Inventory Control Using ABC Classification and Min-Max Stock Method in The Manufacture of Armored Vehicle Body Hull at PT XYZ

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Abstract. Research and development efforts are currently underway to enhance inventory control systems. However, fluctuations in demand often pose challenges to achieving optimal inventory management. To address this issue, it is crucial to establish efficient control measures that maintain an optimal inventory level. This study focuses on finding an effective approach for PT XYZ to manage stockpiles of raw materials for armored vehicle body hulls, aiming to prevent shortages or excessive stockpiling. The research uses the ABC categorization system and the min-max stock approach as its material inventory control strategies. Inventory classification, inventory turnover, the amount of safety stock, minimum stock, maximum stock, and order quantity are all determined using this procedure. By conducting a case study on PT XYZ's material inventory control for Panzer body hulls, it was identified that 3 materials fell under the important category (A), 3 materials in the moderate category (B), and 20 materials in the less critical category (C). The findings of this research are that the ABC method and min-max stock can be used as a reliable foundation for establishing inventory control parameters. Companies are advised to evaluate and consider the rules for each material, such as material costs, rare or not material types, and a history of delays from suppliers. These factors play a significant role in determining appropriate inventory control measures.

1 Introduction

Inventories are materials or goods that are stored and will be used for certain purposes, in this case, production and assembly needs. Inventory can be in the form of raw materials, supporting materials, work in process, finished goods, and spare parts. Therefore, inventory planning and control is an important thing in the company, because it determines the smooth running of production and sales, inventory must be managed appropriately by determining the optimal amount of inventory, to meet every incoming demand [1]. Inventory control must take safety stock into account in a system with variable demand to prevent delays in the delivery of raw materials from distributors [2]. Safety stock is the amount of inventory maintained in quantity so that it remains available and can be obtained to anticipate requests during uncertain lead times [3].

ABC classification generally represents the most important aspects described in categories A, B, and C. Usually with a composition of 20% Category A, 30% Category B, and 50% Category C [4]. Min-max stock analysis is used to determine the minimum and maximum inventory values. The minimum and maximum inventory results are then implemented to make inventory ordering rules [5].

PT XYZ, a state-owned enterprise, produces both commercial and military goods. Ammunition, weaponry, heavy equipment, special vehicles, and transportation infrastructure. PT XYZ produces goods on a make-to-order basis or by customer demands and every year, the demand fluctuates. This company manages inventory using SAP, which is an Enterprise Resources Planning (ERP) based software that is used for company or business activities, the aim is to monitor and manage information to make it more effective and efficient. In managing inventory at the Randalprod and Warehouse Department, there are 5 stages, namely Bill of Material (BOM), Purchase Request (PR), Purchase Order (PO), Material Inspection, and Good Receipt (Septiani, 2018).

According to the Head of the Rendalprod and Warehouse Department at PT XYZ's explanation, uncertain safety stock frequently renders the necessary material unavailable. Additionally, the lack of a maximum stock means that material must be transferred to another warehouse, prolonging production times. The available material stock is uncertain for each material, and material purchases are made when the inventory in the warehouse has run out. In this research ABC classification and the Min Max stock rules method will be applied to solve the problem.

The purpose of this study was to find material classification using the ABC method and to provide suggestions for material control for Armor Vehicle Body Hull at PT XYZ.

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2 Literature review

2.1 Inventory control

Inventory can be defined as goods stored for use in the next period. Inventory is an important factor in the manufacturing industry. Inventory control is the point where a balance of quality and raw materials is required at minimum cost. The function of inventory control is to keep the company from running out of raw materials and the production process to run smoothly, to keep inventories not too large so that costs are not too large, and to ensure that purchases are not repeated [6]. Inventory control is also an activity of supervising inventory or inventory so that it can determine the amount or level of an inventory of raw materials and goods produced for the smooth running of company purchases [7]. This research was conducted due to shortages and overstock from PT XYZ for several materials based on direct observation, viewing company document archives, and viewing SAP data. In addition, there are no rules from the company regarding minimum stock and maximum stock in the warehouse. The function of the inventory includes anticipating the risk of delays in the delivery of raw materials, anticipating the risk of material defects that must be returned, anticipating inflation risk, anticipating the possibility of scarce raw materials, increasing profit, and the service will continue

2.2 ABC Classification

ABC classification is a method used for inventory management by grouping goods based on the use of goods. The ABC method explains that the important role of inventory is the use of large items but a small number of items [8]. The grouping of the ABC method is divided into three categories.

- Category A

  If the amount of cost absorbed is between 70% and 80% of all costs paid from the complete inventory and the amount of goods is between 10% and 20% of all goods, the minimum cumulative amount is 75%.

- Category B

  If the cumulative is between 75% and 95% and the absorption of funds is around 15% of all costs offered from the total inventory.

- Category C
  if the total cost of all costs covered by the inventory is approximately 5%, then the total cost absorption will be between 95% and 100%.

The procedure for grouping materials using the ABC method according [9] is as follows.

1. Determines the usage volume for each period
2. Multiply the volume of usage by the cost per unit and orders in one period
3. Sum all the costs of all materials
4. Find the percentage by dividing the total cost per unit by the total cost of all materials
5. Sort by highest percentage 6. Classify in ABC form

2.3 Inventory turnover

Inventory Turnover (ITO) is a ratio to measure inventory liquidity. This ratio is used to measure inventory turnover in one period. Inventory turnover is a comparison between requests in one period with the average inventory of material. The higher the inventory turnover value, the better the liquidity of the inventory [10]. Inventory turnover is the ratio used to find out the funds invested in inventory in one period, the smaller the ratio, the worse it is. The formula for finding inventory turnover is as follows,

$$ITO = \frac{Demand\ in\ one\ period}{Inventory\ average} \quad (1)$$

2.4 Min-Max stock

Min-max stock is a method of structuring the basic inventory mechanism that has been set by the company. Min is the inventory value that triggers the reorder and Max is the stock level value from the reorder result. The distance between the order and the maximum stock is called the Economic Order Quantity [11]. Min-max stock has the following calculation stages.

2.4.1 Determining safety stock

Safety stock is the minimum inventory that must be available to anticipate additional needs or delays in the arrival of goods. Safety stock is very necessary for the smooth running of the production process because if there is insufficient inventory it will cause production to stop [12]. Safety Stock can be obtained by multiplying the standard deviation by the root of the lead time and the Z determination.

$$Safety\ Stock = SD\ x\ \sqrt{Lead\ time\ x\ Z} \quad (2)$$

2.4.2 Determining reorder point

Reorder point (ROP) is the point where inventory needs to be reordered to fill stock shortages. ROP functions to find out when an order will be made by a company. This process occurs when the amount of inventory contained in stock decreases continuously so it must be determined how much the minimum inventory level limit must be considered so that stockouts do not occur. ROP is ordered before inventory is at zero or at the safety stock level, so that when inventory is at minimum stock it has been replenished [13]. The formula for finding the Reorder Point is multiplying the average usage by the lead time and adding it by the safety stock.

$$Reorder\ Point = (dxL) + SS \quad (3)$$

2.4.3 Determining economic order quantity

Economic Order Quantity (EOQ) is a way for companies to find out the economic order quantity. EOQ can be interpreted as the number of units of an item that must be ordered each time an order is placed so that procurement costs are minimal and optimal. The EOQ method is used to determine the number of inventory orders that minimizes storage and ordering costs [12]. The EOQ formula is the root of twice the demand multiplied by the usual order and divided by the holding cost.

$$EOQ = \sqrt{\frac{2DS}{H}} \quad (4)$$

2.4.4 Determining the maximum stock

The maximum inventory is the allowed amount of material in the warehouse. The maximum inventory is obtained by adding up the minimum inventory with the company's order quantity.

$$Maximum\ stock = Safety\ stock + EOQ \quad (5)$$

3 Methodology

Before performing a min-max stock analysis, prioritized raw materials must first be determined using an ABC classification. These materials will then be assessed for category A and B materials to generate the best possible inventory control solutions. Record each material, the amount needed for one time, and the cost per unit of material first. After that, by multiplying, the total amount needed to produce the armored vehicle body hull was determined. Excel and POM QM applications are used to assist in calculating the ABC categorization. After obtaining Category A and B, the computation of the minimum and maximum stocks is done by determining the safety stock, reorder point, EOQ, and maximum stock.

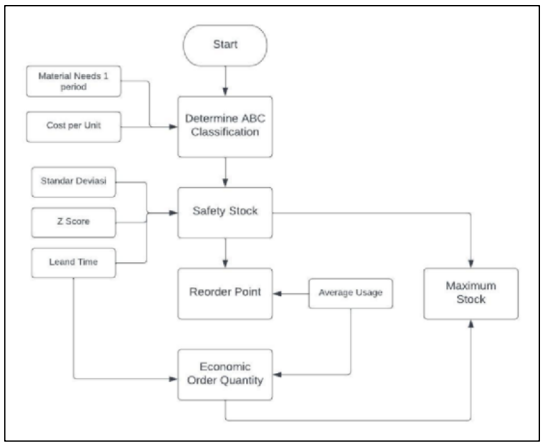

Fig. 1. Problem solving tapes

4 Result and discussion

Calculations can be done using MS. Excel and POMQM software to determine material classification, inventory turnover, safety stock, reorder point, Economic Order Quantity, and maximum stock using the data obtained from PT XYZ, specifically data on material requirements, price per unit, lead time, average production demand, and average inventory data for the 6x6 Panzer body hull material. The outcome of MS computations is as follows. ABC-based categorization of Excel inventory.

Table 1. Material category A

Bj. Tahan Peluru	2,80	Rp 57.738.027	10	Rp 1.616.664.762	63,110%	A
10x2485x8000	0,95	Rp	10		63,110% 78,964%	A
Bisplate 400	5,20	42.750.400	10	Rp 406.128.800	81,474%	A
#10 Plat		Rp		15,854% Rp		
ST.37 #2		1.236.857		64.316.588 2,511%		

Table 2. Material category B

Material	Needs	Price/Unit	Needs 1 year	Total	Category	Percentage	Comulative	
Plat ST.37 #10	1,40	Rp 3.665.760	10	Rp	51.320.640	2,235%	83,710%	B
Plat ST.37 #6	2,20	Rp 2.220.400	10	Rp	48.848.800	2,215%	85,924%	B
AS ST.37 Φ8	0,70	Rp 66.600	10	Rp	466.200	2,166%	88,090%	B

Table 3. Material category C

Plat ST.37 #2	5,20	Rp 1.236.857	10	Rp 64.316.588	2,136%	90,226%	C
AS ST.37 Φ16	1,40	Rp 253.080	10	Rp 3.543.120	2,003%	92,229%	C
AS ST.37 Φ8	0,70	Rp 66.600	10	Rp 466.200	1,907%	94,136%	C

In calculating the ABC classification, POMQM software is also used. The following is the result of the POMQM calculation of inventory classification using the ABC method.

Item name	Demand	Price	Dollar Volume	Percent of $-Vol	Cumulty $-vol %	Category
Bj. Tahan Peluru 10x2485x8000	2,8	3833	10732,4	63,12	63,12	A
Bisplate 400 #10	,95	2838	2696,1	15,86	78,97	A
Plat ST.37 #2	5,2	82	426,4	2,51	81,48	A
Plat ST.37 #5	2,6	146	379,6	2,23	83,71	B
Plat ST.37 #3	3,2	118	377,6	2,22	85,93	B
Plat ST.42 #6	1,2	307	368,4	2,17	88,1	B
Bj. Tahan Peluru 6x1500x6000	,35	1038	363,3	2,14	90,24	C
Plat ST.37 #10	1,4	243	340,2	2	92,24	C
Plat ST.37 #6	2,2	147	323,4	1,9	94,14	C
Plat ST.37 #8	1,5	195	292,5	1,72	95,86	C
Plat Alumunium #2	2,2	86	189,2	1,11	96,97	C
Plat ST.37 #4	1,7	105	178,5	1,05	98,02	C
Pipa Square 40x40	4,5	26	117	,69	98,71	C
Pipa Seamless 3	,2	329	65,8	,39	99,1	C
Bj. Tahan Peluru 8x2485x8000	,01	3865	38,65	,18	99,28	C
AS ST.37 ?16	1,4	17	23,8	,14	99,42	C
Handle Pintu Belakang	1	23	23	,14	99,55	C
Plat ST.42 #12	,04	454	18,16	,11	99,66	C
AS ST.42 ?20	,3	60	18	,11	99,78	C
AS ST.42 ?8	,3	27	8,1	,05	99,81	C
Name Plate Body	1	8	8	,05	99,86	C
Plat RAM Expanded #1	,65	12	7,8	,05	99,9	C
Pipa Santary 2"	,3	21	6,3	,04	99,94	C
Plat Strip	,6	9	5,4	,03	99,97	C
AS ST.37 ?8	,7	4	2,8	,02	99,99	C
AS ST.37 ?10	,25	7	1,75	,01	100	C
TOTAL	36,55		17004,16			

Fig. 2. Result POMQM

Three materials were discovered to be included in Category A, three materials in Category B, and twenty materials in Material C, according to the results of processing the classification of the Panzer body hull material. Turnover calculation comes next after the material classification calculation. The material turnover for the 6x6 Panzer body hull is calculated to see if it is satisfactory or still too low. The inventory turnover calculation is shown below.

Table 4. Inventory turnover

Category	Material	*Turnover*
A	Bj. Tahan Peluru 10x2485x8000	9,33
	Bisplate 400 #10	47,50
	Plat ST.37 #2	5,20
B	Plat ST.37 #5	5,20
	Plat ST.37 #3	6,40
	Plat ST.42 #8	6,00
C	Bj. Tahan Peluru 6x1500x6000	17,50
	Plat ST.37 #10	1,40
	Plat ST.37 #6	1,10

From the results of inventory turnover processing, material inventory turnover for the Panzer body hull still varies between materials, there is a material that is already high which means it is good, but there are still many materials whose turnover value is still low so the material is not by needs and settles in warehouses in quite a long time.

The next calculation is to calculate safety stock to determine minimum stock and anticipate stock shortages in the next period. The following is the result of calculating the safety stock of each material for making a Panzer body hull using MS. Excel.

Table 5. Safety stock material category A

Category	Material	Standar Deviasi	Lead Time	Lead Time ^1/2	Z	Safety stock
A	Bj. Tahan Peluru 10x2485x8000	6,0288	6	2,45	1,64	24
	Bisplate 400 #10	6,0288	6	2,45	1,64	24
	Plat ST.37 #2	6,0288	3	1,73	1,64	17

Table 6. Safety stock material category B

Category	Material	Standar Deviasi	Lead Time	Lead Time ^1/2	Z	Safety stock
B	Plat ST.37 #5	4,2426	3	1,73	1,64	12
	Plat ST.37 #3	4,2426	3	1,73	1,64	12
	Plat ST.42 #8	4,2426	3	1,73	1,64	12

Table 7. Safety stock material category C

Category	Material	Standar Deviasi	Lead Time	Lead Time ^1/2	Z	Safety stock
C	Bj. Tahan Peluru 6x1500x6000	5,5678	6	2,45	1,64	22
	Plat ST.37 #10	5,5678	3	1,73	1,64	16
	Plat ST.37 #6	5,5678	3	1,73	1,64	16

Apart from using MS. Excel, safety stock calculations also use POMQM software. Following are some visualizations of calculation results with POMQM.

Parameter	Value
Z value	1,64
Expected demand during lead time	168
Safety Stock	24,22

Fig. 3. Safety stock material A1 POMQM

Parameter	Value
Z value	1,64
Expected demand during lead time	78
Safety Stock	12,04

Fig. 4. Safety stock material B1 POMQM

Parameter	Value
Z value	1,64
Expected demand during lead time	21
Safety Stock	22,36

Fig. 5. Safety stock material C1 POMQM

After obtaining the minimum stock in the form of safety stock, the next step is to calculate the reorder point. Reorder point is a point where you can place an order so that there is no shortage. The following is the result of the reorder point of the material for making the Armored Vehicle Body Hull.

Table 8. Reorder point material category A

Category	Material	Average Usage (d)	Safety Stock (SS)	Lead Time (L)	*Reorder Point*
A	Bj. Tahan Peluru 10x2485x8000	28	24	6	38
	Bisplate 400 #10	9.5	24	6	29
	Plat ST.37 #2	52	17	3	30

Table 9. Reorder point material category B

Category	Material	Average Usage (d)	Safety Stock (SS)	Lead Time (L)	*Reorder Point*
B	Plat ST.37 #5	26	12	3	18
	Plat ST.37 #3	32	12	3	20
	Plat ST.42 #8	12	12	3	15

Table 10. Reorder point material category C

Category	Material	Average Usage (d)	Safety Stock (SS)	Bj. Tahan Peluru 6x1500x6000 3.5	Lead Time (L)	*Reorder Point*
				22	6	24
C	Plat ST.37 #10 Plat ST.37 #6	14	16	3	19	
		22	16	3	21	

The reorder point calculation is used as the basis for when ordering material must be made so that when the material has reached the safety stock the material has arrived back so that stock shortages do not occur. This calculation is done by multiplying the lead time (L) by the usage per month (d) and adding it up the safety stock (SS).

Next, calculate the Economic Order Quantity to get the most efficient and optimal order for the Panzer body hull material at PT XYZ. The following is the result of the EOQ calculation for each material in each category.

Table 11. EOQ material category A

Category	Material	EOQ
A	Bj. Tahan Peluru 10x2485x8000	18
	Bisplate 400 #10	11
	Plat ST.37 #2	18

Table 12. EOQ material category B

Category	Material	EOQ
B	Plat ST.37 #5	12
	Plat ST.37 #3	14
	Plat ST.42 #8	8

Table 13. EOQ material category C

Category	Material	EOQ
	Bj. Tahan Peluru 6x1500x6000	6
C	Plat ST.37 #10	9
	Plat ST.37 #6	11

The results of calculating the economic order quantity as the basis for determining the maximum stock obtained from the sum of safety stock and economic order quantity. The following is the result of several maximum stock calculations

Table 14. Maximum stock material category A

Category	Material	Min Stock	EOQ	Max Stock
	Bj. Tahan Peluru 10x2485x8000	24	18	43
A	Bisplate 400 #10 Plat	24	11	35
	ST.37 #2	17	18	35

Table 15. Maximum stock material category B

Category	Material	Min Stock		EOQ	Max Stock
	Plat ST.37 #5	12	12		25
B	Plat ST.37 #3	12	14 8		26
	Plat ST.42 #8	12			21

Table 16. Maximum stock material category C

Category	Material	Min Stock	EOQ	Max Stock
	Bj. Tahan Peluru 6x1500x6000	22	6	29
C	Plat ST.37 #10 Plat	16	9	25
	ST.37 #6	16	11	27

Based on the results of processing and calculations using the ABC method and min-max stock, PT XYZ can evaluate the body hull material inventory for making 6x6 armored vehicles. These results become the basis for the company to carry out inventory control so that the problem of delays in raw materials can be overcome. Based on the previous policy, the company experienced a shortage of stock and overstock and the proposed policy is expected to reduce the risk of shortages and excess stock.

Companies also need to evaluate each year regarding the turnover of materials so that the needs of product manufacturers can be readjusted.

5 Conclusion

The conclusions from this study are that the ABC method and min-max stock can be used as a basis for determining the limits of inventory control, namely to determine material categories, material turnover, material orders, material availability limits, ordered material quantities, and maximum inventory in the warehouse. According to PT XYZ's case study on material inventory control for the Panzer body hull, there were 3 materials identified as important materials and included in category A, 3 materials identified as important materials and included in category B, and 20 materials identified as key materials and included in category C.

Companies need to evaluate and consider the rules for each material, such as material costs, rare or not material types, and a history of delays from suppliers. There needs to be a safety stock to avoid production delays and a maximum stock is needed so that excess stock or overstock does not occur.

Future researchers need to perform a factor analysis of supplier delays at PT XYZ and consider all the factors that caused PT XYZ not to implement the integrated supply chain, using multi-criteria decision-making.

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