TECHTALK 3

Lecture on Technology Management

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Experience in Managing Technology in HMT

By
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Dr. S.M. Patil, whose career as an engineer and a manager has spanned four decades, was the architect of HMT. After graduating in Mechanical and Electrical engineering from the University of Mumbai, he joined Cooper Engineering in 1942 and rose to the position of Works Manager in that company.

He joined HMT in 1953 as Superintendent (Works) and rose to become Managing Director of the company in 1964 and Chairman and Managing Director in 1967. He was also appointed Chairman of the Gujarat State Machine Tool Corporation, Bhavanagar in 1975.

During his tenure as CMD of HMT, Dr. Patil was responsible for the introduction and implementation of a major programme of product development and diversification. A number of machine tools of advanced design were introduced. With a ten- fold increase in annual turnover, during his tenure, Dr. Patil successfully steered HMT into a fast growing, diversifying and profit making enterprise - indeed to a position of pride and eminence in our machine tool industry.

Dr. Patil was Honorary Director of the Central Machine Tool Institute, Bangalore from 1961 to 1969. He then became its President in 1970 and held that position for seven years. He was also Director of the Central Board of the State Bank of India over 1972-77.

Dr. Patil has served as Consultant and Expert on several panels and committees, of various agencies of the United Nations and other international organisations. He was a member of several committees set up by Government relating to machine tools. Currently Dr. Patil is Chairman/Director of a number of companies.

For his outstanding contributions to the field of engineering, Dr. Patil has won many awards: the Sir Walter Punkey Indian Award for the most significant contribution to Production Engineering in India in 1963; "Padma Shri" in 1966; "Man of the Year" Award for 1973 and FIE Foundation Award in "Engineering Administration" in 1978.

EXPERIENCE IN MANAGING TECHNOLOGY IN HMT

INTRODUCTION

Technology is a means of converting scientific ideas and conceptual designs into products and process realities. Its evolution and development is a continuous process targeted towards achieving perfection in all directions, including quality, cost and environmental safety, of its end products and processes. Being a continuous process, technology should make use of state-of-the-art innovations, methods and manufacturing engineering. In short, technology is an applied science and an aid to convert basic science and research into practical end-use products and processes.

The crucial and indeed vital role of science and technology in the development of the economy of any nation needs no emphasis. Technology representing, as it does, the industrial application of science, is an embodiment of skills, knowledge and processes for production of goods and services through a systematic application of scientific laws and principles. Its development has to be implemented in a planned manner to enable it to meet the social and economic needs of society. These needs obviously differ from country to country and even in the same country, from time to time and so any blue-print to fulfil them, calls for an amalgamation of basic science on the one hand and technology on the other. In both the cases, it is necessary to inculcate in our minds, a constant awareness of development in other countries as well as the will and ability to adapt and improve on them to meet local conditions and requirements.

TECHNOLOGY POLICY

Perhaps, the most outstanding example of successful technology policy adopted by any country is provided by Japan. It made a conscious effort to gain access to the latest technology developed in any country in the world in order to make Japanese products more competitive in the world market, not on account of their low price but on account of the excellence of their quality. Import of technology for them was not the end but the beginning of the task. The imported technology had to be absorbed and then improved upon to make Japanese products superior to what other countries had to offer. So, today, in cameras, optical instruments, electronics, automobiles, TVs, VCRs, CDs, machine tools and a host of the industrial goods, Japanese products and the technology that goes into them has a much higher ranking than those manufactured in the countries whose technology was originally imported by Japan. By deliberate and intelligent exploitation and utilisation of work done in other countries, the Japanese so organised their programmes of technology development and commercialisation, supported by a sense of discipline and a remarkable devotion to objectives, as to now rank as one of the super powers in the industrial field, with a sound science and technology base.

TECHNOLOGY IN INDIA

Fortunately, right from Independence, this country has given high priority to science and research. With remarkable foresight, our first Prime Minister, Pandit Jawaharlal Nehru, with his scientific bent of mind, gave a great impetus to science and research activities. We started a chain of R& D centres now under the Council of Scientific & Industrial Research (CSIR), like the National Physical

Laboratory, Chemical Laboratory and the Aeronautical Laboratory. Some of our Universities also started post-graduate courses in advanced science and engineering. The Indian Institute of Science, Bangalore and the Metallurgical Laboratory in Jameshedpur, were already there to undertake research in their respective areas.

The Government of India has, in recent years, spelt out the country's technology policy as one directed towards achieving the objective of self-reliance, particularly in strategic and critical areas, besides being export oriented. That technology policy has from time to time, been reinforced and elaborated so as to guide our industry in fulfilling national goals in terms of : technological research and development, industrial growth, dispersal of industry to economically backward areas, rapid growth of small scale and rural industry and so on. The policy has been flexible and has been directed towards changing socio-economic environment in the country. The major thrust of our technology policy has been to identify obsolete technology in use and arrange for modernisation of both equipment and production processes so as to attain internationally competitive levels.

Not only has the Technology Plan formed a part of the Planning Commission's task of overall Development Planning, but allocation of the necessary funds for executing the Plan were also provided by the Planning Commission in the Five Year Plans. Later, in 1970-71, a special Department in the Ministry of Planning was created with a Union Cabinet Minister in charge of Science and Technology activities. The Department has since been separated and has now become an independent Ministry of Science & Technology with a Secretary in charge of the Department of Scientific & Industrial Research (DSIR). The Department closely monitors the technology plan approved by the Government with various companies, institutes, and establishments in industrial research. One of the main tasks on which the DSIR is concentrating, is to establish closer relations between industry, universities and the research institutes so that the country derives maximum benefits from scientific and industrial research.

We have come a long way since Independence by way of technological development in industry. Starting our industrial development with the main thrust on saving and conserving scarce foreign exchange through import substitution and a high degree of import restrictions, we are now entering a new phase of liberalisation and international competitiveness to free our national economy from many of the inhibiting controls and restrictions of the first three-and-a-half decades of our industrialisation efforts. Export has assumed a special priority. As a result, upgradation of technology and improvement of quality and productivity in industry to ensure high rates of economic growth, have assumed special significance.

IMPLEMENTATION OF TECHNOLOGY PLAN

There appear to be two main courses open to developing countries like India to build a technological base for their industries. One is to import readymade designs and production technology from the developed countries and the second, to make use of the scientific ideas and technical innovations in R & D institutions and laboratories to develop designs and technologies on their own for manufacturing industrial products. Of course, these are two extremes of the whole range of possible solutions. Any cut and dry answer to the question of how to develop a technological base for a particular country would not be possible since it would ignore the realities of the diversities in economic and industrial development of any newly independent developing country. What is probably right at one stage, for example, at the beginning of the development process, may prove wrong at a later stage of development. It is important, therefore, to formulate general principles of approach to the solution of this problem. But one thing appears to be definitely essential viz., the imported industrial designs and technology cannot be mastered, adapted to local conditions and improved upon or renewed, without scientific and technological infrastructure and the build-up of local R & D capabilities.

Immediately after Independence, under Panditji as our Prime Minister, the country adopted the first choice of importing technology to speed up the process of industrialisation of the country. That we continued with this policy for too long a period, despite the rapidly changing international technological environment, and depended mostly on import substitution in order to be selfsufficient in our requirements, was perhaps wrong. This seems to have worked against the interest of indigenous research and development efforts, an aspect which will be elaborated subsequently in this lecture.

METHODS OF IMPLEMENTATION OF TECHNOLOGY

The international technology market for designs and know-how for products and processes, presents a fairly wide range of technological possibilities and choices, except perhaps in respect of highly sophisticated technologies. It is imperative that a choice of designs and technology, as also that of licensor, is exercised with great care and deliberation. There are many forms of technical collaboration which our industry has adopted. Some of the more common ones are enumerated below:

Joint Ventures : The process of acquiring designs, production technology and know-how by a developing country like India, may have to begin with greater dependence on foreign collaborators. The type which is usually adopted by the developing economies, appears to be that of financial participation - joint ventures with trans-national corporations who have well established the technology sought for. At the time of Independence, this was perhaps quite an appropriate type of collaboration as in the case of the Hindustan Machine Tools Ltd., (HMT), Bangalore, who had a joint venture with Messers. Oerlikon Machine Tool Works, Buehrle & Co., (Oerlikon), Zurich, Switzerland.

Turnkey Collaborations : The second type which is usually expensive but more suitable for less developed developing countries, is turnkey arrangements. Even in such arrangements, the entrepreneur must be capable of knowing what he wants and should have experience in negotiations with foreign collaborators/ licensors of technology. It may not be always possible that entrepreneurs in developing countries have the required experience in both these areas, particularly in the negotiating part of the business. In such cases, it is advisable to seek the assistance of international agencies like the UNIDO or specialised governmental agencies set up for the purpose of assisting entrepreneurs.

Licence Collaborations : With experience, a developing country like India, would have generated sufficient talent, managerial capabilities and administrative acumen to advance to the next type of collaboration viz., limited licence arrangements for acquiring a particular technology. In this type of arrangement, it is normally the practice to pay a lumpsum amount to compensate the licensor for his costs of development of the product design, technology of production and patent rights if any. In addition a reasonable royalty is allowed, only on the indigenously manufactured content of the product under licence, with such royalty payments varying from five to ten years over the years from the commencement of commercial production by the Indian company involved.

Technology against bulk orders : An ingenious type of collaboration arrangement is to place a bulk order for products and acquire the product drawings, process details and technological know-how of manufacturing as part of the purchase of the product. But this may not always be possible and hence has not been so common.

Limited arrangements for acquiring technology :

As a country which gained considerable technical capability and negotiating strength, we have adopted a limited type of collaboration arrangement to acquire technologies. This is to buy a full set of drawings and production documentation. With such drawings and using our own engineering and

production facilities, it is possible to successfully develop production technology and produce the licensed designs of a product. The compensation for the collaborator could be in the form of either a down payment or a royalty.

Reverse Engineering : Reverse engineering is possible in a country like India which has developed strengths in various technical and

business fields. But in case of advanced technologies, it is not advisable to adopt such a strategy. While it may be feasible to develop designs and drawings of certain components of a product, it may not always be possible to evolve appropriate manufacturing and assembly technologies. This method is comparatively more difficult in the case of process industries and services. Many developing countries simply do not have the software to successfully implement some of the more sophisticated processes and services.

MANAGEMENT AND DEVELOPMENT OF TECHNOLOGY IN HMT

The production of machine tools on more modern lines seemed to have been established in India during the IInd World War period, 1939-45. This was due to the financial and technical assistance of the British Indian Government as part of their War efforts. According to the report of the Machine Tool Panel, since the shipments of machine tools, among other items required for ordnance and arsenal factories of the Allies, was being bombed on high seas, the British decided to develop the Indian machine tool industry on more modern lines.

The end of the War, however, saw the Indian machine tool industry in doldrums as foreign machine tools were again available freely and the demand for Indian made machine tools drastically declined because of their outdated designs and poor quality. Many of the Companies engaged in the production of machine tools during the War time, mainly for the Government, gave up machine tool manufacturing and started making other items of machinery, like diesel engines, agricultural machinery and implements, textile machinery etc. When the indigenous industry, including machine tools, was in very serious trouble, the independent Government of India took an altogether unconventional decision in late 1940s, of setting up basic heavy industries, like steel and non-ferrous metals and capital goods in the public sector.

The industrialisation of the country thus started soon after Independence under the guidance of Pandit Jawahar Lal Nehru. Being capital intensive industries, the policy makers and planners felt that the production of these items was only feasible in the public sector in view of the massive investments needed in these undertakings. To support these industries, it was necessary that the country should have strong machine tool production facilities.

During February 1948, the Ministry of Industry & Supplies of the Government of India appointed a "Disposal Utilisation Committee" to advise the Government on, how best to utilise several crores worth of War Surplus merchandise like raw materials, machinery, machine tools and other equipment lying in the stores of the Director General, Disposals. The Committee submitted its Report during May 1948 and recommended the establishment of a number of large scale engineering units to manufacture essential capital goods and items such as ships, aircrafts, telecommunication equipment and machine tools in the public sector.

Realising the importance of the machine tools industry, which was then mainly in the private sector and was languishing badly, the Disposal Utilisation Committee strongly recommended setting up of a Machine Tool Factory (MTF), in the public sector. Offers from Czechoslovakia and Switzerland were received for setting up the unit. The Government selected Messers Oerlikons as the most suitable collaborators. Oerlikons had earlier been associated with the Government as they had set up the Ordnance Factory in Ambhajari and the Training Centre in Ambernath. The Government of India signed a preliminary agreement with Oerlikons on 28th Feb., 1949 and they had a minority share-holding in Machine Tool Factory (MTF). When this idea was mooted there was considerable resistance from the private sector units spearheaded by the Machine Tool Manufacturer's Association. However, with the strong support of the Prime Minister, steps were initiated to establish MTF for manufacturing various types of machine tools in the public sector inspite of the opposition from the private sector.

I must make a mention here of the major contribution made by late Shri S. S. Iyengar, Officer on Special Duty, in the then Ministry of Industry and Supply, who prepared the Project Report of MTF in 1950 and was responsible for laying the foundation of HMT. He later served HMT as the General Technical Manager, before his demise in 1956.

The period 1949-53 seems to have been spent on preliminary work on the project, like selection of site, scrutiny of Detailed Report from Oerlikons and recruitment of key personnel. It was only during the middle of 1953 that the training of key personnel including me, commenced in Zurich at the Oerlikons' Works and in the MTF factory in Jalahalli, Bangalore. In the meantime, MTF underwent a legal transformation from a Government Departmental Organisation to a Joint Stock Company under the Company Law. On 7th Feb., 1953, the Company was registered as Hindustan Machine Tools Ltd., which later became HMT Ltd.. Shri Aftab Rai was appointed as its first Managing Director.

First Phase - 1954-56 : In the initial phase, transfer of technology relating to manufacture of machine tools was totally on a turn-key basis. The task was entrusted to the Swiss collaborators - Oerlikons. Initially production of H-22 lathes of the stateof-the-art design was taken up. Right from the layout of shops of the factory, selection of plant, machinery and equipment to complete production, testing, painting and packing of the machine, was executed under close technical supervision of 84 Swiss, German and Italian technical experts headed by a German General Technical Manager from Oerlikons. An Indian understudy was attached to each one of them to take over the job from foreign experts on expiry of their two to five years contract with HMT. The last person to leave HMT was the General Technical Manager and I took over from him towards the end of 1959 as the General Manager of HMT Though transfer of technology, know-how and its management was not completely smooth, yet it was total and rewarding. Even after several years of the departure of the experts, our supervisors and technicians always performed their tasks as per the techniques and instructions passed on to them by the foreign experts. I must say that this was an example of a successful transfer of technology, though it cost the Government of India, an enormous sum of money.

Second Phase - 1956-64 : By 1956, the Chief Executive of HMT was changed and Shri. M. K. Mathulla, took over charge as its Managing Director. He was well qualified in Finance and had extensive experience in TISCO, Jamshedpur. He soon realised the importance of indigenising management of technology and dispensing with foreign control in all matters including technical issues. For example, under the advice of Indian managers, he soon realised the need for diversification to introduce other modern general purpose machine tools which were in great demand. In spite of opposition from Oerlikons, he allowed the Indian Technical Managers, who with the co-operation of the General Technical Manager, started scouting for a suitable design, and a foreign collaborator for the manufacture of medium size kneetype Milling Machines. Simultaneously, the Managing Director persuaded the Government of India to buy the Oerlikons shares so as to become financially independent. During 1956, HMT became independent of Oerlikons.

In 1957, the company finalised the licensing of technology with Fritz Werner A.G., Berlin, West Germany for manufacture of M2 type Milling Machines. Being the first licensed design, we had to work hard to draw up technical specifications and details of what we should ask for from the collaborators apart from the drawings. This took us a couple of months and under the guidance of the General Technical Manager, we drew up the clause relating to technology which was to be incorporated in the draft agreement to be negotiated with the collaborator. We had worked this special clause in so much detail that it became our guide for future licencing arrangements. In course of time, we further refined it and based on our expensive reduced our requirements so that we could discuss reduction in down payments. From part list and drawings of components to material specifications, heat treatment details, operation process details with timings, jigs, fixtures and toolings, assembly and testing details, painting and packing details, were all incorporated in the technical clause of the draft licence agreement. As we gained experience, later with other collaborators, we even demanded pattern drawings and the details of foundry technology. Since most of our collaborators did not have their own foundry, we insisted that some of our foundry technicians be given training in foundries from where they purchased castings.

Besides the Milling machines, HMT wanted to expand its operations and introduce other modern general purpose machine tools like Radial Drilling Machines, Grinding Machines, etc. Accordingly, a proposal was sent by HMT to the Government of India to step up the capacity of HMT from 400 nos. of standard machines per year to 1000 machines per year to include, besides light duty Tool Room Lathes and Medium Heavy Duty Lathes, new types of machine tools. The Government appointed an Expert Committee to examine the proposal and I worked as HMT's representative of the Committee. Based on the recommendations of the committee, which were accepted by the Government, we introduced the Radial Drilling Machines of Herman Kolb, Koln, West Germany, Cylindrical Grinding machines of Olivetti S.P. A., d'Ivrea, (near Torino), Italy and light duty Tool Room Lathes of Farnault Batignolles in Chole (near Paris), France. Along with these developments, we established a Meehanite foundry as captive to the Bangalore operations with a capacity of 1000 tonnes per annum. In this project, we were assisted by foundry experts from the Railway's Chittaranjan Locomotive foundry.

While our Managing Director and I were in France during 1958 to select a suitable design for a Radial Drilling Machine, the former was invited to visit the Renault's factory in Billiancourt in the outskirts of Paris. He was so impressed by the automatic production of component parts of the car, using some special machines manufactured by Renault's Machine Tool Division, that he made me stay a day longer in Paris and arranged for my visit to Renault's factory. I was similarly impressed and learnt that they were producing 1450 gear boxes per day with hardly 40 workers using Special Purpose Machines (SPM) designed and manufactured by Renault's. I thought that we should as well produce such machines in HMT, since there could be demand for them from the automotive and other industries. Later, the Managing Director with one of my colleagues, visited Paris during the latter part of 1960 and finalised arrangements with Renaults for licence manufacture of their Special Purpose Machines in HMT and signed the agreement with them in March, 1961.

It was Shri. Mathulla who made the base of HMT strong during his 8 years of service in the Company from 1956 to 1964 as Managing Director and later as Chairman and Managing Director of HMT. He believed in large scale production and in fact before his retirement in early April 1964, at the time of the inauguration of HMT III Unit at Pinjore near Chandigarh by Pandit Jawaharlal Nehru, during October 1963, he made a public announcement that progressively one unit of HMT would be open every year in each State.

Third Phase - 1964-78 : When I took over as the Managing Director during March 1964, there were three units of HMT-two in Bangalore and one in Pinjore. These units were engaged in manufacture of different types of machine tools. We had also planned to set up two more Units, one in the state of Kerala and the other in Andhra Pradesh. We shifted the production of Milling Machines from Bangalore Unit to the Pinjore Unit (HMT III) and the rest of the products including SPMs were still being manufactured in HMT I & II, Bangalore Units, before allotting some of these machines to our other new Units. By then we had covered manufacture of some of the General Purpose Machines and established the basic technology for manufacture of machine tools under licence, in HMT.

In the meantime, the nucleus of design staff in Bangalore had to be expanded. An expert Machine

Tool Designer, an Indian, was recruited in Europe during 1961. He was a qualified graduate engineer from the Zurich University with E.T.H. Degree in machine tool technology. He was teaching machine tool technology at the Institute. From a mere drawing office to adapt imported designs of machine tools to suit our standards and available raw materials and bought out components, we had to enhance the strengths and capabilities of our designers who could undertake independent designs of machine tools. In addition, the manufacture of Special Purpose Machines involved considerable amount of design talents and hence, a large number of designers capable of designing Special Purpose Machines were required. Of course we had a collaboration with Renaults but that was for a limited area of designs viz., Unit Heads, Tables including Indexing Tables and Feed Units. The rest of the configurations of Special Purpose Machines meant for manufacture of certain specific components including fixtures, had to be designed by us to meet the specific requirements of customers. No doubt, we had the guidance of Renault experts but this was limited to the short period of their contract. We, therefore, started recruiting a number of machine tool designers from within our organisation, who had the manufacturing and planning experience in the Company though a few were also recruited from outside. Many of these designers were sent abroad for training at our collaborator's works and were also required to visit regularly , factories and machine tool exhibitions abroad, to gain knowledge of the latest designs of machine tools.

I must add here that we simultaneously set up a full fledged Standards Department with adequate number of Standards Engineers, who produced several thousands of work standards for our own purpose and took active part in the activities of the Indian Standards Institution. They also participated in discussions and conferences at the International Standards Organisations, which were organised mainly in Paris. We also had a well staffed Tool Design Office. Industrial Engineering Department was another Wing which was established a little later in HMT and contributed significantly, particularly in the area of Value Engineering and enabled us to cut down considerably our costs of manufacturing imported designs and those developed by ourselves. One must appreciate that all these activities are essential and without the support of these important wings we cannot develop any modern designs and technology for the machine tool industry.

During the third phase of development (1964-1978) and by the year 1966, most of our imported designs of machine tools like those of Lathes, Milling Machines and Grinding Machines had undergone considerable design changes. The older designs had been updated in machining technology. This also facilitated export of these machines, as under the licence arrangements with the foreign collaborators, which we could not have exported in their original form.

The year 1966 commenced with bad omens, not only for HMT and the Indian Machine Tool Industry but for the entire country. The year was one of the worst for the Indian economy since Independence. Nature let down the country badly and the drought, experienced in the crucial months of the second half of the year caused by the failure of monsoons, was unknown in the history of India and resulted in near famine conditions over a very wide area of the country. The food production during the year was hardly 70 million tonnes. As a result, available resources had to be diverted for importing food grains and other essential articles.

Added to this, we faced a military threat from Pakistan resulting in heavy import of defence requirements. Together with heavy imports of food grains and inputs for agriculture, India's trade deficit had increased considerably. The balance of payment position became severely strained and the import of raw materials and components for industry has been drastically curtailed, resulting in serious set back to industrial production during the year 1966-69. To check the inflationary trends, the bank borrowings had been squeezed to the utmost extent. Due to these and several other adverse factors like severe recession, hefty devaluation of the Rupee in June 1966 and the postponement of the IV th Five Year Plan by three years from 1966 to 1968, the investment market dried up considerably, resulting in highly depressed demand for capital machinery including machine tools.

During the same period, HMT's new machine tool units came into operation; HMT III, Pinjore had reached its full capacity, HMT IV, Kalamassery was almost reaching its full capacity and HMT V, Hyderabad had just commenced production. With these new Units, together with the older two units in Bangalore i.e., HMT I & II, we had theoretically reached a capacity to produce over 2000 standard machine tools per annum. Against this capacity, orders for machine tools were barely trickling in by ones and twos and at the most, could absorb hardly 50% of the total capacity.

There was a Board resolution towards the end of 1966 to lay off 5000 of our labour. But being in the public sector, this could not be done. Instead, the Ministry offered to help us by procuring Government loan on easy terms. This we declined under the fear of losing our financial independence. Instead, we relied heavily on the cash income from our Watch Factory, to meet the revenue expenditure of all our Units. This also gave us an idea of diversifying our Production Programme outside the machine tool line. We soon entered into lines like production of agricultural tractors, printing machines, die casting and plastic injection moulding machines. In addition, we had to diversify vertically as well, by taking up the production of such of those Machine Tools which were being imported under licence from abroad. In fact, this was a much better and speedier way, though it presented us with a lot of manufacturing problems, being complicated machines. In addition, we had to evolve our own designs of latest types of machine tools for which there could be some demand in the country. Further, we had to double our efforts in exports. We opened our own export offices in Melbourne, Australia and in Auckland, New Zealand and located a reputed machine tool manufacturing company in Cincinnatti, U.S.A., viz., the American Tool Works (ATW) as our partner to handle our exports through the network of their own dealers. We appointed agents in Holland, Denmark and Sweden. Rest of Europe was being looked after by Oerlikons, Zurich. In UK we appointed a reputed firm in Coventry to look after our interests. By taking these measures, I must say we were fairly successful in warding off a serious situation in HMT, and its very survival.

It so happened that the DGOF was wanting to import several crores worth of machine tools for modernising their Ordnance Factories. However, due to some strategic reasons, manufacturers of machine tools abroad, mostly from Germany, France, U.K. and the U.S.A., were prohibited from supplying equipment to the arms and ammunition factories in India. Hence, perhaps being in the public sector, I was asked by the Ministry of Defence Production, if HMT could import the required machine tools. We agreed to take up this responsibility but indicated that we should be free to negotiate with suppliers for any possible manufacturing arrangements with them. So, during the icy cold November of 1966, I went with our Chief Designer to Europe and U.S.A. We signed licence agreements for the manufacture of Multi-Spindle Bar Automatic and Heavy Duty Copying Lathes both with French Companies and Shell Turning machines with a U.S. Firm, by placing bulk orders on them.

On return however, I had to face serious opposition from our manufacturing people as these machines being highly complicated, they considered, could not be manufactured under the existing conditions. However, I explained to our production staff, that orders for the current machines had almost disappeared and hence there was no alternative but to make efforts to produce these modern and complicated machines which were required in the country. For the DGOF, we started with the assembly of their machines from SKID (in semi-knockdown) conditions under the supervision of experts from foreign collaborators. Later on, we installed some minimum balancing plant and got our engineers trained in the works of our collaborators to indigenise substantially the production of these machines. We supplied many of them to the Indian industry.

Opportunities, they say, do not come normally without looking for them. We learnt that DGOF was going to import couple of crores of rupees worth of modern Milling Machines (275 numbers), not in our range, from a German firm through the latter's Indian joint venture for the Small Arms Factory in Tiruchirapalli. Our allelectric Milling Machines produced in Pinjore (HMT III) under licence from Fritz Werner, Berlin did not come up to the specifications demanded by the DGOF. Having known the DGOF rather intimately, I appealed to him that HMT should be given the chance to design the machine and manufacture their full requirements. This would save the DGOF couple of crores of rupees in valuable foreign exchange besides giving an opportunity to Indian designers and more so, when HMT was suffering badly, for want of orders. In spite of some opposition from his staff, the DGOF asked HMT to submit a proposal with conceptual design for E2 Milling Machines, which were to be supplied within two years with full complement of toolings for producing components of the Small Arms. Of course, it took us another year or so for debugging the design and manufacturing defects and prove the quality and quantity of production of components of the Small Arms at Tiruchirapalli. In the process, the Company incurred some loss but then we could keep our factories running. Besides, we learnt the first lesson in designing a modern machine tool from scratch and gained confidence in evolving modern designs and technology of metal working machine tools.

Similarly, we found out that TELCO, Jamshedpur, were in the process of setting up a new unit in Poona for manufacturing trucks. We got into touch with the firm and quoted several of our new types of machine tools like the Heavy Duty Copying Lathes, Single and Multi Spindle Automatics, etc. In the process, I came to know their Managing Director, who proposed that HMT should also explore the possibility of producing Heavy Duty Presses, as Telco, Poona was wanting some of these machines with capacities varying from 500 tonnes to 1000 tonnes. I believe he even suggested the name of a possible collaborator in the U.S.A. Taking advantage of this opportunity, I made a quick trip to Germany and the U.S.A. to preliminarily investigate the possibilities. After several trips to the U.S.A. and meetings with collaborators, we concluded a licence agreement for manufacturing modern designs of Heavy Duty Presses, both hydraulic and mechanical types, with a firm in Chicago, U.S.A.

Thus, we entered into a new area of technology of metal forming machines and set up a separate division in Hyderabad adjacent to our HMT V Unit. We supplied the full complement of presses to Telco, Poona. Of course, we had several teething problems, but with the help of our collaborators and experts from Chicago, we were able to solve them. In the process, our designers learnt the art of designing metal forming machine tools and our production engineers, the manufacturing technology of producing heavy duty metal forming machines. During 1976, we fulfilled a prestigious order for a 2000 tonne Hydraulic Press for BHEL, Tiruchirapalli.

During the same phase of technology development in HMT, we signed several licence agreements with foreign firms, some against bulk orders like the Pegard Horizontal Boring Machines from Belgium. In due course of time, we designed a new Horizontal Boring Machine with the help of our collaborators, which was more suitable to the Indian market. Under pressure from the U.K. Government, we jointly converted the inch design to metric design of Maxicut Gear Shaping Machines of Drommond Asquith Ltd., and started producing these machines in Bangalore. We entered into an agreement for production of Gear Hobbing Machines with a firm in West Germany and these were also being produced in Bangalore. We signed a limited licence agreement with a French firm for the production of Coordinate Production type Vertical Drilling and Boring machines. These machines were being produced in our Bangalore factories. We signed up with an East German firm for producing precision Surface Grinding Machines and made them in Bangalore. In our maiden effort to evolve mass production technology, we supplied the Renault Transfer line from HMT V, Hyderabad to the Telco factory in Poona during 1967. Being a light duty machine, however, Telco was not happy with the performance. Hence after great struggle and delay, we succeeded with the Government and obtained sanction for signing a licence agreement with Cross and Fraser, Detroit during 1976, to manufacture more sturdy types of Special Purpose Machines and Transfer lines in HMT V, Hyderabad. Just after I had retired in 1978, HMT supplied the first "Cross" Transfer line machine to Bajaj Auto Ltd., Poona. By then, HMT had delivered innumerable Special Purpose Machines for the Indian Industry, particularly the Automotive Industry, Ordnance factories, Chittaranjan Locomotives factory, Locomotive factory in Varanasi, BHEL's various factories for the production of Boilers, Generators, Turbines etc. Thus, HMT became a leading machine tool Company in India.

Our efforts in the export field also paid good dividends. One of the reasons for the growth in exports was that we designed and produced machines to suit the requirements of the customers and countries. For example, we produced a series of Heavy Duty Lathes ("C" type) for the U.S. markets based on the guidance and advice of our agents, ATW. In a matter of 10 years, our exports had reached a figure of Rs. 5 crores worth of machine tools, mostly to the developed countries. Besides product exports during the later years (1976-77), we entered the area of "Management Consultancy" abroad and set up factories in Algeria for the production of Gas Regulators and Water Meters against management consultancy fees of $ 12 million.

An important landmark in the development of machine tool technology in HMT was the introduction of the NC and CNC (numerically controlled / computer numerically controlled) machine tools in the final years of my tenure. Though the demand for these machines was almost nil during 1975, I visualised that there would be a great prospect for these machines in the future. In spite of adverse criticism from my colleagues in the machine tool industry, that I was wasting public funds in developing NC machines without any market, I went ahead with the idea.

It was not possible, during those years, to easily locate any collaborator from abroad for acquiring this latest technology and even if we could succeed in our efforts, this could involve huge sums of money *by way* of down payments and royalty. Discussing the subject with my friend who was the Chairman of the American Tool Works (ATW), Cincinnati, agents of HMT in U.S.A., we hit upon an ingenious plan. We invited the leading Japanese firm, Yamazaki of Nagoya and the wellknown British firm, Messrs Marwin Ltd., (which later became Kearney

Trecker & Marwin Ltd., (KTM), Brighton) and along with ATW and HMT, we could evolve designs of Machining Centres which could compete in the international market. After several rounds of discussions in Nagoya, Cincinnati, Brighton and Bangalore, Yamazaki dropped out of the project. In the meantime, ATW, Cincinnati was sold and so KTM and HMT were the only two left to take up the project. HMT was entrusted with the design of the machine and building up of prototypes under the guidance of KTM designers from Brighton. KTM would interface the CNC Control Systems and we would jointly approve the machine, its price etc. As a first exercise, we built two prototypes of the CNC Turning Machines and sent one to Brighton for testing. We retained the second machine in Bangalore for testing ourselves. Finally, after several months of hard work, towards the end of 1974, the prototype of a CNC Controlled Turning Centre which our collaborators called the "Moghul" lathe, came out of the assembly line in HMT I & II, Bangalore. We subsequently got orders for 75 nos. of these machines from KTM for worldwide distribution. In the process, our engineers and designers learnt the art and technology of building CNC machines. With the result, we soon came out with a Vertical Machining Centre in Bangalore and later with a Horizontal Machining Centre in Pinjore. After gaining sufficient experience in building CNC machine tools and Machining Centres, we came out with an inclined bed CNC Controlled Lathe in HMT IV, Kalamassery, which was well received in the market. Before retiring, I initiated the development of a simple "Tool Changer" and saw in progress the prototype of 20 nos. of Tool Changers to be fitted on to the Horizontal Machining Centre, in HMT III, Pinjore.

By the time I retired in April 1978, HMT was manufacturing practically all types of General Purpose machines, including the updated designs of Crankshaft Grinders and Production type Internal Grinders, from HMT IV in Ajmer in Rajasthan. More than 50% of these machines were designed and updated by HMT. Besides, HMT was manufacturing a variety of Special Purpose Machines, Transfer lines and CNC Machining Centres, all designed and developed by the Company. HMT thus became not only the largest manufacturer of machine tools in India, but came to be recognised as one of the renowned manufacturers of machine tools in the world.

I must mention that in all my efforts to bring up HMT, I have had the whole hearted co-operation, support, hard work and dedication of my colleagues and employees in HMT. I was also fortunate in enjoying the kind assistance and support of the Ministers and Senior civil servants in the administrative ministry in charge of HMT. I was given the best of treatment by both these important agencies, whose understanding and approach were pragmatic all through. But for this kind of assistance, it would not have been possible to build HMT, which became a premier enterprise in the public sector - the "jewel in the Public Sector" as complimented by late Prime Minister Pandit Jawaharlal Nehru and the "Magnum Opus" as Shri Manubhai Shah eulogised the Company, while he was the Minister of State in the Ministry of Industry, Government of India.

When I took over as the CMD of HMT, I had the vision that I must provide the Indian industry with the machine tools it needed, particularly those with high technology content, fully realising that no country, including the advanced countries, are self-sufficient in the requirement of machine tools. For instance, the country which has the largest turnover in machine tools, normally also is the biggest importer of machine tools. However, my target was, that at least the balance of trade in machine tools, including the import of raw materials, components and other inputs, was in our favour. I had the intention of producing a diversified range of machine tools with production facilities in our six machine tool units spread over the country. I wanted our country to occupy a place of pride in the world map of machine tools.

I would also like to share with you a few of the important strategies followed to achieve these objectives. Firstly, I wanted all my senior executives and designers to be well aware of the latest developments in machine tools and pick up those high-tech designs which were required in the country. We therefore, used to send our executives, designers, production engineers and marketing personnel to attend exhibitions, seminars and workshops all over the advanced world. I also used to send our executives for training in the management institutes in the country, besides providing in-house training at the Organisational Development Centre (OD) of HMT. Those in design engineering were deputed to the best R& D centres that were existing in Germany, the U.S.A., U.K. and the USSR. I adopted the strategy of developing designers from production engineers within HMT, who had the aptitude for innovation and design. This led to the designers being highly practical oriented rather than being theoretical in their approach.

Thrust was given on exports, not only as a means to earn foreign exchange, but also for the exposure of HMT executives and designers to the latest advancements in the field. Along with exports, marketing was the area which was given the maximum thrust. It was through marketing that HMT got an insight of what technologies were needed within the country and for exports. Again, I made sure that the marketing team was mainly drawn from production engineers who had shop floor experience. In HMT, we have all along been customer oriented. Emphasis was therefore laid on supply of machines to meet the specific requirements of the customers. The thrust was on improving and updating the manufacturing technology of our customers.

Technology forecasting was another important area which we conceived. There was a development cell at the corporate headquarters consisting of designers, marketing executives and production engineers. This cell worked under the Chief Designer. The cell would make a study of various types of "futuristic" conceptions in machine tools. These study reports were examined at the Headquarters and "make or buy" decisions were taken. If the technology was to be purchased, attempts were made to select an optimum technology.

In case, however, these were to be developed within the country, respective units of HMT, specialising in that particular discipline were assigned the task of detailed designing, developing and manufacturing of the items. Before the process was taken up by the Unit, they were required to make a detailed report on the development project inter-alia covering financial requirements, time frame, manpower requirements, etc. Only after its feasibility was well-established and our central marketing had assured adequate market for the new products, the development project was taken up. The progress used to be very closely monitored. The above strategy was followed for development of new items; however, in case of incremental improvements in the existing types of machines, it was the responsibility of the respective Units.

As a result of these and various other efforts, HMT occupied the position of a market leader in machine tool industry in the country. It also had a place of pride in the world map of machine tool manufacture. With all humility at my command and in spite of some others not agreeing with me entirely, I must say that HMT was instrumental in the development of the machine tool industry in the country, on modern lines.

The rest of our machine tool industry followed a growth pattern similar to that pioneered by HMT, except for the production of NC/CNC machines which started in the private sector *only during the mid 1980s i.e. five to* seven years after HMT, and that too under licence from foreign firms.

From the end of the 1970s till about the mid 1980s, perhaps mainly because of the boom in the market for general purpose machine tools in the country, HMT seemed to have almost stopped the development of CNC technology and its application in manufacturing engineering. Similarly, the Indian machine tool industry in the private sector was quite content with the domestic order position during this period. But both the private machine tool industry and HMT suffered serious set-back from *the middle of 1980s, when several* CNC machining centres were imported by the Indian metal cutting industry and the automotive industry in particular. It appears that these industries and some of the new engineering companies had, in the meantime, undergone considerable transformation in machining technology and required many modern machine tools including the Machining Centres and hence the requirements of these machines had to be met through imports.

Learning from the mistake the industry made during 1979-85 period, whereby more than 60% of the total requirements of machine tools in the country were being imported, mainly the NC and CNC machines, today the situation has slightly improved, whereby import of machine tools has gone down somewhat. The production of NC and CNC machines constituted almost 50 % of the total production of Rs. 1000 crores worth of the Indian machine tool industry including HMT, during 1994-95.

STAGNATION IN TECHNOLOGY DEVELOPMENT

However, over 45 years since independent India started its Five Year Plans during 1950, significant growth in the machine tool industry and the industrial sector in general took place, primarily under a closed economy and protected market. We seemed to have gone wrong somewhere down the line, these 45 years. Firstly, we seem not to have changed with the times. On the contrary, for various reasons, including ideological, we continued to give high protection to our industry, whether in the private sector or in the public sector. Emphasis was laid more on import substitution than on opting for high technology, which led Indian scientists and industrialists to become imitative instead of being innovative. In short, not only did we **not** change with the times, but we insulated ourselves from the conditions prevailing in the advanced world.

Indian industry lagged behind in three primary areas viz., technology, marketing and exports. As a result, the technological development and growth in most of the companies was at a minimum level. As far as the machine tool industry was concerned, the very fact, that the country imported $ 369 million (Rs. 1290 crores) worth of machine tools during 1995-96 as against the estimated indigenous production of Rs. 1500 crores, is indicative of the stagnation of the machine tool technology in the country.

With the micro-chip getting more and more powerful, we have entered the computer and information age. With the "Internet" which is mankind's leap into the millenium, the world has shrunk into a tiny planet within the reach of every nation, to enable them to go ahead along with the tremendous development that is taking place in industrial, transportation, communication and other economic activities.

It was only during 1990-91 that the Government realised, that to march ahead we must join the international technological stage and open up our economy globally. However, the extra ordinarily rapid and advanced technological developments, taking place in the industrialised countries, require appropriate restructuring of the economic, social and organisational pattern and a clear cut appreciation of globally integrated economy.

The biggest victim of protected economy in India has been technology development. In fact, though it made some progress now and then, mainly through import of better and more advanced technology, yet there was not any all- round upgradation of technology in the country, which could match the advances taking place elsewhere in the industrialised world. This was perhaps because the industry, including machine tools, could find a ready market for their products more or less in a protected atmosphere. There was no competition from abroad and even within the country, the competition was not so strong. Export, though attempted with some degree of thrust, our industrial products, being technologically outdated, could not find substantial markets abroad.

In spite of several research laboratories and agencies such as the ICAR, ICMR, CSIR, etc., with the exception of ICAR, the industry considered that it was expedient to import technology from abroad, rather than depending upon the work carried out in these laboratories and institutes. They argued that our researchers were working in ivory towers and came out with work which was unrelated to the requirements of the industry. The Research Institutes on the other hand, complained severely that the industry was callous of the long term interests of the country and imported cheap ready made technology, mainly driven by the idea of making quick profits under the protected market. They proved by statistics, that in the developed world industry spent $ 3 to 4 on R &D as against the Government's one $ expenditure. It has been the other way round in India. It is clear, they say, that industry has not invested enough money even to absorb and improve the imported know-how to make it our own and self generating. They further support their argument, that all too frequently, the embargoes have prevented access to some of the critical components of technology needed to build the hardware. Hence, in fields like Nuclear Power, Space and Defence, research from foreign sources was just not available at any cost. Therefore, the country over the years has not only developed these technologies to produce these components, but is now competent to come out with advanced technologies like super computers, parallel processing, artificial intelligence, space technology of satellite and Light Combat Aircraft (LCAs). They argued that when we buy production know-how and technology from abroad, we cut the umbilical cord connecting the R & D invention and production know-how, making the upstream activities irrelevant.

These arguments and counter arguments apart, one major defect in our system which prevents the growth of indigenous technology is the lack of appropriate linkages between development of technologies in the Research laboratories and Universities on the one hand and their application in industry on the other. Once the technology has been developed in the laboratory, it has to be commercialised. This largely depends upon the industry sponsored research projects. The recent study sponsored by the Government of India and carried out by UNESCO and UNDP has concluded, that the linkage between the Universities and academic institutions on the one hand and industries on the other has been too weak and with few exceptions, not much has been done to promote this interaction in the country. While import of technology in the initial stages may be desirable or even necessary in some areas like machine tools, no industry can prosper in the long run, unless it builds a self reliant base by forming a partnership with educational institutions and R & D establishments.

One of the best examples of the cooperative efforts between Industry and Research and Development Institutes is provided by the Central Manufacturing Technology Institute (CMTI), Bangalore under the Ministry of Industry.

During the middle of 1961, Government of India, Ministry of Industry, requested HMT to assist them to set up a Machine Tool Design and Research Institute for which they had concluded an agreement with the Czechoslovakian Government. The Machine Tool Design and Research Institute in Prague (VUOSO), had submitted a proposal to the Government which was discussed by me with the experts of the Institute, in Prague. We finalised the arrangements to set up the Machine Tool Design Institute near HMT, Jalahalli. I was appointed as the first Honorary Director of the Institute, then known as the Central Machine Tool Institute (CMTI). Later on, when the CMTI started functioning during 1965, a permanent Director was appointed and the Governing Council of the Institute consisting mainly of industrialists connected with the machine tool industry in the private sector. I was representing HMT. Subsequently, after the retirement of couple of Presidents of the Governing Council, I took charge and continued as President till I retired.

The Central Machine Tool Institute now known as the Central Manufacturing Technology Institute, has been rendering significant services to the development of machine tool technology and training of machine tool designs. The Institute develops conceptual designs mainly for the private sector machine tool industry, particularly for the medium and small scale sectors. Recently, it has set up a NC and CNC Centre with CAD/CAM facilities with UNDP/ UNIDO assistance and has come out with several conceptual designs of CNC machines. They are presently in the process of installing a small size Flexible Machining Centre from Japan, also with the assistance of the UNDP/UNIDO.

Another important activity carried out by the Institute is testing of machine tool prototypes from the industry and issue of Certification of Worthiness. It conducts seminars, discussions and other activities related to the manufacturing industry in general and machine tools in particular., In short, it is serving as a great facilitator for the development of latest machine tool technology in the country.

Similarly, we have the Defence Ministry's Laboratories, and Research Institutions like the NAL, DRDO and others, contributing significantly to the research and development of relevant and state-of-the-art technologies. The Indian Space Research Organisation and the Atomic Energy Establishment have been rendering valuable contribution to technology in their respective fields. It is heartening to learn that Dr. R. A. Mashelkar, the Director General, CSIR and Secretary, Department of Scientific & Industrial Research, in his outline "CSIR 2001 Vision and Strategy" is focussing on industry-sponsored programmes in CSIR and wants the scientists to work together with the user industries and make available their research to them.

OVERVIEW OF TECHNOLOGICAL DEVELOPMENT IN MANUFACTURING ENGINEERING IN THE DEVELOPED COUNTRIES

The whole concept of machine tool technology, has undergone a change in the industrialised countries. Large manufacturing industries rarely buy stand-alone machine tools but go in for a whole lot of manufacturing systems in which modern machine tools play their own part. An integrated manufacturing system has become quite a common feature.

Computer Aided Manufacturing System (CAM) : A computer aided manufacturing system (CAM) - a closed loop regulating system, is a conglomerate concept where the ability of the computer is used at every stage of manufacture, by evolving a cellular structure. Though this type of manufacturing may appear related to the transfer line concept, CAM has the flexibility, unlike transferlines, to alter the type of product and the product flow sequence from machine to machine. The alteration of product flow sequence is done in such a manner so as to keep the idle time of any machine to the minimum. Such flexibility is achieved because of the monitoring and control exercised by the Central Computer. The flexibility offered by the new hardware and software is encouraging a shift from fixed programme mass production facilities to variable programme automation.

Flexible Machining System (FMS): Flexible or Agile Machining Systems (FMS) have three distinguishing characteristics - potentially independent CNC machine tools ; a transport mechanism; and an overall method of control that co-ordinates the function of machine tools and the conveyor systems so as to achieve flexibility. Flexible manufacturing systems based on group technology or cell production principles, using CNC machines and gauging equipment, are now being installed with robot handling devices and palletised conveyor supply units, to machine families of parts.

Development is also proceeding with the automation of metal working machines using mini-computers and micro-processors. Programmable turret punches, auto-controlled guillotines and shears and manipulative equipment are in use. Robot developments applied to metal forming operations will enable a considerable degree of automation in this class of piece-parts manufacture. It is now possible to construct metal forming production cells with the aid of robots, that will blank, pierce and bend a family of components using a common stock material.

Computer Control and Inspection of Machine Tools : The evolution currently taking place in the direction of computer control and inspection of machine tools represents the most progressive field of development of modern machine tools. More and more mini-computers are being used at the workplace. Because of the linkages between work stations, the trend is towards a decentralised computer, which allows a partial separation between data processing and control functions. This is especially true of computer control of machine tools. The computer has thus become the most modern device for error diagnosis and correction on modern machine tools. The future trend will be towards the development of methods which facilitate automatic corrections of malfunctions. The computer, as soon as it detects the conditions that may lead to an error, will alter machine parameters in such a manner that the error will not actually take place. In case of malfunctioning , the computer will send a command for the replacement of the defective electrical or mechanical module. Thus, it is now possible to operate machine tools without operating personnel.

Use of Robots : Robots are at present applied in a wide range of tasks, including loading and unloading of machine tools and presses, removing parts from die casting machines, handling and transfer of materials, specially in foundry and forge, welding and painting. The computer programme is the key to turning robots into assemblers. More advanced robots can be told what to do by typing the instructions on the computer key board in a language that includes about hundred English words. Eventually, the evolution of robot language will make it possible to give robots more complicated instructions.

Machine tool builders in developed countries are trying to evolve reliable unmanned machining systems capable of substantially boosting machine tools throughput, ensuring strict adherence to stringent quality control standards, minimising inprocess inventories and guaranteeing production rates.

Automation, leading to unmanned factories is technologically feasible in the industry, yet its effects on people could cause complex social problems. The widespread use of unmanned factories may, therefore, come about only gradually, although the scope for unmanned operations under certain circumstances will increase in developed countries.

Digital Factory : The latest concept, the American invention, is the Digital Factory or the Soft Factory. How quickly things change in the advanced world ! Just ten years ago, the American innovation known as the Flexible Manufacturing Systems (FMS) was the latest in manufacturing engineering. Priced at $ 25 million each, such systems typically included computer controlled machines to machine a large variety of complicated metal parts, robots to carry out complex handling chores and remotely guided carts to deliver materials to the production lines. Nearly every major US manufacturer fell under the spell of FMS. But years of costly efforts to install flexible or agile manufacturing systems taught them a bitter lesson. Too much automation can actually be a losing proposition. For one thing, despite the engineers' efforts to build in safeguards, large complex systems are inherently vulnerable to failures. As business struggled to escape the FMS trap, " Soft manufacturing" was born. Engineers broke down mammoth FMS installations into more manageable "Cells" - smaller constellations of machines that are just as versatile but less apt to fail. Robots, in particular, turned out to be a disappointment. They could not improve them to become faultless assemblers, because the robots in some cases would dumbly try to jam a nut into an opening even if it did not fit. Use of robots has been thus relegated to simple jobs at which they excel, like spot-welding and painting even uneven corners and bends, as in auto bodies.

Americans have done lot of research about what is reasonable to automate and what is not. They found that it is much more cost efficient to use hand labour with a software network rather than to use robots.

Call it the digital factory for its dependence on information technology or the soft factory for its mix of the human and the mechanical, soft manufacturing brings unheard of agility to the plant. Companies can customize products literally in quantities of one, while producing them at mass production speeds and at much lesser costs.

Cellular Manufacturing : Yet another concept of production technology is known as Cellular Manufacturing System. The System is based on product-unit-structure concept. In a function-based manufacturing system, the factory is broken up into a number of shops, each one of which is specialised in a particular task. In the cellular based manufacturing system, the plant is broken into a number of cells which form the building block of the plant. Each cell consists of a natural group of people and machines working together to complete a task. The speciality of this system is, that at one end the raw component enters and the finished product unit comes out of the other.

CONCLUDING REMARKS

In India, the technology gap in the manufacturing engineering and machine tool technology is thus wide and the gap is widening continuously. This makes it rather impossible for us to catch up with the developed world.

Even so, we must try. Of course, older methods like licensing new technologies appear difficult and a costly affair. Hence new and innovative methods of working with transnational MNCs would have to be found. One way is to establish strategic alliances with them. The Indian automobile industry has already shown the *way.* Practically, all the reputed foreign auto manufacturers are already here in India like GM, Ford, Mercedes, Volkswagon, BMW, Peugot, Daewoo, Fiat and others like Toyota, Mitsubishi, Renault are on the way. However, for machine tool manufacturers, this route appears to be somewhat difficult. First, the worldwide market for machine tools is insignificant as compared to the market for automobiles. For instance, the entire production of machine tools in the world is less than the annual turnover of General Motors, U.S.A. ! Even so, when such a large number of multinationals are trying to come to India, there must be some self-interest. Some of the incentives appear to be the vast market India provides and the low cost of manufacture for not only sourcing their requirement of components, accessories, etc., but to build cars and possibly machine tools for the third markets.

Liberalisation and global integration of the Indian economy have thrown up opportunities and challenges as well, for the Indian industry. While opening of the domestic market has exposed the

Indian industry to foreign competition, globalisation has provided an opportunity for the industry to compete effectively in foreign markets. For this, it is clear that the latest technology, not only for machine tools, but for the industry as a whole, has become indeed imperative.

The dynamics of technology change in the machine tool industry internationally is very rapid. The machine tool industry, at the present situation, is perhaps not geared to take up that challenge. A more intensive thrust should be given by the industry to augment their current level of R& D without having to wait for Government props. This can be achieved through close and strategic alliances with Indian R & D institutes, and where needed, with foreign organisations. There appears to be no escape from these endeavours.

I do not advocate that we should blindly copy some of the labour saving high technologies of the developed countries, but it is good to know these technologies so that we can go about choosing such of those manufacturing technologies which are suited to our own conditions and ethos and try and develop them inhouse.