The environmental aspect as an important part of the digital transformation in metallurgy

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Abstract. The fourth industrial revolution is the continuous automation of traditional production processes and production practices using modern intelligent technologies. In the context of the fourth industrial revolution development the digital transformation of the economy is a prerequisite for the possibility of competing at the global level. Digital transformation is an important step for the Russian economy. Metallurgy is traditionally considered a conservative industry, but it has a great digital potential. With industry in mind, the environmental aspect plays a significant role. Thus, the goal of the study is to analyze the experience of digital transformation of a metallurgical enterprise in the context of the environmental agenda. NLMK Group is a vertically integrated metallurgical company that implements the principles of agile manufacturing. It pays great attention to the introduction of modern digital technologies along with the environmental component. NLMK is currently ranked first in the ESG RAEX rating.

Keywords: digital transformation, agile manufacturing, metallurgy, environmental agenda, Russian industry.

1 Introduction

The fourth industrial revolution [1] marked the transition from the development of individual technologies and solutions to large-scale digitalization, automation and robotization of production, and the development of cyber-physical systems. The logical outcome is a "smart factory", where machines and technologies are woven into a single network capable of developing and self-learning. And this is not something from the distant future. The future is already here.
Digital transformation is a strategic imperative of the Russian economy. In the context of the development of the fourth industrial revolution, the digital transformation of the economy is a prerequisite for the possibility of competing at the global level. Russia still lags far behind the countries of the world in terms of digitalization of basic industries.

The digital transformation of the Russian economy will have an ever-increasing impact on various industries. According to experts from the McKinsey consulting company, the additional increase from the introduction of digital technologies will average from 0.4 to 0.9% of GDP per year until 2025. Comparing this increase with the projected growth rates of the Russian economy allows us to estimate the contribution of digitalization at the level of 19% to 34% of real GDP growth from 2015 to 2025.

Metallurgy is traditionally considered a conservative industry. However, digital technologies have long been part of the production processes at metallurgical enterprises. The metallurgical complex plays an important role in the economy of any state. The contribution of the metallurgical industry to Russia's GDP is up to 5%, and to the value added of the manufacturing industry – 17.4%. The development of other metal-intensive industries, especially mechanical engineering, fuel and energy complex and construction, depends on metallurgy. Digitalization of the industry creates new opportunities to increase its efficiency, minimize costs and optimize production processes. According to experts, the Russian metallurgy has a fairly high digital potential.

The theoretical and practical issues of digital transformation of the enterprises including implementing effective management models which meet the requirements of transformation are explored by many scientists. Among them the following scholars are highlighted: Kidd (1994), Goldman, Nagel and Preiss (1995); Gunasekaran (1998), Yusuf, Sarhadi, and Gunasekaran (1999), Larman (2004), Tapscott and Williams (2009), Hansen (2009), Camarinha-Matos, Afsarmanesh, Galeano and Molina (2009), Sutherland (2014), Cooper and Sommer (2018), Huikkola, Kohtamäki (2020), Zhang, W., Jiang, Y., and Zhang, W. (2021), Thompson (2021), Rini, Priyamvada and Jaggi (2021), Ding, Hernández and Jané (2023). It is noteworthy that effective management models which meet the requirements of digital transformation have received wide recognition abroad, both theoretical and practical aspects. In Russia, the spread of these management models is poorly expressed. In particular, too little attention is paid to the environmental component of digital transformation in metallurgy.

Thus, the objective of the study is to analyze the experience of digital transformation of a metallurgical enterprise in the context of the environmental agenda.

2 Methods

The digital transformation [2-7] of an industrial enterprise is a complex process that requires a thorough understanding of the essence of digitalization and knowledge of appropriate management models. Agile manufacturing [8-16] becomes particularly relevant in the context of the formation of the fourth industrial revolution. This concept is able to solve the most urgent modern problems, which consist of uncertainty and rapid changes in business environment. Agile is a strategy for achieving a sustainable development through adaptation to all challenges of the external environment. The essence of the agile methodology is based on the following fundamental principles:

• technical units in cooperation with the business department are located in an open area;
• test scripts are developed before programming stage;
• the development process consists of "sprints" (work cycles lasting from one to four weeks). The output of each cycle is the working code. The widely-known Deming cycle (PDCA) [17] underlies the logic of the algorithm of this process;
• daily morning meetings with a brief discussion of the problems encountered.
So, agile manufacturing can be defined as short cycles of product development that deliver product incremental updates rapidly based on the changing needs of the customer. This method is the opposite to the traditional methods, which value extensive planning and preproduction.

The principle of functioning of agile methodology in information technologies sphere is transformed into its application in the most effective manufacturing strategy within the framework of the fourth industrial revolution. The main regularities of the mechanism for introducing and using the model under consideration, with an emphasis on the scale of activities and taking into account modern means of developing communications are preserved. Next, it is necessary to highlight a number of characteristic features of the agile strategy:

• dual operating system, consisting of the synthesis of a classical hierarchical organizational structure and a dynamic network structure, designated by Kotter [18], as necessary to match modern organizations with the requirements of a rapidly changing business environment;
• rapid reconfiguration of labor and material resources;
• wide application of cloud technologies for integration of interacting companies among themselves and with the external environment;
• multidisciplinary team of the main company;
• avoiding multitasking;
• minimization of losses from possible, unexpected negative changes;
• an extensive partner network of companies;
• high level of customization.

According to a study by company «Trust Technologies», when assessing the positive impact of technology on the environment and occupational safety, 56% of respondents say that the effect will be significant. In the last few years, a significant number of solutions in this area have appeared. The main reason is the desire of companies to demonstrate their involvement in the ESG agenda. Against this background, many industry leaders are actively developing projects in the field of monitoring atmospheric air for the presence of chemically hazardous substances, reducing smoke emissions that form when metal is heated, and purifying water from harmful elements.

3 Results and discussion

NLMK Group is a vertically integrated metallurgical company, the largest in Russia and one of the most efficient steel producers in the world with a vertically integrated business model [19]. The company adheres to the principles of agile management. NLMK is a company that is actively engaged in the implementation of digital technologies for environmental impact monitoring. NLMK is currently ranked first in the ESG RAEX rating.

NLMK Group is one of the leaders in the introduction of modern environmental technologies in the global metallurgy industry. The company's goal is to consistently minimize the impact of production on the environment and strive to achieve the best standards in the field of ecology. NLMK Group has invested more than $2 billion in environmental projects since 2000. During this time, production has doubled, and the company has become the largest steel producer in Russia. At the same time, the environmental impact has significantly decreased due to the introduction of modern technologies and large-scale modernization of equipment.

The long-term environmental program is designed for the strategic cycle of the company and is part of the Group's investment program. The program is aimed at
preventing and minimizing environmental impacts and meeting the best environmental standards in the global metallurgy industry.

The implementation of the environmental program will ensure the achievement of the environmental goals of the 2023 strategy:

- compliance with environmental standards by NLMK Group enterprises;
- reduction of CO₂ emissions \( (\text{scope}_1 + \text{scope}_2) \) up to 1.84 tons per ton of steel and cast iron;
- reduction of NLMK Group's emissions to the level of the best available technologies in the global metallurgical industry – 18.0 kg/ton of steel;
- reducing the discharge of pollutants by 25%;
- an increase in the degree of waste disposal to 92%.

The total volume of investments in environmental protection measures and projects at NLMK Group enterprises within the framework of the 2019-2023 environmental program will amount to about 80 billion rubles.

The need of the present time is the introduction of environmentally friendly innovative technologies at the enterprise using such production methods that will ensure the formation of low-waste and expansion of waste-free technologies with a high level of efficiency and environmental safety for the environment and people.

Currently, the company is working on and testing innovative projects in several areas of activity:

- the use of CO₂ as a marketable product.
- modeling of slag quenching to assess the release of hydrogen sulfide.
- online monitoring of atmospheric air and analysis of the data obtained.
- equipping emission sources with automatic control systems.
- the use of environmental monitoring of unmanned aerial vehicles.
- new technologies for water purification.
- dust suppression from unorganized sources.
- recycling of secondary raw materials.

There are innovations in the field of environmental control.

- Modeling the impact of emissions. A digital service has been developed as part of an innovative approach to assessing NLMK's impact on atmospheric emissions. With its help, the time required to perform an analysis of the state of the atmosphere in various sections is significantly reduced. The program allows you to automatically build user-friendly graphs and diagrams. NLMK processes data from daily measurements (three measurements per day) performed on 9 substances at 12 points in the city, as well as data from 5 observation posts of Roshydromet, to assess the impact on atmospheric pollution in Lipetsk. Both the assessment methodology itself and the digital monitoring data processing service are innovations that make it possible to improve the efficiency of decision-making in terms of atmospheric air protection.
- Analysis of visible emissions. Currently, NLMK has developed a system for analyzing visible emissions using machine vision algorithms and deep learning methods. This will help to identify any atypical emissions into the atmosphere recorded by video surveillance cameras, determine their location and estimated volume. The results are sent to the specialists of the production units and the industrial ecology department of the plant to conduct detailed inspections and establish the causes of emissions. Video cameras cover the observation of the main facilities of the plant with significant gross emissions, organizations bordering the plant with a
significant visible effect on the atmosphere, sources with specific odors. The cameras also capture the view of the enterprise from the point of view of the residents of the city.

- Use of unmanned aerial vehicles for environmental monitoring. The use of unmanned aerial vehicle technology at NLMK Group enterprises has expanded the possibilities of monitoring the environmental situation on the territory of the enterprise and beyond, made it possible to cover the entire area, including inaccessible areas and facilities, and increase the frequency of control.

- Automated control posts at the border of the sanitary protection zone of the enterprise. A new online air quality monitoring system has been introduced at NLMK and Stoilensky GOK sites. The equipment will allow collecting data for a more detailed and reliable analysis of the company's environmental impact. The complex consists of mini-posts with special sensors, which are located on the border of the sanitary protection zone of enterprises. Sensors measure the concentration of controlled substances and transmit readings every five minutes to a single system where environmentalists can monitor the state of the environment and respond to deviations. The complex also takes into account the parameters of weather conditions, which allows you to adjust production processes if necessary. There are 12 complexes installed on two sites.

NLMK Group has fulfilled all the key objectives of the environmental strategy until 2023: it has reduced specific emissions into the atmosphere by 13%, increased the level of waste disposal to 96% (the level of recycling of all recyclables is 99%) and reduced runoff into water bodies by 2 times.

4 Conclusions

Planning and implementation of digital technologies involves a number of barriers for metallurgical companies, among which, according to the respondents, the following are the most common:

- the complexity of integrating new technologies into existing production and organizational processes;
- uncertain return on investment;
- insufficient qualifications of employees;
- financing.

In this regard, in 2022, companies are more careful about prioritizing and selecting investment projects, including IT technologies that are planned to be implemented in the coming years, and pay more attention to managing the effects and risks of projects.

Summing up the results of the study, the following conclusions should be allocated:

- NLMK adheres to the principles of agile management. It is a company that is actively engaged in the implementation of digital technologies for environmental impact monitoring. NLMK is currently ranked first in the ESG RAEX rating;
- the long-term environmental program of NLMK is aimed at preventing and minimizing environmental impacts and meeting the best environmental standards in the global metallurgy industry.
- the environmental impact has significantly decreased due to the introduction of modern technologies and large-scale modernization of equipment.

In summary, the digital transformation of metallurgical enterprises can bring companies to a new level of competitiveness in domestic and foreign markets. In 2023, the
Russian government adopted a new Strategy for digitalization of the manufacturing industry until 2030. According to the document, after 7 years, the share of enterprises whose main production processes have reached digital maturity should be 85%. The authorities also plan to increase the number of companies that use digital twins to 80%, the industrial Internet of Things to 95%, and AI technologies to 85.2%. The largest financing will be received by the interdisciplinary project "Smart Factory" – 8.8 billion rubles. And, of course, the environmental aspect plays an important role.

The most important challenge for the steel industry today is the task of switching to low-carbon development. Already today, metallurgy is beginning to feel pressure from investors, regulators and customers. European countries, China, Japan, and South Korea have set goals for achieving carbon neutrality in 2050-2060. Probably, in the next decade, carbon regulation of greenhouse gases will be implemented in all significant countries of the world. Together with cross-border regulation, it will stimulate the reduction of CO2 emissions in industry.

References

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