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Tendencies in Improving Production Systems in Engineering

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ABSTRACT: Nowadays, developed countries undergo a slow evolution of the traditional system of production towards a higher form of the operational management based on advanced production systems – a synthesis of the manufacturing and mechanic systems. The new strategy is the consequence of the acceleration at the present day technological progress, through the massive introduction of information technology and electronics in the field of the management of production process

ТЕНДЕНЦИИ ПРИ ПОДОБРЯВАНЕ НА ПРОИЗВОДСТВЕНИТЕ СИСТЕМИ В ИНЖЕНЕРНАТА ПРАКТИКА
РЕЗЮМЕ: В днешни дни традиционните производствени системи в развитите страни претърпяват бавно развитие към по-висока форма на оперативно управление, базирайки се на усъвършенстваните производствени системи – синтез на системи за производство и механични системи. Новата стратегия е следствие от ускореното развитие на технологичния прогрес посредством всеобщото въвеждане на информационни технологии и електронни системи в управлението на производствените процеси.

Dynamic and unpredictable, contemporary strategies have gone into the melting pot, especially in the last decades, therefore the complexity and discontinuity of changes dominate the background against which companies develop in present days. This is the result of the new and often cross-correlated trends and phenomena that came out to challenge companies in this third millennium. There are some things that must be considered: the globalization tendency of the market, accelerated internationalization and globalization of economies, which suggest the emergence of an interconnected economy in progress in a boundless world, the importance of technical and technological changes, the information outbreak, the intensification of international competition together with the shifting of emphasis from price factors upon technical quality factors, the diversification and gradation of requests together with “the personalization of commodities”, limited resources and requirements regarding environment protection and ecologic equilibrium, high costs and mobility of capitals, and so on. Such changes as those mentioned above do not only generate problems but also have the ability, on the other hand, to break the ground for companies and managers who are creative and flexible enough when conceiving strategies.

The development of the production system in engineering implies a relatively short period of time starting at the end of the 19th century and the beginning of the 20th century, as it is highly dependent on the economic and social changes.

At the beginning of industrial activities, the systems of production were part of a “manufactory system”, the so-called “*craftsmanship system”*. Within the system, the human factor played an important part in designing, producing, verifying the quality of products and selling them using less complex working aids. Afterwards, the increasing number of inquiries for products in a certain branch of manufacture laid manufacturing plants under the obligation to simultaneously turn out more products per each operation, anticipating, thus, serial production. Hard as it might have tried to improve, craftsmanship systems faced the problem of extremely high costs (even though the volume of production was increasing) and of poor quality products from the following points of view: maintainability and operation safety.

The need to eliminate these deficiencies led to the implementation of a new production strategy between 1900-1950, relying on *computer assisted production systems* (also called conventional systems) and completely different from the manufactory system.

The theory of this new type of production was based on Taylor’s scientific management (in “*Principles of Scientific Management*”) and on his general administrative theory (in “*General and Industrial Administration*”). In accordance with Taylor’s and his followers’ analyses (Frank and Lillian Gilberth, Henry Gantt, H.B. Maynard, and so on) operation management has improved significantly.

The manufacturing process has been divided into partial operations, phases and procedures while manual workers have specialized in certain procedures and they now carry out only a limited number of partial operations. According to new organization principles, production systems have been organized into specialized departments with specific tasks. Carrying on Taylor’s theory, the American manager Henry Ford introduced “assembly lines” in 1913, which led to job breakdown (an individual task took around 30 sec. And it was carried out almost 1000 times during a shift). Undoubtedly one of the most remarkable strategies in the field of manufacturing, Ford’s assembly line tripled the volume of production from 76150 cars to 264972 cars between 1912 and 1914. Four years later, Ford’s company turned out more than 2 million cars a year on condition that cost, quality and productivity indicators kept growing in a spectacularly rhythm. Henry Ford’s mass production allowed production to be lotted while manufacturing plants were organized into production equipment groups, which is still the case for most part of machine industry both in our country and in the West.

Despite remarkable performances, machine-based production systems infect the creativeness of the human factor (people are just performers of some routine operations) and they are added to organizational problems generated by uncorrelated activity of specialized departments (design office, supply stations, production departments, checking stations, and so on.) While manual workers were able to manufacture products to order but at high costs and in small quantities, conventional systems equipped with automatic machines are characterized by low unit costs and increased output in the case of standard production. However, it is this production homogeneity that represents "*Achilles' heel*" in the case of conventional systems, because completely or partially replacing specialized equipment to turn out new products is a very expensive and lasting procedure. In conclusion, the flexibility of production is minimum when conventional systems turn out large quantities of the same product.

Irrefutable successes of the companies that had implemented mass production led to the development of this production type in all the countries in the world and within all industrial branches. However, the disadvantages mentioned above, have connected traditional mass production to the trajectory of a slow evolution towards the so-called "fordism" or "neofordism".

Numerous statistics show that a high percentage of the companies that use the neofordist production system are highly efficient. The main reason might be the fact that this system implies very low unit prime costs because of the large volume of products and it turns to profit the resources it uses.

It is worth mentioning that between the '60s and '90s mass production became a dominant manufacturing strategy of computer assisted production systems. Although the number of companies that used manual workers was decreasing, such companies have survived due to segmentation strategies (conceived for limited volume of production). Under the impact of the technical-scientific revolution, strategies based on craftsmanship systems have changed radically. Thus, the so-called "*computer-assisted craftsmanship*" uses modern information technology and automatic equipment for high quality and low price piece production (according to consumers' requirements) over short periods of time. The best tools and equipment, computers and non-conventional materials can be found within the companies that come into line with this strategy (most of them are automobile companies: Rolls-Royce, Jaguar, Porsche, Ferrari, and so on), but just like in the past, the human factor plays a decisive part in production (hence it results the originality of the denomination: "*computer-assisted craftsmanship")*. Though scarce, craftsmanship strategies and conventional strategies coexist within companies in the field of machine industry.

At present, in developed countries we meet with a slow evolution of traditional production systems towards a superior form of management based on advanced production systems – a synthesis of craftsmanship and machine systems. The new strategy represents the acceleration of the contemporary technical progress, materialized through an intense introduction of computers and electronics in the field of production management. "*The step forward*" implies quick adaptation to the changes within the business environment and to the variety of requests from consumers. This tendency has been anticipated ever since 1981 by an American futurologist Alvin Toffler who states "*while some industries shift from mass production to small-lot production, others have overcome it and they are now making their way towards continuous-line piece production".* The same author also asserts that this new "craftsmanship" has a "*cerebral*" dimension based on information and super-technology since finished products are not made up of the million standardized identical pieces any more but of goods and services adapted to customers' orders.

Advanced production systems (APS) have broken through in economically developed countries (Japan, USA, France) but they can only anticipate radical changes almost similar in magnitude as the ones that took place in mid 20th century, following the transition to automatic systems. *Advanced production systems are forms of modern production based on computer integrated manufacturing, on equal organization of human abilities and on adapted technology.* This concept aims for the development of a flexible, innovative and efficient work and for a more complex industrial manufacturing process, which includes research, development, marketing and services. The research made by "EC Monitor – FAST Program – Forecasting and Assessment in Science and Technology" regarding advanced production systems has led to the conclusion that mere technical ingredients do not place companies in the top of competitive and productivity hierarchies, it is the diversity of specific advanced technologies combined with an efficient work and capability organization.

Advanced production systems concentrate the previous systems of production in the following respects: the part played by the human factor goes beyond the traditional tayloristic paradigm (men can make the most of their creativity, knowledge, innovation and experience, and thus doing more than just carrying out routine operations); high production equipment flexibility tends to the success of piece production at costs that can easily be compared to those turned out on a repetitive manufacturing line; operating process management and coordination uses highly advanced computer technology; systemic approach of the manufacturing process enables the integration of structural components, which are subject to the same strategic objectives. As a matter of fact, the experience accumulated so far in using advanced production systems – although it is relatively poor - reveals their main advantage: competitiveness backed up by a quasitotal adaptability to environmental changes. Because of the competition in these days, similar products are most of the times the result of totally different manufacturing processes; therefore new competitive advantages are made available for managers to profit by. Manufacturing strategies are very important and efforts to improve and develop manufacturing processes reflect on products competitiveness.

The beginning of the '80s, a turning point in competition, has been identified with information technology, based on new policies in the field of manufacturing: the use of robots, computer integrated manufacturing (CIM), flexible automatic manufacturing systems (FMS).

Computer integrated manufacturing (CIM) is an automatic manufacturing system within which the management of production processes – design, supply orders, production, commercialization of finished products - is assisted by computers. CIM first came into vocabulary in 1970. According to SME (Society Manufacturing Engineers), CIM designates a concept or a methodology and a system that can be updated, thus it enables to use one of the most appropriate methods to completely automate the company. Later on, CIM was considered the most important technologic concept of the pilot project conceived to introduce computer-assisted manufacturing in USA's ammunition industry. In 1987, CIM referred to integrated technology and included research and development, production and marketing as managerial strategies. In conclusion, CIM, which was initially considered the company's information network, has later developed into a data processing system, which incorporates computer-aided design and manufacturing (CAD/CAM), production management computers and other controllers used in workshops and offices.

The most significant difference between traditional manufacturing and integrated manufacturing lies in the fact that in the case of the latter apparently opposite and discrepant objectives (efficiency, effectiveness, quality, flexibility, volume, variety, innovation) coexist. Owing to the possibility to instantaneously change the type of products manufactured in the case of mass production, CIM turns out products that satisfy the clients' requests. On principle, CIM can be structured in relation to the company's main activities: Computer-Aided Design (CAD), Computer-Aided Planning (CAP), Computer-Aided Manufacturing (CAM), Computer-Aided Quality Assurance (CAQA), Computer-Aided Logistics (CAL) and Computer Financial Planning (CFP).

If we compared advanced production systems to a human body, we could say that CIM represents "*the nervous system*" that equally controls and correlates the complex system of production, whereas CAM, the subsystem of production is the "*heart*" of any production system.

By incorporating CIM with FMS, the implementation of advanced production systems proves to be more efficient; this new automatic system that breaks through uses programmes and techniques, which are part of the CAM subsystem. As a rule CAM can be designed to suit any production system, but the use of flexible ones is much more convenient, at least from some points of view: organic intercorrelation of several activities like CAD, CAL, and so on. CAM enables FMS-s to satisfy various requests by simply modifying the existing software, thus there's no need to re-design the equipment.

In accordance with the definition given by UNO Committee for Europe, "*a Flexible Manufacturing System is a computer controlled integrated system, which consists of machines with keyboards, automatic equipment to shape raw material and to handle tools, automatic quality assurance equipment because it takes less time and less human effort to carry out production procedures and it can finish, to the best of its abilities, any product in a series of products according to a pre-established manufacturing programme.*"

Although present-day FMS-s are the result of an evolution that spreads over 100 years, the first officially registered FMS dates back to 1968 and was implemented by Cincinnati Milling as the "*variable mission manufacturing*". The new system introduced innovative concepts for that period of time, concepts that are now used on a large scale in engineering: automatic tool control equipment, automatic change of blades and heads, machines and conveyors connected to a main computer server, various products (produced by a certain group of machines) are automatically worked on at random, flexibility to turn out a range of products by small lots, a short period of time is needed to shift to a new type of product or to re-examine the models.

During the breakthrough years words like "*computer manufacturing system*" and "*variable mission manufacturing*" were used as synonyms for FMS. Nowadays there are other meanings for FMS (some of the more or less concurrent); the major differences between them are not functional, they refer to complexity and coverage.

Therefore, researches carried out by UNO Committees can identify three FMS stages:

* *Flexible processing unit*, which is a complex machine (a processing service) assisted by robots and equipped with keyboards.

* *Flexible manufacturing cell*, which consists of a machine and tool layout and of other equipment needed to provide appropriate working conditions in order to turn out products, unfinished products or similar components. The most common manufacturing cell consists of a manual processing unit, while the sophisticated one has several processing units with keyboards, grouped around one or more machine-tool controllers.

* *Flexible manufacturing system* includes two or more interconnected flexible cells (common or complex,) using automatic controllers and carriers (automatic vehicles controlled by computers), which move and off-load blades, components and tools. Thus, FMS is under direct control of a central or local computer, which controls measuring and testing equipment and automatic machine tools, as well.

The major differences between flexible and rigid manufacturing systems are: adaptability to the shifting from one product to another (this implies only a software restoring and not an equipment re-adjusting); integrability (it makes CIM more efficient); the possibility to finish unfinished products at random; the use of hi-tech equipment – computers, robots, automatic controllers and carriers and so on. Nowadays, most of active FMS-s are used in mechanical working processes, but it is estimated that in the near future even more sophisticated systems will appear and these will be able to finish and assemble products (they will be under CIM's control). The development of flexible systems on the American market (nearly 27% during 1989-1998) shows people's great interest in implementing FMS-s.

Advanced production systems represent the natural response of contemporary management to the changes in the competitive business environment. They cannot possibly be considered a "*momentary trend*", although they are not keenly assimilated. Undoubtedly, this will make the strategic decision of the new millennium (2000-2010) and it will be the turning point in the slow transition towards a new production system characteristic for industry, especially for engineering. The magnitude of such change can be compared, from historic point of view, to the "*industrial revolution*" which renewed not very efficient workshops.

References

Bibu N. A., *Flexible Assembly System Management. A Challenge of the Company of the Future*, Sedona Publishing House, Timişoara, 1988

Bărbulescu C., *Efficient Management*, Economica Publishing House, Bucureşti, 1995

Dean J., Snell S., *Integrated Manufacturing and Job Design. The Manufacturing Effect of Organizational Inertia*, Academy of Management Journal, nr. 3/1991

Drăgoi S., Guran M., *Computer Integrated Manufacturing*, Technical Publishing House, Bucureşti, 1997

Platon V., *Advanced Production Systems*, Technical Publishing House, Bucureşti, 1997

Toffler A., *The Third Wave*, Political Publishing House, Bucureşti, 1983.