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Role of Innovation and Technology Upgradation in Nation's Economic Development

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The economic, environmental and strategic spectrum of the world today is admittedly governed by the developments in Science and Technology. The emerging national economy environment is largely dependent on the global business climate and as such demands a new, innovative and challenging role of engineers so that the planet earth can have energy efficient, environment friendly and total quality products and machines providing a sound assurance for the survival of humankind in modern technology age.

Atomic energy, computers, production-line systems of manufacturing, aircrafts, telephones, plastics, guided rockets and television are the eight spectacular innovations of the modern age which have greatly influenced the relationships of nations and quality of life of the people. There should not be any doubt that these innovations in S&T along with some more will surely transform the community of nations into a global village without physical boundaries. The unity of the world of nations and amity of the people will be an eventual outcome of this transformations. However, the management of the large system with large number of variables and constraints in this global economic village of the future will require the genius and skills of scientists, technologist and management professionals far beyond our imaginations today. The engineers, the main architect of this change, are to play a role beyond design and manufacturing. They are to integrate the society and economy in their plan of action, so that the benefits of S&T developments could improve the quality of life of people.

Jawahar Lal Nehru's declarations at the Indian Science Congress in 1938, "It is Science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstitions, dreading customs and traditions, of vast resources running to waste, of a rich country inhabited by starving people..." is still relevant and we could add that it is science and technology innovations that can solve the global problems of green house effect and ozone depletion, of devastating effect of vehicular pollution, industrial effluent and hazardous waste. The future belongs to those who make friends of science and technology and adopt technology innovations to support the development of an environmental friendly society.

Engineers & Evolution. The role of engineers in technology development is inextricably linked with the needs of a society. From a primitive agricultural society, we are now in an era of highly sophisticated and automated world where even the household has become a micro-system involving the use of micro-processor controlled devices offering comfort and convenience beyond the normal expectations. The man has thus become fully dependent on science and technology innovations. This shift from dependence of nature to a dependence of S&T development has alienated the man from the surrounding to which he truly belongs causing a serious concern for the protection of environment.

Pre-Industrial Society. The process of evolution which mankind has witnessed over the years seems to be very simple but the evolution has involved a large variety of experiments. Man has lived in close contact with natural and technological changes. The physical world around him too is in constant change. In the pre-industrial society, people used to live in small groups.

The life was simple and the basic human needs and aspirations were confined to food, shelter and entertainment The men and women were dependent on nature which was the protector as well as the destroyer. The challenge which the humanity faced at that time was to understand the play of nature, its forces of devastation and its forces of creation and preservance. The man of talent and skills, engineers of this age were guided by their inventive genius and inspiring intuitions which helped them to develop tools and devices to enhance man's productive capabilities.

The Industrial Society. The emergence of industries in the eighteenth century brought about a marked change in the economic structure, the benefits of which were originally encashed by the western countries. A large number of small, medium and large industries came into existence, and large colonial empires were established primarily on the strength of economic and industrial superiority of a few nations. This superiority was primarily established through a large-scale applications of science and technology which has resulted in the mechanisation of production systems. The essential features of the engineering activity during this period was a systematic application of available scientific knowledge to have

an organised, efficient and large-scale production of goods employing an organised economic business system.

The growth of manufacturing industry also resulted in a boom for the service industries. During the early years of industrial revolution, the reliance on experience and intuition which characterised the engineering activity has continued to date. Many a great technological advances were made by the engineers and the technologists who worked without the benefit of an organised technical education system. Much of engineering and technology development was either an individual or a localised industrial effort almost till the middle of last century.

The Modern Society. The post-industrial revolution is marked by enormous changes in the level and quality of scientific and technological achievements. USA, USSR and European countries established several centres of organised engineering and technology education and sustained research and development efforts in the universities. Specialised institutions were created to innovate and carry out spectacular advances in atomic fission and fusion, genetic engineering, and on-line production systems.

The engineering profession adapted the research techniques and methods of science to achieve excellence in agricultural and industrial production, communication systems, and transportation. Though political exuberance of certain nations has used science of atomic fission for the appalling annihilation of people in Hiroshima and Nagasaki, the engineers and technologists of today have extended the atomic fission for electricity production, medical sciences and several other areas of human relevance which if pursued with care and caution shall bring an era of unprecedented plenty and prosperity.

The size, complexity and sophistication of technology has given rise to multinational organisations, large state supported projects and undertakings. In the past four decades, science and technology has achieved very significantly in: aviation, space, computers, communication, biotechnology, robotics, production-line systems of manufacture, automobiles guided missiles, image processing etc.

While, each achievement of science and technology is a fascinating mixture of accident, climate change, genius, craftsmanship, careful observation, ambition, greed, war, religion, belief, deceit, and a hundreds other factors, the ultimate goal has always been directed to remove the boundaries of nations, castes, creed and sex, and march towards unification of the world.

The leadership in technology which was confined to a few countries in America and Europe, has now spread to several countries, specially Japan, Korea. Malaysia and Singapore, who have assumed leadership in many emerging areas through successful integration of science and technology with industrial development. Governments across the world are playing an increasingly important role in development, international trade and commerce. The nexus between technology and economic leadership has prompted governments to take initiatives in promoting science and technology through university-industry interactions.

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Global Economic Scenario. In a global economic environment, the nation capital growth should be highly dynamic. While the world economy grew by 0.4% only in 1992, the economies of South and East Asia exhibited an overall growth rate of 5.5% and considered to be the most dynamic. GDP is considered to be a measure of the economic development of a country and on this scale, India's performance is quite dismal. Several economist feel that GDP is not a true measure of the economic development of a country as the economy is dependent on a large number of parameters viz., population growth, privatisation of industry and trade, foreign trade and export, social issues, industrial relations and taxation and duties.

Though India had opted for stagnant and largely subsistence agricultural economy for quite a long time, a new beginning has been made since 1991 onwards. India has made a significant progress in the industrial and agriculture production and today we are self-sufficient in food with an extensive infrastructure base. The country has one of the largest pool of scientific, engineering and managerial manpower in the world.

This transformation has taken place within the democratic framework and on the basis of resources primarily raised internally. Liberalisation of Indian economy in 1991 is directed to make it more dynamic, vibrant and progressive. Delicensing of most of the industrial activities, the liberalisation process of regulations related with the foreign investment and technological collaborations and reform of public sector enterprises to improve efficiency and productivity are some of the steps which will reduce the drain on national budget. However, the foreign investors are need to be encouraged and assured for the reliability of infrastructure and quality of the products.

Technology and Economic Development. Science and technology have been recognised as being enormously powerful forces of economic and social changes. The Scientific Policy Resolution of the Government of India of 4th March, 1958 stated that: "The key to national prosperity, apart from the spirit of people lie in technology. The technology can grow out of the study of science and its applications. Scientific techniques can, in fact, make up for a deficiency of capital..."

However, the economic development of a country is dependent on four major technology based components, namely production, energy, communication and transportation system. Innovations in

technology are needed to achieve success in all these four components. Whatever technological developments have been achieved in pre or post-industrial era, were essentially directed to have maximum production, better communication and faster mode of transportation systems.

The modern age has more concern on energy efficient and environmental friendly technologies. Through plan development, India were able to achieve significant success in per capita availability of several important articles of consumption, There exist a large gap in GDP, life expectancy and adult literacy.

In last four decades, India has developed a good capacity to manufacture both kind of capital goods special purpose equipment for the process plants and general purpose machines amenable to mass production. However, we are not able to develop desired capabilities to design and further improve upon the product for many kinds of capital goods.

This is primarily due to two reasons; the first that the contracts to import technology did not include the transfer of all elements of design and production knowhow, secondly a proper environment was not available to our dedicated and hardworking engineers due to bureaucratic hindrances, closed economy, and protected market environment, while engineers of developed countries have directed their energy, skills and innovative attitude to achieve high industrial production in almost all the areas, the role of engineers in India was mainly confined to marketing, administration and services.

While Indian industries preferred to give responsibilities of production to less skilled persons produced by ITIs and polytechnic, they also not cared for quality of the products in the protected market environment. The main objective in India was essentially to produce less at a low cost so that they can sell it easily in the market.

This has not only increased the technology gap between India and the developed countries but it has severely effected the concept of quality in our industries which is evident from the fact that though we produce a large number of goods, we do not have a single brand name to boast of in the international market.

Our education system also did not equip our engineers to start their own enterprises as the objective of education was primarily restricted to knowing and learning. The mad rush of engineers towards IAS and allied services in India is an indicator that the best brains are attracted to administrative assignments despite possessing high degree of analytical and practical knowledge.

This is primatial due to the lack of appropriate environment in our country which instead of encouraging the engineers towards innovation and creativity, forces them to quit from the mainline pursuits of an engineer profession. Further it is rather surprising that the industries do not rely on innovative skills of their engineers. The industries in India prefer foreign collaborations instead of having their own appropriate technology development programmes. While foreign collaborations are welcome, the total reliance on foreign partners for R&D and product development activities not a healthy practice specially in the emerging global environment which is highly competitive and quality conscious.

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Utilisation of innovative and creative skills of our engineers shall help adopt, innovative and develop relevant technologies and products suitable for market at home and outside. There is no doubt that there exists tremendous possibility of improving productivity in our industrial, energy, agriculture and domestic sectors.

The engineers of tomorrow have to play a vital role in the development of a reliable and efficient communication system efforts of Dr. Sam Pitroda through his innovative ventures in C. DOT. are commendable as these have been revitalized the telecommunication industry in this country. It is probably the only area where we are able to adopt, absorb and innovate the imported technology to meet our needs.

The experience of Japan in respect of adaptation and improvement of product design and manufacturing is something which the developing nations with high intellectual power can immolate. The innovative skills of engineers can best be utilised in this way as a start.

However, strategies for a fulfilment of the talent through R&D and mission oriented technology programmes must be pursued side by side in the educational as well as in the research laboratories. A much greater interaction between the institution, industries and research laboratories is required to meet this objective.

The other area of relevance in which the creative and innovative skills of our engineer can play a vital role is the transportation sector. With the increase in population in countries like our's, the transportation system faces enormous challenges. Further, the teenagers of today understand that the wheels are not merely transportation but they are the major source to enthuse the feeling of freedom, mobility and power.

Automobiles have not only expanded the range of social relationship but also helped in reducing communal character of the neighbourhood by providing greater mobility to people.

Further this sector has also greatly affected our standard of living, accomplishment of production of agriculture and industries, international trade and business, interdependence of countries and our conquest to space, besides providing a greater harmony between the nation and the people of the world. Far from reducing our dependence on automobiles, the need of the hour is to

develop reliable, energy efficient, fast and pollution free transportation system.

Though efforts are already on to have improved transportation technology, there are many areas of concern which have attracted very little attention of the engineers. S&T personnel engaged in transportation sector must look at the incongruities between economic realities of this industry.

In addition innovation also require a true perception of realities and assumptions about the problems. It is still more important to understand the need of actual consumer values and expectations, and also the inconsistencies within the rhythm or logic of a process. Successful innovations are simple, targeted and focused on specific objectives, for example, improved design of automobile engines and use of electrical power for transportation purposes are the immediate needs.

Alternate fuels such as hydrogen, compressed petroleum gas and metal hydrides needs special attention along with large storing capacity. Improved design of traction batteries and small sized fuel cells are to be made viable alternatives for future automobiles.

Economic development has a direct bearing on the efficient transportation system. Intercontinental transportation of goods at a cheap rate will not only give an economic edge, it will also help achieve economic and cultural integration of the peoples of the world. The world of international business has an interlinked relationship with the transportation sector.

Innovations & Engineers. Innovation is the specific tool by which a scientist, a technologist, an entrepreneur and a successful human being can exploit the change as an opportunity or can create changes, advancement and upgradation of man, material and processes for economic developments. Successful innovations in S&T today need a purposeful and organised search for energy efficient and environmental friendly technologies for production, transportation and communication.

This will essentially require monitoring of seven sources of innovative opportunity which includes— (i) the unexpected success, the unexpected failure, the unexpected outside events; (ii) the incongruity between reality as it actually is and the reality as it is assumed; (iii) the process need the necessity is the mother of invention; (iv) the changes in S&T, industry and market that catch everyone unaware; (v) demographics; (v) the change in mood, perceptions and meaning and (vi) new knowledge both S&T and non-S&T.

It is generally assumed that innovations are stimulated by war, accidents, unforeseen circumstances, physical and climatic conditions, but the engineers have a natural tendency to innovate machines, mechanism and processes as they develop intimacy with these physical entities.

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The inborn love to create aspires engineers to innovate, to make their creation more perfect. Though much of the engineering development in the past were based on successive improvements in product design, the engineers of today are well equipped with the S&T database and the fast computing machines such as computers which can offer an extra-ordinary helping hand to achieve quantum jumps in the product quality and product utility. The simulating techniques help to try out innovations without going for a prototype.

The engineers of today should keep two things in mind before taking up any innovative work. The first is that no inventor works alone. The myth of lonely genius filled with vision and driven to exhaustion by his dreams, may be deliberately fostered by some, but even those who cannot invent without the help of their colleagues can take inventive strides today given the team work environment prevailing in R&D centres. Collaborative efforts have become important in the present era of global interaction as the pace of development is so high that even the experts have fears in their mind that what they develop could become outdated before it reaches to the market.

The second aspect is to take full advantage of the treasurer of information which is now available with ease and speed. It is very essential to have communication links either through printed ideas or by satellite assisted telecommunication system to keep the technical persons abreast with the latest developments in their fields of activity.

In the present era of S&T revolution, as the wealth of innovative ideas increases, a high degree of specialised knowledge becomes necessary to utilise this wealth for the betterment of the humankind. The problems created by industrial society can be solved only through recourse to innovations leading to development of energy efficient, pollution free and cost effective technologies.

The economic development of the country is dependent on the advancement in the sphere of science and technology. However, since S&T based development is also associated with several problems, it is imperative that the S&T personnel specifically the engineers play a vital role in producing wealth for the nation without sacrificing the human interests, the world today is passing through a phase where the survival of mankind has been threatened due to ill-effects of growth and development based planning. Global warming and ozone layer depletion are the global threats and the concrete efforts are required to save the planet. Scientists and engineers can sensibly help to save the planet, if S&T are to be pursued vigorously by all of us who are involved in making S&T a valid means of techno-economic change. ■