

MANUFACTURING ENGINEERING EDUCATION IN INDIA

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Received: 23 December 2015

Accepted: 21 February 2016

ABSTRACT

Evolution of manufacturing technology has been a definitive indicator of human society's development. From the wheels that started the spree to the world of machines that have revolutionized the manufacturing processes, manufacturing tools have been indicative of eras of development. In this paper, we have focused on the branch of engineering that deals with manufacturing - specifically its structure in India. In this study we investigate some premier government institutes with respect to Manufacturing Engineering Education. We have also included the technical education model at different education level.

KEYWORDS

manufacturing engineering, technical education system, India.

Introduction

Manufacturing engineering is a branch of engineering which involves planning, designing, analyzing & applying manufacturing methods and managerial processes so that quality products can be produced at a competitive cost. They also oversee the running, maintenance & improvement of the production or manufacturing unit. It is the manufacturing engineer who is accountable for the efficient production of quality products with it's cost. Manufacturing Engineering is based on core mechanical engineering skills, adding elements from basic engineering sciences, mechatronics and business management [1–4]. Here we would like to define a clear line between production and manufacturing. Production refers to the conversion of input into total output by means of some processes whereas Manufacturing is a systematic and well organized way of producing goods by individuals through different techniques or chains of processes [16].

In curriculum, the study of manufacturing techniques is done under the subject of Manufacturing Science/Manufacturing Technology.

The latter one is focused heavily on the practical aspects while the earlier one discusses contrasts and explains theoretical aspects of technologies. This subject is of great importance for developing nations. Evidently the GDP of any country is directly proportional to its manufacturing produce. If there are a number of manufacturing facilities in a country it ensures a boost to economy. It also generates income, jobs and improves the quality of general life. India is the seventh largest country in world by area & second largest country by population with biggest population of young people in the world. India has largest number of technical institutes & engineering students in the world. After the independence of India, industrialization process started through Public Sector Units (PSU) which is set up Indian government & private sector companies set their manufacturing units to fulfill the demand generated by locals, manufacturing sector got accelerated and there was a great demand of skilled engineers across the industry.

Present paper is divided into three parts; first we have discussed about the manufacturing engineering education in India at five different stages, diploma, undergraduate, postgraduate, doctoral & post-

doctoral level, then future scope of manufacturing engineering in different industry with the employment of manufacturing engineers and at last conclusion of manufacturing engineering education in India.

Manufacturing Engineering in India

Basic structure of engineering education in India

India has a big number of technical educational institutes with polytechnics, technical institution & technical universities, which offers diploma degree in, 60 major disciplines, undergraduate degree in 45 major engineering disciplines, post graduate degree in more than 200 engineering specialization, doctoral degree in almost each area of technical core or sub core areas of the technical disciplines [5–7]. Post doctoral degree is also offer by the top technical institutes in India, which is more specific to the industry base research issues. Indian Institute of Science (IISc), Indian Institute of Technology (IITs), National Institute of Technology (NITs), Indian Institute of Information Technology (IIITs), Indian Institute of Space Science and Technology (IIST) are top technical institutions in India.

Manufacturing process is the base of any industry, whether it is computer hardware, electronics product, metal associated work etc. Manufacturing science or manufacturing technology as a subject is offered in the first year undergraduate studies (all technical disciplines) as a subject which includes the metal & it's alloy properties, metal forming, casting process, welding process, different applications of manufacturing engineering in the industry. This subject is offered by the mechanical engineering department, which is associated with the field of manufacturing engineering. Two subjects associated to the advance manufacturing science are in the curriculum of the mechanical, production & industrial engineering which are offered to students in the second & third year. One subject related to the material or metallurgy manufacturing is offered to the metallurgical & materials engineering students. Beside these, some technical institutions offer process modeling, flexible manufacturing system, finite element methods in design & manufacturing, industrial productivity etc as optional subjects to their final year undergraduate students of mechanical, production, industrial or metallurgical engineering which is associated to the manufacturing engineering.

Duration of diploma degree course is six semesters or three years, undergraduate degree course (B.Tech or B.E.) course is eight semester or four year, dual degree course (B.Tech with M.Tech or

B.Tech with M.B.A.) is ten semester or five year. Duration of doctoral degree program is normally three year but it can be extended up-to six years according to need of the research topic. Students have to do the two semester course work which includes two to four subjects according to their research topic which gets approved by their supervisor. Post doctoral program is of two years duration but it can be extended one more year according to the requirements.

Specifics of manufacturing engineering

At Diploma-level

Diploma courses in manufacturing engineering are offered by few polytechnics across India. In diploma, manufacturing engineering has common subjects with mechanical & production engineering with basic science subjects. AICTE (All India Council for Technical Education) has approved and given a model for diploma level courses on manufacturing engineering. Major subjects included are Engineering Mechanics, Strength of Materials, Manufacturing Processes, Workshop Fittings, Machine Drawing, Heat Power Engineering, Process Planning & Cost Estimation, CAD, Hydraulics, CAD/CAM/CIM, CNC Laboratory, Mechatronics, Computer Network, Plant Maintenance, Pneumatic & Hydraulics and final semester project.

At Undergraduate level

At undergraduate level (B.E. or B. Tech) there are about 6-10 core subjects which are directly associated with manufacturing engineering, rest of them are related to mechanical engineering, management & couple of courses related to interdisciplinary courses. Lab work is done in the field of welding, casting, fluid mechanics, heat & mass transfer, machining & metrology, electrical machines, CAD design, design of machine elements & operations management. UG curriculum includes a major project which is done in the final semester on the field robotics, machine design, instrumentation, welding, control engineering, casting etc. The UG course of manufacturing engineering at National Institute of Technology, Jamshedpur has laid out a proper format which includes appropriate courses from mechanical engineering & other departments[8]. Central Institute of Plastics Engineering & Technology (CIPET) at Ahmedabad, Bhubaneswar, Chennai and Lucknow offer B.Tech course in Manufacturing Engineering /Technology. Core courses associated to manufacturing engineering are manufacturing by shaping & joining, production management, non traditional manufacturing process, design of production tooling, ma-

chinery fault diagnostics and signal processing, quality production methods, organizational behavior & industrial psychology, work system design & human factor engineering etc. Four to six elective courses are also offered which are more focused to the sub fields in which students work on their final year projects.

At Post Graduate, Doctoral and Post-doctoral level

At the postgraduate level manufacturing engineering is offered under the specialization Manufacturing Technology, Manufacturing Systems Engineering (NIT Jamshedpur), Manufacturing Engineering, Manufacturing Science & Engineering (IIT Kharagpur), Manufacturing and Precision Engineering (IIT Madras) & Integrated Design and Manufacturing Engineering (IIT Hyderabad) under mechanical engineering department. NIT Tiruchirappalli offers M.Tech in Manufacturing Technology under production engineering department. IIT Kharagpur & IIT Madras offer dual degree (B.Tech with M.Tech; five-year course) in manufacturing engineering. IIT Kharagpur also offers dual degree (B.Tech with MBA; five year course) in manufacturing engineering.

Major theoretical topics studied under postgraduate degree course include computational methods in engineering, tooling for manufacturing, flexible manufacturing systems, modeling of manufacturing processes, manufacturing management, manufacturing of non-metallic products, rapid manufacturing, lasers in manufacturing, design for manufacture, intelligent manufacturing systems, sustainable manufacturing etc. In last semester, student has to defend his/her dissertation before an audience, which includes an examiner from another institution in India.

Doctoral research in manufacturing engineering is done in the field of production management, production and manufacturing engineering, robotics, automation, CAD/CAM, production, R.E. and R.P. with cad application, solar energy, energy management, machine design, production engineering, industrial engineering etc [8]. At doctoral level, students do theoretical or practical problem analysis for their doctoral thesis. Some research projects funded by funding agency may form a part in their research work.

Post doctoral level research in Manufacturing Engineering is offered by top technical institutions in India by their mechanical engineering department.

A note on literature

Due to the nature of work, many courses took by students during undergraduate course of man-

ufacturing engineering are same as those took by mechanical, production or industrial engineering undergraduate students. R.K. Rajput, Dr. Khwaja Moeed, Groover, Serope Kalpakjian, R.K. Jain, Jacobs, Phillip F. Ostwald, Jairo Munoz, P.C. Sharma, R.S. Khurmi, O.P. Khanna, J.K. Gupta, Parashar B.S. Nagendra, Mittal R. K. etc are the famous authors whose books are adopted as text book in the different courses associated with the manufacturing engineering.

Available simulation tools

MATLAB, NI-LabVIEW, Mathematica, Maple are the major simulation tool used for solving mathematical (algebraic) computation problems. Scilab, Elmer, Sage, GNU Octave, Maxima, Freemath and R are some open source tools useful for solving mathematical computation & statistical problems. OpenFOAM is a fluid mechanics tool which is used for computational fluid dynamics (CFD) both as a teaching and a research tool. SolidWorks, FreeCAD, LibreCAD, Solid Edge etc are designing simulation tools use by UG & PG students to solve designing problems.

Indian Government Initiatives

Indian Government has taken many initiatives to enhance teaching & learning through the online web medium. Indian Government has develop virtual labs, online videos lecture database through National Program for Technology Enhanced Learning (NPTEL) & online thesis management system Shodhganga [9-11]. Virtual labs are developed with partnership of technical institutions & Ministry of Human Resource Development (MHRD). Some labs such as metal forming lab, mechanics of machine lab, machine dynamics & vibration lab, general purpose production shop simulation lab, laser based flow diagnostics laboratory, virtual combustion and automatization laboratory etc have been already developed which is associated to the students of manufacturing engineering. Some labs are still in development phase[11]. NPTEL program gives the students a opportunity to learn course through the famous faculty of the other institution. It is open source repository in which lectures of the faculty store & students can access through online with out paying any cost. Students can ask questions in some on-going courses[9]. Shodhganga provides a platform for research scholars to access the research work happen in Indian universities & scholars. They can also submit their doctoral theses and make it available to the entire scholarly community in open access through out the globe. The repository has the ability to index, store, dis-

seminate & preserve ETDs (Electronic Theses and Dissertations) [10].

Present Scenario

There is no independent department of manufacturing technology in any IIT but manufacturing technology is offered as a specialization discipline for M.Tech courses in many IITs under mechanical engineering department. Only one NIT, NIT Jamshedpur is having an independent department, which offers undergraduate engineering degree B.Tech (H) in manufacturing technology [8]. Department of Mechanical and Manufacturing Engineering (MME) at Manipal University was established in 1960, is the oldest department which offers post graduation degree in manufacturing engineering. Figure 1 and Fig. 2 gives the overall statistics of Manufacturing Engineering course (PG level) in Indian Institutes of Technology (nineteen in number) & National Institutes of Technology (thirty-one in number). National Institute of Foundry and Forge Technology, Ranchi, which is a government funded institute, offers four year B.Tech in manufacturing engineering.

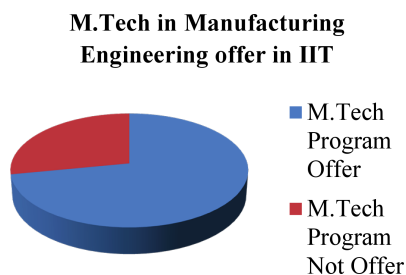


Fig. 1. Manufacturing Engineering (PG) at IITs.

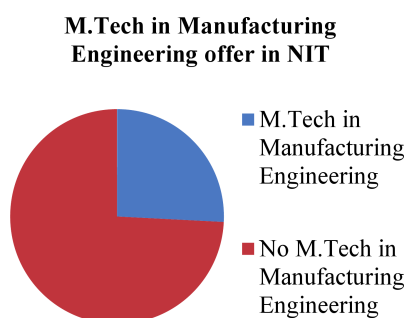


Fig. 2. Manufacturing Engineering (PG) at NITs.

Future Scope of Manufacturing Engineering

Manufacturing Engineering is the base for any type of industry. Graduate engineers having bachelor degree in manufacturing engineering get the opportunity in production & manufacturing firms in private

& government sectors. They are eligible in private production units, railways, armed forces & PSUs. Most of the job role for the engineers are supervisory or managerial where critical decision making skill is needed for the smooth production & high performance of the industry. Engineers having master & doctoral degree in manufacturing engineering can work in top levels in the industrial & management field. Engineers having doctoral degree can also opt for career as faculty in technical universities across the globe. Engineering graduates with management degree have a good job prospects then other ones in industry. Manufacturing engineering graduates get the jobs in industry as plant engineer, process engineers, quality engineers, industrial managers, operations analyst, management engineer, manufacturing engineer, quality control technician etc. Beside these, manufacturing engineers are also eligible for the certain jobs of mechanical engineers in government own companies including railways, Indian Engineering Services (IES) & automobile companies in major.

Central Manufacturing Technology Institute (CMTI) is a registered Government of India Society, an autonomous institution under the administrative control of the ministry of commerce and industry (MoCI) which offers one year (two semester) post graduate diploma in advanced manufacturing technology (PGDAMT) in collaboration with Karunya University, Coimbatore. This course has objective of making fresh engineers industry ready. This course trains on typical manufacturing industry processes, advanced technologies, live applied research projects and industrial visits.

Recent initiative of Indian government "Make In India" will help manufacturing engineers as Indian government is inviting the manufacturing firms to open their manufacturing plants in India for production. This step will generate the jobs for the candidates having engineering degree in manufacturing engineering [12].

Conclusions

Brief Comparison of Manufacturing Engineering Education status in top universities of BRICS countries

We have used widely accepted QS university ratings for shortlisting the universities to compare.

Tsinghua University, China has a separate Institute for Manufacturing Engineering. It was established in 1996. It has many application based research centers focusing on computer integrated manufacturing, robotics, graphics and CAD. Shanghai

Jiao Tong University has a department for Industrial Engineering. Other top five universities of China do not have separate departments for manufacturing related courses.

Bauman Moscow State Technical University of Russia has a program in Industrial engineering. Other top Russian universities do not have any industrial related program. Russian universities have targeted programs on fixed domains.

The University of São Paulo, Brazil offers many graduate programs including manufacturing engineering. Brazilian government has provided a vision for education prioritizing on science and technology which reflects in their curriculum.

University of Cape Town has programs covering the economic aspects of services and manufacturing. Other universities too have either a department or a course on manufacturing.

When compared to India, Brazil and South Africa have a better laid out plan for expansion of manufacturing engineering courses. While surprisingly Russia has merely a number of colleges focusing on industrial or manufacturing engineering. China stands at par with India with respect to manufacturing engineering education curriculum [13].

There are programs like Platform for E-Learning and Telemetric Experimentation (PeTEX) which is an EU funded project to enhance and support eLearning and provide remote experiment laboratories for manufacturing engineering. Such programs could also be learned from by BRICS countries [14].

Manufacturing Engineering is a crucial field of engineering for the proper development of industries in any nation. Indian government's initiatives in setting up manufacturing plants for those products which India is importing from the other parts of the world since independence is commendable. These production plants across country will see the boon in the manufacturing & production engineering.

Present scenario of manufacturing engineering education seems in its early stages in India. With mere number of colleges offering this stream in undergraduate studies leaves a void to be filled rapidly in coming years. Although the platform set in India regarding manufacturing at present gives a good launching pad for employment and research opportunities in Manufacturing Engineering.

Authors would like to thank Ish Bajpai and Siddiqui Sajida Asif for their valuable suggestions.

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