

Conceptual model for assessing the digital maturity of the production system

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Abstract: *The intensity of technology development that we have witnessed in recent years has changed the expectations and attitudes of customers, as well as their understanding of value, and is becoming the new leading factor in the development of the industry. A retrospective of industrial production shows that all stages of change and development that it has gone through are stimulated precisely by the desire to meet the demand, expectations and needs of customers. In this sense, industrial enterprises around the world are clearly aware of the need for change. They should review their current production and sales strategies and focus their attention and efforts on building dynamic production models that will allow them to continue to operate successfully in a highly competitive market environment and changing customer requirements. Digitalization plays a key role in this new scenario in which industrial enterprises must fit in today. Digital technologies and the opportunities they create are the main driving force for the necessary radical change, which companies must rely on in order to increase their efficiency and, respectively, to maintain their competitiveness. This publication presents a conceptual model for assessing the digital maturity of the production system of the industrial enterprise.*

KEYWORDS: INDUSTRY 4.0, DIGITALIZATION, SMART MANUFACTURING, DIGITAL MATURITY, PRODUCTION SYSTEM

1. Introduction

Creating a production model in accordance with the requirements of digitalization is not an easy task and requires a good understanding of the main issues, trends and potential that digitalization creates. According to the author, it is the good understanding, on the one hand, of the requirements and problems / challenges that digitalization poses to industrial enterprises, and on the other hand, that the opportunities it opens for their development should serve as the basis on which to build. Overall concept for digital transformation of production.

In recent years, the problems associated with the processes associated with the digital transformation of business are discussed in depth in the scientific and business circles. The digital transformation is at the heart of the Fourth Industrial Revolution or the so-called Industry 4.0. The technological potential of Industry 4.0 has a crucial role in increasing the efficiency of the functioning of the production subsystem in particular, as well as the enterprise as a whole [1, 2, 3, 4, 6, 7 etc.], allowing to improve the ongoing production and operational processes through the use of high-tech solutions (for example: 3D - printing allows for a quick response to changes in the design of the product, which increases the flexibility of the production system Internet sensor networks make it possible to monitor the implementation of production processes in real time, machine learning software systems allow for predictable maintenance, monitoring, control and optimization of production processes, etc. under).

Businesses in different industries are moving at different speeds on their digital transformation [1,3]. They face a number of difficulties of financial, technological, social nature, etc., which manifest themselves and dominate with varying strength given the specifics of the activity, as well as given the attitude, motivation and will of the workforce to adapt to the new production environment, which is imposed by Industry 4.0.

One of the main questions that arises in this regard is: "What is the level of digital maturity of the production subsystem?" In the author's opinion, finding an answer to this question is crucial for the implementation of effective digital transformation of production, as enabling businesses to:

- to make an objective self-assessment, both of their capabilities and of the progress made in terms of design, organization and management of production processes in a digital environment;
- identify Key Performance Indicators (KPIs) in terms of process digitization;
- to build a clear strategy to follow in the process of digital transformation of production.

2. Model for Assessing the Digital Maturity of the Production System

The author's thesis is that for the implementation of effective digital transformation of industrial production, attention should be focused on optimizing the physical (production/operational) processes and increasing the efficiency of the production system as a whole.

The essence of the model proposed here consists in the analysis and assessment of the situations in which the production system of the enterprise may find itself in terms of the requirements for its digital transformation. These situations are formed under the influence of a wide range of factors, which are generally related on the one hand to the specifics of the physical design of the production system and the current way and efficiency of its functioning, as well as the attitudes of human capital to change imposed in the process of transformation.

The assessment of digital maturity of the production system can be represented by a four-step model, which is shown in fig. 1. Each of the presented levels represents a different degree of digital maturity of the production system of the Industrial Enterprises (IE).

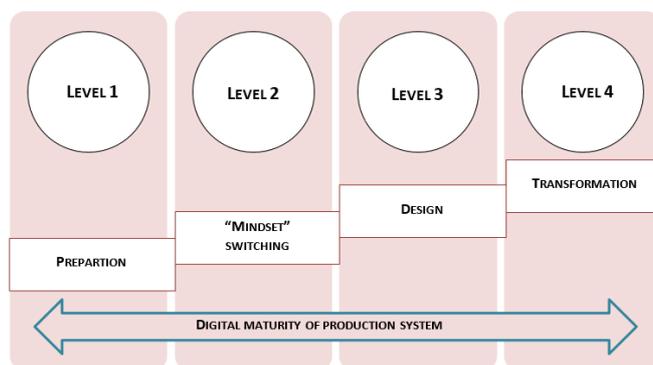


Fig. 1. Levels of digital maturity of the production system of the IE

Level 1: Preparation

At level 1, enterprises and in particular senior management are already beginning to realize the importance of digitalization and the need for serious and in-depth study and acquisition of knowledge and skills in this area in order to lay the foundations of the process of digital transformation of production. At this stage of their digital maturity, enterprises must have a clear idea of the scope of the process of transformation of the existing model of functioning of the production system. As here, it is important to emphasize that digital transformation should be considered on three main levels, namely: (1) technological, (2) organizational and (3) cultural [5]. In other words, at this stage it should be realized that the digital transformation does not simply mean the introduction of new

technologies to support and optimize the functioning of the production subsystem. Due attention should be paid to the construction of the so-called digital or cloud culture, as well as to the way of organizing and managing the processes.

A questionnaire can be used as a tool for level 1 assessment, and for passing this level companies should have a clear understanding of:

- the main reasons that impose the digital transformation as vital for their survival in the modern network economy;
- current technological trends.

The main question to be answered at this level of digital maturity is: "Why things should be done in a new and different way?" The answer to this question must be sought in the understanding that the application of new technologies will not only change the efficiency of the production system and customers' understanding of "value", but will significantly affect the way people work in the company.

The author is of the opinion that the awareness of the need to change this level is crucial for "switching" to a new way of thinking (digital way of thinking), which already provides the potential to move to the next level of digital maturity.

Level 2: "Mindset" Switching

At this level 2 of digital maturity, it is very important for employees from different levels of government (strategic, tactical and operational) to build a new way of thinking. It is necessary to achieve "thinking outside the box". I believe that this is one of the most important factors for a successful digital transformation.

Indeed, the digital transformation is the subject of serious changes in terms of the role of man and his contribution to the efficient functioning of the production subsystem, as well as to the enterprise as a whole.

As a result of digitalization, we are witnessing a significant change in the division of labor between humans and machines, and the following features should be taken into account:

(1) the machines / robots acquire an increasing degree of importance for the functioning of the system, and also become more autonomous / independent decision-making from the lowest level / in the implementation of the tasks / operations assigned to them;

(2) the place and contribution of the human factor to the functioning of the system is substantially changed;

(3) human-machine interaction moves to a new "intelligent" level;

At first glance, it may seem that the responsibilities and workload of people are reduced as machines take over a significant part of their functions. It should be borne in mind, however, that the cyber-physical production environment is characterized by a high degree of technological complexity, which will increase, and this in turn implies the performance of tasks by people / workers in the process of interaction with the system changed and to some extent complicated. The cyber-physical system with which the person will interact directly imposes the need to hire specialists with interdisciplinary knowledge. Given what has been presented so far, it can be said that for the effective transformation of the production system into a "cyber-physical production system" it is important that employees from all hierarchical levels of the organizational and management structure are open to change and have the attitude, the will and motivation to adapt to new roles and the new work environment, as well as to develop skills for continuous interdisciplinary and lifelong learning...

It should also be noted that management should expect the development of some barriers that would make it difficult to pass to level 2. The following may be such barriers:

- workers' resistance to change;
- striving to preserve the style of work adopted so far;
- fear of changing duties and responsibilities;
- fear of changing priorities;
- "we don't need that"
- "this is not applicable to our conditions"
- etc.

The listed barriers should not be ignored, because such behavior on the part of employees would significantly increase the levels of risk and ultimately the transformation would be ineffective.

This connection, in order to successfully pass this level of digitalization, to work actively in the direction of motivating and involving all employees in the transformation process. Every employee must recognize themselves and have a clear understanding of their place in the enterprise and their contribution to the process of digital transformation.

At the output of this level 2 it is necessary:

- to have a new type of organizational culture - cloud culture, which helps to "switch" to the new way of thinking (digital thinking);

- to have a developed policy to support the adaptation of the workforce to the new production environment;

- thanks to the latter, the levels of resistance of the labor force should be minimized;

The toolkit that is proposed to be used for this purpose is again a questionnaire to examine the attitudes of the workforce towards the forthcoming changes.

Level 3: Design

During level 3, companies should start building the vision for creating a digital production model. Successful level 3 coverage involves going through the following phases:

- Phase 1: Analysis

In this phase, the current state of the enterprise should be analyzed in terms of:

✓ The elements of the market environment

Here it is necessary to study the expectations of customers and trends related to their understanding of value. In order to establish the attitudes of the customers in the modern market conditions, a survey can be conducted. Its results will be of paramount help in orienting producers to the expected value of products / services for which customers are willing to pay.

Next, competition and the progress it has made in terms of digital transformation should be examined here. This will enable manufacturers to establish how they are positioned in relation to their competitors and to predict how the new digital production model could contribute to improving the market position, for example.

✓ The readiness of the workforce to the requirements of the digital production environment

As already mentioned, the participation and motivated assistance of all employees in the company (from the strategic, tactical and operational level) is one of the key factors for the realization of a successful digital transformation of production.

In fact, it should be noted here that the process of bringing the workforce ready for the changes caused by the digital transformation begins at level 2, where it is expected to build a new type of organizational culture and, accordingly, a new way of grinding.

In level 3, the relevant deficits should already be analyzed as competencies of employees in connection with, for example, the need to retrain them due to taking a new job / position or to be further qualified in connection with changes in the way they perform their previous tasks. Due to this analysis, appropriate employee training should be planned in phase 2 of this level.

As here, it should be emphasized that digital transformation does not only need IT specialists. In fact, operations management professionals, for example, are becoming quite valuable to businesses.

Table 1 presents an example form for analyzing the competencies of employees in relation to digitalization.

Table 1 Form of competence analysis

Competence	Type of Competence			Applicability
	Basic	Key	Expert	
Competence 1	x			
Competence 2	x			
Competence 3			x	
...		x		
Competence N			x	

✓ *The readiness of the digitization processes*

Bringing processes ready for digitization is crucial for carrying out an effective digital transformation of production. In the author's opinion, the potential of the Lean Manufacturing concept can be used for this purpose.

✓ *The technological potential for ensuring the requirements of digitalization*

Here it is necessary on the one hand to make a study and acquaintance with the new technologies and the possibilities to integrate them into the new production model, and on the other hand to establish what technological basis is currently available and how it can be adapted to the requirements of the new digital production model. Research can be used again as a tool / marketing, literature, good practices... /, in order to identify the latest technological trends.

- Phase 2: Planning

Based on the results of the "Analysis" phase, here in phase 2 - "Planning" it is expected to develop a comprehensive strategy for the transformation of the existing production model into a digital production model. In fact, here producers need to have a clear idea of the scope of work related to bringing production in line with the requirements of digitalisation. The project management toolkit, namely the Work Breakdown Structure (WBS) approach, can be used for this purpose. The main groups of works (Work Packages / WP) of the project for digital transformation of production are the following:

✓ *WP 1: Development of a plan / program for building the necessary competencies of employees in connection with the digital transformation*

As a starting point for the development of the program for building competencies and organizing the respective trainings of the Project staff, a completed competency map will be used in the "Analysis" phase. Of course, the individual areas in which training will be needed should be prioritized according to the needs of the first time. The latter is valid especially with regard to the training of employees at middle and operational levels of management.

✓ *WP 2: Designing the future state of the production system using the Value Stream Map/VSM approach*

Here the value added map for the current state of the production processes is used as initial information, as in the design of the future state all activities that do not add value are removed (minimized).

I support the thesis that in order to transform into "Smart" production processes must be "Lean" „

✓ *WP 3: Designing the requirements for the technological and information infrastructure necessary for the digitalization of production*

Based on the analysis of the current technological potential of the production system, a vision should be developed for the need to master and implement new high-tech solutions. It is necessary to develop a plan for the implementation of new technologies so as not to disrupt the current functioning of the system. Next, the necessary documentation should be prepared, which concerns the

individual elements of the production system. Its data should be accumulated in the central server of an embedded system.

At the exit of this level should be built the so-called "Roadmap for digital transformation" - an example of such is presented in Fig. 2.

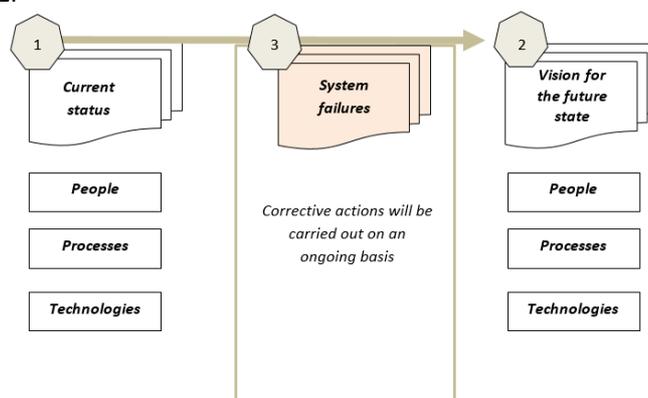


Fig. 2. Example form of a roadmap for digital transformation

Level 4: Transformation

At this level of maturity, enterprises, based on the diversified roadmap for digital transformation, are currently starting to implement their missing practices. In other words, at the level of transformation, the team engaged in the implementation of the "Digital Transformation Project" must deal with the sustainable implementation and implementation of ideas, programs and procedures developed at the level of "Programming". Of course, at this stage they should have already realized that transformation is a continuous process of self-analysis and improvement.

It is important to note that for the successful implementation of the process of digital business transformation it is necessary to continuously monitor and analyze how the role, efforts and incentives of human resources involved in the transformation process have contributed to the management of change, which occurs at each of the maturity levels. Continuous monitoring of the transformation process will make it possible to identify the main positive and negative factors that have influenced the transition of construction in the enterprise of a digital production model.

3. Conclusion

Building a digital production model is one of the main strategic decisions that the company must make and which largely determines its potential to meet the specific requirements of customers. This publication presents a concept of a model for assessing the digital maturity of the production system.

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