Research Article

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Proposal for the flow of material and adjustments to the storage system of an external service provider

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Abstract: This article deals with issues related to the flow of material to the assembly line and examines the possibilities of reducing the costs of this process. It is based on the current state of the transport of individual parts to the producing company and the storage system using Kanban and Just in Sequence (JIS) logistics technologies, and the subsequent collection of material for transport to the assembly line. The change in the system of transport technology has led to a reduction of the total storage space and costs, and at the same time, the processes related to storage and collection of parts have been simplified. The whole process of material flow to the assembly line is solved using the real supply system via the JIS technology, together with the system of receipt and storage of components in connection with individual operations during the handling and storage of these components, and their picking and transport to the assembly line. Evidently, the change in the system and the associated savings can also be employed to warehouses and manufacturing companies of the automotive industry, which use automated assembly lines with the timing of the assembly process of the final product.

Keywords: technology, storage, transport, assembly, production

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1 Introduction

Nowadays, it is no longer valid that the price of products is given by the seller of the goods, but it is rather determined by the competitive struggle that takes place among individual producers and sellers. Should a company be able to compete, it must try to minimize the total logistics costs, not just part of them, or the costs of the specific activity, because reducing the costs of one activity can lead to increased costs of another [1].

Logistics costs can be divided into six areas, which are interconnected and include the main logistics activities. Not all logistics activities of the company fall within the competence and responsibility of the logistics department, but still, they significantly affect the overall logistics process, including the costs [2].

Six areas of costs of logistics are as follows:
- level of customer service,
- transport costs,
- costs of stock-keeping,
- storage costs,
- quantity costs,
- information system costs [2].

The reduction of costs of logistics must be done by improving processes in individual segments of the supply chain [3]; this includes, in particular, the use of logistics technologies [4,5] associated with transport [6–8], choice of material and handling, including modeling [9,10], and simulation of individual activities [11,12].

Transport of individual components for assembly is a process during which the optimization of individual steps was investigated in order to save costs, especially those of picking from the warehouse and supplying the material to the assembly line in order to avoid disruption of the continuity of production. In addition, cost savings are looked for in the field of human resources, or storage and production, which is reflected in the overall cost of the finished product.

The material flow from the supplier to the assembly line can be divided into two parts. The first part deals with methods of delivery of material from suppliers to the warehouse of manufacturing company, while the second deals with methods of delivery from the warehouse to an area near the assembly line. The business logistics can be divided into the following three areas: Inbound, In-house, and Outbound. The Inbound system deals with supply logistics, i.e., all activities that need to be performed within the framework of logistics in order to provide the necessary material for production. The In-house system is focused on all flows and activities that take place in the manufacturing company. It, therefore, includes activities such as the receipt of material into the warehouse, methods of storage and handling of material, methods of picking and delivery of material to the assembly line, and further steps of the in-house logistics. The Outbound system deals with all activities related to the dispatch of finished products to the customers (Figure 1).

1.1 Direct transport

Direct transport means that the supply is carried out by means of one vehicle from the supplier to the customer. It is used for supplies of parts or material, which can fully load the vehicle in the range of 80–100%. The direct transport is shown in Figure 2.

Direct transport should not be used for parts that are not in regular use or parts small in size, which means that many pieces can be loaded for transport, or for other reasons that prevent the vehicle to be fully loaded.

1.2 Transport to the collecting point

Transport to the collecting point works on the principle of supply of several types of materials from several suppliers. Usually, the individual supplies are carried out by a selected transport company. The costs for the transport of the material are determined according to the capacity taken up on the vehicle, i.e., for a m^3. The schematic representation of the transport to the collecting point is shown in Figure 3.

2 Methods

For collection and supplies of parts to the manufacturing company, which serve for production and assembly, the technologies Just in Sequence (JIS) and external Kanban are used to solve the related issues.

2.1 Just in sequence technology

The supply of material is carried out in a precisely predetermined order, i.e., in sequence. Material is delivered on special JIS pallets lined up according to the order of its usage.

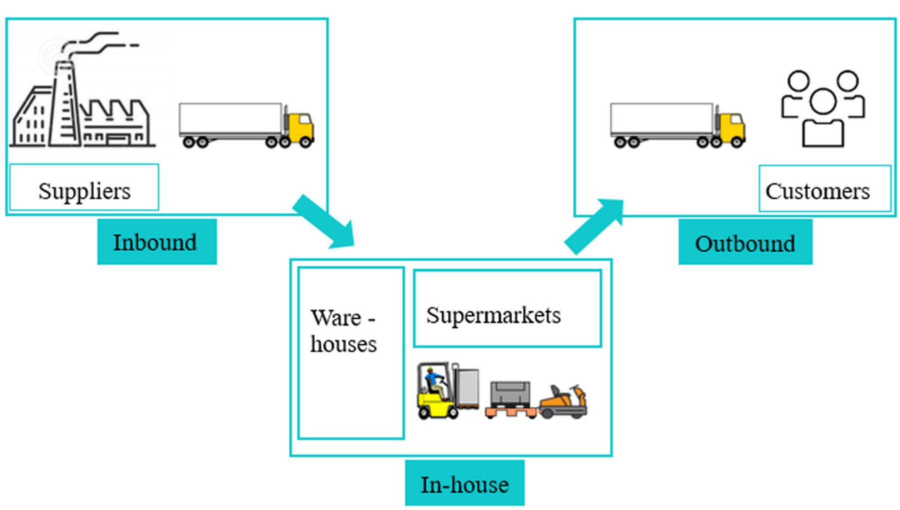

Figure 1: Inbound in-house outbound. Own source.

Figure 2: Direct transport diagram. Own source.

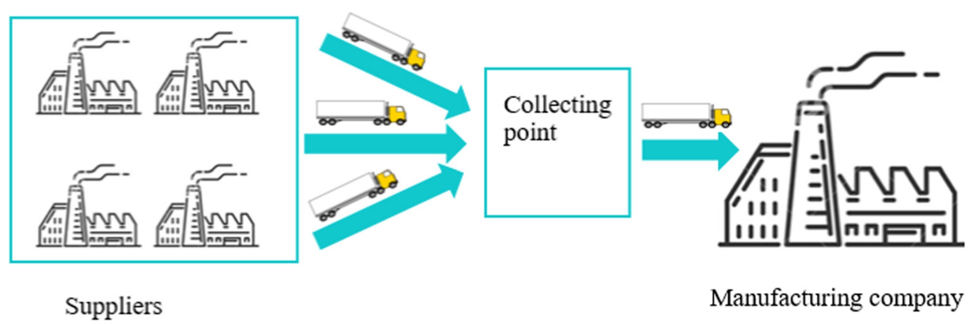

Figure 3: Transport to the collecting point. Own source.

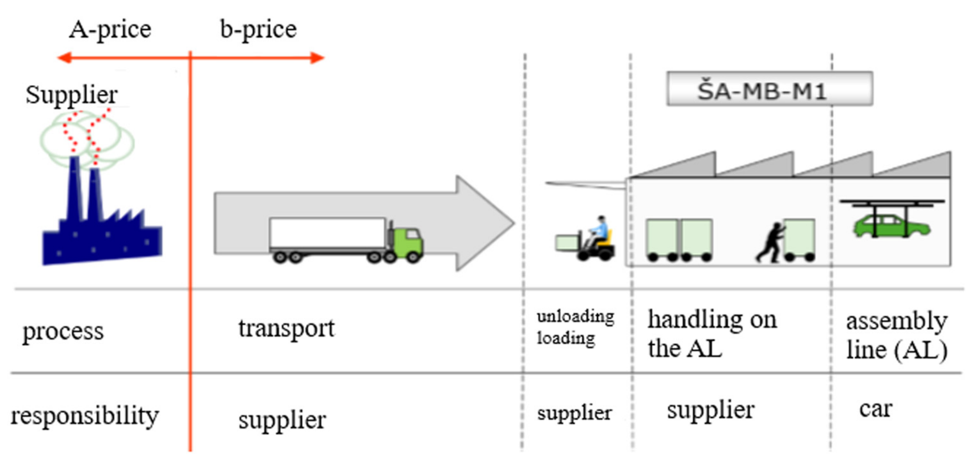

Figure 4: JIS A diagram. Internal source: LK 001-18-01 LAH SK270.

The supplier is responsible for the entire logistics process, i.e., from the time the material exits the ramp of the supplier's manufacturing plant to the place where it is to be removed from the pallet and used by the customer.

However, the supply of material within the JIS technology is not always the same. There are three types of JIS supplies, which differ from each other in certain steps. They are as follows:

- JIS A,
- JIS B,
- JIS C.

2.1.1 JIS A

The supplier of material produces the components in their manufacturing plant. This production is done based on the call-off orders received from the customer. The material produced is then placed on a JIS pallet according to the specified order known to the supplier in advance. JIS pallets with the chosen material are transported, according to the set time, to the customer at the place of usage, to the so-called JIS zone, where the material is unloaded from the vehicle. From this zone, the material is then moved to the assigned logistics zone inside the production hall, from where the pallets with the chosen material are supplied to the place of usage. As can be seen in Figure 4, the boundary between A-price and b-price is on the ramp of the material supplier; it means that the costs caused by the high complexity of the supplied materials fall within the A-price [13,14].

2.1.2 JIS B

The supplier produces material in its production plant based on long-term call-off orders, which are later specified by detailed call-off orders. The supplier of material uses transport pallets to move the material as required from their plant to an external service provider, which provides the supplier with storage and sequential collection of the material. The transport of parts between the production plant and the external service provider falls within the full competence of the supplier. The necessary stock is kept in order to provide a continuous supply to the customer [13,14].

The supplier uses detailed call-off orders to manage the stock. Based on the sequence call-off order, the external logistics service provider transfers the parts from the transport pallets to the JIS pallets in the correct order according to the specified sequence. Furthermore, the external logistics service provider transports the parts from their premises to the designated place of unloading inside the plant, unloads the truck, and transfers the parts into the assigned logistics zone. In addition, they provide for the handling of parts or the JIS pallets from the logistics zone to the place of their usage. As can be seen in Figure 5, JIS B differs from JIS A by another added element, which is an external logistics service provider. As a result, the partial costs of stock-keeping are borne by the logistics service provider [13,14].

2.1.3 JIS C

The final assembly of the material and parts that are supplied to the customer by means of the JIS C system is performed by the supplier, while all services provision for the supplier are done by the external logistics service provider.

As can be seen in Figure 6, the purchasing department is responsible for the transport of components, provision of pallets, and security of the process. All of this is included in the A-price [13,14].

2.2 A-price and b-price boundary

A-price is the price that falls within the purchasing department of the customer. The process that is carried out at the material supplier, all costs associated with activities performed before the material is loaded on the vehicle and in some cases the transport to an external service provider are included in the A-price, depending on the chosen type of the JIS supply.

The price that is calculated and paid by the customer's logistics department is called the b-price. As

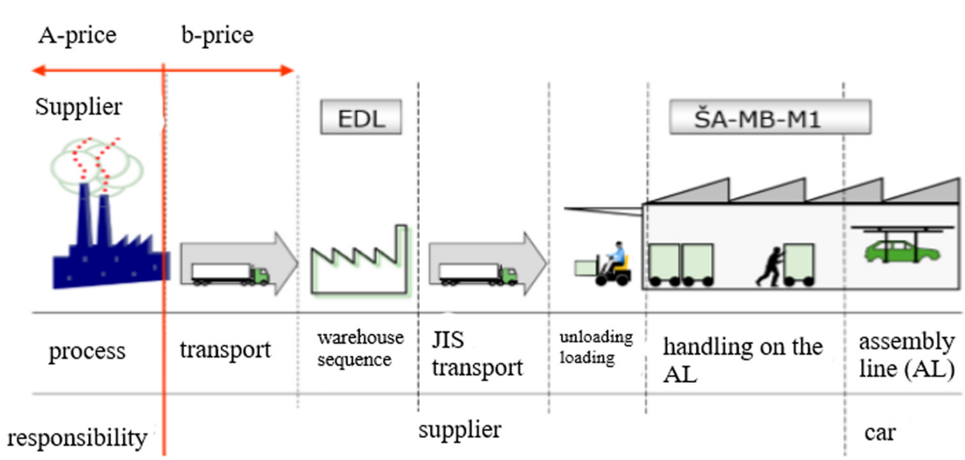

Figure 5: JIS B diagram. Source: ref. [14].

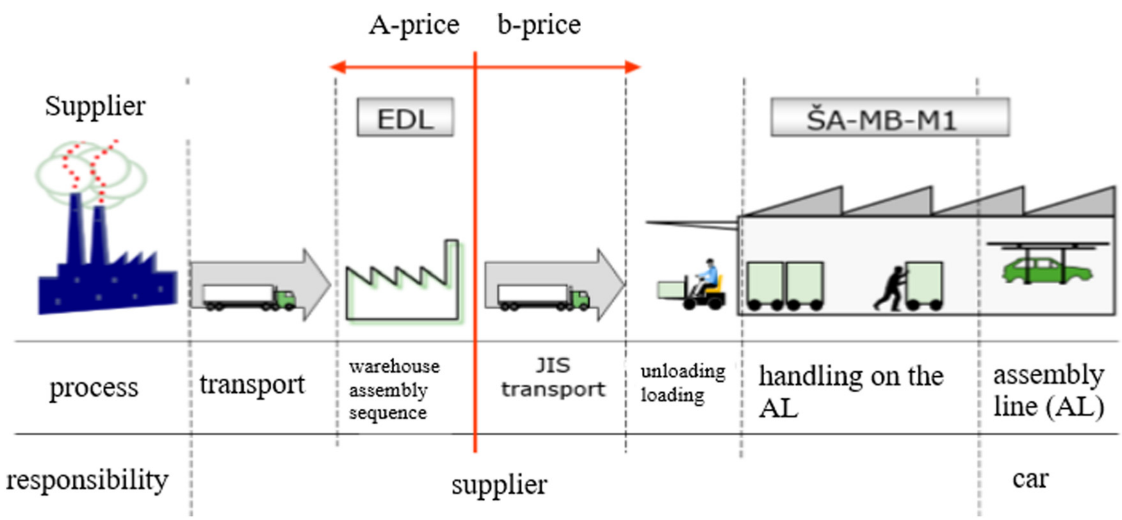

Figure 6: JIS C diagram. Source: ref. [14].

apparent from Figures 4–6, the b-price is calculated from the point at which the A-price, for which the purchasing department is responsible, ends.

Therefore, the boundary of A-price and b-price differs depending on the type of the JIS supply. For instance, the costs related to the high complexity of parts and materials are borne by the purchasing department in the JIS A system and by the logistics department in the JIS B system [13,14].

2.3 External Kanban

One of the options for supplying material to the company is by means an external Kanban. In the case of the supply of material by the external Kanban, the stock of material in warehouses is kept for about 1.5 days. This method of supplying material to the manufacturing plant has its advantages and disadvantages. There are also conditions that must be met so that this method of supply can be applied. If the external Kanban is used for supplies of specific material from the given supplier, only small stocks are kept, and therefore, the supplies of material to the company must be more frequent than with standard delivery methods. The material must be supplied at least once a day, while the vehicle must be loaded at least at 80%.

The use of external Kanban reduces the need for packaging. As the supplies of material are carried out more often than standard supplies, the need for the number of packages for the given material in circulation also decreases.

2.4 Flow of material from warehouses to the assembly line

Stored material can be transported from the warehouse to the assembly line as follows:

- directly from the warehouse to the assembly line,
- through the station,
- through the AGV station,
- through the sequential workplace.

Pick-by-systems are used for the correct picking of material in sequential workplaces. These are supported assistance systems that significantly reduce or almost eliminate the risk of confusion when picking the material.

3 Results

The results achieved after the implementation of the external Kanban are as follows:

3.1 Material warehouse

The stored material is listed in Table 1, including information on the average occupancy of standard storage positions and the percentage utilization of the warehouse, which is equal to 100%, which means that the average number of occupied 1,155 storage positions is considered as 100% in the table.

Table 1: Multiple criteria analysis of the selection of suitable material for optimization

Material	Supplier's country	Daily volumes (number of packages)	Utilization (%)	Suitable for optimization
Part A	Hungary	25	32	No
Part B	Poland	42	54	No
Part C	Czech Republic	54	69	No
Part D	Czech Republic	68	87	Yes
Part E	Poland	31	40	No
Part F	Poland	31	40	No

3.2 Implementation of the external Kanban

Table 1 contains individual criteria that must be met in order for an external Kanban to be used for the given supplier and material. The daily volume must be sufficient, and at least 80% of the capacity of a standard truck must be utilized. Another condition for using the external Kanban is the place of origin of the supplier – the Czech Republic; in certain cases, the supplier may be from Slovak Republic. This condition is met by Part D.

3.3 Evaluation of the external Kanban implementation

The first optimization, which leads to a reduction in stocks, is the implementation of an external Kanban. Based on the average utilization of individual warehouses for the reference period, part D was chosen for the purposes of optimization. Upon the analysis of the stored material, a back spoiler was chosen, which occupies many storage positions in the warehouse and has a large share in the capacity utilization of the warehouse. At the same time, it is the only material in the F3 warehouse that meets both basic conditions for the implementation of the external Kanban, i.e., dispatching is carried out in the Czech Republic and the standard vehicle used is utilized at least at 80% during the daily supplies of the material.

The implementation of the external Kanban for material D leads to:
- reduction of the warehouse capacity utilization,
- financial savings when storing material in internal areas.

Prior to the optimization, this material occupied an average of 244 standard storage positions. This number corresponded to stock for 3.5 days, which is more than the average stock of all materials delivered from the Czech Republic.

After the implementation of the external Kanban, it is necessary to keep stocks in the customer's warehouse for 1.5 days; this means that the stock of material D will occupy only 102 standard storage positions on average. These calculations are based on the information, which states that due to the average usage and the number of pieces of material D in a package, it is necessary to keep on stock 68 packages per day.

After the implementation of the optimization proposal, the average capacity utilization of the warehouse decreased from the original 97 to 85%, and thus the optimal utilization of this warehouse was achieved.

3.4 Storage of material in internal areas – financial savings

If the warehouse is occupied above the set optimum, some solution must be found in order for the stocks to be reduced. In this case, the solution was to implement the external Kanban for the most suitable part located in this warehouse. Provided that no material meets the conditions for the implementation of the external Kanban method, or the stocks cannot be reduced in another way, an alternative solution would have to be found to improve the situation in the warehouse and to enable its standard operation.

Another possible solution to keep the capacity utilization of the warehouse at an optimal level is to lease storage space from an external service provider and move most of the stocks there. The external service provider must be located in close proximity to the customer's production plant. Instead of the delivery to the customer's production plant, the material is supplied to the external service provider, where the majority of the ordered material, i.e., most of the stock, is kept. The external service provider, abbreviated EDL from German "Externe Dienstleister," gradually supplies a small amount of material to their customer as required. Therefore, the customer keeps in the warehouses only a part of the stocks of specific material, for example, just for half a day. In the event of unexpected problems, the rest of the material is only a few kilometers away and the situation can therefore be solved reasonably quickly. The customer must pay the agreed amount to the provider for the lease of the storage space.

Simply speaking, the implementation of the external Kanban for material D reduced the need to store this or other material with the external service provider, and thus the costs associated with leasing space and services, especially for handling the material, never incurred.

Because of this optimization measure, the average stock in the warehouse was reduced. Originally, material D occupied 244 standard storage positions; after optimization, it occupied only 102 positions and the capacity utilization was reduced from 97% to the optimal 85%. It can therefore be said that the transfer of material occupying 142 storage positions in the warehouse was prevented.

For 142 standard storage positions, 128 m^2 would be needed in the warehouse at the external supplier's. This value is obtained using Formula 1 to calculate the storage needed, in which the length of the package and the width of the package and the "aisle coefficient" are multiplied and consequently divided by the stackability of the given package. In this example, the length of the package is 1.2 m, the width is 1.0 m, and the aisle coefficient is 3, which means that the aisle distance between individual shelves or rows will be 3 m; the aisle is used for passing through and movement of handling equipment. The stackability is 4. This value states how many packages can be stacked on top of each other.

Calculation of the storage space needed:

$$\left(\frac{1.2 \times 1.0 \ \times \ 3}{4}\right) \times 142 = 128 \text{ m}^2.$$

When storing material at the external service provider's, the customer pays for the following services:
- storage space,
- material handling.

If the price of the lease of the storage space is CZK 2,141/m^2/year, the price of the lease of 128 m^2 is to be CZK 274,048 per year.

When storing material at the external supplier's, the customer pays not only for the lease of the space but also for the services related to the storage. These include material receipt, storage, handling, dispensation, and transport to the customer. The price for these services is much higher than that for leasing the space and it is not possible to set a fixed rate per unit, as this is affected by the types of packages that are being handled. The resulting price is mainly affected by the dimensions of the packages and the number of pieces of material in them. In this case, the amount is CZK 719,325/year.

In order to get the final price for the storage on 128 m^2 at the external service provider's, it is necessary to add up the previously mentioned prices. The price obtained is then CZK 993,373/year.

The implementation of the optimization proposal by means of the external Kanban for material D reduced the capacity utilization of the external supplier's warehouse from 97 to 85%, and thus it prevented the use of 142 standard storage positions for this material, corresponding to 128 m^2 at the external provider's, which led to reducing the total costs by CZK 993,373/year for storage and handling.

4 Conclusion

The process of optimizing the storage space, the use of logistics technologies, improvement of the transport system, material picking, and new trends and methods of implementation enable the company to reduce logistics costs, and therefore, improve business processes. Simultaneously, it becomes possible to accelerate the production, save human resources, and reduce demands on the use of handling equipment and means of transport, which results in a reduction of the environmental burden in accordance with the current trends in the Czech Republic and other countries worldwide.

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