Design Supply Cycle for Inventory Management

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Abstract **– In each company within the application of the lean principle for the material flow area, the inventory management is essential. The subject of this paper is to describe the application of differentiated inventory management. Some businesses have a large number of warehouse items, and it is therefore necessary to identify and work with inventory information. In terms of logistics, it is important to take into account the general rule, which is to keep the amount of inventories at minimum, as well as, the principle of minimising any unnecessary waste. The main purpose of the inventory management is to determine which items are important for the company. The aim of the paper is to demonstrate that the implementation of inventory management could contribute to an increase of certain sales aspects of the company. This article applies a case study scenario in order to analyse a logistics company's sales records, from the sale of car components. The final parts the article provides a comparison of the improved situation within company, in terms of monitored sales parameters. The comparison includes parameters such as the number of deliveries, speed of delivery, and the number of distributed quantities before and after the implementation of differentiated inventory management model.**

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1. Introduction

Differentiated inventory management is related to other logistical activities, namely transportation and transport, as well as the calculation of costs for transport. Cost calculations in transport depend on the technological operations, handling and other performance components. For inventory specification and inventory management, it is important to have at a disposal [1]:

- Basic data (item number, name, designation, mode of operation, major and subordinate measurement units).
- General characteristics (production and ordering time, minimum stock, insurance stock, mode of operation, etc.).
- Technological properties (MRP calculation, Bill of Material - BOM type).
- Material stock properties (stock price, value, minimum stock, last received date, etc.).
- Economic characteristics (economic benefit, method of calculation, etc.).
- Business characteristics (price, pricelist, VAT, etc.).

The main part of the logistics processes of a company is the material flow. The main task of the material flow management is to control the movement of material, raw materials, semi-finished products, in order to describe the dynamics of production in space and time. The material flow itself, defines the arrangement of production facilities, as well as the work units. Material flow can be specified by stock, energy, and other media or other indicators related to the production process up to distribution. In the material flow analysis, it is advisable to concentrate on material transfers between individual inputs and outputs of the material [2], [3].

Important condition for the material flow adjustment is a systematic approach to material flow analysis that requires information gathering, processing of product handling information, quantity, movement of material, activities that affect material movement and time of individual operations. The purpose of material flow analysis is to investigate the efficiency of material movement between individual parts of the production process such as production, transport, handling and storage processes [4], [5].

The inventory management involves maintaining a fine balance between the benefits considering keeping a sufficient amount and variety of inventory, and the necessary costs involved with maintaining mentioned inventory. The obvious benefit of maintaining an inventory has goods items when requested. The main costs involved in maintaining an inventory are tied to the cost of all inventory items, plus ordering costs and the costs for storage. Therefore, the task of inventory management is to reach maximum net benefit without the cost of the inventory [6].

There are several differences between inventory items in regard to their inventory management. The items might differ in the amount of space they need within a warehouse, or their profitability on the market. Higher inventory, however, increases costs for the actual storage capacity, required insurance, and the amount of damaged or spoiled inventory, or added interests if the inventory was acquired using borrowed funds [7].

In order to maintain optimal inventory levels, company management must consider several factors in order to ascertain adequate inventory levels. This will be different with each company, as the factors include company financial liquidity, sales turnover, available financial resources, reliability and availability of suppliers, seasonal patterns of sales and others. A sufficient amount of inventory levels reduces the potential risks of lost sales due to the inventory unavailability [7].

According to McComas [8], the following steps might be taken into consideration, in order to successfully manage inventory within a company:

- Set up guidelines for purchasing inventory items.
- Limit the amount of purchased inventory items needed for a specific production period.
- Cooperate with suppliers in order to improve the purchasing routines.
- Implement effective inventory management systems in order to maintain inventory control.
- Support the practice of material exchange between company departments.
- Consider the system of just-in-time production.

In current situation in business, companies rely heavily on the just-in-time management approach, and therefore the inventory issues are more relevant than ever. Excessive inventories, despite the costs, were considered necessary in the past to ensure smooth production and customer demand. Today, the trend is to minimize inventory, and from the logistics point of view, the need for a large stocks indicates rather badly organized production processes. Also, large stock inventories bind financial funds that could be used to address other problems or innovations [9].

Additionaly, in order to control the inventory levels, management can apply a so called control level method. This method is clear and intuitive. According to this method, stocks are divided into 5 categories [10]:

- Insurance supply - performs a security function.
- Minimum stock - represents a signal level that means that stocks have fallen to a minimum and immediate action is required.
- Maximum stock - represents the amount of inventory immediately upon receipt of a new delivery.
- Technical level - performs the processing function.
- Delivery size – amount of the current order.

The stock management is an essential part of successful inventory management. It is necessary to ensure the optimal level of inventory for the efficient operation of the whole company, in order to know what, when and how much to order.

Inventory records include operational, statistical, and accounting records of levels, and movements of all types of inventory in the warehouse. Stock records are particularly specific to each business. It depends on the type of business performed by the company, its size and distance from suppliers, product range, storage capacity, technical equipment and many other aspects. Thanks to computation and other technological advances, the use of different inventory tracking and monitoring systems is very convenient, allowing for easy record, analysis, warehouse status and activity reports that could be used to rationalize the entire inventory [9].

Subsequently, the networking of the following departments in the company is also necessary to ensure in-house information logistics to streamline, not only the supply, but also all other activities of the company [11]:

- Production planning - background for production plan, consumption forecasting and consumption rationalization.

- Operational production management - reports from production, preparation and delivery, spare parts and repairs.
- Quality control - solving problems with poor quality inputs or outputs.
- Transport - ensuring a regular and urgent supply of material.
- Financial department - budget, turnover and billing inventory.
- Marketing and sales - assortment creation and commissioning.

Inventory tracking allows to easily to adjust inventory turnover rates. The speed of inventory turnover depends on binding of funds business in inventories. The aim is to keep inventory turnover rates as high as possible, and thus to keep bounded finances as low as possible.

2. Specification of material flow

Material flow in the company begins by unloading the means of transport intended for the transport of goods into the zone of unmarked and unidentified material. Once it has been unloaded (the entire batch ordered), the quantity is recalculated and recorded in the "check" sheet designated for this purpose only. Subsequently, a check is carried out according to the supplier's delivery document.

Collected and inspected data is imported into the business system from which the warehouse worker draws information on the materials received. Subsequently, it prepares ID cards (VDA labels) and labels the material they have supplied. After the marking is completed, the material is stored in the appropriate placement (layout).

In case if the material ID card contains a "KO" label, the assigned quality officer performs a check in accordance with the predefined quality parameters (the warehouse worker prepares the material for the check to be carried out as quickly and efficiently as possible).

If the material does not meet the required parameters, such material is temporarily stored in a non-conforming material zone, and the responsible employee acts according to the quality manual (informs the supervisor, supplier, claims material, etc.).

If the controlled material meets all the parameters, the quality officer releases it, and the material can be stored in the input material store. At the customer's request, the logistics worker will prepare a worksheet with all the necessary information (who is the customer, what is the production batch, what is the packaging specification, what is the estimated production time, etc.). It will be handed over to the warehouse worker, who, as instructed, will prepare the material for the place where production will take place.

The term stock intensity λ describes the spending of goods when there are no additional supplies of the required goods. Based on this principle, it is possible to identify the problem in a production company in which inventory deficits may cause disruption of production. A specified disruption of production can be detected at the price of already increased costs. The formula for storage costs for existing stocks and costs associated with lack of inventory is [12]:

$$C_{SS} = Q - s \tag{1}$$

where:
CSS – storage costs,
Q – stock size,
s – deficit.

$$C_a = MWQ \cdot P \tag{2}$$

where:
MWQ – minimum withdrawal quantity (kg),
P – price per unit.

$$C_s = PS \cdot P \tag{3}$$

where:
PS – package size (m^2),
P – price per unit.

$$C_p = MWQ \cdot P \tag{4}$$

where:
MWQ – minimum withdrawal quantity (kg),
P – price per unit.

$$C_d = C_p \cdot \lambda \tag{5}$$

in which:
λ – monthly material consumption.

The formula the optimal order size with a deficit [12]:

$$Q^* = \sqrt{\frac{2 \cdot \lambda \cdot C_a \cdot (C_s + C_d)}{C_s \cdot C_d}} \tag{6}$$

Optimal average inventory:

$$\bar{Q}^* = \frac{Q^* - s^*}{2} \tag{7}$$

Optimal delivery cycle length:

$$T^* = \frac{\bar{Q}^*}{\lambda} \tag{8}$$

Calculation of the order level:

$$r = \lambda \cdot \tau - m \cdot Q^* - s^* = \mu - m \cdot Q^* - s^* \quad (9)$$

A continuous supply process, which sustains the production process, is important for manufacturing the company. High inventory level freezes the movement of cash flow, and creates the need for new and larger warehouses. On the other hand, it should be stressed that the low inventory level has the potential effect of suspending production, and ultimately, stopping the production process completely. The company can thus lose profit, and also the credibility of its own customers. For the smooth running of the production process, optimum inventory needs are to be determined in order to reduce and eliminate undesirable aspects that can have a negative impact on the company (loss of credibility, suspension, eventually stopping production, increasing the cost of additional ordering of goods, etc., Figure 1). Based on the calculations of the modelling inventory with a deficit, the results for the production company are as follows [12]:

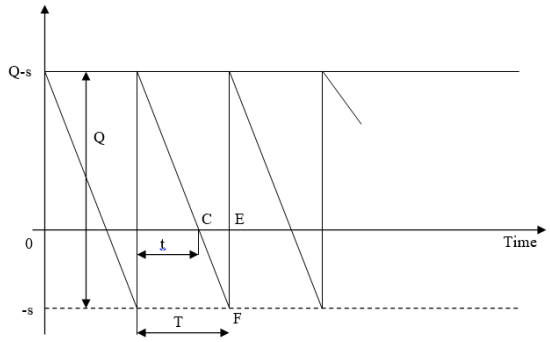

Figure 1. Movement of stocks with deferred consumption [12]

The average inventory level will be reduced to 1,453.63 € month^{-1} if the company already anticipates a change in the supply cycle of the ordered goods, and anticipates the material deficient. The current number of shipments is twice a month. A new delivery cycle would represent three to four shipments a month. Considering the monthly need for goods and materials, the company is in constant shortage because of the incorrectly chosen type and cycle of transport, as the monthly need is 70 750 kg of material, and using its own transportation the company can transport to its premises only 48 000 kg of material.

Table 1. Calculation of supply cycle and quantity

Output parameters	Model without deficit	Model with deficit
Optimal delivery	5 082.64 kg	5 089.59 kg
Optimal deficit	-	2 182.33 kg
Average stock inventory	2 541.32 kg	1 453.63 kg
Delivery cycle length per month	0.0718	0.0719
Number of orders per month	13.92	13.90
Number of deliveries on the road	6.00	6.00
Order level	2 520.85 kg	296.79
Variable costs	343,078.00 €	342,609.00 €
Total costs	872 213 015 €	872 212 547 €

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These deficiencies are compensated by special transports, whose amount is to 2,500.00 € per month and 27,500.00 € per a year, or by the setting priorities to material supplier for loading the material into the ordered means of transport. Specified shortcomings represent redundant work for logistics workers, namely frequent changes in the production plan, as well as the actual suppliers.

Based on the results obtained, it is possible to propose that the investigated company reach out to at least three forwarding companies, and ask them to prepare a quotation. Each company was tasked with developing a quote for two types of goods transport (type of transport: kit and semi-trailer). The average transported quantity will be 22 098 kg (based on the calculation of the optimum monthly order converted to four transports per month). The criteria listed in Table 2 have been specified when selecting the most appropriate offer of freight forwarders to carry the goods / material transport of the company under review.

Table 2. Specified criteria for the carriage of goods

A	Costs:	Cost without deficit
B		Deficit costs
C		Transport costs
D	Warehouse capacity:	Material stocks without deficit
E		Stocks of deficit material
F	Stock level:	Minimum vs. Maximum
G	Variation of changes:	Increase customer orders
H		Reduce customer orders
I		Flexibility
J		Service
K		Administrative claims
L	Invoice maturity:	Transport companies
M		Contractors
N		Customers
O	Cash flow:	Turnaround

Company offer A:

- semi-trailer with a total load capacity of 24t, the price of one shipment excluding VAT is 2,420.00 € (cost of 9,680.00 € compared to the current state of 9,320.00 €),
- a set with a total load of 14t, the price of one shipment excluding VAT is 2,300.00 € (costs per month 16,100.00 € compared to the current 9,320.00 €,
- combination of both vehicles with a ratio of 3:1 – cost per month 9,560.00 € compared to the current status of 9,320.00 € (the difference is 240.00 € more per month).

Company offer B:

- semi-trailer with a total load capacity of 24t, the price of one transport without VAT is 2,490.00 € (cost per month 9,960.00 €).

Company offer C:

- semi-trailer with a total load capacity of 24t, the price of one shipment excluding VAT is 2,280.00 € (cost of 9,120.00 € compared to the current state of 9,320.00 €),
- a set with a total load of 14t, the price of one shipment without VAT is 2,080.00 € (the cost of the month is 14 560.00 € compared to the current 9,320.00 €,
- combination of both vehicles with a ratio of 3:1 - cost per month of 8,920.00 € compared to the current status of 9,320.00 € (the difference of offer is 400.00 € less per month).

3. Conclusion

The result of the price comparison is that the most suitable offer is the offer of shipping company C with a total cost of 8,920.00 € per month (annual shipping costs of 98,120.00 €). The result is that transport costs would increase by 1,760.00 € per month, and the company would save 431.63 € per month, compared to savings on total costs, variable costs and average stock levels in stock. However, an important factor in this proposal is the elimination of downtime in the production process, improved customer and supplier reputation, reduced pressure on logistics workers, variability in order changes for suppliers, and customers, a significant reduction in unsatisfied customer orders, better visualization of minimum and maximum inventory values.

The most appropriate offer is combined transport, in which two types of vehicles will be used, namely a semi-trailer and a set. The second option envisages the use of only one type as a mean of transport and, in particular, a set. On the basis of the indicators surveyed, it is possible to describe the conclusions regarding the increase of the transport cycle:

1. Ensuring the customer needs are met on a regular basis due to a sufficient stock of material.
2. The cash flow turnover will increase, thus reducing the one-off maturity of the invoices for the material, as well as for the transports.
3. Clears the warehouse capacity for future stocks, reduces variable and total costs.
4. The cooperation and commitment of a particular shipping company in the form of a guarantee contract.

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