OPTIMIZATION PROCESSES IN WAREHOUSE MANAGEMENT

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Absract: This article aims to show the essence and importance of optimizing warehouse processes. Efficiency itself is an inseparable element of development, it drives the industry and allows for constant development. The idea behind the optimization of warehouse processes is an important element of business development, thanks to optimization you can save both time and money, and the pursuit of self-improvement should guide every organization striving for excellence in terms of services offered and the manner and time of order execution.

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Introduction

Modern societies have many different needs, from the simplest - physiological to the most demanding. The task of logistics is to meet these requirements.

Logistics in essence is a system that is responsible for the flow of information and materials or finished products. Many times you can hear the truthful view that logistics is a pillar of the economy.

Logistics in its sphere of operation combines orders, inventory management, storage and transport (logistics-mix) as well as products, price, promotion and distribution (Marketing-mix). The primary task of logistics is to ensure constant access to goods and after-sales service. One of the key activities of logistics is the flow of information that allows you to determine the demand and design production in relation to orders, the information is two-way in nature, on the one hand, data from the customer is received, and on the other hand, the company sends it to sellers informing about how much product the company is able to deliver at the desired time.

In today's market economy, the customer decides what to buy, and logistics is not entirely based on mass production, but customer-oriented production and marketing. In this system, the producer has to provide the customer with an outlet, which is fed by integrated supply chains.

When designing a supply chain, many variables should be adopted and a complete supply cycle should be established for each branch of production. Therefore, the complete picture of the chain, the individual links of which ultimately contribute to the creation of a product of full value for the customer, should be taken into account. For each industry, the customer is the final stage of the chain, therefore, for the steelworks, the customer will be a metallurgical plant, and for retail stores, a private person or company [Grzecha, 2011, p. 627].

Supply logistics exists at virtually every stage of production, in the external and internal supply processes, each enterprise generates supply needs, supply logistics ensures their implementation and enables the functioning of many economic units. There are many concepts to support logistics activities, and this is some of them [Dyczkowska, 2011, p. 200]:

- Just in Time is a method of production and supply management related to the individual demand of a given unit for specific products, goods, semi-finished products, etc. the genesis of this system is at the Toyota Motor Company. The main principle of this system is to resign from maintaining stocks, all production is based on just in time (JiT) deliveries, for this purpose the production company builds a network of mutual connections creating a group of companies (keiretsu) in which suppliers are an integral part of the entire company. This cooperation is based on mutual trust in the supplier and its reliability and production capabilities, in addition, the concern provides an emergency fund and mutual assistance in the event of serious problems in the functioning of the company, such companies are characterized by the quality of manufactured elements. The JIT system assumes that any delay may mean stopping the entire production line, which, for example, in the automotive industry may have negative effects, in addition, each element must meet the precise expectations of the customer. The implementation of Just in Time from scratch is a long and difficult process, but the resignation from maintaining stocks in favor of maximizing production and the associated profits over time constitute a good alternative to traditional methods of supply. Należy zaznaczyć że wyróżnia się także wariant JIT wykorzystywany w branży automotive, Just in sequence (JIS) [www1] this system is an extension of JIT and is associated with the implementation of a system in which, already at the stage of preparing the delivery, the sequence of demand for specific production lines is determined to minimize the time needed for

the component to travel from the reception area to the production line, in such a system the number of one-day deliveries may be even 400 package,

- supply with the maintenance of resources - the second rule is present in most companies around the world, is characterized by regular orders and deliveries as well as keeping stocks in stock, goods are ordered when a given assortment reaches the minimum state or runs out. It is quite simple to implement and very common, the main disadvantages of this concept are the cost of maintaining inventory and wastage of resources, delivery synchronized with production or consumption. Its essence is to maintain the minimum stocks in the warehouse and the implementation of deliveries (JiT) in accordance with the demand, it is assumed that this principle is a transition stage for companies that plan to introduce the JiT method in their supply system or reduce the costs related to stocks and their maintenance, but at the same time prefer to maintain this emergency stock, it is supported by the fact that this stage was part of the modernization of the Toyota factory when the company decided to introduce JIT.

Inventory maintenance is currently the most common supply system, the company carries out orders in regular cycles or due to demand, stores and uses its stocks until reaching minimum levels, it requires constant supervision over the entire warehouse and frequent inventory taking to monitor both stock and inventory status. and calculating losses. The optimal choice would be to introduce on-time delivery systems or to reduce stocks, but these are costly processes.

Manipulation of goods is one of the most frequently performed activities in the warehouse. Depending on the sources, manipulations are defined with the division into mechanical and manual manipulations, but many authors combine both of these methods, so the most common opinion is that manipulation is the efficient movement of goods over short distances, which usually takes place within a building and between an object and a transport broker [Coyle, 2002, p. 360][65].

Manipulating goods is nothing more than moving them within a warehouse building, but manipulation is also a means of action that is used to perform other warehouse tasks.

When manipulating, several basic elements of this process are mentioned [Coyle, 2002, p. 360]:

- relocation; - i.e. changing the location of the object, the flow of materials, products, semi-finished products and goods within the warehouse,
- time; the efficient operation of the warehouse requires quick and precise

performance so that the customer receives the ordered products on time and the production line can continuously produce goods. The warehouse should be designed in such a way that the internal roads are arranged in a way that is optimal for the use of all handling means and employees,

- quantity; in this case, the essence is to transport at the same time such a number of goods to meet the demand of the customer,
- space; the storage capacity is limited and additionally reduced by racks, during manipulation, a place for means of transport and their operation should be provided, front trucks must be able to manipulate the goods and move efficiently along the marked paths,
- coordination; when creating an internal transport line, it is necessary to optimally,
- design the operation of all measures, for this purpose WMS systems are increasingly used.

Currently, warehouses are getting higher and higher, it is directly related to the increase in production and demand for goods, which means that there is not enough space in warehouse facilities, shelves and the buildings themselves are modernized so that they can accommodate more goods without much interference in the reconstruction of the facility itself, it is associated with efficient use of storage capacity. This term determines the boundaries of the warehouse, and the possibilities of its development and space management, in most cases these are permanent objects, the expansion of which may be an unnecessary cost, when designing a warehouse it is necessary to use the maximum space, manipulation allows you to maintain this state by filling the gaps and optimal positioning of the stored goods [Cywinski ao, 2021, p. 78].

When manipulating, it is very important to follow certain rules that will avoid serious intakes:

- principle of planning - all activities that we undertake should be planned,
- system principle - integration of all activities performed in the warehouse,
- material flow principle - determining the order of material flow,
- the principle of simplification - optimization of work by simplifying the operation of the system,
- the principle of gravity - if possible, use the force of gravity to move goods,
- the safety principle.

In the past, the work of a warehouseman required him to be very physically fit, because each load had to be moved with his own hands, this applied to all handling works, moving loads within the warehouse, their picking or loading, in addition, full knowledge of the object and places to which the goods must be moved was required, over time, the development of technology brought automation, starting with the invention of the steam engine, when the machines took over some of the duties in factories and Thus, they significantly increased the speed of production, with time and further development, more and more modern systems of cranes, robots and transporters were created, which, without diminishing the role of man in the warehouse, made his work much easier [Cywiński, 2020, p. 69].

Analysis and evaluation of the optimization process

Quality management often defines the optimization process as continuous improvement in order to achieve the highest possible results by generating the lowest possible costs. In the era of rising labor costs and employee retention, process optimization should be one of the company's priorities, by introducing simplifications that speed up and facilitate the processes performed by employees, the company is able to save up to several thousand dollars.

There are many possibilities to carry out an optimization analysis, it can be an empirical analysis carried out in laboratory or environmental conditions or theoretical one, simulating the possibilities and results obtained after applying specific optimization methods. For the purposes of the empirical study, Luca systems enabling self-picking and multi-picking using two types of transport trucks were used.

Figure 1. Pick-by-frame system trolley with visible pick=by-light diodes.

Source: own study

The Pick-by-frame system is equipped with electronic supporting devices, it has screens that describe the location of the next collection point, and a pick-by-light system that indicates the quantity and method of distribution of products to collective transport units (here plastic containers).

Figure 2. Shelf with the Pick-by-light system marked with a diode, the collection point of the assortment.
Source: own study.

The Pick-by-light system allows for quick navigation in the warehouse during order picking, it works in two modes: Pick-by-all (it displays immediately all collection points including the one) and Pick-by-step, where the next picking point is indicated only after downloading the product from the previous point, each download of the product is confirmed by pressing the button on controller and scanning the EAN code with a manual or handheld scanner

Figure 3. Pick-by-frame with a visible system of diodes, the numbers represent the quantity of goods that should be completed in the marked packaging.
Source: own study.

The Pick-by-point system offers precise route indication thanks to the marking of products with bright light, this system works with the pick-by-light system, the use of which is based on the indication of only one product at a time, the disadvantage of the pick-by-point system is the small radius Therefore, in a large warehouse, its implementation may turn out to be demanding, both technically and financially.

The idea behind the analysis was to optimize the order picking process using the ERP pick-by-light system and the standard optical EAN code scanner. The analysis assumed 29 self-picking measurements (picking one order at the same time), taking into account the use of the pick-by-light setting in the pick-by-all format, marked below as PbP-all, and 29 measurements using the Multi Picking method (picking many orders at the same time) also with using the Pick-by-all setting. The main purpose of the experiment was to compare the two above-mentioned methods of picking in terms of the average time difference between them, and on the basis of the obtained data, determination of possible changes in the enterprise after applying the best possible form of optimization.

Data analisis

PbP-all (sec)	Multi (sec/szt.	Różnica (sec)	Procent (%)
37,00	17,67	19,33	0,52
24,00	13,60	10,40	0,43
39,00	14,20	24,80	0,64
37,00	15,07	21,93	0,59
37,00	14,67	22,33	0,60
30,00	13,60	16,40	0,55
34,00	12,80	21,20	0,62
36,00	13,67	22,33	0,62
30,00	13,67	16,33	0,54
33,00	16,07	16,93	0,51
30,00	14,93	15,07	0,50
30,00	16,87	13,13	0,44
29,00	14,80	14,20	0,49
32,00	15,87	16,13	0,50
28,00	16,33	11,67	0,42
28,00	14,80	13,20	0,47
28,00	12,47	15,53	0,55
18,00	15,20	2,80	0,16
50,00	15,67	34,33	0,69
33,00	14,47	18,53	0,56
27,00	13,20	13,80	0,51
29,00	13,40	15,60	0,54
34,00	14,73	19,27	0,57
30,00	13,67	16,33	0,54
19,00	14,00	5,00	0,26
32,00	16,40	15,60	0,49
29,00	13,07	15,93	0,55
27,00	16,07	10,93	0,40
23,00	14,47	8,53	0,37
	srednia	**16,12**	**0,51**
	odch	**6,09**	**0,11**
	vs	**0,38**	**0,22**

Figure 4. Ttable presenting the measurement results.

Source: Own study

To carry out the analysis, a total of 58 measurements were made, 29 using pick-by-all (PbP-all) self-picking and 29 in multi-picking using the pick-by-all (Multi) method. The measurements were to simulate the working time of one warehouse worker on order picking, in the self picking method, picking was for one order, while in the multipicking system several orders were picked simultaneously by using the pick-by-frame system, i.e. a special trolley equipped with ERP systems. Based on the recorded times of each performed test, the differences between the measurements were calculated and then saved in numerical and percentage formats to illustrate which method of completion is the least time-consuming and thus optimal. Thanks to the obtained results, it was possible to establish that the difference between the Self-picking and Multi-picking systems is 16 seconds (51%) with the benefit of the multi-picking system, this result concerns the time needed to pick one product.

Table 1. The result of the empirical analysis

Number of operations/ 8h shift	1 shift 21 days	1 shift 30 days	2 shifts 21 days	2 shifts 30 days	3 shifts 21 days	3 shifts 30 days
3	1 015,82	1 451,17	2 031,64	2 902,34	3 047,46	4 353,52
10	3 386,07	4 837,24	6 772,14	9 674,48	10 158,21	14 511,72
100	33 860,69	48 372,41	67 721,38	96 744,83	101 582,07	145 117,24
200	67 721,38	96 744,83	135 442,76	193 489,66	203 164,14	290 234,48
1000	338 606,90	483 724,14	677 213,79	967 448,28	1 015 820,69	1 451 172,41

Souce: Own study

In order to design a model of possible changes, a table was created. A model was designed in it showing the time in seconds saved after using the Multi-picking method in one, two and three shift formats in variants of 21 and 30 working days per month, the assumed working time was 8 hours, this analysis was to compare how much time can be saved using the multi-picking method, assuming that the employee performs 3, 10, 100, 200 and 1000 operations consecutively during his shift. For this purpose, a formula has been derived like:

*estimated working time in the company = number of operations / 8 hours * average * number of shifts * number of working days*

Table 2. The result of the analysis in PLN

Result in PLN					
19,75	28,22	39,50	56,43	59,26	84,65
65,84	94,06	131,68	188,11	197,52	282,17
658,40	940,57	1 316,80	1 881,15	1 975,21	2 821,72
1 316,80	1 881,15	2 633,61	3 762,30	3 950,41	5 643,45
6 584,02	9 405,75	13 168,05	18 811,49	19 752,07	28 217,24

Souce: own study.

Next, it was necessary to determine the amount of money that can be saved in the time specified in the table, for this purpose, the average cost of an employee per hour of work was calculated which amounted to PLN 70. It was calculated on the basis of data from various companies using the formula: estimated working hours = unit time + preparation and completion time. Then the cost time was determined for one second of work:

70 PLN/60min/60sec = 0,02 PLN

Thus, it was possible to establish that the unit labor cost of one employee is PLN 0.02 per second of work, after multiplying the empirical data by the value of the obtained labor cost, a table was constructed containing data on the money saved.

Conclusion

Table 3. return on investment for selected volumes of operations performed during an 8-hour shift.

Number of operations/ 8h shift	Time needed to perform one operation	Time given in units	Return on investment

3	2,67	Operation by 2,67h	investment is not profitable
10	0,80	Operation by 0,8h	investment is not profitable
100	0,08	Operation by 8 s.	investment moderately profitable
200	0,04	Operation by 4 s.	profitable investment
300	0,03	Operation by 3 s.	profitable investment

Source: Own study.

Based on the collected data and calculations, it can be concluded that the difference between self parking and multi-picking is about 50% with a differentiation of 22%, at the same time it should be noted that the result is positive for multi-picking. In order to check possible changes, on the basis of the average labor costs in Gorzów Wielkopolski, a summary of the analysis was prepared, a table containing information on the profitability of the project based on the time saved for performing one operation. The calculations show that the investment in implementation of the ERP system presented in the analysis begins to be profitable after reaching the threshold of 100 operations per 8 hours of work, which gives about 8 seconds per one operation performed by an employee, it allows to save from about PLN 658 for one-shift work to PLN 2,821 per month for three-shift work, for one employee, each time acceleration and improvement of working conditions allows you to save more and more money and time needed to complete the order. In the perspective of the future, the company can bring significant savings resulting from increasing the ability of one employee to perform tasks, thus saving capital allocated to employing a larger number of employees. An efficient system will allow you to delegate some employees to other tasks, thus leaving the number necessary to fulfill the company's orders in the warehouse. Based on the empirical data collected during the optimization process, several additional conclusions:

- the use of an EAN code scanner put on a hand or a glove with a scanner would significantly speed up the process of scanning and taking the assortment. An alternative would be to place a handle or a holster that allows you to quickly put down or pick up a handheld scanner,
- the pick-by-light-all system is distinguished by greater precision in navigating, the employee, seeing the next picking point, finds the way to the destination much faster, the additional implementation of screens displaying the next collection point

significantly increases the speed and convenience of work.

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