

Industry Practices of Digital Twin Technology Application in the Russian Federation

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Abstract—The introduction of digital technologies at the enterprises of different economy branches contributes to more intensive transition to the Industry 4.0. It is based on automation and digitalization of all the processes occurring within the activity frames of business units. Digital twins of products and production processes become one of the profusely developing solutions. Their application supports increase of enterprises' competitiveness, productivity growth, effective project management along the entire life cycle. The research results presented in this article are intended to determination of the digital twins' role in management and control on the entire enterprise and its operation and project activities, to development of recommendations regarding implementation of the digital twin technology in different industries of the Russian economy. The basic research methods were analysis and assessment of effectiveness of the technology implementation. The factors determining interest of enterprises in implementation of digital twins were analyzed. The areas, mostly actual for implementation of this technology, were defined. The obtained economic results of the technology introduction at the enterprises were investigated. The application domains limiting expansion of the digital twin technology were revealed. The legal safety of the digital solutions and technology availability were analyzed. Additionally, the approaches as data synthesis, comparative analysis, graphic data representation, strategic analysis of digital twin technology impact on development of enterprises were applied. The recommendations of industry related implementation of the digital twin technology were complied, the advantages of enterprises at that implementation based on the analysis of the business units' activity were revealed.

Keywords: *digital technologies, digital twins, enterprise, transformation of industry*

I. INTRODUCTION

Automation has been one of industrial growth drivers for decades. It has been providing sustainable competitive advantages and enabling to increase product quality and manage costs effectively. The next technological jump in industrial production was process, product and system digitalization.

Digital economy is based on processing big data and intended to transformation of high-tech production complex into digital industry. Digital technologies may support such trends of year 2020 as hyperautomation, autonomous things, transparency and traceability [11], because maximum cost reduction is impossible without digital process transformation.

One of the directions to build digital economy is introduction of digital twins. This technology has been firstly introduced in 2000-s and within two decades it has become available for most of the companies. However, there are discrepancies in translation of terms and definitions, the technology opportunities are underestimated, there are relatively less scientific approaches to its introduction into industry.

Provision of sustainable introduction of the digital twin technology in industry arises a row of both scientific and practical problems, in particular:

- Transitional terminology in the field of digital twins;
- Not enough open data on experience of the technology introduction both at Russian and foreign enterprises;

- Insufficient analysis of branch opportunities of the technology development in the middle-term prospect;
- Absence of complex approach to the technology introduction at an enterprise;
- Insufficient elaboration of information safety issues.

We will consider these problems more detailed.

A. Transitional terminology in the field of digital twins.

Currently under the term of a digital twin, principally different approaches to digital product generation are understood. Some companies, scientists, developers believe this is a separate technology enabling creation of a virtual product or virtual production [15]. Thereby all the objects of this system shall be mutually integrated and exchange information operatively.

Other companies understand a digital twin as a complex of technologies [9], providing co-use of elements of computer simulation and IoT (Internet of Things). Digital twin assume an entire copy of already existing and acting physical object reflecting all the physical processes being performed in it [3].

The experiences of Russian enterprises show that a digital twin is a 3D model of an object generated with standard CAD (computer-aided design) programs into which metrical services enter detailed data of a real object for its further structuring or construction. That is a digital twin is often created before the product is created; it controls stages of design, construction and mounting. Such projects are implemented in shipbuilding and engine building.

Thereby there is no unified approach neither to creation of a digital twin, nor to its purpose and functions it has to fulfill.

B. Not enough open data on experience of the technology introduction both at Russian and foreign enterprises.

In the Russian Federation, building of digital economy is one of the development priorities. Thereby the information availability via internet for citizens, development of digital platforms, assurance of information safety, and preparation of personnel for digital economy are highlighted [16]. The matters of introduction of digital solutions into activities of enterprises are poorly researched; the program of Digital Economy of the Russian Federation has no benchmarks in this direction. Statistic monitoring also gives data on introduction of ERP (Enterprise Resource Planning), SRM (Supplier relationship management) systems, electronic document flow only, without detailed statistics related to modern digital solutions [12].

C. Insufficient analysis of branch opportunities of the technology development in the middle-term prospect.

The KPMG Company has conducted a research involving over 1,300 big companies worldwide, being industry leaders, and has found that despite of consideration of digital technologies as must have for further growth, 300 companies plan their introduction in long-term prospect only [13]. Experts believe that the Russian Federation is behind the introduction of modern digital technologies for 5-7 years

averagely. As per business and society readiness to introduction of digital technologies, we take the 41st position with significant gap to the leaders [10].

D. Absence of complex approach to the technology introduction at an enterprise.

Very few companies of high-tech economy sector consider digitalization as a complex solution for business management. In 2018, the share of high-tech activities in the Russian Federation was of 21.1%. The digital twin technology may be applied only at the enterprises that have transferred many of their business processes into digital form, use MES-systems (Manufacturing Execution System) in production process management actively. In the Russian Federation, only 12.2% of enterprises use ERP-systems, 10.3% applies SRM-systems [12]. Just few of them understand rationality of digital twins and are ready for their implementation.

E. Insufficient elaboration of information safety issues.

Digital twin is an analogue of a physical object and possesses all its features. However, by nature it is a mathematic model in a continuous development, being no static object with a complete set of features. Many digital models are created with participation of Russian and foreign companies (for example, projects on exploitation), continuously corrected; and the information protection of such developments is very important. Protection of a real object copy is a priority task for enterprises, but it is hardly reflected in the Russian legal acts, based on the opinion of representatives of such Russian companies as RosAtom.

During the research in the field of digital twin implementation, the following research questions arose:

Which is a real readiness of industries to introduction of digital twins?

What are the factors limiting development and implementation of this technology?

May Russia be one of the leaders in introduction of digital solutions in industry?

Assumingly the answers to the above-mentioned questions will help to elaborate approaches to activation of industrial enterprises for introduction of the digital twin technology in those branches where it is mostly applicable; and in the middle-term prospect it will enable to create competitive advantages for the Russian companies.

II. RESEARCH METHODS

Initially the analysis of approaches to determination of a digital twin has been conducted. The digital twin types have been evaluated for the purpose of their applicability in different industries.

The term of a digital twin was introduced by NASA expert John Vickers. Further Prof. Michael Grieves used it to describe a model enabling product life cycle management (PLM) [1].

Currently some scientists join this vision of technology introduction aims and believe that digital twin is a comprehensive representation of an individual product that will play an integral role in a fully digitized product life cycle. [2]

Companies like Siemens represented by Siemens PLM Software, leading CAD/CAM/CAE and PLM systems' developer, are of the same opinion.

Other scientists believe that a digital twin can be stated as a virtual model of process, product or service [7].

There is also one approach showing no precise compliance of a digital twin with a real existing object. Digital twin is a virtual model of a future product or process. It is created on the designing stage, which virtually corresponds with the PLM theory. For example, Shoumen P. A. Datta says that 'In the industrial arena "things" may not be created without an engineering plan, technical specs and CAD/CAM models. The physical entity must be conceived as a digital model, before birth of the product' [6].

From the point of view of simulation forms' development and their applicability in industries, 'the digital twin approach is the next wave in modelling, simulation and optimization technology' [5]. Whereas a sample model is generated with the following features:

- scalability (ability to provide an insight at different scales);
- interoperability (ability to convert, to combine, and to establish
- equivalence (between different model representations);
- expansibility (ability to integrate, to add, or to replace models);
- fidelity (ability to describe the closeness to the physical product).

Within this research, we suppose to determine the digital twin as a set of mathematic models showing dynamic behavior of a real physical object or representing prototype of a future physical object.

The analysis of the statistic information and the results of the companies' focus group enquiry (340 enterprises of different industries in different regions of a country) showed that only 13% of the Russian enterprises perform product life cycle management (among those are Transneft, Aviaagregat, OAO, Perm Motor Plant, OAO). The world leaders are aerospace and defense industries with 24%. In addition, this approach is well spread in such industries as oil extraction, oil production, electric energy, automotive industry, aircraft construction, shipbuilding. These industries are leaders in mastering digital twin technology, because for its introduction high level of digitalization of production, designing and business process management is required.

Applicability of digital twins in Russia is assessed at the level of 10%. The following companies report planning their application: Rosatom, United Shipbuilding Corporation,

United Aircraft Corporation, Kamaz. It is worth to mention that the world statistic is around 16%.

The following factors determine interest of the Russian companies in introduction of digital twins [14]:

- Designer optimization;
- Reduction of object design and construction self-costs;
- Reduction of time costs of a production cycle;
- Real time operation mode control with the following scenario analysis.

Efficiency of the technology introduction is considered from the point of short-term payback as an instrument of cost reduction and optimization of resource application.

III. FINDINGS

The enquiry conducted gave the following results. Of the focus group, 38% of the respondents showed interest in introduction of the digital twin technology in the future. Whereas the probability of the technology introduction in the middle-term prospect is assessed as of 17%. Based on it a conclusion may be made that there are limiting factors with a high level of impact.

In addition, the enterprises were asked to assess their own readiness to introduction of the digital twin technology and to determine whether the digitalization level complies with the requirements. The results were relatively high, over 50% of the respondents in 6 industries declared their compliance with the digital economy requirements. Consumer goods industry shows the lowest rate of 16% (Fig. 1).

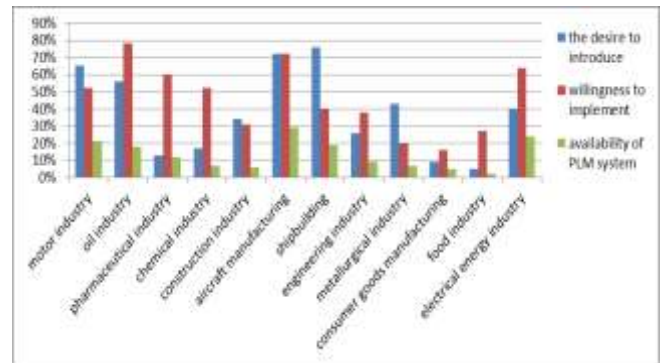


Fig. 1. Branch analysis of readiness to digital twin introduction

Enterprises actually implementing modern management approaches, in particular PLM-systems, contradict readiness of enterprises to introduce complicated digital solutions. In most of the branches, this management system is not applied. The market leaders only use PLM systems in some branches as oil producing, aircraft construction, shipbuilding, and electrical energy industry.

The Ministry for Digital Development, Communication and Mass Media of the Russian Federation has created the Road map of development of end-to-end digital technologies [14]. Smart Design (PLM-systems, digital twins, MES-systems) is among the main sub-technologies considered for

introduction at industrial enterprises. It is considered to introduction into automotive industry, shipbuilding, engine building, and engineering (atomic, heavy engineering, railway). The benchmarks are as follows: 25-50% of enterprises will use Smart Design before 2021; 50-100% of those before 2024. Whereas to 2021 developments of the high-tech products shall reduce for 15%, and to 2024 for 25%. Actual achievement of these values after analysis of statistic data and completion of the enquiry shows that this is more optimistic than realistic approach.

IV. CONCLUSION

The study identified factors limiting the implementation of digital twins technology in the Russian Federation. The following can be distinguished among them:

1. Small share of high-tech industries.
2. High costs of the technology introduction with unobvious economic effect in the short-term prospects.
3. Crisis condition of the economy.
4. Complications with fundraising for development projects.
5. Deficit of high-qualified personnel.
6. Actually insufficiently high level of business organization, change risks and company sustainability.
7. General underestimation of digital twin technology efficiency.
8. Digital twins are objects with low legal protection and information safety level, their introduction is considered also as business risks et al.

If we talk about the readiness of the industries of the Russian Federation to introduce digital twin technology, we can draw the following conclusion. Economic results of digital twins introduction are obvious for market leader enterprises only. For example, for oil producing enterprises the oil extraction coefficient increases for 10%; for shipbuilding the costs for development and construction of objects reduce for 5-15%. Nevertheless, Russian enterprises do not fully appreciate this technology from the position of the life cycle management.

Before the massive introduction of digital twin technology in industry, it is necessary to intensify the approach in the field of government management. A project for the creation of digital twin cities with a population of more than one hundred thousand people is under preparation. It will allow to assess the level of infrastructure, take into account the requirements for the overhaul of facilities, and mathematically calculate the economic stability of the city agglomeration. Creation of digital twins for assessment of building telecommunication networks efficiency can be one of the examples of international experience [4]. In addition, digital twin technologies may be applicable for simulation of the complex defense system, risk consideration, determination of development directions of enterprises of military industrial complex [8]. Positive experience in introducing technology

with the involvement of public funds can show private business the effectiveness of the approach

May Russia become a leader in introduction of digital twins?

There are currently significant restrictions on the software market of the Russian Federation. Many software products that support PLM, SRM, MES systems are not available for implementation due to sanctions; some software products are very expensive to implement, taking into account the cost of maintenance. To ensure a leading position in this area, it is necessary to increase the number of Russian software in the market, to form an affordable price level. It is also necessary to create a product support system implemented in the form of training courses for companies' executives.

The effective use of digital twins is not possible without the initial digitalization of business processes, and it is becoming a priority for Russian industry. Given that the creation of a digital twin of a complex object at an enterprise with a high level of digitalization of processes takes about two years, in the middle-term prospect, the technology of digital twins is available only to a limited list of industries and enterprises with a high level of capitalization.

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