the Earth Sciences students and CSE students have developed a geometry code on Gram ++ developed by CSRE for water-shed/storage estimation. Civil Engineering researchers will undertake Geodesy, Dam Design, Construction and Analysis. Humanities and Social Sciences staff and students will conduct a need analysis, site selection and social analysis. ADS will be responsible for the social mobilization, local support and execution getting technical consultancy from Gangotree, an agency with considerable experience in social watershed development. Rough estimates for the dams are Rs. 12 lakhs for Belachiwadi and Rs. 18 lakhs for Gudwanwadi, which is being raised through donations from corporations and individuals. A large donation of Rs 20 lakhs by IITB alumni, Dr Shridhar Shukla, of G S Labs, Pune has been instrumental in taking this initiative further.

IIT Bombay sets up a Centre of Excellence in Nanoelectronics

IIT Bombay is setting up a Centre of Excellence in Nanoelectronics on its Campus to undertake state-of-the-art research in nanoelectronics, train manpower in this area, interact with industry, research laboratories and government departments, and create facilities to be used by nanoelectronics researchers all over the country.

Funded by the Ministry of Communication and Information Technology (MCIT), a similar Centre of Excellence is also being set up at the Indian Institute of Science (IISc) Bangalore. The total cost of the project is Rs. 99.8 crores spread over 5 years, shared equally by the two Institutes.

In addition to some common areas of research, the team at IITB will focus more on the devices and circuits aspects of nanoelectronics and the team at IISc will focus more on the materials aspects of nanoelectronic devices.

Clean-room in Nanoelectonics Centre

Nanoelectronics is the emerging area of electronics dealing with nanometer-sized devices used for electronic circuits and systems. Nanoelectronics is probably the most advanced of the nanotechnologies, and products are starting to appear in the market utilizing nanoelectronic devices.

This project represents the first collaborative effort between two leading academic Institutes in the country, to carry out a joint program in an important emerging area. In addition to Prof V Ramgopal Rao and Prof J Vasi, Department of Electrical Engineering as the Principal Investigator for this project, over 20 faculty members from six different department/schools are involved from IITB.

The joint activity between IITB and IISc is expected to have two major benefits. Firstly, it will ensure that several major equipments do not get replicated at two centres, thus leading to considerable cost saving. Secondly, it will ensure that the complementary expertise of the two teams is effectively used. In terms of manpower training, the centres will produce highly trained, innovative scientists and engineers with hands-on experience through the post-graduate and under-graduate programmes of these two institutes, as well as through the research assistant / associate programme. The number of trained personnel produced at the two Centres is expected to be about 200 per year at all levels. In addition, the centres will run several continuing education and short-term courses for participants from industry, government and research laboratories. The facilities created through this project will be available to researchers, scientists, engineers and users from other organizations, including academia, industry and government through the auxiliary "Indian Nanoelectronics Users Programme" (INUP).

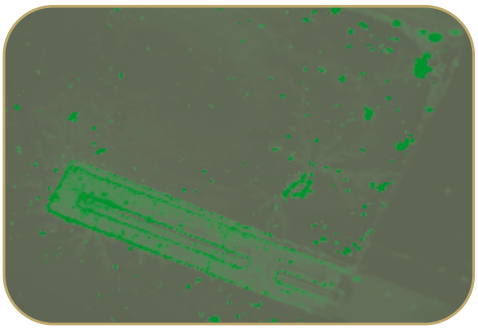
Contact: rrao@ee.iitb.ac.in

Consultative Meeting - WIPO Draft Treaty for Protecting the Rights of Broadcasting Organizations

The World Intellectual Property Organization (WIPO) is currently discussing the draft of a treaty to provide for protection of the Rights of Broadcasting Organizations in the TRIPS framework. The Ministry of Human Resource Development, Government of India is engaging all stakeholders in these discussions before formulating the country's position in Broadcasting and Copyright related issues.

In this regard, IIT Bombay and Ministry of Human Resource Development, Government of India had on 3rd September 2005, jointly organised a consultative meeting on a Draft Treaty for protecting the rights of broadcasting organizations. The treaty would have wide ranging implications on the rights of creators over the content carried on broadcast signals. Noted artists from the Indian film industry including writers, composers, lyricists, and singers enthusiastically participated in the meeting. Mr Sudeep Banerjee, Education Secretary, Ministry of Human Resource Development elaborated on the technicalities of the treaty and emphasised on the Government of India's willingness to safeguard the rights of all creative persons whose work come under this treaty. The artists expressed the views and concerns of creative community and requested for the safeguard of their rights. Mr Madhukar Sinha, Director, Copyright Division, Government of India discussed the key points of the draft treaty for protecting the rights of the broadcasting organisations.

Biosensor Array for Detecting Cardiovascular Diseases



A multidisciplinary team of faculty members is developing an integrated system that can provide point-of-care diagnostic support for cardiovascular diseases. Called "infarcSens" or "iSens", the system is a cantilever and molecular FET-based affinity biosensor array for sensing myocardial infarction and subsequent cardiac status prognosis, using a suite of molecular markers. It is particularly useful in detecting heart attacks that go unnoticed before a major or fatal attack occurs. The sensing electronics and the associated data management software for tracking the markers, with the time required for creating an epidemiological database is also being developed.

The development of such Nano-electromechanical biosensors (NEMS biosensors) involves fabrication of integrated polymer-nanocrystalline silicon based cantilever arrays for detecting markers for Acute Myocardial Infarction (cardiac muscle damage that accompanies a heart attack). The system uses a drop of blood drawn from the patient and injects it on a cartridge containing the arrays. The cantilevers are equipped with piezo-resistor grids with dimensions varying from 10 nanometers to 100 micrometers, and provide sites that bind marker proteins. The resultant mass or stress-induced deflection is sensed optically, as well as through a change in resistance.

The aim is to develop field-portable, high-throughput, protein detection systems as a common platform for characterizing a wide spectrum of diseases. The advantage of such a "protein-chip" is that it detects multiple markers in a single reaction, whereas currently available assays require a separate reaction for each analyte. This will reduce both the time and cost of diagnosis. In the first phase, the team is developing sensors for the markers, myoglobin and CK-MB. The work has been funded by the Government of India as part of the National Programme on Smart Materials.

Contact: mukherji@iitb.ac.in, rlal@iitb.ac.in, rrao@iitb.ac.in

VLSI Research Consortium

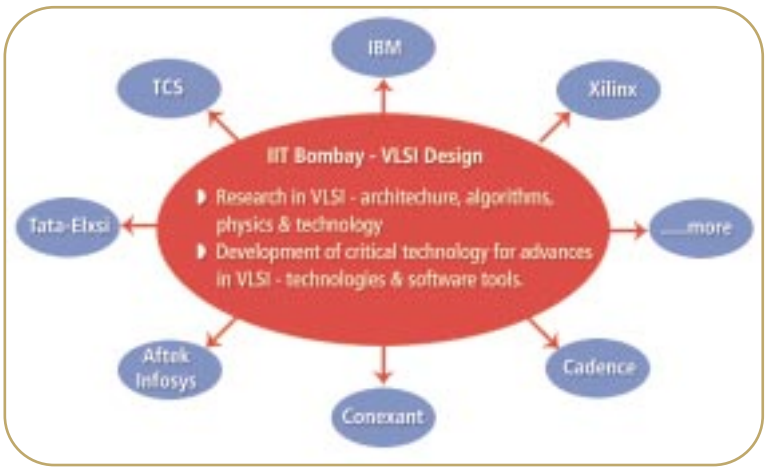
IIT Bombay has recently launched an initiative for supporting research in VLSI circuits and systems. This involves the organization of a research consortium consisting of participating industries together with IIT Bombay. The primary motivation for forming this consortium is:

- to provide a stable means of support for long term research in VLSI design.
- to increase the depth of industry/academia participation.
- to increase the exposure of students (especially post-graduate students) to significant issues facing the VLSI community.
- to create a knowledge and resource base in VLSI.

Even though there has been considerable interaction between industry and IIT Bombay, this has usually been in the form of focused, shorter-term projects looking at immediate problems. Some of the successful technologies resulting from this collaboration are: the Silicon locket (with TCS), a 3D capacitance extractor (with Intel), a packet classification circuit (with Switch-On networks), a FPGA based simulation and computing platform (with TI, Powailabs), among others. The consortium offers the possibility of sharing resources to address longer-term problems in VLSI, which arise due to the evolution of technology into the nano-scale.

Some Research Themes of Interest

- Large scale system partitioning and circuit simulation
- Asynchronous circuits and systems
- Memory sub-systems in systems-on-chip
- Reliable circuit design with unreliable devices
- Analog self-calibrating circuits
- Interconnect aware VLSI design
- High-performance computing using FPGAs
- RF circuits



The consortium operates on a simple model: companies can become members by paying an annual fee (currently set at Rs. 5 lakhs per annum), and joining for a minimum of three years. The member contributions are used to fund research (student stipends and equipment) in selected themes of interest. The consortium is advised by a steering committee, which is responsible for review and oversight of the research projects carried out under the consor-

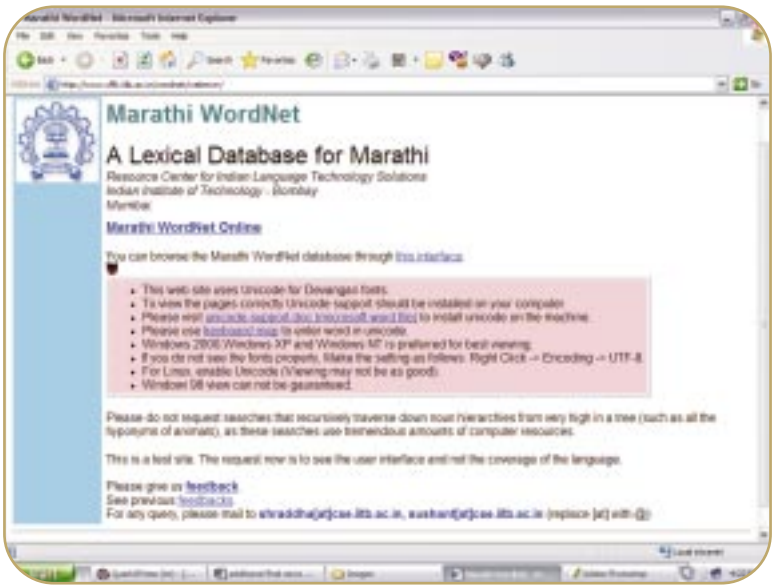
tium. The steering committee consists of IIT faculty and industry representatives appointed by the Director, IIT Bombay. The intellectual policy of the consortium is also simple: all Intellectual Property generated out of the research is owned by IIT Bombay. Member companies get unrestricted rights for internal use, and can obtain a right to sub-license all Intellectual Property in the consortium by the payment of an additional flat-fee.

This consortium holds the promise of a broader and deeper interaction between academia and industry, and it is hoped that it will serve as a means of exchange of ideas between experts in India and abroad. Currently, companies such as TCS, Cadence, Xilinx, Conexant and IBM are part of the consortium with several others expressing interest.

Contact: madhav@ee.iitb.ac.in

Online Lexical Knowledge Base for Marathi

The Prime Minister of India will release the Marathi CD which contains software on Marathi Language Processing developed at IIT Bombay and CDAC. IIT Bombay's contribution has been in the creation of high end tools and resources which include the Marathi Wordnet, spell checker and e-dictionaries. These tools and resources have been developed at the Centre for Indian Language Technologies (CFILT) at the Computer Science and Engineering Department at IIT Bombay, under the project Technology Development for Indian Languages. The CD will be distributed through CDAC.



An online lexical knowledge base for Marathi language, the Marathi Wordnet contains sets of synomymous words called synsets linked by the semantic relations of hypernymy, meronymy and cross part of speech linkage among others. Currently, there are about 10,000 synsets which correspond to about 22,000 unique words. On an average, 23 synsets are created and 12 corrected everyday. The web interface is at www.cfilt.iitb.ac.in/wordnet/webmwn. When completed with about 25,000 synsets, the resource will prove indispensable for automatic machine translation from and into Marathi, language teaching and text mining and information extraction applications. The resource has already been linked with the Global Wordnet Grid: www.globalwordnet.org.

Contact: pb@cse.iitb.ac.in

Highlights of Techfest 2006

Sadanand Kamath*, IIT Bombay

Techfest 2006, the ninth edition of IIT Bombay's Annual Science and Technology festival, was held from twentieth to the twenty-second January 2006. Techfest 2006 marked a radical departure from the conventional technical fests that focus on engineering fields only. Instead at Techfest 2006, the emphasis was on the latest technologies and their widespread applications. In tune with this approach, the six themes of Techfest 2006 were: A I (Artificial Intelligence), Cosmos (Space Exploration Technologies), Sixth Gear (Automobile and Aviation Technologies), e-Rustique (Emerging Rural Technologies), Smart Tech (Smart Technologies) and CONCREaTE (Modern Structural Engineering). Not only do these themes have widespread applications in today's world but also possess immense potential for the future. Each of these themes was explored in detail through various competitions, workshops and exhibitions.

The biggest draw at Techfest 2006 was Arizona State University's (ASU) Mars Rover Exhibition. ASU has collaborated with NASA on the Mars Rover project and the exhibition highlighted the various aspects of the project through scaled down models, fist sized meteorites, videos of Martian terrain and live feed from their cameras on Mars. The exhibition, held for only the second time outside USA, was led by a team of 5 senior researchers from ASU who had lively interactive sessions with the audience as well as lecture sessions.

The other exhibitions were from National Innovation Foundation (NIF) on indigenous technological developments, ISRO's India in space on India's moon mission - Project Chandrayaan as well as the Indian Air Force Exhibition (IAF) that showcased some of the latest defense equipment like radars and missile systems. The IIT gymkhana grounds were witness to spectacular shows of sky diving by the elite Akashganga team of the IAF and the Indian Army Adventure Wing's ballooning display.

With its growing international stature, Techfest in its recent edition saw four major competitions each of which car-

ried prize money of US $1000 for the winners. These were Micromouse (A I), The Simple Life v1.1 (e-Rustique), Full Throttle (Sixth Gear) and G R I P (Cosmos). Micromouse is an international fixture that required participants to devise an autonomous machine that could navigate its way in a maze. Full Throttle was a racing event with a difference, where participants used IC engines (3.2 cc) to power their way to the chequered flag. G R I P, one of the most challenging problems ever at Techfest, saw machines that could traverse a grid of cylindrical pipes and perform tasks along its path. The Simple Life v1.1 had participants developing innovative softwares that could be used in village kiosks to improve the rural scenario.

The winning entry was software for mobile phone solutions while other interesting entries were information channels, information and service provider, remote health care, web translators and weather prediction systems. Another notable event was Prayaas, a competition to develop aids for the physically challenged. This event, conceived in association with the National Association for Blind (NAB) and Happy Hours Centre (HHC), showcased a number of interesting entries like prosthetic hands, indoor navigation system for visually impaired, hands free web browsers and page turners and talking taxi meters. Along with these events, each theme had a host of other competitions over the three days.

Techfest continued into the nights with Technoholix or 'Techfest at Dark' to provide the entertainment and unwinding needed after a long day's work. The final night saw scintillating display of quizzing in the grand finale of the SciTech Inter Collegiate Quiz hosted by Barry O'Brian as well as the distribution of the Technovision Awards - the awards instituted by Techfest '06 to recognize and award innovative ideas in the fields of science and technology.

The lectures at this year's Techfest witnessed talks by leading authorities from various fields. The speakers were:

- Prof Anil Gupta, who holds the Kasturbhai Lalbhai Chair in Entrepreneurship at IIM Ahmedabad and also Executive Vice Chair of National Innovation Foundation
- Prof Rodney Brooks, head of MIT's Computer Science and Artificial Intelligence Lab and chairman of iRobot Corporation
- Mr Mark Shuttleworth, the second space tourist, technology entrepreneur and also head of The Shuttleworth Foundation a non-profit organization dedicated to social innovation
- Dr Amar Bose, founder and CEO of Bose Corporation, internationally renowned for their powerful and efficient sound systems
- Mr Sam Pitroda, head of WorldTel and the man responsible for bringing about a telecom revolution in India in the 1980s

Another major festival event was the roboTRIx workshop. Through its various competitions, most notably Yantriki, Techfest has played an instrumental role in the spread of robotics in India. Workshops have special significance because they focus on hands-on learning that goes beyond text book knowledge and gives the participants a great practical experience. Putting the two together was the roboTRIx workshop in which participants were taught to design a robot of their own over a period of three days with a special robotics kit. This workshop saw a tremendous response drawing participants from all across the country. Other workshops held during festival were Codec (digital coding and formatting), Grey Circuits (neural networks and fuzzy logic), CreateCAD (Auto CAD) and Iterations (CFD).

Air Force Exhibition at Techfest

Team preparation for the Full Throttle Competition

The events described above are just a small fraction of the numerous events that happened over the three days and three nights of Techfest 2006. Despite stepping away from the traditional approach, the 2006 edition of the technology festival was a huge success receiving wide coverage and appreciation.

Contact: sadananddk@iitb.ac.in

*** Second Year B Tech Student of Department of Chemical Engineering**

Automatic Flood Warning System for Mumbai

The Brihanmumbai Municipal Corporation (BMC) will install an automatic flood warning system for Mumbai by the monsoon of 2006. At a recent meeting, the BMC decided to test the system in 25 flood-prone spots in the city and figured that its core components would cost approximately Rs 50 lakhs, a senior official said.

The system will consist of electronic rain gauges rigged to send alarm signals to a central control room in the event of a rise in the water level. If the system is found effective, the control room will be enhanced to send out flood warnings to public transport undertakings such as the railways and the BEST. Mumbai's system should be able to warn citizens half an hour before a flood such as 26/7 occurs, the BMC has estimated.

While the BMC has been mulling over a flood-warning system since 26/7, the meeting is a concrete step in that direction. In this regard, the BMC has appointed IIT Bombay as consultant for the warning system.

Apart from designing the system, the institute will identify about 25 sites to install the electronic rain gauges. Most sites may likely be in the suburbs, the worst-hit by the 26/7 floods. The institute will also peg the water level at which the electronic rain gauges should send warnings.

The rain gauges measure rainfall by accumulating rainwater. When it rains at a certain level above expectation, the gauges send out a warning to the control room which relays it to the general public. The electronic rain gauges will have to be imported at an estimated cost of Rs 2 lakhs each, and their supporting IT infrastructure will cost extra.

Similar systems are already in use abroad. Thirteen eastern states in the USA have about 1,300 electronic rain gauges. China has installed water-level and rainfall gauges at 70 locations along the flood-prone Yangtze river.

Contact: kgupta@iitb.ac.in

A Silent Revolution: Assessing Output of Women Graduates & Post-graduates from IIT Bombay

S P Sukhatme* and P P Parikh*

A silent revolution has gradually made its impact felt across the country in the last twenty-five years through the increasing participation of women in the engineering profession. Till the early 1980s, the output of women with a Bachelor's degree in engineering was negligible. However, since then the enrolment and consequently the output has shown an increasing trend. The trend began first in the southern states. It spread to the western states and is now gradually making its presence felt in the north and the east of the country.

Keeping the importance of the subject in mind, two extensive studies on women engineers were taken up at IIT Bombay [Parikh and Sukhatme 1992, 2002 & 2004] through sponsorship from the Department of Science and Technology. One of the issues analyzed in the studies was annual data on the turn-out of women engineers both state-wise and discipline-wise. The data obtained showed that the turn-out increased very slowly from less than 1 per cent to about 1.5 per cent through the seventies and early eighties. Thereafter the percentage output has been increasing steadily. Today it is estimated that for the nation as a whole, the output of women engineers is between 10 and 15 percent. Because of the steep rise in intake capacity, the national output has increased from about 25,000 engineers in 1980 to about 200,000 in 2005. This implies that the national output of women engineers has increased approximately from 300 in 1980 to a number between 20,000 and 30,000 in 2005. This represents a hundred fold increase!

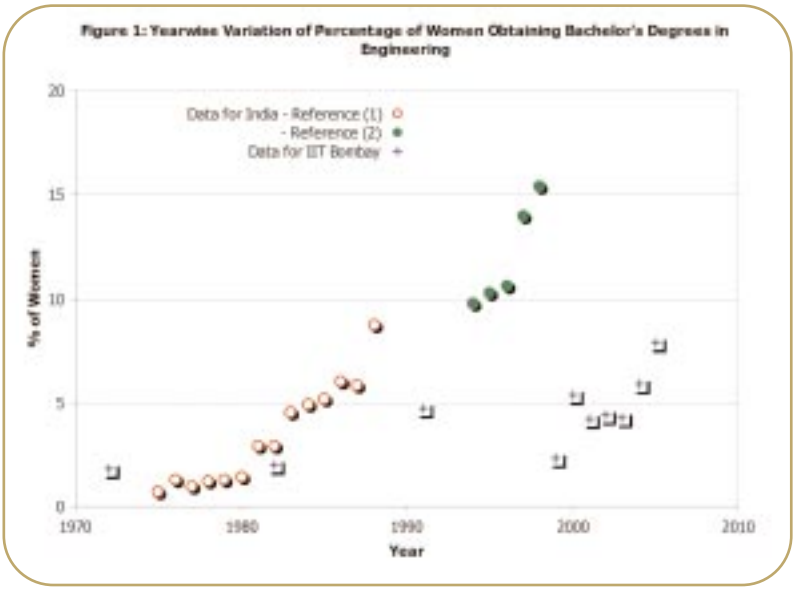
IIT Bombay Data

Keeping in view the national scenario, it is of interest to study the trends at IIT Bombay by analyzing data on women graduating from the Institute over the last few years. The data on the B Tech and the post-graduate programmes was compared with the national estimates. These data have been compiled from the reports printed at the time of the convocation every year.

Table 1: Data for the BTech Degree Programme

Year	1972	1982	1991	1999	2000	2001	2002	2003	2004	2005
No. of Women	6	5	14	8	17	13	13	12	15	22
Total Number obtaining BTech degree	342	252	301	343	315	307	293	282	254	279
% of Women	1.8	2.0	4.7	2.3	5.4	4.2	4.4	4.3	5.9	7.9

Data for the B Tech programme have been obtained for seven years in a row (1999 to 2005) and for three earlier years (1972, 1982 and 1991) and is presented in Table 1. The data show that the number of women obtaining their B Tech degrees from IIT Bombay has always been low and that the percentage has ranged from 1.8 to 7.9, with the value for many years being between 4 and 5 per cent. There is some indication that the percentage values are increasing. However the values for IIT Bombay are clearly lagging behind the national data obtained in earlier references (Parikh and Sukhatme, 1992 & 2002) and observed in Figure 1. The percentage of 7.9 in 2005 is also considerably less than the value



for colleges and universities in the western region. In Mumbai, most colleges at present have an output percentage exceeding 20. It may also be worth noting that the values obtained for IIT Bombay are a reasonable representation of the picture at other IITs.

Table 2: Percentage of Women Passing Out of Various Academic Programmes at IIT Bombay

	Year						
Degree Programme	1999	2000	2001	2002	2003	2004	2005
B Tech	2.3	2.3	4.2	4.4	4.3	5.9	7.9
Dual degree	--	--	8.4	4.5	5.4	3.5	4.3
M Tech	8.0	9.7	12.0	8.5	9.8	9.5	9.0
M Sc 2-yr & 5-yr	22.2	35.9	39.1	17.4	37.6	25.0	22.4
M Des, M Phil M Mgt, MS	21.6	17.9	21.9	12.1	9.8	18.8	19.0
Ph D	16.1	16.5	15.1	21.3	18.1	24.3	13.0

Table 3: Combined Data for All Degree Programmes

Year	1999	2000	2001	2002	2003	2004	2005	Total
No. of Women	92	116	127	100	125	112	136	808
Total number of students obtaining degree	989	937	1013	1113	1116	1015	1247	7430
% of Women	9.3	12.4	12.5	9.0	11.2	11.0	10.9	10.9

One can also similarly analyze the percentage data for all degree programmes at IIT Bombay (**Table 2**). It is seen that the values for the dual degree programme are similar to those for the B Tech programme. This is to be expected since admission to both the programmes is through the same Joint Entrance Examination (JEE). In the other programmes, the values are also generally low though higher than the values for the B Tech programme. It is also noticeable that there are no trends indicating an increase in the percentages over the years 1999 to 2005 in any of the programmes.

More specifically for the engineering based M Tech programmes, the percentages of women graduates range between 8 and 12 with the average for all years being 9.5 per cent. On the other hand, for the science-based M Sc programmes, the per centages are higher and range from 17.4 to 39.1 per cent. For the other Master's degree programmes (M Des, M Phil, M Mgt & M S) the percentages range from a low of 9.8 in 2003 to a high of 21.9 in 2001. The Ph D degree includes the sciences, engineering and technology, management and the humanities and social sciences. Here the per centage of women ranges from 13.0 to 24.3 per cent, with the average value for all years being 17.3 per cent.

The combined data for the period 1999-2005 for all programmes at the Institute are also of interest **(Table 3)**. It is seen that the percentage output of women has fluctuated between 9.0 and 12.5 per cent. Over the years, the number of women obtaining degrees has increased by about 25 to 30 per cent. However this is not reflected in an increase in the percentage output because the overall output of the Institute has also increased. The output for the Institute as a whole is now around 1250 compared to an output of slightly less than 1000 in the late nineties.

An Assessment

It is clear that the percentage of women passing out of the B Tech and dual degree programmes of IIT Bombay is however still low. This is because of the fact that the percentage of women who appear for JEE is itself low. The figures for the other programmes are a little better, but should certainly be higher. The picture at the other IITs is probably the same.

IITs are institutions with a national mandate. Thus it would be appropriate and worthwhile to adopt a pro-active stance and undertake some special measures. These would ensure that more talented women join our Institute and receive the benefit of education of the highest quality. In this context it is worth reflecting on the following issues: (1) The Institute should organize awareness programmes to make the public aware of the facilities and academic courses available. Such programmes can be held both inside and outside the campus at selected locations on a regular basis. The media can be actively used for such purposes. (2) The information brochure for JEE and brochures issued in connection with admission to our other programmes should describe the on-campus facilities and opportunities for women students at IIT Bombay. Such brochures could also highlight success stories of our women alumni. (3) In conjunction with other IITs, IIT Bombay could consider the possibility of exempting women students who qualify through JEE from payment of fees. This type of encouragement is being offered for engineering degree programmes in some states in India and has proved to be rather successful. (4) Alumni of the Institute should be requested to help in the effort to persuade more women students to join IIT Bombay. The establishment of more scholarships for women students would be an important step in the right direction. Alumni could also help by pledging funds for a new ladies hostel on the IIT Bombay campus.

Contact: sukhatme@iitb.ac.in, b2parikh@yahoo.com

*** Prof S P Sukhatme and Prof P P Parikh are both Professors Emeritus, IIT Bombay**

Novel Processes Recently Developed Utilizing Unique Properties of Carbon Dioxide

Mamata Mukhopadhyay, Department of Chemical Engineering

Increasing demand for superior quality and safety of foods and medicines, as well as serious concern for environmental protection have given impetus to develop newer technologies all over the world. Over the last two decades Supercritical Fluid Extraction Technology (SCFET) using carbon dioxide (CO_2) as the solvent above its critical pressure of 73.8 bar and critical temperature of 31.1^{O}C, has globally emerged as a superior alternative to the conventional steam distillation (SD) and solvent extraction (SE) techniques in food, pharmaceutical and cosmetics industries. CO_2 is clean, environment-friendly, and non-polluting. It is generally regarded as safe (GRAS). Also $SCCO_2$ offers high selectivity, tailor-made solvency, easy availability, low cost, non-flammability and non-toxicity. It yields contaminant-free, tailor-made extracts of superior organoleptic profile and shelf life, with high potency of active ingredients and better blending characteristics. In view of India's rich botanical and marine resources, SCFE has high potential in achieving a significant value-addition to its traditional export of raw natural materials. In addition to SCFE, the unique thermodynamic, transport, physico-chemical and biological properties of CO_2 at supercritical (SC) and subcritical (SB) conditions have given impetus to develop several innovative processes for production of nanoparticles, purification and preservation.

Supercritical Fluid Extraction Technology

Only a decade ago SCFET was successfully developed at IIT Bombay through a MHRD-sponsored Mission Project to make it commercially viable in India for a variety of natural extracts. The key element in the indigenous design and development activity was to optimize the capital investment cost for the SCFE plant and equipment. Even at the existing price (of extracts from SE and SD) of oil and oleoresins, the investment on SCFE has been made profitable which now justifies it to be the preferred route based on the IIT Bombay Technology. IIT Bombay, in association with an industrial partner, now offers world-class economically viable SCFE plants at a substantially lower cost than the imported equivalent.

Innovations in SCFE for Recovery of Enriched Nutraceuticals

Natural colors and vitamins have wide ranging applications because of their importance as micronutrients and can be extracted from plant sources. An innovative process has been developed for recovery of two natural color compounds, namely lycopene and lutein, and an antioxidant-carotene, a precursor to vitamin A, from sources like tomato, marigold flowers and carrot respectively. For the recovery of carotenoids, the conventional SCFE uses $SCCO_2$ at very high (400-700 bar) pressures, despite a long feed preparation and elaborate pretreatment procedure to release active ingredient (AI) from the bound state. An improved feed pretreatment protocol (Indian Patent Application 545/MUM/2004) has been developed for extraction of nutraceuticals with enriched AI at relatively moderate pressure (<400 bar) of $SCCO_2$ in much less time. The new process facilitates very high (92-97%) recovery with relatively high concentrations (15-20wt.%) of carotenoids, unlike the existing processes.

Direct SCFE for Metal Ion Separations

Reprocessing of the spent nuclear fuel for extraction of plutonium (Pu) and uranium (U) is conventionally carried out by the PUREX process using tributyl phosphate (TBP) as the extractant and dodecane as the diluent. However, as this process generates considerable volumes of highly active nuclear wastes, SCFE is being explored as an alternative to PUREX for significantly reducing the reprocessing cost of the radioactive wastes. Direct supercritical extraction of U and Pu from spent fuel uses both neutral organo phosphorous ligand, eg, TBP-HNO3 complex and fluorinated ß diketone. As it needs to combine with nitric acid first, in our work, direct $SCCO_2$ extraction of valuable heavy metal ions has been successfully accomplished from the used oxide spent fuel, without the usage of nitric acid. The selective direct extraction of metal ions has been aimed at in-situ conversion of lanthanide oxides to metal chelates using $SCCO_2$ modified with TTA or TBP or both, followed by SCFE. The chelation is enhanced by adding a nitrogen donor like imidiazole along with TTA.

Production of Ultra-fine Particles Using $SCCO_2$

There has been increasing demand for ultra-fine particles with a narrow particle size distribution (PSD) for utilizing the new drug delivery systems, such as dry powder inhalers, needle-free injections and controlled release devices. These are used to enhance the drug dissolution rate and bioavailability, to provide prolonged action of the drug, and to eliminate repetitive/excessive dosages. Nano/ultra-fine particles have been produced recently by rapid crystallization using $SCCO_2$ as antisolvent in the solution of the solid drug in an organic solvent, by means of the Gas Antisolvent (GAS) and Supercritical Antisolvent (SAS) processes.

Novel Process for Nanoparticles using Subcritical CO_2

The $SCCO_2$ processes for production of ultra-fine particles require (i) very high pressures of the order of 200 to 400 bar, (ii) high pressure CO_2 pumps, (iii) nozzle devices of micrometer size for spraying, which are prone to clogging and (iv) usage of large flow rates of $SCCO_2$ for removal of solvent. Accordingly a novel process (Indian Patent Application 544/MUM/2004) has been developed for production of nanoparticles in the range of 0.1 to 1 μm using $SBCO_2$ without using a nozzle and a pump. The process instantaneously lowers the temperature (in the range of -15 to -55 ^{O}C) in the CO_2-dissolved solution at pressures of 50-70 bar and temperatures of 20-30 ^{O}C without the use of high-pressure pumps and specially designed fine nozzles. The process has been validated for production of ultra-fine particles of various solid drugs such as cholesterol, citric acid, aspirin, ascorbic acid, paracetamol, PLA, and PEG-4000 from their solutions in a number of organic solvents.

Purification of Lecithin and Bioactive Compounds by Subcritical CO_2

Gas Antisolvent Crystallization (GASC) has been utilized for purification of bioactive compounds by dissolution in an

organic solvent, followed by crystallisation with dense CO_2 as the antisolvent at a near ambient temperature in the pressure range of 50-65 bar. This has been effectively utilized for refining of crude lecithin from its solution in hexane, leaving behind its oil in the solution for enrichment up to 98.6 wt. % lecithin in the solid product. As lecithin is less soluble in hexane than oil, the antisolvent effect of the CO_2 dissolution selectively lowers the solubility of lecithin in preference to that of oil. Similarly ethyl acetate solution has been used for purification of ß-carotene and Lico chalcone-A, and acetone for a-hydroxy citric acid.

Food Preservation using $SCCO_2$ Processing

$SCCO_2$ has been utilized for sterilization and stabilization of liquid and solid foods and health care products without degrading the bioactive components and without any additives. A recent process (Indian Patent Application 543/MUM/2004) developed at IIT Bombay has been demonstrated to remarkably enhance the shelf life and safety of a variety of food products as listed in **Table 1**. In this process both aerobic and anaerobic microorganisms, spores, fungi are inactivated and even enzymes are deactivated, for making the foods shelf-stable while retaining their original freshness (color, flavor, taste, texture, and nutrients). The mild operating temperature of $SCCO_2$ retains the bioactivity and nutrients of the foods with no artifacts, while minimally affecting organoleptic characteristics. $SCCO_2$ used in the process, diffuses out of the food system after the processing and leaves no residual contaminants. The pretreated soybeans are auto-dehulled, sterilized, shelf-stable and stored as ready-to-use stock for preparation of instant soymilk or any desired soy products later. It does not have any beany flavor, chalky taste, tripsin inhibitor and can be stored without refrigeration.

Table 1: Shelf life of Different Food Systems after SCCO2 Processing

Sample	Initial Microbial Count CFU/ml	Final Microbial Count CFU/ml	Shelf-Life without Refrigeration, Days
Tomato	190×10^2	10^2	120
Sugarcane Juice	315×10^2	6×10^2	15
Milk	296×10^4	10^4	05
Water	240×10^7	0	45
Aloe juice	105×10^2	7×10^2	40
Soymilk Soybean	1.156 (FFA) ---	0.5263 (FFA) ---	15 35
Rice bran			45

Conclusions

Supercritical fluid extraction (SCFE) technology for production of biologically active principles and natural concentrates has been made cost-effective for the food, cosmetics and pharmaceutical industries. New process innovations have lowered the pressure requirement and time of processing. Recently $SCCO_2$ has been used as for production of ultra-fine particles, due to its excellent transport and thermodynamic properties. Even subcritical CO_2 can be utilized for production of nanoparticles without a high-pressure pump and spraying nozzle and also for purification of lecithin or bioactive compounds. Novel processes developed using $SCCO_2$ at moderate conditions can be used for preservation of solid and liquid foods with remarkable enhancement of shelf-life.

Contact: mm@che.iitb.ac.in

Solar Concentrator for Industrial Process Heat

Shireesh B Kedare, Energy Systems Engineering

A group of ex-IITians working as consulting engineers of Clique Developments Private Limited with research support from IIT-Bombay has achieved a landmark in the field of Solar Energy Utilization. They have successfully installed and commissioned a large solar concentrator that can generate process heat at about 200°C, store it and supply it at desired process temperature any time of the day or night. The technology holds potential to save up to 6 to 10% of India's oil imports thus saving on huge foreign exchange reserves. It also opens up the doors for solar power generation by thermal route at less than half the cost of the Solar Photo-Voltaic (SPV) systems available presently.

Figure 1: ARUN160, installed at Latur for milk pasteurisation - June 2005

Figure 2: The focus of ARUN160 on focus plate at the receiver mouth

ACKNOWLEDGEMENTS

The system at Latur is being installed under R&D project of IIT-Bombay with Clique Developments Pvt Ltd as collaborating organization. It is sponsored by MNES (Ministry of Non-conventional Energy Sources, New Delhi) with Mahanad Dairy contributing 50% of the Solar System cost and Clique bearing part of the design cost.

Table 1: Technical specifications and performance of ARUN™	
Fluids used	Water-steam or thermic fluid or air
Temperature range	Up to 250°C
Operating wind speed	15 m/s or 54 kmph
Survival wind speed	39 m/s or 140 kmph
System life	25 years

Table 2: Single Unit Performance		
Performance of a single unit of ARUN	ARUN70	ARUN160
Reflector area	55 m^2	123 m^2
Aperture area	70 m^2	160 m^2
Thermal power (annual average)	20 to 35 kW_{th}	50 to 80 kW_{th}
Annual operating hours	3050 to 3125 h/yr	3200 to 3350 h/yr
Annual fuel savings (Furnace Oil or Diesel)	6 to 8 kL/yr	16 to 24 kL/yr
Annual electricity savings	55 to 70 MWh/yr	140 to 180 MWh/yr
Aerial clear space required for a dish	15 x 10 x 12 m ht	25 x 20 x 18 m ht
Foot-print / clear area required on ground / roof	2 x 2 m	3 x 3 m
Tracking power (W)	300 W	500 W
Annual reduction in CO_2 emission	20 to 100 tonnes	42 to 200 tonnes

The experience of successful commercial development of solar flat plate water heaters in household sector has made it clear that solar energy is economic today in its thermal form. However, for widespread and technically convenient utilization of solar energy in industrial sector, higher temperatures from 100°C to 200°C are needed. Hence, solar concentrators of high efficiency and improved economy is the need of the day. Many efforts have been reported on the development of Parabolic Trough as well as Paraboloid Concentrator with Point Focus. Most of the efforts involve construction of a curved paraboloid support structure fixed with small mirrors or reflecting surfaces to form the paraboloid reflector. However, with a combined synergy of IIT Bombay's research capacity and Clique's industrial designing and implementation capacity, an easier, cheaper and more efficient technology was developed consisting of Fresnel Paraboloid Reflector with point focus (or a focus of small area) with reflector facets fixed on to a flat tracking surface. Further, the system has tracking mechanism to continuously face the Sun which helps in operating the system near its peak capacity for 7 to 8 hours a day.

For the first time in India a Solar Concentrator for Industrial Process Heat is available with:

Largest aperture area and highest annual heat generation capacity, highest operating temperatures and highest stagnation temperatures and capacity of day-long energy storage and integration with a wide range of applications.

The Solar Concentrator System, named ARUN [Trademark Registered] is a Fresnel Paraboloid Concentrating Solar Collector System, with two-axes tracking flat reflector dish of 160 sq.m aperture area having 800 mm diameter cavity receiver at focal point. It is a solar device providing medium range temperatures for industrial thermal applications. The dish and support structure are made up of mild steel (MS). The reflectors made up of flat mirrors are inclined at pre-calculated angle. They reflect and concentrate the solar beam radiation at its focus having about 500 mm diameter area and generate high temperature heat energy. It is absorbed by hat-shaped downward facing cavity receiver designed for minimum thermal loss. This receiver has low view factor of about 0.1 that reduces radiative losses. Its downward cavity shape helps in stagnation of hot air and reduces convective losses. An insulate pipeline delivers this heat-energy to user. The system fluid outlet temperature can be up to 200°C. The Micro-Processor based electronic control circuit automatically drives the dish on two axes such that it always faces the Sun. Process and safety controls are built into the Micro-Processor based control circuit along with emergency alarm system and user-friendly display unit. The reflectors are made up of glass, which can be easily cleaned and its reflectivity can be maintained even in the industrial environment. Accessories are provided for cleaning the reflectors daily with ease. The system, named ARUN, installed at Latur for milk pasteurisation is seen in **Figures 1 and 2.**

Salient features of ARUN:

- Fresnel Paraboloid Solar Concentrating Reflector with Point Focus
- Two-axes tracking mechanism for automatically tracking the sun giving maximum daily output
- Specially designed receiver with minimum thermal losses developed by IIT-Bombay fixed at focus
- Water or thermic fluid or industrial oils or air as working fluid
- Storage vessel for heat delivery any time of the day or night
- Built-in safety controls with emergency alarm system and user-friendly operating unit
- Testing procedure developed by IIT-Bombay
- Available in two sizes: ARUN 70 and ARUN 160

Applications of Solar Concentrator

The ARUN Solar Concentrator System can be used in 'ADD ON' mode and can be retrofitted to the existing boiler or heater system in the industry. In this mode it delivers energy whenever beam radiation is available and saves fuel used. This uses minimum storage capacity. The thermal energy generated can also be stored in thermal storage to supply energy requirements during evening and night. Pressurized water system is used for evacuation and storage of thermal energy.

The unit is best suited for the industrial applications using thermal energy from electricity or liquid fossil fuels. The thermal medium can be high or low pressure process steam, hot water, hot air, hot thermic fluid or oil. It can be used for providing process heat for a wide range of industries and chemical processing plants using boilers or heaters, textile mills, sugar mills, vegetable oil mills, agro and food processing industries, timber industry, milk processing, drying of horticultural, food and fruits products, drying of chemicals as well as units using vapour absorption refrigeration for space cooling. It is also suitable for hotels and hospitals for providing hot water, steam and cooling.

This Arun Solar Concentrator can be fitted with 25 kW Stirling engine to generate electrical power through thermal route. Presently a one MW plant using 40 units of solar concentrators of similar size is being installed at Mojave Dessert near Las-Vegas, USA. Solar farms with 500 MW and 800 MW capacity are also planned there. With the ARUN solar concentrators already in place, India is not far behind.

The Underlying Economics

The system with 160 sq m of aperture area including tracking controls and mechanism as well as thermal circuit is designed and fabricated using indigenously available material and has system cost of Rs.15,000 to 17,000/sq m of aperture area. It can save about 18,000 to 22,000 liters of liquid fossil fuels or about 160,000 kWh of electricity if used for heat generation. This system installed at Latur for supplying thermal energy (heat) for pasteurizing 20,000 lit of milk daily, can save 50 to 70 litres of furnace oil per day or a saving of approximately 20,000 liters of furnace oil annually. A smaller system of 70 sq m of aperture area has also been designed.

Soft loans can be available through financing institutes covering 80% of the initial cost for installing this Solar Thermal Concentrator System @ 7.5% pa. The system can save more than the EMI of this loan for non-cloudy clear months if it is used to replace heating that otherwise uses FO, LDO, diesel or electrical heating. The annual operating and maintenance cost of the system can be as low as 2% of its capital investment. Economic analysis suggests that a payback period of 4 to 5 years is possible when liquid fossil fuels are saved. The system then provides free energy for 20 more years. The IRR comes to 30 to 70% depending on the fuel saved. The economics improves when electricity is saved.

Contact: sbkedare@iitb.ac.in

The Challenges of Adopting Better Corporate Governance Norms

Praveen M Bhasa*, Shailesh J. Mehta School of Management

The recent growth in corporate governance literature has focused on ways that corporations work. Firm behavior was earlier modeled on the argument of the neo-classicists who asserted that firms are nothing more than production counters. All activities of the firm were geared so as to maximize profits. Finance literature in particular came a long way in explaining the various financial theories of firms and the behaviours associated with them. With the increasing understanding that mere economic and production based explanations do not exhaustively describe the motivations for governance, researchers have focused on the behavioral side of firm performance to justify the economic rationale of such typical behaviors.

The foundational argument of corporate governance as seen by both academic as well as other independent researchers can be traced back to the pioneering work of Berle and Means (1932) who observed, as early as the 1930s, that the modern corporations having acquired a very large size can create the possibility of the separation of control over a firm from its direct ownership. Erstwhile promoters who largely controlled and managed their organizations increasingly needed specialized skills. Professionals with the required skill-sets were to be hired. Berle and Means' observation of the departure of the owners from the actual control of the corporations led to a renewed emphasis on the behavioral dimension of the theory of the firm.

The modern day uproar over corporate governance problems of insider trading, excessive executive compensation, managerial expropriation of shareholders' wealth, false reporting, non-disclosure of certain accounting and governance malpractices and self-dealing among others, are assumed to be related to the theory of separation of ownership and control.

Theoretical interest in corporate governance in India is a recent phenomenon. It is a result of a spate of corporate scandals that shook the country during the early liberalization era (Goswami, 2000). Obscure companies quickly listed on the exchanges during the stock market boom of 1993-94 only to disappear after siphoning off public funds and leaving the retail investors with illiquid stock. The sudden appearance of fly-by-night operators during the period coupled with the emergence of a new breed of shareholders like the foreign investors, institutional investors, mutual funds and private equity placement companies and their demands for better governance practices has compelled the policy makers to think of the governance anomalies in corporate India.

Before the onset of liberalization the Indian organized sector dominated by public and private enterprises did not meet the expected norms and standards of governance. Both the public and the private sector enterprises were bracing themselves to meet the challenges of globalization. Moreover, with increasing foreign investment in Indian industries, accountability to foreign shareholders had become an increasing necessity. With the institutional investors emulating the practices of their counterparts from developed economies, better governance practices had to be adopted for such organizations to sustain themselves in the economy for longer periods.

The demands of financial liberalization, it appears, have helped in imparting greater control to the banks in their

operations. Responsibility has now been totally fixed upon them for any likely loan losses (D'Souza, 2000). This has led to banks now extending external finance in lieu of some control rights, apart from their regular pecuniary priorities. Since the structure of corporate finance in India is highly dependent on bank's financial resources, some authors argue that the legal structure should be so developed that banks are freed from excessive portfolio restrictions and governance mechanisms be so devised that bank representations on boards become a reality. This would enable banks to maintain proper checks and balances apropos of, expropriation of shareholder value by the managers.

Varied opinions were articulated in India in response to wide ranging corporate scandals like violations of foreign exchange regulations, making clandestine payments to politicians, involvement in illegal activities and unethical deals by the top industrial houses (Godbole, 2002). While some suggested that the investigations might scare away the foreign investors and the economy would once again be in tatters, others stressed on the importance of social responsibilities of business. However, not until the groundwork done in terms of preparing a code for corporate conduct by the Confederation of Indian Industries (CII) in 1998, was the importance of corporate governance officially realized. The code was prepared with the view that Indian companies had to adopt the best of corporate practices if they were to access domestic as well as foreign capital at competitive rates. The code agreed that there was no unique way of understanding corporate governance. Different structures established in different countries might not be pertinent to local conditions. With increased exposure to global markets it became imperative on corporations to focus on transparency and adopt full disclosure mechanisms apart from consistently directing themselves towards amelioration of shareholder value. The code initially focused on the public listed companies.

Corporate governance practices have gained a greater impetus after the adoption of the much-celebrated Securities and Exchange Board of India (SEBI) appointed Kumar Mangalam Birla Committee (KMBC) Report on Corporate Governance. The acceptance and ratification by SEBI in early 2000 of the KMBC report on corporate governance has paved the way to rationalize and restructure governance practices in corporate India. The SEBI report was a timely intervention to keep a tab on the uninhibited corporate misdemeanors rampant in India. The recommendations are supposed to be enforced through provisions in listing agreements by local stock exchanges where the companies are listed.

However the report does not bring under its purview unlisted firms, which are mushrooming rapidly. Moreover, given the illiquidity of most of the firms in stock exchanges, stronger listing norms do not have any necessary material effects if such firms do not adhere to the mandatory disclosure norms. Only companies that are in the highest bracket and that trade voluminously are affected by such norms and hence try to abide by them.

The new recommendations have forced a dramatic alteration in the disclosure norms for closely-held firms or family-dominated firms. Demands made by the report of certain disclosures and the mandatory setting up of the recommended sub-committees will strike a hard blow on majority of the listed firms. The mandatory nature of the recommendations, whose failure would invite strict action by the local exchange, will compel a firm to make disclosures despite a seeming reluctance.

The existence of a reasonably strong financial press in the country has paid dividends by obliging the law-enforcing bodies to be extra vigilant. For the past few years the press has been buttressing the need for disclosure through its financial analysis and revealing stories of corporate misdemeanors. Overall, it can be said that corporate governance as a concept is slowly seeping into the Indian business practices, whatever the compulsions of avoiding it may be. The pace at which corporate governance practices are being adopted by the industry does however cast a doubt on the intentions of both the regulators and the industry. The practical difficulties of adopting transparent mechanisms that would remove the veil of accounting practices that firms have so far adopted has led to the slow acceptance of corporate governance norms. Nevertheless, for reasons mentioned above, it is clear that the adoption of better governance practices cannot be done away with because the costs attached to non-compliance to global standards would take a heavy toll on those firms that would want to be long-term players.

Contact: mpbhasa@iitb.ac.in **(*Ph D Graduate of Shailesh J. Mehta School of Management)**

Technology Developed & Transferred to Industry* (cover photographs)

In the first row
1. K-Yan
2. Bio-char Unit

In the second row
1. SCFE Unit
2. Asan Bank
3. MoU signed with NTPC
4. Heat Recovery Unit

Address for Correspondence:
Dean R&D, Industrial Research & Consultancy Centre (IRCC)
IIT Bombay, Powai, Mumbai 400076
Tel.: +91 22 2576 7039 Fax: +91 22 2572 3702 / 3480
E-mail: update@ircc.iitb.ac.in

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