Operations System Agility – the Underlying Factor for Mass Customization and the Most Important Feature of New Industrial Revolution

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Abstract

Modern products become more and more complex and along with this, the requirements for reducing time-to-market and costs are increasing continually. The demand for customized products is growing at the same rate, as well as the search for more effective and efficient utilization of resources and energy, which is already a distinguish feature of industrial development nowadays. In turn, increased agility and velocity of production processes significantly increase the requirements for modern production systems. In order for industrial companies to survive and keep their competitiveness in such a dynamic environment, they must not only increase their productivity, but to improve their operations strategy in terms of agility as well, offering their goods and services. Latter puts new challenges to modern companies.

Introduction

First industrial revolution "elaborated the hardware" for the modern factories and founded the beginning of their industrialization. **Second industrial revolution** provided the "software" – new forms of organizing manufacturing processes (i.e. flow line), the basics for scientific planning and optimizing operations. This contributed to a sharp improvement in productivity. This way, mankind faced next issue (again a "hardware" one) going up on the spiral – the automation. With the introduction and use of electronics and information technology to help the automation, the **Third industrial revolution** began – so-called "Digital revolution". It is also characterized by the integration of programmable logic controllers for automated production systems (SPS). With the increasing product complexity and reduced production batches, however, again new demands are put on the flexibility of production system that are now associated with: market globalization, consideration of the effects and characteristics of individual countries/regions, as well as products/services customization [1,2].

This brings us to the present day and the **Fourth industrial revolution**. It implies a qualitatively new level of organizing and managing the entire value chain, which is oriented now towards individualized customer desires. Essentially, value chain covers the entire life cycle of products, including: the concept, design, development, manufacture, product delivery, its after-sale use and recycling, including related services [1,3,4,5]. Companies already use their operations systems (machines, equipment etc.), as well as the ones of other companies through internet thereby forming so-called *Virtual organizations*. This leads to implementing integrated IT concepts for the whole value added chain, based on the Cyber-Physical Systems – Smart Enterprises, Smart Cities [6, 9]. Involving such intelligent components, the way is paved to the new technology era [7,10,11] (Fig. 1).

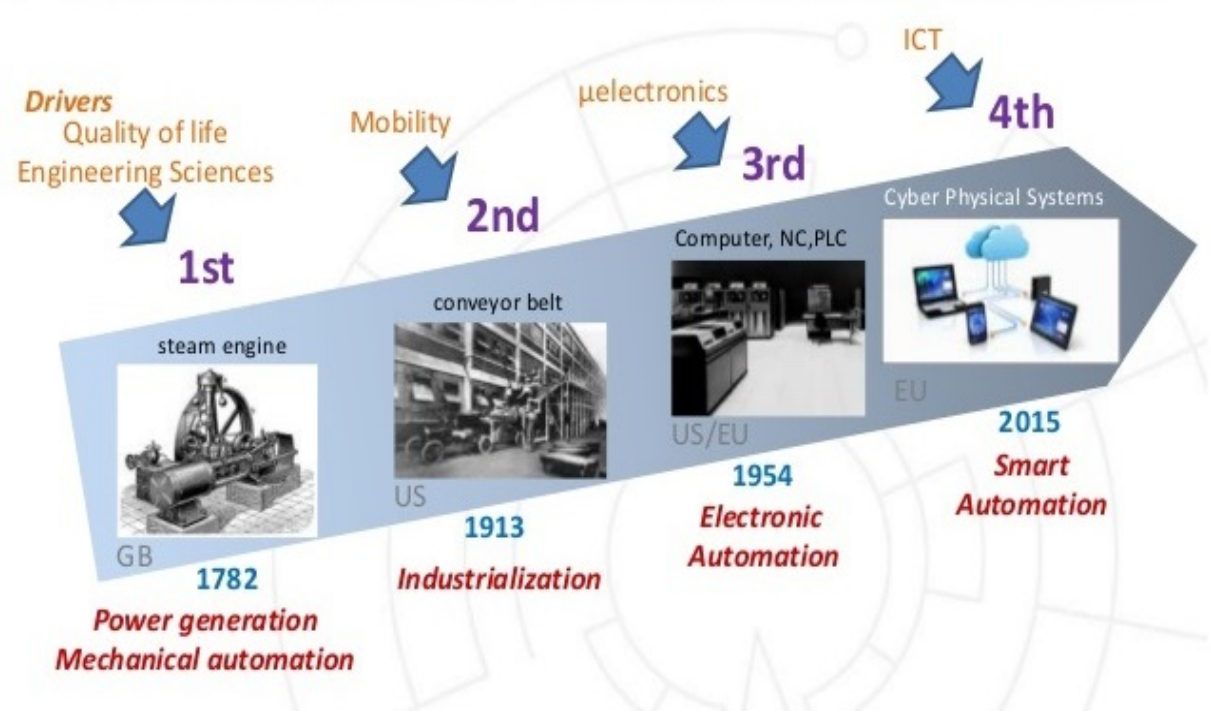


Figure 1. Four industrial revolutions – progressive development of the "hardware" and "software" of factories, i.e. – technology and operations management. Source: German Research Center for Artificial Intelligence (DFKI) [5]

New Industrial Revolution and Agility

Industry 4.0 is radically changing operations and business models, providing opportunities for greater flexibility and efficiency not only in the field of manufacturing, but in the use of resources as well. Among the factors that force these changes are [3,4,5,9]:

- Increasing requirements in terms of flexibility and agility in all phases and areas of operations development;

- Product customization and efficient resources utilization;
- Integration through the whole supply chain and value chain;
- Reengineering of supply chain and value chain with respect of globalizing market.

Given the above, industrial development is focusing on:

- Intelligent production systems that are able to match customers' individual requirements, profitably producing small batches and/or single pieces;
- Agile creation/planning and execution of manufacturing/services;
- Creating new "forms" of added value and new technology/business models;
- Facing challenges such as resource and energy efficiency, demographic changes and trends, "urbanization" of manufacturing etc.;
- More intense and flexible cooperation with business-partners, as well as with the employees;
- Flexible and social-responsive working places;
- Based on the intelligent systems, releasing employees them from routine tasks and helping them to focus on the creative activities with bigger added value. Having in mind upcoming shortages of skilled workers, it is possible that way to prolong professional life and productivity of older specialists and workers, who would combine in a better way their professional life with the private one, as well as with a better training;
- Communications agility allows the direct incorporation of the clients into the creation and manufacture of the products/services, and thus leads to a cheaper customization.

Agility and Opportunities to Optimize Added Value Chain

The challenges and requirements for value chain optimizing can be considered as requirements for a greater flexibility and agility in the following areas [1,2,6,8]:

- Joint development of information technologies and production/operations devices/machinery;
- Shortening Time-to-Market solutions and introducing new technological solutions;

- Implementing agile IT systems without introducing production IT platforms;
- Safety at work without additional investments in complex safety infrastructure;
- Integration and an active support to SMEs with the required IT and manufacturing technologies.

Requirements to the manufacturing companies that are a result of further development of IT cannot be achieved only by focusing on the automation of operations. The establishment and implementation of comprehensive technological approaches is needed. This approach involves a "massive flexibility" to meet the growing and individualized customer requirements [1,4,5].

The Role of ERP Systems in Agility Growth

The new generation ERP (Enterprise Resource Planning) systems support dynamic processes, which are used to increase operations agility. Companies use such ERP systems, according to the conditions of the new operations and market environment. These are intelligent ERP systems with service-oriented architecture (Service-Oriented Architecture – SOA). It enables using services of other software vendors through standardized interfaces. The most important is that it creates opportunities for direct communication of ERP system with the Cyber-Physical Systems (CPS) and “smart products”. Thus, when changes are needed in the production, a simulation is performed using the “in-memory” technology. Operations processes improvement is going now faster and better. Direct access to production data from such ERP system provides much needed "transparency" of technology and business processes while processing individual orders. These solutions are easy to implement as simulations and forecasts ERP system creates are presented in a user friendly way on mobile devices, such as tablets, smartphones etc.

In addition, new ERP systems use the opportunities of Cloud Computing for the so-called Internet-Of-Services (IOS), including these, being performed as web-based software components.

Individualization of Mass Production

The individualization of mass production is characterized with the following important features [1]:

Radically Increased Agility

The high degree of the production system agility is vital for the company's ability to offer a wide variety of customized products (small batches and/or single pieces of end items) at prices that are comparable to those which were typical for the mass production until recently. The trend is increasing the flexibility/agility of the production system on account of reducing batches (Fig. 2).

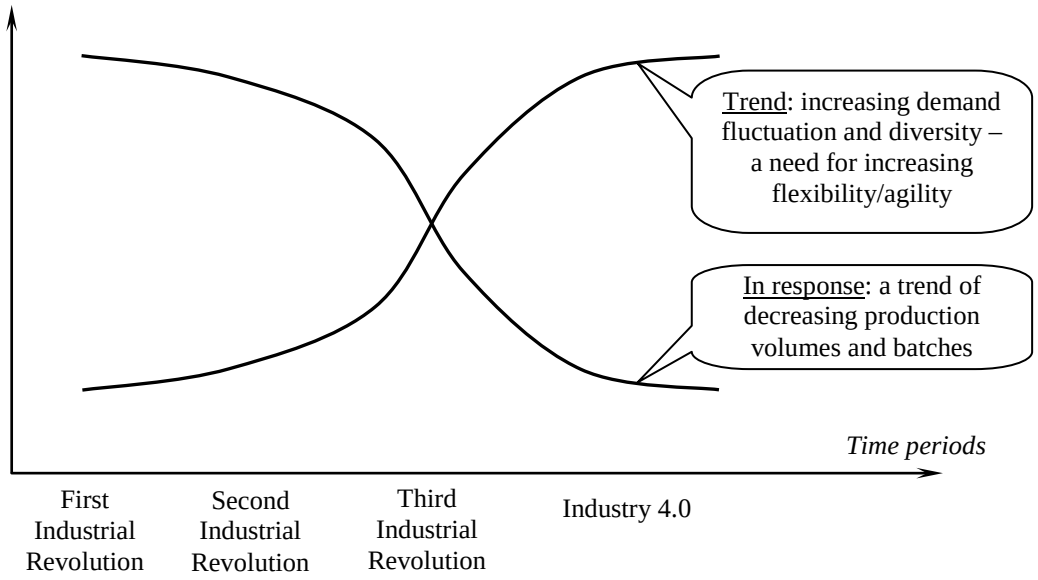


Figure 2. Growth of Flexibility/Agility in response of a changing demand

Quick Innovation Obsolescence

а) Изострената и глобализирана конкуренция води до все по-малки жизнени цикли на продуктите и необходимост от съответно скъсяване на иновационните цикли – пътят от идеята до пазара, както и тяхното „застъпване“ с оглед запазване конкурентната позиция на предприятието.

б) Освен посоченото продуктите стават все по-сложни и комплексни, което увеличава тяхната потребителска стойност и себестойност при неумолими ограничения „отгоре“ за цените.

Много често едното е за сметка на другото, което увеличава пресата върху производствената система на предприятието (фиг. 3).

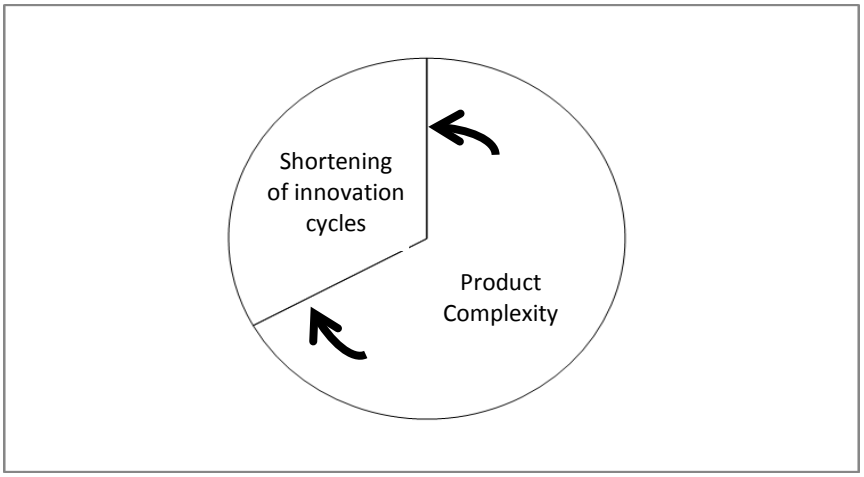


Figure 3. Complexity and innovation obsolescence of products and services

Increasing Efficiency of the Production System

One of the main factors for production system efficiency increasing is the utilization of raw-materials and energy consumption in company operations. The trend is: continuously growing efficiency to maintain or improve company competitive position (Fig. 4).

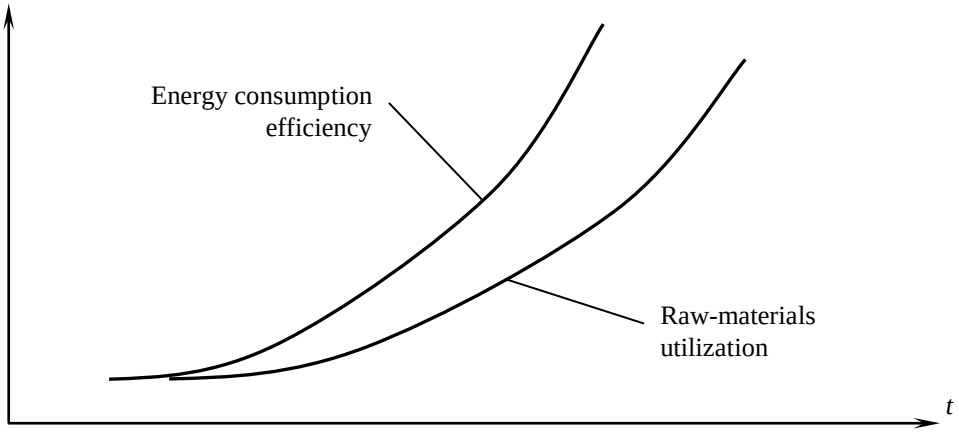


Figure 3. Continuously growing efficiency of operations

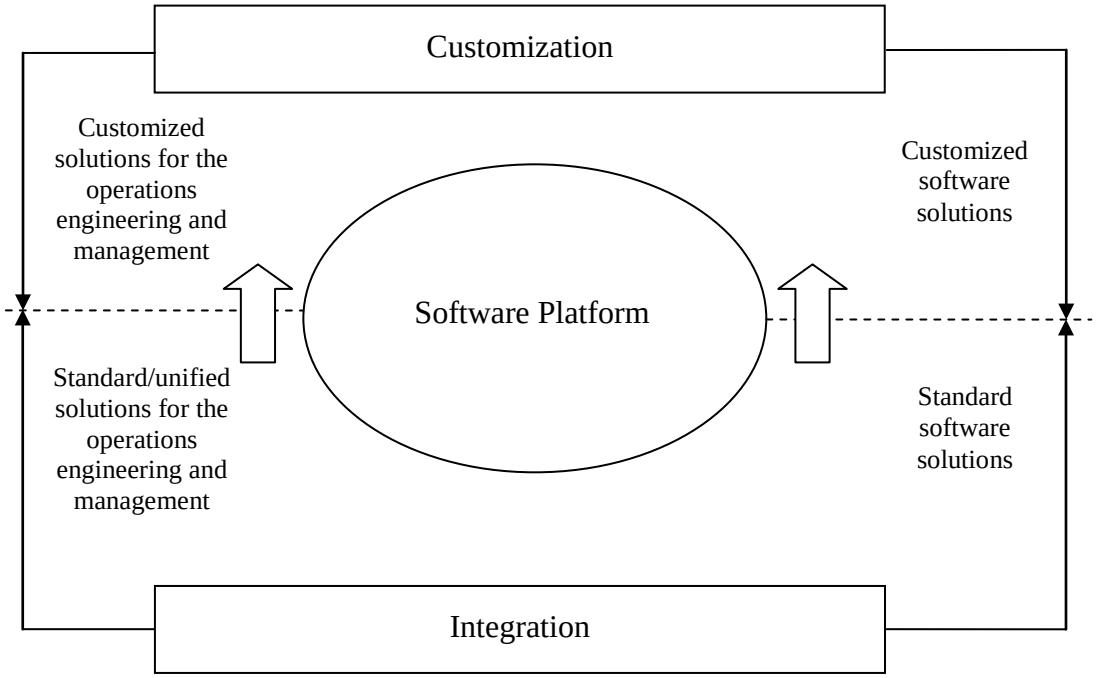
Industrial Software Packages

Over the past 15 years, many industrial companies build their own portfolios of software products that enable customers to take participation through the entire value chain, i.e. they participate in the creation, production and/or distribution of products. This process is increasingly expanding and imposes the principles of mass production to be applied to individual orders – so-called Mass Customization Era came into power. The same trend is also evident in the software market – software platforms with "inter-operations" solutions (customization and integration – Fig. 5). Among the companies in Bulgarian market, the most

common and acceptable solutions seem to be the products of Siemens AG [12]:

PLM Software

Siemens software „Product Lifecycle Management“ (PLM) enables an effective management of the entire product life cycle – from the idea, through design, production, after-sale support and service, to the recycling. By PLM, the packages of Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer Aided Engineering (CAE), Product Data Management (PDM), Digital Manufacturing etc., complement seamlessly.



Фиг. 5. Features of software solutions

Manufacturing Execution System (MES)

SIMATIC IT is a modern MES, which offers a width functions variety and allows to efficiently combine productivity with quality, as well as to accelerate time-to-market. This way, the company can react more quickly to the changes in volumes and diversity, i.e. to ensure greater agility. MES from SIMATIC IT is a component of MOM (Manufacturing Operations Management) of Siemens AG for the digital companies. This solution supports the whole chain of product/service added value.

Digital Enterprise Software Suite is a complete solution of Siemens Industry and also covers the entire product life cycle.

Conclusion

From the foregoing, it can be concluded that today's service-oriented society, as well as the customization of production/services, i.e. co-participation of customers in the production process will have important consequences for the society as a whole in terms of:

- Creation of new technology and business models based on the product life cycle and service orientation, focusing on digital processing and customization of their manufacturing;
- Systematic development of above models and their implementation in practice is to be based on the product/service customization;
- Creation of independent software platforms for small special solutions that lead to increased flexibility/agility;
- Creating opportunities for the end customers directly and accurately inform manufacturers through Internet about their needs and requirements – in terms od variety and time;
- Alternative solutions are now becoming easier to be found by the customers, and potential business models – easier to be "killed in the bud";
- Industrial companies must dramatically reduce production time and increase their flexibility/agility in terms of the trend of mass customization, and in reducing the consumption of raw-materials and energy;
- The process of transformation should help to correct determination of the necessary professional skills and the needs of qualified personnel;
- Engines for development in this direction are mostly SMEs. This process reflects in the growth of new businesses and self-employed people.

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