The Application of Process Mapping to Create Improvements in Production Logistics at the Example of the Shipbuilding Industry Plant

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Abstract: The hereby article presents an example of application of the process mapping method in analysis of barge production logistics. The method was described briefly and the logistics of production of a barge produced in the shipyard industry were characterized. Three possible modernizations were suggested on basis of the prepared production process map that consist in technological, organizational improvements and an option that combines both of these solutions. AnyLogic program was used for comparative analysis of the suggested options in relation to the process in the base option. This is particularly important for proper drafting of the process computer models in applications for their modeling and simulation.

Keywords: Process mapping, production logistics, process improvements, shipyard industry.

1. INTRODUCTION

Logistics is not a new concept. Its origins date back to a distant past, and the source of the word comes from the Greek *logos* or *logicos* (counting art, counting, correctly thinking, reasonable), or the French *loger* or *logis* (accommodation, accommodation) [8].

Logistics as a field of knowledge owes its development to military forces. It is a theory and practice of military activity in the fields of supply, transportation and communication, administration, maintenance, repairs, evacuation of injured and sick people, use of local resources, implementation of construction projects and investments. Military logistics is understood as a uniform process of supply (materials, equipment), activities (identification of needs, delivery, division), and functions (planning, organization, execution, control) [6, 9].

Logistics in a civil perspective is not clearly understood by many people, even those who are involved in it. However, this term did not have a uniform definition, such as production or marketing. Logistics is usually understood as the management of movement and storage operations, which are intended to speed up the movement of products from their places of origin to their final consumption, and to provide information in order to offer the customer an optimal level of service at a reasonable cost. Product should be considered in this definition in a broad sense, both as services and goods [1, 5].

The system approach is one of the basic forms of modern logistics. The different definitions of the concept of logistics draw attention to its systemic nature. The identification and definition of logistic systems focuses on a comprehensive analysis of functional, instrumental and structural features, as well as the problems of their formation and the effects of interactions in the form of an integrated concept of raw materials flow, information flow and logistical activities [1, 5].

Presentation of the company as a system of behaviors in which parts are interrelated by various transformation processes facilitates the transfer and use of the assumptions of the system concept on the basis of logistics, and at the same time it requires it. The defined tasks and objectives of logistics identify the basic transformation processes in terms of time and space, quantity and quality in the space of goods and information flow, constituting an integrated logistics transformation subsystem.

The logistic system can be presented as a general set of logistic elements whose relations are concretized by the above mentioned transformation processes. Between these elements, with certain properties, there are close links, also in the organizational sense. This means that the structure of the logistic system is built only by those logistics processes that are connected in a systemic way with due organizational solutions. All this leads to a new organization or reorganization in the field of logistics in terms of the requirements for the operation of the logistics system [1, 5].

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Analyzing the logistics system as the structure of an enterprise, it can be presented as a subsystem of an enterprise. However, the company may be part of the logistic chain structure, perceived as a meta- or macro-economistic system. In such a case, the company should demonstrate specific logistical and system characteristics that allow it to be linked to other companies or entities in the logistics chain. Which of the layouts will be treated as a system, and which as a subsystem, depends on the purpose and outcome of the analysis and also on the problem to be solved [1, 5].

Looking at the comprehensive approach to the concept of logistics, it should be remembered that in the process of the synthesis of the logistics system, the identification of links between its various elements is becoming increasingly important. Individual behaviors between the elements of logistics are the key to defining and identifying the logistics system, which makes it possible to integrate elements on a company-wide scale.

Logistics systems are open systems because their components are in relation to the system environment. An example can be an element of logistic service, which is related to the activities of production, supply and supply of the enterprise and other enterprises. The logistics system can also include logistic processes between the company, its suppliers and customers as partners in the creation and delivery of logistic values. The organization and presentation of logistics processes as a logistical system enables the analysis of this system from the point of view of its behavior. The way in which the logistics system behaves is a result of cooperation between all elements of the system and between each other, as well as with the system's environment [1, 5].

The basic problem concerning the identification and shaping of the logistic system leads to defining the structure of the system and determining the relations between it and the elements of the company. The lack of appropriate criteria for the allocation and structuring of the logistics system may lead to the fact that the most important links between the elements of the system and its environment will not be taken into account. Tool that can be used to analyze the structure (system) of company's logistics may be e.g. *process mapping method*. Thanks to it you can present the whole logistic structure of the company.

Process mapping is a method that consists in graphic imaging of the functioning of the given process or a group of processes, operations and presenting the relations between them. In the majority of cases it needs to be, however, understood what activities such a process is composed of. Creating a map of relations is an essential step in the mapping process. The process map presents particular actions that combine into material, informational and financial flows in the given process. Such schemes often give managers the very first comprehensive view of how a given process operates. The experts designed a set of graphic symbols that present various aspects of the process [7]. Figure **1** presents the most common symbols.

Due to the high level of detail orientation, the diagrams of sequence of subsequent actions within the process may quickly become overly complex or wander off track if no effort is made to stay focused on the given goal. It needs to be remembered that the idea of mapping consists in documenting the real course of the process and not people’s concept of it. In most cases employees must physically familiarize themselves with the production process. The management will have to make the decision as to which stages of the process they wish to be analyzed. The areas that are beyond the managers’ control and those not directly connected with the process should be skipped [2, 4].

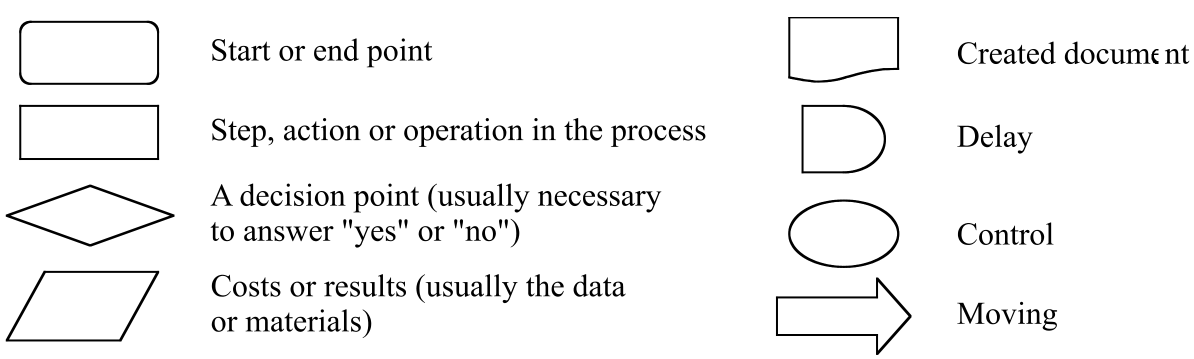

Figure 1: The most common symbols used in the processes maps [7].

Figure 2: View of the finished barge while launching [12].

The hereby work presents results of analysis of barge production logistics using the process mapping method which made it possible to suggest a number of organizational and technological improvements of the production process [3].

2. CHARACTERISTICS OF BARGE PRODUCTION LOGISTICS

The first steps preparing for barge production (Figure **2**) is delivering material lists to the supply and quality control departments. The supply department places materials orders in accordance with the materials list, which is followed by the quality control department performing their verification on basis of the documentation and certificates. The next step is collecting the ordered materials, which are stored on the facility premises, part of them in the warehouse and the large metal sheets in open air. They are then marked depending on the size, thickness, type etc. The transportation department deals with their delivery into the production hall.

The material processing is carried out in a multi-channel way. Metal sheets of different formats are delivered onto the CNC (Computerized Numerical Control) heat cut-off machine, where first particular sheet elements are marked and then the previously marked elements are cut in accordance with the documentation transferred into the machine's computer. Some of them later undergo processing (e.g. shape) on other posts. The thus created elements are then passed on to the assembly groups composed of fitters and welders.

The fitters then use these elements to assemble a construction (with contact welds) e.g. section, hull, bridge house etc., while the welders finalize the whole work. They must hold special qualifications depending on the welded connections they deal with. On the stage of making particular barge sections the so-called construction straightening takes place so that no incorrect matching occurs when the sections are put together into larger ones. In order to make the best possible use of time works connected with reinforcing the barge are carried out as the block is welded. The barge is equipped with all kinds of passes and chucks for water, electric, air, sewage and oil installations. If, however, the given block is finished, a control of the welds quality and leakage tests are carried out. A barge is composed of three blocks. The whole external construction of the barge is created when they are welded together.

The next production stages are: sanding, metallization and painting. They are carried out by external companies on the facility premises. Sanding consists in cleaning the material surface of all kinds of impurities using sand blasted at high-pressure thanks to compressed air. The metallization is supposed to protect the given surface against corrosion by spraying a thin layer of metal (zinc). Painting is the last process, which consists in subsequent paint layers being sprayed over the painted surface.

The next process is equipping the unit with proper devices, installations, systems etc. Part of that takes place during painting when the construction is still in the wharf, while the rest after the launching. When all

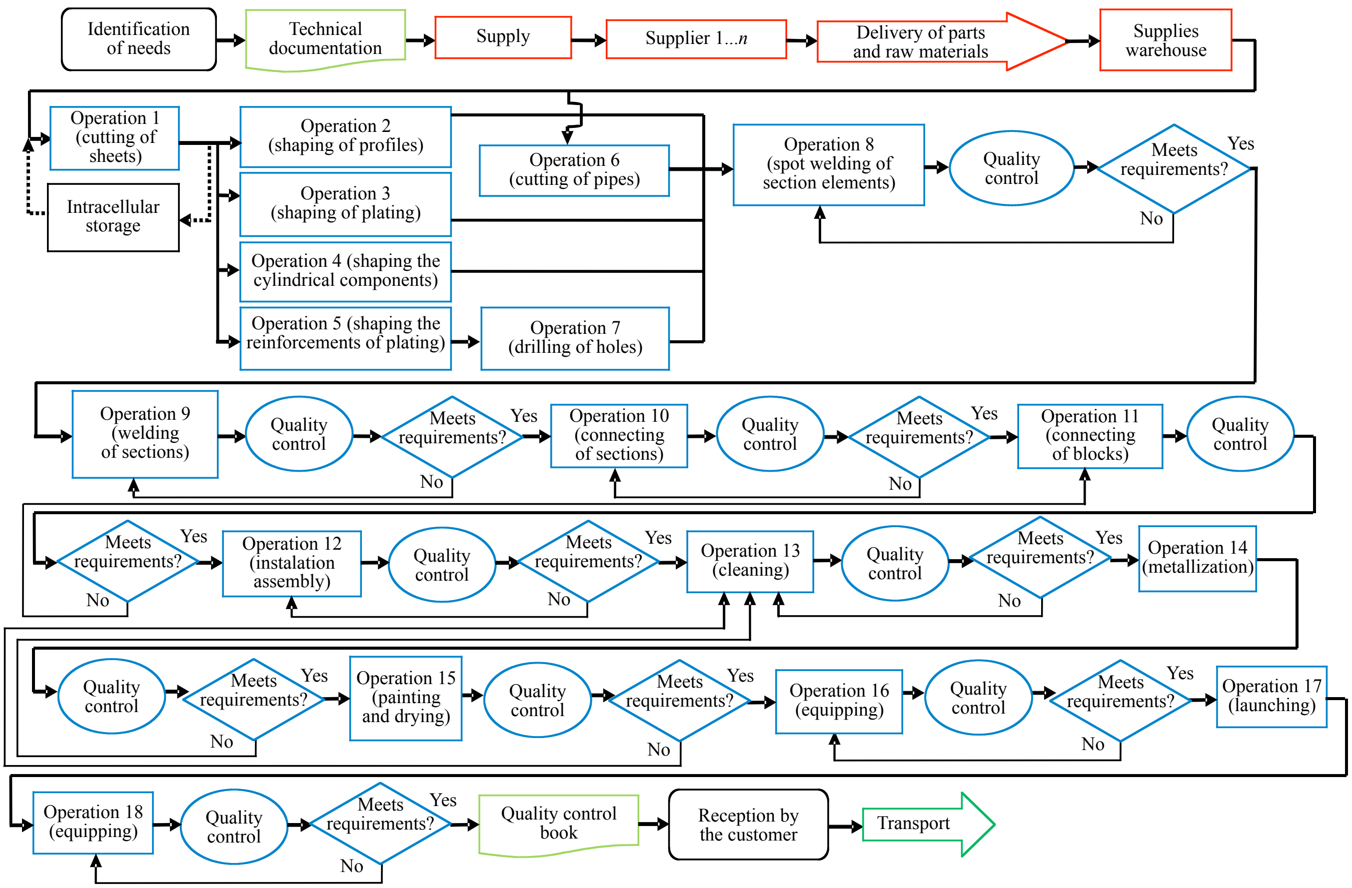

Figure 3: Map of logistics process – the state before the improvement.

the works have been carried out, the barge undergoes the final hull leakage test and all of its devices and systems are checked. If that goes well the contract undergoes final commissioning in the presence of the mandator. The barge then needs only to receive the unit status granted by the Maritime Office and is transported using a seagoing tug to its destination.

3. MAPPING THE LOGISTICS PROCESS OF BARGE PRODUCTION

On basis of the conducted analysis of the processes taking place in the company, a map of the logistic process used in barge production was presented (Figure **3**). Three improvements were suggested on basis of the prepared map of barge production logistics process: technological improvements (marked as improvement 1), organizational improvement (improvement 2) and an alternative process combining both of the aforementioned approaches (improvement 3), whose map is presented in Figure **4**.

The technological improvement focuses on changes that would contribute to increasing the production efficiency. Majority of machines used in the basic process could be substituted with CNC machines. Introduction if such devices should shorten the duration of particular production operations and improve their quality. Application of automated machines is a long-term investment which will pay off. It also makes it possible to speed the whole production up, thanks to which more orders can be accepted for realization by the production plant. Unfortunately such an investment is rather costly but it shall increase the company profit in the future. Introduction of CNC machines into the production process allows for quicker changes of given element processing parameters. Such machines can remember the introduced settings which makes it possible to change them quickly without the necessity of redefining them.

Another form of improvement entails organizational changes of the production. This involves implementation of the *Just-in-Time* method [10]. The recommended changes also consisted in eliminating the central supply warehouse and the inter unit warehouse for the cutting operations. Another recommended change is reducing the number of barge equipping operations from two to one that may be carried out directly after the barge is launched. Thanks

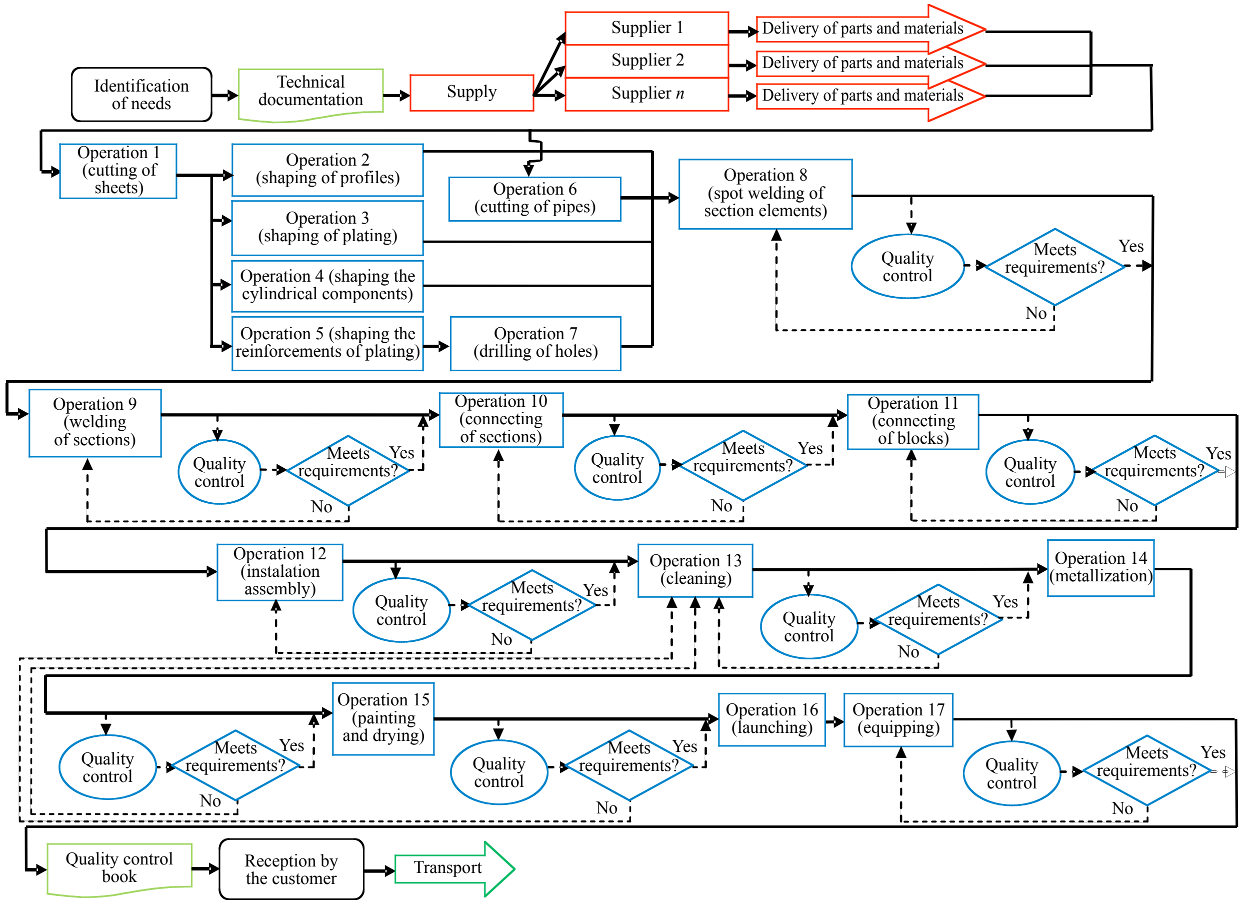

Figure 4: Map of the process with the technological and organizational improvement.

to this all necessary equipment elements etc. would get to one place, which would improve the work organization.

The third improvement (Figure **4**) involved integration of technological and organizational improvements that should result in the greatest shortening of single barge production process completion.

4. COMPARATIVE ANALYSIS OF DEVELOPED IMPROVEMENTS IN THE *ANYLOGIC* SOFTWARE

A comparative analysis was carried out in order to determine the possible benefits of implementing the suggested barge production logistics process improvements. The tool that was used for this purpose was an application for computer modeling and simulation of processes called *AnyLogic* developed by *The AnyLogic Company* (Russia). This software is the only simulation tool that supports all the most common simulation methodologies in place today: System Dynamics, Process-centric (AKA Discrete Event), and Agent Based modeling [11].

Figure **5** presents a model of the basic (before improvements) barge production process developed using *AnyLogic* software. The model was used to conduct a simulation of the process of producing a series of 50 barges. Results of the simulation obtained for the process before the improvements showed that a single barge production time lasted on average ~880 hours. It was observed that 70% of the produced barges were made within 800-850 hours. The remaining 30% of barges took, however, longer to make (the maximum production time was ~1295 hours, while the shortest ~812 hours). This means that some of the products did not pass their quality control the first time and required corrections, which considerably prolonged duration of the production.

In case of the technological improvement a single barge production process lasted on average ~805 hours, which means it was ~8.5% shorter than the base process. As many as 78% were made in the time frame of 750-800 hours. The longest barge production time was ~1017 hours, while the shortest was ~679 hours. As a result of this improvement the time range is more limited, which results from the shorter time

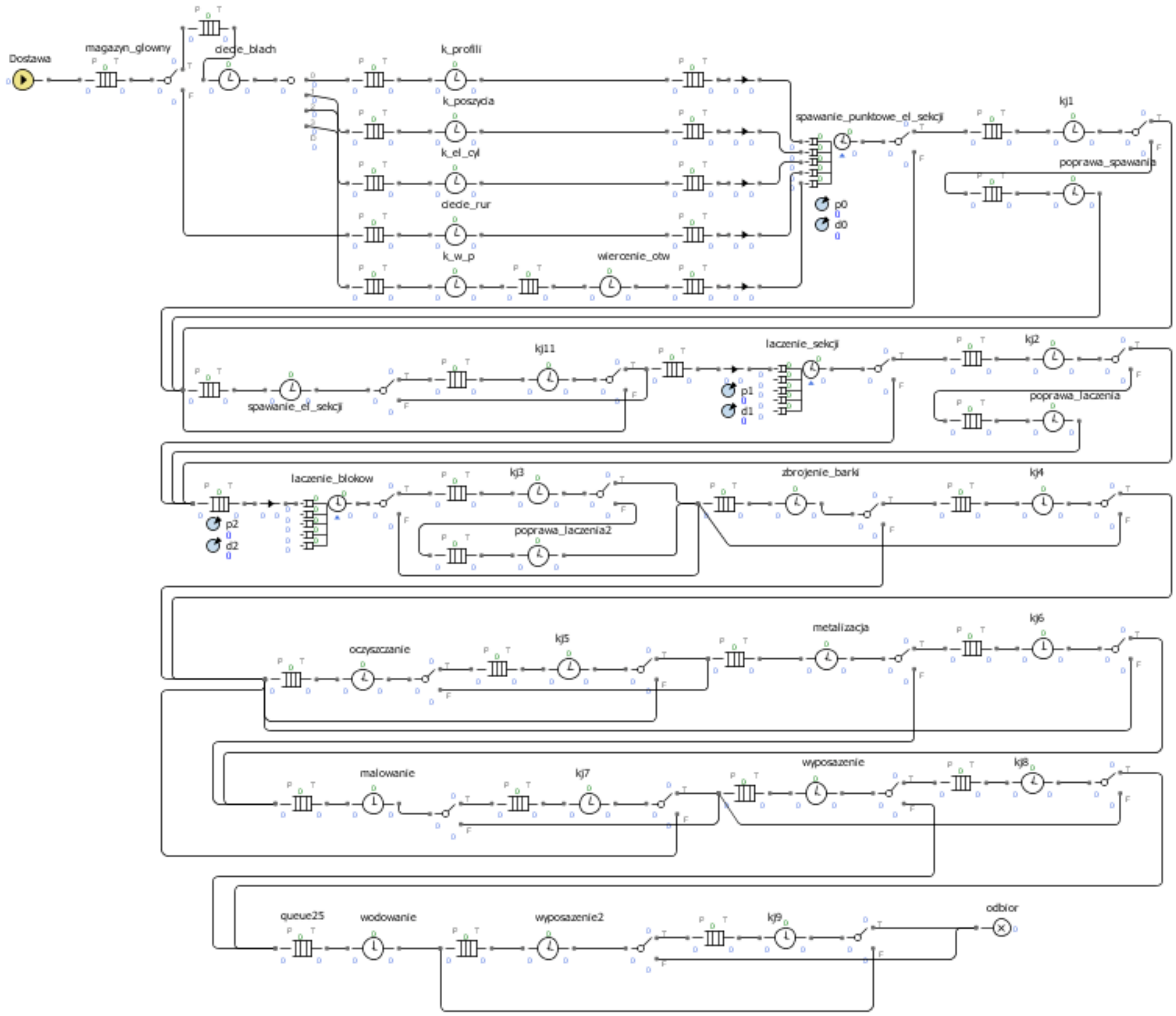

Figure 5: Model of the manufacturing logistics process of the barge (the state before the improvement) drawn up in the *AnyLogic* software.

required for performing operations in which the new generation devices were used.

The second improvement entailed application of the *Just-in-Time* method. It eliminated the warehouses, reduced the number of the equipping operations to one, made use of random quality control, depending on the operation, of each second or third element. Moreover, production quality was increased from 95% to 99%. Thanks to these changes the single barge production process lasted on average ~808 hours. As compared to the base process it is ~8.2% shorter. In this case the majority of barges (32%) was made within 800-810 hours. The remaining barges were made at either a shorter or longer time. The longest barge production time was ~829 hours, while the shortest lasted ~774 hours.

Integrating both of the above-mentioned modernization types shortened a single barge production time to the average of ~760 hours. As compared to the base process it is ~13.5% shorter. The simulation showed that 22% of barges were made in the time frame 765-770 hours. The longest barge production time was ~777 hours, while the shortest lasted ~737 hours.

Figure **6a** presents the minimum, average and maximum single barge production time. The chart shows that the greatest difference between the minimum and maximum time occurred in case of the base process and the first improvement. This results from conducting quality control after majority of operations in these processes. Both in case of application of random quality control and the second and third improvements, the barge production time

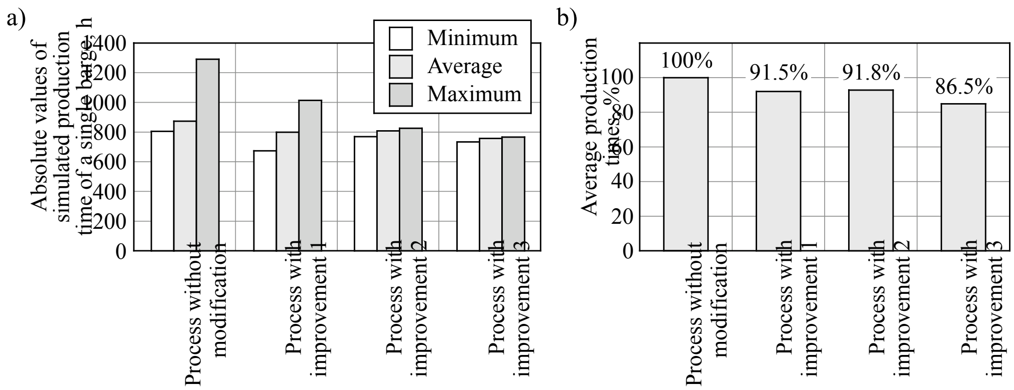

Figure 6: Summary results of the simulation of a single barge production time in several variants of analyzed logistics process obtained with the use of AnyLogic software: a) absolute values of time; b) comparison of the average production times expressed relative (in percents).

fluctuations grew smaller. Figure **6b** presents a chart illustrating the change in average production time as compared to the base process expressed in percents.

CONCLUSIONS

This work showed that analysis of barge production logistics using the process mapping method makes it possible to clearly present all processes taking place in the shipyard industry company in a detailed manner. Production process mapping using *AnyLogic* software made it possible to present the process in the same way as in the mapping method but also enabled parametric analysis of the flows and dependences between the given process stages. As a result of the carried out simulations it was concluded that:

- Implementation of the barge production process technological improvement may shorten its production time by 75 hours (which is 8.5% of the total production time).
- Implementation of the barge production process organizational improvement may shorten its production time by 72 hours (which is 8.2% of the total production time).
- While combining both these improvements in one process makes it possible to shorten the production time by 120 hours (which is 13.5% of the total production time) and corresponds to 15 working days.

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