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Joanna Rut[1, 2]✉, **Natalia Kłysz**[1], **Michał Podpora**[3], **Halyna Kenyo**[2]
[1] Opole University of Technology
[2] Lviv Polytechnic National University
[3] University of Opole

The Role of Industry 4.0 in Reimagining Manufacturing Logistics: Empirical Study

Rola Przemysłu 4.0 w Logistyce Produkcji: badania empiryczne

Abstract. In the context of advancing Industry 4.0 technologies, manufacturing organizations face operational impediments within their logistics frameworks. This study examines these challenges, exploring how the integration of sophisticated information technologies and cyber-physical systems can transform manufacturing processes. Identifying and addressing these barriers is crucial for enhancing global competitiveness and fostering intelligent manufacturing environments. Through a comprehensive analysis, this manuscript critically assesses the impact of deploying Industry 4.0 technologies on the operational effectiveness and competitive positioning of the firm. It reveals that the implementation of these technologies not only improves manufacturing efficiency and product quality but also reduces equipment idle times and leads to cost savings. Additionally, the study highlights the increased adaptability to consumer preferences and discloses considerable gains from these technological adoptions. The findings suggest that the adoption of Industry 4.0 technologies is pivotal in transforming manufacturing practices and positioning enterprises at the forefront of global competition. It underscores the need for continuous enhancement of operations and proposes further strategic interventions. The shift presents both significant challenges and unique opportunities, which require tailored management strategies to leverage the benefits fully and mitigate the risks associated with technological transitions.

✉**Joanna Rut** – Opole University of Technology, Faculty of Production Engineering and Logistics; e-mail: j.rut@po.edu.pl; https://orcid.org/0000-0001-9014-8874

Natalia Kłysz – Opole University of Technology, Faculty of Production Engineering and Logistics; e-mail: n.klysz@student.po.edu.pl

Michał Podpora – University of Opole, Institute of Computer Science; e-mail: michal.podpora@uni.opole.pl; https://orcid.org/0000-0002-1080-6767

Halyna Kenyo – Lviv Polytechnic National University, Institute of Computer Technologies, Automation and Metrology; e-mail: halyna.v.keno@lpnu.ua; https://orcid.org/0000-0003-2347-0833

Key words: Industry 4.0, logistics processes, management, improvement, competitiveness

Synopsis. W kontekście rozwoju technologii Przemysłu 4.0 organizacje produkcyjne napotykają operacyjne przeszkody w swoich strukturach logistycznych. W niniejszym artykule autorzy analizują te wyzwania, badając, w jaki sposób integracja zaawansowanych technologii informacyjnych i systemów cyberfizycznych może przekształcić procesy produkcyjne. Identyfikacja i rozwiązywanie tych barier jest kluczowe dla zwiększenia globalnej konkurencyjności i wspierania inteligentnych środowisk produkcyjnych. Poprzez wszechstronną analizę, niniejszy artykuł ocenia wpływ wdrażania technologii Przemysłu 4.0 na efektywność operacyjną i pozycjonowanie konkurencyjne przedsiębiorstwa. Ukazuje, że implementacja tych technologii nie tylko poprawia wydajność produkcji i jakość produktów, ale także zmniejsza przestoje maszyn i urządzań oraz prowadzi do oszczędności kosztów. Dodatkowo, badanie podkreśla zwiększoną zdolność adaptacji do preferencji konsumentów i ujawnia znaczące korzyści płynące z tych technologicznych wdrożeń. Uzyskane wyniki sugerują, że przyjęcie technologii Przemysłu 4.0 jest kluczowe dla przekształcenia praktyk produkcyjnych i pozycjonowania przedsiębiorstw na czołowej pozycji w globalnej konkurencji. Podkreśla potrzebę ciągłego doskonalenia operacji i proponuje dalsze strategiczne interwencje. Ta zmiana niesie ze sobą zarówno znaczące wyzwania, jak i unikalne możliwości, które wymagają dostosowanych strategii zarządzania, aby w pełni wykorzystać korzyści i zminimalizować ryzyka związane z postępem technologicznym.

Słowa kluczowe: Przemysł 4.0, procesy logistyczne, zarządzanie, doskonalenie, konkurencyjność

JEL codes: L22, L26, E23, M11

Introduction

The progressing digitization and the rapidly changing economic reality pose great challenges to enterprises, forcing them to constantly search for important tools to create and maintain a competitive advantage. Industry 4.0 is considered to be a revolution in manufacturing, helping to achieve maximum efficiency by minimum resource utilization. Along with the evolution of Industry 4.0, new technologies and ideas play a key role in the development of manufacturing enterprises and the processes taking place within it [Lasi et al. 2014, Stock and Seliger 2016, Frank et al. 2019]. Logistics is of great importance to manufacturing companies and plays a strategic role as it helps to reduce production costs, increase profits, and improve customer service. The development of digitization and Industry 4.0 also improves the efficiency of logistics processes, which include procurement, production, storage, distribution, transport, and waste management. Industry 4.0 is considered to be a technological revolution aimed at achieving higher efficiency and productivity and a technologically advanced strategy aimed at increasing the competitiveness of enterprises [Xu et al. 2018, Bag et al. 2020, Xu et al. 2021, Shamout et al. 2022].

Industry 4.0 aims to meet challenges such as resource and energy efficiency, urban production, social needs, and demographic changes [Kagermann et al. 2013]. Optimization of logistics processes includes, among others, standardization of information recording and real-time tracking of processes that increase the productivity of enterprises, but also the effective use of modern technological solutions of the Industry 4.0 concept, consistent with the current needs of the enterprise [Bayarcelik and Bumin Doyduk 2020, Efthymiou and Ponis 2021, Woschank and Dallasega 2021, El Hamdi and Abouabdellah 2022, Elhusseiny and Crispim 2023].

Nowadays, every company strives to expand its activities as much as possible, which directly translates into visible productivity. To achieve the intended goals, enterprises are looking for solutions in Industry 4.0 and the upcoming Industry 5.0, which offer many possibilities in the interactive connection of all people, machines, devices, and human-machine interaction systems into one large logical, organized, and integrated IT and executive system.

The purpose of the study is to present an analysis and assessment of the possibility of implementing Industry 4.0 technology in selected logistics processes on the example of a specific production company, taking into account the identification of functional problems, significant benefits of the proposed solutions and proposals for changes and opportunities to further improve the company.

Industry 4.0 as a key principle of an efficient enterprise

The digital transformation of industry is still progressing, and the opportunities associated with it are being noticed by an increasing number of entrepreneurs. Industry 4.0 not only brings many benefits, but is always a costly, long-term, and sustainable investment. The application of the Industry 4.0 concept significantly affects the logistics processes taking place within it.

Industry 4.0 is a concept of industrial transformation based on the use of digital technologies and automation of production processes. As a result, enterprises can increase their efficiency, reduce production costs, improve product quality, and react faster to changing market conditions [Buchi et al., 2020, Meindl et al. 2021]. Key technologies supporting the concept of Industry 4.0 include the Internet of Things, Artificial Intelligence, process automation, robotization, data analytics, and Virtual and Augmented Reality [Pacchini et al. 2019, Morgan et al. 2021, Stentoft et al. 2021, Fragapane et al. 2022]. The implementation of the Industry 4.0 concept requires companies to invest in new technologies and implement thorough organizational and cultural changes.

The fourth industrial revolution creates numerous development opportunities for manufacturing companies. It increases the efficiency and productivity of production processes through the use of modern tools, technologies and approaches, e.g. robots, sensors, monitoring systems, and vision systems. By using these tools, enterprises are able to optimize their production processes, which leads to more products being produced in less time and with lower costs [de Assis Dornelles et al. 2022, Han and Trimi 2022, Sigov et al. 2022]. With these advanced technologies, manufacturing companies are able to adapt production to the needs of customers, their production becomes more flexible, and the process of delivering products is more individualized. Industry 4.0 provides the opportu-

nity to better manage resources such as raw materials, energy, and time [Castelo-Branco et al. 2022, Gupta and Jauhar 2023]. Enterprises are able to optimize energy consumption and use it more efficiently, leading to lower costs and increased profits. Thanks to the automation of production processes and the use of advanced technologies, such as Artificial Intelligence, enterprises are able to improve the quality of their products. Machines and systems are able to detect production errors, which allows for quick response and elimination of problems [Ching et al. 2022, Hughes et al., 2022, Tang et al. 2022]. Industry 4.0 allows manufacturing companies to react faster to changing market conditions and to adapt to customer needs. Enterprises that implement advanced technologies gain a competitive advantage and increase their chances of success in the market. All these benefits brought by Industry 4.0 make manufacturing companies more flexible, effective, and competitive.

Logistics processes and Industry 4.0

Logistics processes focus on the activities that enable the acquisition, production, and distribution of goods. They consolidate the activities in the company. Depending on their specificity, companies have appropriately adapted and developed processes and focus mainly on areas related to supply, internal production, distribution, storage, and transport. Logistics processes should be understood as all activities in the enterprise, through which there is a flow of products and materials [Facchini et al. 2019]. It is worth paying attention to the development of systems from which the entire enterprise will benefit. Therefore, periodic analyses should be carried out in a rational manner, which will show what can be improved or completely changed at a given moment. The way processes are organized is also important because it should ensure continuity and constant dynamics of work. Due to the fact that logistics processes cover a significant portion of the enterprise, they have a major impact on the effectiveness and efficiency of the unit's operation [Waters 2003, Harrison et al. 2019, Alsudani et al. 2023].

Industry 4.0 is a concept related to the transformation of industry in the digital age, which includes the use of the latest technologies, such as the Internet of Things (IoT), Artificial Intelligence (AI), robotics, and automation. Industry 4.0 focuses on increasing efficiency, improving the quality and flexibility of production, as well as increasing customer involvement and creating new business models [Masood and Sonntag 2020, Olsen and Tomlin, 2020]. In the context of logistics processes, Industry 4.0 introduces a number of innovative solutions, such as the automation of warehouse processes, the use of intelligent transport systems, and the use of data analysis and machine learning to optimize the supply chain. Thanks to this, enterprises can increase their operational efficiency, reduce costs and improve the quality of their services [Da Silva et al. 2020, Sony and Naik 2020, Luo et al. 2023, Pozzi et al. 2023]. Industry 4.0 is changing the traditional way a company carries out its business activity [Olsen and Tomlin 2020, Ammar et al. 2021]. The key pillar of Industry 4.0 is new technologies that fundamentally change logistics processes. Industry 4.0 focuses on the automation and digitization of processes and systems and the exchange of data throughout the enterprise. Using this concept can lead to improvements in production, the supply chain, and logistics [Barreto et al. 2017, Xu et al. 2018, Abdirad and Krishnan 2021].

Materials and Methods

The purpose of this study is to provide an essential insight into the appropriateness of the application of Industry 4.0 in selected logistics processes in a specific manufacturing company by identifying functional problems within the company's operations and proposing appropriate solutions. The main theme of these activities is to increase the operational efficiency and strengthen the company's competitive position in the market. The article involves various research tools, both theoretical and practical. Among the theoretical tools, literature studies on logistics processes in manufacturing enterprises and the concept of Industry 4.0 are used, as well as quantitative and qualitative research methods.

The analyses include an assessment of the company's functioning, order fulfillment, production implementation (including an assessment of the machinery stock), and the effectiveness of company management, as part of which measurements and statistical data analyses were performed. As a result, functional problems related to the company's activities in the area of logistics processes and company management were also identified, in which interviews, a survey and an analysis of company documents were carried out, and possibilities for improvement were proposed. The identified functional problems resulted from outdated and improperly functioning machinery, insufficient company management, and limited storage and order completion space. The research showed that the inefficiency of the machinery park resulted in a small quantity of low-quality manufactured products being produced, as well as delays in order fulfillment. The analysis of the proposed Industry 4.0-related solutions showed that the Industry 4.0 concepts would have a positive impact on solving the identified functional problems, bringing many benefits to the analyzed company enabling its further development.

Characteristics of the company – case study

The manufacturing company (name and location undisclosed upon the request of the company) was founded in 1978 and has been developing its position in the international market since then. The company currently has 10 production plants around the world, including in France, Switzerland, Poland, Tunisia, Singapore, and the United States.

The company entered the Polish market in 2007, but due to gradual evolution and production quantity increase, the company decided to build a larger plant. After the construction of the new building was completed, the company's former location was moved to the new complex. The company received permission to invest in and operate in a new location, i.e. in the Wałbrzych Special Economic Zone, at the end of 2017. The construction was completed in mid-2019, but the building still needed to be equipped with the necessary machinery. Therefore, the official opening took place in December 2019. The new headquarters of the company was created with new customers in mind, mainly from Germany, the Czech Republic and Poland.

The company specializes in the mass production of small turned and prestressed elements. The company mainly produces for the home automation sector (components for switches and plugs), for the automotive sector and for the communications sector. It sells

its products in Poland, as well as in Germany, Turkey, France and Italy. The company currently employs about 100 employees, most of whom work in production, with machines, as well as sorting and packaging. The rest of the staff is responsible for administrative, logistical and control tasks. The company is equipped with machines required for production, such as automatic lathes, welding machines, production machines, and washing machines.

Analysis and assessment of the functioning of the enterprise

The company has implemented a system that employees use via a virtual machine. Employees who are responsible for using the system have passwords with which they log into the system where files and information about the company are located. The ERP system that the company uses to run its entire business is the Orchestra program. In this program, all activities that take place in logistics processes are documented.

Persons responsible for specific activities enter relevant data into the system, which will later be used in subsequent stages. In the program, it is possible to find information about the current state of details, orders and deliveries. Then, if necessary, the program also generates the appropriate documents. Each customer has an individual number assigned in the system, thanks to which orders can be added (and the necessary information can be found) in a simpler and faster way. Each product manufactured or received by the company also has such a number.

One of the most popular heuristic analytical techniques used to organize information – the SWOT analysis – was used in the study as an analysis tool to assess the functioning of the company [Teoli et al. 2019].

Table 1 depicts the SWOT analysis – strengths and weaknesses of the company as well as its opportunities and threats. As can be seen, the company has a modern machine park, but this is due to the fact that the plant was launched recently. Although a wide range of products is offered, the downside of this is that more and more often, there is no space in the warehouse. Opportunities that can be used definitely include the development of the industry in the market. Threats that may affect the company include an increase in production or material costs, which may be very difficult to eliminate. Another threat is high inflation and possibly new taxes, which the company has no influence on and unfortunately has to adapt to the new regulations. The only possible solution that can reduce the difference in costs is to increase the price of the services. The five most important features were given consecutive values. Their sum must equal 1.

The next step was to answer the questions presented in Figure 1 using numbers: "1" when we agree with a given question and "0" when we disagree. An example showing the assigned weights is shown in Table 2.

The conducted SWOT/TOWS analyses showed the results presented in Table 3, from which it can be concluded that the company's strategy should convert into an aggressive strategy (Table 4). An aggressive strategy is characterized by the fact that the strengths prevail in it, and there are "strongly associated opportunities" in the environment. The aggressive strategy also means that the company is currently in the best position to

Table 1. SWOT analysis
Tabela 1. Analiza SWOT

	Strengths	Weaknesses
Internal factors	– variety of products offered, – convenient location (on the outskirts of the city), – high quality of services, – modern machinery, – experienced staff of many years, – good reputation among customers, – permanent cooperation with clients all over the world, – private parking for clients and employees, – many years of experience in the industry.	– no advertising, – too little storage space, – insufficient staff, – lack of technological training for employees, – constant changes in customer orders, – delays in orders, – delays in production.
	Opportunities	**Threats**
External factors	– market development of the sector, – opportunity to expand the product range, – new jobs, – wide market, – high demand, – cooperation with companies all over the world, – constant demand for services.	– increase in production costs, – increase in material costs, – increase in transport costs, – high inflation, – lack of materials needed for production, – new legislation, – lack of training, – new taxes.

Source: own study.
Źródło: opracowanie własne.

Table 2. SWOT analysis with selected features and assigned weights
Tabela 2. Analiza SWOT z wybranymi cechami i przypisanymi wagami

Strengths		**Weaknesses**	
variety of products offered	0.1	lack of advertising	0.2
convenient location (on the outskirts of the city)	0.2	too little storage space	0.3
high quality of services	0.2	constant changes in customer orders	0.1
modern machinery	0.2	delays in orders	0.2
permanent cooperation	0.3	delays in production	0.2
Total	1	**Total**	1
Opportunities		**Threats**	
growth of the sector on the market	0.2	increase in production costs	0.3
possibility to expand the product range	0.1	increase in material costs	0.2
wide market;	0.2	increase in transport costs	0.2
high demand	0.2	high inflation	0.1
constant demand for services	0.3	lack of materials needed for production	0.2
Total	1	**Total**	1

Source: own study.
Źródło: opracowanie własne.

focus on its development and market expansion. The key aspects that an enterprise should now consider are:

– detecting potential development opportunities, i.e. identifying and using opportunities that appear in the company's environment in order to increase competitiveness and profits;
– taking over similar enterprises, strengthening the position on the market, developing a strategy that allows it to increase its market share and acquire new customers, as well as acquire new technologies, products, or services;
– constant strengthening of the position on the market, in order to maintain the competitiveness and stability of the company, using current market trends and available opportunities, in order to optimally shape the company's strategy.

Table 3. Sample results – SWOT analysis regarding the question: Does the weak side limit the use of an opportunity?
Tabela 3. Przykładowe wyniki – analiza SWOT dotycząca pytania: Czy słaba strona ogranicza wykorzystanie szansy?

Opportunities / **Weaknesses**	sector development in the market	possibility of expanding the product portfolio	wide market	high demand	constant demand for services	Weight	product of weights and interactions	growth
lack of advertising	1	0	1	1	0	0.2	0.6	5
too little storage space	0	1	0	1	0	0.3	0.6	5
constant changes in customer orders	0	0	0	0	0	0.1	0	2
orders delays	0	0	0	0	0	0.2	0	2
production delays	1	0	0	1	1	0.2	0.6	5
Weight	0.2	0.1	0.2	0.2	0.3	**sum of interactions**		**3.4**
product of weights and interactions	0.4	0.1	0.2	0.6	0.3	8		
growth	4	1	2	5	3	**Sum of products**		

Source: own study.
Źródło: opracowanie własne.

Table 4. SWOT/TOWS analysis result
Tabela 4. Wyniki analizy SWOT/TOWS

Swot	**Total of interactions**	**Total of products**
Strengths/opportunities	35	14.1
Strengths/threats	7	2.8
Weaknesses/opportunities	23	9.4
Weaknesses/threats	12	5

Source: own study.
Źródło: opracowanie własne.

The company should also analyze how to minimize the risks that may significantly impact the company's future development, considering the longer time horizon.

Analysis and assessment of logistics process management in the company

Logistics processes operating in each enterprise are interdependent, closely related, and interact with each other, shaping the final added value of the enterprise. Any incorrect functioning of logistics processes may interfere with the efficiency of the entire enterprise, which is why the proper management of logistics processes and their continuous improvement have become so important.

The logistics processes in the surveyed company focus mainly on making the production process run as efficiently as possible as shown in Figure 1. Therefore, all processes occurring in the company are adjusted to be used for production. Each of them is responsible for specific actions and is monitored.

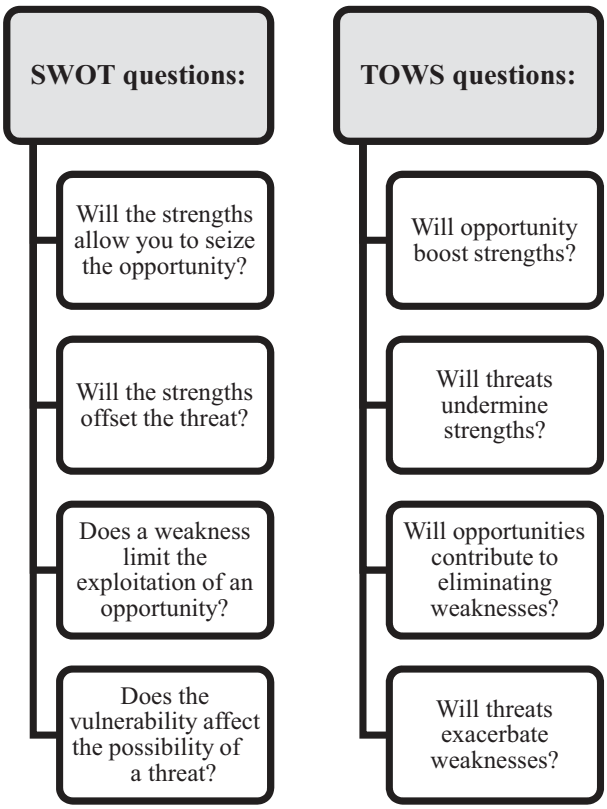

Figure 1. Questions for SWOT and TOWS analysis
Rysunek 1. Pytania do analizy SWOT i TOWS

Source: own study.
Źródło: opracowanie własne.

Figure 2 shows the algorithm of the order fulfillment process, starting from receiving the order from the customer, through loading the means of transport (truck) with the product, to delivering the order to the customer.

There are two production halls at the production site of the company, with one having only automatic turning machines and washing machines, while the other production hall has automatic turning machines and production and assembly machines. In this hall, there

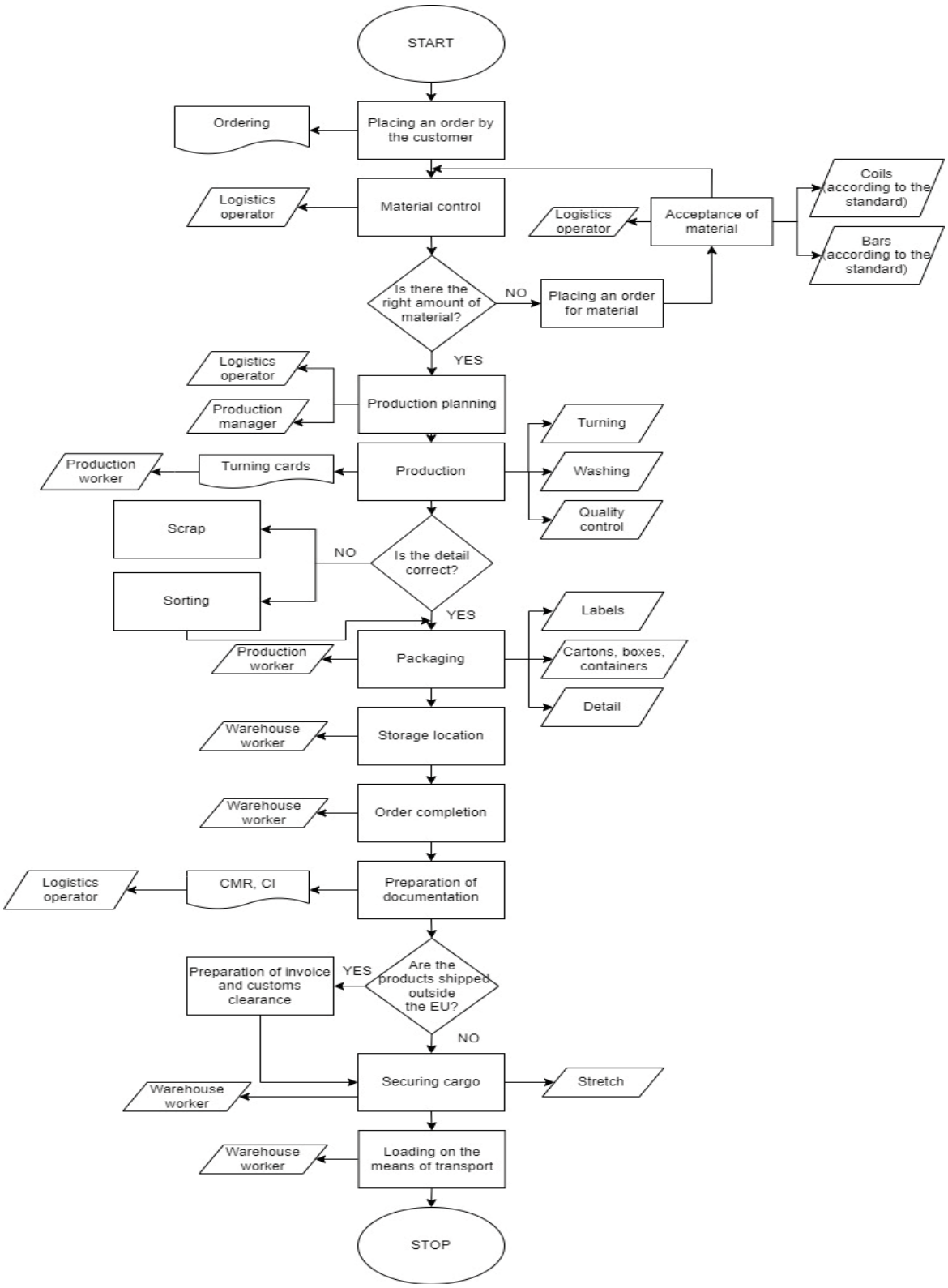

Figure 2. Order fulfillment process
Rysunek 2. Proces realizacji zamówienia

Source: own study.
Źródło: opracowanie własne.

is a place for sorting and packing details . The production stage depends on the manufactured detail. Each detail is unique, which requires appropriate adjustment of the production batch parameters. Some elements are not manufactured in the company because the company does not have the appropriate facilities or infrastructure and due to the rarity of such orders. Therefore, if such an order appears, the company uses the services of external subcontractors, specifying the parameters for the production of appropriate semi-finished products. Then, the semi-finished product (or the finished product) returns to the enterprise for further processing in additional stages of production and/or is prepared for shipment. The production process is shown in Figure 3.

The company has three designated warehouses, one of which is used only to store the material (raw material) for production, while the second one stores all details produced at various stages of production, and the third location stores only one type of material in the form of steel rods. The company does not have its own transport fleet, but it cooperates with transport companies that carry out transport on commission.

Logistics operators are responsible for the distribution of manufactured products; they always control the processes in such a way that orders go out according to the customers' schedules. Their task is also to prepare the appropriate documentation for the shipped detail. The management of logistics processes in the company is supported by the Orchestra and ERP-class IT systems, which coordinate, among others, the flow of information on orders, costs, cash flow, and customer service.

In the surveyed company, all generated waste is collected by external companies. The main waste produced in the company is scrap (details that are not suitable for shipment to customers or do not meet the quality control requirements), chips (generated in the production process), cardboard, municipal waste and oils (oils are classified as hazardous materials).

A survey was conducted at the surveyed company, where employees could express their opinions on the use of modern technology. The respondents' answers are presented in Figure 4.

Starting to implement Industry 4.0 in the company would be received optimistically, as 80% showed that it would have a positive impact on the company. However, 20% of employees do not respond positively to using technology in their workplace. This could be due to a lack of understanding of the technologies in question or working in a position where they would not find their application. However, it should also be noted that employees may be concerned about the risks that come with implementing new technology.

It was decided to analyze the potential risks that may occur and affect the operation of the company under study during the implementation of Industry 4.0 technology. A risk matrix was used for this purpose, and the following are the risks identified with the company's employees, along with an assessment of the likelihood of occurrence and impact on the organization:

– increased number of cyberattacks (medium/high),
– mass layoffs of employees (low/medium),
– technology failures (high/high),
– high costs associated with investment in improvements (high/high),

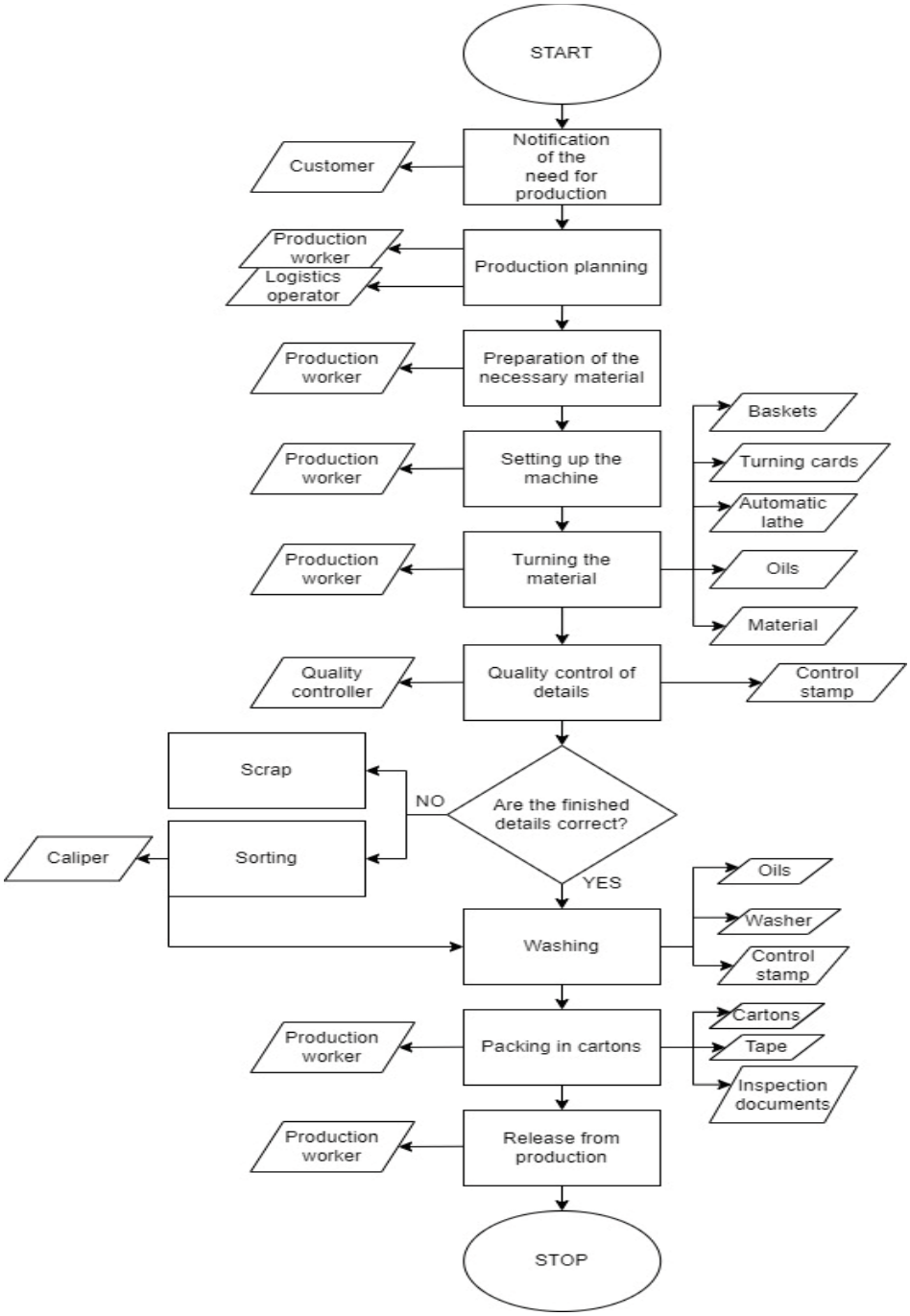

Figure 3. Production process
Rysunek 3. Proces produkcyjny

Source: own study.
Źródło: opracowanie własne.

– higher costs associated with technology repair (medium/medium),
– lack of compliance with laws and regulations (low/high),
– lack of integration between systems (low/high).

The company has 3 risks in the red zone (Table 5), and these are the ones they should focus on the most when it comes to preventing and mitigating against these risks occurring. The high costs associated with starting such a huge investment can

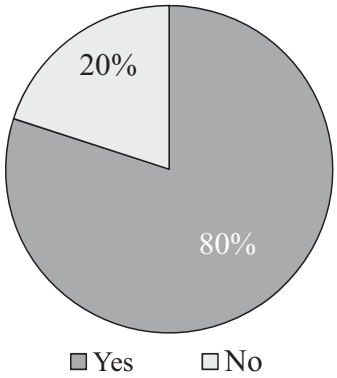

Figure 4. Would implementing modern technologies positively affect the company?
Rysunek 4. Czy wdrożenie nowoczesnych technologii miałoby pozytywny wpływ na firmę?

Source: own study.
Źródło: opracowanie własne.

Table 5. Risk matrix showing the threats affecting the company to the greatest extent
Tabela 5. Macierz ryzyka przedstawiająca zagrożenia, które w największym stopniu dotykają przedsiębiorstwo

Consequences (impact on the organization)				
	HIGH	2	1	2
	AVERAGE	1	2	
	LOW			
		LOW	AVERAGE	HIGH
			Likelihood	

Source: own study.
Źródło: opracowanie własne.

be very difficult to eliminate, but you such solutions should be sought to achieve the best possible savings, e.g. constant cooperation with the implementing company, which will also repair any defects and failures that may arise. Another risk is the failure of modern technologies, but in order to avoid them, it is necessary to train the team to operate these machines as properly as possible, so that failures occur as rarely as possible, and in the event of their occurrence, the company implementing them can help. Another significant threat is the increased number of cyberattacks resulting from the greater digitization of the company. To protect against possible cyber threats, you need to establish cooperation with companies that ensure the protection of employee data and the functioning of the entire company.

Results

As a result of the analysis, functional problems were identified in the area of production and storage that require improvement. The response proposes the application of the Industry 4.0 concept, with the comments described below. Regarding the production area, it is proposed to use advanced information technologies and cyber-physical systems to improve the efficiency and quality of production. One of the proposals is a system that could significantly eliminate problems related to machine and equip-

ment downtime. This system would be designed to control the operating status of the machines and devices in real-time, enabling quick detection of downtimes and failures, as well as quick intervention and repair. As a consequence, production would run without major downtime, which would improve the efficiency and profitability of the company. Another improvement involves a system for automatically correcting manufactured details, which will make it possible to minimize the number of defective details and increase the quality of the manufactured products. This system would enable the automatic detection of incorrectly made details and their correction, which would significantly reduce the costs associated with rejects and defective products. In addition, using this system would increase the efficiency of production and improve the quality of products, which would increase the level of customer satisfaction and competitiveness of the company.

The application of the Industry 4.0 concept is also proposed in the area of storage, especially in the field of IT system integration, automation and real-time data processing. Thanks to this, it would be possible to monitor and manage warehouse processes in real-time, which would allow for cost optimization and an increase in the functional efficiency of the warehouse. As an example of implementing elements of the Industry 4.0 concept, RFID systems can be used to enable the identification and location of products in the warehouse, which would facilitate order picking and increase the accuracy of inventory management.

Moreover, the use of automation and robotization could help in the process of storing and moving products in the warehouse. This would increase work efficiency and help avoid mistakes and human errors.

The application of the Industry 4.0 concept in the form of advanced IT and cyber-physical systems, such as a machine and equipment downtime monitoring system and a system for automatically correcting details, can significantly improve the efficiency and quality of production, as well as increase the competitiveness of the company. The introduction of the Industry 4.0 concept to the reality of the warehouse can contribute to improving the efficiency and quality of warehouse processes and also increase the competitiveness of the company.

Significant benefits resulting from the proposed solutions

The use of the modern Industry 4.0 in the enterprise can increase its position and improve its functioning and organization of work, as well as automate everyday work, which affects the efficiency and speed of order execution. The machine monitoring system would make it possible to control downtime and estimate the time to catch up with production, as well as generate production reports and quickly remove failures. An automatic detail correction system would increase the product quality and reduce the number of defective production batches, which would save costs and energy. A company implementing Industry 4.0 can gain higher equipment efficiency and make more accurate decisions by using data from the monitoring system. It is emphasized that the introduction of modern technologies should take place gradually and in a controlled manner.

Proposals for changes and opportunities for further development of the company

Modern enterprises must focus on continuous development and implementing new solutions to keep up with the rapidly changing market. One of the solutions that can have a positive impact on the operation of a goods warehouse is to build a new warehouse or rent one in a convenient location. Of course, such an investment involves additional costs, such as property rent, transport fees, and hiring new employees. For this reason, building a new warehouse facility may be more profitable than renting it, because this makes it possible to precisely adjust the space to the needs of the company.

A new warehouse can help to minimize clutter in the warehouse and create designated areas, for example, for order picking. In addition, the additional space would make the company able to store more finished products, which may affect the number of orders. It is also worth considering implementing autonomous robots in the new space to optimize employee involvement in the warehousing process.

Employees in the warehouse could focus on controlling the activities performed by these robots. However, due to the number of incoming orders, the company may have difficulties in providing enough employees to carry out the logistics processes. In this case, hiring new employees may be a good solution, which would increase the efficiency and speed of order fulfillment. Therefore, continuously striving to improve logistics processes in the company can contribute to increasing its efficiency and competitiveness in the market.

Discussion

Logistics processes in the company are carried out in an orderly and regulated chain of operations that is closely related to production. Each of the logistics processes taking place in the company is properly planned. Each logistics process is supervised by qualified staff who supervise the course of the logistics processes. The analyzed company appears to be a well-functioning organization. However, after a deeper analysis, it was determined that not all areas function properly, because there are some functional problems that should be paid special attention to. These areas require improvement or changes in order to achieve better operational efficiency of the company and strengthen its competitive position in the market.

Identification of problems occurring in the examined enterprise

The company has been operating in the new location for only 4 years now, but despite the fact that the company is new and equipped with machinery and equipment, there are functional problems in the company that it is struggling with. The greatest difficulties in the functioning of the enterprise occur in the area of production and storage.

Functional problems – production area

A common problem in the company is unplanned downtime and failures of machines that are expected to produce details continuously, 24 hours per day. Problems faced by employees operating machines are usually damaged parts and components of machines. Repairs of such damaged machines and devices are difficult due to the lack of original spare parts on sale. In order to remove a machine failure as soon as possible, the company uses third-party replacements of machine parts, which are not always of good quality. Therefore, failures of machines and equipment are frequent. It should be noted that the repair of machinery and equipment is quite complicated, so the appropriate specialists are required to come to the company. Machines that are actively involved in the production process are usually designed to increase efficiency and speed up production. However, their effectiveness may be limited. One of such cases is the machine that produces details (Fig. 5).

Figure 5. Container with produced details
Rysunek 5. Kontener z wyprodukowanymi szczegółami

Source: own study.
Źródło: opracowanie własne.

The machine has satisfactory performance because it is able to produce about 50,000 pieces of detail over an 8-hour working time (without any stops, downtimes, or failures). However, the product produced does not always meet the expected quality. Therefore, it is necessary for employees to manually check the manufactured details in order to accurately control the quality of the product and exclude damage to the product's elements by the machine. Each container contains 2,000 pcs of details. The process of manually checking the quality of the product is inevitable and necessary because the company does not have any improvement that could automate this stage of control and significantly speed it up. Before purchasing a machine for producing details, the elements of the finished product were joined using manual machines operated by employees. Even though the process was automated, it did not bring many benefits.

In the enterprise, an employee within an 8-hour working day is able to make about 6,700 pieces of details. In contrast, an automatic machine can produce about 50,000 pcs

in the same time period. The number of parts produced by a man working on a manual machine in comparison with an automated production machine is shown in Figure 6. This is a huge difference in the number of products produced between the production capabilities of man and machine. However, it is difficult for the company to achieve such results because there are often situations where the machine has an unscheduled stoppage, often due to its failures. Repairs take time and are often prolonged. This generates delays in production and failure to meet the deadlines for the execution of orders, which has consequences in terms of compliance with the provisions of the order agreement, sales, and customer service.

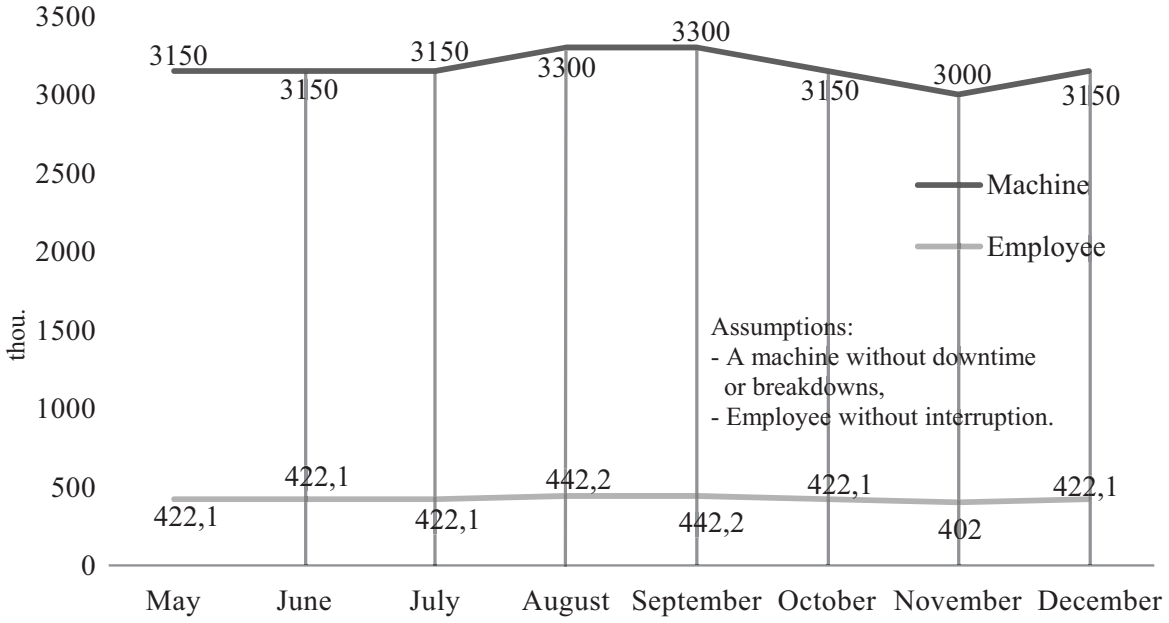

Figure 6. Order fulfillment process (number of parts produced by a human operator working on a manual machine compared to an automated production machine)

Rysunek 6. Proces realizacji zamówienia (liczba części wyprodukowanych przez operatora pracującego na maszynie ręcznej w porównaniu do maszyny produkcyjnej zautomatyzowanej)

Source: own study.

Źródło: opracowanie własne.

Figure 7 shows a cause-and-effect diagram that identifies 4 factors that cause delays in production. In the context of business management, there are various challenges that must be faced in order to be successful. Problems related to business management require different solutions depending on their nature. Hiring new employees and providing them with appropriate training [Gardecki et al. 2023], as well as providing relevant information and having contingency plans in place, are key factors that help in managing the production processes and minimizing errors. Incorrect communication and an incorrect flow of information can lead to production errors, which also negatively affect production efficiency. Therefore, the transmission of important information and the correct flow of communication are crucial.

Above all, the company should focus on minimizing the impact of problems on the production process by developing strategies and contingency plans. One approach that can be taken is to use tools and technologies that allow problems to be monitored and diagnosed before they become serious. By implementing the Industry 4.0 concept, a company can react faster and take corrective action, minimizing the impact of the problem on the entire production process, which affects all logistics processes in the company and the overall functioning of the company.

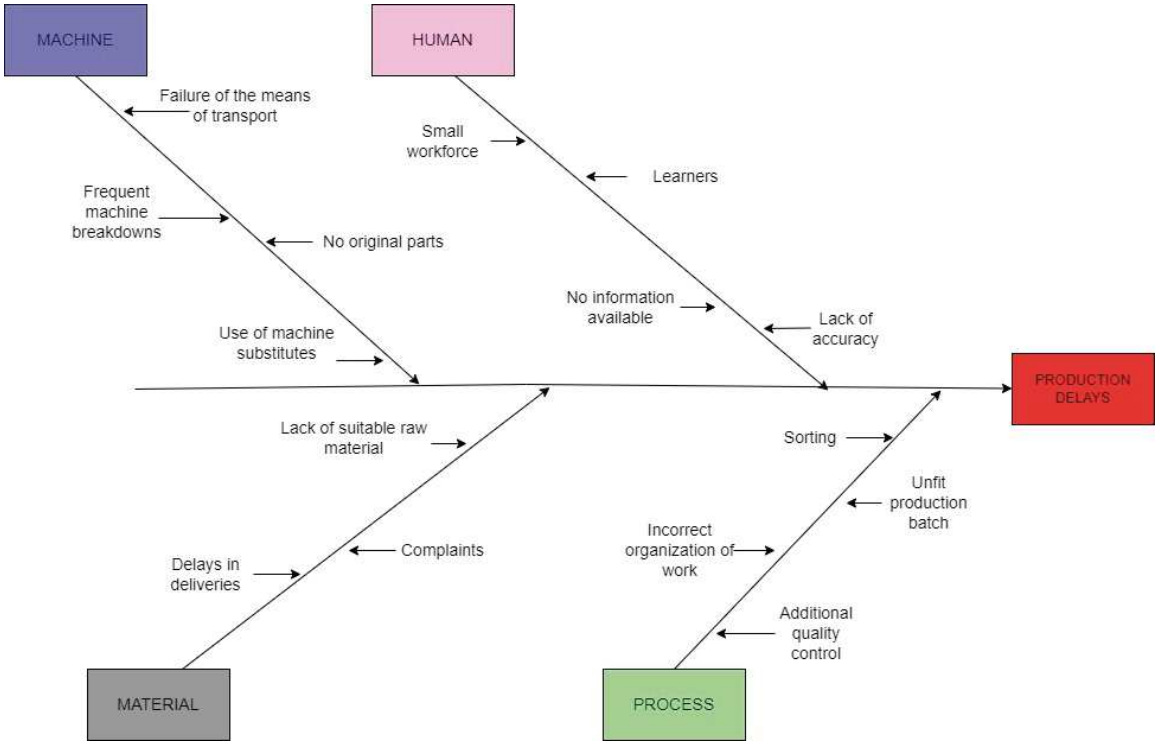

Figure 7. Ishikawa diagram
Rysunek 7. Diagram Ishikawy

Source: own study.
Źródło: opracowanie własne.

Functional problems – storage area

The next area in the company where there are functional problems is the storage area. From a process point of view, it appears that the company's warehouse is too small. Although the area dedicated to storing finished products during the production process covers an area of about 1,300 m^2, due to the constantly expanding range of the company, it is becoming less and less sufficient. In addition, increasing the number of orders for products leads to increased production. This results in the depletion of storage space.

The stored material is located in another part of the plant, but there is also a lack of available space there. The rods and coils of raw materials for the production of details are difficult to arrange in the storage space, which causes significant difficulties in their storage. For instance, the rods used for the production of details can only be located where the crane can reach because this is the only way to transport them. The lack of space in the

warehouse also results in specific manufactured details not having their assigned target locations in the warehouse, but are instead transported to the zone associated with the target recipient/customer or an intermediate stage of production of a given detail. However, this can be very troublesome because, although the elements are located in a given zone, they must still be searched for on all shelves or racks belonging to this area, which means that time is often wasted looking for where a given detail has been placed.

Functional problems also arise during order picking. There is no specific place in the warehouse for picking orders. Employees pick the order on racks intended for storing finished products, located immediately in front of the entrance gate, through which loads are transported. The warehouse worker has problems completing orders because he has to remember what has been put where and for which customer it is intended. The markings of places and racks describing the characteristics of the manufactured product are also a big problem in the warehouse, as they are not updated on a regular basis or there are none. The employee has to look for the products on the shelves, wasting time. This is a major impediment to the proper functioning of the warehouse and related processes.

Summary and conclusions

The concept of Industry 4.0, understood as a shift toward the digitization and robotization of processes, can be implemented (holistically or even in part) to successfully improve a company's operations and logistics processes. It should be noted that the process of introducing Industry 4.0 to the existing reality of a company requires time and commitment of resources (including financial ones). Industry 4.0 brings significant benefits to an enterprise, resulting in an improvement of its functionality and helping to advance its further development.

The analyses presented made it possible to draw appropriate conclusions. The SWOT/ /TOWS analysis carried out showed that the company should follow the principles of an aggressive strategy in order to carve out a stable and strong position in the market.

It was important to determine the employees' opinion on the application of Industry 4.0, given that they are mostly responsible for the functioning of the company. Working in a friendly environment with the use of modern technology will definitely have a positive impact on the company.

The risk matrix showed the company's most important and most threatening risks, together with their probability of occurrence and their impact on the company under review, which is particularly important as it is these that the company must focus on and plan in order to minimize or eliminate the aspects associated with their occurrence.

The automated production process has definitely sped up the production of one specific product, but it should be remembered that work on improving this area does not end here. On the contrary, it should be worked on even more intensively in order to eliminate the factor related to employee quality control and to minimize machine breakdowns as far as possible.

Functional problems exist in every company, which is the natural order of things. However, there are ways in which they can be easily eliminated. These problems also occur in the company under study and are inevitable. Delays in the production process are caused by the human factor of human error, but also by machine and equipment

failures that are beyond anyone's control, the lack of necessary materials and components for production or order picking, and the occurrence of non-releasable batches of parts. It should be mentioned that there are also problems that can be solved, and it is on these that the plant should currently focus.

In summary, the information presented, as well as the analysis and research carried out, showed that even a long-standing, successful company needs to continually invest in new technologies, as well as solutions, in order to continually develop and improve the efficiency and quality of its services.

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