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Editorial

Productivity Theory for Industrial Engineering

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A ground-breaking innovation in engineering

Productivity Theory for Industrial Engineering is the first synthesized the universal theory for industrial engineering with mathematical models for productivity rates of industrial machines and complex structural systems. This theory enables delivering exact decisions for engineers and practitioners of any industry and presents in the book "Productivity theory for industrial engineering", Taylor and Francis, London, 2018.

Beginning with the Industrial Revolution, production industries accumulated experience in creating many machines and systems to put out various goods and products for people. All these machines of unique designs and complexity passed the thorny path of perfection, mostly through practical solutions. The mathematical models for the productivity rates of the machines developed by scientists around the world were simple and yielded big differences from the real output of machinery. Engineering principles of creating the high productive machinery had kept in step with the evolution of science and knowledge. The independent several theories, methods, and criteria cannot compute and design the optimal solution of the production system.

Accumulated practical experience in industries solves mainly this problem. Several methods that are not combined analytically in the holistic mathematical model solve the pivoted problem of the productivity rate of industrial machines. The theory of technological processes, the theory of computing and design of machinery, the reliability and probability theory, the automation theory, the maintenance theory, the management theory, the optimization theory, the economic theory, and other auxiliary methods have their own approaches and methods and used for creating of industrial systems. Under these circumstances, the perfectness of production systems is reached by the spending time and effort for the design of machines that lead to their high cost. Industries sharply need the holistic theory that combines methods of main engineering theories for computing the productivity rate of machines with warrant results both at the project stage of their design and exploitation.

Productivity Theory for Industrial Engineering is the holistic productivity theory for industrial engineering, which combines major theories mentioned above and has an influence on the output of machines and systems. The first factor is the technological processes that are the essence of design for any machine, which define the limits of the productivity rate. Other theories enable decreasing the time loss of manufacturing systems. The aim of the productivity theory is to provide the methods and mathematical models for studying the regularities and causal links in the design of manufacturing machines and systems with optimal structures and machining regimes that yield their maximal productivity rate. Productivity theory considers machines and systems in terms of the physical productivity rate, i.e., the number of products manufactured per observation time that ASME accepted. The holistic productivity theory presents mathematical models of productivity rate for machines and systems and shows the links between physical productivity rate, reliability, technological and technical parameters, the structure of machines and systems with complex designs, and manufacturing management.

The productivity theory is developed for the manufacturing industry, in which machinery has big diversities in design than other industries. The mathematical models for the productivity rate presented for the single machine and the complex systems as automated lines of parallel-serial structures, divided into sections

with the embedded buffers of the limited capacity. All mathematical models contain the parameters of the technological process, design of machines and stations, structure, reliability, service system, and management. The unique holistic mathematical models enable computing the productivity rate for any complex production systems with high accuracy, defining the optimal machining regimes, optimal structures by the criterion of the necessary and maximal productivity rate. The derived theory is universal and can be used in any industry (transport, chemical, agricultural, food processing, textile, etc.) with technologies of original nature. The productivity theory for industrial engineering presents the unique combination of superb engineering and science and shows profound contributions to humanity.

An innovation brings global benefit to humanity

Improving the human standard of living has been an important priority since human civilization began. The growth of population and the necessity to improve human life resulted in the Industrial Revolution. Scientists and engineers have seen that the wealth and standard of living can be solved only by creating industrial machines of the high productivity rate that satisfy the necessity of human life by the different goods and products. To solve this problem effectively, it was necessary to work out the productivity theory for industrial engineering. The productivity theory for industrial engineering presents a profound impact on engineering science. Manufactures can compute for a short time, design and exploit the industrial machines and complex structural systems with a warranty of the high output that is defined by the necessity of population.

The productivity rate of industrial systems is the primary task of any industry in the world. The index of the machinery's productivity rate is a major component of the microeconomics, which is part of the macroeconomics. The theory of the labor productivity or macroeconomics of the state considers the ratio of the output (productivity rate) to the input of labor (fixed and variable capitals). The labor productivity is variable with the time of the economic system service. It grows intensively in the first years of functioning, then the growth is decelerating and monotonically comes to its limit. With the years of service, it becomes obsolete and does not respond to the marketing environment. It means the economic system should find ways for constant growth and not to be bankrupt. To have high labor productivity is necessary to create new production systems with a high productivity rate. The combination of the productivity theory for industrial engineering and labor productivity enables solving analytically the complex problem of the optimal years of service of the economic system by the criterion of maximal labor productivity. The productivity theory of industrial engineering has a direct influence on the labor productivity and economy of the state. The holistic theory an compute optimal designs of the production systems of different structures by the criterion of the maximal productivity rate. This theory is a powerful tool for economists that can predict the time for the launch of the engineering system with a high productivity rate, which satisfies the state demand for goods and products at a global scale.

In addition, the profound impact of the productivity theory for industrial engineering is to perfect the industrial engineering systems that fabricated goods and products for a population to lift the standard of living of a human. Universities will give his theory to students that will work at companies and improve the production systems and economics. The productivity theory of industrial engineering plays a key role in developing engineering systems and economics of states that will have profoundly affected human life. Increasing the productivity rate of the production system leads to a decreasing the cost of the output products, increasing purchasing ability of the population, and lifting up the standards of living.

Researchers have had a pivotal role in this development

- Over two centuries, scientists and engineers found many solutions to increase labor productivity. The early 20th century brings forward F. W. Taylor, H. Fayol, C. I. Barnard, H. Ford, and others which solutions were based on management and organizational theories of production processes with the labor force having the physical limits. Their management and organizational theories led to significant breakthroughs and shaped modern methods of mass production and structural organization in industrial practices. The creation of industrial machines with a high productivity rate is beginning in World War 1. Since that era, levels of industrial automated machines of the high productivity rate have grown exponentially throughout much of the world.
- The engineers and researchers J. P. Womack, D. T. Jones, and D. Roos have seen that the machine will change the world because the labor force has limits in productivity rate. O. Taiichi, H. Gienke, R. Kämpf, D. McCallum, T.

Kretschmer, T. Strobel, E. Brynjolfsson, J. Yang, and others consider the productivity problems of technological processes by organizational and management methods refereeing to the use of the industrial machines. The following scientists and engineers describe the partial aspects of the productivity rate of machines and systems by the mathematical models. The comment of their publications shows the solved problems.

- Ben-Daya M., Duffuaa S., Raouf A., Maintenance, Modeling, and Optimization, Kluwer Academic Publishers, 2000. The mathematical models described by principles of the probability theory the optimal maintenance of the production system with a minimum idle time of machines.
- Chryssolouris, G., Manufacturing systems: Theory and practice. 2nd ed, Springer, New York, 2006. The balancing of the technological processes, idle times of the machines in terms of reliability, structural arrangements of the manufacturing systems, cyclic time of processes present the partial aspects of the productivity rate of manufacturing systems. The book does not contain the mathematical models for the productivity rate of the manufacturing system.
- Diamantidis, A. C., Papadopoulos, C. T., Heavey, C., Approximate analysis of serial flow lines with multiple parallel-machine stations, IIE Transactions, Vol. 39, Issue 4, 2007, pp. 361-375. The work presents the numerical results of the output for the production lines and does not have the mathematical models for the productivity rate.
- Freiheit, M., Shpitalni, S. J., Hu, S. J., Productivity of Paced Parallel-Serial Manufacturing Lines with and without Crossover, J. of Manufacturing and Eng., 2004, Vol. 126, pp. 361-367. The paper considers combinatorial algebraic models by Markovian analysis for the productivity of parallel-serial configurations with crossover. The work considers parallel independent lines with different stations and times of processing. Idle times and reliability of stations does not consider.
- Groover, M. P., Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 4th ed., (Lehigh University), Wiley, 2010. The work considers the productivity rate of the cyclic process only.
- Gershwin, S. B., Design and Operation of Manufacturing Systems. The Control-Point Policy, IIE Transactions, Vol. 32, No. 2, 2000, pp. 891-906. It describes a decentralized scheduling/control policy and proposes a method for analyzing the performance of systems that are operated according to the policy. It presents three views of the production system: surplus-based, time-based, and token-based; and shows how they are equivalent in special cases. While there are no assurances of optimality, experience suggests that the policy has desirable characteristics.
- Hon, K.K.B., Performance and Evaluation of Manufacturing Systems. CIRP Annals 54(2), 2005: pp. 675-690. This paper reviews the historical evolution of and modern developments in manufacturing performance measurement within a systems framework based on five metrics and five levels from a single workstation to the entire manufacturing network.
- Kalpakjian S, Schmid S.R., Manufacturing Engineering and Technology, 6th ed. Prentice-Hall, 2009. The book considers the productivity rate of machines by the cycle time of the balanced manufacturing process.
- Koenig, D. T., Manufacturing Engineering: Principles for Optimization, 3rd ed. ASME, 2007- 01-30. The work does not consider the mathematical models for the productivity rates of production systems.
- Rao, R.V., Advanced Modeling and Optimization of Manufacturing Processes, 1st ed., Springer Series in Advanced Manufacturing, 2011. The work does not consider the mathematical models for the productivity rates of production systems.
- Presented publications and others consider the partial solutions related to the productivity rate of manufacturing machines and systems. The mathematical models are simple and describe the reliability of machines, tool life, probability of processing, cycle time, maintenance, optimization of the process, structures of production systems, and other aspects and do not have holistic mathematical models for productivity rates.

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