India: set for a new technological epoch

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India's chemical industry has not been an innovative one, tending to rely on its market size to ensure profits. A less protective domestic market now brings increased competition from the outside, demanding that new prescriptions for technological development now come to the fore. *Dr. Sivaram*, head of polymer chemistry at the *National Chemical Laboratory in Pune*, explains.

TECHNOLOGY CAN be broadly defined as a technique of manufacturing and/or delivering a product according to defined specifications with consistent quality standards in a repetitive/reproducible manner and in a cost effective way. Technology development therefore constitutes the process by which an organisation acquires the knowledge for taking part in the technology.

In general, there are two distinct processes by which the technology is acquired for practice:

- direct acquisition of technology from an established practitioner (technology transfer or licensing);
- technology development, originating from scientific innovations and its progression from the conceptual level through various stages of manufacturing and finally into the marketplace.

In the Indian environment, direct technology through transfer licensing or joint venture partnership has been the preferred mode for technology acquisition. The reasons for this are the desire of Indian industry to quickly 'leap frog' in terms of market size, scale of operation and upgrading of technology; to overcome weak R&D culture; inadequacy of pilot plant facilities; and limited project/process engineering competence.

Indian industry has depended mostly on market size for ensuring its profits. Truly knowledge-based products have not entered the Indian market. The Indian chemical industry in general continues to be a follower not a leader, in spite of the fact that the chemical industry is one of the

largest industrial sectors with a sales turnover of Rs50 000 crores (US$3.75bn), a growth rate of 8-10%/year and exports exceeding Rs4000 crores.

Technology development is a multifaceted activity and involves R&D, manufacturing, quality management, safety, information and intelligence, application development as well as financial and risk management. It requires an effective management, of diverse people, often with conflicting objectives. It needs a strategy as well as a vision.

Success in technology development in the Indian chemical industry has been modest and isolated in nature. They were products of a protected economy and free from the environment of competition with little premium on knowledge-based innovation. Yet, they were valuable exercises in gaining experience and learning.

They gave rise to a sense of confidence, competence and optimism. It is obvious that while vast resources in process chemistry exist, strengths in process engineering are relatively weak. Although successful examples of commercial development abounds in technologies related to agrochemicals and drugs, the fact remains that no new molecule has been discovered in India. In the area of fine chemicals too, no major innovations are obvious.

India's past experience in technology development indicate an unusually long period between the time the project was conceived to the time the product was commercially produced.

However, these tenets have served well in an era when 'self sufficiency' was the aim in highly protected domestic markets insulated from foreign competition and narrow in focus. In general, capacities were small, quality dubious and the industry lacked the impetus to upgrade technology.

In spite of some impressive successes in the past, much remains to be done if India is to accomplish this task in the emerging industrial scenario. With increasing competition from quality products and rapid changes in technology, the old prescriptions for technology development will no longer be sufficient. India needs to explore new paradigms in its ability to manage innovations, to ensure quality in R&D and to deliver quality products to customers in time.

The environmental pressures that will drive this process are:

- increased competition in the marketplace;
- increased customer awareness as well as market fragmentation;
- tightening patent regimes, especially for drugs and agrochemicals;
- ability to bring new products quickly to the marketplace;
- ability to retain market share based not only on size but quality, price and continuous product innovation.

This means greater emphasis on R&D, quicker time cycles for commercial development, better project management techniques and more productive use of financial resources for R&D.

Just as quality and manufacturing excellence are important to competitiveness, superior technology development capabilities will also become crucial in the coming years. Recent studies have found a strong link between an organisation's competitiveness and its ability to commercialise technology. The ability to move a product from concept to market quickly and efficiently is crucial in light of changes in the business environment.

These competitive realities make the ability to develop technology at least as important as traditional advantages such as scale, skilled labour, possession of proprietary technology and access to capital.

The four factors that determine an organisation's ability to commercialise a technology are:

- time to market
- range of markets
- breadth of technologies
- number of products

Technology development capabilities as well as management within organisations must be further strengthened by placing commercialisation of technologies on the corporate agenda; specifying key technologies in which the organisation must lead; setting targets for price/quality; and building cross functional skills.

In addition, the country must strive to create organisations which are seamless, taking an interventionist attitude by asking hard questions and demanding honest answers about technical performance from their development teams.

All this will need major shifts in focus on the part of both corporate and R&D management.

With sophisticated customers demanding greater performance and new, aggressive and often subtle product characteristics, successful technology development requires managing an increasing number of complex decisions as well as interfaces.

Success will come to those organisations whose top management set the right priorities as well as goals, promote cross functional skills and debureaucratise decision making.

India's technical strengths and weaknesses		
Agrochemicals		
Example	**Strengths**	**Weaknesses**
Endosulfan Malathion Quinalphos Chlorpyrifos Synthetic/ pyrethroids Brassinolides Glyphosate	Process chemistry Process development Basic/detailed engineering Turnkey plants with guarantees Formulation know how	No new molecule discovered Poor patent portfolio
Pharmaceuticals		
Anticancer Antibacterial Antiviral	Process chemistry Process development Formulation know	No new molecule discovered Poor patent portfolio

Antiinflammatory Analgesic Cardiovascular Antileprosy Antidepressant Contraceptive	how Newer processes for known chemical entities	Poor infrastructure for drug evaluation Poor emphasis on biotechnology based products
Fine Chemicals		
Acrylates Phenolic antioxidants Sulfolane Adipic acid Methylamines Piperazines Diethylbenzene Drug intermediates	Process chemistry Basic and detailed engineering	No innovations in in process chemistry Poor patent portfolio
Petrochemicals		
p-Xylene Hexane LAB (alkylation and dehydrogenation) BTX Naphtha reforming Ethyl benzene/styrene	Catalyst development (drop in replacement) Catalyst manufacture Reasonable patent portfolio	Limited experience in process engineering
Polymers		
Nitrile rubber ABS	Process chemistry Product application	No innovations in chemistry

Polystyrene/HIPS Thermosets Unsaturated polyesters Resins/Latex for paints Surface coatings and adhesives Speciality polymers/ formulations Blends/alloys	development	Poor patent portfolio Poor process engineering