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Practical Aspects of Technology and Innovation Capability Building: Learning from the Case of Mechatronics Lab

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Abstract

Technology and innovation capabilities are becoming important as Indian organizations and firms prepare for next level of international competitiveness. Emerging technologies such as Mechatronics can be a growth engine for many firms as well as a country if international competitiveness is achieved and sustained. Our ongoing research on technology and innovation management and their role in competitiveness has thrown light on some key dimensions of the concepts and problems in India. Drawing on exposure to grassroots in India as well as the most sophisticated technological contexts such as Europe, Japan and the North America provides interesting insights into differences between India and other countries on key dimensions and gaps for India. Experimentation, research and consulting have provided glimpse of opportunities and challenges. Learning from the case study of "Mechatronics Laboratory", IIT Delhi are synthesized here and generalized to draw implications for professionals and organizations. The focus here is on technology capability building. Consistent support from industry and other achievements are indicative of the capabilities of the lab. The drivers of the success can be traced to sound people and technology management being experimented and practiced by the team at lab. This case study may provide ideas to many budding laboratories, firms and organizations working in such emerging industries to think about technology or innovation capabilities for competitiveness.

Keywords: Innovation, Technology Management, International Competitiveness, Technology Capability Building, Flexibility, Mechatronics,

Introduction

India, will all resources and skills, still lags far behind developed countries in terms of the capabilities as well as competitiveness and need to act fast if aspirations of masses are to be met. Country of the size and challenges that India is can not be competitive just by leveraging its comparative advantages such as abundant human and other resources to gain cost advantages. Sustained research by our teams (Momaya, 2001; Shee 2001; Ajitabh and Momaya, 2004) on competitiveness has thrown some light on dynamics of competitiveness. While terms such as competitiveness and innovation are widely used in India, the road from awareness, ideas, appropriate definitions, frameworks and measurement matrices to innovation and competitiveness is rarely well traveled with achievements. Trends in comparative picture of competitiveness of India and select developed and developing countries are give in Table 1. They clearly hint that India ranks quite low and she is not progressing fast enough to make impact. In fact, gaps with countries such as China are fast widening. Very slow pace of enhancement of competitiveness and quality of life for masses in India can be partly attributed to weaknesses in technology and innovation management.

Table 1: Country's Performance Rank on Select Criteria (World Competitiveness Yearbook Ranking)

Country	*Year*		
	2002	*2001*	*2000*
USA	1	1	1
Singapore	5	2	2
Canada	8	9	8
Australia	14	11	10
Japan	30	26	24
Korea	27	28	28
Malaysia	26	29	27
China	31	33	30
India	**42**	**41**	**39**

(Source: WCY, 2002)

Technology and innovation capabilities are crucial to competitiveness and progress of a country. Most of the countries that rank high on global competitiveness Olympics have remarkably high technological and innovation capabilities. Numerous leading management guru or researchers across disciplines (Drucker, 1992; Jelinek, 1990; Hamel and Prahalad, 2003) have emphasized the importance of Innovation for competitiveness. Years of observations by the authors about ground reality in some of the most competitive developed countries and attempts at analysis of reasons have hinted at massive scope of improvement for India on many fronts including competitiveness, technology and innovation capabilities.

Weaknesses in the capability building processes were identified as a root cause of the problem (Momaya, 2004) and need to be addressed. This case study provides a glimpse of key dimensions of capabilities, indicators of performance as well as processes by taking a real context where ideas to implementation has been experimented continuously. Learning are also identified and implications drawn for professionals and teams.

Definitions

Some clarity on acceptable definitions of key terms will help improve our reading of this paper. These terms include capability, competitiveness, technology, innovation, technology capabilities. Internationally used standard definitions were adapted in most cases. The goal of an organization is to develop its technology capability and enhance its overall competitiveness.

Technology

Technology is so common; it is usual yet under defined term. Here technology can be defined as all the knowledge, products, processes, tools, and systems employed in the creation of goods or in providing services. It consists of following interdependent, co-determining and important components: Hardware, Software, Brainware and Know-how (Khalil, 2000). Any individual technology consists of a particular expertise, based on past experience and technological solution (Irani in IMAE, 2001)

Capabilities

A capability is the capacity for a set of resources to integratively perform a task or an activity (Hitt, 2001). Through continued use, capabilities become stronger and more difficult for competitors to understand and imitate. As a source of competitive advantage, a capability should be neither so simple that it is highly imitable, nor so complex that it defies internal steering and control.

For instance, the knowledge possessed by the firm's human capital is among the most significant of an organization's capabilities and may ultimately be at the root of all competitive advantages.

Intuitive definition is expertise and abilities to satisfy the technological requirements of the industries (locally and / or globally). It seems that developers and managers of the lab are more focused on customer satisfaction and the expertise and abilities needed to meet them. The important process dimension of TCB remains quite intuitive and tacit.

Technological Capabilities

The notion of technological capabilities attempts to capture the great variety of knowledge and skills needed to acquire, assimilate, use, adapt, change and create technology. It goes well beyond engineering and technical know-how to include knowledge of organizational structures and procedures as much as knowledge of behavioral patterns, e.g. of workers and customers. Firms need certain complementary assets and capabilities in order to create, mobilize and improve their technological capabilities, among which may be noted organizational flexibility, finance, quality of human resources, sophistication of support services and of the information management and coordination of capabilities. The national technology capability can be termed as sum of technological capabilities of the country's firms. Technology capability building is the process ability of organisation to handle technologies and cope up with technological changes or the ability of an organisation to undertake various technology activities.

Innovation

In simple management terms, innovation is a new product or service that is successful in the marketplace. Among many typologies of different type of innovations, some are listed as (a) the degree of technology management capability required to successfully perform them; and (b) their impact on enterprise's sustainable competitiveness. Broader definitions of innovations, often discussed as management innovation, incorporate important dimensions of market/customer innovation and operational innovation in addition to innovation of technology / product / service (Fukushima, 1999). At higher level one has to consider national/international and societal innovations. For instance, European Union (EU) has taken up number of initiatives to strengthen innovation systems in member states through interventions such as innovation relay centres. The focus of this paper is technological innovation.

Competitiveness

Competitiveness is a very useful yet complex subject and encompasses different issues depending on levels: country, industry, firm, product and technology. Detailed definitions at different levels including measurement variables have been synthesized through an extensive literature review by Banwet et al (2002). Here a simple definition of competitiveness at the firm level is adapted from Momaya (2001). Competitiveness of a firm is the ability to undertake any or all activities on the value chain from conceiving, designing, engineering, manufacturing, marketing, financing to servicing of a product or service or bundle of products and services, superior to those offered by competitors considering the price or non-price quality on a sustained basis.

In light of above definition, technological competitiveness can be defined as the ability to develop, transfer, absorb, produce or commercialize technologies to support competitiveness. Detailed criteria has been identified in the book (Momaya, 2001) for technological competitiveness under each of the facet of competitiveness: Assets, Processes and Performance

Case Study: Mechatronics Laboratory, IIT Delhi

The case study about the laboratory, where number of experiments in technology, innovation and management were undertaken is focus of the study. Here salient features are given and some technical details are given in the appendix.

Brief Background

The Mechatronics Laboratory has been established in July 2001 within the Department of Mechanical Engineering, IIT Delhi. The term `Mechatronics', coined in Japan in the 1980s, is a combination two words MECHAnical and elecTRONICS. Note the uppercase letters of the two words that form MECHATRONICS. With almost every machinery and equipment being electronica/computer controlled, synergistic integration of mechanical systems with the electroincs/electrical hardware, computers and programming (i.e., IT) is essential in order to achieve higher efficiency and productivity, and reduce design cycles.

Hence, such activities are common throughout the world, including India. Such need has been felt in IIT Delhi since late 90s when the Mechatronics courses were developed and floated to the UG and PG students. In early 1999, when the Ministry of Human Resource and Development (MHRD), Government of India, has decided to put Mechatronics as one of the Thrust Areas, the Department of Mechanical Engineering has submitted a project proposal to the MHRD to initiate research activities and develop necessary experimental set-ups to conduct experiments. With the sanction of the project by late 1999, a physical space was also allocated for the lab within the Department of Mechanical Engineering. Upon completion of the physical constructions, the lab has formally hosted in Room No. 420 of Block II.

The laboratory is now in its fifth year with several hardware and software facilities, as listed in Appendix A. Besides carrying out regular course-related practical classes for the UG and PG students, the lab. conducts courses for the industries (either general, e.g., *Technology Appreciation Seminar and Interactive Workshop* in October'01, or tailor-made for a particular industry, e.g, for *SAMTEL Color Ltd., Ghaziabad*, in December'02 and March'03). At any point of time there are several Government and industry sponsored projects, e.g., by the Department of Science and Technology (DST), Government of India, Sona Koyo Steering Systems Ltd., Gurgaon, running in the lab, which are undertaken by the Ph. D, M. Tech and B. Tech students as their academic projects or by the project staff hired for the specific purposes. A faculty-in-charge and a technical staff together with students and project staff look after the lab for its smooth functioning and efficient implementation of new ideas.

Key Achievements

The key achievements of the lab is categorized into three categories, namely, (i) Catering the need for the department and insitutite courses, (ii) Supporting industry requirement and attracting projects, and (iii) Implementation of good managerial practices for smooth running of the lab.

(i) Catering for the courses

In order to supplement the lecture teaching of the Mechatronics, Robotics, Multibody Dynamics, Mechanical Design, and related courses, several facilities have been created. For example,

- Six exprememtal set-up to learn Digital Logic Circuits

- Six microprocessor kits
- Six Lego-Mindstorm sets
- Pick-n-place robot from Systemantics India Ltd., Bangalore, RTX robot from England, and ER-9 robot from Israel
- XY-table and the PLC controlled Intelligent Conveyor System
- Six licenses for Automatic Dynamic Analysis of Mehanical Systems (ADAMS) software
- In-house developed window based Recursive Inverse Dynamics for Industrial Manipulators (RIDIM) software.
- Design and development of a Fibre Optics Sensor and a Robot Gripper which won the MM Suri best hardware B. Tech projects award in 2001 and 2004, respectively.
- Design of a trench-less drilling machine which won the TCS best software B. Tech project award from which a patent is also filed, and

many others, as listed in Appendix A. Besides, many UG and PG students carry out their research or project activities using the computers, CROs, Function generators, and other tools available in the lab.

(ii) Supporting industry needs

In order to support the industry requirement the lab has already carried out several courses in the area of Mechatronics and completed several projects successfully. Some of them are:

- Technology Appreciation Seminar (TAS) & Interactive Workshop (IW) on "Mechatronics Applications" in October 2002, where industries like Sona Koyo Steering Systems Ltd. and EEL Ltd., Gurgaon, BHEL, Bhopal, and DENSO and SAMTEL, UP, and academic institutes like NSIT, New Delhi, ITMMEC of IIT Delhi have participated. The feedback by the participants was excellent.
- Two tailor-made courses for SAMTEL.Color Ltd., Ghaziabad. After participating in the above TAS&IW, the company has approached the Mechatronics Lab of IIT Delhi to expose their mechanical engineers in the areas of electrical /electronics /control engineering and vice-versa. As a result two courses were conducted in December 2002 and March 2003.
- Two industry consultancy sponsored by Sona Koyo Steering Sytems Ltd., Gurgaon completed and two are on-going. In order to help the company to improve one of their manufacturing process and to improve the steering design two projects were completed in 2002 and 2003, respectively. At present, two projects are running for the development of smart-steerin system, where the comapany has sponsored one candidate to pursue his Ph. D at IIT Delhi.

(iii) Managerial Practices

In order to run the lab smoothly it was felt that two employees provided by the institute, namely, the faculty-in-charge and technical-in-charge are not sufficient. Hence, a need is felt in the lab that students and project staffs participation is must. Over the years, the lab has been able to implement some of the good management practices which led to the following achievements, as received from several outsiders through the feedback forms used during the courses and other programs, like Open-House, etc.:

- Easy where about of a person in the lab by just looking at the board placed in the front of the lab, where everybody puts where they are by placing "In," "Out," "Library," "Bank," "On Leave," etc. cards next to their name plate. This helps to contact the person in case of emergency.
- A very systematic description of the facilities in the frame and white boards. Any outsider who wants to know about the activities of the lab may understand through these board even asking anybody in the lab.
- Easy access to documents in library area
- Clean working area and care for environment
- Medical first aid facilities
- Dissemination of information through e-group
- Regular seminars by the Ph.D. and M.Tech. students
- Application of 5-S Japanese working style

Indicators of Competitiveness

The concept of competitiveness is often not defined and consensus is rarely achieved on indicators in most academic institutes in India. At IIT Delhi also, there are fever formal norms about competitiveness. However, following indicators were identified during interviews with key stakeholders and observations of Mechatronics lab that can serve as useful measures:

- Customer satisfaction (incl. industry customers)
- Nurturing of talent in an emerging area (number of researchers interested and actively working in the lab)
- Number of new equipments developed / installed
- Sustaining an excellent learning environment
- High productivity in terms of publications (more than 15) and reports (about 3)
- Have helped development / implementation of robots for industry
- Working culture conducive for research (e.g. harmonious teams,..)
- Quality of research (e.g. several best project awards)
- Effective information system management for lab documents and tools
- Development of new course on Mechatronics at IIT Delhi

Indicators of Technology Capability Building

- Excellent technology utilization capability
- High technology creation capabilities
- Effective re-engineering and re-use of imported technologies
- New use of technology developed through innovation
- Cost effective solutions
- Award received for Fiber Optic Sensor

TCB Processes

The Technology Capability Building (TCB) process is the heart of technological capability building. TCB processes at the Mechatronics Lab started with the strong desire of the then users of the laboratory to become one the best laboratory since its establishment in 2001. It was realized that only two personnels, namely, the Faculty-in-charge and the Technical-in-Charge, provided by the institute are not sufficient to run a lab. Hence, the participation of all the students were realized. Moreover, the students' participation in managing the lab would bring their belongingness to the lab, which is an important component of any home or organization, whatever small it may be. Hence, it was decided that each user of the lab, be him/her a student, project staff, faculty, attendant, technical staff, must take some responsibility of the lab besides his or her own academic work. At the time of writing this paper, the following responsibilities are distributed:

- One student takes care of the computers, i.e., he is given the administrative power to create and maintain the computer accounts of the lab users, report to the concerned staff/faculty in case a computer is not running, etc.

- One student takes care of all the robots in the lab, i.e., to know how to operate them, and in case of not functioning properly report to the lab technician or faculty-in-charge.

- One student classifies the leaflet/brochure/technical directory, etc. in order to find a certain information easily.

- The faculty-in-charge looks into the beautification of the lab, i.e., to see if things are kept in proper places after use, creating documents for easy location of the items, etc.

- The lab-technician takes the responsibility of the first-aid box and look into the safety issues of the lab, e.g., whether the dettol and other items of the first-aid box, fire-extinguishers are expired or not, etc.

- One student takes care of the tea facility, i.e., collects subscriptions from the users, gets tea bags, etc.

Note that none of the above responsibilities are imposed but are voluntarily taken after realizing the need of such activities. Moreover, in order not to feel much pressure it is made sure that not more than half an hour to one hour per week is spent for the lab work.

Besides, the team meets once in a week, again not more than 30 minutes, for the lab meeting to discuss any issues related to the smooth functioning of the lab. Besides twice tea times in a day are really sough-after time by the students and staff members, when everybody shares jokes, talks movies, politics and anything else other than academics or lab. This allows the lab to go beyond the typical Teacher-Staff-Student relations and helps in understanding each other better. It really helped to maintain cordial interpersonal relations. In order to disseminate the information about the activities of the lab it publishes an annual brochure not more than two pages (can be downloaded from the web page of the lab www.angelfire.com/indie/mechatronics). Also, to monitor its own progress it brings out annual reports containing the number of courses conducted in the lab, student projects carried out, number of publications from the lab, number of visitors, number of seminars given by the students, etc.

On technical front the following activities are performed to encourage creativity and innovations:

- Innovative systematic mathematical modeling and simulation of mechanical systems like Intelligent Conveyer System, XY Table, Serial industrial robots, Steering system, and others.
- Development of simple robots like HaPRA and Parallel drive robot
- Experimentation with toy robots, e.g., making a computer programs for internet control, and making electronic driver circuit for computer control of the robots.
- Development of virtual prototype of new ideas using ADAMS and ULTRAGRIP software.
- Making real prototype of new ideas using Lego-MS kits.

Road Ahead for the Mechatronics Lab and Key Challenges

The lab has already attracted the attention of the all the faculty and students of not only IIT Delhi but also to the outsiders coming from other parts of the country and abroad. One DRDO official once commented it to be one of the best Mechatronics Labs he has seen in India. Another student from Switzerland who came for an exchange program to IIT Delhi and has taken a course on Mechatronics was also very impressed with the style the lab operates. One of the objectives of the lab is to maintain its excellence. At the same time it wants to be supportive to other students and institutes to create similar facility and environments. However, in its endeavor it faces challenges; some of the challenges are listed below:

- Difficulties in keeping all facilities operational: Any mechanical/electrical/electronics if not used for sometime (say six months or so) may malfunction. With the students not interested every year to take projects with all the hardware, it is very difficult to keep all the facilities functional.
- Under utilization of some of the facilities: When the students do not take up a project with a robot, it remains unutilized for a semester or so. As a result a costly equipment is remaining idle.
- Unavailability of good vendors, problems in repairs: Once the system is not functioning, it is very difficult to get the suppliers to attend the problems or the vendors to repair the same.
- Planning and reliability of some students is slow/ weak: Since many students feel that the lab equipment is the departmental property they mishandle the system without proper precautions.
- Poor commitment of the students: This is a very challenging task to motivate the students to treat every equipment sensibly, as if they are their own.

Learning

While the case study may capture only limited facets of the TCB opportunity, rich experiences of the authors in Indian as well as international (both Western as well as Eastern) contexts might provide some best learning. Hence, learning are classified in two groups here: from the caselet and experiential.

Learning from Caselet

- Technology assimilation activity was assigned the highest importance, followed by use, adapt and change. Technology creation activity was assigned lower importance.
- The TCB of the lab is best indicated by new products developed, operational efficiency, intellectual output (e.g. patents, copyrights,..) and productivity.
- Scarcity of support facilities, weaknesses in support from higher levels and low team work were identified as major problems in TCB.
- Considerable amount of technological and innovation capabilities are nurtured in India in many labs such as Mechatronics Lab taken in this case, often without known too much beyond small group.
- While such labs often focus on training human resources and demonstration of their technological achievements the process through which the capabilities are built are not of much interest to them and are rarely documented.
- Quick survey of other technology labs in IITs and other national institutes such as NITs hint that such labs with excellence are few and there is considerable potential for improvements in other labs if learning and knowledge of best practices from excellent labs are documented (this case study is just a small example), disseminated and adapted by aspiring labs.
- Culture of team work and innovation needs to be well designed and at times need to be enforced with strict discipline as basics of concerted team work for complex tasks are often weak in students in India.

Experiential Learning

- Minds can provide the first starting point. Many minds in India are still colonized most of time (often unknowingly), although India became politically free more than five decades ago.
- Self confidence and continuity and pursuing activities to achieve the goals are primary keys to such development. Patience and not looking for success immediately should be kept in mind. One should look for far reaching goals.
- Real dimensions of innovation and TCB relevant for Indian context are quite complex and rarely understood
- It demands enormous personnel commitment on part of leaders to nurture such labs in face of enormous hurdles
- While learning can be looked at from different contexts, indigenous approached need to be developed to address real issues relevant in India context

Implications for Professionals, Teams and Organizations

Attempt has been made here to draw few important implications for professionals working in technology, management and related areas and their organizations.

Professionals / Teams

- We have to learn to understand the bigger problems that we often blame and find root causes. Years of living in a culture and environment that can be quite discouraging for even most committed and capable team, often brings pessimism. But we must overcome it. It is very urgent that we identify root causes of problems and act fast to address them collectively.
- We must examine our internal processes; identify barriers to indigenous innovation and products.
- Long term success and sustainability of laboratories depends a lot on strong teams not individuals. Hence, attempts should be focused on nurturing highly committed teams.
- Orientations or quick training in basics of competitiveness and innovation / technological capability building may enhance foundations of teams to leverage their strength and indigenous innovations for competitiveness.
- More professionals (incl. researchers/students) should explore oriental contexts (e.g. China, Japan, Korea, Taiwan) after good orientation and preparation to balance that learning which become distorted due to excessive dependence on English language knowledge sources from the West.

Organizations

- Organizations should review their systems and processes to identify barriers to technology / innovation capability building and initiate measures to address them

- Flexibility in systems is needed to adapt to rapidly changing dynamic environment. Even best of the institutes such as IIT can face crisis in number of their areas and programs in absence of flexibility in systems.
- The opportunity of emerging as leading education and research institutes in the world can be leveraged, if institutes such as IITs can evolve mechanisms to channelize enormous capabilities of individuals (faculty, researchers, students, staff, alumni, etc.) in team contexts of firms, other institutes and associations to take ideas up to grassroots.

Conclusions

Surging demand for technology-based products and low technology value-added in India are creating vast demand-supply gap between technology need and indigenous creation. This needs to be bridged fast, if technology is to become a lever for economic progress for masses. This can be partly bridged with rapid scale-up in innovation and technological capabilities of laboratories, institutes, organizations and firms doing activities across the value chain from design and engineering to manufacturing and service. Attempts have been made in this paper to synthesize practical learning about problems and their root causes from a case with experiential insights based on years of exposure to some of the most competitive countries. To bring a paradigm shift needed for the scale-up, massive changes in organization systems and culture, driven by capable professionals may become essential. Without such foundations for enabling environment, it will be very difficult to build technology and innovation capabilities.

Development of technology and capabilities at the Mechatronics lab is a commendable effort where the team is trying to synergize `various disciplines of engineering viz., mechanical engineering, electrical engineering and information technology for the integrated design of intelligent systems to enhance the applicability and effectiveness of mechanical system for economical use by the Indian industries. This is a unique lab in itself. The technology capability process in this lab includes doing fundamental modeling, simulation, experimentation and trying to adapt it to the local environment.

Luckily, many progressive individuals, team, firms and organizations are active. Learning from their good work should be adapted, experimented and scale-up by many to make progress fast.

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Appendix

A.1 The Mechatronics Lab

The lab has started in July 2001 and is located in the Department of Mechanical Engineering, IIT Delhi. For effective utilization of the space with respect to its activities, the is divided into three distinct parts

1. Instrumentation and Sensor area: In this area electronics related experiments are performed. Moreover, any tests with the sensors are also performed here.
2. Computational area: Computers are placed in this area. Some computer interfaced hardware like ER-9 and RTX robots are also placed in this zone because the computers get utilized when the hardware are not in use.
3. Hardware application area: This is planned to be harsh area to simulate industry scenario. Hardware set-up like XY Table that simulates the CNC machine is kept here.

Key facilities of the lab are listed in Table A1.

Table A1 Mechatronics Lab Facilities

Computers		**Hardware**		**Software**	
C1	SGI WS [S2,5]*****	H1	CNC XY Table [C5]	S1	ADAMS 11.0 [C2-3]
C2	COMPAQ [S1,4,8]	H2	Intelligent Conveyor [H3,C6]	S2	ADAMS 8.0 [C1]
C3	P-III [S1,4,8]	H3	Fiber Optic Sensor [H2]$	S3	ULTRAGRIP [C4]
C4	P-I [S3,4,8]	H4	MA3000 Robot [C8]	S4	MATLAB 5.3 [C2-5]
C5	P-I [H1,S4,8]	H5	RTX Robot [C7]	S5	C, C++, F77 [C1]
C6	IBM 486 [H2,3,7S4,8]	H6	HaPRA Robot [C9]	S6	VC++ [C4]
C7	486 (DOS) [H5]	H7	OWI Robot [C6]	S7	BASIC [C8]
C8	286 (DOS) [H4]	H8	TURTLE Mobile Robot [C9]	S8	MS Office [C2-6,10]
C9	286 (DOS) [H6,8,10]	H9	HEXAPOD M/C Model		
C10	486: Six	H10	Rotary Index Table [C9]		
		H11	Microprocessor Training Kits: 5		
		H12	Phantom [C9]		

Note: *Numbers inside [ ] is the interfacing component(s); $BTP Best Project Award in 2001

A.2 Key Activities of the Lab

The key activities of the lab are compiled every year and published in the form of a brochure during the month of August/September. They are distributed to the visitors when they come to see the lab. Besides, they are also posted in the website address of www.angelfire.com/indie/mechatronics. Some of the key activities are listed here as follows:

1. Intelligent Conveyor System

As shown in Figure 1, sorting out of items, e.g., boxes, can be performed by this conveyor system comprising of a belt conveyor, sensors, and a pneumatic pusher. This is useful for industries requiring automatic sorting, fault detection. This technology is ready to transfer.

Figure 1 The intelligent conveyor system.

2. Fiber Optics Sensor

The sensor is integrated with the above conveyor system to replace the existing and counting of accepted / rejected parts. The sensor has others application of proximity sensors. This was awarded 2001 ICIM best BTP award. The technology is ready to transfers.

3. MA3000 Robot

This five-degree of freedom robot can move in a straight or circular paths, its characteristics studied its using a data acquisition system.

4. Recursive Inverse Dynamics Of Industrial Manipulators (RIDIM)

An in-house developed software in C++ / VC++ used in robotics and multi-body dynamics courses at IIT Delhi and made available free of cost to others academic institutes. Such a program is useful for robot control, Industrial robotics companies should find it attractive.

5. Virtual Robotics and Mechanisms Laboratory

Students are able to perform robot experiments in this virtual environment, which is based on Automatic Dynamic analysis of Mechanical Systems (ADAMS) software. In fact, VRL has expanded the utilities of ADAMS software at IIT Delhi. Similar virtual prototypes for the simple mechanisms are also added recently as the Virtual Mechanisms Laboratory (VML) which is used in the on-going course on Kinematics and Dynamics of Machiernery for the 2nd year UG students.

6. A CNC XY Position System

AC-servo motor controlled positioning system is to simulate a CNC milling /grinding table. Mathematical models are developed and results were compared with its actual behavior. Such a study based on mathematical model is essential in order to be able to predict a system¡Çs behavior with confidence. Such a tool enables to bring a new product in the market cheaply and faster , as the numbers of prototypes building and their testing are less.

7. RTX and ER-9 Robots

Programs are developed to write characters by the RTX robot, which can be used for teaching purpose. In 2002, ER-9 robot by an Israeli company has been added.

8. PPR Robot

This robot is procured from an Indian company which claims to export the robot for the first time in India. An M. Tech and two B. Tech projects have completed using this robot.

9. Internet Controlled OWI Robot

Programs are developed to control a toy robot through Internet using Java programs. This robot is useful to work in a hazardous environment.

10. Many Other Projects

Parallel-drive robot, HaPRA, Hexapod, HEXA-slide Manipulator, Gripper, Ttraining Robot, etc.