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THE APPROACHES OF ADVANCED INDUSTRIAL ENGINEERING IN NEXT GENERATION MANUFACTURING SYSTEMS

The article deals with new approaches to the development trends in the advanced industrial engineering in manufacturing systems. The authors emphasize the need for integration of advanced industrial engineering in next generation manufacturing systems, which responds to new trends of production, innovation and advanced technology. This integration represents a sustainable development so that humanization of work is increased, more effective use of natural and energy resources are achieved and production costs are reduced. Trends in the products manufacturing must meet both industrial engineering as well as production management. The development trends in the industrial engineering in manufacturing organizations must use methods and tools of advanced industrial engineering to achieve competitiveness. The third part of this article deals with specification of these approaches in next generation manufacturing systems.

Keywords: *Advanced industrial engineering, development trends, manufacturing system, intelligent agent, autonomous control.*

1. Introduction

Advanced industrial engineering (AIE) must be able to use the opportunities of information technology and scientific methods of industrial engineering. Currently, enterprises are unable to adapt to rapidly changing market and to increasing demand requirements, therefore, we focused on clarifying the possibilities for further development of today's modern techniques of AIE. Industrial Engineering will be recognized as the leading profession whose practitioners plan, design, implement, and manage integrated production and service delivery systems that assure performance, reliability, maintainability, schedule adherence and cost control. These systems may be socio-technical in nature, and will integrate people, information, material, equipment, processes, and energy throughout the life cycle of the product, service, or program. The profession will adopt as its goals profitability, effectiveness, efficiency, adaptability, responsiveness, quality and the continuous improvement of products and services throughout their life cycle [1]. The humanities and social sciences (including economics), computer science, basic science, management science, highly developed communications skills along with physical, behavioral, mathematical, statistical, organizational, and ethical concepts will be used to achieve these ends. Both definitions are clearly aligned with the engineering profession as a whole. The key ingredients that make IE unique in both definitions concern the human and organizational perspectives as bodies of knowledge to be used in developing the desired systems. In this paper, we analyze the advanced industrial engineering in next generation manufacturing systems. The paper is organized as follows: Section 1 discusses the advanced industrial engineering. Section 2 introduces the holistic production system. Section 3 presents results of integration of advanced industrial engineering to the next generation manufacturing companies and future work. Section 4 gives conclusions.

2. Advanced industrial engineering

Advanced industrial engineering (AIE) is based on the standard industrial engineering and pursues a goal to change companies by using new methods and approaches. It deals with the implementation of these systems and the approaches to manufacturing [2].

The significant way in advanced industrial engineering is:

1. The first such a significant way that can be expected in advanced industrial engineering is the development of information and communication technologies that will continue to influence all engineering disciplines, including the education of industrial engineers [3].
2. The second direction is to combine the artificial intelligence (AI) with robotics to create a space for the development of adaptive manufacturing, intelligent devices, and for the development of intelligent manufacturing systems [4].

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3. AIE will more and more move into consulting and service area at the expense of traditional production (research and development services, services related to the use of information and communication technology, management consulting, services related to enterprise management) [5].
4. Significant development of virtual reality and digital factory and their integration into design applications and make process of optimization in laboratory conditions and the following implementation in an industrial environment very fast. This is a major competitive advantage [6].
5. Another change or direction which is to be expected and advised to AIE problems is a question of a new form of cooperation. They should use the knowledge of supply chain management in virtual enterprises. Get in the virtual factory knowledge of all partners to work together in future production [7].
6. It will require a synergy of networking to create added value.
7. In the future, industrial engineering will use more techniques of operations research with advanced base of PC models for production and service problem analysis [8].
8. With the expansion of e-business, companies will need more advanced and accurate techniques for predicting the outputs. These techniques are based on computer simulation [9].
9. Modern IE must be able to use the opportunities of information technology and scientific methods of IE. It must be able to work with the principles of the new Taylorism - human knowledge base and its manufacturing expertise. We also realize a new paradigm of development of industrial engineering.
10. The integration of man and his knowledge base in manufacturing processes.

That's the premise of its success in the future. New directions in relation to the technology platform that is being developed in Europe are the basis for the development of advanced industrial engineering The idea of advanced industrial engineering was well developed by the German professor Westkamper. Advanced industrial engineering is focused mainly on subgroups: industrial networks, adaptive production and digital engineering. They form the core of the changes through which the European Union intends to increase its competitiveness [10].

Decisive role of the rapid adaptation of production depends on the production variability and reduced time for outsourcing. Requirement for adaptive production requires a high degree of control complexity composed into the company network.

Innovative organizational performance is contingent upon the development of its innovative potential. The significant problem in the organization is the question on how to identify it and subsequently quantify it.

In general, the potential characterizes the extent of opportunities of the object under examination which are available to achieve the desired effect. We understand the desired effect as a transformation from the existing state (IS) to the target state (WILL BE).

In relation to the need for creating and commercializing innovation it is necessary to distinguish:

1. **Innovative potential of the product.** Products and services are marketable products of human labor which must be capable of fulfilling the requirements of a potential customer. That is why the first natural object of examination is the product.
2. **Innovative potential of people.** People are carriers of the ability to invent, develop and implement new products. Therefore, the human (humanity) is another object of the study.
3. **Innovative potential of the organization.** For creating innovation and its commercialization, it is necessary to obtain tangible and intangible resources. Usually the working environment of the organization is the environment that allows you to connect the innovative potential of individuals and working groups with innovation potential of knowledge networks.

In the following sections differences of innovative potential of the product, innovative potential of people forming those innovations and innovation potential of the organization are highlighted.

3. The holistic production systems

The systems approach is based on the view that managers should focus on the role that each part of an organization plays in the whole organization rather than dealing separately with each part. It takes into account the different needs of various functional management areas, such as production, marketing and finance. For example, the marketing department might want to be able to sell a large variety of products, while the production unit would prefer to have long production runs of a few items, and financial managers might be mainly concerned with keeping costs as low as possible [11]. This interaction requires a high degree of communication and the breaking down of barriers between the various departments and functions of an organization. The emphasis is on management awareness of:

Subsystems - the individual parts that make up the whole organization, for example a unit, department, company or industry.

Synergy - emphasizes the interrelationships between all the parts of an organization; thus reflecting the concept that the whole is greater than the sum of its parts. This suggests that departments and units in a business are more productive when they work together than when they operate separately.

Open and closed systems - reflect the extent to which an organization interacts with its environment. Companies providing services to the public will normally be open systems, while those working within a larger organization, such as component part manufacturers, will be more closed.

Boundaries - in a closed system will tend to be more rigid than those in an open system where boundaries with the outside environments are constantly changing.

Flows - of information, materials and human energy which move through a system and are transformed in the process into goods and services.

The organization must always be ready for the future, look for technological trends which are perspective to include to their policies, early prepared for the development and production in order to minimize time needed for introducing the product to market and to allow customer to start using it at the right time [12]. The goal of the holistic production system is especially high added value, competitive ability and creative innovation and share knowledge in manufacturing organizations [13].

4. Integration of advanced industrial engineering to the next generation manufacturing companies

Importance is placed on the ability to adjust quickly to the new production of existing requirements and the turbulent states which may be internal or external. The aim of the system is to maintain its competitiveness in the market through the production of sufficient quantities of low-cost, high products quality that meet customer demand. Due to the fact it is necessary for future generations manufacturing companies to be able to autonomously react to generating changes.

Enterprises need to have an integrated telecommunications network and information technology through which they can transmit the necessary information and dates within the organization [14]. Customers require specific and innovative products which can have adverse effects on the environment (Fig. 1).

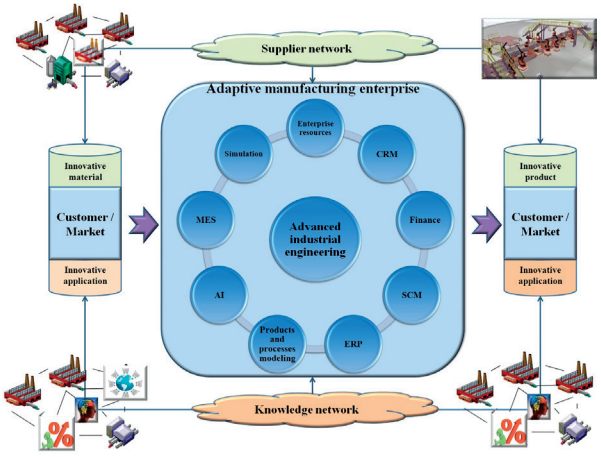

Fig. 1 Network architecture of future manufacturing enterprises

For the development of new product platforms it is necessary to ensure mutual cooperation with partner companies to provide the necessary knowledge to develop new products and solutions on base of sharing experience [15 and 16]. At the same time the intention is to develop advanced materials and new approach to analysis. Simultaneously, the customer must specify requirements through the communication interface over which the enterprise will obtain documents on draft products:

- Implementation of unique information technology.
- Reliable modeling, monitoring and simulation of manufacturing processes.
- Reliable detection of abnormalities.
- The sustainability of production.
- Fast reconfiguration depending on the external environment.

The development of sophisticated information technology and intelligent control of business processes is the key to the humanization of human labor. The trend will accelerate depending on the production environment. In production it is necessary to use a number of information technologies with support of digital engineering (control systems), modeling and monitoring systems. In view of turbulent external environments it requires a high complexity of supply chain management which affects the development of software platforms for enterprise resource planning, management of finances and time efficiency performance of the contracts.

4.1 Digital manufacturing

The turbulent market and global competition affect the requirement for shorting the innovation cycle. Many enterprises tasks are generated as a result of these aspects and growing of complexity within the network cooperation. Disposition of product models allow more simultaneous realization of product development and manufacturing [17]. Consequently, the time which is required to construct models will be shortened and simulation will provide the desired results for the optimum adjustment of production processes.

Digital manufacturing (Fig. 2) provides effective support to business process in manufacturing companies. New product development and meeting deadlines of orders forms an essential application area of supporting tools for digital production.

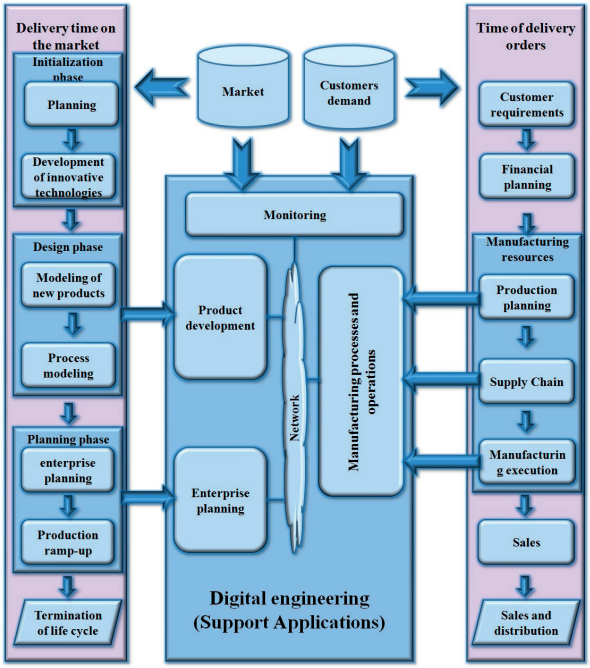

Fig. 2 Digital manufacturing in enterprise processes

4.2 Integration of artificial intelligence

Artificial intelligence that ensures autonomous tasks directionally through the agent communication should be integrated into an enterprise system. Individual agents can transmit tasks and in the frame of interactive activities conduct evaluation activities. Mutual communication is based on priority rules for the realization the current transformational needs of the

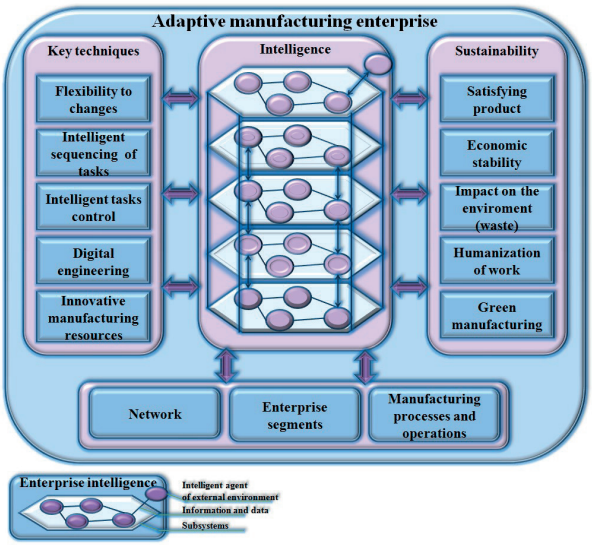

Fig. 3 The integration of artificial intelligence into enterprise infrastructure

defined roles in meeting the corporate goals. The key technology is needed to build an adaptable manufacturing enterprise with embedded intelligence. This technology is represented by the agent communication infrastructure.

Intelligent control mechanism should ensure the transfer of data and information which subsequently perform analytical procedures, evaluation action and remedial activities (Fig. 3). The aim of the integrated control system is the sustainability of the production company in a competitive environment which includes the prerequisites.

4.3 An intelligent learning mechanism

The mechanism is designed to educate the manufacturing facility for the purpose of autonomous operation (Fig. 4). The emphasis is on acquiring knowledge from external and internal environment which is necessary for optimizing the design of products, manufacturing processes, operations and production plan [18]. Output parameters are monitored by the sensory disposition which converts the signals into actual data values and initializes activity of detection mechanism to detect abnormalities through a simulation model. The increasing complexity of system architecture may result in adverse effects on the autonomous control system tasks and system reliability. In view of the fact that manufacturing or assembly system must be equipped with reconfigurability which provides quick configuration of maintenance system and switches generating variants by switching generating tasks depending on the need of production of a particular family of work pieces and subassemblies parts by adding or removing functional elements.

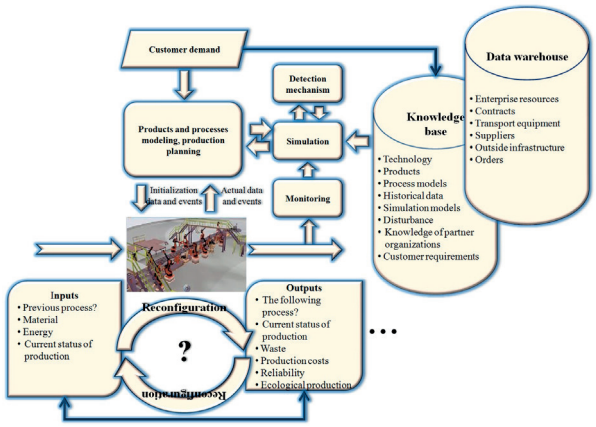

Fig. 4 Intelligent learning mechanism of manufacturing resources

The purpose of the reconfiguration is to change system functionality and ensure the scalability of production capacity. Based on rapid response to changing requirements and the actual behaviour of the manufacturing system, machines (handling

units) can be independently added, removed, modified and converted by the reconfiguration of system. The system with given ability may increase life of production and should offer a cost effective solution in the long term.

5. Conclusions

Transferring this holistic view of a production plant leads to main partial systems that have to be considered: product design, process planning (with interlinked machines and personnel controlled through production management), energy model (the technical building services and the building shell). Having in mind the integrated process model, all involved input and output flow result in a complex control system with dynamic interdependencies between these subsystems via different internal and external influencing variables. Advanced industrial engineering cannot function without the excellence industrial engineers. As a result of the competitive struggle it is necessary for existing enterprises to adapt rapidly and flexibly to the changing requirements of the current market environment. In view of the fact it is necessary to rebuild the thought architecture of today's manufacturing companies.

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