

# THE ROLE OF CONCURRENT ENGINEERING IN DEVELOPMENT AND DIGITALIZATION OF INDUSTRIAL ACTIVITIES

Tanya Panayotova  
 Technical University of Varna, Bulgaria  
 tagea@abv.bg

**Abstract.** *The modern stage of development is associated with increasing requirements to products and need for sustainable growth, as well as with strive for effective application of technical achievements, industrial and information technologies. The new production concepts require fundamentally new ways for technological construction. The application of the global information networks allows intensification of production and significant improvement of manufactured product quality. The present paper follows the development of Concurrent Engineering (CE) and systemizes its development directions as a whole complex integrated process. It attempts to clarify and determine the place of CE at the stage of general digitalization of project and production activities in an industrial enterprise. Special attention is paid to new software products and their compatibility to the requirements of modern production reality, such as digitalization, artificial intelligence and virtual reality.*

*The place and role of CE in the new world of smart technologies is not only a subject of scientific research but also a huge challenge for its practical utility.*

**KEYWORDS:** ARTIFICIAL INTELLIGENCE, CONCURRENT ENGINEERING, DIGITALIZATION, INFORMATION TECHNOLOGIES, PRODUCTION ACTIVITIES

## 1 Concurrent engineering as an integrated comprehensive approach

Concurrent engineering (CE) occur as a concept and methodology at the end of the last century and was defined as a systematic approach to integrated and co-design of products and their related processes. Typical of the CE is the use of modern high-efficiency methods, tools and procedures based on the latest advancements in the range of computer technology and software, as well as specific techniques of collective work which ensure the production of competitive products in. It was a necessity imposed by the technical development and competitive struggle between manufacturers to reduce costs by means of engineering chain and production efficiency' increasing [7]. Through the application of the CE was achieved the greatest economy of time, because simultaneously is used the effect of the time shortening and reconciliation of allowable times for different stages of engineering project, and the whole project cycle too. The effectiveness of CE use in different directions may be summarized as follows [8]:

- By using of CE is reduced the time from birth of the idea for the design of new product to its submission on the market;
- In CE the product is projected with the right demanded by the market quality characteristics;
- The process at CE is optimized in terms of the costs incurred for design;
- There are obtained products with the right desired by user quality characteristics for the shortest possible period of time and occupying the maximum market niche.

The development of scientific and technical progress led to such technologies by means of which it is possible the application of modern organizational forms in the transfer of information as well as for coordination and permanent control of the stages of development and manufacturing. This development is characterized mainly by improvement of hardware and software products for transfer of information - computer networks. According to its scope of activities they are local and global. The development of global information networks enable the creation of virtual manufacturing where all exchanges of data, results and technologies is based on the principles of CE [7].

## 2 Modern stage in the development of CE

Following the development of CE may be noted that it is characterized with general resources of the complex digitization of design and production activities in industrial enterprise, but also with the special features relating to the engineering nature of the problem [1]. This is may be noted in the latest versions of software products and their suitability to the new production resources, such as digitization, artificial intelligence and virtual reality. Therefore, the role of CE for optimization of resources in real time and needs of flexibility of the engineering process are intertwined with the capabilities of totally integrated automation (TIA). TIA is an open

system architecture, which covers the whole production process and provides an effective interaction between all automation components.

TIA stands for a new concept to realize industrial automation tasks. Existing automation solutions are together composed from a mix of different system technology and manufacturers [5]. Programmable logic controllers are employed in the field level whereas the cell level uses a mixture of PC and PLCs and the process control level only uses PCs. So far it is customary that each of these systems uses a whole different type of software and user interface. Additional differences result as soon as different manufacturers provide the components or include enhancements. By the variety of these different solutions, frequent communication problems occur. Data must be read or written multiple times so that no consistent concept for the preparation of large data quantities exists. The fundamental idea is a consistent technology base for individual problem solutions. It should demand a thorough project maintenance and service philosophy. TIA means the overcoming of the existing system limit. All devices and systems are integrated into a thorough automation solution in which uniformity is reached in data storage, configuration, and in programming as well as communication.

TIA enables the manufacturing industry to optimize its value chain. Having all automation components working together efficiently offers clear benefits in each phase of the production process [5]. TIA brings together the following areas:

- Industrial Communication – Maximizing planning flexibility and implementing the most appropriate network infrastructures while minimizing costs;
- Industrial Data Management - Transparency of all data recorded/generated during operation end ability of high decision-making certainty – for maximum plant operations cost-efficiency;
- Industrial Security;
- Integrated Engineering - Integrated engineering saves time, money, and effort while increasing the profit ability and competitiveness of engineering projects;
- Integrated Security - Systematic minimization of the danger of an internal or external attack on plants and networks.

The implementation of these areas creates an opportunity for flexible organization of production, shorter deadlines for implementation of projects avoidance of duplication of efforts, comprehensive process control consistent quality data documentation, integration of mechanics, electrical systems and automation. TIA in production is related to so called vertical and horizontal integration, which is the basis for the future development of production systems. An important part of this integration takes CE. Cooperation between machine-web, machine-man and machine-machine in the value chain in real time is a modern production system [6]. Automated operations will be interconnected in multitude of networks. Software and networks will connect the intelligent products, digital services and consumers with new engineering solutions.

Horizontal integration processes in engineering create preconditions for [3]:

- dynamic design of the manufacturing processes, thereby providing a rapid and flexible response to extraneous interference;
- complete transparency of manufacturing processes;
- optimal solutions finding;
- new forms of added value;
- new technology and business models;
- response to the contemporary challenges such as resource saving and energy efficiency, urban production and demographic changes;
- greater cooperation between business partners (suppliers and customers) as well as between employees as a result of new opportunities and benefits.

A special place in this integration process is given to and multidisciplinary teams involved in implementation of new tasks in CE [2]. The effects are as follows:

- Workplaces can meet the demographic factor and can be socially committed;
- Based on intelligent systems for support the teams can focus on creative value added activities and can be exempt from routine tasks.
- Considering the upcoming insufficiency of skilled workers it would be possible to keep the productivity of older workers for a longer working life;
- The flexible labor organization will allow employees to combine better their professional and private life, as well as to combine it with better training and improve the work life balance;
- The digital network will enable direct involvement of the customer requirements and cheap customization of products and services;
- There is huge potential for new services and solutions.

### 3 New software packages defining integration essence of engineering

With the development of CE and digitization there are used different types of software that serve the engineering activities. Generally currently they may be grouped in three areas [3]:

First, these are the most used software tools: Product development (CAD / CAE), Process planning (CAP, CAM), Order management (CRM, ERP, PPS, SCM), Operational management (MES, BDE, QM) and Service (IPS).

Second - built in the recent years software packages from industrial companies, making it possible to trace the value chain and to bring them closer to the requirements of cyber physical systems (CPS).

Third. There is a trend of software development for Web services and connectivity via platforms. In this direction operate many companies, technology centers and research institutes. Towards this direction may be referred and software for digital companies. Developed a portfolio of software-based systems which is based on a platform for cooperation (Backbone Data).

The development of the software market, which is closely related to the development of CE, is shown in Fig. 1.

Driving force of modern industries is to prepare the companies for future challenges that follow the increasing digitalization.

Particularly indicative in that regard is the company Siemens, which offers an optimized platform Industrie 4.0 Processes with Digital Enterprise Software Suite, which combines the advantages of the software product for management of product lifecycle Product Lifecycle Management (PLM) with the proven properties of TIA via a common database [4]. In addition to the horizontal integration in the Digital Enterprise Software Suite is available a software of vertical integration – Execution System Manufacturing (MES), thereby it is provided the necessary relation with the levels of management. The advantages are obvious: Everyone involved in the process has access to the same consistent database where any change any update and each subsequent version is immediately visible and accessible to all. On the Fig. 2 is shown the decision of Siemens for implementation of TIA.

#### Process automation includes:

- Management, Planning and Reporting - Manufacturing Execution System;
- Operations, Engineering and Maintenance - Simulation, Process Control System, Energy Management, Maintenance;
- Automation - Controller, Communication, Power Supply and Distribution;
- Field - Process Instrumentation, Process Analytics, Weighing and Dosing, Drive Systems, Industrial Identification, Remote I/O.

#### Factory automation includes:

- Management Level - Manufacturing Execution System;
- Operations Level- SCADA System, TIA Portal Engineering Framework, Energy Management;
- Control Level - Controller, HMI, IPC, Communication, Motion Control, CNC;
- Field Level - Power Supply and Distribution, Industrial Identification, Distributed I/O, Drive Systems, Industrial Controls.

Application of PLM allows effectively manage the product lifecycle from the idea, design, manufacturing, maintenance and recycling, as well as to create and optimize new, non-manufactured till now products [9]. Compliance between the phases of Life Cycles of the Product, Engineering and Project is shown on the Fig. 3. [9]

By PLM are complemented Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer-Aided Engineering (CAE), Product Data Management (PDM) and Digital Manufacturing without problems.

Other product is SIMATIC IT that is a modern MES (Manufacturing ExecutionSystem) with high large scope, offering a variety of functions and allows being combined efficient production with quality and transparency. MES of SIMATICIT is a part of MOM offer (Manufacturing Operations Management) of Siemens for digital companies[4]. This comprehensive solution supports the entire value chain from product development, planning, production, improvement and operation. The result is that on the basis of specific and customized solutions are integrated standardized problems and standardized software by building of a software platform with a single interoperable solutions.

Fig. 1. Development of the software market related to CE.

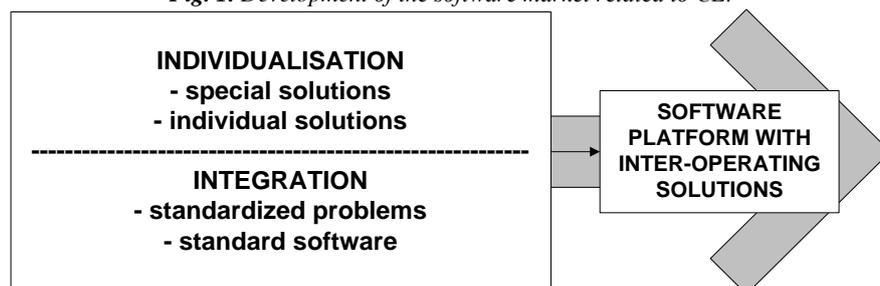


Fig. 2. Decision of Siemens for implementation of TIA [4]

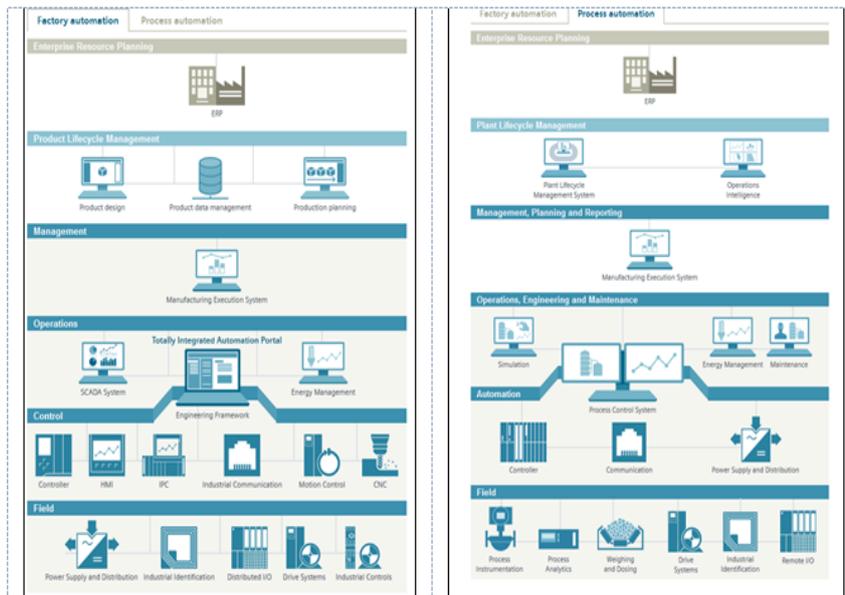
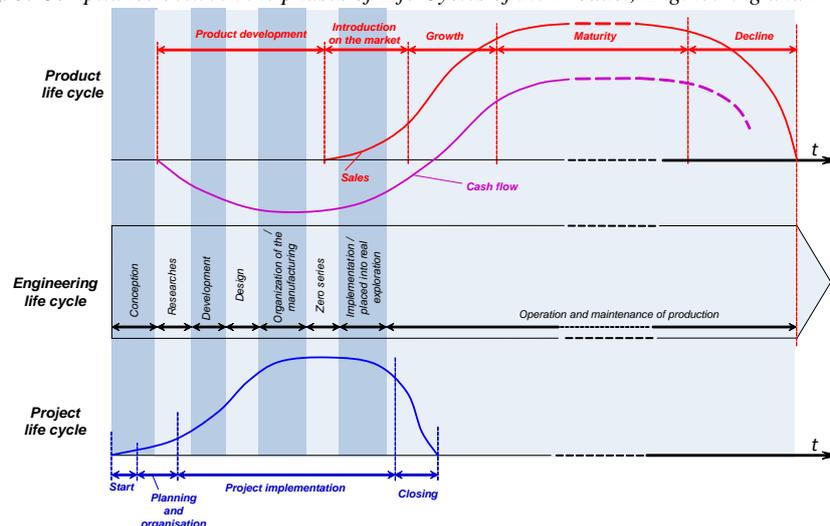


Fig. 3. Compliance between the phases of Life Cycles of the Product, Engineering and Project



#### 4 Conclusion

Based on the above may draw the following conclusions:

1. CE is an integrated comprehensive approach in the modern technological development of industrial companies.
2. The role of CE or optimization of time, quality and cost are interwoven with the capabilities of TIA.
3. The horizontal integration is directly related to engineering.
4. There is identified and clarified the place of CE on the stage of comprehensive digitization of design and production activities in industrial enterprise.
5. New software packages are developed defining integration essence of engineering in recent years, many industrial companies have built a portfolio of software products that enables customers to track the entire value chain.

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