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ABSTRACT

Engineering education in the countries of India and Singapore is described. The post-secondary engineering program in India is offered at 132 institutions. Admission procedures are explained, as is the curriculum for students interested in production engineering. Descriptions and photographs of some final year projects are provided. In addition, an explanation of graduate engineering programs and the author's observations concerning student behavior are included. The explanation of engineering education in Singapore begins from a historical sketch of the development of the nation from 1961. During the period of 1962 to 1971, industrial employment has increased from 10,500 to 155,000 persons. Post-secondary education and vocational education are described, as well as the university system. At the university level, the manufacturing engineering curriculum is detailed. Also, as for India, the graduate engineering programs and observations of student behavior are provided. (CP)

3280

The Teaching of Manufacturing Engineering In India and Singapore

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The Teaching of Manufacturing Engineering In India and Singapore

The two countries of India and Singapore have been developed under the English educational system and have many points in common. However, in recent years, they have each responded to their own particular needs and have been successful in obtaining outside assistance in the attainment of their goals.

India

Engineering Schools

There are 132 engineering colleges in India. At the top of this group are the 5 Indian Institutes of Technology or I.I.T.'s. They are sometimes referred to as the "Super Techs". They are located at Kharagpur, Bombay, Madras, Kanpur, and Delhi. (Fig. 1).

Each of these schools has had massive aid from the following principal benefactors: Kharagpur - UNESCO, Bombay - USSR, Madras - West Germany, Kanpur - U.S., and Delhi - Great Britain. The schools are well-equipped and have excellent staffs.

Schools that compare quite favorably with these five schools are the Indian Institutes of Science at Bangalore,

the Benares Hindu University, the University of Roorkee, and Jadavpur University. (Also shown on Fig. 1).

Admission. Admission to the I.I.T.'s is by entrance examination which is the same throughout India. The exams are conducted by the five I.I.T.'s which cover the five zones of India. As an example, I.I.T. Madras conducts the exam for the four southern states. Between 3,000 to 5,000 students in this southern zone become eligible annually to take the exam. Out of this number, only 200 or 250 are accepted or about 5%. A merit list is made up from the five zonal results. The first 1250 students in order of merit are assured seats in the I.I.T.'s, and are able to select any school they like. The middle and lower ranks must then go to the I.I.T.'s that are still available. Some seats are reserved for foreign students.

Production Engineering

A few schools such as Bombay and Jadavpur offer courses leading to a degree in Production Engineering. Other schools such as the I.I.T. at Madras, which probably has the best facilities in India for the teaching of Production Engineering, offers it as an elective major in the final year of Mechanical Engineering. At the present time, about two-thirds of the students in M.E.

elect to take the Production Engineering option. This becomes available in the third year since the first two years are common. The following courses make up this option:

First Semester

Production Management
Mathematics
Automatic Controls
Computing Techniques
Production Metallurgy
Metal Cutting & Tool Design
Production Engineering Project/Tool Design Assignments

Second Semester

Industrial Engineering II (3 hrs./wk.)
Machine Tools (3 hrs./wk.)
Project (26 hrs./wk.)

Final Year Projects. Much emphasis is placed on project work which is industry oriented and executed either in industry or in the school laboratories.

Examples of "in house" projects carried out this past year at Madras are:

Electromagnetic Forming

Wire Drawing

Electro-Chemical Machining

Photo-Fabrication

Examples of final year projects carried on outside the campus at Madras in 1973-74 are:

1. Optimum layout of manufacturing facilities for a proposed press working shop at Metal Box Company.
2. The design and fabrication of an automatic counting and packaging machine for cigarette cartons requested by the India Tobacco Company Ltd.
3. A feasibility study for the production of a camera case by injection molding.
4. A study of queing and idle time for various maintainance and process facilities at the Union Carbide Company.
5. Design and testing of a prototype reduction mechanism used to drive a telescope for tracking astronomical bodies with an error of $\pm$ 2 seconds of a degree. Project requested by Indian Astronomical Association, Hyderabad.

Graduate Programs

Three post-graduate programs are offered in Production Engineering at Madras. These are:

1. A two-year course in machine tools leading to a Masters Degree (M. Tech.). Significant projects are undertaken. Some examples are shown in the following figures:
   a. A small column and knee milling machine of the horizontal type, (Fig. 2). It has a gear drive with 8 spindle speeds. A vertical attachment was also developed.
   b. A multispindle pantograph engraving machine. Each of the 6 spindles can be operated simultaneously with the same reduction in size, (Fig. 3). The machine is now in use in industry making numbers for numbering machines.
2. A one-year graduate course in Production Engineering leading to a diploma of Indian Institute of Technology (DIIT).
3. An M.S. program of two or three years duration that is almost entirely research or design oriented with a few courses related to the research topic. Some examples of the type of projects undertaken are:

a. A concrete bed lathe, (Fig. 4). This lathe bed is made from prestressed, reinforced concrete. Experimental work indicated the bed was less expensive than cast iron, and it had improved rigidity and vibration properties. A rack and pinion manual feed is used.

b. A vertical milling machine, (Fig. 5). This machine is equipped with electromagnetic clutches and brakes for electrical programming. It was retrofitted with a numerical control system developed at I.I.T. Madras for a 3 axis-point-to-point milling. Diffraction gratings are used to maintain accuracy for each of the 3 axis of movement. The tape reader was manufactured by the Hindustan Teleprinters.

c. A vertical boring machine, (Fig. 6). This fabricated machine is made with cast iron guide ways, gear box, and spindle head. This is a special purpose machine for rough and fine boring automobile starter motor housings A rapid return is provided for the quill as well as instantaneous spindle rotation braking.

Teaching Quality Improvement Programs

Staff members from other institutions attend the I.I.T.'s on either a part or full-time basis under the Quality Improvement Program (QIP) set up by the Indian Government. The M. Tech program is also included for staff members who have only a basic B.S. degree.

Machine Tool Development in India

There are a great many factors that must be assessed in noting a country's industrial growth. However, to make progress in today's competitive, ever more sophisticated market requires considerable engineering background. It is of interest to note that in 1972 India ranked 17th in the world in machine tool production. It led other much more developed countries such as Australia and Canada.

Virtually all of the graduates of the two-year post-graduate course leading to a degree of Master of Technology in machine tools now hold responsible positions in machine tool industries and research institutes.

Personal Observations

I had been told before going to India that there was a great love for the theoretical but not much inclination for the practical. I did not find this to be true. Labor-

atory periods relating metal cutting to material microstructure were met with enthusiasm as were laboratory periods in metal cutting. Several periods were spent on metal cutting forces, machinability, surface finish and chip formation.

Only one assignment became bogged down. After discussing the principles of jig and fixture design the class was taken to the adjoining pump, motor and lathe plant. Here they were asked to spot parts that could be better produced with a proper jig or fixture. With a little help from the plant supervisors enough projects were obtained so that no more than three students were working on any one problem. After twice the allotted time only a few concrete designs were sketched. Most of the problems never advanced past the discussion stage.

SINGAPORE

Introduction

The Republic of Singapore is located on a small island off the southern tip of the Malay Peninsula, Fig. 7. The island is 15 miles wide and 25 miles long. It has a population of 2.2 million of which 76% are Chinese and the remainder principally Malays and Indians. The national language is Malay; however, English is the language of

administration and is widely used. In 1965 Singapore separated from the Federation of Malaya and became an independent sovereign Republic.

Singapore's economy is based largely on trade, manufacturing, banking, insurance, tourism and communications. In recent years manufacturing has contributed 29.8% of the Gross Domestic Product.

Manufacturing in the metals sector consists principally of metal fabrication, foundry, extrusion, die casting and several enterprises in the field of precision engineering (tool and die making, gage manufacture, measurement instruments, watch parts and optical equipment).

The rapid industrial expansion can be attributed to the forward looking, effective government policies. In 1961 the leadership realized the island economy, made up primarily of trade, would not be able to support a burgeoning population. As a consequence, 9,700 acres have been acquired and set aside for an entirely new town and an Industrial Estate.

Many incentives were given to industrial concerns, either local or foreign, or both, who could qualify as "Pioneering Industries". By pioneering is meant a company that is able to produce a product that had not heretofore

been produced on the island or least not in sufficient quantity to meet local needs. It may also be an industry that sets up primarily for export.

The plan worked so well that unemployment which had been 7.7% in 1968 virtually disappeared by 1973. In fact, workers even had to be imported from nearby countries. Industrial employment jumped from 10,500 in 1962 to 155,000 in 1971.

To meet the needs of the rapidly expanding industrial community, education became the second largest item in the budget, second only to defense.

Education

Industrial and Vocational. Many firms were attracted to Singapore because of the incentives mentioned earlier and because an ample supply of skilled or semi-skilled labor was available at a reasonable cost. Much of the skilled and semi-skilled labor was provided by a system of eight government vocational schools and three post secondary schools.

Post Secondary Education. A higher level of training is provided by three post secondary schools. Diploma and certificate courses are offered in a wide variety of subjects such as mechanical engineering, industrial

electronics, and production engineering. These schools provide the intermediate training that is between the vocational school and the university.

Vacation Employment. A feature of the technician course at the Polytechnic was to help the students gain industrial experience before they graduated. Therefore, a concerted effort was made by the Administration through the Board of Governors to secure summer jobs for the students. In my opinion the program was only partially successful. Although quite a number of students were placed, they felt they did not obtain satisfactory experience.

University Courses in Manufacturing Engineering

In 1972-73 the University of Singapore and the Board of Governors concurred in that there was a need for more engineers who had a knowledge of production systems and manufacturing methods. As a result a new department was established, that of Industrial and Systems Engineering, (I&SE). Thus there are now two departments in which manufacturing engineering courses can be pursued, I&SE and Mechanical and Production Engineering.

Common First Two Years. As in India, the first two years of the Engineering Curriculum are common. Manufacturing

courses included are two units of workshop technology and four units of material science or a total of about 16%.

Mechanical and Production Engineering. In the mechanical and production engineering curriculum the manufacturing courses required are similar to many used in the states, mainly a course in materials and a course in manufacturing processes. However, in the fourth year there are five core subjects and a minimum of three elective courses. The elective subjects are to be chosen from five option areas. The options are:

1. Materials
2. Control systems
3. Thermal and fluid engineering
4. Marine technology
5. Engineering mechanics and design

A student interested in manufacturing can take a materials option and follow it up with such courses as industrial management, operations research, control sytems and inspection and testing of materials.

Independent projects are started in the second semester of the third year and are continued in both semesters of the fourth year for a total of 12 to 18 units or roughly 20% of the unit load for the third and fourth years.

Thus the independent projects can be quite substantial both from a design point of view as well as actual fabrication. An example of one that stands out in my mind is a hand operated hydraulic fork lift truck of about 500 lbs. capacity, made to lift items from floor level to about 6 ft.

Industrial and Systems Engineering. Courses directly related to manufacturing in the newer industrial and Systems Engineering are:

Methods Engineering

Manufacturing Processes

Production Systems Analysis & Synthesis

Tool Design

Quality Control, Reliability and Industrial Management

Again there is a project in the fourth year that is valued at 12 units or about 16% of the unit load for the 3rd and 4th years. The project may be either academic in nature or industrially oriented. As an example, Singapore, being one of the four largest port cities in the world, has gone extensively into containerization. This process has largely eliminated the individual crating of each shipment. It also facilitates handling and maximizes space utilization. One project this past year was a study of cargo handling by containerization. Other projects worked out with

local industry deal iwth Inventory Control, Management Information Systems, Operations Research and Work Studies.

Masters Degree

A Master of Science in Industrial Engineering curriculum has been developed primarily for people in industry. It is designed as a part-time course and is variable in length from two to five years. The courses offered are largely management oriented. An independent industrial project is required. These post graduate projects are supported by grants and contracts with industrial organizations, foundations and public agencies.

Personal Impressions

My most lasting impression of the classes I taught in Singapore was the eagerness to learn on the part of many of the students. Seldom if ever could I walk away from a lecture as I have done here. Most often the question and answer period would run twenty to thirty minutes after the lecture with a few students following me down to my office.

In some classes slides were used. After class students came and asked if they might run them over for their own use.

A take home exam on materials brought in the best results I have seen from any class. Not all the students were of this caliber, percentage wise perhaps only one fourth but enough to make all the extra effort worthwhile.

Fig. 1 The five Engineering Indian Institutes of Technology are shown in upper case letters, and the four Indian Institutes of Science are shown in lower case letters.

Fig. 2 A small column and knee milling machine made as a special project in M. Tech course in I.T.T. Madras.

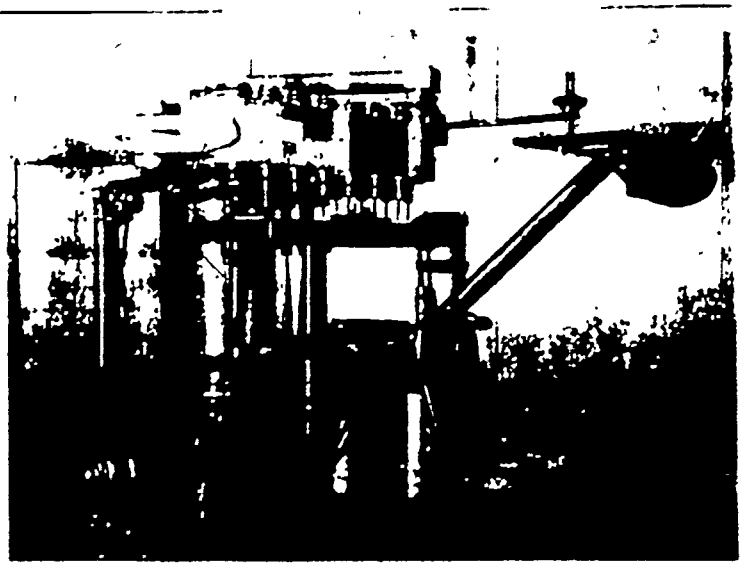


Fig. 3 A multiple-spindle pantograph machine made in the M. Tech course in I.T.T. Madras.

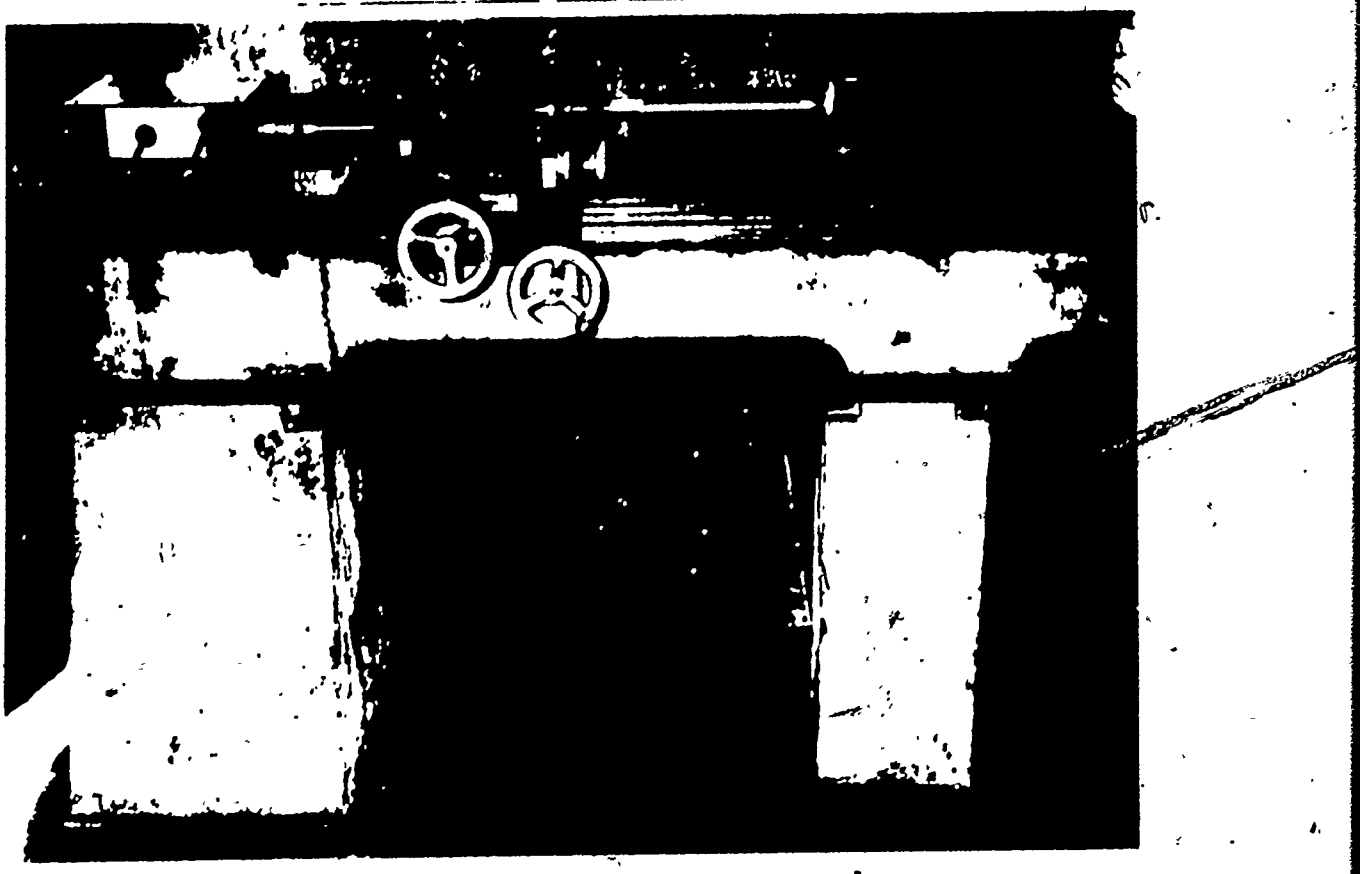
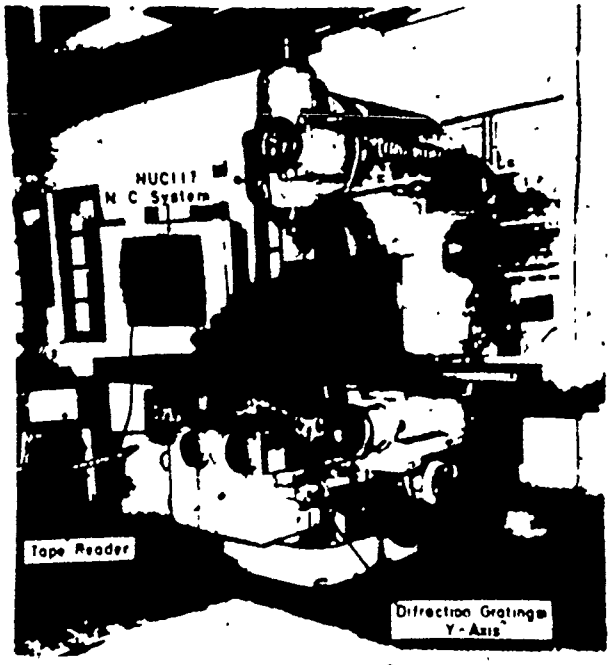


Fig. 4 A concrete bed lathe made as a special project in M.S. degree at I.T.T. Madras.



FRITZ WERNER Vertical Milling Machine (Type 2FV3D) is seen here retrofitted with a NUCIIT Numerical Control System developed by the Production Engineering Section of IIT Madras, for 3 axis point to point positioning for straight line milling

Fig. 5 A vertical milling machine was fitted with electric clutches and brakes for electrical programming. It is retrofitted with a numerical control system developed at I.I.T. Madras for 3 axis point-to-point milling.

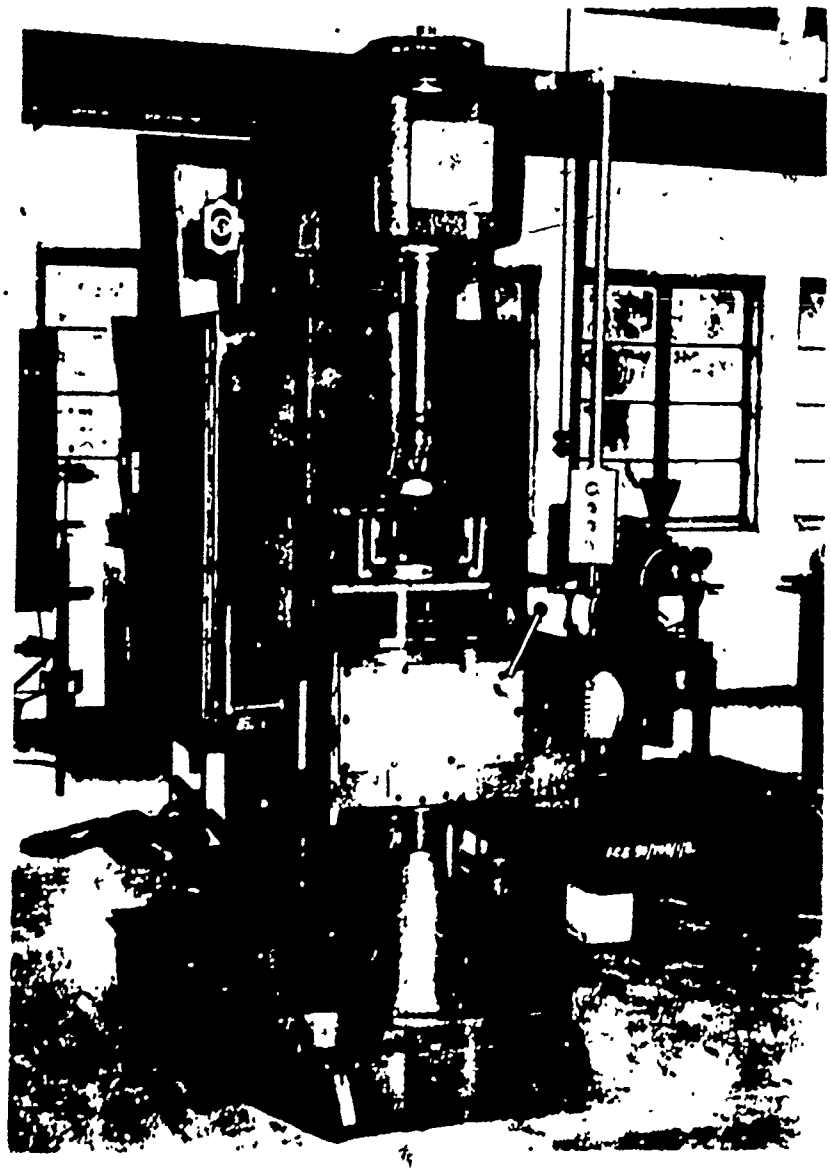


Fig. 6 A vertical boring machine fabricated as a special project at I.T.T. Madras.

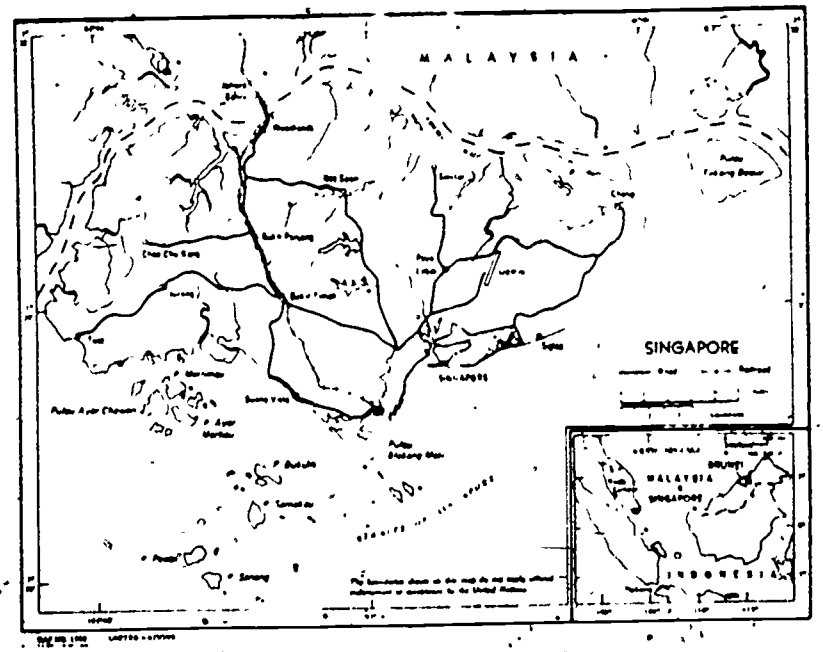


Fig. 7 Singapore is a small island located just off the tip of the Malay Peninsula, see inset.