INNOVATION MANAGEMENT
AN INDIAN EXPERIENCE

Abstract

Technology Innovation is the key to productivity, growth and international competitiveness in industry. This article provides an insight into technology innovation initiatives especially among the Indian small & medium enterprises (SMEs). The article attempts to delineate various innovation management models as experienced in TIFAC programmes. With the objectives of promoting key technologies in the country and facilitating SME-led technology development efforts in early stages of the innovation chain, TIFAC had initiated programmes on home grown technology, advanced composites, bioprocess & bioproducts etc. The aim is to promote public-private partnership for generating market-driven projects with potential applications in areas such as chemical, bio-medical, pharma & nutraceuticals, transportation, tourism etc. The article brings out a few case-studies of successful technology innovation that improved turnover and profitability.

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Introduction

Technological Innovation can be defined as a dynamic network of agents interacting in a specific industry. Technology innovation is the key driver for growth, and profitability in an economy. There are several components of technology innovation. Inputs from various stakeholders are necessary viz. industry, extraneous knowledge sources, new sources of raw material, new methods of production, inspection & certification agencies and most importantly, the users or market feedback. However, technology innovation becomes complex in rapidly changing technological and economic environments. Innovations that do not succeed are often good ideas and may still fail due to budgetary constraints, lack of skills or poor fit with current goals. Hence, failures should be identified and screened out as early as possible in the process. A networked innovation system is presented in Fig. 1.

SMEs play a significant role in Indian industry. Today some SMEs are investing in R&D in order to compete globally. They are generally more flexible, adapt themselves better, and are therefore better placed to develop and implement new ideas. The flexibility of SMEs and their simple organizational structure, low risk and receptivity are essential features that make them more innovative. SMEs help in the socio-economic advancement in the developing country through employment generation, low investment, significant export earnings,

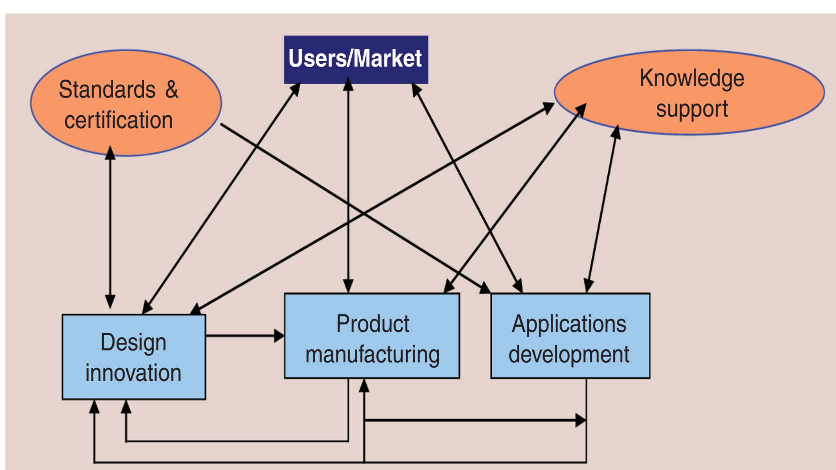

Fig. 1. Networked innovation system

> To facilitate SME-led technology development efforts in early stages of the innovation chain, TIFAC had initiated a few programmes of national importance on advanced composites, bioprocess and bioproducts etc.

labor intensive production, capacity to develop appropriate indigenous technology and high contribution to domestic production. They constitute 15 million units, and contribute ~7% of India's total GDP. SMEs contribution is estimated at ~50% of exports, and 40% of industrial production in India. They are the biggest employers after agriculture, employing 29.4 milllion people. It is estimated that SMEs account for almost 90% of industrial units in India and 40% of value addition in the manufacturing sector. Technology innovation has been the key to their survival and success. Finance is an important driver for innovation among SMEs and the cost of funds should be attractive enough for them to invest in projects involving technological risks. They are often beset by multi-faceted problems, which include:

- inadequate infrastructure facilities;
- availability of skilled labour;
- access to market;
- in-house technical & managerial capabilities;
- long product development cycle;
- extraneous knowledge support;
- lack of standards & certification process in some cases;
- internal resistance to change;
- cheaply available foreign imports; and
- delayed payments by large industries.

To avoid such problems and ensure a seamless technology development process, the need for a well-defined strategy was strongly felt by the Government of India (GoI). Four decades of planned development have elevated India to a stage, where the country demonstrates remarkable strength in modern technologies for achieving development goals. There exists a chain of national laboratories, specialized R&D agencies in defence, atomic energy and space, Indian Institutes of Technology (IITs), universities and other academic institutions of higher learning, which are capable of providing world-class expertise, technically trained manpower and technology support to the industry. The institutes have been pursuing application-oriented research, which has led to amassing an excellent knowledge pool. However, the extent of knowledge flow from such centres of excellence to the industry for its actual exploitation has been rather limited. Various policy interventions were designed by the Government from time to time to bridge this gap.

Technology innovation approaches for effective public-private partnership

In view of the critical need for technology innovation, Technology Information, Forecasting and Assessment Council (TIFAC) was conceptualized as a unique knowledge networking institution in India for facilitating novel technology developments in key sectors of the economy. TIFAC was established as an autonomous organization under the aegis of the Department of Science & Technology, GoI. To facilitate SME-led technology development efforts in early stages of the innovation chain, TIFAC had initiated a few programmes of national importance on advanced composites, bioprocess and bioproducts etc. The programmes were conceptualized with the basic premise of promoting public-private partnership for generating market-driven projects with potential applications in areas such as chemical, bio-medical, pharma & nutraceuticals, transportation, tourism etc.

Advanced Composites Programme

Following a detailed sectoral analysis and a technology assessment exercise, composites were recognized as an important performing material in India with a wide array of applications that touched a large number of people from different walks of life. The increasing demand for materials with higher strength-to-weight ratio led to the cognizance of composites. The Advanced Composites Programme, initiated by TIFAC, aims to promote various composite applications. In view of the application potential of composites, a fast-paced indigenous product development and its induction was felt necessary for key sectors. Other aspects such as usage of natural fibre in composites, development of new fibre and resin system, recyclability/reusability of composites and their effective disposal were also addressed.

Bioprocess & Bioproducts Programme

The Bioprocess & Bioproducts Programme of TIFAC has been conceptualized as the other major technology initiative at the national level. While catalyzing technology innovation, the programme focuses on the development and demonstration of select technologies for conversion of biomass to fuels, chemicals and other value added products. Optimizing utilization of bio-resources, the programme also aims to promote indigenous technology through the involvement of a wider cross-section of stakeholders in the national and international arena.

Innovation management models

With technology innovation, plant modernisation, product quality upgradation assuming importance in the present day scenario, TIFAC had experimented with various innovation management models while implementing its technology development programmes, as explained below.

Model-I: Laboratory based technology development

In the early days, when projects were launched technology development activities would be undertaken by a national R&D lab. While the projects would be financially supported by TIFAC and the participating industry, the funds were released to the R&D lab working on the project. The industry partner was required to absorb and upscale the technology for commercial use once the product was developed successfully. Though the projects were conceptualized on a tri-partite basis, the R&D laboratory played the pivotal role (Fig. 2). A few of the products targeted development of high-technology applications warranting extremely critical testing & certification regime. In fact, the criticality of testing requirement and product acceptance were not assessed properly prior to project conceptualization. The project evaluation and monitoring mechanism did not foresee any involvement of users or certification agencies. With the product development process distancing itself from the market, prototypes developed faced difficulty in being accepted by users.

The participating industry was not much inclined, especially for providing funds to the R&D lab. As the lab was the centre of all actions, the industry perceived itself as extraneous to the entire development process. Moreover, all the assets were being created within the lab premises with the financial support from TIFAC and the industry – this was not an attractive proposition for the industry. As the project involved very sophisticated level of technology development, followed by critical testing procedures, the development cycle experienced many bottlenecks and delays. In due course the industry partner lost interest in the project as it showed no promise of early commercialization.

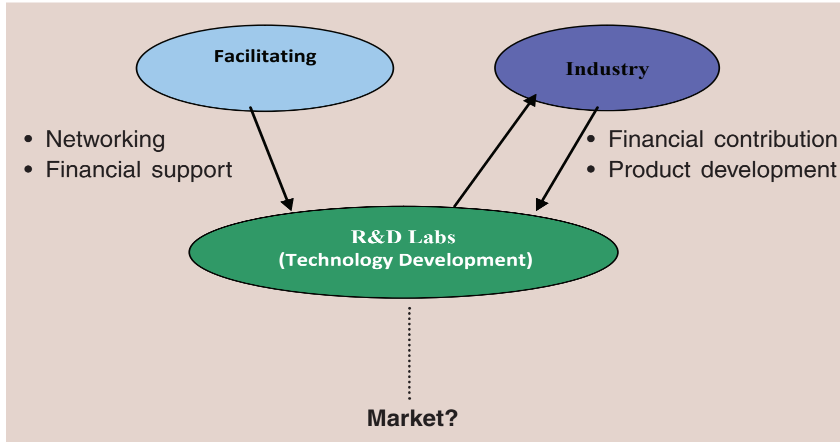

Fig. 2. Technology development in R&D laboratories

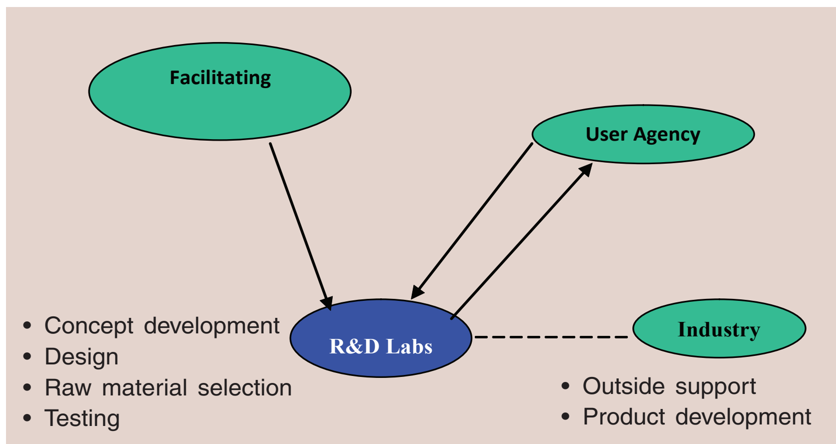

Fig. 3. Technology development in R&D laboratories with industry involvement

Model-II: Lab oriented technology development with extraneous industry involvement

Technology development at the R&D lab did not meet with much success as explained above. This prompted involvement of user agencies more proactively projects, to the extent of sharing development costs along with TIFAC (Fig. 3). In this new approach, the financial support was still extended to the national R&D labs but industry partners were not directly involved in the project.

The knowledge partner (R&D lab), identified for a particular project, had sufficient expertise in product design and development, selection of raw materials and necessary product testing. The user agency had to identify the product to be developed and show interest in participating in the TIFAC mode of project implementation. They took active part by extending financial assistance to the R&D lab to the tune of 50% of the project cost, and the balance was provided by TIFAC as technology facilitator. The user agency helped in finalizing the design approach, carrying out necessary in-house testing and field trials for prototype approval. Such involvement of the user agency was expected to play a catalytic role in early induction of the product. Successful technology development and transfer of technology licensing rights to the user agency also ensured repayment of funds to the facilitating agency, TIFAC.

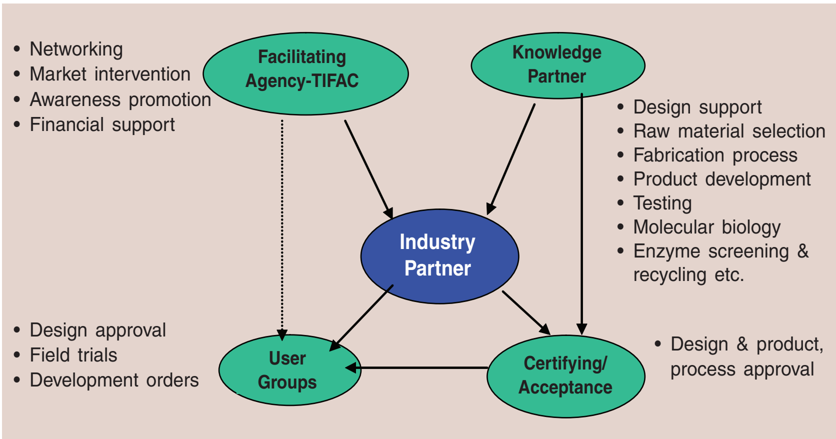

Fig. 4. Industry-centric innovation

This approach was followed in the case of development of FRP sleepers for railway girder bridges under the Advanced Composites Programme. The Research & Development Establishment (Engineers), Pune was identified as the R&D lab and Research, Design & Standards Organization (RDSO), Lucknow acted on behalf of the user agency, Indian Railways. Composite sleepers were designed to replace the existing wooden sleepers on girder bridges. The sleepers were successfully tested and finally accepted by the Indian Railways due to excellent vibration absorption, extended life cycle, considerable weight saving and improved maintainability.

However, there was no direct involvement of the industry in the entire development process. While the R&D lab designed the product and finalized its fabrication process, they could not develop the prototype for lack of advanced fabrication equipment. Hence, the technology was required to be transferred to competent composite fabricators with good technical capabilities for prototype development and its large-scale replication for commercial induction. Though industries were identified at a later stage for the prototype development, they were not fully geared to adopt and absorb the technology from the R&D lab. This led to delay in the entire product development cycle.

Model-III: Industry centric innovation

Based on 'mixed' successes, TIFAC programmes were reoriented considerably, ensuring active involvement of industry in the entire process of technology development. It was realized that successful technology development model should be industry-centric, keeping industry at the heart of all actions namely, product conceptualization and design, assets creation for prototype development and in-house testing, and finally large-scale replication for wider induction (Fig. 4). This called for extraneous knowledge support from leading centres of excellence across the country, and brought the industries closer to technology absorption, development & dissemination. The knowledge partner provided design support to industry in terms of engineering drawings, advice on raw material selection, fabrication process, testing etc. for development of the prototype. The programme involved faculty members from the renowned institutes such as IITs and scientists from national labs.

To reduce the technology development cycle, programmes started involving key persons from the user groups, certifying agencies etc. in the project. The project review team provided a right mix of expertise in design, process, machine/equipment, testing and quality assurance. Such a user-driven project approach has been the cornerstone of project management initiatives by TIFAC, greatly enhancing the market reach of products and their acceptance in the shortest possible time.

> Successful technology development model should be industry-centric, keeping industry at the heart of all actions.

The major thrust was on generating market-driven projects with potential applications in sectors such as railways, telecom, building & construction, bio-medical etc.

TIFAC has generally adopted a two-pronged approach for such technology innovation programmes. The tri-partite arrangement involved the knowledge partner (usually public funded research labs/academic institution), the industry partner implementing the project, and TIFAC as the facilitator providing soft development finances. In some cases, for SMEs with strong in-house knowledge base, a bi-partite arrangement was worked out between the industry and TIFAC.

Supported by the Technology Development Assistance from TIFAC, industries had set up advanced fabrication system in-house and testing and quality control facilities for manufacturing products meeting international standards and quality norms. This greatly contributed to capability improvement of the industry and generated confidence among users in products. In some cases, industry partners have achieved strong and profitable growth (+10% to 30% of sales increase per year generating 10% to 40% of returns on capital employed).

Select case studies

Based on the most successful technology innovation approach as discussed under Model-III, a few case studies for developing products, and processes for their development and outcomes are described below.

Composite interiors for driver's cabin in diesel locomotive (2004-05)

The driver's cabin in its existing design then was too cramped for free movement and comfort of the operators. The consoles appeared cluttered with several dials and gauges. The Indian Railways had been seriously contemplating an ergonomic improvement of the driver's cabin interiors along with an aesthetic appeal in the diesel locomotives.

In view of the long-felt above need a project was launched under the Advanced Composites Programme in partnership with M/s. Black Burn Co. Pvt. Ltd., Kolkata. The Industrial Design Centre (IDC) of IIT-Bombay extended knowledge support in terms of prototype design and development, preparation of various design drawings, assistance during fabrication of full-scale prototype etc. For a user oriented development approach, experts from Railway Board, Research Design and Standards Organization (RDSO), Diesel Locomotive Works (DLW), Diesel Locomotive Modernization Works (DLMW) and Western Railway were inducted in the project review and monitoring activities. The new design of the cabin that evolved has provided comfortable seats for drivers, clear visibility while operating the locomotive, heat and sound insulation etc. In addition, safety features such as increase in roof height inside the cabin, scientifically designed illumination of the cabin etc. were addressed. The modifications, as suggested by the users, were incorporated at various stages of project implementation.

On acceptance and approval of the full-scale mock-up, the driver's cabins of two diesel locomotives were furnished with composite interiors for extensive field trials. The diesel loco maintenance unit of the Indian Railways was satisfied with the newly furnished diesel loco driver's cabin, that had created a conducive workspace. The total product development cycle spanned two years, including design of interiors, prototype development, field trials, finalization of technical specs, and acceptance by users. Efforts are underway for inducting the composite interiors on a large-scale by Indian Railways.

Composite houseboat for tourism (2005-06)

The houseboat is a recent innovation positioned as a unique attraction for the tourism industry in Kerala, a southern Indian state. Traditionally made of resinous wood, it takes 8-10 trees (70-80 years old) to build a houseboat. Apart from denuding the forest cover, building a traditional houseboat is extremely manpower intensive requiring nearly 40 man months of skilled labour. The wooden hull is highly prone to decay due to continuous contact with water calling for regular tarring of the hull and frequent outages of the houseboat. The superstructure outer surface thatched with woven bamboo mat requires replacement every year due to an excessive fungal attack in a humid environment. Thus the cost of maintenance becomes prohibitive, passed on to the tourists to enjoy that 'ultimate in luxury'! All these made the houseboat a good candidate to be developed in composite material for corrosion resistance, ease in fabrication and maintenance-free service.

The development of composite houseboat was taken up as a project under the Advanced Composites Programme of TIFAC in partnership with M/s. Samudra Shipyard Pvt. Ltd., Cochin for improved aesthetics, boat stability, comfort level and maintainability. A multi-agency approach was adopted for seeking expertise in hull design, testing, fabrication assistance, design of superstructure, interiors, amenities etc. NGN Composites-Chennai, a consulting agency working in composites technology development, assisted in mechanical design and fabrication of hull, deck and superstructure. The Dept. of Ocean Engineering of IIT-Madras provided hydrodynamic design of boat hull, bulkheads, ballasts and conducted the necessary tests for boat stability. The Industrial Design Centre (IDC) of IIT-Bombay extended design support for developing a superstructure with improved space utilization, aesthetics and ergonomics of the living area with the detailed design of bedrooms including design of panels, partitions & other interiors. The high point of IDC's contribution was a modular design approach of the entire superstructure. The Department of Ocean Engineering & Naval Architecture-IIT, Kharagpur provided necessary technical guidance while monitoring the project right from the beginning. As the project dealt with the development of house boats for the tourism sector, senior professionals from the Department of Tourism (Govt. of Kerala), and leading tour operators of house-boats were also involved in the project monitoring.

The sandwich hull with polyurethane foam core was fabricated in composite. The decking for the houseboat has always been a problem area with a whole lot of wooden planks being used in conventional ones. This problem was addressed by using moulded composite gratings. The entire superstructure was made into five modular parts requiring only three moulds for fabricating the half modules. The superstructure was configured to accommodate two bedrooms each measuring 4.00 m x 3.50 m. The houseboat components such as the hull, deck and superstructure consumed about 19.20 tons of composites, making it one of the largest composite products in the country.

The composite houseboat has been a small step in technology development but will go a long way in saving the environment. Involvement of the multi-agency expertise and a user-oriented approach were instrumental in reducing the product development cycle, limiting the entire exercise to under one year. With its long coast line, large natural inland water bodies and long rivers, development of composite boats of various forms and functions would soon assume importance in India and attract investments.

Filament wound composite road tanker (2007-08)

Traditionally used steel tankers for transportation of liquids are prone to corrosion resulting in contamination, high maintenance cost and limited life span. Rubber lining done inside to resist corrosion does not last long and re-doing of rubber lining adds to higher cost. This had been a critical issue for transporting corrosive chemicals like acids and alkalis.

Composite or glass fibre reinforced plastic (GFRP) road tankers are most ideal for transportation of corrosive liquids due to their lightweight and corrosion resistance. While such containers are in use in advanced countries, their application did not pick up in India due to the lack of good design, technological capability and manufacturing facility in the country. On assessing the merits and market potential of such composite road tankers over the conventional ones, a project for design and development of composite road tankers using filament winding technique was launched under the Advanced Composites Programme in partnership with Modern Engineering & Plastics Pvt. Ltd., Mettur (Tamil Nadu) and technology support from NGN Composites, Chennai, led by an expert formerly from IIT-Madras. The technology consultant carried out mechanical and structural design of the composite tankers keeping in view the safety, functionality and durability requirements along with the design of the collapsible mandrels. Further, NGN Composites assisted in filament winding of the tankers and designed the tanker mounting mechanism on the vehicle chassis. The project review team comprised a well-known transportation agency owning a large fleet of steel tankers from southern India, and a reputed heavy vehicle manufacturing industry promoting bulk procurement composite road tankers.

During project implementation, the industry partner had acquired adequate technical capability and set up a modern indigenous facility for 4-axes CNC filament-winding machine for fabricating the road tankers. The prototype composite road tanker with capacity of ~15 KL was successfully fabricated and subjected to on-road trials for about 5000 Kms. to assess its road-worthiness. Composite road tankers works out to be an economically attractive proposition based on their superior life cycle and zero maintenance. The additional carrying capacity due to saving in tare weight makes it even more cost effective. The partnership project has led to the development of a new composite application in India.

Enzymatic conversion of racemic molecules for stereo-specific active pharma ingredients (API) (2008-09)

The project on optimization of process parameters for synthesis of three low-volume, high-value active pharma ingredients by biosynthetic route has been successfully completed by TIFAC under Bioprocesses & Bioproducts programme in partnership with M/s Hi-Tech Bio Sciences India Pvt. Ltd. (HTBL), Pune. While HTBL was involved in process scale-up, technology demonstration and product marketing, they also tied up with other institutions for knowledge support in terms of molecular biology work, enzyme expression studies, development of membrane reactor system for enzyme recycling, kinetics and immobilization of enzymes. The following molecules were developed for the first time in India under the project:

- 11-hydroxy Canrenone: An important intermediary for the manufacture of eplerenone. The hydroxylation at 11 position of Canrenone cannot be performed chemically and calls for biotransformation.
- Eplrenone: An aldosterone antagonist used in the management of chronic heart failure. It is similar to spironolactone and is specifically marketed for reducing cardiovascular risk in patients following myocardial infarction.
- S-Indolene-2-carboxylic acid: An important chiral intermediate in the manufacture of pharmaceuticals such as perindopril and similar long-acting Angiotensin-Converting Enzyme (ACE) inhibitors.

The technology development activities were monitored by a team of experts inducted from academia, pharmaceutical industry and a leading financial institution.

The innovations involved in the project were development of economical and sustainable sources of enzymes, isolation of fungal isolate and development of process for bioconversion of steroids, use of molecular biology tools for over expression of enzymes and their utilization. The total estimated demand for 11-hydroxy-Canrenone is in the range of 3 to 4 tpa, which is being imported at around INR 40,000 to 45,000 per kg. The present domestic demand for eplerenone is around 2 tpa costing about INR 300,000/- per kg. The total estimated demand for S - Indoline 2 Carboxylic Acid is estimated at more than 25-30 tpa with a price tag of INR 20,000/- per kg. The pilot plant has successfully been set up by the company for production of the aforesaid three molecules at 50 kg per month capacity.

Development of prostaglandins by bioconversion (2009-10)

Prostanoids are chemical/biochemical precursors and chemical derivatives of prostaglandins having application in diverse human conditions viz. labour induction, congenital heart disease, primary pulmonary hypertension, treatment of glaucoma, breeding management, prevention of NSAID-induced Ulcers, healing of gastric/duodenal ulcers etc.

The prostaglandin and its advanced intermediates are optically active compounds. Hence one needs optically pure 4R-hydrodroxycyclopent-2-ene-1-(S) acetate, the building block for prostaglandins, with high chemical purity (>98 %), which can only be obtained by biotransformation.

The National Centre for Industrial Microorganism/National Chemical Laboratory (NCL)-Pune, India had been granted a US patent for identification of the specific strain of microorganism and its efficient use in the biotransformation of racemic molecules to prostaglandins. Based on laboratory studies at NCL, excellent results were obtained using the mesodiol diacetate as the substrate leading to optically pure 4-(R)-hydroxycyclopent-2-en-1-(S)-acetate with high yields.

Hygeia Labs, a knowledge driven company has tied up with National Chemical Laboratory (NCL) for licensing the above process for technology demonstration of prostaglandin intermediates with financial assistance from TIFAC. Hygeia Labs aims to develop the process on a pilot-scale to produce at least 50 kg of bio-transformed product. The technological implications of the innovative process included (i) using a cheap whole cell culture and (ii) carrying out bio-transformation in a fermenter in high concentrations, leading to commercial feasibility.

The prostaglandins have good market potential not only in India but also at the international level. Hygeia has successfully developed the product and supplied domestically at a small level. Biotransformation trials are underway for pilot plant scale. The global demand for prostaglandins and prostaglandin intermediates are expected to increase manifolds in the coming years. Currently the market for advanced intermediates for maternal health care products alone is ~ USD 500,000. There also exists a good demand for veterinary care and other applications.

Development and optimization of enzymatic process for producing Stevioside from Stevia leaves (2009-10)

The project is aimed at development and optimization of process parameters for an efficient enzymatic pretreatment and extraction process for producing Stevioside from *Stevia rebaudiana* leaves, and Lycopene from waste tomatoes conforming to international benchmarks.

Stevioside is a zero calorie natural sweetening agent, which is 200-250 times sweeter than sugar and has excellent compatibility with tea, coffee and other hot or cold beverages like diet cola. It has excellent export potential.

M/s. Stanpack Pharma Pvt. Ltd., Baddi, Himachal Pradesh, India has developed and optimized a low-cost and efficient enzymatic pretreatment and extraction process for producing Stevioside from locally available raw materials. The process involves enzymatic pretreatment of the raw material for improved extraction efficiency resulting in increased yield and reduced number of process steps. The process development and optimization is happening with completely indigenous efforts. Currently a few companies in India are making formulated products by importing these ingredients from China. Setting up a pilot plant would lead to an in-house capacity in developing other value-added phyto-chemicals from locally available bio-resources. Indigenous production would make the products available at competitive prices. The pilot plant erection has been completed and trials show Stevioside produced meet the desired specifications.

Efficient utilization of jatropha seed cake by detoxification and recovery of residual hydrocarbon (2010-11)

Appropriate utilization of Jatropha seed cake, which is toxic in nature, left after the extraction of the oil is very important for the viability, sustainability and wider acceptability of the Jatropha-based biodiesel production. Currently jatropha seed cake is being disposed off as low-cost agricultural manure. With expansion of biodiesel production, huge amount of residual seed cake would require careful handling as it contains primary toxic factors like the phorbol esters. The proposed project aims to remove the toxic contents of jatropha seed cake, rich in nutrients, thus increasing the value of treated seed cake as good animal fodder. During the oil extraction process, heavy hydrocarbons left in the jatropha seed cake would be recovered by enzymatic bio-cracking process.

The project has been launched jointly with TIFAC, Osmania University (OU) & M/s Naturol Bioenergy Ltd., Hyderabad, India as an industrial partner. The proposed enzymatic cracking process would be operated at low temperature with reduced energy input. This is expected to make the process economical by recovery of residual oil and detoxification of seed cake. Analysis of major toxicants (phorbol & saponin) in jatropha seed cake was carried out by Osmania University. Four efficient *Pseudomonas* species were isolated for degradation of these toxicants. After successful completion of process development abd scale up of technology, the industry partner, Naturol Bioenergy Ltd. would use the technology for commercial exploitation.

Process development for production of L-arginine by fermentation (2010-11)

L-arginine, an amino acid considered the most potent nutraceutical, has numerous functions in the body. It is needed to create urea, a waste product that is necessary for toxic ammonia to be removed from the body. Arginine is considered semi-essential because even though the body normally makes enough of it, supplementation is sometimes needed. For example, people with protein malnutrition, excessive ammonia production, excessive lysine intake, burns, infections, peritoneal dialysis, rapid growth, urea synthesis disorders, or sepsis may not have enough arginine. Symptoms of arginine deficiency include poor wound healing, hair loss, skin rash, constipation, and fatty liver.

The project, launched jointly with TIFAC, Jawaharlal Nehru Technological University (JNTU), Hyderabad & M/s Celestial Labs ltd., Hyderabad, India as an industrial partner, aims at production of L-arginine from select microorganisms. The strain would be improved by conventional mutagenesis and recombinant approaches. After production, L-arginine would be purified and crystallized for packaging. After completion of process development studies and scale up of L-arginine at 10 litre capacity, Celestial Labs Ltd. would further scale up the process to 100 litre capacity.

The conventional process for L-arginine production suffers from drawbacks in terms of less yield and longer production time. The fermentative L-arginine production is relatively faster process with improved yields.

Conclusion

Various programmes of TIFAC have been truly successful experiments in innovation management in the Indian context. The early innovation management approaches as described in this article had their efficacies and significance in specific cases. Building on the experiences of initial models, the industry-centric innovation model has emerged most successful in catering to short-term deliverables. The projects conceptualized were concluded successfully with products reaching users. The key attributes of the industry-centric model such as financial assistance, technological risk sharing and knowledge-based project monitoring by experts have proved useful. With market intervention helping reach out to users, the projects have seen success in a short time-span.

> Building on the experiences of initial models, the industry-centric innovation model has emerged most successful in catering to short-term deliverables.

This model has suffered from a few limitations too, especially under the Advanced Composites Programme, in which some of the products developed, directly substituted the conventional materials. In such cases, the projects and partnering industries gradually gravitated towards those products and technologies whose commercial successes were well predicted. This was dictated more by the repayment plan of the industries for the financial assistance extended by TIFAC.

A major fall out of the industry-centric model has been generation of fewer projects catering to novel applications with high technology content and risks involved. To reorient the innovation programmes with higher technology content, the model may warrant a few modifications. Under the changed scenario, the initial technology development could be carried out in national research labs/academic institutes with financial support from the government on grant-in-aid basis. An industry partner may be inducted into the project for outsourcing certain activities like process scale-up, prototype fabrication under guidance from the project beneficiary (research lab/academic institute) primarily aimed at developing a technology transfer package. Once the technology is developed successfully with attractive economic returns, the next phase could be implemented in partnership with an industry. Phase-II of the project could be supported on 50% cost basis with repayable funding at cheaper rate for capital assets for manufacturing, product testing and other issues of commercialization. It may be noted that not all the innovation development projects supported at national labs/academic institutes may be economically viable. Some projects may just result in knowledge creation. Such models could prove to be useful for minimizing risk exposure especially of partnering industries.

However, the cornerstone of the industry-centric model, developing an effective networking among the academia/research institutions, standards and certifying agencies, as well as experts from the actual users would continue to play a vital role.

Further, modern day technologies are assuming greater complexity, and are faced with stronger market competition. Hence, there is constant pressure to innovate and improve, calling for concerted efforts from the government and SMEs to face such challenges. Technological innovation, in-house R&D and joint efforts through various linkages for technology development by SMEs need to be encouraged. Also, the quantum of financial support needs to be increased by the government/financial institutions in order to handle the growing investment demand for adopting world-class technology innovation/modernization in SMEs. ❑

Note: The views expressed by the author are their own and they do not necessarily reflect those of the organization they belong.