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INTERNAL TRANSPORT AS AN INTEGRAL PART OF LOGISTICS IN PRODUCTION PART 1

The article describes the division and functions of internal transport in production logistics and internal transport systems. Its characteristics and main assumptions were presented. An internal transport analysis of the selected manufacturing company was performed. Selected results of the research in the production company were presented using the PFMEA method. Through the use of PFMEA analysis, the causes of the errors encountered during transport in the company were identified and corrective measures proposed, so that the transport system fulfills its role, does not interfere with the production process, and ensures safe movement of cargo.

INTRODUCTION

In terms of logistic understanding of the flow of goods in the production company, transport meets one of the main functions that decides on the physical flow of goods. Transport means enable to perform operations connected with transport of people and goods. One can distinguish means of near transport where transport is carried out between points located close to each other on a particular area, and the distant one where transport is carried out between the distant points.

Near transport, which is related to the supply of raw materials, semi-finished products, materials and the collection of finished products and waste, as well as the entire transport of materials on the premises of the establishment is the so- called company transport. It consists of external transport (material delivery, collection of finished goods) and internal transport, which includes storage transport, production transport (inter-departmental, inter-post, post).

In manufacturing companies, means of near transport are used, i.e. with limited reach, which includes: cranes, transport trolleys and conveyors. The mentioned machines and devices are part of internal transport, inseparable from the production process. The transport classification is shown in Figure 1. It shows both the division of internal transport and its linkage with external transport.

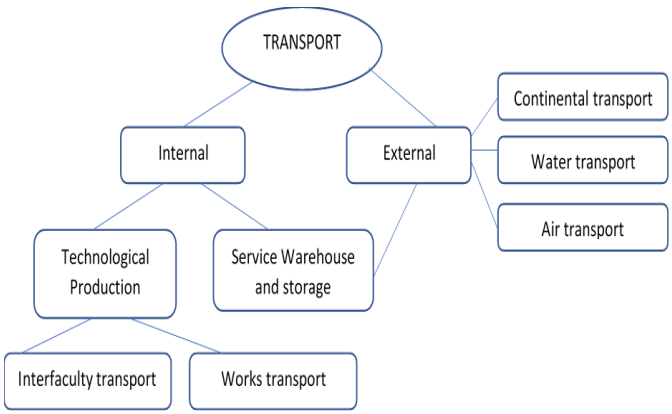

Fig. 1. *Internal transport division and its relation to external transport.*

In each manufacturing plant there is a transport linked to the production process and service transport, i.e. transport serving raw materials and semi-finished goods and finished goods warehouses. Warehousing is related to external transport, which is carried out by means of long-distance transport of unlimited range. In very large buildings, for example in steelworks, shipyards, construction sites for internal transport, in addition to means of transport, distant means (e.g. motor vehicles, rolling stock) are also used.

Selection of means of internal transport in newly established enterprises is carried out simultaneously with work on the whole plant. When designing internal transport, the size of the company, its nature and the type of technological process to be run in it should be taken into account. Internal transport is an integral part of this process. The task of well-organized internal transport in an enterprise is to provide (usually combined with transshipment) certain types and quantities of raw materials, semi-finished or finished goods at the right time and place. Correctly organized internal transport ensures continuous, unidirectional flow of materials and other loads through all workstations, control and storage.

The design or existing spatial layout of the whole plant (departments, workstations) and transport routes are important as the choice of means of transport depends not only on the size of the enterprise, but also on the mode of production (e.g. unit, mass or mass), or service range (seaport, aviation, spare parts warehouse). In the selection of means of internal transport it is helpful to know the most commonly used machines and transport equipment, the nature of their work (intermittent, continuous) and the basic parameters (characteristic values). Improving the organization of technological processes and modernizing the internal transport are usually aimed at reducing or eliminating manual labor. Internal means of transport, especially those with intermittent traffic, often require manual operation. Nowadays, in many Polish companies a large part of the work is carried out by hand or by means of very simple means of transport. This is particularly true for small and medium-sized enterprises. In some cases simple and inexpensive manual means of transport can contribute to the improvement of transport in an enterprise, irrespective of its overall degree of mechanization, than complex and expensive high-powered mechanics. An application of the latter benefits with relatively high manual labor costs.

The purpose of this article is to analyze the internal transport process mainly of the transport of load units between production

and storage facilities in a company dealing with the production of fasteners.

1. SYSTEMS OF INTERNAL TRANSPORT

Organization and selection of the proper internal transport system [1] depends on the company's demand and the conditions under which the production takes place, as well as on the economic assumptions. One can distinguish the following internal transport systems, the first two of which can be classified as the most commonly used [2]:

- shuttle system
- peripheral system,
- radial system,
- irregular system (non-scheduled).

In the shuttle system transport occurs when the means of transport moves the goods only between two points. The transport of the load is constant and uniform and the displacement of the goods from point X to Y and back is one full cycle. During the shuttle transport there is a possibility of one empty passage, which means that the full cycle is loaded only in 50% (transport of the means of transport without goods).

The perimeter transport system is when the means of transport moves the goods over a network containing several receiving points. The movement of the transport means runs along the designated road. There are three cases of the peripheral system [2]:

- peripheral transport system with decreasing torrent - means of transport of goods from the warehouse to selected collection points, while return to the warehouse is empty,
- peripheral transport system with rising stream - the means of transport from individual points receives the finished parts or semi-finished products, and the transport of the means of transport from the first link is empty,
- perimeter transport system with uniform load - the means of transport at each point of the route receives and delivers the goods.

The radial system consists of combining a single point of dispatch with a few receiving points. There is also one empty passage. The system of irregular journeys is characterized by journeys that result from the unsystematic and varied work of the in-house transport worker and unplanned transports resulting from additional transport orders [2]. The selection and design of the in-house internal transport system takes into account, in particular, the economy, which is to achieve the lowest cost while delivering a reliable and efficient transport system [3].

2. INTERNAL TRANSPORT IN THE COMPANY ANALYZED

Research on internal transport was carried out in a company producing fasteners used in construction and industry. For more than 20 years the company has been involved in the processing of plastics, the manufacture of fasteners for interior fittings, thermal insulation, roofing and light industrial structures. In-house transport plays an essential role in the company's operations. With the layout of the buildings it is difficult to imagine the existence of a production without a well-designed transport system. The main role of transport in this and other companies is, among others: delivery of materials to specific sites, delivery of raw materials directly to production, and transport of goods directly to the warehouse. Means of transport were chosen in such a way as to be able to transport a particular assortment. The internal transport process is mainly concerned with the transport of load units between production facilities and storage facilities.

All employees are required to have all the necessary skills and qualifications. The internal transport team consists of two employees - the driver of the tractor whose task is to reach the vehicle stops and the forklift operator who at the stoppage of the tractor handles the loading of the loading units from the plant facilities and loads them onto the trailer. For the transport of materials between objects, a tractor is used together with an open trailer on two sides which are loaded with loading units using the fork lift truck. Further stops where the tractor stops to load or unload the material is shown in Figure 2.

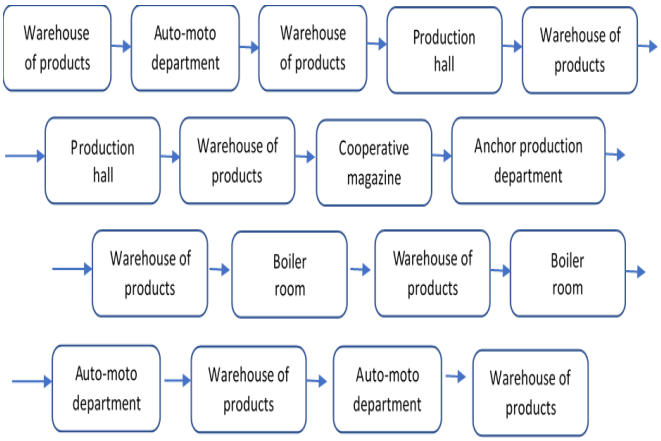

***Fig. 2**. Przykładowe kolejne przystanki w których zatrzymuje się ciągnik w celu załadunku lub rozładunku materiałów*

However, the arrangement of loading units on the trailer together with the direction of loading is shown in Figure 3.

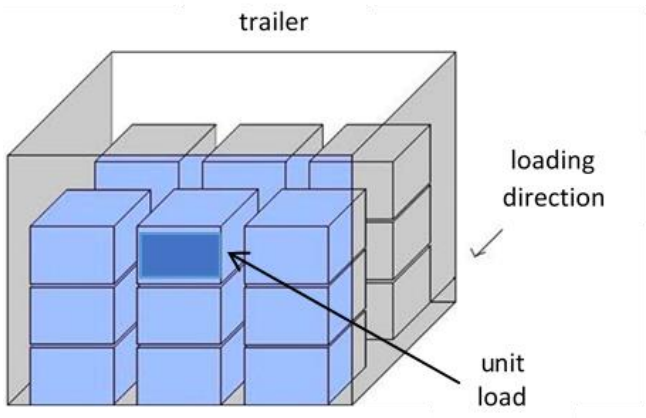

***Fig. 3.** Scheme showing the arrangement of loading units on the trailer*

The analysis of internal transport is simpler and the result is clearer if it is presented in a simple and understandable way and the data is saved on sheets. The number of loaded loading units was placed on the sheet as the percentage use of the loading area. For example, the loading of one unit was recorded as 6%, two - 11%, three - 17%, etc. Table 1 shows an example of a data sheet for the use of a loading surface.

The maximum amount that can be loaded onto the trailer is 18 unit loads. The most common unit loads were metal boxes for bolts, and pallets on which materials were completed so that the size was similar to the size of the metal crates.

Tab.1. *Sample data sheet (Z - loading, R - unloading, R+Z loading and unloading)*

Place	Use of surface (%)	Comments
Warehouse of products		
Department of protective coatings	100	Z
Auto-Moto department	0	R
Production hall	33	Z
Warehouse of products	0	R
Department of protective coatings	83	Z
Production hall	67	R+Z
Tool department	61	R+Z
Warehouse of products	0	R
Tool department	22	Z
Warehouse of products	0	R
Department of protective coatings	83	Z
Production hall	33	R+Z
Warehouse of products	0	R
Production hall	39	Z
Warehouse of products	0	R

Figure 4 shows the number of runs with a certain level of using the cargo area.

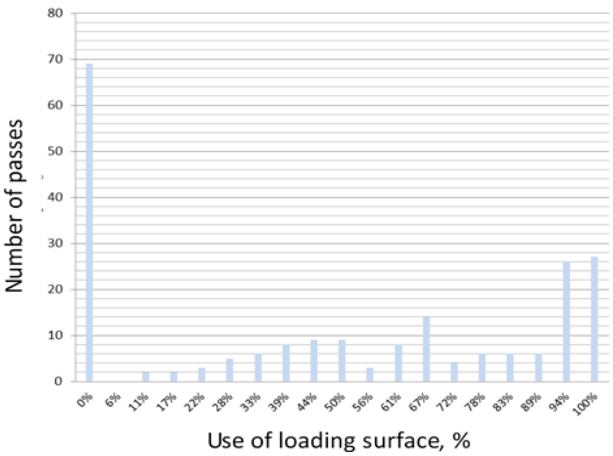

Fig. 4*. Number of journeys with a certain degree of utilization of the load area*

The average use of space is 42% including empty runs, but without taking into account the average use it is 66%. Of all the course, as many as 36% of journeys were with zero using of the loading area, while only in 14% of journeys the entire loading surface was used. When analyzing the data collected for the use of the surface during travel, as well as the order of travel between stops, there can be seen several situations which offer other solutions than those that were applied. Table 2 shows the use of the loading surface during the internal transport process.

Tab. 2. *Part of the data sheet for the internal transport process*

Place	Use of surface (%)	Comments
Warehouse of products	67	Z
Auto-Moto department	72	R+Z
Warehouse of products	0	R
Production hall	56	Z
Warehouse of products	0	R
Production hall	72	Z
Warehouse of products	0	R

Considering the situation from the moment when the tractor-trailer loaded in 72% in the Department of Auto-Moto goes in the direction of the Products Warehouse for unloading, then with an empty trailer goes to the Production Hall, where there is a loading of 56% of the surface use, then the situation repeats, but the second time the trailer is loaded to 72%. The described situation is shown in Figure 5.

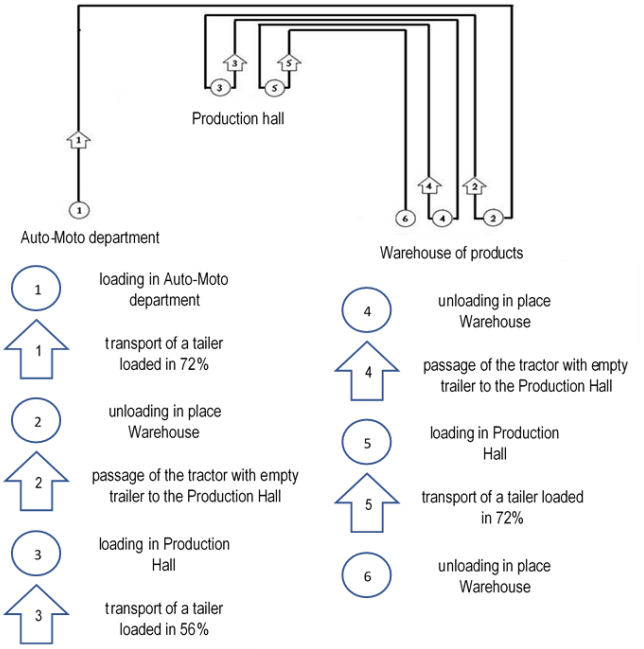

Fig. 5*. Material flow diagram*

If, while traveling from the Department of Auto-Moto a trailer loaded on a 72% tractor on the way to the Warehouse of Goods would take from the Production Hall (which is "on the road" and to which later anyway will go) cargo occupying 28%, loaded in 100% would go to Warehouse Products. There the trailer would be unloaded and the trailer with empty trailer would go to the Production Hall where the trailer would be loaded 100% and discharged in the Warehouse.

In both cases, 23 load units are loaded in the Production Hall (56% + 72% in the first case and 100% + 28% in the second case). However, in the second case, the total route traveled by the tractor is much shorter. In the first case the total route traveled by the vehicle is approximately 2075 meters and in the proposed solution about 1395 meters. The situation in which another solution of transportation can be discerned also occurs on another day. This case is presented in Table 3.

Tab. 3. *Part of the data sheet for the internal transport process*

Place	Use of surface (%)	Comments
Warehouse of products		
Department of protective coatings	67	Z
Cooperative magazine	0	R
Department of protective coatings	72	Z
Cooperative magazine	0	R
Department of protective coatings	28	Z
Cooperative magazine	0	R

In this situation, three loading units are loaded in the Department of Protective Coating, during which 30 load units were loaded (67% + 72% + 28%) and discharged in the Co-operative Warehouse. It is easy to see that two transits of up to 15 load units are enough to carry 30 load units.

In order to eliminate the most frequently encountered problems related to the implementation of transport tasks using a trailer tractor, the analysis of causes and effects of potential defects related to

transport process by FMEA (Failure Mode and Effects Analysis [4]) has been conducted. In the FMEA method, a quantitative analysis of defects, which aims at estimating risk factors, is used. Each process defect evaluates the integer from the range (1-10) due to three criteria:

- frequency of defect/process error (risk of defect/process error) - Number (R)
- possibility of detecting the occurrence of the cause before the occurrence of the fault will occur (W)
- significance of the defect for the user of the product - number (Z)

Based on the above numbers, one can calculate the so-called RPN (Risk Priority Number) also known as P and described by the formula: P = R x Z x W. It can accept values in the range of 1-1000. As P increases, the risk of a defect increases. The so-called critical level, i.e. the value of P, above which all defects are analyzed. This allows for preventive action.

The FMEA analysis for the process (in this case, the transport process) is referred to as PFMEA [5]. The analysis of PFMEA is presented in Table 4. It was carried out for the factor "vehicle failure".

Tab. 4. *Results of FMEA*

Name	Damage, problem	Effect	Cause	R	Z	W	RPN	Corrective / preventive actions
Vehicle failure	Wheel damage	Delay in transport	Bad state of the road	3	2	2	12	Checking the status of spare wheels
Vehicle failure	Motor damage	Looking for another means of transportation	No review	4	3	6	36	Obtain in an additional means of transport

The disadvantage that PFMEA has received the most points is a vehicle failure that prevents it from being used. There are serious failures that require the vehicle to be serviced for a longer period of time. Apart from the costs that need to be repaired, it is strategically important to transport materials from one place to another.

The PFMEA analysis has been designed to identify the causes of the errors encountered during transport within the company and to propose corrective measures so that the transport system fulfills its role, does not interfere with the production process, and ensures safe movement of cargo.

CONCLUSIONS

The paper analyzes the data on one of the areas of the internal transport functioning in the company involving the transport of loading units between buildings at the plant. In the first case it turns out that way of travel of the means of transport to another places is not executed in an optimal manner and you will notice other more effective solutions. The use of optimal solutions in a situation where planning subsequent operations is carried out by the current, call dispatchers with the operators of means of transport is possible only with very efficient and well-organized system of information exchange between the participants of the transport process. Another way to optimize routes is updating, and strict adherence to the agreed timetable. These solutions can only be achieved when transport processes taking place between objects, processes, buildings and transport within the production process will be integrated with each other and will operate depending on each other.

The results of the investigations allowed, in case of deficiencies, to formulate the corrective and preventive measures to be taken by the company. Appropriate transport connections should be designed during design

REFERENCES

1. Biniasz D., *Rola i funkcje transportu wewnętrznego małych przedsiębiorstw produkcyjnych - studium przypadku,* Logistyka 2014, nr 3
2. Skowronek Cz., *Logistyka w przedsiębiorstwie*. PWE, Warszawa 2003.
3. Coyle J., Bardi E.: *Zarządzanie logistyczne*. Polskie Wydawnictwo Ekonomiczne, Warszawa 2002.
4. Puente J.: *A decision support system for applying failure mode and effect analysis,* International Journal of Quality & Reliability Management, vol. 19, 2002
5. Johnson K.: *A study into the use of the process failure mode and effects analysis (PFMEA) in the automotive industry in the UK*, Journal of Materials Processing Technology, vol. 5,2005

Transport wewnętrzny jako integralna część logistyki w produkcji cz. 1

W artykule opisano podział i funkcje transportu wewnętrznego w logistyce produkcji oraz systemy transportu wewnętrznego. Dokonano jego charakterystyki i przedstawiono główne założenia. Dokonano analizy transportu wewnętrznego wybranego przedsiębiorstwa produkcyjnego. Zaprezentowano wybrane wyniki badań w przedsiębiorstwie produkcyjnym wykorzystując między innymi metodę PFMEA. Poprzez zastosowanie analizy PFMEA zidentyfikowano przyczyny błędów występujących podczas transportu w przedsiębiorstwie oraz zaproponowano działania korygujące, tak aby system transportu spełniał swoją rolę, nie zakłócał procesu produkcji, jak również zapewniał bezpieczne przemieszczanie ładunków.

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