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ENGINEERING AND ENTREPRENEURIAL THRUST

Dr. S. M. Naqi

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(Dr. S. M. Naqi)[1]

SYNOPSIS

The Industrial Revolution was triggered off by Entrepreneur Engineers, when they invented and built 5 basic machines in England to speed up production of textile products, to satisfy the expanding markets, created by colonization. This occurred in the later part of the 18th century. The Revolution travelled to Europe and then the rest of the world. It spread with such rapidity that making things by machines had become a rule by 1825 A.D.

Industrial revolution came to Japan in 1867 after the Meiji Restoration, when Mutsuhito, the Emperor King, who got the title of Meiji (the enlightened rule) declared 4 reforms, one of which was – Industrialize Japan with speed.

Industrial Revolution in Pakistan came only after Independence in 1947, when Engineers like C.M. Latif created the Entrepreneurial Thrust.

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PREAMBLE

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INTRODUCTION

During my association with engineering profession for over 60 years, to my reckoning, it is hardly ever been that from any technical or professional forum of engineers, the subject of engineering itself has ever been discussed. To be able to grasp the real meaning and value of the profession, I have chosen this subject for presentation at the current annual convention of the Engineering Congress.

The meaning of engineering is, the art or profession extended to apply certain techniques or processes to create structures, products or devices for the use of fellow beings. The origin of this word is in Latin language and will be elaborated later. Even though it is commonly understood that engineering is something to do with engines and engines, on their side, are visualized as the devices, which provide power to drive a certain system or sub system. In countries like United States, even a locomotive driver, in common parlance, is called engineer.

Engineering in fact is a profession, which did not start with motive power but instead it started from the building engineers who built roads, structures, homes, etc. The first profession of engineering was thus, what is now called Civil Engineering. Mechanical Engineering was developed much later. The then motive or mechanical power was developed, still later. The steam engine was developed and applied first time to a textile, mill as recently in history, as in 1785, and thereafter improved and applied to Railways in 1802, till it was partly replaced by diesel engines in early 20th century.. These machines were developed by entrepreneurial engineers. It is not that the word engineering was derived from engine but on the contrary the name of the motive power as engine was drawn from engineering itself. So, this fallacy has to be cleared for those who are associated with this profession.

There are several fields of engineering now and these are growing in numbers, as technological advancement continues to march on.

In order to be able to elaborate on this, I would like to give some more details regarding the historical perspective of this discipline and also, before that, proceed to see the variety of human activity that the entrepreneurial spirit amongst the engineers accomplished for improving the life of the human beings on this earth.

Relying on the information from secondary sources, I would proceed to present as follows.

ENGINEERING

Engineering is the profession that puts scientific knowledge to practical use. The word engineering as mentioned earlier, comes from the Latin word ingeniare, which means to design or to create. Engineers use principles of science to design structures, machines, and products of all kinds. They look for better ways to use existing resources and often develop new materials. Engineers with their entrepreneurial spirit have had a direct role in the creation of most of modern technology – the tools, materials, techniques, and power sources that make our lives easier.

The field of engineering includes a wide variety of activities. For example, engineering projects range from the construction of huge dams to the design of tiny electronic circuits. Engineers may help produce guided missiles, industrial robots, or artificial limbs for the physically handicapped. They develop complex scientific equipment to explore far reaches of outer space and the depths of the oceans. Engineers also plan our electric power and water supply systems, and do research to improve automobiles, television sets, and other consumer products. They may work to reduce environmental pollution, increase the world's food supply, and make transportation faster and safer.

In ancient times, there was no formal engineering education. The earliest engineers in the pursuit of entrepreneurial ventures developed tools by trial and error. Today, special college training prepares engineers through structured techniques to work in a certain branch or field of engineering and create standards of quality and performance.

The branches of Engineering

Most of the specialized fields of engineering have been developed since about 1750. Before that time, engineering dealt mostly with the construction of buildings, roads, bridges, canals, or weapons. As people gained more knowledge of science and technology during the 1700's and 1800's, engineers began to specialize in certain kinds of work.

Today, new fields of engineering are continually emerging as a result of scientific and technological breakthroughs. At the same time, the boundaries amongst the various fields are becoming less and less clear-cut. Numerous areas of engineering overlap, and engineers from different specialties often work closely together on projects. The following section discusses the major branches of engineering, as well as some of the smaller specialized fields.

Aerospace Engineering involves the design, production, and maintenance of commercial and military aircrafts. Engineers in the aerospace field also play an essential role in the development and assembly of guided missiles and all types of spacecrafts. Aerospace engineers help build wind tunnels and other testing equipment with which they carry out experiments on proposed crafts to determine their performance, stability, and control under flight conditions. Aerospace research ranges from efforts to design quieter and more fuel-efficient commercial aircrafts to the search for new materials that can withstand the high radiation levels and extreme temperatures of space flights.

In order to design strong, safe vehicles, aerospace engineers must know and put into practical use the principles of aerodynamics, the study of the forces acting on an object due to air moving past it. They must also have a thorough understanding of the strength, elasticity, and other properties of the materials they use and be able to predict how these will behave during flights. Aerospace engineers work closely with electrical engineers in developing guidance, navigation, and control instruments and with mechanical engineers in designing suitable engines. They also assist civil engineers in planning airport facilities.

Biomedical Engineering applies engineering techniques to health-related problems. Biomedical engineers develop aids for the deaf and blind. They cooperate with physicians and surgeons to design artificial limbs and organs and other devices and machines that assist or replace diseased or damaged parts of the body. Biomedical engineers help provide a wide variety of medical tools, from instruments that measure blood pressure and pulse rate to surgical lasers, concentrated beams of light that can be used to perform delicate operations. Some biomedical engineers specialize in programming computer systems to monitor a patient's health or to process complex medical data. Others cooperate with architects, doctors, nurses, and other specialists to plan hospitals and community health centers.

In choosing materials for artificial aids and organs, biomedical engineers must understand the physical and chemical properties of the materials and how they interact with each other and with the body. One of the chief areas in biomedical engineering research focuses on the development of materials that the human body will not reject as foreign substances. In their work, biomedical engineers often use principles of biology, chemistry, and medicine and of electrical, materials, and mechanical engineering.

Chemical Engineering deals with the large-scale processing of chemicals and chemical products for industrial and consumer uses. Chemical engineers are concerned with the chemical processes that change raw materials into useful products. They plan, design, and help construct chemical plants and equipment and work to develop efficient and economical production methods. Chemical engineers work in many industries, including the manufacturing of cosmetics, drugs, explosives, fertilizers, food products, fuels, plastics, and soaps.

Chemical engineers must know how to handle and transport large qualities of chemicals. They have to understand such problems as heat transfer from one substance to another, absorption of liquids and gases, and evaporation. They control such processes and operations as distillation, crystallization, filtration, mixing, drying, and crushing. Incidentally, most of these processes were designed by Musa Jabbir Ibn-e-Hayan in the second century Hijra, and are still being used.

The work of chemical engineers relies heavily on principles of chemistry, physics, and mathematics. Chemical engineers consult with electrical, mechanical, and industrial engineers in the design of plants and equipment. Some chemical engineers work closely with environmental engineers in seeking safe disposal methods for hazardous by-products of chemical processing.

Civil Engineering, the oldest of the main branches of engineering, involves the planning and supervision of such large construction projects as bridges, canals, dams, tunnels, and water supply systems. Civil engineers also cooperate with architects to design and erect all types of buildings. Other civil-engineering projects include airports, highways, irrigation and sewerage systems, pipelines, and railroads.

Civil engineers work to build strong, safe structures that meet building codes and other regulations and are well suited to their surrounds. They are responsible

for surveying and preparing building sites and for selecting appropriate materials. Civil engineers must also understand the use of bulldozers, cranes, power shovels, and other construction equipment.

Some civil engineers specialize in the study of the physical characteristics of soils and rocks and the design of foundations. Others concentrate on the management of water resources, including the construction of flood control and irrigation systems, hydroelectric power plants, and water supply and sewerage systems. Still others are concerned with designing transportation systems and methods of traffic control. Many civil engineers are involved in city planning and urban renewal programmes.

Electrical Engineering deals with the development, production, and testing of electrical and electronic devices and equipment. Electrical engineers design equipment to produce and distribute electricity. This equipment includes generators run by water power, coal, oil, and nuclear fuels; transmission lines; and transformers. Electrical engineers also design and develop electric motors and other electrical machinery as well as ignition systems used in automobiles, aircraft, and other engines. They work to improve such devices as air conditioners, food processors, and vacuum cleaners.

Electrical engineers who specialize in electronic equipment are often referred to as electronics engineers. Electronics engineers play an essential role in the production of communications satellites, computers, industrial robots, medical and scientific instruments, missile control systems, and radar, radio, and television sets. Some engineers in the electronics field develop master plans for the parts and connections of miniature integrated circuits, which control the electric signals in most electronic devices. Many electronics engineers design, build, and programme complex computer systems to perform particular tasks. Telecommunication, the transmission and reception of messages over long distances, is another major specialty of electronics engineers.

Environment Engineering concerns efforts to prevent and control air, water, soil, and noise pollution. Environment engineers develop equipment to measure pollution levels and conduct experiments to determine the effects of various kinds of pollutants. They design air pollution control devices and operate water purification systems and water treatment plants. They also develop techniques to protect the land from erosion and from pollution by chemical fertilizers and pesticides.

Environment engineers are specialists in the disposal of hazardous wastes from factories, mining operations, nuclear power plants, and other sources. They work to clean up unsafe dump sites created in the past and do research on new storage and recycling techniques. Environment engineers are also involved in the development of cleaner and more reliable forms of energy and in developing ways to make the best present and future use of natural resources. Environment engineers work with agricultural and mining engineers to develop production techniques that do the least possible damage to the land. They assist civil engineers in the design of

water supply, waste disposal, and ventilation systems and chemical and nuclear engineers in waste disposal.

Industrial Engineering applies engineering analysis and techniques to the production of goods and services. Industrial engineers determine the most economical and effective ways for an organization to use people, machines, and materials. An industrial engineer may select the location for a plant or office, determine employee requirements, select equipment and machinery, lay out work areas, and plan steps in operations. Industrial engineers also develop training and job evaluation programmes and work-performance standards, and help determine wages and employee benefits. They work to solve such problems as high costs, low productivity, and poor product quality.

Mathematical models developed on computers enable industrial engineers to simulate the flow of work through an organization and to evaluate the effects of proposed changes. Industrial engineers also use data-processing systems to aid in financial planning, inventory control, and scheduling. Their work often requires a knowledge of economics, psychology, and personnel management. Industrial engineers work in a wide variety of businesses and industries, including banks, construction and transportation firms, government agencies, hospitals, and public utilities.

Materials Engineering deals with the structure, properties, production, and uses of various materials. Materials engineers work with both metallic and non-metallic substances. They try to improve existing materials and develop new uses for them, as well as to develop new materials to meet specific needs. Mining and metal-engineering are major subdivisions of materials engineering. Mining engineers work closely with geologists to locate and appraise deposits of minerals. They decide how to remove the ore from the ground as cheaply and efficiently as possible. Mining engineers have to know about civil, mechanical, and electrical engineering in order to plan shafts and tunnels, ventilate mines, and select mining machinery.

Metallurgical Engineering deals with separating metals from their ores and preparing them for use. In extractive metallurgy, engineers remove metals from their ores and refine them to pure state. Engineers in physical metallurgy develop methods for converting refined metals into useful finished products.

Other materials engineers specialize in the production and uses of such synthetic materials as ceramics and plastics. Material engineers help develop new materials for the aerospace, biomedical, construction, electronic, and nuclear fields. They cooperate with chemical, industrial, and mechanical engineers in working out the complex processes that convert raw materials into finished products.

Mechanical Engineering involves the production, transmission, and use of mechanical power. Mechanical engineers design, operate, and test all kinds of machines. They develop and build engines that produce power from steam, gasoline, nuclear fuels, and other sources of energy. They also develop and build a wide variety of machines that use power, including air-conditioning, heating, and

ventilation equipment; automobiles; machine tools; and industrial processing equipment. Mechanical engineers are involved in every phase in the development of a machine, from the construction of an experimental model to the installation of the finished machine and the training of the workers who will use it.

Mechanical engineers work in many industries, such as power generation, public utilities, transportation, and all types of manufacturing. Many mechanical engineers concentrate on research and development because new types of machinery are continually in demand. Mechanical engineers are involved in almost every other branch of engineering, wherever a new or improved machine, device, or piece of equipment is required.

Nuclear Engineering is concerned with the production and applications of nuclear energy and the uses of radiation and radioactive materials. Most nuclear engineers design, construct, and operate nuclear power plants that generate electricity. They handle every stage in the production of nuclear energy, from the processing of nuclear fuels to the disposal of radioactive wastes from nuclear reactors. They also work to improve and enforce safety standards and to develop new types of nuclear energy systems.

Nuclear engineers also design and build nuclear engines for ships, submarines, and space vehicles. They develop industrial, medical, and scientific uses for radiation and radioactive materials. Some nuclear engineers specialize in designing and constructing particle accelerators, devices that are used in scientific studies of the atom and in creating new elements. Others specialize in the development of nuclear weapons. Nuclear engineers also play a role in the development of radiation sources, detectors, and shielding equipment. The work of nuclear engineers frequently overlaps with that of electrical, environmental, mechanical, and materials engineers.

Other Specialized Fields focus on even more specific areas of engineering than do the major branches. This section describes a few of the more important specialties.

Acoustical Engineering deals with sound. The work of acoustical engineers includes designing buildings and rooms to make them quiet; improving conditions for listening to speech and music in auditoriums and halls; and developing techniques and sound-absorbing materials to reduce noise pollution.

Agricultural Engineering involves the design of farm buildings, agricultural equipment, and erosion control, irrigation, and land conservation projects. Agricultural engineers are also concerned with the processing, transporting, and storing of agricultural products.

Computer Engineering involves the development and improvement of computers, storage and printout units, and computer information networks. Computer engineers design the features of computer systems to suit particular operations.

Marine Engineering concerns the design, construction, and repair of ships and submarines. Marine engineers are also involved in the development of port facilities.

Ocean Engineering involves the design and installation of all types of equipment used in the ocean. The products of ocean engineers include oil rigs and other offshore installations, marine research equipment, and breakwater systems used to prevent beach erosion.

Petroleum Engineering deals with producing, storing, and transporting petroleum and natural gas. Petroleum engineers locate oil and gas deposits and try to develop more efficient drilling and recovery methods.

Textile Engineering is concerned with the machinery and processes used to produce both natural and synthetic fibres and fabrics. Engineers in this field also work to develop new and improved textiles fabrics.

Transportation Engineering involves efforts to make-transportation safer, more economical, and more efficient. Engineers in this field design all types of transportation systems and develop related facilities for reducing traffic problems.

March of History

The history of engineering is the record of entrepreneurship and human ingenuity through the ages. Even in prehistoric times, people adapted basic engineering techniques from things that were available in nature. For example, sturdy sticks became levers to lift large rocks, and logs were used as rollers to move heavy loads. The development of agriculture and the growth of civilization brought about a new wave of engineering efforts. People invented farming tools, designed elaborate irrigation networks, and built the cities. The construction of the gigantic Egyptian pyramids at Giza during the 2500's B.C. was one of the greatest engineering feats of ancient times. In ancient Rome, engineers built large aqueducts and bridges and vast systems of roads. During the 200's B.C.. the Chinese erected major sections of the monumental Great Wall of China.

Early engineers used such simple machines as the inclined plane, wedge, and wheel and axle. During the Middle Ages, a period in European history that lasted from the A.D. 400's to the 1500's, inventors developed machines to harness water, wind, and animal power. The growing interest in new types of machines and new sources of power to drive them helped bring about the Industrial Revolution of the 1700's and 1800's. The role of engineers expanded rapidly during the Industrial Revolution. The practical steam engine developed by the Scottish engineer James Watt in 1760's and applied in 1785 revolutionized industry and transportation by providing a cheap, efficient source of power. New iron making techniques provided engineers with the material to improve machines and tools and to build bridges and ships. Many roads, railroads, and canals were constructed to link the growing industrial cities.

Distinct branches of engineering began to develop during the Industrial Revolution. The term civil engineer was first used about 1750 by John Smeaton, a

British engineer. Mechanical engineers emerged as specialists in industrial machinery, and mining and metallurgical engineers were needed to supply metals and fuels. By the late 1800's, the development of electric power, and advances in chemical processing had created the fields of electrical and chemical engineering. Professional schools began to be founded as the demand for engineers steadily increased.

Since 1900, the number of engineers and of engineering specialties has expanded dramatically. Artificial hearts, airplanes, computers, lasers, nuclear energy, plastics, space travel, and television are only a few of the scientific and technological marvels that engineers have helped bring about in the last century. Because science and technology are progressing and changing so rapidly, today's engineers must study throughout their careers to make sure that their knowledge and expertise do not become obsolete. They face the challenging task of keeping pace with the latest advances while working to shape the technology of the future.

ENTREPRENEURIAL THRUST IN PAKISTAN

In the engineering field, the Government of Pakistan, in their weaker moments, in mid 1970's issued an excellent policy framework, popularly called, the Deletion Programme.

In a nut shell it laid down that the car and other consumer durable assembly plants must necessarily localize, progressively, a certain percentage of, erstwhile imported components for assembly, viz. average of 75% in 5 years or else suffer some penalties.

This triggered off an activity never before witnessed in the engineering sector.

Entrepreneurs were encouraged and enabled by the assemblers and helped and supported to meet mandatory targets. The Franchisers of those assemblers were forced to share their guarded technologies or else they could not do business in Pakistan.

So far the car and tractor industry had only been a fake one, meaning import of semi-knocked down cars and tractors, etc., being only a screw driver away from delivering the complete vehicles to the markets, with hardly any local value addition except for the profit, that the traders picked up in distribution.

These new part manufacturers that emerged, the entrepreneurs called vendors, achieved wonders. Parts, nobody at one time, could imagine, would be produced in Pakistan, are being made, matching the quality of the imported components and in certain cases, even surpassing them in their quality, standard and performance.

Currently, by the year 2005, there are over 1000 such vendors, employing over 200,000 technicians and engineers and contributing to GNP to the extent of 200 billion rupees; paying nearly 65 billion rupees as direct taxes to the government revenues and saving foreign exchange to the extent of 1.6 billion U.S. dollars.

This entrepreneurial activity has developed skills and technologies which are being used in the Engineering Industry, the mother industry, that supports various other activities, like agriculture, and defence.

ENTREPRENEURIAL SPIRIT

At the foundations of all these activities in the engineering field is the entrepreneurial spirit which impelled individuals in history to strike on their own by leaving the beaten tracks and experimenting with new things, ignoring the ridicule, loss of time and money and face, that could accompany the possibilities of failures.

It is the entrepreneurial spirit, eventually, that has put the man on the moon and explored the farther recesses of the universe, fathomed the deep seas, created new products and processes and revolutionized life on this earth.

In contemporary world, it is the entrepreneurship that has built industries and businesses and turned companies and countries into economic power houses.

Hermes Spirit

While discussing achievement motivation, McClelland (1961) has shown that this spirit, in fact, existed from the beginning of human history. He has pointed out that this dynamic spirit and perpetual restlessness is found in Greek Mythology. The member of Greek Pantheon, who fits the high achievement spirit of entrepreneur, appears in the personality of Hermes. The image of him that fits into the description of entrepreneur is provided in the Homer's "Hymn to Hermes". The mythological story describes Hermes to have discovered a tortoise from which he made an immense fortune by constructing its shell into a musical instrument. This was a simple technological innovation which is the characteristic of entrepreneurship specially when it involves to make money out of it. The spirit of Hermes also expressed restlessness, preference for sombre colours and flair for travel including social mobility, etc. and not only that, Hermes spirit also involves "Hustling". As soon as he leaped from the immortal thighs of his mother, he did not lie long in the sacred winnowing basket that was his cradle; instead he jumped up, and was off in search of the cattle of Apollo. Thus Hermes wasted no time and hurried off. Once again if we identify this with the entrepreneurial spirit we might expect that individuals imbued with that spirit have special attitude towards time - in particular that they would not want to waste it; would perceive it as moving swiftly, would generally be in a hurry or be busy.

Sources of entrepreneurship

This spirit has its roots in the human psychology. It has been found that some conditions in a society arise, often, based on ideological movements which lead parents to give their children early achievement training of a certain special type. They give more freedom to children, let them experiment and still maintain tolerance for failure. They understand that cost of a failure is the cost of learning. Trailing behind every success, in human life, there are, usually, a series of failures.

This, in turn, produces more such children with high need for achievement, who, given some favourable conditions, are apt to become successful inventors, innovators and entrepreneurs.

Our research shows that all human beings are born entrepreneurs. Every one who is born has almost inherit and innate qualities of restlessness, inquisitiveness and risk taking evident in every child. These are the basic traits and characteristic of entrepreneurs.

It is the subsequent child rearing practices in certain societies where over protective parents suppress these traits, particularly in societies like the one's in Pakistan, where the feeling of insecurity is in the extreme. Thus, the spirit of enterprise is suppressed and sunk into the sub-conscious mind.

No wonder that in such societies, by and large, no new things are attempted. No wonder also, that no new grounds are broken and no land mark discoveries made.

When the divine message was received in the saw, in the 7th century A.D. and minds were freed to think, such people laid foundations of a large number of successes and made ground breaking discoveries through research.

And then something happened and a class of backward looking obscurantists came into the field and blocked the thinking of the people and the lead in science was lost. Others then took over and went on to make new discoveries and created new concepts and developed new sciences. The result is that all that we see around us as scientific marvels, none could be attributed to those who originally freed the human minds.

If we want to regain the lead, the dormant entrepreneurial spirit has to be awakened, by appropriate training and education.

All that is needed is an entrepreneurial thrusts and science, and technology will be at our feet.

Interapreneurship

With the success of small business and the entrepreneurial initiatives the large corporate bureaucracies abroad and their members, of late, have devoted their attention towards inculcating and encouraging the spirit of entrepreneurship amongst the employees. In this context the term Intrapreneuring has been coined and quoted by writers like Gifford Pinchot III (1985).

The management literature on the subject typically starts with a citation like the following:

The Intrapreneur's Ten Commandments

1. Come to work each day willing to be fired.
2. Circumvent any orders aimed at stopping your dream.

3. Do any job needed to make your project work, regardless of your job description.
4. Find people to help you.
5. Follow your intuition about the people you choose, and work only with the best.
6. Work underground as long as you can - publicity triggers the corporate immune mechanism.
7. Never bet on a race unless you are running in it.
8. Remember it is easier to ask for forgiveness than for permission.
9. Be true to your goals, but be realistic about the ways to achieve them.
10. Honor your sponsors.

RECOMMENDATIONS

1. All engineers, irrespective of the professional callings that they may be pursuing must continue to learn other allied professions in the Engineering field;
2. Cross disciplinary continuous learning should be a perpetual way of life with the Engineers;
3. Research and Development must be encouraged and fully supported with funds;
4. To encourage Engineers to innovate and invent, senior managers and engineers must develop tolerance for failure; and
5. Intrapreneurship must be encouraged in established organizations that may have routinized their normal working, and otherwise are approaching the end of their life cycle.

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