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STREAMLINING THE CAR ORDER PICKING TASKS IN A WAREHOUSE

Abstract: An attempt to find the best possible way to allocate goods in a warehouse, so as to make the process of completing the order as short as possible, is the subject of this paper. Order picking is the most laborious warehouse process and it contributes to 55%–65% of all the costs of operations performed in a warehouse. In a modern warehouse every manipulation of materials is subjected to detailed verification at the stage of planning. The best possible goods' allocation allows to fully exploit the limited capacity of a given warehouse and to reduce the number of manipulations with a given product. The small shifts of goods on a short distances are starting to play a very important part. On the basis of a practical problem observation in a company, a computer program has been created. This program helps to simulate different goods allocation variants in a way which makes the process of order picking as short as possible.

Keywords: order picking, simulations, goods allocation in a warehouse.

1. Introduction

In order to be competitive in a dynamic environment, companies keep on looking for new managing concepts. In recent years there was a focus on logistics concept of management which is based on the complex analysis of the flow of goods and information. A logistic system is described as a path on which the products travel from the supplier to the consumer.

The understanding of the way in which the goods are moved between the specific elements of logistic chain allows to plan and optimize individual stages of goods movement. In the modern logistic system every manipulation of materials is subjected to detailed verification at the stage of planning. The small shifts of goods on a short distances, which happen in the premises of a given building (warehouse, production plant), and between the building and transport intermediary, are starting to play a very important part (Coyle *et al.* 2002).

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The order picking problems are especially visible in logistic centres which are becoming more and more important in the modern supply chain management (Chiang *et al.* 2005, p. 1003). They focus on: finding the best possible way to locate the goods on a given space, using the limited capacity of the building to the utmost, and reducing the number of manipulations with a given product.

Logistic managers supervise a logistic centre in a way which allows them to make the most of the available space, and in the same time, to provide the right accessibility and security of stored goods, resulting from their specification. In this way the storing space is not only treated as an area of a given size, but, first and foremost, as a place which provides right conditions needed for storing goods in time (Fijałkowski 1987, p. 1–5).

2. Order picking systems

Order picking is a process of logistic activities, operational and organizational. It is based on the combination of specific subsets (goods), from the prepared set (assortment), on the basis of order information in the form of commission . There also occur a change of a specific state of stored goods into a characteristic state released goods. In other words order picking is searching for and completing, from storing places in a warehouse, specific goods which are on the order list placed by a customer (Petersen *et al.* 2004, p. 534–544).

The process of completing an order can be accomplished on many different ways and via many different methods. The right choice of order picking systems is possible due to the analysis of different factors. The most important factors are (Kizyn 2006, p. 36–38):

- the structure of stored warehouse goods (kind, size, shape, weight, packaging, qualities, etc.);
- size and the range of completing activities resulting from the turnover in a warehouse;
- the size and the arrangement of warehouse's area, a division into functional zones, the characteristic of goods flow through the zones in the warehousing process;
- the level of mechanization in a warehousing process and possible to implement, the level of mechanization of order picking procedures;
- organization system and the control of warehousing process activities, and possible to apply system of organization and control of order completing process activities;
- the amount of available funds for improving the order completing system;
- the planned range and level of customer service, and, resulting from it, tasks for the order completing process.

Order picking systems are created because of the basic actions which are the part of this process (Tab. 1).

Table 1. *The basic variants of order picking on the account of actions which are the part of this process*

Basic functions	Variants of completing the action	
preparation to pick up	static	dynamic
picking up	manually or mechanically	automatic
movement	one-dimensional	multidimensional
release	central	decentralized

Source: Fijałkowski (1987)

The combination of above mentioned completing variants results in 16 different order picking systems. In Poland and all over the world the majority of systems are based on manual or mechanical goods pick up (De Koster *et al.* 2007). Order picking is the most laborious warehousing process, which, according do different research, constitutes from 55% (Frazelle, Apple 1994) to 65% (Coyle *et al.* 2002) of all operation costs (Tab. 2).

Table 2. *The activities which are the part of order picking process and their labour intensity*

Activity	Activity percentage during order picking
movement	55%
seeking	15%
picking up	10%
release	20%

Source: Bartholdi, Hackman (2008, p. 23)

According to the research, movement is the most laborious activity. In other words movement is travelling a given way, between the points of taking the order, and places of picking up and release of goods. Works of scientists and researchers aim at speeding up and reducing the costs of completing the order. In order to meet the requirements of general system efficiency the three basic questions, which determine the overall time of order picking process, need to be answered. First of all, how to pick up goods (complete), secondly, how to store (stock up), and finally how to move to get the ordered commodity?

Publications answering the question: how to pick up the good(picking policies) focus on the division of labour among workers, so that the time of picking the goods, according to the order picking list, is as short as possible.

In accordance with the division made by Ackerman, there are three approaches in order picking policy: strict order picking, batch picking, and zone picking Ackerman 1990. Strict order picking assigns an individual worker who directly completes a single order. Batch picking assigns a single warehouseman to the bigger number of orders during the order picking route, whereas zone picking assigns

a warehouseman to one zone where he is responsible for the goods which are on his order picking list (Petersen 2002, p. 794).

We can distinguish three types of zone picking: *sequential zone*, *batch zone* and *wave zone*. *Sequential zone* picking is typical for one order which is completed at a single carrier. In this type the carrier is transported by means of sequential vehicle from one zone to another, and in every zone a warehouseman, responsible for a given area, completes the order which is assigned to a given part. In *batch zone picking* the order is picked separately but simultaneously in every picking zone, and at the end of the process it is put in to one complete whole which goes to the client. *Wave picking* is a special type of *batch zone picking* in which a warehouseman picks some large batches of goods and his actions are not based on the number of products from the order list but on the order picking time (usually from 30 min. to 2 h). After the process of continuous order picking, which is discontinued only for unloading a full carrier, there is a consolidation process of a given order which is done by the workers on the basis of goods brought in Frazelle, Apple (1994, p. 22–36).

The way of goods storage – storage *policies* is another topic analyzed and considered by scholars and logistic practitioners. Storage policies deal with assigning some specific locations for given goods (storage). There can be some different ways of storage. The first one is called *random storage*. This approach is based on storing the goods in a warehousing space in which there is a free room for it. In this way the time is reduced which is needed for putting the product down, yet it increases it in the order picking process.

The second approach is based on allotting a specific place in a warehouse, which can be distinguish taking into account several factors, to a given good. Storing goods on the same carrier (euro-pallet) together is the first factor. It's very convenient for the technological reasons as it helps to optimize the storing space on the stand. The second factor comes down to a simple rule according to which goods with the fastest rotation have to be located as close as possible to warehouse's exits so as to minimize the order picking time (Ghiani *et al.* 2004, Manning 2008).

Routing policies are the last major point in the order picking research. The most important point of this studies is to find some ways to minimize the distance that warehousemen have to cover on a route, in order picking process. Out of different algorithms, which try to solve the problem of minimizing and shortening the length of order picking route, the most popular are heuristics algorithms. Their universality results from the facts that they are very easy to implement and have similar results to algorithms with accurate results (Ratlif, Rosenthal 1983, p. 507–521). The limitations with using algorithms with accurate results are caused by too big number of variables, and difficulties in creating new models for such a varied order picking lists.

3. Order picking problems in the examined warehouse

Described problem concerns the warehouse of a logistic operator. This is a warehouse which basic functions are limited to reception, storage, order picking, and release of goods which belong to various production and retail companies, which have the basic

warehouse processes carried out by external companies. Warehousing premises are located in Bielany Wrocławskie and are rented from developer by the logistic operator. The warehouse is divided into several zones. The space allotted to receiving and releasing goods is mutual for every delivery.

Whereas, the biggest warehousing area, designed for storing goods, is divided into several smaller subzones in which the good from a given supplier is stored individually. The rule which says: one subzone for one supplier is followed. In this way the logistic operator has regards for his customers who, on visiting and controlling him, can see their goods grouped in one, specifically designed for this purpose, place.

Commodities are stored on the five-row pallet stands by means of two carriers – euro-pallet and industrial pallet. There are side passages between stands, which are about six meters wide. The warehouse, apart from the places designed for storing goods, has got seven places for order picking called docks. They are of the same size: six meters wide and twelve meters long. The commodities which are ready to send are put there and from this place the lorry, which drives up to the entrance gate of the warehouse, is loaded. The storing space and the order picking area are separated from each other by passages six meters wide.

In this paper one of the zones, allotted to reception, storage, order picking, and release of three products owned by the biggest customer of this company – baby food manufacturer, is examined.

In the Figure 1 there is a horizontal projection of this zone.

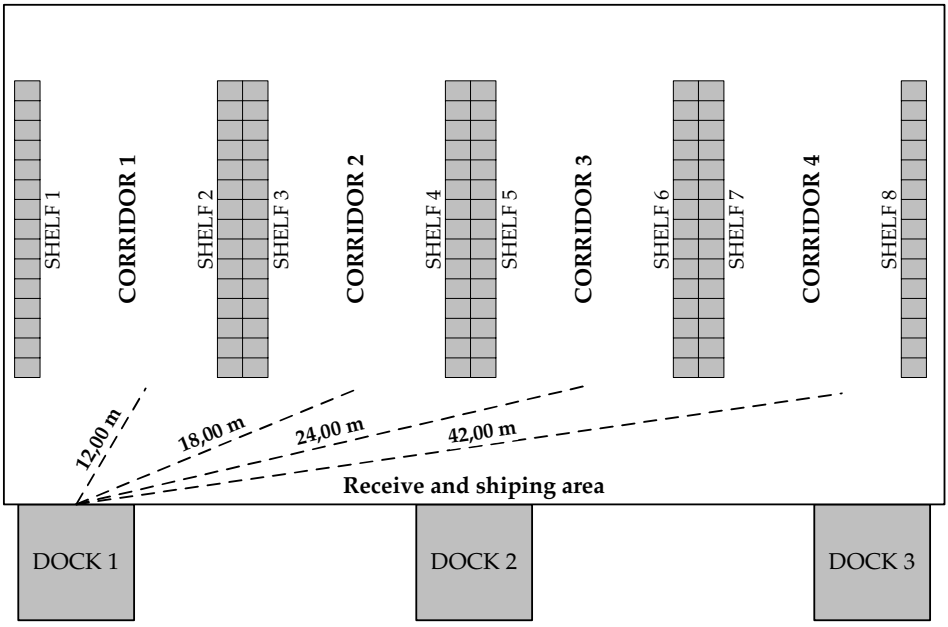

Fig. 1. *Horizontal projection of the warehouse's zone allotted to the customer producing baby food*

Table 3 represents the distances between the centers of beginnings of every passage and the docks.

Table 3. *The activities which are the part of order picking process and their labour intensity*

No. of passage's head	The distance between dock 1 and the heads of the passages	The distance between dock 2 and the heads of the passages	The distance between dock 3 and the head of the passages
1	12.00	30.00	42.00
2	18.00	12.00	36.00
3	24.00	12.00	18.00
4	42.00	30.00	18.00

Source: own elaboration on the basis of company's data

In the examined zone, allotted to the company which produces baby food, it is possible to store 600 euro-pallets. In the event that the number of pallets exceed the storage capacity of a given zone, an additional space for storing in another part of the warehouse is used. Demand for this products is fairly big, however, throughout the year is constant. Table 4 shows the destination and the size (number of euro-pallets) of shipments in August, the month when the research was carried out. Figure 2 shows the percentage of shipped goods to a given country.

Table 4. *The activities which are the part of order picking process and their labour intensity*

Country/Date	03.08	04.08	05.08	06.08	07.08	10.08	11.08	12.08	13.08	14.08	17.08	18.08	19.08	20.08	21.08	24.08	25.08	26.08	27.08	28.08
The Netherlands	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
Great Britain	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Germany	66	0	33	0	33	66	33	0	33	0	66	0	33	0	33	66	33	0	33	0
France	0	33	0	33	0	33	0	33	0	33	0	33	0	33	0	33	0	33	0	33
Russia	33	0	33	0	33	0	33	0	33	0	33	0	33	0	33	0	33	0	33	0
Ireland	33	0	0	0	0	0	33	0	0	0	0	33	33	0	0	0	0	33	0	33
Portugal	0	0	0	33	0	0	0	33	0	0	33	0	0	33	0	0	33	0	0	33
Belgium	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12
United Arab Emirates	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pakistan	0	0	50	0	0	0	0	50	0	0	0	0	50	0	0	0	0	50	0	0

Source: own elaboration on the basis of company's data

Products sent to the logistic operator have got their destination specified from the very beginning. It means that the logistic operator, on receiving products knows their destination (e.g. country). Baby food manufacturer does not have its own warehouses, as a result the whole process of storing ready-made goods is assigned to the logistic operator.

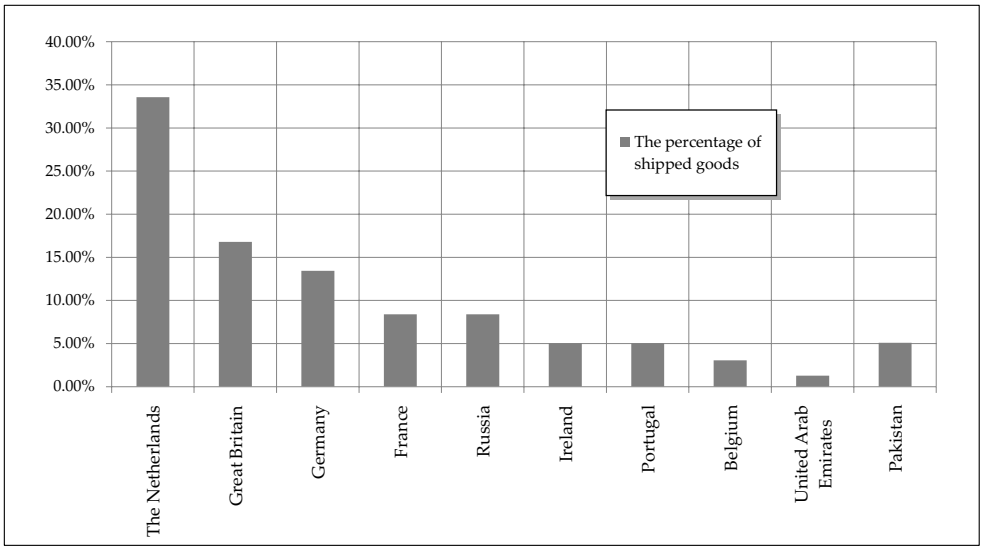

Fig. 2. *The percentage of shipped goods to a given country*
Source: own elaboration on the basis of company's data

In the examined case, storage of goods relies only on the experience of the operator, and the products are stored in the space which is free and available in a given moment. Such practice leads to bizarre situations in which the goods with the fastest rotation time are put in barely accessible places, which were free at the moment of product reception. It is normal that in this way all deliveries are mixed up and the goods prepared for shipment to same parts of the world are not grouped next to one another. It has to be said that, when it comes to this very company, the order picking process itself is simplified, as only the loads consisting of the whole pallets are picked.

The main objective of this task is an attempt to allocate products in a warehouse in a way which enables to minimize the working time of forklift trucks, which work on order picking. In this paper a solution to this problem is provided. It is based on the policy of fixed storage places where a specific warehouse space is allotted to particular goods. Destination and shipment frequency are the factors which have got an influence on the choice of these places. The idea of this model is that goods sent to the same country should be stored in the same place and the storage spaces for countries with the highest delivery and shipment rate should be placed as close as possible to the docks.

4. Solution to the problem of goods allocation in a warehouse

In order to solve the problem of allocating goods in a warehouse, one has to follow a simple rule which says that commodities, with the fastest rotation time, need to be located as close as possible to warehouse's exits, so as to minimize the order picking time (Ghiani *et al.* 2004). In this task the distances between the head of the passages

and the docks were calculated (Tab. 3). The size of the stands (in a given warehouse) and internal transportation norms were also taken into consideration. In order to streamline and improve the process of order picking the goods, a special computer program was used. The program is able to calculate the time needed for order picking goods when there are different variants of goods allocation in a warehouse.

Table 5. *Time norms in units for the basic movements of a battery forklift truck with a carrying capacity of 20 kN*

Lp.	The basic forklift movements	Load	Unit	Symbol	Time norm [min.]
1	2	3	4	5	6
1	Moving forward at a full speed (it starts when the forklift reaches maximum speed after accelerating, and ends when forklift starts to brake)	empty	per 1 metre	FE	0.0076
		loaded		FL	0.0089
2	Simple withdrawal at the first height (it includes removing the forks from the pallet or taking out the pallet; moving and stopping is included in the time measurement)	empty	full operation	10 E	0.0600
		loaded		10 L	0.0650
3	Lifting the forks during the stop	empty	per 1 metre	UE	0.1120
		loaded		UL	0.1320
4	Lowering the forks during the stop	empty	per 1 metre	DE	0.1200
		loaded			
5	Turning left moving forward (changing the direction of movement to the left angle 90 degrees with the minimum radius while moving forward)	empty	full operation	TFL	0.0550
		loaded			
6	Right turn while moving forward (change the direction of movement to the right angle 90 degrees with the minimum radius while moving forward)	empty	full operation	TFR	0.0550
		loaded			

Source: on the basis of Fijałkowski (2003, p. 68–69)

Computer simulation was done in JAVA. Five dimensional board, which is a computer reflection of the warehouse, is the main data base:

- the first measurement stands for the dock number (starting from 0),
- the second measurement denotes the stand number (they are numbered from 0),
- the third measurement stands for the left or right side of the stand (0 for left, 1 for right),
- the fourth measurement stands for shelf number (shelves are numbered from 0),
- the fifth measurement denotes the row number (rows are numbered from 0).

The incoming data are loaded to the program from three txt. files. The first input file consists of eleven lines with the following structure:

- the first line denotes the number of rows,
- the second line stands for the number of shelves on the first level of the stand,
- the third line denotes the shelves' width (the program calculates the length of the stand as a product of the second and the third line of the first txt. file),
- the fourth line denotes the number of docks in a warehouse,
- the fifth line denotes the number of rows in a stand,
- the sixth line stands for the number of pallets in an order,
- the seventh line stands for the value of the time unit in which a forklift truck covers the distance of on metre,
- the eighth line denotes the action of lifting the forks while standing,
- the ninth line denotes the time need for lowering loaded forks,
- the tenth line stands for the time needed to cover the turn,
- the eleventh line denotes the number of orders.

In the second input file the distances between given docks and the stands in a warehouse are stored. This file relies on the data included in the first input file in which the number of docks and stands in a warehouse is specified.

In the third input file, the allocation of goods in a warehouse and dock in which the order will be completed are stored. This file contains as many lines as there are pallets in an order (the sixth line of the first input file) and it's in the form of above described five dimensional table. In this file we can choose the dock where the order should be placed, as well as the number of items and the place where the pallets are located.

The *main* function of the program is loading and processing the data from the three input files, and on their basis is able to calculate the order picking time, including the different variants of goods allocation in a warehouse. In the first stage the situation from August, where the goods were located in different parts of the warehouse according to the randomly storage policy, was reconstructed. The simulation of 120 actual order completing processes was carried out. As a result of having the warehouse measured, internal transportation norms, and historical data concerning the order picking processes, the average order picking time, consisting of 33, 50, and 12 pallets, was calculated. The results were approximately 28.864 min, 88.651 min, and 19.057 min accordingly.

In the second stage, on the basis of the observation, commodities were grouped in accordance with two criteria. First of all, the goods which are shipped to some countries most frequently were put in the most accessible places of the warehouse. As a result of the simulation, it was concluded that the most accessible places are not necessarily located in the vicinity of docks. The floor of the stand is the most decisive parameter here.

The time of forklift ride forward at a full speed per one meter equals about 0.0076 min (empty) or 0.0089 min (loaded), whereas the time of lifting and lowering the forks equals 0.1120 and 0.1200 accordingly. The 0 floor is the most accessible place in a stand, as it does not require to lift or lower the forks of a forklift truck.

Table 6. *Time (in minutes) needed for order picking the pallet depending on the row and the column of a stand without considering the distance of a given place from the docks*

Column no./ Row no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.017	0.033	0.050	0.066	0.083	0.099	0.116	0.132	0.149	0.165	0.182	0.198	0.215	0.231	0.248
2	0.411	0.427	0.444	0.460	0.477	0.493	0.510	0.526	0.543	0.559	0.576	0.592	0.609	0.625	0.642
3	0.805	0.822	0.838	0.855	0.871	0.888	0.904	0.921	0.937	0.954	0.970	0.987	1.003	1.020	1.036
4	1.200	1.216	1.233	1.249	1.266	1.282	1.299	1.315	1.332	1.348	1.365	1.381	1.398	1.414	1.431
5	1.594	1.611	1.627	1.644	1.660	1.677	1.693	1.710	1.726	1.743	1.759	1.776	1.792	1.809	1.825

Source: own elaboration on the basis of company's data

Another rule, taken into consideration, is placement of goods, shipped to specific countries, together, so as to avoid wasting time for looking for products which are sent to the same destination . Thanks to this approach the average order picking time of 33 pallets equalled 25.284 min, 50 pallets increased to 90.745, whereas the average order picking time of 12 pallets was reduced to 16.002 min.

The increase of order picking time when the order consists of 50 pallets results from the fact that in the research the variant, which takes into consideration the rotation of goods designed for shipment to specific countries, was used.

The goods are not frequently sent to Pakistan and Arab Emirates that is why the products for these countries are stored in the more distant places in a warehouse. This approach is different from the random storage policy. Table 7 contains average order picking times for every country at the present situation, and for the suggested solution.

It can be concluded, that as a result of implemented experimental method the majority of order picking times decreased. It results from the fact that a warehouseman picking an order to specific countries avoids wasting of time for searching for products scattered all over the warehouse.

Table 7. *The average order picking time for particular countries, taking into consideration two examined variants*

Country	The average order picking time with the current placement	The average order picking time with the experimental placement	Difference in order picking time	
			[minutes]	[%]
The Netherlands	24.007	21.076	−2.931	−12.21
Great Britain	25.087	22.032	−3.055	−12.18
Germany	32.008	29.127	−2.881	−9.00
France	34.012	30.002	−4.010	−11.79
Russia	37.002	32.103	−4.899	−13.24
Ireland	36.009	33.043	−2.966	−8.24
Portugal	36.156	34.161	−1.995	−5.52
Belgium	19.057	16.002	−3.055	−16.03
Arab Emirates	89.008	92.033	3.025	3.40
Pakistan	88.562	90.423	1.861	2.10

Source: own elaboration on the basis of company's data

5. Summary

Storing goods according to their shipping destination plays an important part in this warehouse, as a warehouseman, who works on order picking, does not have to look for commodities in the whole storehouse. Another very important criterion is allotting the storage spaces in warehouse in such a way that goods of the countries to which deliveries are most frequent, are located in the most accessible places in a warehouse. Owing to this approach, the average order picking time, in the examined warehouse, for a vehicle with the carrying capacity of 33 pallets decreased about 3.178 min, which is a very positive result.

Thanks to the simulation program it is possible to test many order picking variants, and choose those which are the best and optimal for a given situation. The program written for this research is simplified, however, it is very universal. Three input files, in which the data, which will be later used in the program, is specified, enable us to reflect the structure of many warehouses.

The possibility to indicate the dock where the order will be completed allows to simulate different order picking variants, and to choose the one with the best time. Simulation programs are the most popular tools nowadays which help to make decisions when it comes to designing, managing, and executing many warehouse activities.

References

Ackerman K.B. 1990. *Practical Handbook of Warehousing*. Van Nostrand Reinhold, New York.

Bartholdi J.J., Hackman S.T. 2008. *Warehouse & Distribution Science*. Georgia Institute of Technology, Draft.

Chiang Y., Chen S., Wu K. 2005. *A Robust Approach for Improving Computational Efficiency of Order-Picking Problems*. Springer-Verlag, Berlin, Heidelberg.

Coyle J.J., Bardi E.J., Langley C.J. Jr. 2002. *Zarządzanie logistyczne*. Polskie Wydawnictwo Ekonomiczne, Warszawa.

De Koster R., Le-Duc T., Roodberger K. 2007. *Design and control of warehouse order picking: A literature review*. European Journal of Operational Research, 182.

Fijałkowski J. 1987. *Technologia magazynowania. Wybrane zagadnienia*. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

Fijałkowski J. 2003. *Transport wewnętrzny w systemach logistycznych*. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa.

Frazelle E.H., Apple J.M. 1994. *Warehouse Operations*. [in:] Tompkins J.A., Smith J.D. (Eds), The Distribution Management Handbook, McGraw-Hill, New York.

Frazelle E.H. 1996. *World-Class Warehousing*. Logistics Resources International, Atlanta, GA.

Ghiani G., Laporte G., Musmanno R. 2004. *Introduction to Logistics Systems Planning and Control*. Halsted Press, New York.

Kizyn M. 2006. *Problemy kompletacji w procesach magazynowych, cz. 1*. Logistyka, 1, 2006.

Kłodawski M., Jacyna M. 2009. *Wybrane aspekty problematyki komisjonowania w funkcji pracochłonności procesu*. 4th International Scientific & Technical Conference, Rawa Mazowiecka 2009.

Korzeń Z. 1999. *Logistyczne systemy transportu bliskiego i magazynowania*. Wyd. Biblioteka Logistyka, ILiM.

Manning A. 2008. *Master order picking and improve how you get product out of your building and into your customer's hands*. Modern Materials Handling.

Petersen C., Aase R., Heiser D. 2004. *Improving order-picking performance through the implementation of class-based storage*. International Journal of Physical Distribution & Logistics Management, Vol. 34, Issue 7.

Petersen Ch. 2002. *Consideration in order picking zone configuration*. International Journal of Operation & Production Management, Vol. 22, No. 7.

Ratlif H.D., Rosenthal A.S. 1983. *Order-picking in a rectangular warehouse: A solvable case of the traveling salesman problem*. Operation Research, 31 (3).