

Modernization of the manufacturing system of national enterprises by implementing modern information technologies

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Abstract. This article concerns the issue of modernization of the manufacturing system of national enterprises by implementing modern information technologies. The analysis of the need for the industrial transformation of Ukraine at the macro level has been conducted. The role of modernization of the manufacturing structure of the enterprise is determined. Changes in technology have significant influence on the transformation of enterprise management system. The role of modern information systems in management of technological processes is analyzed.

Effective Enterprise Management System (EMS) shall harmoniously combine diverse targeted components into the new competitive socioeconomic system. Changes in areas of EMS improvement during the process of formation of information infrastructure are shown in this research.

MES system is a key element of the overall enterprise information structure; it is able to meet the challenges of the manufacturing sphere.

The existing barriers to the development of production systems for national enterprises are also analyzed and summarized.

Key words: Enterprise Management System, MES-system, manufacturing process, modernization, information technology.

INTRODUCTION

Since 1990 a deep transformation has occurred in the Ukrainian economy. In particular, machine-building complex had experienced long crisis accompanied by significant losses in production and human resources, more than two-fold decrease in the share of engineering products in industrial production of Ukraine, lack of innovation and investment. At the same time, the

machine-building complex in general has managed to preserve its potential, and has found the way to adapt to the new market conditions and to the development of new industrial markets.

Every society is constantly accumulating technological capabilities and potential. Scientific and technological progress has become a determining factor in the transformation of management of manufacturing processes. Economic globalization has become possible due to the technological revolution based on the development of the inventions of the fifth technological structure: speed of production and capital movements through the world has increased dramatically. Today, almost all scientists agree that such factors as constant changes and continuous modernization affect business in today's world.

It should be noted, that changes in technology have significant influence on the transformation of enterprise management system. However, organizational changes mostly precede changes in technology and take place irrespective of such changes, preparing methodological basis for the implementation of this methodology. For example, automation of production was preceded by division of the work into tasks and simple operations that can be performed by low-skilled workers. Organizational technology was not just a simple result of the technological changes; it rather determined the appearance of automated technologies. For example, the Kanban system used by Toyota in the early 50s was based on certain standardized circulation of documents. Summarizing these findings, one could argue that the best results can be obtained by combining the strategic management with the development of manufacturing technologies.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The issue of modernization of the national economy and individual companies draws the attention of national and foreign economists. Recently, a lot of researches highlighted such issues as lack of resources in the national economy at the macro level [1], management capabilities and enterprise development based on modernization [3, 12, 17-18], modernization as an essential condition for the economic reconstruction of the national socio-economic system [9], the issue of innovation and technological modernization [2]. But even more scientists are highlighting the essential need for purposeful transformation of the production management structure with a focus on converting management information system [16]. The most important researches in the field of industrial technologies were conducted by Chernov S.K., Chukhray N.I., Dzhonson M., Flys I., Koshkin K. V., Kristen-

sen K., Kagermann Kh., Kiyentsle O., Kuzmin O.Ye., Mayorova S.A., Meleschenko Yu.S., Svidersky V.I., Habel H. [4-7, 11, 14-15] and many others. On the basis of their researches we can identify patterns of influence on production technologies in the industry (Table 1).

OBJECTIVES

The aim of the research is to develop the concept of modernization of industrial enterprises taking into consideration the conditions of production system.

The authors had the following tasks:

- conduct the analysis of needs for the industrial transformation of Ukraine at the macro level;
- identify the role of modernization for the manufacturing structure of the enterprise;
- summarize the existing barriers to the development of production systems for national enterprises;
- form a concept of modernization of the industrial enterprises of Ukraine.

Table 1. Patterns that have an impact on the manufacturing technologies in the industry

№ n/n	Patterns
	Improvement of the incorporated materials
1.	Changes in the use of materials
1. 1.	Searching and diversification of the natural materials
1. 2.	Creation of new materials for technical use
1. 3.	Identification and using of new features of the natural and synthesized materials
1. 4.	The increasing focus for technical equipment of the application materials
1. 4. 1.	Purposeful selection of materials in accordance with the structure and properties of the technical equipment
1. 4. 2.	Rational use of materials in quantitative terms
2.	Improving the organization of the natural processes
2. 1.	Mastering the more complex forms of motion and expand the range of processes in the engineering
2. 2.	Using increasingly sophisticated and powerful sources of energy
2. 3.	Intensity of the processes increasing (pressure, temperature, speed, voltage)
2. 4.	The purposeful use of the manufacturing processes to increase their utility and rationality
2. 4. 1.	Improvement of the selected principle of action
2. 4. 2.	The transition to a fundamentally new principles of action
3.	Improvement of the work equipment, its structure and function
3. 1.	Wide range of industrial automation tasks
3. 2.	The principle of increasing complexity of the technical objects
3. 3.	Differentiation and specialization of the technical systems, its elements
3. 3. 1.	Functional specialization of the work equipment for a typical operations
3. 3. 2.	Specialization of the work equipment to perform limited and rigid action program
3. 4.	The harmonious relationship of technical parameters of the object
3. 5.	Correlation parameters of the one a number of the technical objects
3. 6.	Selection, extension and consolidation requirements of set-functions
3. 7.	Systematized phasic development of the technical objects
3. 8.	Progressive structural evolution of the technical objects
4.	Evolution of anthropogenic systems
4. 1.	Saving the basic functions of the developmental systems
4. 2.	Relative and partial workaround contradictions of the anthropogenic systems
4. 3.	Increased functional and structural integrity of the systems
4. 4.	Continuity of the functional and structural organization of the multilevel systems
4. 5.	Adequacy of a functional and structural organization of the appointment system
4. 6.	Reducing the stages of development by reducing periods of evolution spirals
4. 7.	Development of the methods for the synthesis of the evolutionary systems
4. 8.	Development of the structural synthesis of the system

Source: grouped and summarized by the author(s) on the basis of the processing of sources:[4, 6-7, 19]

Table 2. Areas of the improvement of the EMS in a process of the information infrastructure building

Management model	Traditional	Modern
Type of management	Focus on functional management	Focus on process-structured management
Goal of the production	The desire for maximum performance	Ensuring flexibility
System of relationships	Inadequate in problem solving	Developed system of the direct and feedback processes
Level of degree of the decision making process	Medium to high	Low
Knowledge base	Absence	Availability
Directions of an optimization	Features	Processes
The level of data concentration	High degree of data integration	Low degree of data integration
The level of data integration	Centralized	Distributed

Source: developed by the author(s)

THE MAIN RESULTS OF THE RESEARCH

The formation of effective Enterprise Management System (EMS) shall harmoniously combine diverse targeted components into the new competitive socioeconomic system. These combinations often require restructured traditional approaches and development of new configurations with unique properties.

Every enterprise is a unique production and technical mechanism. The structure of the enterprise is a composition and collaboration of its internal units, such as: productions facilities, departments, offices, laboratories and other components which are combined into one business unit. There are such factors that determine the structure of the company: the nature of products and technologies, scale of production, a level of specialization and cooperation with other factories and plants, as well as a measure of specialization in manufacturing inside of the enterprise.

Operating structure of the enterprise is dynamic. Production structure is improved together with the improvement of processes and technology, production and workforce management. Modernization of industrial structure creates conditions for intensification of production, efficient use of workforce potential, material and financial resources, and improvements of product quality.

Currently, the development of the system of management for business with an interaction component, in order to support the decision-making process, draws much attention. Management information systems have ensured forward and backward linkages in the broad information infrastructure of the specific business partners that are involved in the economic process in different forms. The changes in areas of EMS improvement during the process of formation of information infrastructure are shown in Table 2.

Very often something new in this area is created not by improving existing management mechanisms but by creating new combinations of them. This can be explained by the fact that current management tools are

highly diversified and therefore their convergence may provide a synergistic effect.

There is an essential need for purposeful transformation of the production management structure with a focus on converting management information system, which explains the natural transfer of personnel from production into information area. These phenomena are associated with the typical features of the information society:

- increased need for operational processing of large amounts of data, in order to control the production and marketing business processes, requires periodic update of the existing processing facilities, transmission, storage and integration of the data. This leads to more complicated business processes in terms of meaningful use and effectiveness of control. It is worth noting that amount of scientific knowledge have doubled in about 2-3 years,
- capital material costs for storage, transmission and processing of information in the information environment are rising substantially. This requires highly effective management for planning the development and organizing its use,
- the lack of common universal software tools greatly complicates description, integration, identification of knowledge in various subjects and areas of business. These processes enhance relevant requirements to the control and revision of information by personnel,
- different data banks are being continuously updated and distributed to global information networks. They reveal opportunities for study or training (including distance learning) for professionals in design centers, academic and industrial organizations.

National industry requires modernization of production, both in the areas of capital equipment and management methodology.

Modernization of technical infrastructure means here introduction of new, more functional equipment with computer management and modern features. The purpose of these changes is to enhance technological

development of the enterprise to the level of modern leading industries. However, if you upgrade only certain elements of the process, the drawbacks at the other stages will arise. It is, therefore, necessary, together with the modernization of technical infrastructure, to improve the organization, planning and management of production and implement methods such as lean manufacturing, calendar resource planning and other methods.

Administration and management of most enterprises already use computer information systems, but there are many gaps between national enterprises in the area of production management. MES system is a key element of the overall enterprise information structure; it is able to meet the challenges of the production. Implementation of

MES system and re-equipment of manufacturing enhances business efficiency. To link the technological capabilities of equipment and modern management techniques such as lean manufacturing, "Just in time" and others we need a management system that is integrated with numerical control machines at the same time. This particular instrument ensures that modernization tools used in manufacturing sphere work effectively.

MES-systems control the current production activities by using data from plans and check it according to orders, incoming requirements of design and technological documentation, actual condition of the equipment, pursuing the goals of maximum efficiency and minimum cost of execution of production processes.

Resource Allocation and Status (RAS)	<ul style="list-style-type: none"> Manages resources including machines, tools labor skills, materials, other equipment, and other entities such as documents that must be available in order for work to start at the operation. It provides detailed history of resources and insures that equipment is properly set up for processing and provides status real time.
Operations/Detail Scheduling (ODS)	<ul style="list-style-type: none"> Provides sequencing based on priorities, attributes, characteristics, and/or recipes associated with specific production units at an operation such as shape of color sequencing or other characteristics which, when scheduled in sequence properly, minimize setup.
Dispatching Production Units (DPU)	<ul style="list-style-type: none"> Manages flow of production units in the form of jobs, orders, batches, lots, and work orders. Dispatch information is presented in sequence in which the work needs to be done and changes in real time as events occur on the factory floor. It has the ability to alter prescribed schedule on the factory floor.
Document Control (DOC)	<ul style="list-style-type: none"> Controls records/forms that must be maintained with the production unit, including work instructions, recipes, drawings, standard operation procedures, part programs, batch records, engineering change notices, shift-to-shift communication, as well as the ability to edit "as planned" and "as built" information.
Data Collection/Acquisition (DCA)	<ul style="list-style-type: none"> This function provides an interface link to obtain the intra-operational production and parametric data which populate the forms and records which were attached to the production unit. The data may be collected from the factory floor either manually or automatically from equipment in an up-to-the-minute time frame.
Labor Management (LM)	<ul style="list-style-type: none"> Provides status of personnel in and up-to-the-minute time frame. Includes time and attendance reporting, certification tracking, as well as the ability to track indirect activities such as material preparation or tool room work as a basis for activity based costing.
Quality Management (QM)	<ul style="list-style-type: none"> Provides real time analysis of measurements collected from manufacturing to assure proper product quality control and to identify problems requiring attention. It may recommend action to correct the problem, including correlating the symptom, actions and results to determine the cause.
Process Management (PM)	<ul style="list-style-type: none"> Monitors production and either automatically corrects or provides decision support to operators for correcting and improving in-process activities. These activities may be intra-operational and focus specifically on machines or equipment being monitored and controlled as well as inter-operational, which is tracking the process from one operation to the next.
Maintenance Management (MM)	<ul style="list-style-type: none"> Tracks and directs the activities to maintain the equipment and tools to insure their availability for manufacturing and insure scheduling for periodic or preventive maintenance as well as the response (alarms) to immediate problems. It maintains a history of past events or problems to aide in diagnosing problems.
Product Tracking and Gencalogy (PTG)	<ul style="list-style-type: none"> Provides the visibility to where work is at all times and its disposition. Status information may include who is working on it; components materials by supplier, lot, serial number, current production conditions, and any alarms, rework, or other exceptions related to the product.
Performance Analysis (PA)	<ul style="list-style-type: none"> Provides up-to-the-minute reporting of actual manufacturing operations results along with the comparison to past history and expected business result. Performance results include such measurements as resource utilization, resource availability, product unit cycle time.

Fig. 1. Functions of MES-systems have been identified by International management enterprise systems association (MESA)

Source: [8, 13]

International management enterprise systems association (MESA) has identified eleven functions of MES-systems (Fig. 1). In a generalized sense MES-system is a source of complete, relevant and reliable information about all aspects of economic enterprises, due to which enterprises can upgrade via timely and reasoned decision-making at all levels of management.

The implementation of MES-systems is complicated because one needs to consider both technical installation of software and hardware from the one side, and organizational processes of personnel and operators working with machines from the other side.

According to MESA international [13] implementing MES in most cases allows achieving the following economic effects:

- reduction of the duration of the production cycle > 45 %.
- increase in work productivity > 30 %.
- reduction of the time for manual data entry > 75 %.
- reduction of the amount of work in progress > 20 %.
- reduction of the time for reporting, filling documents > 60 %.

MES is a part of a unified ERP system for production management with long cycles.

The development of the concept of production in Ukraine has a positive trend; many companies have achieved success in this area. However, there are some issues and limitations that slow down the implementation of ideas, methods and tools for manufacturing systems.

All constraints of production systems can be classified as follows: external factors that prevent the spread of the concept among the enterprises of the national industry and internal constraints that hamper the development of the production system of the enterprise. The external factors are the following [2, 10, 20]:

- controversial, contradictory, diverse terminology,
- lack of information about the phenomenon and practical application of the tools of production system,
- lack of qualified professionals,
- unfavourable market (financial) situation,
- absence of external requirements (from suppliers and customers).

The most common internal factors include:

- insufficient financial resources,
- lack of time for the personnel that is fully involved in current operations,
- unwillingness of employees to develop production system or to participate in the process in any way, natural resistance to the change,
- current organization of workplaces and existing production facilities are also a substantial constraint and hamper the implementation of new tools,

- piecework salaries, which, according to many scientists, limits the possibility to minimize losses by enhancing employees' productivity.

Having analyzed the existing barriers to the development of production systems for national enterprises we came to the following conclusions:

1. According to our estimates, development of new concepts (mentioned above) will be relevant not more than 2-3 years.

2. Development of external and internal evaluation systems for industrial systems has already begun, so their lack will be resolved within 5 years.

3. Factors that hinder the development of the production systems in enterprises will constantly arise, neither Japanese, nor German and American companies can avoid them using their own estimates.

CONCLUSIONS

1. At the present stage the national industry needs modernization of the production in the area of means of production and management methodology. MES system implementation is one of the effective tools.

2. The automation of manufacturing sphere aimed at giving quick response to changing market requirements should be based on the use of the process approach, focused on improving quality and shortening production with minimal costs of all resources.

3. Formation of positive attitude towards the implementation of the manufacturing system, active participation of managers in the implementation, organization of teams and working groups in the workplaces, regular evaluation of the performance of production system professionals, reduction of the distance between the management board and the employees, good financing of the implementation process are those success factors that affect the development of production system that will eliminate the inherent limitations to its effective implementation.

REFERENCES

1. **Balitska V.V. 2012.** Source of the national economy: the proclaimed objectives and the actual state. Actual problems of economy, scholarly economic journal, n. 12 (126), 73–83. (in Ukrainian).
2. **Burov Y. 2014.** Business process modelling using ontological task models. Econtechmod: an international quarterly journal on economics in technology, new technologies and modelling processes. – Lublin–Rzeszow, – Vol. 1. No. 1. 11–22.
3. **Buzhymyska K.O. 2009.** Some components of theoretical and methodological base of innovation and technological upgrading. Bulletin ZSTU, n. 4, 202–207. (in Ukrainian).
4. **Chernov S.K. and Koshkin K. V. 2012.** Conceptual basis for the development of science-intensive enterprises in the competitive environment. East-European Journal of Advanced Technologies, n. 1/2(43), 20–22. (in Ukrainian).
5. **Chukhray N. 2012.** Competition as a strategy of enterprise functioning in the ecosystem of innovations.

- Econtechmod: an international quarterly journal on economics in technology, new technologies and modelling processes. Lublin, Lviv, Rzeszów. – Vol. 1, No. 3, 9–16.
6. **Dzhonson M., Kristensen K. and Kagermann Kh. 2009.** Inventing new business-model. Strategii n. 1–2, 14–24. (in Russian).
 7. **Flys I. 2014.** Conception of simulating the processes of innovative projects initialization for agro-industrial production in Ukraine. Econtechmod: an international quarterly journal on economics in technology, new technologies and modelling processes. Lublin, Lviv, Rzeszów. – Vol. 1, No. 4, 75–81.
 8. Freedom Technologies Corporation website. Understanding Manufacturing Execution Systems (MES). Available online at: <http://www.freedomcorp.com/>.
 9. **Kachala T.N. 2011.** Modernization as a necessary condition for the economic reconstruction of the national socio-economic system. Bulletin Volyn Institute of Economics and Management, n 2, 163-171 (in Ukrainian).
 10. **Karpov D. V. 2010.** Problems of implementation of ERP-systems. Journal of the Nizhyn Novgorod University named by Lobachevsky N. E, n. 4 (1), 233–239 (in Russian).
 11. **Kuzmin O.Ye., Melnyk O.H. and Mukan O.V. 2012.** Polycriterial diagnostics of the enterprise development. Econtechmod: an international quarterly journal on economics in technology, new technologies and modelling processes. Vol. 1, V 3, 55–65.
 12. **Lushchak N.S. and Bepalyuk K.M. 2013.** Modernization as a Process of Change Management in Organization. Proceedings of the 3rd International Conference of Young Scientists EM-2013 of the 4th International youth science festival “litteris et artibus”, Lviv, Ukraine. Electronic edition on CD-ROM, 148–149.
 13. MES center. Available online at: <http://www.mescenter.ru/>
 14. **Novakivskii I. 2013.** Developing a regional information network to support structural forms of business. Entrepreneurship and management. Publisher SAN, Vol. XIV – Issue 8, 301–315. (in Polish).
 15. **Novakivskiy I.I., Bepalyuk K.M, and Lushchak N.S. 2014.** Optimization model of distribution of investment between business lines diversified enterprise. Scientific journal "Business – Inform", Kharkov, Publishing House "INZHEK» n. 5, 133–139. (in Ukrainian).
 16. **Petrovich J.M. and Novakivskii I.I. 2012.** Modern concept of a model design of an organizational system of enterprise management, Econtechmod: an international quarterly journal on economics in technology, new technologies and modelling processes. Vol. 1. No. 4. Lublin, Lviv, Rzeszów, 41–48.
 17. **Shpak, N. and Goryachka O. and Adamiv M. 2013.** The role of innovative creative collectives in anticipatory management of enterprises, Econtechmod: an international quarterly journal on economics in technology, new technologies and modelling processes. Vol. 2. No. 3. Lublin, Lviv, Rzeszów, 65–70.
 18. **Valinkevych N.V. 2012.** Management capacity and enterprise development based on modernization. Bulletin of Chernivtsi Trade and Economic Institute, n. 1 (45), 128–134. (in Ukrainian).
 19. **Volkova G.D. and Novoselov O.V. 2010.** The study outlines the engineering enterprise management, Moscow, Publishing center “Mechanical Engineering”, n. 3, 62–66. (in Russian).
 20. **Zinchenko S. 2013.** The introduction of the concept of production systems in Russia: the typical obstacles and challenges, Almanac "Production Management" № 1, 11–16 Available online at: <http://www.up-pro.ru>.