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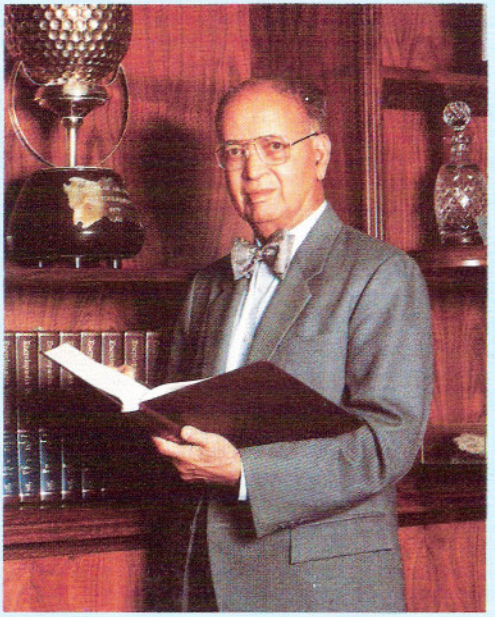

S. L. KIRLOSKAR MEMORIAL LECTURE : 1999

BY

DR. R. A. MASHELKAR, FRS
Director General, Council of Scientific and Industrial Research

22nd July, 1999

CENTRE FOR ADVANCED STRATEGIC STUDIES

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Director General, Council of Scientific and Industrial Research (CSIR)
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DR. R.A. MASHELKAR, FRS
DIRECTOR GENERAL (CSIR)
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH, NEW DELHI

ON BUILDING A GLOBALLY COMPETITIVE INDIAN INDUSTRY : THE ROLE OF RESEARCH & TECHNOLOGY

22 JULY 1999

I feel greatly privileged & honoured that I have been invited to deliver the Fifth S.L. Kirloskar Memorial Lecture. I am grateful to the Centre for Advanced Strategic Studies and the house of Kirloskars for having done me this great honour. When I look back on all my eminent predecessors, who have given the previous Kirloskar memorial lectures, I feel truly overwhelmed. I accept this honour with great humility and pride.

Shri S.L. Kirloskar was a legend, a visionary, a pioneer and a giant among the industrial leaders of this country. We see today the great product coming out of his pioneering efforts, namely this outstanding Kirloskar group of Companies; but what we must also admire is the process through which he did it, it was path-breaking, daring and he was always ahead of his time. As a senior statesman,

his voice was heard with respect by the government, even when he criticised the stiffling government controls in his characteristically forthright way. His exceptional courage & conviction, his honesty, his high ideals, his patriotism & his faith in his people made him stand as a giant among the men of this century. The present century is coming to close and we should draw a list of the top hundred Indians, the twentieth century Indian Hall of Fame, if you like, who have made a difference to India through their contribution in all walks of life; industry, politics, science & technology, arts, sports and so on. I am sure when this list is drawn, Shri Kirloskar's name will adorn amongst the top select few; his contributions to nation building are so legendary. I, therefore, feel doubly privileged that I have this rare opportunity to pay my own humble tributes to this great son of India by delivering this lecture.

I want to congratulate the Centre for Advanced Strategic Studies for the outstanding work it has done over the past several years. The eminence of the leadership that it has been fortunate to have so far has made it a unique centre connected with research and analysis on national sensitive issues. In today's context, it is not the defence security alone but economic security, food security and health security, which needs a close analysis and planning. I am going to focus today on some issues connected with our economic security. Although India is predominantly an agriculture based country, it is quite clear in my mind that its economic security will depend upon rapid industrialization, and increasing the share of the GDP through increasing our industrial production and productivity. Science and technology is going to play an increasingly crucial role in this endeavour in the coming century. Therefore, my focus is going to be on the role of S&T in providing a global competitiveness to Indian industry. But what will be the

setting in which the Indian industry will have to survive and succeed. What will be our tomorrow like?

Knowledge Centred Tomorrow

Let us set the stage by visualising our future. Tomorrow's societies will be knowledge societies. Tomorrow's economics will be economics of knowledge. Tomorrow's markets will be knowledge markets. Tomorrow's wars will be fought not by the conventional weapons, guns, missiles and so on, but they will be fought in the knowledge markets with the new thermonuclear weapons called information and knowledge. The war on a patent right, which took place between Eastman Kodak and Polaroid, was settled for about one billion dollars recently. This is half of India's R&D budget! So these wars in the knowledge market will be quite expensive.

The power of knowledge in the knowledge society is there for all of us to see. The paradigm shifts are truly dramatic. For more than a century, the world's wealthiest human being has been associated with oil, starting with John Rockefeller in the last nineteenth century and ending with the Sultan of Brunei in the late twentieth century. But today, for the first time in the history, the world's wealthiest person is a knowledge worker, his name happens to be Bill Gates! And this phenomenon is not taking place in that distant land, USA. Infosys Technologies, an information and knowledge based company, our own Indian company, is showing the way in which the knowledge workers can revolutionise the world. On 21 July 1999, the market value of Infosys Technologies (calculated at the stocks intra-day high) stood at Rs.19,096 crore, just Rs.268 crore short of matching the market value of the

petrochemical giant, Reliance industries, which stood at Rs.19,368 crore.

Increasingly the traditional factors of production – land, labour and capital – are becoming less important when compared with technology; the economists have termed this as the 'expansion of the production frontier'. The source of technology is in science that is rooted in knowledge. It is easy to visualise that tomorrow's industries will be knowledge industries. The emphasis will be less on physical or tangible assets, and more on intangible knowledge assets. The value of intellectual capital of an industry will determine its rank and competitiveness. In such industries, there will be a major shift from people, who handled information and did routine and unthinking work, to those who will use knowledge at every stage. For knowledge workers, information and knowledge will be both the raw material of their labour as well as its product.

One might wonder as to why the physical assets such as machinery in a factory, are becoming less important. Plant and machinery are tradable commodities today. Even capital was a scarce commodity until recently and was used as a competitive advantage. But with globalised markets the companies around the world have access to finances at inexpensive rates. So even capital is no longer a scarce commodity. It is the intangible assets, which are knowledge based, and that are non- replicable, unique and proprietary, that are providing companies with a competitive edge.

The nature of intangible assets will vary from industry to industry, but they will include several commonalties such as research and development, patents, proprietary technologies, databases, brands and even relationships, people and so on.

Paradigm Shifts

World's major growth industries – such as microelectronics, biotechnology, designer-made materials, and telecommunications – are already brainpower industries. These knowledge industries stimulate other industries, in turn, to become knowledge based. Consider the oil industry. The issue of "bottom of the barrel" is driving the economics of these industries. New knowledge embedded in three-dimensional acoustical sounding, horizontal drilling, and deep offshore drilling is turning oil business into a knowledge industry. And so is the food industry, leather industry. Let us therefore reconcile to this fact that to survive and succeed every industry in India must become a knowledge industry.

I am reproducing below an analysis done by the Indian Institute of Foreign Trade of how a nation gets a competitive advantage in exports. It is based on resource, labour, scale, technology and product differentiation (See Table). As one can see, we still continue to seek advantage from resource-based and labour-based factors. Knowledge based value addition as reflected by technology and product differentiation is very poor in our case. See how Singapore boasts of over 70% through these two factors on technology and product differentiation, as against our 5%! Obviously, we are way behind. A nation that will not increase the content of knowledge in its exports will remain behind. India that sells zirconium sand at one cent per Kilogram and buys stabilised zirconia at 150 dollars per kilogram will only be a helpless spectator watching others add value through knowledge. The challenge before us is that it is us, who have to add this value by increasing the knowledge content of everything that we export, be it a product or a service.

Exports (1994)
Value Addition (%)

	India	Malaysia	Singapore
Resource based	28.7	5.1	2.6
Cheaper Labour	49.6	18.7	11.5
Scale based	17.1	8.6	13.5
Differentiation	1.2	57.1	41.9
Technology Driven	3.4	9.0	30.5

Indian Industry and the New Challenge

What would be the new challenges before Indian industry? The short term challenge, as I see it, is going to be quality, productivity, cost, response time and innovation. In the long term, the challenges will be scale (our scales have been miniscule), technology upgradation (our technologies are outdated), product design (we have very poor concepts of product design) and finally strategic partnerships not only within India, but outside. Most important will be attitudinal changes and mindset changes. Let me specifically focus on the technology issue now.

In July 1991, when we moved to integrate the Indian economy with the global economy, it was a monumental step. Unfortunately many believed that the integration started and ended with the capital T, as in trade. But unless the other T, as in technology, is emphasized and technology is also integrated, we cannot reach a competitive position. The second problem is that we had a misperception that with the opening up, there will be an enormous flood of foreign capital & foreign technology. This has not happened for a variety

of reasons. If we look at 1991 upto 1997, we will find that the flow of technology has not really taken place in important areas. If one compares the data in technology related payments during from 1993-94 to 1996-97, one sees a substantial increase in professional services ($96 million to $394 million), management fees and office expenses ($ 652 million to $7148 million) but an actual decline in technology fees ($ 603 million to $459 million).

We must realise that the technology acquisition game is becoming more and more complex, since India is no longer being considered as a bottomless pit of demand by the developed world any more. Technology buyers from India are being seen as potential competitors in the world market. Therefore, technology sales are being conditioned with marketing territory restrictions. The age of straightforward technology licensing agreements is also over. It is giving way to technology-cum market, technology-cum-stakeholding, technology-cum-product swap, etc. Technology is available to an Indian buyer only if it fits in with the supplier's global scheme. The 'buy' option is, therefore not as easy as many thought.

When it came to technology, the Indian industry always considered the 'buy' or 'make' options, which unfortunately got converted to 'importing' and 'import substituting' in the closed economy that we had. But the real life is more complex. Indian industry will have to carefully consider not just the two options of 'making' or 'buying', but also 'buying to make better', 'making to buy better' and 'making it together'. Let me explain what I mean.

'Making' has been a preferred course of action, but one cannot make everything. Also if one has to reach a high rate of economic growth, then other alternatives have to be sought. 'Buying' the knowledge embedded in a technology or a machinery is possible,

when the owner is willing to part with it. I have already alluded to the complexity of the technology buying option earlier.

Smart countries like Japan opted for the third option of 'buying to make better' route. They acquired knowledge through licensing, absorbed it and developed superior products, which competed with the best in the world. India did not do that; we kept on buying and buying. Take the example of compressors. We have been producing them for several decades. But when banning of CFC was on cards, and we had to look for alternatives, we again went back to acquire new technology from abroad. The process of understanding technology involves design, process know-how, and parts fabrication assembly. When we bought technology in the past few decades, we concentrated on being very skilled assemblers. The real challenge is the mastery over process know-how and design. Then only can we master technology. It is an iterative process, full of learning and creative experience.

The entire chain of acquiring the know-how package, evaluating prevailing resources, formulating manufacturing methods, determining import content, accumulating engineering experience, commercializing the product, observing the product behaviour, working out the design modification process and finally using that experience to create new products, forms that real chain of innovation which involves both learning and doing. Had we pursued this innovation path with vigour, Indian industry would have been in a different position today.

We have also not followed the fourth option of 'making to buy better'. Familiarity with a knowledge or a technology domain gives one an advantage in negotiations, strategic positioning and so on. I recall a personal experience. Ten years ago, I was on the Board of Directors of IPCL in Baroda. While planning its giant

petrochemical complex at Gandhar, we had added alpha olefin in the product slate. We went to buy alpha olefin technology from Idemitsu in Japan, Shell in Europe, Chevron in USA and so on. No one will give us the technology. The unfortunate part was that IPCL itself had started R&D work on alpha olefins in early eighties. There were splendid leads that we had. Neither were these protected through patents nor were investments made in pursuing the pilot plant work. Had we created a strategic position with this work with even a 'potentially' superior technology, even at a pilot plant level, there would have been a veiled threat and we would have acquired the technology. Therefore, the option of 'making' to buy better' is a smart option, and it does require building strategic positions by 'making upto a critical point in the early innovation chain.

For a resource poor country like India, 'making it together' is one of the best options in the long run. This means creating knowledge networks between the productive sector and all the knowledge centres in the academic world, national laboratories, etc. Let me pursue this option in some depth.

Thanks to the foresight of the founding fathers of our nation, India today possesses a massive science and technology infrastructure spread across the country, with close to 250 universities, 1500 research institutions and 5000 Ph.Ds being turned out every year. India is in an enviable position as regards its S & T manpower. Right from the time of independence, scientific institutions have been set up and nurtured in many diverse sectors. These have included agriculture, atomic energy, electronics, environment, ocean, space, biotechnology, non-conventional energy sources, defence, health and so on. This chain of national laboratories, has built several core competencies. I believe in the

early part of the next century, in a list of competitive advantages that our nation will be proud of, its R&D strengths could be easily at the top. But it will be of no use, if this competitive advantage is not used by our Indian industry by knowledge networking.

How do we build knowledge networks between the productive sector and the R&D institutions and what are the hurdles? There needs to be a change of mind set on part of both the partners. First the industry. Publicly funded R&D institutions should be used as idea generators and providers of new concepts by the industry. Indian industry should not look at institutions as super markets where off-the-shelf technologies are sold. Nowhere in the world does this happen. Indian industry should be prepared to assume the role of partners, who have the technical, financial and marketing strengths to take ideas to the market place. The products emerging from R&D laboratories invariably come out as some sort of packages containing knowledge and information, whereas the business units will have to convert these into goods and services, which are saleable. The Indian industry should willingly integrate national R&D resources into their business strategy. Improved communication and understanding, faith in mutual growth and development of healthy working relationships will be necessary for this to happen. That the competitive advantage in business will be reached by using cutting edge knowledge, and that this can be sourced from these institutions has to be realised by our industry.

There is a change of mindset required from the side of Indian institutions also. The fact that new knowledge has to make an economic sense has not been by and large realised by our institutions. There has to be a meeting ground between the long-term horizon of R&D institutions and the short-term horizon of business units. CSIR, as a large publicly funded R&D system, is

trying to make a cultural shift in its operations, by looking at research as a business, defining a new product, defining a new process and doing it in a business like manner. The transformation process has just begun, but CSIR hopes that it will become an effective hub in the Indian knowledge network.

I have spoken about the Indian knowledge networks, but I see equally exciting possibilities for global knowledge networks for economic gains, where India could assume a dominant position. The chain of concept to commercialisation necessarily crosses transnational boundaries today. Thus many major multinational corporations in USA and Europe, whose R&D budgets are larger than even India's R&D budget, are becoming partners of India's R&D laboratories. CSIR's partners today include giants such as Mobil, Amoco, General Electric, Du Pont, Boeing, Smith Kline and Beacham and so on. Right here in Pune, our National Chemical Laboratory earned 4 million US dollars last year by exporting knowledge to Europe and USA. For India, rather than remaining a perennial seeker of knowledge from the west, opportunities are opening up for doing even reverse transfer of knowledge.

What is driving this process? Many companies across the world today consider it to be rather unwise to attempt for self-sufficiency in technology development, particularly in an era, where the R&D costs are increasing rapidly. The concept that technology could be acquired rather than reinvented is gaining momentum. As a part of the global innovation strategy, several companies world over are scouting for new ideas and patents. These companies believe that the surest way of becoming technically strong is through knowledge networking with premier organisations across the world. In an era of global connectivity through modern information technology, the concept of a virtual laboratory is

gaining ground. These global networks are allowing the real-time management and operation of laboratories in any part of the world. Thus, companies are seeking to gain a competitive advantage by using the global knowledge resource and working with a global time clock. The Indian Knowledge Network will thus have to synergistically lock with the Global Knowledge Network to derive the maximum advantage of our strengths in our industry and in our institutions.

Harnessing the Potential of Indian Knowledge Industry

For a cash poor country like India, emergence of knowledge industry is a good news. But for harnessing the full potential of knowledge industry will require an aggressive and visionary policy framework, creative planning, daring and risk taking. It needs to be recognised that the knowledge industries such as software development, pharmaceutical industry, biotechnology, etc. operate in a highly competitive environment with great demand on the speed of response in dynamic market conditions. A high operational efficiency and functional flexibility is crucial for such industries. The Government policies, therefore, have to be conducive to provide these.

We will need a fundamental change in the way we value knowledge and knowledge-based intangible assets. Will the accounting norms for intangible-asset-dominated companies change? Can the intangible assets be valued and formally be a part of the balance sheet of firms? Will our stock markets be willing to recognise intangible assets as something real, particularly when accounting norms do not do so? The financial institutions and the banks in India offer funds on the basis of traditional collateral and asset based securities. Will the lenders be prepared to consider knowledge assets? One does believe that this paradigm shift will

come in the near future and the balance sheets of knowledge based companies will undergo a formal change. After all Japan is already accepting intangible assets such as intellectual property as a security against loan and not insisting on fixed assets. A couple of years ago, CSIR laboratories were allowed to use knowledge as an equity in start up companies, and not insist on payment of fees. Such and other formal recognitions will push companies into developing their intangible assets further leading to a better performance.

We must create opportunities for setting up new knowledge based industries with several young technopreneurs, who have the potential to become the Bill Gates' of India. For this, India will have to set up proper technology financing mechanisms, which are risk taking and which can cater to the knowledge industries. In particular, the venture capital financing is very poor in India and yet at the same time we recognise that Apple in computers and Genentech in biomedical products would not have seen the light of the day but for the venture capital financing.

Let us pursue the issue of venture capital a bit further. In the vest, it is specifically defined as equity linked investments in young privately held companies, where the investor is a financial intermediary, who is typically active in the firm. The venture capitalists provide equity investments in companies that are not mature enough to get access to capital market but have high growth potential to compensate for the risks inherent in such ventures.

US have been a pioneer in venture capital. In the formal venture capital industry in the US dates back to the formation of the first fund, American Research and Development, in 1946. However, the flow of money into new venture funds for the next three decades never exceeded a few hundred million dollars annually. A dramatic change came with the 1979 amendment to

the *'prudent man'* rule explicitly allowed pension managers to invest in high-risk assets, including venture capital. In 1978, when $424 million was invested in new venture capital funds, individuals accounted for the largest share (32 percent). Pension funds supplied just 15 per cent. Eight years later, when more than $4 billion was invested, pension funds accounted for more than half of all contributions, and this proportion has been growing over the years.

The panel on knowledge based industries set up by the government has made several suggestions on venture capital financing, which require a detailed study and implementation. The suggestions include certain changes in the CBDT guidelines, creation of a proper regulatory framework for structuring the funds, especially a need for a tax efficient vehicle for setting up VC funds, allowing pension funds and insurance companies to invest in VC funds, permitting overseas funds freedom in exit valuation and repatriation without the intervention of RBI, especially replacing the requirement of prior approval from RBI with post-repatriation reporting, removing the concept of *'par value'* of share in knowledge based industries so that technopreneurs can fully avail themselves of the advantages of sweat equity. These and other such measures will require immediate attention of RBI, SEBI, and the finance ministry.

The labour laws in India are obsolete when one considers the environment in which knowledge workers in knowledge industry thrive. For instance, Shops & Commercial Establishment Act, 1961 and Rules restricts working hours to 9 hours on any day and 48 hours in a week whereas in knowledge industries, flexible timings to meet the needs of the global customers are absolutely essential. It is important to recognise that knowledge work in knowledge intensive industry cannot be governed by using the laws meant for physical labour. The changing context will mean

changing the content, of both our act and our actions. The radically changing world of 'cerebral commodities' is going to put new demands on both the government and the industry.

IPR and Industrial Competitiveness

I made a reference earlier to the expensive wars in the knowledge market that the Indian industry will have to face, as it integrates its economy with the global economy. Intellectual Property Rights (IPR) will be crucial in fighting these wars! Indeed in the world of knowledge based competition, IPR will emerge as a key strategic tool. India is way behind the rest of the world and the continuing illiteracy in IPR will hurt us badly. Incorporating strong systems on generation of IPR, its capture, documentation, valuation, protection and exploitation will need a massive thrust.

The issue of patents in particular, has created a national interest and debate of great dimension. A weak physical infrastructure, inadequate intellectual infrastructure, poor public awareness and delays in framing and implementing government policies is hurting India today. We are behind the rest of the world in patents, both quantitatively and qualitatively. Many of the Indian R&D institutions and industrial firms have so far focussed on imitative research or reverse engineering. How do we change our mindsets so that we move on to doing truly innovative research or doing forward engineering? This is the first big challenge.

Skills in filing, reading and exploiting patents will be most crucial in the years to come; but our ability to read or write patents is very poor. Manpower planning for IPR protection needs priority. IPR must be made a compulsory subject matter in the law courses in the universities in India. Our graduates coming out of engineering and technology streams have no idea about IPR, and

yet it is these young people, who will have to fight these emerging wars in the knowledge markets. A number of patent training institutes will have to be set up. China has already set up 5000 patent training institutes! Judicious management of patent information will require well-structured functioning of information creating centres, information documenters and retrievers, information users, IPR specialists and information technology experts.

The future strategies of growth and competition in Indian industry will have to be based on building up strong IPR portfolio and leveraging it to get technology and market access. These strategies will also have to define entry into both product markets and knowledge markets; experience shows that a few critical patents on key components can create a situation where firms have been forced to do technology negotiations, forge partnerships or pay compensation. In a limited way, CSIR itself has discovered it. It was NCL's single US patent on a product, of which a leading multinational had a 40% market share, that forged a strategic alliance between that multinational and NCL, and it is now bringing NCL handsome cash flows today. Dr Reddy's two patents on new molecules have enabled him to forge strategic partnership with firms abroad, at the same time bringing in milestone payments of millions of dollars. Unfortunately, such strategies have not become a part of the corporate business and competition strategies. The Indian industry is not aggressive in innovating and protecting its innovations abroad. The data down loaded from the website of US patent office shows that during the period 1994-98 these happen to be led by CSIR (66), and followed by individual inventors (44), Texas Instruments Inc (14), Hoechst (10), Ranbaxy (10) and Lupin (7). We need to step up our innovation and patent effort enormously.

The knowledge based industry in India, such as the IT industry, pharmaceutical industry, etc. will have to face new challenges in

the new IPR regime. The IT industry has maintained an impressive growth rate and we have the dream of becoming an IT super-power, raising our software exports from $ 2 billion to $ 50 billion in the next 10 years. If this has to happen, then we will have to reduce the content of body shopping and move on to innovative IT products, which will need IP protection. The Indian IT industry has not so far cared for this, but it will have to play an increasing attention to this aspect.

The same is the case with our pharma industry. From an importer of even the formulations in early 50s, our pharma industry has become a net exporter. We need to recognise that it will start feeling the heat of the global competition soon. It grew by copying the molecules developed in the west, sometimes with innovative processes and sometimes with not so innovative processes. But with 1.1.2005, product patents will come in and this luxury will end. But the time to change the strategies is now, not wait till the crunch comes in 2005. I do strongly believe that the Indian industry can once again rise to the occasion just as it did in the 70s under the provisions of the Indian Patents Act 1970.

Building Innovative Indian Enterprises

The new millenium Indian enterprises must be innovative enterprises. They will have to be led by innovative leaders, who are visionaries and thinkers, who are capable of thinking of the impossible and inspiring people to make it happen. They will have to innovate in the total chain, mind to marketplace.

After all, there is a definition of an innovator. They say innovator is one who sees what everyone else sees but thinks of what no one else thinks. Innovator is also one, who does not know that it cannot be done. An innovative leader is one, who sets

stretched targets. The chairman of 3M said in 1993 that 25% of its sales would be based on 3M's innovation carried out during the last 5 years. Later, he increased the challenge by changing this from 25% to 30% and 5 years to 4 years.

Risk taking must become a part of the innovation policy of firms. Innovative institutions have no place for those who preserve the systems in a pre-fabricated and unaltered way. A friend of mine, who is a CEO of a company from abroad, once said, ' We do not shoot people, who make mistakes. We shoot people, who do not take risks!' Then he asked me 'What do you do in India?'. I said 'We shoot people, who take risks'. We must change this. We must value and reward people, who are prepared to take risks.

The new innovative Indian firms must allow people to dare, to think. We must facilitate the process of allowing inspired people to convert inspiration into solutions and ideas into products. Again at 3M, and I am sorry I keep on coming back to 3M, which is my favourite, they do something interesting. When people come up with ideas that do not fit in with their divisions' business plan, they can apply for special grants to pursue their objectives. All technical people are allowed to invest 15% of their time pursuing their own ideas – beyond the assigned tasks. Let alone now thinking, we can look back on our organisational set ups and ask as to whether we leave our people even time to think!

Knowledge and innovation management will require a special emphasis in everything that we do. India has number of outstanding schools of management. Whereas they do an excellent job of providing graduates in management of business, finance, marketing, etc., there is no thrust on technology management – more importantly on knowledge management, and most importantly, on innovation management. Innovation management has to be brought to the centre stage in our management schools.

Innovation is the first reduction of an idea to a process that rarely can be planned and controlled with the kind of analytical certainty that the conventional manager associates with other operations. The process of innovation tends to advance in a bubbling way. There is a clear conflict between the standard management practices and good innovation management practices. Innovation management is not based on turn around strategy. It is based on turn around thinking. Standard management practices are based on avoiding conflict, whereas innovators are bound to create conflict. The process of innovation brings in spontaneity and exceptionality. Standard management practice is based on how well a job has been done. Innovation leads to things that have never been done before. What kind of management do we need to have then, if that job has not been done before at all?

Finally, the management structures of firms themselves will have to undergo innovative changes. Around the world, top management is always the grand strategist and decides on the allocation of resources, and the lower management merely implements and administers the strategy. For sustaining innovation, the new management will create only an overarching purpose and an environment in which the people have the freedom to deliver. This means the emphasis will shift to defining the purpose of the organisation, setting the right process and getting the right people and empowering them to deliver. The shift is from the rigid strategy-structure-systems model to the purpose-process-people model in the new innovation strategy. The cry for innovative leadership will mean that our Indian Chief Executive officers will have to assume the role of Chief Innovation Officers.

Finally,

People call me a dangerous optimist. But I have a great abiding faith in India and its future. Next century is going to be the century

of knowledge. It is going to be the century of mind. Therefore, India will have legitimate right to lead. I believe the next century will belong to Asia and India will occupy a pivotal position as an economic power and as an intellectual capital of the world. For too long, we have talked about the potential of India and the potential of Indian industry. Let us unlock this great innovative potential of an Indian mind and convert this potential energy into kinetic energy. After all the potential energy is static but kinetic energy incorporates a velocity, a motion, a movement. I have no doubt that the Indian industry of the next millenium will be an industry, which will be on the move not to just capture the Indian markets but to capture the world markets. And it will do so with world class research and technology. I am sure if Shri S.L. Kirloskar was amongst us today, reaching a great century of a glorious life in 2003, it would have been his dream. Ladies and Gentlemen, we owe this dream to this great son of India as we enter the next millenium. Let us make it happen.

What will be the new challenges in technology that will be generic in nature that will come up for India? First is the miniaturization. Products with precision, automation, minimum raw material will assume importance. Increasing productivity will be of paramount importance. Doing things right the first time, new tools requiring information technology and robotics become crucial. Cost reduction, value engineering to increase the life cycle and reaching masses, are important challenges. Submicron, microelectronics and micro-machining will have to assume crucial importance sooner rather than later.

Manufacturing technology will be driven by the urge to do materials substitution. Reducing ecosystem load, getting more from less, making stronger, lighter and cheaper products faster and faster.

Next standardization will be the key in globalisation. There will be nothing like an Indian standard. Standards for performance, for systems and environmental aspects will be global. Finally, time management due to increased pressure, due to increased specialization and working on a global time clock will drive the change. All these will drive the future of new manufacturing technology.

The process of understanding technology involves design, process know-how, and parts fabrication assembly. When we acquired technology in the past few decades, we concentrated on being very skilled assemblers. The real issue is the mastery over process know-how and design. Then only can we master technology. It is an iterative process, full of learning and creative experience. But we have not gone through that process as much as we should have done.

The entire chain of acquiring the know-how package, evaluating prevailing resources, formulating manufacturing methods, determining import content, accumulating engineering experience, commercializing the product, observing the product behaviour, working out the design modification process and finally using that experience to create new products, forms that real chain of creative learning and doing. Had we done this process systematically & with vigour, Indian industry would have been in a different position today.

Take the examples of compressors. We have been producing them for several decades. But when banning of CFC was on cards and we were looking for alternatives, what did we do? We again went back to acquire new technology from abroad. We need to change our ways and become technology generators & providers and not just technology seekers.

The methods of technology development have changed today and we need to take note of that. The serial development method of product design, going down to production through the chain of manufacturing process design, prototype test, support process design has been replaced by the simulation-based integrated product and process design because again speed is of prime essence.

Options on knowledge generation and acquisition

I was attending a meeting of the Third World Academy of Sciences in Trieste recently. Fredrico Mayor, the Director General of UNESCO made an interesting statement. He said "Knowledge flows from north to south and wisdom flows from south to north". I remember making a small correction; 'knowledge' may flow from north to south but 'usable knowledge' does not flow that easily' from north to south, since usable knowledge has the potential to create wealth. No country, no corporation gives a competitive advantage to another, excepting at a price. India itself has realised this in the post liberalisation era.

Basic skills are gaining importance and the new paradigm is skill-based competition. The high technology companies are asking as to what skills, capabilities and technologies should they build up, rather than asking a stereotype question, as to which markets should they enter, and with which products. I see an enormous opportunity for India to become a global knowledge platform in the coming century, by partnering these companies in areas where we can cooperate, leveraging strategically those Indian niches, where we have a competitive advantage.

Knowledge industries

Increasingly the traditional factors of production – land, labour and capital – have become less important when compared with technology; the economists have termed this as the 'expansion of

the production frontier'. The source of technology is in science that is rooted in knowledge. It is easy to visualise that tomorrow's industries will be knowledge industries. The emphasis will not be on physical or tangible assets, but on intangible knowledge assets. The value of intellectual capital of an industry will determine its rank and competitiveness. In such industries, there will be a major shift from people, who handled information and did routine and unthinking work, to those who will use knowledge at every stage. For knowledge workers, information and knowledge will be both the raw material of their labour as well as its product.

World's major growth industries – such as microelectronics, biotechnology, designer-made materials, and telecommunications – are already brainpower industries. These knowledge industries stimulate other industries, in turn, to become knowledge based. Consider the oil industry. The issue of "bottom of the barrel" is driving the economics of these industries. New knowledge embedded in three-dimensional acoustical sounding, horizontal drilling, and deep offshore drilling is turning oil business into a knowledge industry.

One might wonder as to why the physical assets such as machinery in a factory, are becoming less important. Plant and machinery are tradable commodities today. Even capital was a scarce commodity until recently and was used as a competitive advantage. But with globalised markets the companies around the world have access to finances at inexpensive rates. So even capital is no longer a scarce commodity. It is the intangible assets, which are knowledge based, and that are non- replicable, unique and proprietary, that are providing companies with a competitive edge.

Finally, for a cash starved but intellectual capital rich country like India, emergence of knowledge industry is a good news. But

harnessing the full potential of knowledge industry requires an aggressive and visionary policy framework, creative planning, daring and risk taking. It needs to be recognised that the knowledge industries such as software development, pharmaceutical industry, biotechnology, engineering services etc. operate in a highly competitive environment with great demand on the speed of response in dynamic market conditions. A high operational efficiency and functional flexibility is crucial for such industries. The Government policies, therefore, have to be conducive to provide these. For example, the knowledge based companies that employ knowledge workers are in great demand and some of them may require global level compensation with schemes to create and share wealth. Employers' stock option plans need to be made available in such industries. India has yet to set up proper technology financing mechanisms, which are risk taking and which can cater to the knowledge industries. In particular, the venture capital financing is very poor in India and yet at the same time we recognise that Intel, Microsoft, Apple, etc. would not have seen the light of the day but for the venture capital financing. Appropriate regulatory frameworks need to be set up. The labour laws in India are obsolete when one considers the environment in which knowledge workers in knowledge industry thrive. For instance, Shops & Commercial Establishment Act, 1961 and Rules restricts working hours to 9 hours on any day and 48 hours in a week whereas in knowledge industries, flexible timings to meet the needs of the global customers are absolutely essential. It is important to recognise that knowledge work in knowledge intensive industry cannot be governed by using the laws meant for physical labour. Several other changes in foreign exchange regulations etc. will be needed to cater to the needs of export intensive knowledge based industries.

We need to emphasize value-added exports, but are we adding value? Here is an analysis done by the Indian Institute of Foreign

Trade of how a nation gets a competitive advantage in exports. It is based on resource, labour, scale, technology and product differentiation. We still continue to seek advantage from resource-based and labour-based factors. Knowledge based value addition as reflected by technology and product differentiation is very poor in our case. See how Singapore boasts of over 70% through these two factors on technology and product differentiation, as against our 5%! Obviously, we are way behind. But do we have a hope? Let me just take a few minutes to reflect on some success stories, which give us the confidence that we can do it! I will take up the issue of technology and scale.

Another challenge for India will be the choice of the big versus the small, centralized versus the dispersed. We will talk of capital intensive 5000 MW power plants, but at the same time, we will have to focus on the smaller dispersed power plants. Not too far from here, our National Aerospace Laboratory in Bangalore, has a nice innovation. The discarded aeroengines are used by it for a 2 MW plant in a very cost effective way with a payback period of about a couple of years. We need to multiply such technologies.

The challenge of promoting innovation, creativity, enterprise and synergy of all the players running through the entire chain, covering concept to consumer, is another big challenge for India. Innovation at each stage, whether in the discovery laboratory or in the market place, will be crucial. The psyche of an Indian consumer is different. Product design for an Indian consumer is going to require a different thinking. New product design concepts, which lead to small, short, lean & thin products, have to be developed for the Indian market. This gives a new orientation to the manufacturing technology in India, quite unlike in the West.

I made a reference earlier to the expensive wars in the knowledge market that the Indian industry will have to face, as it

integrates its economy with the global economy. Intellectual Property Rights (IPR) will be crucial in fighting these wars! Indeed in the world of knowledge based competition, IPR will emerge as a key strategic tool. India is way behind the rest of the world and the continuing illiteracy in IPR will hurt us badly. Incorporating strong systems on generation of IPR, its capture, documentation, valuation, protection and exploitation will need a massive thrust.

New IPR regime and Indian knowledge industry

The knowledge based industry in India, such as the IT industry, pharmaceutical industry, etc. will have to face new challenges in the new IPR regime. The IT industry has maintained an impressive growth rate and we have the dream of becoming an IT super-power, raising our software exports from $ 2 billion to $ 50 billion in the next 10 years. If this has to happen, then we will have to reduce the content of body shopping and move on to innovative IT products, which will need IP protection. The Indian IT industry has not so far cared for this, but it will have to play an increasing attention to this aspect.

The same is the case with our pharma industry. From an importer of even the formulations in early 50s, our pharma industry has become a net exporter. We need to recognise that it will start feeling the heat of the global competition soon. The global pharmaceutical industry is a knowledge industry and the emerging Indian pharma industry will have to be no exception. It has survived so far without developing new molecules. Indeed, only fourteen new molecules have been developed so far in the last forty years, out of which eleven have been from the CSIR system. But with the advent of the new patent regime, the strategies will have to change. I do strongly believe that the Indian industry can once again rise to the occasion just as it did in the 70s under the provisions

of the Indian Patents Act 1970. Indian pharma industry, apart from pursuing novel synthetic routes to known molecules must pursue basic research for patent-worthy inventions comprising new molecules. It will have to forge partnerships with national laboratories in a Team India spirit to surge ahead. As a new strategy, the pharma industry could pursue the development of new molecules up to the point of pre-clinical stage and then forge strategic alliances for co-development or license these to national and international partners. Some of the enlightened pharma players in the Indian industry are already beginning to reap the benefits of this strategy.

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