

Engineering Associated with Research and Development

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Abstract : It is found, at the beginning of the civilisation, technology was developed without science. In later stages technology followed science. At present both run parallelly. Though engineering plays a role in basic research, it is more dominant in applied research. Research normally becomes more fruitful when its results are translated to the benefit of the society through technology development and transfer. The R&D starts with conception of an innovative idea and followed by evaluation, accomplishment, development and culminate in release.

The R&D scientist see their ideas to reality through three distinct parties - management, customer and engineering. The engineering aspects of R&D can be generalised through four phases viz., planing and specification, design, process/prototype and release. Earlier it was thought it is better not to control R&D. When competitiveness increased, control became necessary. Attempt is made to enumerate the role of engineering in R & D in nutshell in this paper. It is also demonstrated that effective innovation management synergising, the efforts of engineering and R&D teams can enhance the quality of collaborative R&D and promotes cutting edge over competition from multinationals. This would also ensure greater confidence and faith in the domestic industry towards indigenous stand-alone R&D institutions.

Keywords : *Engineering, Science & Technology, Innovation, Phases of R&D, Strategic planning, Engineering associated with R&D.*

INTRODUCTION

As we enter the new millennium, knowledge based industries sustained by collaborative R&D has become one of the key players

of industrial development. The first generation R&D departments limited to bench scale innovations, are increasingly becoming unmarketable. This is because, while R&D institutions came up with new inventions, large organisations having engineering skills transferred these inventions into products, processes and delivered to receptive customers. In this process, the product used to take several years to come into the commercial production. The invention taken up by the industry for commercialisation needed several refinements and its techno-commercial viability is to be proved. This normally takes several years to mature at the hands of industry. As the competitiveness increased, industries have resorted to captive R&D to meet their own R&D requirements. This had led to the shortening of the product maturity time. The best example for this would be the pharmaceutical industry. However, engineering sectors need massive investments and this was possible only in case of multinationals from developed countries. Hence majority of the Indian industries have to have some working relationship with dedicated R&D institutions.

In a developing economy like ours, state support is highly essential for the Indian industry for R&D requirements. As rightly visualised, Government of India established various R&D institutions to support Indian Industry. For several years the domestic industry was protected and R&D institutions used to cater to the requirements. As R&D requirements grew with time in terms of technological advancements, quality and timeliness of deliverables for global competitiveness, the domestic institutions struggled to cope up with demands of the industry. With the opening up of the economy, modern technologies from the industrialised nations became easily available. While the industries tried to grab the opportunity in spite of huge investments to be competitive globally, the domestic R&D institutions grappled with realities of changing trends. As the state support became increasingly need based, barring the mission areas outlined by the Government, the R&D institutions started wooing industrial customers for business. This was not so easy as the industry and R&D institutions speak different languages.

In the current scenario, R&D institutions cannot stand on the innovation alone to convince the industry the commercial

viability of the developed process/product. The present day industry demands fully matured commercially proven process/products for technology transfer. Especially with the liberalised era, the industries are looking towards foreign technologies for their immediate requirements rather than depending on indigenous R&D institution for the support in spite of huge capital outlay to cut down time. So, the onus lies with Indian R&D institutions to develop proven and commercially viable technologies to gain confidence of the Indian industries. This needs greater synergistic efforts between R&D and engineering teams to go hand in hand and develop, in shortest possible time, process/products that are techno-commercially viable. This paper deals with the various aspects of role of engineering associated with R&D in the contemporary scenario.

Science and technology relation

The relation between Science and Technology is very complex. If we look back to the history, the needs of the society created technologies. As long as the technologies remained workable, there were hardly any serious efforts to understand the science behind the technology. Sometimes, the pressure for technology development also pushed the science behind to meet the requirements of the society at that particular instant. For example, there was a great demand for the supply of war ships during the World War II. This led to the development of production of ships using welding technology. But the catastrophic failures in the welded construction forced the technologists to look for the science behind the failures. The understanding thus received from the science has fuelled further technological developments in the field of construction materials and welding process & consumables. This is a very clear case of technology succeeding the science. Today, the science and technology has to go hand in hand to produce fail safe technologies/products for commercial exploitation.

As the demands for commercially proven products have increased, the science and technology needed greater efforts from R&D and engineering during various stages of development. This collaboration has to start right from the basic research stage through applied research and apply appropriate design & engineering skills for scale up and prove the process or prototype product for its techno-commercial suitability.

Phases of R&D

Traditionally, a typical R&D effort used to start with the conception of an idea/ innovation. This idea undergoes several workings and evaluations to arrive at an appropriate product or process. From these various evaluations, a suitable accomplishment is selected. Further, the accomplishment undergoes various developmental processes such as scale up/ prototype development etc., with the support of engineering. Then, the sustained development is released for commercial acceptance. The commercial acceptance further required continuous support from the engineering groups until the development is successfully transferred to the industry.

Table 1: Development time spent in reaching commercial production for some typical Inventions

Technology	Invention	Production	Development Time
Fluorescent Lighting	1852	1934	82 Years
Radar	1887	1933	46 Years
Ballpoint Pen	1888	1938	50 Years
Zipper	1891	1923	32 Years
Collophane	1900	1926	26 Years
Rockets	1903	1935	32 Years
Helicopter	1904	1936	32 Years
Television	1907	1936	29 Years
Kodachrome	1910	1935	25 Years
Transistor	1940	1950	10 Years
Thin Film Head	1971	1979	8 Years
MR Head	1971	1990	19 Years
GMR Head	1988	1997	9 Years

In the liberalised economy, traditional approach to manage innovations would not be sufficient as the time required for the technology to mature is very large. Table 1 gives development time spent in reaching commercial production for some typical innovations. To minimise the lead-time for developing commercially viable products, a greater management of innovations is needed. A typical flow of development in managing innovations is shown in Fig. 1. The R&D management prepares R&D policy that suits the current market demands, by involving customer, R&D team and engineering support groups. Having understood

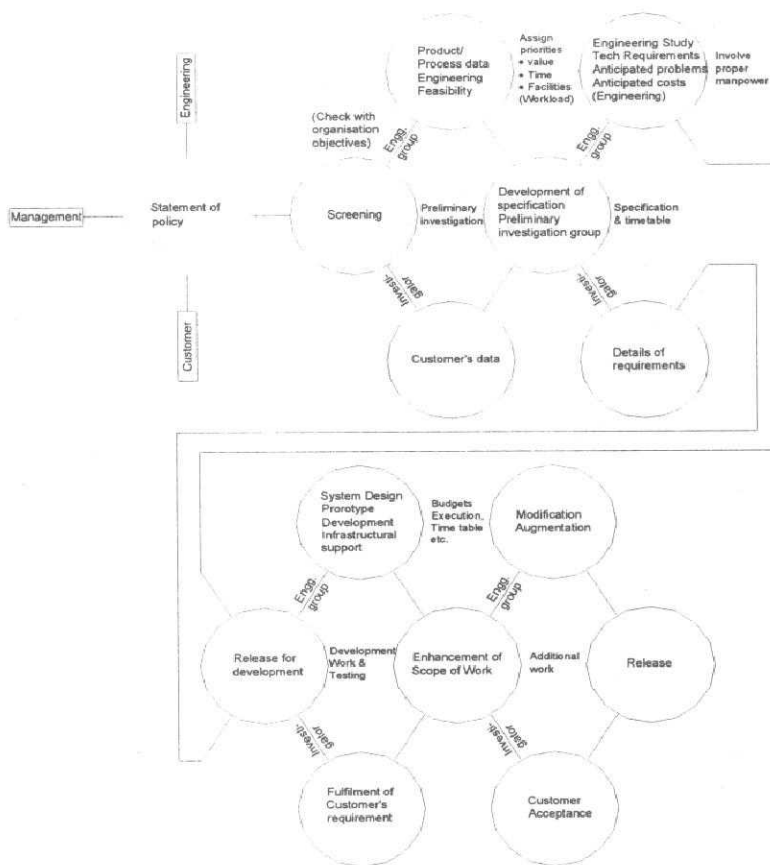


Fig. 1: Flow of development of innovation to commercial success

the customer's requirement, R&D teams comes up with innovative ideas which are put to preliminary investigations with the help of engineering groups. This would lead to the development of primary specification of requirement for the customer. Such specifications are discussed with the customer in detail and then released for the development with specific time targets. While R&D teams would thrive for fulfilling the customer's requirements in terms of product specifications or process flow sheet & parameters, engineering teams would work on system design, prototype development and infrastructure support. At every stage of innovation & development, customers' requirements are reviewed. The investigation team would work for the

commercial acceptance of the innovation. Engineering group would work on modification, augmentation and relevant documentation. Fig.2 shows the basic Development Cycle of the innovation process. The various stages involved in the development of innovation are overlapping. With the greater in-

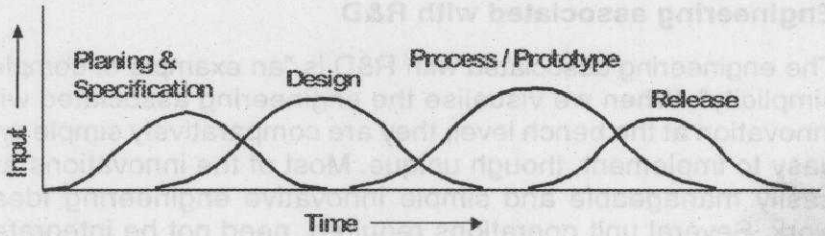


Fig. 2: Development cycle of innovation process

volvement of engineering group and customer, right from the beginning of the development cycle, reduces the lead-time. In case of stand-alone R&D institutions, the model shown in Fig.1 is of great significance to sustain in the present liberalised era to cope up with the changes in Government's policy, the demands of the customer and competition from multinationals.

Requirements of R&D

There is an immense need for strategic planning involving organisation's current mission and environment and then setting forth a guide for tomorrow's decisions and results. A typical strategic planning "forced choice model" seems to be more appropriate for stand-alone R&D institutions. In a forced choice model, environmental assessment vis-à-vis organisation's capabilities is carried out by the R&D management to evolve strategic options. The ongoing R&D efforts are analysed in terms of tangible cost versus potential benefits. Long range business plans are set forth in niche areas for futuristic development. Further to sustain the organisation, in available free time, contractual research is also carried out.

To match the strategic planning envisaged, there is a need for greater co-operation between investigation and engineering teams. Unless the efforts are synergised in a co-ordinated manner, it will be extremely difficult for the successful innovation development. There has to be great confidence and respect to

the skills of each other and appropriate communication channels are needed between R&D and engineering teams. Apart from this, the resources such as knowledge, manpower, finance, energy, time, materials and facilities needs to be carefully managed.

Engineering associated with R&D

The engineering associated with R&D is "an example of complex simplicity". When we visualise the engineering associated with innovation at the bench level, they are comparatively simple and easy to implement, though unique. Most of the innovations are easily manageable and simple innovative engineering ideas work. Several unit operations required, need not be integrated to prove the novelty of the innovation. When the innovation has to mature from the bench scale to pilot scale, the operations, which were hitherto thought disjointed needs discipline and proper integration through logical sequencing. At this stage the amount of raw materials to be handled would also increase many fold. Increment of material handling associated with larger equipment sizes needs greater engineering acumen to logically sequence various operations involved, in arriving at the new product of innovation/ novel process. Additionally, the behaviour of the material in bulk in larger equipment may be different from that of smaller quantities involved at the bench scale. This needs further refinement to the innovation to meet the product quality requirements. Hence, in order to maintain the same quality of the product/process as that of bench scale, there is need for greater involvement requiring skills from various engineering disciplines and continuous interaction with R&D teams. They need to synergise their efforts. to meet the product quality requirement as obtained in bench scales. The degree of complexity regarding engineering requirements increases as innovation moves from conception of idea to commercial exploitation.

Involvement of engineering in the management of innovation

Involvement of engineering during innovation process is varied and multi disciplinary. Unlike industry, the scope of engineering associated with R&D involve assimilation of latest knowledge and appropriate engineering practices to be able to apply for the development of innovation. Progressively the customer and

R&D teams are taken into confidence in the design, specification and estimation. Subsequently appropriate procurements are made. Installation and commissioning of machinery is carried out, required operational practices are defined and documented and maintenance practices are standardised. The engineering team also takes up the responsibilities of educating and training the customer to manage the new product/process out of innovation process. Table 2 shows the details of various levels of involvement of engineering in the process of innovation management for commercial product development.

Table 2: Involvement of engineering in the process of innovation management

Organisational design	
• Engineer of respective discipline (from conception to delivery)	• Co-ordination
Design practices	
Latest available	
• Operation	• Maintenance
• Fulfilment of requirements	• Audit
Specification practices	
• Performance	• Maintenance (only user to define?)
Estimation practices	
• Rough estimate	• Final estimate
Procurement, progress, Installation & commissioning practice	
• Quality	• Preparation of check list
• Changes	• Test schedule
• Delivery schedule	• Static
• Familiarisation	• Running
• Critical study drawings	• Technological consideration
• Interaction with supplier/ contractor/ designer/ user	
Performance monitoring and Operational practices	
• Output	• Labour
• Yield	• Fuel
• Rejection	• Labour
Maintenance practice	
• Involvement from design stage	• In built health monitoring system (on line condition monitoring)
• Comprehensive documentation	• Interaction design/ user/ contractor
Personnel, education & training practices	
• Education	• Posting
• Training (multi skill)	• Team work concept

Table 3: Typical nature of engineering groups in stand-alone R&D institutions

What are different in engineering • Nonrepetitive assignments • Normally not involved from the beginning • Objectives/requirements are not well defined • Routine/ minor maintenance not carried out by user • Arranging 3 Ms take more time • More conflict • Jobbing workshop • Routine • Prototype What are normally done..? • Conceptual design • Specification • Installation & commissioning • Maintenance • Co-ordination	And in R&D lab. • Planning not carried for execution • Discussions not with open mind • More data insufficiency • Assigning priority • Lack of info regarding capability • Less time provided for execution • Interface between scientists & others • Detailing • Checking • Attending to trouble shooting • Documentation
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In a stand-alone R&D institution the involvement of engineering plays a significant role for the commercialisation of the innovation. Table 3 shows typical nature of engineering groups in stand-alone R&D institutions. For a successful innovation process the R&D team should ensure that the objective requirements and responsibilities are clearly understood by the engineering teams. The management should ensure greater co-operation among R&D team, engineering and administration teams. The engineering team should ensure cohesiveness of various engineering disciplines. On the other hand the engineering group should also ensure the quality of deliverables and meeting the delivery targets with the help of proper interface between different teams. Should the conflict arise the management should ensure appropriate credit sharing using different criteria suiting various backgrounds of teams involved. Such process ensures synergistic effect between investigation, engineering and administration teams for successful innovation process.

CONCLUDING REMARKS

Attempt is made to enumerate the role of engineering in R & D in

nutshell in this paper. It is also demonstrated that effective innovation management synergising, the efforts of engineering and R&D teams can enhance the quality of collaborative R&D and promotes cutting edge over competition from multinationals. This would also ensure greater confidence and faith in the domestic industry towards indigenous stand-alone R&D institutions.

Abstract : The paper discusses the role of small scale industries (SSI) in the growth of national economy. The small scale industries contribute substantially to the employment generation, industrial production and exports. The difficulty faced in adopting new technologies by SSI has been explained. The author points out that in many cases the know how developed in the laboratories do not have cost analysis, details of equipment required for setting up the plant based on the basis of know how. The author suggests that the small scale industries can support R&D only when the technology is fully established before that the expenses incurred in the development of technology for SSI should be reimbursed by the ministry of small scale industries. However, the facilities for trials be extended by small scale industries. The collaboration between SSI and R&D institutions will go a long way in improving the economy of the country.

Keywords : Technology transfer, Small scale industry, R&D Management

INTRODUCTION

Continuous improvement in the technology of manufacturing is a must for the growth and survival of small industries. It is more so in the post WTO implementation period - A global free market economy which is turbulent and full of uncertainties. However, the effort for technology transfer to SSI is weak both from the transferors and transferees side.

Technology transfer to SSI has a special importance. Although