functional slow release urea at acceptable costs. The acidulation of phosphate rock with nitric acid should be yet another thrust area.

### Engineering services and software packages

We should make a determined effort and provide composite, quick-action, reliable engineering services across the board. The scope is much more than we are inclined to believe as India can muster, at the drop of a hat, 100 engineers of any kind. We should remove irritants due to bureaucracy. We have made an impact in selling software, but the scope is far too great. Here capital cost can be minimal in relation to pay-outs and long-term contracts can be undertaken.

### Nuclear and space programmes

The spin-offs of entirely civilian technologies are really impressive but we have yet to cash on our capabilities. The use of radioisotopes over a wide spectrum, food irradiation, nuclear medicine, etc. are only few examples. Satellite-based surveys can be conducted and interpreted for many poorly explored areas of the globe.

### Concluding remarks

We as a nation will have to innovate to survive and chance favours only the best-prepared minds. To trigger innovation we have to radically change our methods and, per force, elitist policies, based entirely on quality of mind, will have to be fostered. We need to remind ourselves that genius prefers homogeneity of individuals rather than heterogeneity of groups. It is also a recognized fact that small firms have much greater propensity to innovate.

We will have to become quality-conscious on a consistent and long-term basis. Productivity ought to be much higher. We must get out of our delinquency and eject ourselves out from vicious circles to virtuous circles.

The time for scientists and technologists to play a pivotal role in ensuring the economic and social well-being of the nation has never before been so urgent. There is no viable alternative to 'technology push' based growth. We are desperately in need to *engineer* financial success. We must rid ourselves of the phobia of legislation and control and provide truly promotional activities. We ought to launch technology as an endless marathon and declare emphatically the support for technology as a potent instrument for rapid growth. We must usher the era of 'Knowledge Engineering'.

Vision is created by gifted researchers and not by Managers and Managing Directors or Committees which only purport to 'manage' but do not lead.

# The role of technology in industrial competitiveness in post-liberalization economy—some issues and challenges for India

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### The role of technology

A brief glance at human history will reveal that technology has been continuously put to use by man in bringing about changes in his environment, his life style, his perceptions. While this process was a gradual and continual one, through technological upgradation and modernization, we are also confronted with phases in human history when major technological break-throughs were achieved to overcome threats and challenges. The application and management of such technologies brought about step-changes in human civilization. Eons ago, primitive man was only a food gatherer. When he managed for the first time to shape a crude implement out of stone, he had harnessed and put to use a major technology (literally a cutting-edge technology) which helped him to meet competition and upgrade himself into a hunter. Similar technologies such as the fire, the wheel, agriculture, the discovery and application of metals, etc., helped him to overcome environmental challenges including survival problems and provided qualitative, quantitative as also directional changes in civilization. At the same time, primitive tribes and nations beset with technological obsolescence, faced extinction. Thus, *the cardinal lesson we learn from human history is that Technology is the prime mover of change in environment.*

Technology implies man's harnessing of knowledge of the total environment around him and application of this knowledge to meet economic, societal, environmental, cultural, and educational requirements in a highly complex socio-economic matrix. Technology today—whether in its most rudimentary form or whether in the most sophisticated hi-tech areas, whether in applied rural technology or the most modern urban technologies—has impacted every walk of human life and its cause and effect relationship has been recognized as a comprehensive socio-economic tool to meet national, industry and corporate objectives as also as a critical input in turn-around management in both developed and developing economies. A nation (at the macro level) as also an organization (at the micro level) which fails to harness technology and ensure efficient management of its effects will lose the cutting-edge for survival in the emerging fiercely competitive eco-environment.

With the opening up of Indian economy and its gradual integration with the global market, we are confronted with the challenges and opportunities of change. The management of this change and the repository of its benefits, i.e. the market place, will, to a great extent, depend on efficient management of technology. The Indian Industry and Business, the various Research Councils, Institutions and Academicia as also the Government will need to come together and evolve a consensual national strategy not only to maintain but also to sharpen our competitiveness—regionally as also globally. Before we address some of the basic issues and concepts, an overview of the global trends in Research and Development and Technology would not be out of place.

## The global scenario

In recent times, with the universal dismantling of trade and economic barriers, there has been a perceptible shift towards free market economies across the globe. Correspondingly, there have been some common traits in the field of Research and Development and Technology investment and planning, particularly in developed and highly industrialized countries. A review of these common traits will be essential in analysing our emerging requirements in the field of R&D and Technology. These include.

A perceptible move in internationalizing the approach to science and technology, and Research and Development work. Many problems that we face today are perceived to be 'Global in nature' which need to be addressed through *international collaboration*, rather than stand alone Research and Development by individual nations. Atmospheric pollution can be cited as one such 'Global problem' where technology and basic research need to be internationalized and integrated.

The recent reports emanating from some of the highly industrialized countries in Europe confirm this directional change. The issue of 'ignoring historical straightjackets' and developing an '*international outlook*' on Science and Technology has been already voiced by the *Advisory Council on Science and Technology* (ASCOT) in UK. Similarly, the central theme of Switzerland's new science policy is cross-border collaboration. In Europe, today, the discussion is on EC (European Community) Research Programmes and formulation of International Standards in order to derive competitive advantage.

*Government and federal spending and funding of R&D activities is being progressively reduced.*

In the free market scenario the industry and in particular the multinationals are advised and expected to invest more in R&D.

Unlike yesteryears *scientists and researchers are becoming increasingly mobile*; attachments to nations have weakened and there has been a distinct blurring of national causes in the post-cold war unipolar world. Hence several nations have been competing with each other in providing attractive industrial research environment in order to mobilize the best of scientific personnel.

*Multinationals* themselves are tending to optimize their operations and R & D activities worldwide with a very close look and analysis of their R & D investment and whether the research is cost effective. In industry sectors like chemicals, concerns on environment, manufacturing yields and manufacturing costs are receiving greater attention; as a consequence there is a renewed emphasis on improving the process technologies rather than developing new products. Even basic research in theoretical chemistry is being aligned with industrially important problems and current business needs, with the *objective of* making *R & D efforts more efficient, focused and cost effective*. For the time being at least and in the foreseeable future, the *balance is tilted in favour of D (Developmental aspects)* rather than R (Fundamental Research) in R & D. Another notable feature in multinationals' R & D activities is *inter-corporate strategic alliances* even with major competitors in the same business. A classic example would be E. Merck & Co., USA who enjoy the largest market share in pharmaceuticals joining hands with their competitors

M/s Dupont as Dupont Merck Pharmaceuticals to reap the benefits of a synergistic spin-of from such alliances. Added advantage derived out of such alliances between multinationals and also between large and small companies is that many companies overcome lack of 'critical mass' to chart on a truly effective R & D programme.

*R & D outlay* of these multinationals continues to remain *at a very high level*, in certain cases far outstripping federal and government expenditure in the area. Again to cite specific examples, Merck & Co., in USA have invested almost US dollars 4.5 bio. in the last decade at a compound annual rate of growth of 15 per cent; their 1991 expenditure in Pharma Research was close to 1 bio. dollars, which is more than the entire US budget on Drug Research for the same year. Similarly, Hoechst have spent close to 2 bio. dollars on Research and Development and their R & D outlay has risen almost by 200% in the last decade. Dupont have an outlay of approx. 1.3 bio. dollars for the current year in pharma-chemicals, polymers, fabrics and material research, which equates to approx. 10 per cent of total US chemical industry spending. Tables 1 and 2 indicate R & D expenditure of some major pharmaceutical and chemical companies and the shares of the same in their sales revenue. Specifically *for the chemical industry R & D will continue to be a motive force to meet competition, reduce operating costs and differentiate products particularly in speciality and niche markets.* There will be definitely *a closer linkage between R & D and corporate goals of these multinationals* not only to maintain profitability, but also to attain leadership and technological supremacy in identified areas. Overall it has been found that the industry average for R & D expenditure is 5 per cent to sales; in the field of pharmaceuticals it is around 12 per cent; in specialities around 8 per cent; in chemicals around 6 per cent; and in bulk chemicals and oil refining around 2 per cent. Our industry and government spending on R & D in India is far below these levels.

*The emergence of Asia Pacific Region as the focal point of growth and development in 21st century is a major development.* This region, which is home to 40 per cent of the global population, is forecasted to achieve annual economic growth rates of 4 per cent to 6 per cent which is twice that of Europe and USA. Even during the current decade, it is estimated that there will be more new industry constructions in this region than all other regions combined. The trade balance of this region will also alter dramatically in relation to other trading blocs and regions.

*Environmental issues will continue to dominate and direct technological research and developments.* Environmental legislations will become more sophisticated and aspects like Accredited Environmental Audit, as also Regional Eco-Audit schemes are likely to be forcefully implemented. The cost implications particularly in terms of technology upgradation and modernization as also developing newer and greener technologies will be enormous which, industries will have to not only bear, but also take into account the profitability of their operations. The Clean Air Bill in USA for the Oil Refineries and Petrochemicals Sector is estimated to have cost implications of US $ 55 to 100 bio. per year. On a smaller scale, American Plastics Council is estimated to spend 1.2 bio. US $ through 1995 on basic and application research for polymer recyclates and additives.

Similarly the US Environmental Protection Agency (EPA) under the Clean Air Act, has already published a detailed time table for regulating industry/source categories with setting up emission standards for the synthetic organic chemical manufacturing sector including basic petrochemicals and many monomers (Table 3). These regulations and standards will have far-reaching implications in terms of current and new technologies for polymer producers. The entire European community is already agitated over the problem of recycling and waste management. Detailed studies, research programmes and technology development

**Table 1.** R & D expenditure by some leading chemical multinationals (1991)

| MNC | R & D expend. 1991 ($ mio.) | R & D expend./sales 1991 (%) | R & D expend. 91 vs. 87 (% increase) | R & D expend. 91 vs. 82 (% increase) |
|---|---|---|---|---|
| Bayer | 1985 | 7.1 | 12.4 | 57.8 |
| Hoechst | 1894 | 6.1 | 1.4 | 35.6 |
| ICI | 1294 | 5.5 | 33.7 | 66.7 |
| DOW | 1159 | 6.2 | 23.0 | 44.2 |
| Monsanto | 627 | 7.1 | (3) | 73.2 |
| Dupont | 948 | 5.3 | N.A. | N.A. |
| Sumitomo | 471 | 5.4 | 7.8 | 54.3 |
| Showa Denko | 175 | 3.8 | 20.8 | N.A. |
| Eni chem | 356 | 3.0 | N.A. | N.A. |
| DSM | 249 | 4.5 | 43.5 | 40.0 |

Table 2. R & D expenditure by some leading pharma multinationals (1991)

| MNC | Sales ($ mio.) | R & D expend. ($ mio) | R & D to sales (%) |
|---|---|---|---|
| Merck | 8020 | 988 | 11 5 |
| Glaxo | 7797 | 1133 | 14.5 |
| Hoechst | 6862 | 852 | 12 4 |
| Smith Kline | 4618 | 692 | 14 9 |
| Boehringer | 2276 | 507 | 18.3 |
| ICI | 2969 | 417 | 14 0 |
| Monsanto | 1531 | 259 | 16.9 |
| Astra | 2021 | 355 | 15.7 |
| Dai Ichi | 1673 | 205 | 12.2 |
| Chugai | 1125 | 176 | 15 6 |

Source: *Chemical insight*.

Table 3. US environmental protection agency (EPA) source categorization for emission standards

| Some selected polymers: | Compliance by |
|---|---|
| ABS and copolymer<br>Epoxy resins<br>PET and polystyrene | 15 November 1994 |
| Phenolics<br>Polycarbonates<br>Polyester<br>Polyvinyl alcohol<br>Acetates<br>Butynol | 15 November 1997 |
| Alkyd resins<br>Phthalate plasticizers<br>PVC and copolymers | 15 November 2000 |

Source: *Plastics and Environment*.

projects have been undertaken in order to ensure resource optimization based on cradle-to-grave life cycle analysis of materials and their products. Aspects like light-weighting and downgauging, energy recovery and clean technology for incineration of wastes, feedstock and chemical recycling, degradability, mechanical and chemical sorting and separation, filtration and compounding of waste polymers and additives thereof, have received considerable attention for commercially viable technologies. A *notable feature of the environmental aspects of science and technology is again the collaborative approach particularly at the industry level.* Thus, we have organizations like Association of Plastic Manufacturers of Europe (APME); Plastics Waste Management Institute (PWMI), Belgium; Ministry of International Trade and Industry (MITI), Japan; and several other multinationals who have established collaborative research programmes for technology evaluation.

Some of the areas which have been identified as key technologies for the 21st century and priority areas for research include.

- Optoelectronics and power electronics.
- Biotechnology including biochemicals.
- Environmental science.
- Advanced materials including speciality polymers, ceramics, alloys and superconductors.
- Knowledge/information technology.

## Management of technology

With the growing impact of technology of business and the growing prominence of R & D in the spectrum of corporate activities, business organizations have to pay considerable attention to efficient management of technology. This calls for formulating technological strategy which can be juxtaposed with corporate goals, objectives and strategies. Particularly in case of technology intensive industries such as chemicals, electronics or aerospace, the implications of technology in corporate business strategy, organization and planning and control are often decisive. CEOs and Business Managers will be increasingly faced with some key issues in ensuring effective management of technology. Some of these are:

*Business strategy.* Where investments in technology and research are consistent with corporate strategy, competition and business environment, threats and opportunities, etc.

*Organization.* Ensuring flexibility of the organization and organizational structures to face rapid technological changes, speedy and successful transfer of technology to the market place for commercial exploitation and technical skills and creativity of personnel, would be some of the important elements of this issue.

*Planning and control.* Business houses will need to clearly specify their research objectives and also their prioritization between Research and Development.

*Marketing.* Factors like technical advantage of products and their attendant costs and investments to derive competitive advantage and above all ensuring complete downstream coupling between Research and Development and the ultimate customer will be critical factors in decision making (see Figure 1). Individual strategies may vary but, in general corporations and industries will need to strategize in the following four or combinations thereof, viz.

| | | |
|---|---|---|
| First to market | : | based on very strong R&D programme and leadership in technology. |
| Follow the leader | : | strong in development resources and fast response to the market change. |
| Application engineering | : | the emphasis on product modification in matured market, and finally, |
| Me-too | : | where importance is given more to manufacturing efficiency and cost control. |

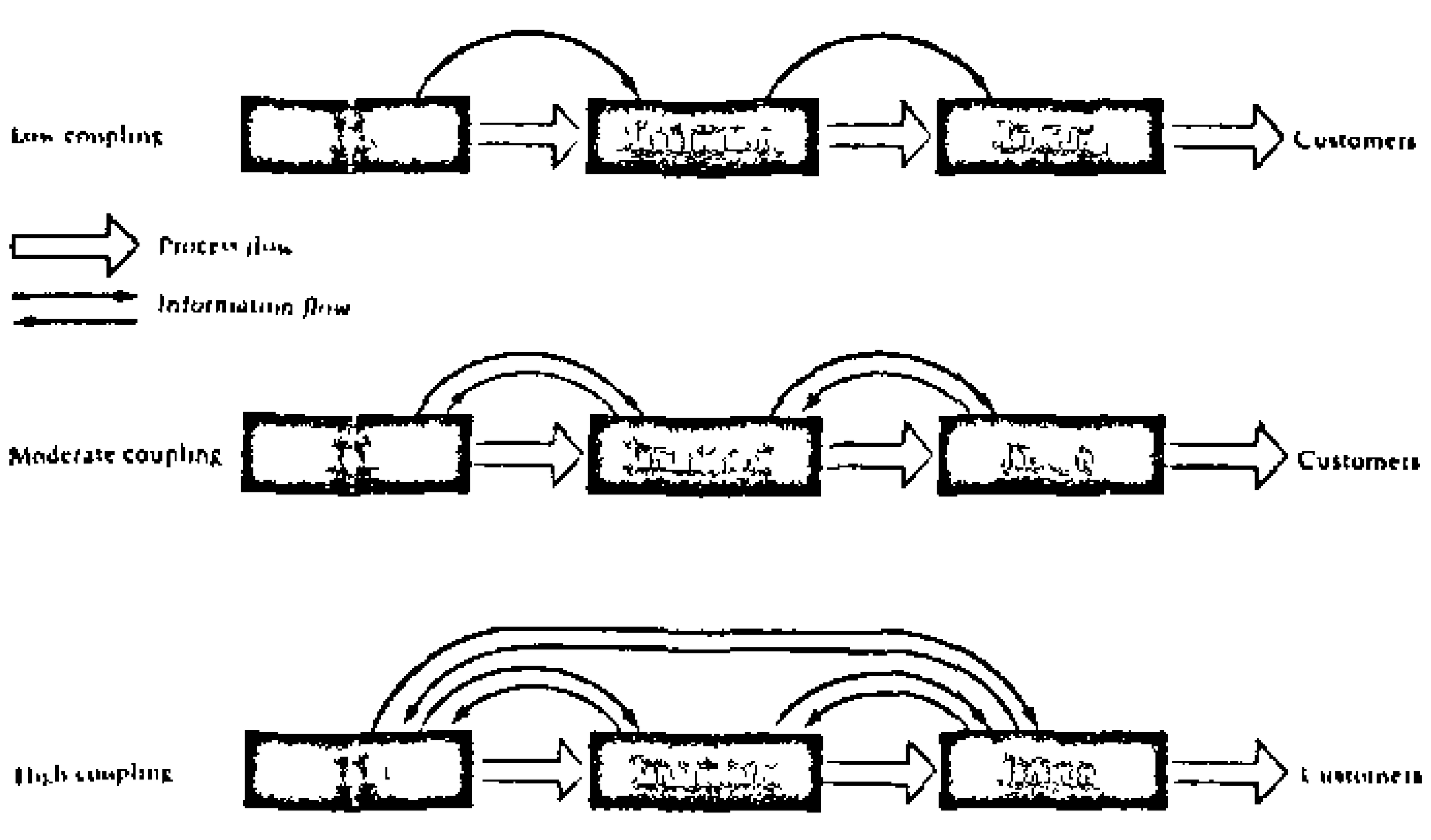


**Figure 1.** A schematic representation of degree of coupling between R & D and the market place.: source: HBR.

It is also increasingly recognized that inputs in R & D and technology are almost entirely ineffective below a certain critical level. Hence, each organization or industry has to develop a *critical mass* in order to ensure that investments in these areas provide both qualitative and quantitative returns. One of the keys to attaining a successful critical mass, besides obvious financial support, is the identification and recognition of *hardcore technical skills* within the organization.

Another important aspect in management of technology is *technical innovation*. This is probably one of the least understood in management process in business. There is a widespread agreement that catalytic agents like 'entrepreneurs', 'innovators', 'product champions' or similar committed individuals are essential to the organization for successful innovation and also that the organizational concept is the central variable in the management process. The concept of innovation runs counter to proponents of stability within corporate entities and this conflict has to be handled judiciously. However, no amount of innovation would be a success unless it is also backed by venture capital. Thus sizeable investments either in retooling or new plant or start-up-costs and similar areas are essential supportive elements to innovation. It has been generally found that large business houses as opposed to individual entrepreneurs or small business have greater capabilities not only to reach the required critical mass but also to successfully implement technological innovations.

Unfortunately, in our country, the management of technology has been neglected in preference to other functional areas. This has resulted in our products and processes losing the competitive edge. Indian business can no longer afford to reap the benefits of a protected market with below-par products and services and static and obsolete technologies. Indian industry as a whole has to reach the critical mass and inculcate the spirit of technical innovation in order to face the challenges of the global market. This will be possible mainly through efficient management of technology.

*Technology forecasting* is also a very critical element in modern technology management. Business organizations, desirably need to set up Technology Assessment Cells whose function would be continuous monitoring, updation and assessment of not only current and changing technology, but also long term future technologies under development or evolution. Personnel with strong technical backgrounds, insight and long term vision are required to predict the trends of future technology and factors of technological obsolescence in order to strategize business goals. A similar approach is essential at the industry and national level too for integrative management of technology. India has already made a start in this direction by setting up Technology Information Forecasting and Assessment Council (TIFAC) comprising of experts from Government, Industry and Academic Institutions but, we are yet to bring about an integrated approach and develop trans-disciplinarity to bring our efforts in this direction to a purposive level.

## Science and technology strategy for Indian industry: towards international competitiveness

Since last four decades Indian industry and business have had to operate under severe constraints and economic aberrations. One of the major constraints has been political interference in decision making which should have been best assigned to technocrats, professionals, and the people 'in business'. The technology and its source was determined more by political expediency and our international alignments particularly in the earlier cold war scenario. Nationally we have paid a heavy price for this in terms of inappropriate, expensive technologies and poor productivity and substandard products. Again, location and siting of important projects and industries both in public and private sectors have been as a matter of rule, rather than exception, decided by political constituencies rather than genuine techno-economic considerations; even factors like proximity of raw materials and captive market place have been ignored. The concept of economies of scale neither existed nor was allowed to take-off in a highly regulated and restrictive industry regime. Our particular national penchant for bureaucracy and red tapism effectively ensured operation of industry on highly uneconomic scales and reliance on permits and licenses to feed a protected and artificially starved market. Planners and policy makers laid overt emphasis on import substitution as panacea for our economic ills; this has resulted in distorted 'tunnel vision' for industry without due considerations to factors like market requirements, economics, technical limitations, and quality aspects. Our entire fiscal planning was geared to low volumes and high imposts instead of high volumes and low imposts which was essential for a highly populated and developing economy like ours. Neither the industry nor the government paid much attention to the debasement and degradation of our environment and its consequential long term social costs. Although our country has been endowed with extensive natural resource and manpower, there have been no concerted efforts towards resource optimization. Finally the spirit of entrepreneurship, so essential for a vibrant economy had been fettered. Today in the post-liberalization era we have made an attempt to come out of this confusing, restrictive and anarchical scenario and move irreversibly in a different direction towards free market economy and global integration. This drastic change has to be managed effectively by business and government within a very short span of time.

Accordingly, I would now like to focus and throw open for debate and deliberations, certain key issues and strategic options that the Indian industry needs to address itself. These, in my perception will be critical determinants for growth, progress and competitive positioning of our industry in the context of a free market integrated global scenario and a rapidly changing business environment.

These are

- Issues and strategies for research and development.
- Critical appraisal of resources with particular reference to inputs for industry.
- Strategies for manufacturing technology.
- Structural adjustments and realignments within the industry.
- Total quality management.
- Environmental concerns.

## Research and development strategy

Traditionally, Indian companies have lagged behind in the primary areas of research and development and marketing; some of the multinational corporations operating in India have been an exception. This area needs to be re-prioritized and given directional change in terms of resource optimization and effective utilization of research and development efforts for both our domestic and export markets. A SWOT analysis will be appropriate in evolving such a strategy.

### *Strengths*

Our national strength is in abundance of technical manpower (3rd largest in the world) of a high quality and relatively cheap compared to international wage levels of researchers. According to a study carried out by Business International, Technical Education is considered to be one of India's major assets for future growth. According to this report, based on the national mapping of our education profile, it is seen that in 1990 there were 3 million *economically active* engineering, medical and science degrees holders (both graduates and post graduates, see Table 4). The other strengths include a very strong business sense, the spirit of entrepreneurship, particularly in the small and medium sector, and finally a very elaborate institutional R & D structure set up by the Government.

### *Weaknesses*

Barring some areas like nuclear and space research, to a very large extent our activities have been highly insular and diffused. Our research programmes, whether Government or private have not yielded any major break-through for the industry either in terms of process or in terms of new products and materials. Many of the programmes have been cost-ineffective and poor efforts and accountability of several programmes have been the bane of our industry. Another major drawback is unwillingness on the part of the industry, particularly to invest in a major way in research and development.

### *Opportunities*

The future opportunities are enormous; we have a very large domestic market which is in a state of flux, ready for new products, new materials, innovations and quality upgradation. The freer availability of technology and greater chances of joint and collaborative research programmes, greater access to technical information, etc. provide ample opportunity for a quantum jump in our research and development activities.

### *Threats*

We need to ensure that we are not swamped with packaged technology and research programmes at the

**Table 4.** Technical manpower in India (1990)—A profile ('000 nos)

| Stream | Total | Economically active |
|---|---|---|
| Science (graduate and post graduate incl. agriculture) | 1941 | 1500 |
| Medical (incl. PG) | 347 | 323 |
| Engineering (degree) | 455 | 397 |
| Engineering (diploma) | 735 | 640 |
| Total | 3478 | 2860 |

Source: *Business International*

cost of local investments and national and environmental interests. The issue of transfer technology and research programmes for environmentally sensitive products and process and any covert attempt to use our region as a dumping ground needs to be cautioned and countered.

Based on the foregoing, the following research and development strategy may be considered at the national and corporate levels.

We need to have a more focused research and development programme. This would require identification of sectoral and industry group requirements and thereafter evolving a short term and long term perspective plan with set targets and time frames.

Our research and development programme needs to have concrete linkages with local resources. This would take into account our resource endowment and the aspect of sustainable development programme, taking *into account the carrying capacity of our environment.* For example, we may need to have a fresh look at coal chemicals—in developing cost-effective and environmentally friendly processes and technologies in order to reduce our dependence on crude oil as a source of chemicals. Similarly hi-tech and hi-performance ceramics based on our natural resources can be an interesting area for exploitation.

*Business houses and corporations within the same* industry group should join hands for a major collaborative research instead of entering into unnecessary competition and duplication of research efforts; such collaborative research would benefit not only the industry but the entire nation at much lower costs. The field of petrochemicals is pregnant with tremendous possibilities for such collaborative research.

Our national laboratory and research institutes should enter into a strategic alliance with their correspondents and also with multinationals on need basis. This will ensure optimum utilization of our very strong resource and infrastructure, faster capitalization of research efforts and immediate access and entry into global markets. Another major benefit of such a strategic alliance would be cross-fecundation of new research ideas and possibilities.

We need to segment our manufacturing activities in terms of technology levels, i.e. low-tech, medium-tech on traditional/conventional and hi-tech industries; for each of these schemes, critical analysis of the current and future requirements in terms of product, process, etc. need to be carried out in order to formulate a focused and appropriate R & D programme. While on this subject, it can be averred that India is fairly strong in medium tech areas, e.g. textiles, paper, cement, dyes and intermediates, etc. Here the role of research and development would be to bring about more of a qualitative upgradation and also ensure reverse technology transfer to other developing countries and economies. In the hi-tech segment, we need to set time-bound targets and the research programme should be set up in phases of sophistication and achievement. The case of Japan is interesting, e.g. they graduated first from optics into opto-electronics and finally robotics. As far as the low-tech area is concerned, our emphasis should be on a very fast capitalization and equitable distribution of research efforts, particularly at rural and grass-root levels.

The documentation of a national perspective plan on research and development will be essential. This needs to be supported by the industry and government alike. It should be based on multi-lateral, multi-goal, integrated and inter-disciplinary approach. The areas of advanced materials, international standards and product and industrial design should receive due importance in this plan document.

We have always looked more to the West (Japan is the lone exception) for our research inspiration. We now need to look more to the East, close around home, and enter into research programmes for the Asia Pacific (AP) region, which is of greater long term strategic importance to our business.

## Resource appraisal

Our nation is characterized by wastes and system leakages—be it in agriculture, industry or government. In spite of being endowed with one of the richest natural resources in the world we have not succeeded as a nation for planned, economic and qualitative exploitation of such resources.

Thus we have blunted a natural competitive advantage. Some of the lacunae that we have faced in resource optimization include:

- lack of holistic approach to exploitation of our mineral and other natural resources;
- ad-hoc approach to quality problems and lack of technological innovation to upgrade the quality of existing raw materials both natural and man-made;
- lack of technical understanding on the impact and implications of impurities in our products and processes as also utilities and a total disregard for the eco-system.

Aspects like quality of energy/power and utilities which also play an important role in cost and efficiency and thereby incompetitiveness have been largely ignored. In order to take care of these inadequacies, and meet the challenges of a competitive global market we propose the following course of action:

*Planned and intensive research and development and technological innovations to upgrade the quality of* *existing raw materials (both man-made and natural).* A few concrete examples will best illustrate the importance of such a programme which needs to be implemented by both, industry and government. The role of government agencies and institutes would be all the more important, particularly in respect of our natural resources like minerals. India has abundant reserves of coal, but bulk of it has very high ash content of between 15 and 30 per cent. In addition, there has been progressive reduction in the calorific value of coal produced due to production from open cast mechanized mines and the share of good quality coking and non-coking coal has declined. In addition to ash, dirt, bounders and lumpy extraneous material impurities have also increased. If the chemical industry tomorrow, has to consider coal as a feedstock, viz. to obtain high calorific value through coal gassification process, we definitely need to come up with technical solutions to tackle this problem of ash content and impurities. Similarly, salt has been identified as a major thrust area for R & D in the caustic soda/soda ash industry with a view to improving productivity. For good quality carbon black, we require high BMCA and low sulphur feedstocks which is in short supply. We have to import fluorospar for the aluminium fluoride industry only because the indigenously produced fluorospar contains excess of phosphorus pentoxide which cannot be removed even after distillation. We still depend on imported wood pulp for our personal hygiene products, locally produced kraft paper does not have the required strength for heavy duty packaging because of inferior pulp. The quality of water which is a very common and important utility is often suspect leading to process and product quality problems. Again, the quality of vital input like electric power is affected by elements such as voltage fluctuations and surges, power factor and intermittent power cuts, heavy line losses, etc., thereby adding to the cost of such vital industries like synthetic fibres, electrochemicals and plastics.

Our problems have been exacerbated due to uneconomic exploitation of our extensive as also scarce mineral resources. The imperatives for technological innovations by the mineral producing and processing industry need to be reemphasized. Areas that require critical evaluation include improved mineral extraction techniques, improved and more economic processing, new product designs and newer material technologies which will ensure usage of smaller quantities of material for specific purpose with scope for recycling and with the ultimate objective of extending our Economically Demonstrated Resources (EDR) (see Table 5). We need to develop enabling technologies to reduce mineral wastages and also to reuse waste products in a meaningful manner. The solvent extraction technology for copper, the recycling of aluminium (which consumes 95% less energy in production compared to primary

**Table 5.** Life estimates of economically demonstrated reserves, some important minerals.

| Mineral resource | Estimated production 1995 (Mio. tonnes) | Depletion date at 1995 level (Years AD) |
|---|---|---|
| Copper ore | 4.17 | 2031 |
| Lead concentrate | 0.059 | 2033 |
| Manganese | 2.13 | 2026 |
| Zinc concentrate | 0.0152 | 2045 |
| Chromite | 0.930 | 2134 |

Source: *Business International*

aluminium), development of high strength to weight ratio metals and alloys for downgauging and light weighting are some typical examples of spectacular technological innovations.

We need to establish a national grid for inter-sectoral linkages in resource optimization. The Planning Commission, The Department of Science and Technology, and also the various user ministries could play an important role in developing such a grid along with industry.

*Asia Pacific Region* must be accorded top priority as a *resource-region.* We should explore the possibilities of *shared common resources* which can be exploited meaningfully and in a collaborative spirit for not only the regional, but also global markets, e.g. natural rubber which is produced both by India and Malaysia; the two countries could work together by capitalizing on mutual strengths and make the rubber industry in this region a global competitive factor. Collaborative research in rubber production and application would go a long way in achieving such as objective.

## Strategies for manufacturing technology

Indian industry is often exhorted to participate in global markets on the basis of its relatively cheap or low labour costs; unfortunately, this is a myth. Business and government must realize that labour cost is only a small element in the total cost of a product. Even today in most sectors of industries we are at a competitive disadvantage on account of poor productivity, low process efficiency and poor yields, high manufacturing and processing losses, substandard and inconsistent product quality, and even more alarmingly very high energy and utility consumption, compared to international norms. The temptation for high technology is not misplaced, but, at the same time we must not lose sight of low and medium tech and conventional manufacturing activities in removing these inadequacies and making us globally competitive. We would thus like to outlay our strategy options in manufacturing technology as follows:

The first priority area relates to economies of scale of production. Industry has to innovate technically within a set time frame (say by 2000) to bring all uneconomic manufacturing units, particularly in the medium and large sector to the required economic level of capacity and operation. This has to be given necessary investment support from both industry and the government. The other hard option would be to either close down some of these non-viable units or to retrofit/modify for manufacturing other products.

The second priority area for technological innovation would be to set time-bound targets for reducing power and utility consumption in the manufacturing sector as per international norms. We propose launching of a Technology Mission nationally to meet this objective. The Mission would look into certain specified sectors of manufacturing activities, particularly those which are energy-intensive and for products which have been considered as thrust areas for exports; identify their present levels of energy consumption as against set norms and standards and suggest technology inputs required to close this gap. The importance of such technological upgradation will be evident from the following examples; in the cement industry, in the wet process, the unit electrical energy consumption is higher by 30% compared to the world average; thermal consumption is higher by almost 35%. An aluminia plant in India consumes 362 kwh/MT compared to only kWh/MT in Australia and Jamaica (for details see Table 6). Chlorate cells operate on a current efficiency of 75% to 85% consuming 5500 to 6500 units per MT of potassium chlorate as against the international average of 90% current efficiency. The small and medium scale plastic processing industry consumes 25% to 30% more power than its counterparts abroad. Can we be cost competitive in such a scenario?

The third dimension relates to productivity, process yields and efficiencies and manufacturing wastes. Here again industrywise technology planning and implementation will be essential to provide cost and quality benefits to our national economy and also to increase our competitiveness. A supplementary objective would be developing economically viable processes to convert

**Table 6.** Some technical recommendations for chemicals and petrochemicals industry in India

| Industry | Recommended technical programme by expert committees |
|---|---|
| Pesticides | Process development of more cost-effective known molecules or products already in world market.<br>Bio-efficacy and toxicological study of new products.<br>Creation of Central Pesticide Institute with Pesticide Development Programme, India as Nodal Agency. |
| Dyestuffs and intermediates | Key intermediate should be switched over to the more economic processes.<br>Microprocessor-based automatic process control systems for safety, security and more so for obtaining better quality products.<br>Pollution control—incorporating new processes for effective effluent treatment.<br>Risk analysis and hazard prediction (computer simulation). |
| Inorganic chemicals (caustic soda) | Captive power generation should be encouraged.<br>Future additional capacities to have an effective chlorine utilization plan as a precondition.<br>Minimum economic size for a new plant should be 200 tonnes per day to ensure economies of scale.<br>Conversion of membrane cells to be encouraged.<br>Improve quality/purity of salt. |
| PVC | Studies in technology development especially the bulk process needs to be taken up.<br>PVC process being energy intensive, attempts should be made to develop minimum energy process.<br>Fundamental understanding on PVC particulate morphology is of utmost importance. |
| Rubber | Tyre machinery upgradation—machinery manufacturers should be encouraged to carry out technological upgradation.<br>Setting up of a National Tyre Research Centre—to develop new process technology.<br>Incentives to tyre and non-tyre sectors for import of technology/equipments, which will result in substantial saving in energy cost and improvement in productivity. |

Source: Perspective plans:
Government of India, Ministry of Industry,
Department of Chemicals and Petrochemicals.

wastes into useful by-products and co-products. Certain industries like petrochemicals, inorganic and organic chemicals, etc. in association with the government have drawn up long term perspective plans wherein due considerations have been given to these factors. Details of some of these technology recommendations on process efficiency and product qualities are given in Tables 7 and 8.

Finally, we need to evolve a national policy on technology for hi-tech industries including the role of private industry in areas like nuclear, defence, aerospace, etc. We consider advanced materials, speciality chemicals and electronics to be of national importance in this direction.

We recommend setting up of dedicated task forces for each of these areas with short term (5 years), mid-term (10 years) and long term (15 years) objectives. For the short term objective, we may have to depend on imported technology in order to ensure easier and faster entry. Therefore we must target for technology absorption, upgradation and finally development of total indigenous technologies as a long term strategy.

### Structural adjustments and realignments

From the criticality of the inputs, technological innovations and environmental controls with concomitant investments it will be apparent that structural changes within the industry is an imperative. Such structural changes may happen along three different directions.

*First*, terms of the size mix of size profile of the industry (i.e. small, medium and large) may have to undergo a radical change and product mix for each of these segments may have to be reorganized and reoptimized.

*Second*, structural changes may also take place along

**Table 7.** Energy consumption in various sectors.

Cement

| Process | Energy | Tyre | Indian scenario | World scenario | Per cent |
|---|---|---|---|---|---|
| Wet | Electricity | (KWh/Ton) | 114 | 87 | 31 |
| | Thermal | (GCal/Ton) | 1.657 | 1.243 | 33 |
| Dry | Electricity | (KWh/Ton) | 155 | 111 | 39 |
| | Thermal | (GCal/Ton) | 0.977 | 0.769 | 27 |

Steel

| Thermal (Gcal/ton) | Bokaro | Durgapur | TISCO | Japan |
|---|---|---|---|---|
| | 7 | 9 | 13 | 6 |

Aluminium

| | INDIA | AUSTRALIA | GUINEA | JAMAICA | SURINAM |
|---|---|---|---|---|---|
| *Thermal (GCal)* | | | | | |
| Steam | 3492.1 | 3601.4 | 3235.6 | 3965.6 | 848.9 |
| Calcination | 1242.5 | 1221.2 | 1221.2 | 1221.2 | 1221.2 |
| *Electrical (KWh)* | | | | | |
| Electricity | 362 | 240 | 240 | 240 | 240 |

Source: Tata Energy Research Institute/TEDDY

**Table 8.** Comparison of injection-moulding machines

| Comparative model of machine | A | | B | | C | | |
|---|---|---|---|---|---|---|---|
| | Indian | Foreign | Indian | Foreign | Indian | Foreign I | Foreign II |
| Screw diameter (mm) | 60 | 60 | 45 | 36 | 100 | 100 | 100 |
| Inj. rate (g/sec). | 330 | 880 | — | — | 2790 | 3530 | 2940 |
| Plasticising rate (g/sec). | 30.60 | 55.60 | 23.05 | 23.05 | 66.66 | 110.00 | 74.50 |
| Screw (rpm) | 165 | 250 | 212 | 350 | 110 | 190 | 130 |
| Connected load (kW) | 42 | 50 | 27 | 24 | 162 | 164 | 107 |
| Connected load/unit output (kW/kg) | *0.38* | *0.25* | *0.57* | *0.29* | *0.68* | *0.41* | *0.40* |

*Source*: DSIR Report, 1990

product lines. For example, in USA the chemical industry in its current stage of development has oriented itself into three major groups.

- Commodity chemicals, plastics and synthetic fibres.
- High technology groups including biotechnology, electronic chemicals and medicals.
- High value small volume speciality chemical groups.

*Third*, restructuring will take place on the basis of individual company policies, including mergers and acquisitions.

Interestingly, as mentioned earlier, competition is being turned around into collaboration; many large companies competing in the same market with different technologies have joined hands for economic and market reasons. Management experts have also noted with satisfaction that concentration of industry or business has improved both competitiveness and performance in the market place.

However, in terms of infrastructure, in spite of policy of privatization, the government will have to play a continuing critical and supportive role through financial and technological investments. Areas like transport, communication, power generation and even housing and building and construction will require governmental support.

We also recommend realignments of our fiscal tax structure particularly in the area of direct taxes for individuals and corporations. The following steps would be a positive boost to industry:

Scientists, engineers, technocrats and entrepreneurs should be rewarded fiscally for creativity and technical innovations. These could be in the form of income tax rebate for individuals to incentivize research efforts and new ideas.

The government can levy a cess on all industries towards creating a National Research and Development Fund, each company will contribute to this fund in the form of cess to be levied either on turnover or on profits. At the same time companies may claim tax rebates and benefits prorata to their R & D investments and achievements to set-off the contributions to the fund. In other words, a special form of depreciation to be allowed on research activities. A National Research Fund would also provide financial support to industry and national research programmes which are of commercial importance.

Extending MODVAT benefits to research inputs which can be costed notionally into existing products and also total excise duty exemption for specified period for completely new researched products.

### Total quality management

Quality will be the pass word to success in the future market place. This is one area where the Indian chemical industry, barring some exceptions, needs to gear up itself to improved international levels of demand. In the words of W. Edwards Deming, known the world over as 'Quality Guru', 'What is required is a 'holistic' approach to management, one that demands intimate understanding of 'the process'—that delicate interaction of people, machines and materials—that determines productivity and quality and holds the key to competitiveness'. He goes on to argue that all processes are subject to some level of variation which is likely to diminish the quality. 'Therefore, every process, whether it involves people or machines, is only as good as the management's ability to control the levels of variation'. Such ability and commitment can be supported only by appropriate technological innovations and technological developments starting from the basic raw material up to the finished product and to put greater emphasis on quality assurance right at the source rather than quality control.

The Total Quality Management (TQM) is only the means to this end. Several industries and business houses have initiated steps to implement TQM with a view to obtaining ISO 9000/9001 certification. Many Indian companies particularly in the engineering sectors have already obtained this certification and accredition. It is expected that 1993 onwards the European Community will enforce this certification for all products reaching their market place. This is a large market for Indian industry. Although there is no such stringency in respect of exports to other regions like Asia Pacific and The Americas, in the long run it will be in our own interest to adopt Total Quality Management as a national policy.

### Environmental concerns

Environment is a vast, complex and sensitive subject for governments and industries across the globe. This cannot be dealt with in a perfunctory manner in a brief dissertation. Hence, we will briefly touch upon some of the aspects of environment that have a direct or indirect bearing on the competitiveness of the Indian industry.

As we are aware the 'Green Dot' has become the entry permit for any goods to be exported to the German market. Many European countries have objected to the green-labelling of products as a trade barrier and discrimination but they too have voiced similar concerns for their own environment and a common green code for the entire European Community market is close to reality. The scheme of Green Dot or eco-label implies codification and certification that the material is environment-benign in its manufacture, conversion, usage and recycling. As of today, very few Indian companies are equipped to answer this eco-challenge of a developed market. A small beginning has been made by the Ministry of Environment in launching a voluntary eco-label scheme for some selected products and industries. We foresee a pressing need for across-the-board compliance for all industries within the next five years. In general Indian industry has been concerned more with end-of-the-pipe controls rather than source reduction which has affected both quality and cost competitiveness. This needs to be reversed. *Source reduction* should receive top priority in terms of Research and Development, technology substitution and upgradation and also very critical look at some of the new emerging clean technologies. This would not only ensure that Indian industry plays a more positive role in environment management but also provides raw materials and finished products of better quality and at lower costs. We need not be so ambitious as say the chemical industry in USA which has set for itself a zero level emission target in the next 10 years through 'Maximum Achievement Control Target (MACT)', but some form of objective setting exercise in this direction will definitely help the industry. Table 9 provides illustration of some of the clean technologies that may be appraised for selected industries.

Small industries are the backbones of Indian economy. A very large percentage of our exports is also accounted for by the small industries. Unfortunately,

**Table 9.** Clean technologies of production: some suggestions

| | Steps towards clean technology | | | |
|---|---|---|---|---|
| Industry | Process modification | Recycle/Reuse | Equipment redesign | Product formulation |
| Pulp and paper | Removal of silica before evaporation process in cooking of rice straw. | White water recycling for washing of pulp | Press drying technology for paper making. | Brightness of pulp regulated to 75% to 80%. |
| | Substitution of chlorine with chlorine dioxide or hydrogen peroxide for bleaching of pulp. | Recovery of sodium sulphide/sodium carbonate in cooking. | | Separation of paper requiring permanent brightness. |
| | | Separation of lignin in bleaching process for use as adhesive agent and raw material for dyestuffs. | | |
| Textile | Thermal printing process for cotton cloth. | Caustic soda recovery in mercerizing. | | |
| | OMC/PVA to replace starch in sizing. | Solid cotton waste separation for use as stuffing for cushions and dolls. | | |
| | Counter current washing. | | | |
| Tannery | Aluminium salts to replace chromium salts in pretanning. | Cuttings, trimmings as raw materials for leather boards. | Use of drums and mixers instead of pits. | |
| | Batch washing of hides instead of continuous washing. | Green scrappings from sawing for glue production. | | |
| | Enzymes to replace sulphate in unhairing. | Tail and body hair for carpet industry. | | |
| Metal finishing | Counter current washing for rinsing. | Cadmium and cyanide recovery through reverse osmosis. | | |
| | Non-cyanide salts for nitriding. | Recovery of noble metals through electrolysis. | | |
| Chor-alkali | Ion-exchange and electrolysis for production of chlorine and caustic soda. | | | |
| Iron and steel | Mechanical cleaning to replace acid pickling. | Blast furnace slag as construction material. | | |
| | Neutral electrolyte process for pickling. | Recovery of hydrochloric acid from pickling process. | | |
| Fertilizer | Nitrophosphate process for NPK complex production. | Nitric acid recovery in ammonia fertilizer plant. | | |

Source: National Environmental Engineering Research Institute, Nagpur.

**Table 10.** Waste utilization opportunities in industry sector: (industrial complexing)

| Industrial waste | Physical form of waste | Source industry | Present disposal method | Potential for use |
|---|---|---|---|---|
| Fly-ash | Power | Thermal power station | i) Pumped in the form of slurry to nearby low lying areas in the wet system of disposal. ii) Fly-ash discharged from the precipitators is conveyed for disposal to the dumps in the dry method | i) In portland pozzolana cement. ii) In construction industry iii) (a) Dam construction, (b) land reclamation, (c) road construction. iv) Cellular concrete v) Lime fly-ash bricks vi) Sintered light weight aggregates. |
| Blast furnace slag | Solid lumps | Steel industry | Dumping in open area | i) As a component in blast furnace slag cement. ii) As a component in binding material i) Road aggregate ii) Slag wool |
| Lime sludge | Slurry/paste | Fertilizer, sugar, paper and acetylene industry | Stored in large outdoor settling ponds | i) As raw material in cement manufacture. ii) In limo pozzolana mixture. |
| Chemical gypsum | Slurry/paste | Fertilizer industry | Pumped in the form of slurry to the dumping ponds. | i) As a set controller in the manufacture of cement in place of mineral gypsum. ii) For making gypsum block board. |
| Red mud | Paste | Aluminium industry | Dumped in open area | i) As a component of raw mix in the cement industry. ii) In the manufacture of building bricks. iii) Light weight structural blocks. |

Source: National Environmental Engineering Research Institute, Nagpur.

many of these units are not in a position to comply with mandatory environmental requirements because of their limited resources. The government along with industry has to promote schemes for common or shared pollution control facilities which will help the industries in producing goods of international quality, environmentally friendly and at competitive prices. A beginning has been made in this direction by the World Bank and its Soft Loan Affiliate (IDA) in sanctioning a loan of US dollars 155 mio. for common water treatment facilities in industrial estates and in Gujarat, Maharashtra, Tamil Nadu and UP.

The government should seriously consider some sort of fiscal incentive to subsidize export of green products.

Industrial complexing has to be adopted as a policy to ensure cross-sectoral usage of waste and bi-products, thereby opening up newer and expanded market for the industry without environmental damages. An example of waste utilization opportunities through industrial complexing is given in Table 10.

We should maximize our efforts in accessing the latest technologies for improvement of our environment. As already pointed out, international collaboration will be a more cost-economic and market-friendly alternative.

# Globalization—an entrepreneur's point of view

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As India sets sail towards export-led growth, liberalization and globalization, the forecast for business organizations is clear—of rough sailing and harsh expectations. We will be in the high seas of mega-competition and world class competitors making inroads on our very own turf.

There are no sops or emotions involved in the new playing field. Those who will grow are the ones who