UNIT 27 SCIENCE AND TECHNOLOGY IN INDUSTRY

Structure

27.1 INTRODUCTION

A look into the history of mankind tells us that science was being put to practical use, consciously or unconsciously, through the centuries. But it was not until the mid-eighteenth century that the Industrial Revolution in Britain showed what a profound effect advances in technology can have on everyday life. The harnessing of energy gave a boost to industrialisation. The Industrial Revolution in Britain triggered off similar revolutions in various other countries, and the resultant economic progress of these countries has encouraged the remaining ones to take up rapid industrialisation.

The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community. And it is out of a recognition of this possibility that the idea of a welfare state has grown.

In this unit, we shall take a look into the interdependence between science and industry. We shall also see how the two together can help us create a welfare state.

Objectives

After reading this unit you should be able to :

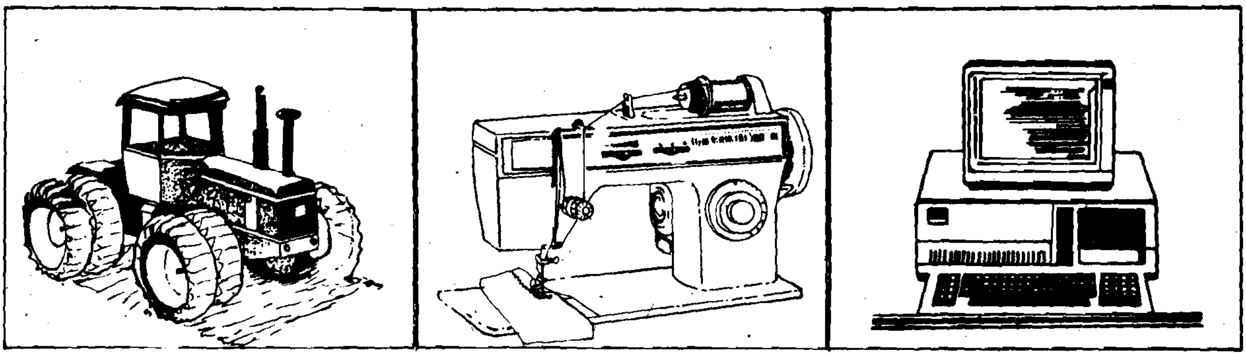
- discuss the current status of science and technology in India,
- describe the role technology can play in improving productivity, leading to economic development,
- explain the need for modernisation of our industrial machinery and processes,
- summarise the importance of R & D in industrial growth, and national development,
- interpret national development information and suggest an approach to solutions of some problems in this field.

27.2 THE INDIAN CONTEXT

Science and technology have totally transformed life from what it was in the beginning of this century, when there were no cars, buses or aeroplanes, no telegraph, telephone, radio or television, and when medicine and surgery had not advanced to raise human life expectancy to over 50 or 60 years. This has been possible through the growth of scientific knowledge, and related skills, as also by the organisation of the production of numerous goods. As the Scientific Policy Resolution (adopted by the Government in 1958) says, such high levels of production of the basic materials needed for a reasonable standard of living for all, have made it possible to think of a "welfare" state—which involves management of distribution of goods so that every one can benefit from them. Our Constitution, indeed, speaks of socialism which involves "distributive justice" and equality of opportunity to all. Without the help of science and technology, we shall not be able to produce enough goods for our needs. For example, we all know that with the help of a tractor a farmer can plough far more land than she/he can with the help of an ox. Mechanisation increases the area of ploughed land, and thus improves human productivity.

One aspect of the development of science and technology is fuller utilisation of the wealth or resources with which a country has been endowed. Without science and technology, neither could electricity be generated from the water running in our rivers, nor could the oil resources buried deep under land or sea be tapped, nor even could our books and newspapers be printed on the paper obtained from the forests that we have. Science provides the key for unlocking the wealth of our natural resources.

When we study science, we look into the laws of nature which, in their turn, indicate the methods of utilising the natural resources of the country for the production of the necessities of life and for their efficient distribution. Mere indication of the methods is, however, not enough. To implement the methods indicated, one has to do work, and here again science comes to our aid. Science provides power, machines and tools for doing the work; devices of all types—those for work involving only muscular effort, for work demanding manipulative skill and, in recent years, even for work requiring brain effort (Fig. 27.1). Without such aids, the rate of production would be extremely low and the country would not be able to produce enough to be wealthy by any standards.



(a) (b) (c)

Fig. 27.1: Devices for work involving (a) muscular effort (b) manipulative skill (c) brain power.

We look at India with about 35% of its people living under the poverty line. The reasons for the poverty of the masses in India are:

A person is said to live under the poverty line if she/he is not able to provide 1500 cals/day for herself or himself.

1) Methods of production are out of date by and large. In recent years, however, some remedial measures have been taken.
2) Since 2/3rd of the work force in agriculture and industry is illiterate, the knowledge and skills are very poor. This factor affects production.
3) In India, where 70% of the people are engaged in agriculture, the use of methods to improve production from the soil and to protect crops is not in keeping with the actual need.
4) In agriculture the small means at the disposal of a farmer and small holdings make it impracticable to use modern technology.
5) Industry, in general, and private industry, in particular, has been unwilling to invest its profits in modernising the machinery. A typical case is that of the jute industry, which is in very bad shape now.
6) The Industrial Policy Resolution, which had been adopted at about the same time (1958) as the Scientific Policy Resolution, has not been implemented effectively due to a number of socio-economic and political constraints.

Again, even where the production methods have been sought to be upgraded, our unit cost of production of many items, for example, steel, is much higher. This is mainly due to the low levels of skill and management in our industries. For instance, Japan and some other countries import iron ore from India. They have high labour cost but because of the efficiency of their production systems, their unit cost of production is lower than ours. Further, a curious phenomenon is noticeable. We have imported technology for alloy steels some 30 years back. But we have been unable to keep pace with the modern developments in the production of alloy steels through our indigenous efforts. As a result, we still have to import special steels from developed countries.

But what is a developed country? Try to solve this SAQ and match your answer with the one given at the end of this unit.

SAQ 1

Which of the following countries would you call a developed country? Make a tick mark in the appropriate box.

i) A country rich in natural resources. ☐

ii) A country with a high per capita income. ☐

iii) A country with advanced health and social security schemes. ☐

iv) A country with a high per capita productivity. ☐

Lead Times of Scientific Development

When we compare the current status of scientific development and technological fall-out from the same, we find that the lead time of scientific discovery and its applications is much shorter in the developed countries. This is because of their constant efforts of research and development for technology upgradation which, unfortunately, have been lacking in our country. It is to be admitted that even in developed countries there is a wide variation in the lead times of different discoveries. These lead times may be quite long in certain cases and quite short in others. For example, aluminium was first obtained in pure form in 1825 and it was only in 1886 that the process of its large scale production was finalised. The lead time in this case was 60 years. On the other hand, the process of hydrogenation of oil in the manufacture of vanaspati originated in 1905, and by 1911 Procter and Gamble Company, U.S.A. had placed its hydrogenated cotton seed oil, which is similar to vanaspati, on the market. As you can see, the lead time in this case was very short: only 6 years.

Fig. 27.2 gives us an idea of the lead times of certain inventions.

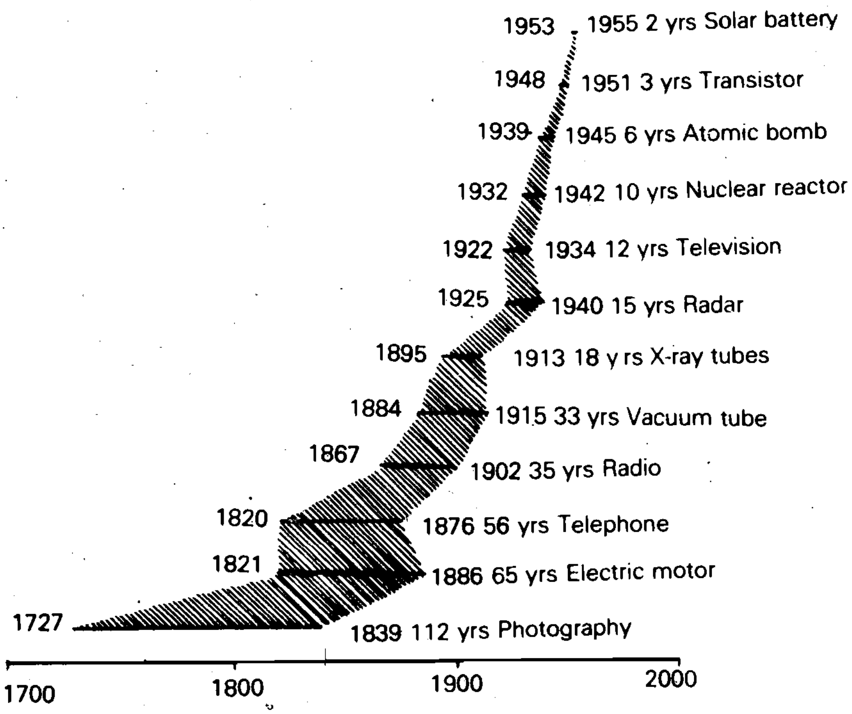


Fig. 27.2: Interval between discovery and application in physical science (after Eli Ginzberg, "Technology and Social Change", Columbia University Press, 1964).

The lead times of scientific discovery and its applications in the field of computers have been among the shortest. One can, therefore, say that the application of any scientific discovery relates to the needs, or compulsions of the situation. It is also a fact, that this depends, to a large extent, on the state of industrial development of the nation and the priority given by the nation to that particular area. From the Indian example we can say, that in such sophisticated areas like nuclear science and technology and nuclear power production, our lead times have been very short. This was possible as appropriate facilities were created, resources were made available, and scientific responsibility clearly given to an organisation. On the other hand, in agricultural technology, India is one of the most backward countries in the world, in spite of the fact that 70% of our population lives on agriculture and our primary products are our major foreign exchange earners.

Now, if you have understood the points discussed in this section, you will be able to solve this SAQ.

SAQ 2

Do you think we have been able to take advantage of the benefits of science and technology? Give reasons for your answer in 4-5 sentences.

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27.3 TECHNOLOGY IN INDUSTRY

One aspect of technology is that the latest scientific methods are used in production. This, in turn, depends on the availability of the right type of scientific manpower. We shall examine in the next unit (Unit 28) how deeply the question of buying technology or developing it within our own country is related to the whole question of economic and political independence. But at this stage it is sufficient to mention that it might seem simple to import technology from the developed countries and use it in our own processes of production, but it is not, in fact, so. It is seen very often that a country from which a technology was imported had access to raw materials of a particular type which may not be available in our country. In other words, it is often necessary, in the absence of a particular raw material, to substitute it by another, or to modify the process.

To give a common example, earlier the composition of vanaspati, the well-known cooking and edible fat used to be 95% groundnut oil and 5% seasame oil. About 30 years ago, groundnut oil was available abundantly. For the last decade or so, both due to paucity of supply and increase of demand abroad. Indian manufacturers had to switch over to other oils, and in recent years more of these have had to be imported. For example, we now have oils such as soyabean oil, Canadian rapeseed oil (Canola) or palm oil imported from U.S.A., Canada and Malaysia respectively, as the major raw material for the vanaspati industry. But the quality, appearance and other properties of vanaspati have been kept the same, because of stringent government regulations. So research and development efforts had to be made by Indian scientists for this adaptation.

Similarly, imported tallow, which was once a major raw material for our soaps and detergents has been totally banned. Indian scientists had to adopt other oils for preparing the same quality of soap, and many processes have been developed. For example, stearine and tallow substitutes have been prepared from castor oil, (one of our industrial oils) by chemical reactions. Such examples can be multiplied from other industries. Further, it would not have been possible to effectively utilise imported technology in many other important industries without the help of skilled human resource. In this respect, training of skilled human resource and maintenance of research laboratories and organisations have played a major role.

From our first five year plan onwards, efforts have been made to increase scientific and technical human resource by creation of engineering and technology departments in our universities. We now have about 200 such institutions as against 21 before independence. In addition to the university departments, six Institutes of Technology (IITs) have been established at Kharagpur, Kanpur, Mumbai, Chennai, Delhi and Guwahati. The first five were set up with the help of developed countries, such as U.S.A., U.S.S.R., U.K. and West Germany. Even before independence, the three old universities of Calcutta, Bombay and Madras, the Indian Institute of Science, Bangalore, engineering colleges like that of Roorkee and Bengal Engineering College, the National Council of Education, the present Jadavpur University, had created many engineering departments.

However, in practice, industries have retained a lot of dependence on imported technology. Often industry prefers to have "turnkey" technology, that is, technology and machines which can be installed and can start producing on turning a key or pushing a button. Thus, the pace and character of their development have reduced job opportunities for engineers and technologists who are being trained in our institutions. The result is that many of our skilled technical personnel and scientists have to seek opportunities abroad in developed countries like U.S.A., or U.K. This is called "brain drain". Our country loses crores of rupees every year, as the expense incurred on the training of these persons, and the much needed technical human resource is lost to India.

Technology in Small Scale Industries

Many people have a misconception that application of science and technology is important only for big industry. Since India consists of more than 600,000 villages, we cannot ignore the relevance of village and small scale industry for giving employment to a large number of our population, who are now dependent on primitive methods of agriculture. Science and technology are equally important in the handicrafts and small scale industry. Agriculture, also, has been modernised with the help of machines like tractors, power tillers, mechanised harvesters, etc. But these attempts have not been very suceessful, because of educational and financial constraints, size of land holdings and social structures.

Improved technology results in improved productivity in terms of capital investment and human resource requirement. At the same time it reduces the job opportunities of a larger number of people. We are faced with a paradox that, whereas on the one hand we need more jobs for the bulk of our population who are jobless, on the other, modern mechanised and automated industries would result in utilising less traditional human skills. Now, how do we resolve this paradox? One way would be to organise a network of small or medium scale industries and village level industries. Then, this network can be used to feed raw materials or intermediates to large scale industries.

The use of electric power and electronics in small scale and village level industries can make efficient quality production possible, as has been demonstrated in Japan. There has to be, therefore, a planning process to make the production methods in village level industries more efficient by the use of appropriate devices and to use the produce from these industries as the feed material for large scale production units. This has been done partially in India, in states like Punjab and Haryana in the engineering industry and also, to a smaller extent, in other states. The role of technology in improved productivity will always be a major role and there will be a need for skilled human resource for this. But a part of them may be deployed in training human resource for the village level industries, miniaturisation of machines, and using the right type of electronic or other devices for working them.

Maintenance of machines in such industries, as also in large scale industries, has always been a neglected area in our country. We have to be very careful about maintenance at all levels. Infrastructure for creation of skilled human resource already exists in the form of Industrial Training Institutions, Polytechnics and the training centres of different industries. These have to be strengthened and re-oriented to serve the present-day needs.

Paucity of capital is one of the difficulties in establishing industries, particularly for small and medium scale entrepreneurs. However, after the nationalisation of banks and creation of financial institutions such as Industrial Development Bank of India (I.D.B.I.), State Industrial Development Corporations, Industrial Credit and Finance Corporation, Unit Trust of India and other financial institutions, nowadays institutional finance is available in the form of loans to any creditworthy industrial enterprise. Both the State and the Central Governments are strengthening these institutions through various savings programmes. The development of such programmes as Science and Technology Entrepreneurship Parks (STEP) in which new entrepreneurs are helped in testing a new technology on a small scale through a pilot plant, to gain confidence before they go in for large scale production by themselves, is also very encouraging. These programmes are assisted by banks. Therefore, a beginning has been made in the right direction.

Such improvements in production methods as automation and use of robots have been demonstrated to be very effective in reducing production cost and improving the quality of production. Unfortunately, apart from their being capital intensive, they oppose labour intensity and create lesser job opportunities. In our country, we have to have a balanced approach. We should keep automation for selected areas, particularly, for our export oriented areas, and use somewhat older, but still efficient, methods of production, which are labour intensive, in other areas. So, while the advantages are there, the implications in the context of our country have to be kept in view and over-mechanisation and over-automation at this stage of our development need to be avoided.

TV studio equipment have also been licenced to different industries. This is just one example of our research programmes leading to industrial growth in related fields. In every field of scientific activity we find that innovations have paved the way for setting up of new industries and also the growth of the existing ones.

In fact, the example of Japan can, to a great extent, be a model for us. In the beginning of this century Japan was a comparatively less developed country. They tried to modernise themselves by importing technology but then they improved the imported technology by:

- creating R & D facilities for adaptation and further improvement of the imported technology,
- creating and sustaining the improvement of technological efforts through their own scientific manpower originally trained abroad, and
- creating a base of scientific human resource to improve their educational system and training facilities.

In 1946, the late Sir Winston Churchill, in a very well publicised speech, stated, "The rise of the Soviet Union as a super power has been mainly due, not so much to their political system which might have helped but to the creation of the right type of institutions for manpower training." Japan has again provided an example of how, from a comparatively undeveloped technological base, they could rise to be one of the most modern technological nations, offering technology not only to the developing and undeveloped countries, but even to the developed countries like U.S.A. and U.K.

Therefore, for international competitiveness, and even for survival, there is need for modernisation through our own research and development efforts and with the help of our own research organisations. One can think of close cooperative effort between government research laboratories, like those under the Council of Scientific and Industrial Research and the research laboratories of universities and higher technological institutions.

Our government has realised the importance of indigenous research to promote profitability and international competitiveness. A number of policy measures were taken to provide incentives to induce industries to set up in-house R & D units. They are given certain facilities for import of raw materials, equipment etc., besides some financial incentives. These policy measures seem to have worked well, as you can see from Fig. 27.5.

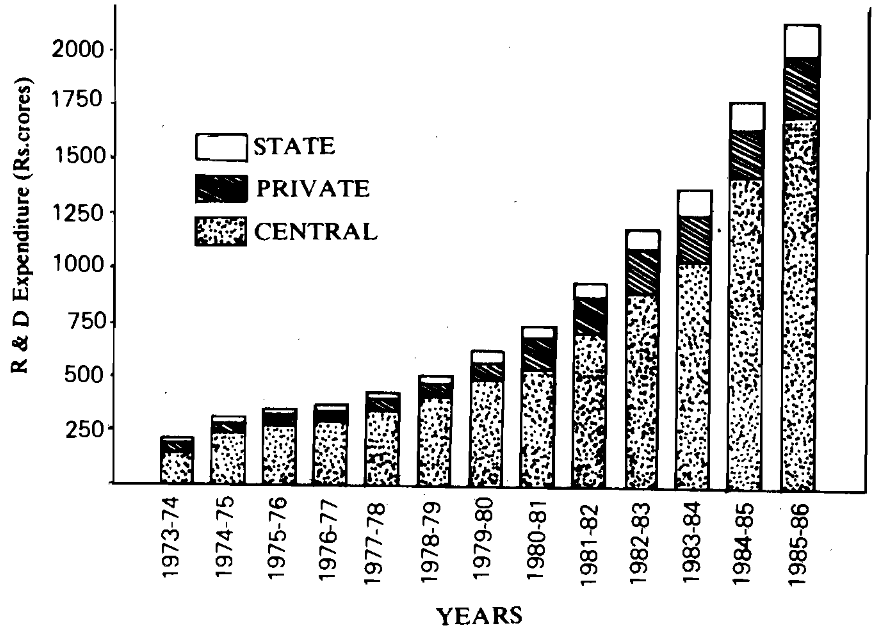

Fig. 27.5: Trends in national expenditure on R & D. (R & D statistics 1984-85, Dept. of S & T)

You can also see from the charts that a major share of the R & D expenditure in our country is borne by the government. This situation is different from the one we find in the developed countries. In those countries a large amount of R & D work is carried out by the private industry. The capital spent in financing R & D units is seen as a good and necessary investment towards future economic progress of that industry. In India, industry spends a very minor fraction of total money spent on research. In Table 27.1 you will find that only 11 leading industrial groups account for 86% of the total expenditure of R & D incurred by industry in our country.

Table 27.1 : R & D expenditure by industrial sector 1984-85

Sl. No.	Industry Group	Public Sector		Private Sector		Industrial Sector	
		No. of Units	R&D Exp. (Rs. lakhs)	No. of Units	R&D Exp. (Rs. lakhs)	No. of Units	R&D Exp. (Rs. lakhs)
1.	Electricals & Electronics	15	5050.40	120	3310.02	135	8360.42
2.	Defence Industry	7	5772.63	—	—	7	5772.63
3.	Fuels	5	5642.12	8	92.27	13	5734.39
4.	Chemicals (other than fertilisers)	7	671.22	124	3074.17	131	3745.39
5.	Metallurgical Industries	14	1922.62	51	1222.04	65	3144.66
6.	Drugs and Pharmaceuticals	3	23.88	62	2437.96	65	2461.84
7.	Industrial Machinery	4	218.55	59	2160.03	63	2378.58
8.	Telecommunication	6	2034.18	17	169.72	23	2203.90
9.	Transportation	1	16.87	29	1903.90	30	1920.77
10.	Fertilisers	5	802.70	2	130.40	7	933.10
11.	Textiles	1	5.60	27	882.42	28	888.02
12.	Other Groups	12	1414.73	183	4723.74	195	6138.47
	Total	80	23575.50	682	20106.67	762	43682.17

There have also been a number of cooperative research associations in our country. The first such institute was set up in 1950 in Ahmedabad for the textile industry. There are many cooperative research associations now in fields like jute, rubber, tea, wool, cashewnut, etc. **Since small industrial units are not able to finance a complete R & D set-up on their own,** such cooperative efforts are the best way out.

A developing country like ours aims to reduce its technological dependence on other countries. We shall be able to achieve this by increasing our R & D efforts. Products and processes developed in our own country will be based on local raw materials and will take into consideration other local factors such as weather. In the process, we will also have the requisite manpower for maintenance as well as further improvement of technology. We should match our R & D efforts with the objectives and policies of our country. Apart from the government laboratories, private industry should take more and more active part in research activities. The commercial application of scientific discoveries can be carried out more easily if there is a direct link between the laboratory and industry. In other words, it would be better if industrial units have an R & D set up within themselves.

Our indigenous R & D units should try to reduce the threat to our environment through innovations in industrial processes. Pollution of environment by industries is a very serious menace in the developed countries. As you know, most of our big industries were set up before the oil prices sky-rocketed in 1973. As a result they rely heavily on oil as their source of energy. With the unprecedented rise in oil prices, and also taking into consideration the limited world reserves of oil, we should try and look for alternative sources of energy which will increase our profitability in the long run. Some experiments are being done with solar energy, and it has also been put to use in some places. But we haven't yet tapped its full potential.

It may be noted that the concept of modernisation is integrally related to the improvement of processes and products. But modernisation as mere gimmickry, for example, to introduce computers where one can do without them, or installing remote control communication **systems and the like can only increase overheads and lead to handicaps in trade.** A balanced approach to modernisation seems to be the need of the hour, and we need to strengthen our own R & D efforts for this. See if you can do this SAQ now.

won't be able to compete in the international markets. The use of technology also helps us produce goods on a large scale. This mass production helps to bring down the cost per unit. If our goods are reasonably priced, they stand a better chance in the international markets.

3) India should follow the example of Japan. If we keep importing the latest technologies and do not strengthen our base of R & D, we shall always remain dependent on other advanced countries. And unless we become self-reliant, we shall have to bow down to the wishes of these advanced countries even though they go contrary to our ideals. At the same time we cannot remain isolated. We have to imbibe the latest technology to fulfil the basic needs of the entire population and to abolish poverty. If we try to acquire the latest technology entirely through our own efforts, it will take a very long time, and we may not be able to catch up with other nations.

   If some other countries have already developed modern technologies, we should try and import them to revamp our industry. But once we have imported these technologies we should keep them up-to-date with our own R & D efforts.

4) There are many reasons for our productivity being lower than the acceptable norms. One reason is that our industry does not use the latest technologies because of the heavy investment needed to install modern machinery. Even where modern machinery has been installed, it is not being properly utilised since the workforce is not adequately trained.

   Sometimes entrepreneurs do not realise the importance of constantly adapting their technologies and refuse to finance R & D programmes. This adversely affects their productivity as their counterparts in other countries are able to achieve a higher productivity by the use of new production processes.