OPTIMIZATION OF INVENTORY MANAGEMENT IN A METALLURGICAL COMPANY

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Abstract

The paper describes an analysis of storing and inventory management in a metallurgical company and proposes actions for the improvement of the current situation. Methods of ABC and XYZ analysis according to the preliminary determined criteria are used for the evaluation of inventory management. The paper also proposes the use of a consignment storehouse and implementation of the inventory management by the supplier for the selected material items.

Keywords: Logistics, inventory, analysis, consignation, storehouse

1.   INTRODUCTION

The theme of logistics can be imagined as a set of consequential activities including management, realization of movement and storage. Costs for raw materials transportation are influenced by combination of these activities, but it is not the only effect. A level of customer's service and a rate of reaction are also appreciated [1].

Storing systems enable concentration of delivery from several manufacturers on one place, from which particular consignments can be delivered to customers according to their needs and requirements. Some individual deliveries can be, thus, replaced by a single delivery and can reduce by this operation costs.

There are several types of storehouses classified by function within the supplying system; this analysis is dealt with consignment storehouses. It means that a customer establishes consignment storehouses at a supplier side, from which the customer withdraws the goods according to its needs and also manages inventory stocks by notifying the supplier about a necessity of their addition (until they mutually interconnected by a suitable information and control system). The goods are stored in consignment storehouses at the expense and risk of the supplier.

The analyzed transnational company, hereunder referred as the company, is situated in South Moravian Region, nevertheless it has its affiliates all around the world. The company includes three divisions. Whereas the division situated in South Moravian Region is one of the world high-ranking suppliers of a wide range of metallurgical material, products from iron that are being used in very different industrial plants. The most frequently manufactured assortment includes tubes, profiles, sheet metal, reinforcement steels, wires, welded meshes used mainly in the metallurgical but also building industry, which are further used in all types of industrial branches.

Criteria being preliminary defined by the company to determine suitability of engaging of the supplier to consignation include A and B inventory stocks determined on the basis of the ABC analysis. It also considers demanding of the storage of such a material and its practical usability for the consignation. And especially whether during implementation of suppliers to the consignation, financial resources will be saved. In practice, the last of the above-mentioned criterion is popular because the most expensive items are proposed for the consignation, however with regards to the frequency of their consumption. A possibility of more frequent material withdrawal, then, suggests itself and, by this, the decrease of the minimum ordering batches.

The analyzed company sees a big benefit in the implementation of consignment storehouses, that's why they attempt to develop them. At the present time, the company have established 50 consignment storehouses. Their number continues to grow. Considerable financial resources are being save by this. The company possesses a central storage premise where a certain premise is reserved for the proper lodgment of suppliers' materials in the consignment. It means that the material is a property of the supplier until it is removed from the storage and transferred to the consumption; at this moment, it is transferred to the customer's property.

2. INVENTORY MANAGEMENT

Inventory stocks represent a big cost investment for each company. Their size influences the operating results. They are a subject of implementation of separate production processes. Their correct management in company can cover unpredictable fluctuations in the production process. Time-related and capacity discordances are often solved between production and consumption. A negative exposure of the inventory stocks is primarily a big allegiance of the capital, further there are risks resulting from technological progresses: it can happen that they would be unusable, and in a worse case unmarketable by reason of non-compatibility with another material [2], [3].

Supplying is one of the most important activities in a company and it is necessary to manage it correctly. Provided it is correctly set, fluency of production and fulfillment of the required aims is then ensured. A size of the inventory stocks is not precisely defined, it depends on a company's strategy and plenty of factors [4].

The logistics department is wrestling with important tasks. The first is that an amount of inventory stocks was always available in a storehouse, however this amount must be chosen so that a course of the work line was not threatened by reason of a lack of material quantity. But on the other hand, it is necessary to be particular on that a capital was not uselessly bound in the inventories. To ensure the effectiveness of this system, the company endeavors to improve the supply-customer's relationships. The most frequent expressions of these relationships are the decrease of the minimum ordering batches to a needed minimum, the decrease of so called safety inventories which have to cover errors occurred from the side of a supplier and last but not least also implementation of consignment storehouses [5]. This special type of storehouses can be characterized as a storehouse which is established by a customer for the supplier and bears all responsibility for its operation. The supplier has a bound capital in inventories in this type of storehouse till the moment of consumption when an invoice for consumed material is issued. A significant benefit of this is that in case of correctly set conditions, whole responsibility is transferred to the supplier and company, thus, saves costs which would result from planning of the purchase orders of the material items [6]. Since the supplier has a precise review about a consumption of its material, and in interest of preservation of the fluency of the production process of the supplier, it governs and optimizes its process of supplying of other inventories [2], [7].

To determine suitability of a supplier for the implementation into the system of consignment, methods of inventory management were applied, in this case these were methods of ABC and XYZ analyses.

2.1. ABC ANALYSIS

This analysis is the most frequently used method going from the formula of the value and inventory volume. Differentiation of inventory management occurs, where a company classifies items depending on their importance. The ABC analysis includes the classic Pareto analysis which is alternatively signed as a 80/20 rule, which means that 80 % of the consequences results from 20 % of the number of all possible causes. To enable application of this method, it is necessary to keep at disposal data about the consumption of separate items for a certain time period [8].

There are the following categories:
- Category A - The most important items with the biggest share in the turnover. The state of inventories is here systematically checked, and they shouldn't be fully run out because they create 80 % of the total

consumption of the company. This type of items should be ordered in a smaller amount and more frequently because it bounds a big volume of capital upon itself.

- Category B - Semi-important items. This category includes about 15% of the consumption. Items are checked less frequently than the items from Category A. It is higher size of supplies here as well as a safety stock.
- Category C - The least important items creating about 5 % of the consumption. These items have the biggest share in a company and they are cheapest [9].

2.2. XYZ ANALYSIS

This method extends the ABC method. It is mainly used in big companies. This method is a classification of company's turnover rate and tracks items depending on a character of their consumption. To enable creation of the analysis, it is necessary to go from either the historical data of the storage movements or on the basis of future predictions [2].

To classify correctly the inventories by category, it is necessary to calculate correctly a coefficient of variation (v_i), according to the formula (1).

$$v_i = \frac{s_i}{h_i} * 100 \ (\%) \tag{1}$$

Where:

h_i - average value of consumption of ith item,

s_i - standard deviation of consumption of ith item, calculated from the formula (2).

$$s_i = \sqrt{\frac{1}{n}\sum_{j=1}^{n}(h_{ij} - h_i)^2} \tag{2}$$

Where:

h_{ij} - value of consumption of ith item in j^{th} month,

n - number of months.

On the basis of the above-mentioned formulas, calculations and parameters for the classification of separate items to the following categories will be obtained [2]:

- X - uniform consumption of items, moderate fluctuations with a high prediction,
- Y - strongest fluctuations, medium-hard prediction,
- Z - irregular consumption of items.

For the creation of the ABC/XYZ matrix, specific strategies of forward buying or storage are assigned to separate classes of types of the material items. The most beneficial usage of the logistics technologies is the AX combination, where the JIT delivery is being used; a delivery can be supplied to a customer in some minutes period of time. Further, AZ and BX, when deliveries can be performed in some hours period of time. On the contrary, the CZ combination means delivery for a demanding purchase order, mainly once in a while, for example, it could be air transport from a central storehouse.

3. OPTIMIZATION OF INVENTORY MANAGEMENT

The ABC and XYZ analysis will be performed in the next chapters with its consequential evaluation. An actual state of the inventories will be investigated, and the minimum and maximum quantity of the inventories to be order will be proposed. The selected types of the metallurgical material items are varied. Ranging from various forgings, castings to tubes, profiles, sheet metal, reinforcement steels and wires that is company working with to best satisfy customer requirements.

3.1. PROPOSAL FOR THE STORAGE AND INVENTORY MANAGEMENT IN A CONSIGNMENT STOREHOUSE

As was already mentioned, classification of inventories with help of the ABC analysis is used while decision-making about which items have to be inserted in the consignment. It is suitable to focus on Category A, where there are items with the highest turnover. The next condition can be identification of critical inventory stocks, which are items that have to be necessarily in stock. And the last condition is also a financial aspect when it is beneficially to put the most expensive items into the consignment.

Table 1 ABC and XYZ analysis [own study]

Inventory stock	CZK/pc	Annual consumption (pcs)	Annual cumulative sales in CZK	Share (%)	ABC	Monthly average consumption	Standard deviation	Coefficient of variation (%)	XYZ	ABC/XYZ
87.90357L	98.45	18,880	1,858,647	17.69	A	1,573	499.36	31.74	X	AX
96.02285M	99.46	11,385	2,991,002	28.47	A	949	265.13	27.95	X	AX
96.00137-1	49.22	14,370	3,698,332	35.21	A	1,198	424.61	35.46	X	AX
01154570P	22.84	30,587	4,396,795	41.86	A	2,549	779.88	30.60	X	AX
96.02194M	125.85	3,780	4,872,499	46.39	A	315	114.06	36.21	X	AX
96.11862-6	71.04	3,832	5,144,736	48.98	A	319	88.77	27.80	X	AX
96.02074	42.12	5,061	5,857,741	55.77	A	422	151.44	35.91	X	AX
96.007204	91.34	2,174	6,255,230	59.55	A	181	57.48	31.73	X	AX
96.00973	91.34	2,098	6,446,863	61.37	A	175	81.76	46.76	X	AX
96.11225	84.24	2,202	6,632,353	63.14	A	184	90.72	49.44	X	AX
96.01637	76.12	1,849	7,900,182	75.21	A	154	75.46	48.97	X	AX
5183-9912K	7.05	14,192	8,685,674	82.69	A	1,183	407.07	34.42	X	AX
96.005566P	33.49	2,329	9,446,548	89.93	B	194	79.77	41.10	X	BX
033370563S	65.80	1,095	9,595,008	91.34	B	91	29.65	32.49	X	BX
96.012213	31.46	1,140	10,504,300	100.00	B	95	39.50	41.58	X	BX
XVC7202-05B	37.86	0	10,504,300	100.00	C	0	0.00	0.00	-	-

As is clear from **Table 1** below, first of all the ABC analysis was carried out, when the sales were calculated on the basis of the determination of the price per one piece of material and the annual consumption of separate inventory stocks. The cumulative share was calculated as a share of so-calculated final cumulative sum and separate cumulations for each inventory stock. It enabled determination of which category separate inventory stocks fall into according to the criteria specified in Chapter 2.1. Consequently, an average consumption of separate inventory stocks was determined, and a standard deviation (2) and coefficient of variation (1) were calculated according to formulas specified in Chapter 2.2. At the conclusion, a matrix consisting of the letters of the results of the both analyses were created.

A supplier for the concrete purpose of consignment in the monitored metallurgical company was proposed, which is a supplier of 16 types of metallurgical inventory stocks in total. On the basis of the ABC analysis, however, there was determined that one type of inventory stock is classified to Category C, which is fully insufficient for the purpose of consignment; a reason of it is its very irregular consumption It was used not a single time for the monitored period of 1 year in the production.

That's why we use other 15 types of inventory stocks for the next research, whereas it is necessary to note that the selected supplier is a suitable candidate for the implementation of the consignment because all material items fall into the AX and BX groups. As is clear from the above-mentioned, it is very important for the company and supplies strategical metallurgical materials. The company uses a form of division of the implementation to several gradual phases, whereas at the present it is in a first phase, i.e. a preparation phase.

Table 2 Proposal for the storage of inventory stocks [own study]

										Actual state		Proposal	
Inventory stock	CZK/pc	Monthly average consumption	Maximum consumption	ABC/XYZ		Actual inventory stocks		Average inventory stocks		Stored inventory stocks		Stored inventory stocks	
87.90357L	98.45	1,573	2,439	AX	649	63,891.00 CZK	253	24,924.56 CZK	240	23,626.87 CZK	240	23,626.87 CZK
96.02285M	99.46	949	1,391	AX	178	17,703.92 CZK	237	23,594.67 CZK	300	29,838.06 CZK	100	9,946.02 CZK
96.00137-1	49.22	1,198	1,820	AX	1,130	55,621.65 CZK	685	33,710.84 CZK	300	14,766.81 CZK	200	9,844.54 CZK
01154570P	22.84	2,549	4,154	AX	4,015	91,683.73 CZK	3,672	83,843.96 CZK	8,000	182,682.40 CZK	300	6,850.59 CZK
96.02194M	125.85	315	549	AX	247	31,084.36 CZK	143	18,053.41 CZK	200	25,169.52 CZK	60	7,550.86 CZK
96.11862-6	71.04	319	488	AX	337	23,941.49 CZK	192	13,666.09 CZK	300	21,312.90 CZK	60	4,262.58 CZK
96.02074	42.12	422	697	AX	584	24,597.15 CZK	359	15,114.76 CZK	1,000	42,118.40 CZK	100	4,211.84 CZK
96.007204	91.34	181	289	AX	255	23,291.96 CZK	131	11,957.37 CZK	280	25,575.48 CZK	40	3,653.64 CZK
96.00973	91.34	175	296	AX	181	16,532.72 CZK	146	13,344.09 CZK	300	27,402.30 CZK	40	3,653.64 CZK
96.11225	84.24	184	351	AX	218	18,363.60 CZK	91	7,627.25 CZK	200	16,847.34 CZK	100	8,423.67 CZK
96.01637	76.12	154	315	AX	249	18,953.26 CZK	124	9,410.89 CZK	400	30,447.00 CZK	40	3,044.70 CZK
5183-9912K	7.05	1,183	1,861	AX	1,148	8,097.53 CZK	987	6,959.66 CZK	2,000	14,107.20 CZK	200	1,410.72 CZK
96.005566P	33.49	194	290	BX	93	3,114.73 CZK	165	5,509.38 CZK	500	16,745.85 CZK	40	1,339.67 CZK
033370563S	65.80	91	153	BX	273	17,964.11 CZK	202	13,274.18 CZK	500	32,901.30 CZK	40	2,632.10 CZK
96.012213	31.46	95	159	BX	76	2,391.10 CZK	124	3,885.54 CZK	200	6,292.38 CZK	40	1,258.48 CZK
Total						**417,232.30 CZK**		**284,876.65 CZK**		**509,834.81 CZK**		**91,709.92 CZK**
Saving										**-224,958.16 CZK**		**193,166.73 CZK**

Table 2 shows an average and maximum consumption of the inventory stocks, a resulting matrix of the ABC/XYZ analyses and a state of actual and average inventory stocks. The current situation of the warehouse stocks was determined by researching, which was - after rounding - multiple by the unit price, and its financial value was, thus, determined. The same procedure was carried out within the proposal for the improvement.

As a result of proposition of more effective storing metallurgical material items and mainly of the implementation of a supplier for the consignment, a significant economy of financial resources was achieved. Concretely, if was from a total amount of the average inventory stock 284,876.65 CZK deducted actual stored inventory stocks of 509,834.81 CZK. As is clear from **Table 2**, that in case of the actual state of inventory stocks, a loss will occur, concretely in the amount of 224,957.16 CZK, and it is caused that the company has stocked too many material items, which it does not need immediately at this moment and uselessly drown its financial resources in it, which could invest elsewhere. The proposed proposal for implementing a supplier into the consignment, in the case of correct proposition of inventory stocks, would save money.

3.2. OPTIMAL ORDERED QUANTITY OF INVENTORY STOCKS

Table 3 describes a actual state in the sphere of packing quantity. The states of numbers of pieces in one package (pallet) compared with their average consumption were recalculated within optimizing the process of supplying and storing and was determined minimum quantity in stock. By multiplying by coefficient 3, the maximal amount was reached in the warehouses, depending on the maximum storage capacity. The maximum quantity of the number of packages to be ordered was determined with help of the proportion of the maximum necessary quantity of the material items with the number of pieces in the package. For the proposed maximum level of number of packages were most of the quantities recalculated so, that the maximum amount was divided by the set coefficient of 150. And whereas the specific contractual conditions between suppliers occurred; and the result is a high economy of the storage premises. With regards to the fact that the supplier is implemented into the consignment with so many products, a big benefit is that the maximum ordered quantity of the inventory stocks can be decreased, because more frequent supplying from the part of the supplier will occur in order to prevent from storing inventory stocks in storehouse.

Table 3 Minimal and maximal ordered quantity of inventory stocks [own study]

Inventory stock	Actual state				Proposal			
	Pieces per package	Min.	Max.	Max. level of the number of packages	Pieces per pacpage	Min.	Max.	Max.level of the number of packages
87.90357L	60	1,620	4,860	81	60	1,620	4,860	81
96.02285M	150	1,050	3,150	21	50	950	2,850	19
96.00137-1	150	1,200	3,600	24	50	1,200	3,600	24
01154570P	4,000	4,000	12,000	3	150	2,550	7,650	51
96.02194M	100	400	1,200	12	15	315	945	6.3
96.11862-6	150	450	1,350	9	30	330	990	6.6
96.02074	500	500	1,500	3	50	450	1,350	9
96.007204	140	280	840	6	20	200	600	4
96.00973	150	300	900	6	20	180	540	3.6
96.11225	100	200	600	6	50	200	600	4
96.01637	200	200	600	3	20	160	480	3.2
5183-9912K	1,000	2,000	6,000	6	100	1,200	3,600	24
96.005566P	250	250	750	3	20	200	600	4
033370563S	250	250	750	3	20	100	300	2
96.012213	100	100	300	3	20	100	300	2

Seeing that the company permanently pushes on decreasing the costs bounded in inventory stocks, the situation must be resolved. A possibility of the creation of consignment storehouses appears to be a suitable solution. Inventory stocks are implemented into consignment storehouses for the purpose of more frequent withdrawal of materials in smaller quantity. This action prevents indiscipline of suppliers in a form of incorrect quantity in package, errancy in the calculations of material consumption per one product, errors of human factor, etc.

4. CONCLUSION

Not only metallurgical companies would like to keep as few as possible of inventory stocks to prevent from risks resulting from big keeping the inventory stocks. Concretely, they are afraid of high fixture of the capital

which can be better invested, for example, in technological development. With regards to the high competitiveness, the company appreciates each customer and doesn't want to face up to risks related to a possibility that the customer can come over to a competing company, that's why it wants to maximally satisfy its needs.

The optimization of the supplying process has to start just from its beginning which is acquisition of input materials. The aim of each enterprising is minimization of the costs to reach maximum profits.

To reach a more effective system of inventory management, it is also recommended implementation of consignment warehouses, and that is by reason of more frequent withdrawal of material and decreasing the minimum ordering batches.

By comparison of the current state with the state which would follow in the case of implementation of a supplier into the consignment, we found out that significant economies would occur, concretely in an amount of 193,167 CZK. Incorrectly set maximum levels of the inventory stocks caused that uselessly big amount of the financial resources is bound in the inventory stocks. Besides of that, storage premises were overwhelmed by inventory stocks and, thus, a lack of the storage premises was originated. By implementing the configuration, this capacity limitation could be avoided, mainly thanks to the fact that the supplier would govern the supplier by itself, would have a clearly given maximum quantity of the packaging level, which it could supply. Also, correct setting of the number of pieces per one package would be reached, which would be simpler for a supplier, mainly by reason of more frequent supplying. To avoid blocking of financial resources in the inventory stocks, this type of actions is desirable for the company. A very big advantage is that a supplier stocks the company by several types of material, which is beneficial for it because it is possible to plan more frequent supplying with regards to the setting of lower ordering inventory stocks.

Another recommendation for the company could be a construction of new storage premises focusing only on the consignment. At present, they are ranked to a collective storehouse, however by a construction of a special storehouse, dependent on continuous expansion of the consignment, this action appears as desirable. It would, thus, cause more transparent management and inventory storage.

ACKNOWLEDGEMENTS

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