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ORIGIN AND DEVELOPMENT OF INDUSTRIAL ENGINEERING: A HISTORICAL SURVEY

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PREAMBLE

WORK: Work and life are inseparable. Hands, Head and Heart are involved in any work -irrespective of its nature and purpose. Any work offers scope for creativity and innovation, if done with passion. Those who are engaged in work they love and love what they do are happy.

TIME: Each moment of time, being perishable, un-storable, hence irreplaceable, is the most valuable resource for any work, unlike other inputs like material, energy or money.

WORK SYSTEMS: Any work situations can be conceived as a system of inputs, worked on by human-technology interaction, to create outputs.

Designing work systems is the basic professional domain of the industrial engineers. It requires creativity and innovation involving 3-H (Hand, Head, and Heart) and offers scope for perpetual pursuit of perfection (3-P). Work and knowledge reinforce each other. As industrial engineering is concerned with work, time, and work system design, its origin is co-terminus with human existence, since Homo sapiens used their hands and legs to gather food.

All living beings, from birth to death, as individuals or as members of teams, willingly or otherwise, have worked and keep working to create everything in the world, in fields or factories. Intellectuals , inventors, and discoverers in all fields: Euclid (323 BC), Gutenberg (1400), Galileo (1616), Isaac Newton (1642), James Watt (1782), Alesandro Volta (1800), Charles Darwin(1859), J. J. Thomson (1897), Max Plank (1900), Albert Einstein (1905), to name randomly, just a few, have created all knowledge: Physical, Biological, Psychological Sciences, Mathematics, and Technological foundation of modern world using which human work made the wonderful artifacts we enjoy on land, water and sky.

Work has also created weapons for violence and destructive wars- conventional and nuclear wars, using most modern and sophisticated sciences and technologies. Imagine the quantum and vast diversity of the work in work systems involved from Industry 1.0 era to the threshold of Industry 4.0 in present century. Search for designing and operating work systems with more efficiency and effectiveness led to creation of the new profession of work study/industrial engineering (IE).

1. IE RELATED THEORIES, PRINCIPLES AND TECHNIQUES: A NARRATIVE

1750-1849: Richard Arkright: Training and factory discipline.

JR Perronet: Systematic overall time study, in secrecy, to establish 'standard' production rate, mechanical inventions, cooperative movement and trade union movement.

James Watt, Jr: Established integrated 'modern' engineering plants. Adam Smith: Causes of national wealth and economic gain from ''Division of Labor' laying the foundation of prevailing free capitalistic economic systems in all democratic countries.

Robert Owen: Liberal and participative management at the New Lanark Mill, work measurement making allowances for fatigue. Few quotes from his books The New Lanark establishment and the New view of society should be inspiring, even today.

"If care of inanimate machines can produce such beneficial results, what may not be expected if you (the owners) devote equal attention to your vital machines far more wonderfully constructed? XXXX Time and capital (must be) more advantageously applied to improve living machines". Hope, we all are listening and trying to follow! S Frederick created the first recorded manual both for the owners and the workers he hired for their factories. Charles Babbage's book Economy of Machinery and Manufacturers laid the foundation of factory accounting and costing. These keep evolving with company laws getting more complicated over the years to strike balance between free economy and more expensive bureaucracies in democratic governance. He was also interested in calculating machines- the fore-runners of computers.

1851-1899: Henry Ford (1863-1947) through his Ford Motor Company producing the Model 'T' pioneered revolutions inroad transportation industry and in Industrial Management.

M. Henry, discussed for finding cost of manufactured products and for administration of workshops, concept of Engineering Economy and profit sharing.

H R Towne, in back ground of these developments, reviewed the need for engineer to be an economist as well, another foundation for the modern Industrial Engineering theory and practice.

FW Taylor, the would be father figure of work study and the scientific management movement in early forthcoming century fired his first thought: A Piece – Rate system, paying employees by their output.

1900-1949: In 1900 Henry Fayol in his presentation formally discussed role and nature of administration in government and in industries.

FW Taylor's path breaking paper and after few years, his Book on shop management were published based on his practice as an Engineer-Manager on the shop floor- classics till date. A couple of years later came his theoretical exposition of concept of 'SCIENTIFIC MANAGEMENT in a book form. Charles Bedaux contributed concept of 'RATING' based on 'tempo' to the STOP WATCH TIME STUDY.

In 1912 in a hearing before special committee of US House of Representatives to investigate Taylor and other systems of Shop Management under authority of HR 90, Taylor explained the core concept as 'Science, not Rule of Thumb' which is not just a bundle of techniques like stop watch time study or incentive systems but involves 'complete MENTAL REVOLUTION on both sides-Workers and Management.'

H. L. Gantt's Graphical Daily Balance in Manufacturing, continues as Gantt Charts and his work, wages, and profits and Harrington Emerson's Rational Basis For Wages and Modern Theory of Cost Accounting continue to be the basis for present day accounting systems.

F.W. Harris formulated often used 'Economic Order Quantity' formula. Haley, Rowan and many others designed wage-incentive plans to reward faster, better operators.

F. B. Gilbreth through Motion Study, Micro –Motion study, 'THERBLIG's was the pioneer in Method Study. The Industrial Engineering is still often viewed by many as WORK STUDY (TIME STUDY plus METHOD STUDY) practitioners.

L.D. Brandeis extended use of Scientific Management to railroads, a new effort beyond conventional, goods, producing factories. AH Church and many others furthered the Principle of Rational Management.

Lillian M. Gilbreth's (wife of Motion Study Pioneer F.B. Gilbreth) seminal book on The Psychology of Management focused on the Human Operators in the Factories. **Our IIIE celebrates her contribution by The Lillian Gilbreth Award.**

HUMAN ENGINEERING/ERGONOMICS

During the First World War (1914-1918), besides many being killed, large number of young veterans returned home without one or more 'working' limbs. To keep them socio- economically contributing and happy, efforts were made to design/redesign machines to suit their limited abilities, starting the HUMAN ENGINEERING era in USA. On the other side of Atlantic it was called ERGONOMICS for sustaining MOTIVATION for Work. A.B. Sagur initiated Motion Time analysis in 1925.

AG Anderson, in 1928, named Work study related work as INDUSTRIAL ENGINEERING.

G Elton Mayo the primary researchers elaborated on 'Human Problems' and Social Problems' of an industrial civilization-two famous contributions.

M P Follett the prolific writer on Management, discussed changing environment facing factory in 'The Dynamic Administration'. Walter Shewhart's Statistical Control charts, since its introduction in 1931, are still extensively used since 1931. The same year LHC Tippet Work Sampling, still in use. Joseph Quick suggested the Work Factor system in 1934.

In 1935, Jack Walch, the Business leader, advised to 'INVEST in PEOPLE,' wise and always relevant as also his counsel: **'strangle bureaucracy or it will strangle you' may all the leaders not only in Business but everywhere, specially in governments, act on this?**

A. H. MASLOW's NEED HIERARCHY- theory for sustaining MOTIVATION for work continues to offer be the much in practice guidance for this vital purpose. Very modest ENIAC Computer by Eckert et.al appeared in 1940 beginning a mighty revolution which continues unabated.

N. Wiener's CYBERNETICS- the Science of control continues to be a much respected classic. Mathematical and statistical study for more effective operation of World War II, spurred the use of these in managing highly competitive Industry/Business Management under the generic title of 'Operations Research' or 'Management Sciences' after the War. In 1947, Michael Porter propagated the idea of 'Competitive Advantage' for planning.

1950-1999: Churchman (et. al) Book Introduction To Operations Research continues to be a popular Text book of the subject in most academic programs.

Herzberg et. al in 'Work and Nature of Man' explain the - TWO-FACTOR theory for motivation at work place. It still awaits widespread experiment. H.A. Simon formally presented Management Science as a new Science.

JW Forrester: INDUSTRIAL DYNAMICS keeps inspiring many researchers to model and analyze many industrial / business in SYSTEM DYNAMICS format. Value analysis started at RCA is much in use with cost vs value comparisons. For Project Management, considering numerous Socio-Economic, Science-technology based 'Projects, Project Evaluation and Review Technique (PERT) of US NAVY and the Critical Path Method (CPM) of Remington Rand are in wide spread application as a very significant part of IE & OR.

A historic moment for the profession of industrial Engineering was its formal definition – too well known: "Industrial Engineering is concerned with Design, improvement, XX of integrated systems of Men, Material and Equipment. XXXXXXX "adopted by AIIE after 5 symposia with 43 participants drawn from Academia and practicing Professional, from 1955-1959 in five different universities, in the third one in Georgia Institute of Technology at Atlanta on November 7-8, 1957. IIIE and many others have adopted the same.

R.N. Lehrer: Use of Science and Engineering as aids to Management, explicitly naming it as the MODERN Industrial Engineering Approach.

S.C. Bhattacharya: Made the earliest survey of origin and application of Industrial Engineering in India way back in 1962.

KC Sahu in 1972 made a brief survey of status of Operations Research in INDIA.

Late Professor R Mishra, my revered Guru and affectionate mentor wrote about Industrial Engineering Education in 1976 of which he was the pioneer, dating back to start of IIT Kharagpur way back in 1951. More on the preceding two references, in the next Section on Industrial Engineering in India.

KC Sahu in 1984 wrote about philosophical ethical Issues in Re-designing Work systems and challenges facing Industrial Engineering as a profession. He explicitly elaborated the basic task of Industrial Engineers as Work System Designers.

G. Saran discussed about Building Productivity culture in the same year. RP Mohanty made the 'state of the art' survey of IE practices in India in 1988.

In 1989, author made a survey of Industrial Engineering- from Taylor Era to Twenty-First Century at an invited Lecture in February 19, 1989, which was later published as a paper in, Jr. of Institute. Of Engineers (India), vol.70, July, 1989.In 1993, his paper on Creativity and Networking for Excellence was presented at the top Management Seminar sponsored by IIIE.

It is an Honor to close this half century with the following wise inspiring quotes of KONOSUKE, (1894-1089) considered as God of Management in Japan:

'Peace with Prosperity', 'Low priced mass-produced goods'. 'Mutual respect and support between Corporation and Employees'.

2. INDUSTRIAL ENGINEERING IN INDIA

Soon after its introduction, Industrial Engineering (USA) / Work Study (UK) have spread all over the World. This last section will be confined to highlight its origin and growth in India only. In 1936, John Moor and Horder Allen from USA started Eastern Bedaux Co. Ushering in IE, the first Indian to join them was Sri MK Rao. The group expanded at the beginning of World War II with few from British Bedaux and three more Indians, Shri DP Basu, Sri VS Vernekar and Sri SP Patel joining the pioneering group.

IBCON started in 1945 laying the foundation of IE in India.IE became a department in Ever-ready Company of India, Calcutta in 1940 where Time study, Job Evaluation and Incentive schemes were started. ICI (India) established IE department and trained personnel at ICI, UK by M. Russel Curie. Labour studies were started in 1038 in Ordnance Factory. O&M studies in Government was started in 1942. **Hope it is still there!** Predictably, Shri JRD Tata encouraged IE from beginning. Planning Commission of Government of India got interested for speedy project implementation.

3. EVOLUTION OF IIIE

Started in 1957 with just 32 Members, with founder Chairman Mr. Farman, Sri HN Thadani was at the helm as Chairman from 1958 to 1969. In 1959, Graduate Membership was introduced. Membership grew to a still modest 140 by 1963. Gradually Chapters were formed.

In 1963, Prime Minister Jawaharlal Nehru inaugurated the institution of Work Study. Spear headed by Defence Institute of Work Study with Productivity Scientists like Brig. Krish Pennathur, Capt. HD Selby, Capt. SS Rao. It was affiliated to Institute of Work study Practitioners (London). Members were from Government Organizations like Defence, Railways, and the Secretariat training school. It conducted examination for Work Study for the practitioners. A land mark event was merger of IIIE and the Institute of Work Study in 1968 and named **Indian Institution of Industrial Engineering, IIIE**. It conducted first **Graduateship Examination in 1971**. Our Journal started in 1957. IIIE has remained very active in international organizations like PAFIE, WCPS.

4. EDUCATION IN INDUSTRIAL ENGINEERING IN INDIA

Education in Industrial Engineering started at IIT Kharagpur since its inception in 1951 as a Department, along with TWO others – at VJTI and II.Sc. Bangalore offering Post Graduate Courses in IE since 1952-53. During the decade of 50s IIT has conducted very popular Short Term Courses / EDPs in Management - General and functional - attended by galaxies of Senior Level Executives and addressed by luminaries like Late VV Giri and Shri R. Mudaliar at IIT, Kharagpur. It continues with unabated qualitative growth with vigorous research in the newest areas.

We all, IE Professionals and Academicians, owe gratitude to Late much-lamented Professor R. Mishra, my GURU and affectionate mentor from whom I learnt the little on IE, I know.

By ILO inspiration and help, in 1958 National Productivity Council came into being and NITIE, devoted exclusively to IE was established in 1961 and started activities since 1964. NITIE has vastly expanded its activities in depth and spread with post Graduate Programs and Research.

5. CONCLUDING REMARKS

This narrative will be closed with two inspiring thoughts rather than the conventional summary of foregoing narrative:

'The IE techniques should be adopted to Indian reality by concentrating on increasing productivity of Capital, Material, and the Equipment rather than of Labor'.

An universally useful advice from Dr. Frank E. Cotton Jr (Ex-President IISE): 'Our critical need is for more effective Management of Technology and prudent design of our SOCIAL Systems. An Industrial Engineer is educated to DESIGN such SOCIAL SYSTEMS.'

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