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Contents

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Implementation of Tools of the Concept of Thrifty Industry 4.0 on Railway Transport of Ukraine

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Abstract

Military aggression and the collapse of entrepreneurial activity in the country significantly inhibit the processes of socio-economic development of railway transport and do not create any prospects for increasing the volume of work in the near future. In the situation of limited internal resources for development and the absence of stable demand for transportation services, Ukrainian railways need to focus key attention on cost optimization by transitioning to frugality in their own activities. It is possible and necessary to ensure the effectiveness of lean production measures on railway transport in the conditions of the formation of a digital paradigm of socio-economic development due to the implementation of «Industry 4.0» tools. On this basis, the fundamental features of the development of «Industry 4.0» are established and the key provisions of the implementation of the concept of frugal Industry 4.0 in railway transport are revealed.

KEY WORDS: *railway transport, industry 4.0, lean manufacturing, principles, concept of lean industry 4.0, operational efficiency*

1. Introduction

The current period of operation of JSC «Ukrzaliznytsia» is perhaps the most difficult in the history of the railway industry. First, the Covid-19 pandemic and the suspension of transportation due to the closure of borders caused huge financial losses to the industry, which reached UAH 12 billion in 2020. Despite a slight resumption of freight operations in 2021 and the achievement of profitability, in particular, revenue from freight transportation increased by 11.2% to UAH 72 billion, and from passenger transportation (compared to the year when the pandemic began) - by 50.7% to UAH 6.2 billion [1], the real test for rail transport was the events of 2022. The military aggression that brought numerous destructions to the country and the industry in particular (as of November 2022, the damage to the railroad infrastructure is estimated at $4.4 billion [2]) has jeopardized the ability of railway companies to meet the transportation needs of the war economy. The losses caused by the physical destruction of railroad fixed assets were compounded by the losses caused by the decline in the volume of its work: by the end of 2022, the total volume of rail freight decreased by 52.1% to 150.6 million tons. Rail transport suffered the biggest losses as a result of a sharp drop in the volume of iron ore, ferrous metals and construction materials transported, which was the result of the destruction of the steel production infrastructure in Mariupol and a decline in global metal prices. In an effort to maintain its financial stability, the railroad industry resorted to a measure that was not popular but essential for its "survival" - raising tariffs. Despite the promises of the industry's management not to increase freight transportation tariffs, in July 2022, the coefficients for different class tariffs were raised by an average of 70%. However, neither the attraction of UAH 11.2 billion by adjusting freight tariffs nor monthly government subsidies of UAH 2-3 billion allowed the industry to break even in 2022 [3].

The critical financial situation of the railways is largely caused by the significant loss of passenger transportation, the costs of which have been offset by freight transportation for many years. In 2018, losses from passenger transportation amounted to UAH 12.4 billion, in 2019 - UAH 6.5 billion, and in 2020 - UAH 8.7 billion. The only exception was 2021, when the industry managed to reach the profitability zone and make a profit of UAH 6.23 billion. The low level of reimbursement for the transportation of privileged categories of citizens and the significant social burden that fell on Ukrzaliznytsia with the outbreak of military aggression (in 2022, the company evacuated more than 4 million people, 2.5 thousand civilian wounded by medical trains) led to an increase in operating losses and resulted in a loss of UAH 13.3 billion [4].

The tendency for operating expenses to exceed revenues from the sale of services of JSC Ukrzaliznytsia is quite stable and, given the complexity of the economic situation in which the industry is currently operating, indicates the need to introduce progressive models of cost optimization and improve the quality of transportation services, which makes it important to develop projects for the implementation of lean Industry 4.0 tools to help railway companies overcome the crisis.

2. Research

The concept of lean manufacturing and its tools are now recognized by practitioners as an effective enterprise management mechanism that minimizes production costs and maximizes the focus of production on customer requirements by creating added value for them. The philosophy of lean production involves building a progressive production system capable of responding quickly to market changes and increasing the consumer value of products, preventing various kinds of losses. Such a system is based on a number of tools such as the 5S system, Total Productive Maintenance (TPM), Single Minute Exchange of Dies (SMED), Just-In-Time (JIT), Kanban, Poka-yoke, Value Stream Mapping (VSM), Standard Operating Procedure (SOP), 7 Questions Method (5W-2H), Lean Six Sigma, Production Preparation Process (3P), Ishikawa Diagram (4M), Production Planning System (PPS), Total Quality Management (TQM), HOSHIN KANRI and others, The optimal integrated use of which allows eliminating all types of losses, engage employees in resource optimization processes and maximize their focus on improving the company's performance, as well as ensure that the quality characteristics of products meet the requirements of consumers and create a positive impression of their use. Global practice proves that optimizing costs and improving communication with stakeholders is only possible if the principles of lean are properly implemented. A lean approach to managing a company's business processes is not limited to the technical implementation of lean tools, but requires the integration of lean manufacturing guidelines into its philosophy. Companies seeking to increase competitiveness and high adaptability to market requirements need to: first, identify the values that are important to the consumer; second, establish operations and processes to create customer value, i.e. identify the value stream; third, maintain the continuity of this stream; fourth, eliminate potential losses during inventory management; fifth, systematically support transformations and production progress [5].

The implementation of the lean production system of JSC «Ukrzaliznytsia», which combines the best international and domestic experience in lean production and total quality management, is the most important task of ensuring the competitiveness and sustainable development of railway transport.

According to the Strategy of JSC «Ukrzaliznytsia» for 2019-2023, the development, approval and implementation of the lean production system is envisaged. At present, JSC «Ukrzaliznytsia» has approved STP 10-005:2022 «Quality Management System. Lean manufacturing» [6]. Main provisions and glossary of terms». In the future, it is planned to approve other regulatory documents regulating the main methods and organization of work on this issue. In the regulatory documents, the lean production system of JSC «Ukrzaliznytsia» is presented as a culture of lean production, a new management philosophy and a system of continuous process improvement to ensure a competitive advantage at the global level.

Organization of business activities of railway transport on the principles of lean should include the following key aspects

– it is necessary to conduct an audit of activities and develop a strategy for implementing lean production integrated with key business areas;

– it is important to ensure the formation of a competent staff in the field of lean production. This requires both training of key employees who will implement the principles of lean in railway transport operations in accordance with the international certification system and familiarization of all personnel with the industry's lean strategy, including on-the-job training;

– an integral part of the industry's transition to the concept of lean is the selection and implementation of a wide range of lean tools, including simulation modeling tools, management decision support systems, and business analysis tools;

– the key point of implementing lean production is to ensure the integration of the selected changes with the corporate culture, which can be achieved by forming sustainable channels of communication with stakeholders, transforming the organizational structure to accept changes and maintaining the relationship between the philosophy, mission and strategy of the railway transport activity, etc;

– introducing qualitative changes in the industry's business models and processes is possible only by systematically identifying key success tools and adapting them to the transformations taking place in the railway transport environment.

Thus, lean manufacturing is not just a system of rules to ensure that railway transport business processes are oriented to the needs and requirements of the consumer, but, above all, it is a systematic process to support a qualitative transformation of the business model in order to form an effective mechanism for managing resources and competitiveness of the railway industry in a dynamic market.

The emergence of the digital paradigm of socio-economic development has given a new lease of life to the concept of lean manufacturing. Industry 4.0 and its digital tools allow us to solve production problems in a qualitatively new way, especially those related to optimization, productivity and controllability of business processes. In fact, both lean manufacturing and Industry 4.0 support common goals, which are to increase the operational efficiency of companies, while using different technological tools. The lean approach to managing a company's business processes is based on integrating employees into the processes of analyzing and improving the efficiency of production activities, eliminating unproductive actions and costs by standardizing processes and introducing a sustainable culture to support transformation. Industry 4.0 is based on a number of digital technologies and tools that allow to increase the adaptability of business processes, ensure the speed, efficiency and coordination of management actions based on the processing of reliable information and data. The Industry 4.0 toolkit, which is represented by additive manufacturing,

robotics, augmented reality, big data and analytics, cloud computing, cybersecurity, horizontal and vertical integration, industrial internet and modeling technologies, not only allows to maintain the flexibility of business processes and business models of companies, but also creates an opportunity for the company to switch to the principles of a self-managed system and its complete reorientation to the client [7, 8]. After all, the technological capabilities of this toolkit allow processing, analyzing, forecasting data, adapting business processes to changes, and, accordingly, systematically supporting transformations, thereby contributing to the achievement of a qualitatively new level of business systems functioning.

For rail transport, Industry 4.0 technologies offer huge opportunities to improve the efficiency of lean manufacturing measures and support systemic transformations in the industry. First, digital technologies can improve the safety and quality of repair processes in railway transport through the introduction of intelligent traffic control systems, microprocessor-based centralization and interval train control systems, on-board and analytical tools for diagnosing and monitoring the condition of rolling stock and railway infrastructure. This, in turn, makes it possible to increase the efficiency of operational management and rolling stock utilization, improve the quality of repairs and optimize the costs of maintaining railway transport assets in working order. Secondly, digital solutions can significantly optimize the repair and production process and thereby reduce the cost of repair activities. In particular, the creation of digital production facilities and the introduction of additive technologies, digital modeling technologies and augmented reality can significantly reduce the time for the development of components and spare parts for rolling stock repair, while reducing the cost of their production [9]. Thirdly, modern digital services and platforms make it possible to maintain effective communication with customers and thereby reduce the costs (both time and financial costs) of servicing them, while maintaining a high level of quality of transport and logistics services. Mobile applications create an opportunity to serve customers in real time, as well as to study and predict their needs, and develop customer-oriented service packages on this basis. Fourthly, the use of digital tools in the field of railway personnel management allows to increase the level of competence of employees and form progressive mechanisms for their adaptation, introduce social packages and, accordingly, form effective motivation mechanisms, which in turn will help to increase motivation to work and reduce the outflow of personnel from the railways.

Based on the above, the main principles of the development of Industry 4.0 in the railway transport of Ukraine should be as follows

– virtualization is to create a virtual copy of the railway transport, which will create an opportunity to simulate, model and control the course of production processes and allow making progressive management decisions;

– cooperation involves the creation of favorable Internet communication channels that will allow machines, devices, sensors, and people to cooperate;

– adaptation and transformation in real time means that the virtual model of railway transport should collect data in real time, store and analyze it, as well as forecast the situation and, on this basis, develop an effective strategy and tactics of management actions;

– service orientation indicates that the business model and all business processes in railway transport should be focused on maintaining high quality customer service, and therefore the latter should be included in the process of creating value through the capabilities of the Internet of things;

– delegation means transferring part of the management functions to cyber-physical systems and involves the fullest possible digitalization of business processes, reducing the function of an employee to a production process controller, etc.

Thus, Industry 4.0 technologies digitize lean manufacturing approaches and expand the capabilities of lean management tools, thereby contributing to the operational efficiency of business processes from the application of the Lean Industry 4.0 concept. Despite the fact that Industry 4.0 and lean manufacturing are different, the functional combination of the tools of these two concepts allows you to build the most appropriate business model of the production system that meets the requirements of digitalization. Implementation of the tools of Lean Industry 4.0 in the railway transport of Ukraine will increase not only the operational efficiency of business processes, but also ensure their strategic sustainability in the context of transformational changes due to (Fig. 1):

First, the elimination of losses. Smart tools underlying virtual production syst First, the elimination of losses. Smart tools underlying virtual production ems are capable of optimizing business processes on their own. In particular, the use of predictive maintenance technologies (intelligent diagnostic and monitoring tools) will allow predicting failures and thereby prevent their occurrence and minimize potential losses. Big data technologies also create an opportunity for systematic quality control of the transportation process and prevention of disruptions in the process of transportation operations due to delays in rolling stock during loading and unloading operations, etc;

Secondly, the introduction of digital technologies within the framework of the Lean Industry 4.0 will significantly reduce both the level of operating costs and the costs associated with the promotion of innovations. After all, modern rolling stock has improved technical characteristics and is characterized by a significantly lower level of resource consumption for the transportation process. At the same time, the use of digital modeling tools and virtual reality will reduce the duration of the innovation and production cycles and, accordingly, reduce the cost of commissioning innovations and manufacturing spare parts, components and assemblies for repair work;

Third, creating opportunities to improve the organizational sustainability of rail transport. After all, information and communication platforms, large database systems and a number of other digital communication support tools allow to keep in touch with all participants in transport and logistics services and coordinate the transportation process at any stage of its implementation. This, in turn, creates an opportunity to develop progressive management decisions and

ensure effective management of rail transport in real time;

Fourth, improving the operational efficiency of business processes in rail transport and increasing the quality of transport and logistics services through the use of Lean Industry 4.0 tools will increase stakeholder confidence in Ukrzaliznytsia and, accordingly, improve its business reputation in the transportation services market. The growth of loyalty and reliability of rail transport as a national rail transportation operator will also ensure an increase in its capitalization level and create the preconditions for sustainable economic growth.

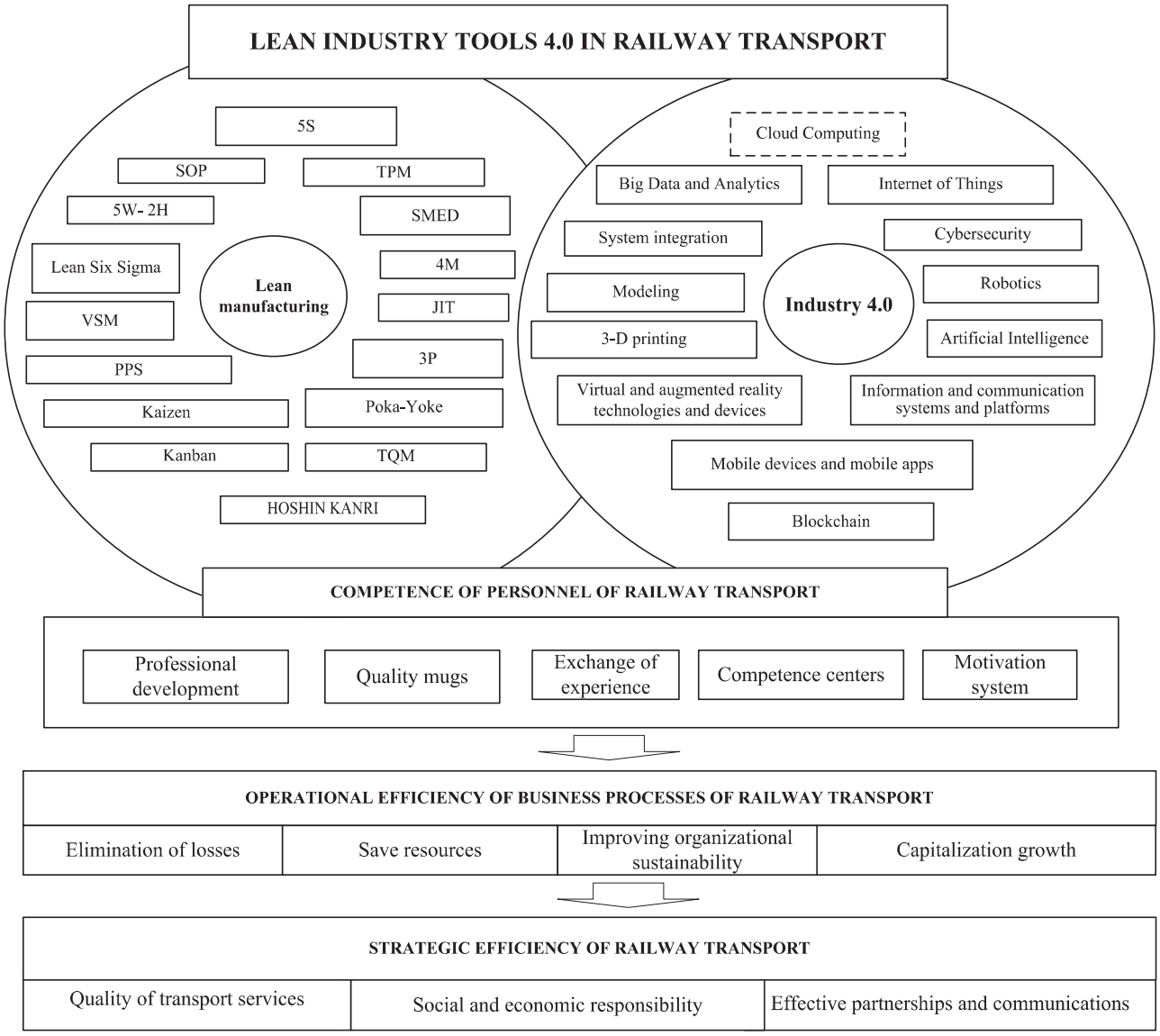

Fig. 1 Key provisions of the implementation of the concept of lean Industry 4.0 in railway transport

When implementing the concept of lean Industry 4.0 in railway transport, it should be borne in mind that the effectiveness of its tools depends on the development of personnel, including their digital competencies. The critical digital skills that need to be developed in railway transport employees in the context of the formation of the lean Industry 4.0 are

– mastery of key competencies and instrumental technologies in the field of work; knowledge and experience in related areas («T-shaped specialist»);

– «digital agility»; ability to work with big data and visualization tools; understanding of the basics of cybersecurity;

– systematic thinking and the ability to assess risks and threats caused by digitalization;

– emotional intelligence;

– ability to work in a team, mastery of modern project management methods for the implementation of tactical and strategic tasks;

– desire to develop an ability to continuously learn;

– ability to solve problems on a turnkey basis;

– flexibility, adaptability and ability to work under uncertainty.

Taking into account the above, the primary tasks of implementing lean Industry 4.0 in railway transport include

training of the company's management and all personnel in the methods and tools of lean Industry 4.0, using the entire arsenal of tools for developing their competence. At the same time, it is important to develop an effective system of staff motivation, using both tangible incentives (introduced or approved before the proposal is implemented) and intangible ones (for example, the opportunity to participate in management, implement their ideas, career development, etc.)

3.Conclusions

The sustainable socio-economic development of railway transport today depends on the industry's ability to effectively use the possibilities of digitalization to qualitatively transform the business model of the industry and increase its operational efficiency. Based on this, the article examines the peculiarities of implementing a lean approach to managing companies' business processes and reveals the key aspects of organizing railway transport business activities on the principles of lean. The fundamental features of the development of "Industry 4.0" are established, and its possibilities for increasing the efficiency of lean production measures and supporting systemic transformations in the railway industry are determined. This made it possible to substantiate the basic principles of the development of Industry 4.0 in the railway transport of Ukraine and to reveal the key provisions of the implementation of the concept of lean Industry 4.0 in the railway industry. It has been determined that the introduction of lean Industry 4.0 tools in railway transport will eliminate losses, ensure resource savings, increase organizational stability and increase the capitalization of the industry, which in turn will help improve the quality of transport services in the industry, implement the principles of socially responsible management and form effective partnerships and communications with key stakeholders in railway transport.

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