SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 196

STORAGE TECHNOLOGIES AND ORDER PICKING METHODS ON THE EXAMPLE OF AN ENTERPRISE

Mateusz CHŁĄD[1*], Kacper MOŻDŻYŃ[2]

[1] Czestochowa University of Technology; mateusz.chlad@pcz.pl, ORCID: 0000-0002-1098-2971
[2] WSB University Dąbrowa Górnicza; kacpermozdzyn@gmail.com
* Correspondence author

Purpose: The aim of the article was to analyze why customers are less willing to use the services of the described company, at what stages of warehouse processes the company wastes the most time, what to do to save time and what solutions to introduce to improve all activities.
Design/methodology/approach: An SMED analysis was performed, which allowed the entire warehouse process to be presented step by step, how much time each stage takes and which of them takes the most time. Then, it was determined what solutions should be made to improve the process. Again, using SMED analysis, the times were verified and at what stage the savings were noticed.
Findings: The conducted research allowed us to determine how important information technology is in current logistics and how the investments introduced allow for a sudden change in the services provided by the company.
Research limitations/implications: The practical part is intended to reflect the actual compliance of the company with the imposed rules.
Practical implications: Analysis conducted before and after introducing the permitted changes determine whether the problem has been resolved and what benefits the company has experienced. Test the time of individual processes allowed for the implementation of a new IT system, which contributed to the development of the company and allowed us to save a large amount of capital.
Social implications: The aim of the proper selection of the strategy is to increase the efficiency of the process, shorten the duration and reduce costs. The main strategies are discrete picking, group picking and zone picking. Discreet picking involves performing single orders, when an employee can assemble items from only one order in one cycle. This is the simplest strategy and is often used when orders have a large number of items relative to media units.
Originality/value: The article draws attention to the importance of a non-routine approach to the dynamics of picking capabilities in an enterprise. This is important for management as a scientific discipline, but also for the enterprise, which indicates various possible development paths.
Keywords: Picking, SMED analysis, logistics, management.
Category of the paper: Research paper.

Introduction

The logistics system is an artificial system created by humans, its purpose is to move goods and/or people. It is a technical and social system because its elements are not only machines and devices that are used to move goods and/or people, but also the goods and/or people being moved, machines and people who manage this movement (Brewer, Speh, 2000). The implemented transformation mechanism consists in moving, i.e. changing the place where a specific good or person is located (Kabus, Piersiala, Miciuła, 2020). This transformation is carried out in order to move a specific good or person to its destination, i.e. where for some reason this good should be located, and the person would like to be there (Bień, Jędrzejczyk, Kucęba, 2020). Characteristics of this logistics system, which is called the flow chain, or goods chain.

Enterprise logistics systems (micrologistics systems) include such logistics processes as: purchasing, inventory management, warehousing, packaging and transport. Integration and coordination of these processes that take place in the enterprise's logistics system can be achieved by having integrated management of all logistics processes that take place within the logistics subsystems of supply, production, sales and service.

The research method used in the article is SMED analysis, which allowed us to compare the time of the warehouse process. The main research goal was to verify the hypothesis that the introduction of modern information technologies and systems in the enterprise will speed up the entire warehousing process, and above all, picking. It was checked based on the SMED analysis, where the company loses the most time during the entire warehouse process, from notifying the driver who will come to collect the goods from the warehouse, to its release. Then, appropriate changes were introduced that will improve the process and it will be verified how much time was saved thanks to the introduced changes.

Literature review

Picking is the process of placing orders consisting of various products that will then be transported to recipients. We have two main types of picking: horizontal and vertical. Horizontal involves placing products on the warehouse floor and handling them using simple tools such as wooden or electric pallets. The priority of this method is easy access to goods, therefore they should be arranged in such a way that employees can easily reach the most frequently rotated products. Vertical storage involves arranging goods in rows; access to them is more difficult than in the case of goods stored horizontally. The use of specialized equipment is required, such as forklifts, ladders and lifts (Buda, Sawicka, 2015). We arrange products

along the entire width of pallet racks to maximize storage space. We also have single picking, where each product is placed separately, and collective picking, where the products are placed together in one package. It is important to choose the appropriate picking method that will best meet the needs of a given company and its recipients. The picking of goods in terms of the method of handling products can be divided into several types: manual picking is based on not using any specialized equipment or machines, the available goods are located on the floor, the employee who picks the goods can easily get to the goods; Semi-automatic picking involves performing some tasks using machines such as forklifts to lift or arrange products, move them to a specific place or sort them (Zając, 2014; Brewer, Speh, 2000). People are responsible for activities such as packing products into packaging or preparing them for shipment. It is most often used where flexibility and adaptation of the process to various types of products or orders are required; In automatic picking, machines are responsible for all activities related to picking: picking goods, arranging and packing them, and shipping orders. The use of this technology, such as industrial robots or sorting machines, makes the entire process very fast and almost error-free. It is most often used in large warehouses, where efficiency and reliability come first. Unfortunately, huge investment outlays are required, but in the long run it can bring very large savings, for example by reducing employee maintenance costs.

Picking is also divided into one-stage and two-stage. One-stage picking, the so-called order picking, is the most common picking model used in warehouses. The picking path is carried out in a "stream" arrangement, which means a unidirectional and alternating arrangement of working aisles (Rostek, Knosala, 2015). During the implementation of single-stage picking, the following organizational assumptions are made: the picking zone is most often located at level "0" of the storage zone and includes goods locations accessible to warehouse employees from the floor level; assortments of individual product groups collected as part of the order are distributed evenly in the picking zone; when locating assortments in the picking zone, the results of the Pareto analysis are taken into account: according to the size of releases, i.e. division into storage technological zones (A, B, C); by editions where location within technological zones (X, Y, Z); the location of the assortments in the picking zone are most often pallet slots for group A goods (most frequently rotating), shelf space for groups B and C (least rotating - group C); picking orders are executed sequentially according to the order of entry (notification), which corresponds to the release (loading) schedule; the basis for completion are system documents corresponding in material terms to the issue document; the picking path in each aisle is unidirectional, and in subsequent aisles the directions will be arranged alternately (Wrzalik, Niedbał, 2022). Two-stage picking, the so-called assortment picking, is a less common picking model used in warehouses (Richards, 2016). The picking path is "mixed": the first level of picking: for group A assortments (zone A) consists of single cycles of picking full load units; for assortments from groups B and C (BC zone) it has a "comb" arrangement, the second level of picking - the picking path has a "stream" pattern (Battini**,** Calzavara, Persona, Sgarbossa, 2015). During the implementation of two-stage picking, the following basic organizational assumptions are made: goods locations

available to warehouse employees from the floor level; assortments of individual product groups collected as part of the order are distributed evenly in the picking zone; when locating assortments in the picking zone, the results of the Pareto analysis are taken into account, as in the case of single-stage picking; A storage area for the stock intended for replenishing the picking zone is most often located above the picking zone; the location of assortments in the picking zone is most often: pallet slots for group A goods, shelf space for group B and C; picking (first stage of picking) takes place in parallel in two zones: location of assortments of group A and groups B and C. The basis for completion is the system document "Collective Pick-Up List", which corresponds to the material scope of the batch of "Issuance Orders". The picking strategy is the way in which employees will perform the picking process, including decisions regarding the number of orders to be completed in one cycle, the area in which the employee will perform activities, the method of completing picking lists, etc. The aim of the proper selection of the strategy is to increase the efficiency of the process, shorten the time duration and cost reduction. The main strategies are discrete picking, group picking and zone picking (Dzideczek, 2018). Discreet picking involves performing single orders, when an employee can assemble items from only one order in one cycle. This is the simplest strategy and often used in situations where when orders have a large number of items relative to media units. It does not require large time and organizational investments. Order batching is a technique of grouping picking orders that are to be processed simultaneously. The goal is to increase the efficiency and productivity of the picking process by reducing the time it takes for workers to move around and pick items. This process is called group picking or group picking (Szymonik**,** 2010). However, properly combining and grouping orders can be a difficult task, known as the order batching problem. In some situations, an increase in congestion in the picking zone may result from the use of this strategy. There are many publications in the literature on the problem of improving order picking processes. Some of them recommend using the branch-and-price algorithm for less complicated problems, while others propose the descent approximation algorithm for more complex cases. In one of the articles, De Koster compared two heuristic algorithms: seed algorithms and savings algorithms, to solve the problem of grouping orders. Two ways of moving employees in the picking zone were analyzed: each aisle (S-shape) and the largest gap (Largest gap). Algorithms were compared in terms of the length of picking time, the number of order groups and the ease of their use. After conducting research, the author concluded that each of the analyzed order grouping methods significantly improves order picking processes compared to the FCFS (first-come first-serve) method (Szada-Borzyszkowska, Szada-Borzyszkowski, 2017). Seed algorithms are more efficient when combined with S-shape routing and the use of larger capacity media. In turn, savings algorithms are better used in conjunction with Large gap routing and using small capacity media. Zone picking is a logistics strategy in which the picking zone is divided into several subzones. Each of them is assigned to one or several employees who will only collect products found in this zone. This method of picking shortens the travel time of employees and enables faster finding of products, which contributes to reducing congestion problems. However, it is necessary to perform additional activities, such as

consolidating orders from individual subzones, before they are sent to the customer. A variation of zone picking is a strategy called bucket brigades. In this strategy, the size of the zones is variable and depends on the current performance of the employees. Each of them moves along the shelves, picking up products and following the principle of "pick until the next employee takes over your list, then come back for another one and start filling it out". Generating picking routes determines the sequence of offer locations that a worker will visit to fulfill customer orders and the route between them. A properly selected method can reduce picking time and distance and improve process efficiency (Kudelska, Pawłowski, 2019). There are different methods for generating routes, such as heuristic and optimization methods. The authors developed an algorithm based on graph theory and dynamic programming that allows to find the optimal picking route for a specific picking zone layout. Unfortunately, the implementation of this and other optimization algorithms can be difficult due to the variety of picking zone layouts in warehouses. In addition, routes calculated using optimization methods can be illogical for employees and be ignored. Another problem is the inclusion of congestion in picking aisles, which increases picking time and efficiency Therefore, heuristic methods are used as an alternative to optimal picking routing methods (Jacyna, Kłodawski, 2019). The most well-known heuristic methods of routing in a warehouse include, m.in, the S-shape method, the return method, the mid-point method, the largest gap method, the combined method and the optimal method.

SMED analysis and implementation of changes

The customer regularly makes notifications at the company where he calls out certain parts of his goods, which he then delivers to his customer. During the first analysis, the client made e-mail notifications, where the forwarder then prepared all the data on a printed packing list, thus confirming the details of the driver who appeared at the office, then placed himself at the ramp and only then was he loaded by the warehouseman. Based on this process, I made an SMED analysis, which presented from start to finish how long specific parts of the warehouse process will last, which will allow drawing conclusions and introducing appropriate changes in subsequent stages. This analysis presents specific stages of the warehouse process during the picking of 33 pallets.

Table 1.
Analysis of the warehouse process

Name of the work item	Starting point	Ending point	Value expressed in minutes	Additional comments (non-cyclical operations)
1. Preparatory activities	6:00	6:35	35	
Receiving a notification with the details of the driver who will collect the goods and information about what goods he will collect	6:00	6:05	5	
Printing information about the picked up goods	6:05	6:10	5	
Contact the warehouseman to direct him to the office	6:10	6:15	5	
Handing over a card containing information about what goods are to be collected by the warehouseman	6:15	6:35	20	The warehouseman heads to the office within a few minutes depending on whether it is busy or not
2. Goods picking	6:35	7:25	50	
Removing pallets from the shelves to a temporary storage place	6:35	7:25	50	
3. Delivery of the goods	8:00	9:00	60	
Driver arrival (driver goes to the office)	8:00	8:05	5	
Confirmation of data by the forwarder and sending it to a specific ramp	8:05	8:10	5	
The driver enters the ramp x - in the meantime, inform the warehouseman under which ramp the driver is entering	8:10	8:20	10	
Driver loading	8:20	9:00	40	
4. Completion of the process	9:00	9:40	40	
The driver goes to the office to confirm that the goods have been loaded	9:00	9:05	5	
The forwarder checks with the warehouseman whether the goods fit	9:05	9:10	5	
The forwarder is writing an e-mail to the client with information that the goods are loaded, and asks to send documents for the driver	9:10	9:15	5	
The driver is waiting for the documents	9:15	9:30	15	
The forwarder prints the documents and gives it to the driver for signature	9:30	9:35	5	
The driver heads towards the vehicle	9:35	9:40	5	

Source: Own study based on internal company materials.

The SMED analysis in Table 1 showed that the entire process takes 185 minutes. In this whole process, the company wastes a lot of time, especially on preparatory activities, the release of goods and the completion of the process. The goods are not assembled for specific exit ramps, the driver does not insert himself under a specific ramp, he has to confirm his identity in the forwarder's office, and above all, he wastes a lot of time waiting for documents that could have already been prepared if the goods data were visible in the system and the forwarder would be aware that the goods will certainly fit on the means of transport.

Table 2.
The sum of time and the percentage of each step in the process

Operations	Time [min]	Participation [%]
Preparatory activities	35	19
Goods picking	50	27
Delivery of the goods	60	32
Completion of the process	40	22
Total process execution time	185	100

Source: Own study based on internal company materials.

The customer regularly makes a notification at company XYZ, where he calls out certain parts of his goods, which he then delivers to his customer. During the first analysis, the customer made an e-mail notification, where the forwarder then prepared all the data on a printed packing list, thus confirming the data of the driver who appeared in the office, then inserted himself under the ramp and was only then loaded by the warehouseman. On the basis of this process, I made an SMED analysis, which presented from start to finish how many specific parts of the warehouse process will last, which in the next stages will allow to draw conclusions and introduce appropriate changes. This analysis shows the specific stages of the warehouse process during the picking of 66 pallets.

Table 3.
Warehouse process analysis

Work item name	Start point	End point	Value in minutes	Additional notes (non-recurring operations)
1. Preparatory activities	10:00	10:35	35	
Receiving a notification with the details of the driver who will collect the goods and information about what goods he will collect	10:00	10:05	5	
Printing information about the picked up goods	10:05	10:10	5	
Contact the warehouseman to direct him to the office	10:10	10:15	5	
Handing over a card containing information about what goods are to be collected by the warehouseman	10:15	10:35	20	The warehouseman goes to the office within a few minutes, depending on whether he is busy or not
2. Picking the goods	10:35	12:00	85	
Removing pallets from the shelves to a temporary storage place	10:35	12:00	85	
3. Release of goods	12:00	13:30	90	
Driver arrival (driver goes to the office)	12:00	12:05	5	
Confirmation of data by the forwarder and sending it to a specific ramp	12:05	12:10	5	
The driver enters the ramp x - in the meantime, inform the warehouseman under which ramp the driver is entering	12:10	12:20	10	
Driver loading	12:20	13:30	70	

Cont. table 3.

4. Completion of the process	13:30	14:15	40	
The driver goes to the office to confirm that the goods have been loaded	13:30	13:35	5	
The forwarder checks with the warehouseman whether the goods fit	13:35	13:40	5	
The forwarder is writing an e-mail to the client with information that the goods are loaded and asks for documents to be sent to the driver	13:40	13:50	5	
The driver is waiting for the documents	13:50	14:05	15	
The forwarder prints the documents and gives it to the driver for signature	14:05	14:10	5	
The driver heads towards the vehicle	14:10	14:15	5	

Source: Own study based on internal company materials.

The SMED analysis in table 3 shows that the entire process takes 255 minutes. Throughout this entire process, the company loses a lot of time, especially on preparatory activities, issuing goods and completing the process. The goods are not picked at specific exit ramps, the driver does not arrive at a specific ramp, he has to confirm his identity at the forwarder's office, and above all, he wastes a lot of time waiting for documents that could have already been prepared if the goods' data were visible in the system and the forwarder would be aware that the goods would definitely fit on the means of transport.

Table 4.

The sum of time and percentage of individual process stages

Operations	Time [min]	Share [%]
Preparatory activities	35	14
Goods picking	85	34
Delivery of the goods	90	36
Completion of the process	40	16
Total process execution time	250	100

Source: Own study based on internal company materials.

In both cases, the entire process took approximately the same time, but in the second case, the completion of goods and their release were longer due to the increase in the number of pallets. Unfortunately, it currently takes a very long time due to the fact that the warehouseman does not have information under which ramp the driver will be loading, so he has to place the completed goods in the temporary storage zone, so it takes longer to transport the goods to the vehicle that takes the goods.

The analysis carried out on the company made us aware of where the greatest time losses are and what needs to be changed to make the entire warehouse process, from the moment of receiving information about the driver picking up the goods to the moment of loading the goods onto the car, more efficient. Table 5 presents the tasks whose implementation will increase the efficiency of the warehouse process.

Table 5.
Record and status of tasks

Lp	Task description	Completion date	Person responsible	Implementation status
1.	Investment in RFID gates	Until the end of the first quarter of 2023	Management of the company	Completed
2.	Purchase of new scanners for warehouse workers	Until the end of the second quarter of 2023	Management of the company	Completed
3.	Presenting the system to customers and providing them with appropriate instructions on how to use it	By the end of the third quarter of 2023	Logistics specialist Sales specialist	Completed
4.	Introduction notification platforms	By the end of the third quarter of 2023	Branch manager Management of the company	Completed
5.	Starting use EDI by customers	Until the end of the first quarter of 2023	Customers of XYZ company	Completed

Source: Own study based on internal company materials.

Ad. 1-2. To shorten the picking time by warehouse workers, the company's management invests in RFID gates and new scanners. The whole idea of the operation is that the warehouse worker will have a picking path that he must follow and this order will automatically be placed on the scanner. The warehouseman no longer has to go to the office to obtain any papers from the forwarder to know what to collect.

Ad. 3. The contract logistics specialist prepares special instructions for the salesperson, who addresses the customers and presents the new system, provides information that it is free (on our company's side), will streamline the entire process and, above all, will help avoid mistakes during picking, the goods will not get lost, and you will always be sure that the goods will fit in the car.

Ad. 4. The company is setting up a notification platform, which allows the warehouseman to automatically verify the driver's data when he arrives at the ramp. When picking the goods at this point, the warehouseman does not pick the goods into the temporary storage zone, but starts picking them at a specific exit gate.

Ad. 5. Customers start sending notifications to us using EDI through interconnected systems. At this point, when entering the shipment into the system, the contractor provides: the number of pallets called (earlier, when the goods reach us, the goods are covered with RFID stickers), the exact dimensions of the pallets are entered into the system (so there is no need to verify whether the goods will fit on the vehicle), provides data about the driver's car and the data of the driver himself. After entering the shipment, the forwarder only verifies the correctness of all data and transfers it to the warehouseman's scanner, the one who is free at a given moment accepts the "order" and starts picking at a specific ramp (the customer adds in the comments what time the driver is notified and at which ramp he will be stood up), following the picking path determined by the scanner based on the pallets entered via RFID.

After implementing the changes, the accuracy and efficiency of the warehouse increased. The use of information technologies allowed the company to develop, reduce the number of complaints, warehouse workers have easier picking, and customers can easily change the details of the drivers who collect the goods or the number of pallets they would like to pick up. After introducing changes in the described company, the client made a notification in which he requested thirty-three pallets to be loaded onto the means of transport, an SMED analysis was made in table 6, which presented a specific time division of the entire warehouse process.

Table 6.
Analysis of the warehouse process

Name of the work item	Starting point	Ending point	Value expressed in minutes	Additional comments (operations non-cyclical)
1. Preparatory activities	6:00	6:15	15	
The customer enters the shipment with information about the driver and the goods	6:00	6:05	5	
Throwing the parcel to the warehouseman on the scanner, printing documents for the driver	6:05	6:15	5	
Acceptance of the order by the warehouseman	6:15	6:20	5	
2. Picking the goods	6:35	7:15	40	
Removing pallets from racks to the exit gate (BWY))	6:35	7:15	50	
3. Release of goods	8:00	8:30	25	
Driver arrival - data verification by the warehouseman	8:00	8:05	5	
Driver loading	8:05	8:25	20	
4. Completion of the process	8:25	8:35	10	
The driver goes to the office to collect the documents that the forwarder has already prepared	8:25	8:30	5	
The driver heads towards the vehicle	8:30	8:35	5	

Source: Own study based on internal company materials.

After analyzing the data in table 6, you can see how much the warehouse efficiency has improved. The duration of the process shrank from 185 minutes to 95 minutes, with the most time saved during preparatory activities, issuing goods and completing the process. This is due to the fact that the forwarder receives the notification together with the warehouseman for a specific product and sees the driver's details, so the driver does not have to confirm them in the office. The warehouseman picks the goods for a specific ramp, because the driver is notified in advance for a specific time and a specific ramp. Most importantly, the driver does not wait for the documents in the office, but receives them almost immediately, because the customer is obliged to enter the dimensions in the system, which helps avoid sending a vehicle that is too small for loading.

Table 7.
The sum of time and percentage of individual process stages after introducing changes

Operations	Time [min]	Share [%]
Preparatory activities	15	17
Goods picking	40	44
Delivery of the goods	25	28
Completion of the process	10	11
Total process execution time	90	100

Source: Own study based on internal company materials.

After introducing changes in the described company, the client made a notification in which he requested 66 pallets to be loaded onto the means of transport, an SMED analysis was made in table 8, which presented a specific time division of the entire warehouse process.

Table 8.
Analysis of the warehouse process

Name of the work item	Starting point	Ending point	Alue expressed in minutes	Additional comments (operations non-cyclical)
1. Preparatory activities	10:00	10:15	15	
Entering the shipment by the customer with information about the driver and cargo	10:00	10:05	5	
Throwing the parcel to the warehouseman on the scanner, printing documents for the driver	10:05	10:10	5	
Acceptance of the order by the warehouseman	10:10	10:15	5	
2. Picking the goods	10:15	11:15	60	
Removing pallets from racks to the exit gate (BWY)	10:15	11:15	60	
3. Release of goods	11:15	12:00	45	
Driver arrival - data verification by the warehouseman	11:15	11:20	5	
Driver loading	11:20	12:00	40	
4. Completion of the process	12:00	12:10	10	
The driver goes to the office to collect the documents that the forwarder has already prepared	12:00	12:05	5	
The driver heads towards the vehicle	12:05	12:10	5	

Source: Own study based on internal company materials.

After the analysis in table 8, you can see how much the warehouse efficiency has improved. The duration of the process shrank from 255 minutes to 130 minutes, the most time was saved during preparatory activities, issuing goods and completing the process. This is due to the fact that the forwarder receives the notification together with the warehouseman for a specific product and sees the driver's details, so the driver does not have to confirm them in the office. The warehouseman picks the goods for a specific ramp, because the driver is notified in advance for a specific time and a specific ramp. Most importantly, the driver does not wait for the documents in the office, but receives them almost immediately, because the customer is obliged to enter the dimensions in the system, which helps avoid sending a vehicle that is too small for loading.

Table 9.
The sum of time and percentage of individual process stages after introducing changes

Operations	Time [min]	Share [%]
Preparatory activities	15	11
Goods picking	60	46
Delivery of the goods	45	35
Completion of the process	10	8
Total process execution time	130	100

Source: Own study based on internal company materials.

Thanks to this method, we managed to notice where the problems are in the company, why it is losing customers and what should be improved by the company to retain customers and even encourage new customers to use the services. The SMED analysis in the tables above in the first part of the analysis allowed us to notice exactly at which stages of the warehouse process the organization loses the most time. Then, the management itself or with the help of specialists from specific departments planned the introduction of investments, changes and certain solutions to make the entire process even more effective. Thanks to this, in the next part it was verified how these investments influenced the effectiveness. This allowed the entire company to shorten the entire warehouse process by as much as 50%. In the example of the warehouse process, where the customer retrieved 33 pallets, from the moment of notification to the moment of the driver's final departure, it took 185 minutes before the changes were introduced, and after introducing them, it took 90 minutes. The same applies to the process where 66 pallets were developed, the entire process from 250 minutes shrank to 130 minutes.

Conclusions from the SMED analysis and the changes introduced

The introduction of appropriate changes to the company allowed for increasing the efficiency of the organization's warehouse processes. Before the changes introduced, the company wasted a lot of time on completely unnecessary things. Simple solutions, investments and focusing on the warehouse process itself allowed us to show how much time can be saved and customer satisfaction. The first SMED analysis showed us that the preparatory activities themselves and the completion of the process take more time in percentage terms than the release of goods or picking, which is completely unacceptable, they took 19% and 22% respectively, taking a total of 41% of the picking time; where issuing goods took 32% and picking 27%, in the case of issuing 33 pallets for a customer. On the example of another notification, which was sent to the company, this time for 66 pallets, it was noticed that, although preparatory activities and completion of the process (14%; 18%) do not take as much time as picking the goods or issuing the goods (33%; 35%), but the sum of these parts of the process is still very high and a solution had to be found that would allow the organization to save as much of this time as possible. Therefore, the Management Board decided to introduce

several investments and innovative solutions that will shorten the entire warehouse process and increase customer satisfaction with the services that are provided to these customers. RFID gateways were introduced, new scanners were purchased, a connection between the senders' systems and the company was introduced, and a platform for driver notification was introduced.

Thanks to this, the whole process has become much more effective and as a result, it was possible to save over 50% of the time that was previously required for such a process: in the case of 33 pallets we needed 185 minutes, now we need 90 minutes, which gives 95 minutes of time savings – about 51%, if we were talking about a notification, as a result of which 66 pallets are called, The whole process has been shortened from 250 minutes to 130 minutes, which also gives 48% savings. The most important parts of the process on which we wanted to save time were: preparatory activities and the end of the process. With the changes made to 33 pallets, the preparation work previously took 35 minutes and accounted for 19%, now it takes only 20 minutes (17%) – the goal has been achieved. Then, talking about the end of the process, it used to take 40 minutes and it was 22% of the whole process, after making changes it takes 10 minutes and it is only 11% of the process, we were able to save time here – the goal was achieved again. Speaking of the other two parts of the process, i.e. picking the goods and the release of the goods, a great success was also achieved here, these parts took respectively: 50 minutes (27%) and 60 minutes (32%), after the introduction of changes they take: 40 minutes (44%) and 25 minutes (28%) – the percentage result is higher, but the picking itself no longer takes place in place of temporary storage, but directly under the unloading ramp, which significantly reduces the driver's loading time.

After introducing the changes, in the case of processing 66 pallets, the preparatory activities previously took 35 minutes and accounted for 19% of the entire process, now they last only 15 minutes, representing 11% of the entire process - the goal was achieved. Then, talking about the completion of the process, it previously took 40 minutes and constituted 16% of the entire process, after introducing changes it takes 10 minutes and constitutes only 8% of the process, we managed to save here - the goal was achieved again. Talking about the other two parts of the process, i.e. picking the goods and issuing the goods, a great success was also achieved here, these parts took respectively: 85 minutes (34%) and 90 minutes (36%), after introducing changes they took: 60 minutes (46%) and 45 minutes (35%). The percentage result in this case is not that impressive, in reality the time has been saved, the percentage is higher, but it should be noted that, as in the case of picking 33 pallets, the picking is also for a specific exit ramp, and therefore the entire loading time is much shorter, and the percentage itself is a larger percentage, but much smaller of the total process time.

References

1. Battini, D., Calzavara, M., Persona, A., Sgarbossa, F. (2015). Order picking system design: the storage assignment and travel distance estimation (SA&TDE) joint method. *International Journal of Production Research, vol. 53, no. 4,* 997-1012.
2. Bień, J., Jędrzejczyk, W., Kucęba, R. (2020). Ekoinnowacyjne potrzeby przedsiębiorstw z sektora MSP a potencjał sieci ekoinnowacji Ecolabnet. *Przegląd Organizacji, 3,* 12-18, DOI: 10.33141/po.2020.03.02.
3. Brewer, P.C., Speh, T.W. (2000). Using the balanced scorecard to measure supply chain performance. *Journal of Business Logistics, Vol. 21, No. 1*.
4. Buda, M., Sawicka, H. (2015). Analiza i ocena procesu magazynowania w przedsiębiorstwie produkcyjnym. *Logistyka, no. 2*.
5. Dzideczek, T. (2018). Czas na zamówienie. *Magazynowanie i Dystrybucja, No. 2,* 26-28.
6. Emerling, I. (2018). Balanced scorecard and its role company management. *Research papers of Wrocław University of Economics, 514*, 108-115. DOI: 10.15611/pn.2018.514.10.
7. Jacyna, M., Kłodawski, M. (2019). Pracochłonność procesu komis jonowania dla wariantowego rozmieszczania asortymentu w strefie kompletacji. *Prace Naukowe Politechniki Warszawskiej. Transport,* 73-84.
8. Kabus, L., Piersiala, L., Miciuła, I. (2020). Ryzyko w zarządzaniu łańcuchem dostaw. *Europejski dziennik badań naukowych, Tom 23*, 467-480. DOI:10.35808/ersj/1694.
9. Kudelska, I., Pawłowski, G. (2019). Influence of assortment al location managein the ware house on the human work load. *Central European Journal of Operations Research*, 1-17.
10. Richards, G. (2016). *Zarządzanie logistyką magazynową*. Warszawa: PWN, 25-45.
11. Rostek, M., Knosala, R. (2015). Produktywność gospodarki magazynowej na wybranym przykładzie. In: R. Knosala (ed.), Innowacje w zarządzaniu i inżynierii produkcji (949-957). Opole: Wydawnictwo PTZP.
12. Szada-Borzyszkowska, M., Szada-Borzyszkowski, W. (2017). Usprawnienie trasy kompletacji zamówienia w magazynie części do montażu pojazdów samochodowych. *Autobusy, No. 7-8,* 278-279.
13. Szymonik, A. (2010). *Technologie informatyczne w logistyce.* Warszawa: Placet, 112-114.
14. Wrzalik, A., Niedbał, R. (2022). *Informatyzacja procesów transportowych i magazynowych.* Toruń: Towarzystwo Naukowe Organizacji i Kierownictwa. Dom Organizatora, 35-165.
15. Zając, J. (2014). Kompletacja jednostopniowa a dwustopniowa – wydajność kompletacji a aspekty organizacyjne. *Logistyka*, 45-47.