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Failure Mode and Effect Analysis Implementation for Spare Part Classification and Inventory Management in Automotive Manufacturing (Case Study of Pt. XYZ)

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Abstract:- This research aims to find out what factors affect the strategy of providing spare parts in warehouses, how the application of FMEA in the classification of spare parts and improvements that must be made related to the implementation of FMEA and inventory management in PT. XYZ. The method used is to use fishbone diagrams, FMEA and ABC analysis related to spare parts supply strategies. This research sample is 12 spare parts that fall into the ABC analysis category. The calculation method uses a replenishment pull system, considering CTI stock, safety stock, PLT stock and minimum and maximum value of kanban. The result of this research is a decrease in inventory value in warehouse of PT. XYZ is 56.86% compared to previous condition.

Keywords:- *ABC Analysis, Fishbone analysis, FMEA, Inventory Management, Replenishment pull system.*

I. INTRODUCTION

Indonesia's automotive industry has become an important pillar in the country's manufacturing sector, with numerous world-renowned automobile companies opening (or reopening) car manufacturing factories or increasing their production capacity in Indonesia as Southeast Asia's largest economy. The automotive industry is one of the nation's major industries, contributing significantly to the national economy.

Country	2018	2019	2020
Thailand	881.832	799.632	768.788
Indonesia	1.208.019	1.013.291	1.061.735
Malaysia	666.465	666.674	580.124
Philippines	234.747	288.609	359.572
Vietnamese	133.588	209.267	270.820
Singapore	47.443	78.609	110.455
Brunei Darussalam	18.114	14.406	13.248
Total ASEAN	3.190.208	3.070.488	3.164.742

Table 1: Car Sales in ASEAN
Source: ASEAN Automotive Federation 2020

The challenges that exist in PT. XYZ are heavily impacted by the delay of existing goods, as shown in the table below. This results in a potential failure of delivery to the customer. At PT XYZ, the number of delays due to delayed import of goods, engine damage, missing stock, and other factors is causing significant disruption in meeting customer needs.

No	Type of Problem	Division	Result	Occurrence Data
1	Raw materials for paper	Production	3-6 days delay	Every 2 months
2	Delayed import of goods	Marketing	2-3 weeks delay	Once a month
3	Missing stock	Marketing	1-2 weeks delay and risk of losing customer	Every 2 weeks
4	Engine damage	Production	4-8 days delay	Once a month
5	Messy inventory	Gudang	dead stock and lost items	Every 2 weeks

Table 2: The main problem that occurs at PT. XYZ
Source: PT XYZ data in 2021

Based on ABC analysis grouping, the population of spare parts at PT. XYZ's warehouse is as follows:

Category	Percentage
Class A	18%
Class B	27%
Class C	43%
Slow Moving	13%

Table 3: PT. XYZ spare parts category
Source: PT XYZ in 2021

Based on the available initial data, the implementation of inventory management is regarded as significant and crucial at PT XYZ to overcome these problems. As a result, the ABC analysis approach will be utilized as the population and sampling basis.

A. *The Purpose of Research*

In accordance with the formulation of the research problem, the purpose of this research is to determine what factors influence the use of FMEA in inventory management at PT. XYZ. Secondly, to observe how the implementation of FMEA in inventory management at PT. XYZ is going, and to determine what changes need to be made in terms of FMEA to inventory management at PT. XYZ.

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II. LITERATURE REVIEW

A. FMEA

According to Nurkertamanda, Denny, and Wulandari, F.T. (2009), FMEA is a method in engineering that is used to identify, prioritize, and reduce problems in systems, designs, or processes before they develop. The Failure Mode and Effects Analysis (FMEA) method is intended to detect possible failure modes in a product or process before they occur, analyze the risks associated with these failure modes, and identify and implement corrective actions to solve the most significant problems. This method analyses system planning from the standpoint of production process reliability.

According to Wawolumaja, R., and Muis, R. (2013), the concept of FMEA can be summarized as follows: Failure is a prediction of the possibility of failing or defect, Mode is the identification of the failure mode, Effect is the identification of each component's effect on failure, and Analysis is a corrective action based on the results of the cause analysis. FMEA (Failure Modes and Effects Analysis) is a method for identifying potential risks, determining the effects of work accident risks, and determining the actions to reduce these risks.

B. Inventory Management

Sutawijaya, A.H., Nawangsari, L.C., and Djamil, M. (2019) define inventory as everything, or organizational resources stocked in preparation to fulfill customer needs or for the company's internal use. Raw materials, work in progress products, finished products, final products, auxiliary materials, or other complimentary components that constitute the company's product output are all examples of these inventories. Inventory is vital for companies, particularly those engaged in manufacturing; this inventory might take the shape of raw materials, auxiliary materials, products that are still in process, finished products, or spare parts. The importance of this inventory comes from the fact that (1) there is uncertainty in demand, (2) there is uncertainty in supply from supplier y, and (3) there is uncertainty in grace period of order. The achievement of these goals, however, has ramifications for companies that face the costs or risks of inventory decisions.

C. ABC Analysis

According to Heizer, J., and Render, B. (2017), using the Pareto principle, ABC analysis classifies inventory into three groups depending on the volume of annual revenue: (1). Category A includes all the items with the highest Rupiah value, which account for 70% to 80% of total revenue volume and 15% of SKUs. (2). Category B includes items with a Rupiah volume of 15% to 25% per year and at least 30% of total SKUs, and (3). Although Category C accounts for only 5% of annual sales, it covers 55% of all SKUs.

Sutawijaya, A.H., Nawangsari, L.C., and Djamil, M. (2019) divide the company's inventory into three groups based on the amount of money spent each year. The Pareto principle, particularly the Critical Few and Trivial Many, is used in ABC analysis, where the company focuses its inventory policy on smaller groups of inventories but in big numbers. The annual value of money in this research is calculated by multiplying the annual demand for each group with the cost per unit. In this case, inventory is divided into three groups: (1) class A inventory, which has a high annual value of money, (2) class B inventory, which has a medium annual value of money; and (3) class C inventory, which has a low annual value of money.

D. Fishbone Diagram

The purpose of creating a fishbone diagram is to figure out what is causing the defects that are discovered during the process. Thus, the suitable solution to correct the defect may be determined afterwards. A fishbone diagram, often known as an Ishikawa diagram, is a way of determining the root of a problem or situation. This diagram is also known as a cause-and-effect diagram. This diagram is used to analyze and identify factors that have a substantial effect on defining the quality characteristics of work output to identify the root causes of a problem.

III. METHOD

The research’s population was warehouse stock data for the classification of all spare parts in PT. XYZ that were available in 2021, especially on sheeter machines. Slow-moving and fast-moving stocks, supporting products, and other commodities would be classified into four groups for spare parts classification. This research would track the in and out of spare parts, as well as warehouse stock and current stock. Spare parts with a high RPN value in certain months for a duration of one year were utilized as the research sample.

IV. RESULT

A. Diagram Fishbone

An analysis was carried out using a fishbone diagram to find out what factors influence the classification of spare parts. This tool is also known as an Ishikawa diagram or a cause-and-effect diagram. By classifying the causes, this fishbone diagram illustrates the connection between the effect (problem) and its probable causes. In this research, employees from several departments (cross function) were involved in the production of the fishbone diagram in the hopes of identifying a problem as a whole and coming up with a more comprehensive solution. The quality control, production, warehouse, and purchasing departments were all involved in this analysis.

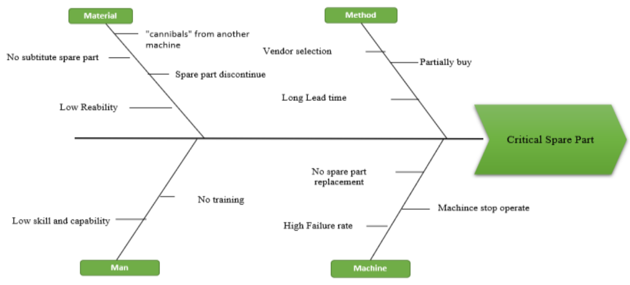

Fig. 1: Fishbone analysis diagram.
Source: data processed 2022

According to the fishbone diagram above, there are four factors that influence spare part classification and inventory management. The four factors are as follows:

- There is no substitute for the spare part.
- Purchasing spare parts requires a considerable lead time (long).
- The rate of machine failure is relatively high.
- Putting a total halt to the machine's operation.

B. FMEA Creation

A risk analysis was performed on all potentials that occur in a quantifiable manner and were translated into severity, occurrence, and detection when creating the FMEA.

No	Part Name	Local Code	Unit price	Forecast monthly consumption (by lifetime)	Monthly number of stock picks (by Usage)	Quantity in Stock	Valued flow	Running total of valued flow	Running total as % of total	ABC category	FMR Number	FMR category	ABC-FMR Category	ABC-FMR Recommendation (Stock or not)
1	1st DIE D7EA AB-D7EA-1D2 10P002	10P002	14,682,054	2	1	23	20,183,321	2.08%	28.8%	A	1	M	AM	Stock
2	CARBIDE TIP UZM3PTK2C1-T4 2P0025	2P0025	365,434	32	24	50	11,399,705	1.18%	39.8%	A	24	F	AF	Stock
3	ELECTRODE BAR C PM-00505-019-014 3P1202	3P1202	1,665,000	7	4	71	11,322,833	1.17%	41.0%	A	6	F	AF	Stock
4	INSERT PUNCH HOLDER PMR7A AB-PMR7A-3P2 10P502	10P502	1,565,860	5	1	82	6,838,578	0.71%	54.8%	A	3	M	AM	Stock
5	CARBIDE INSERTS UZM3PTK2B-0-T4 2P0016	2P0016	374,908	17	29	50	6,211,968	0.64%	56.1%	A	29	F	AF	Stock
6	C.F. REAMER C 7 HA AG-WR-613N30-5 2P1029	2P1029	1,242,582	5	6	44	5,806,942	0.60%	59.2%	A	10	F	AF	Stock
7	METAL SHELL PRESSER C PM-23207-040-002 3M2018	3M2018	682,449	4	0	8	2,821,426	0.29%	77.7%	A	0	R	AR	Not Stock
8	MANDREL B-S AG-SM-M03 2P5001	2P5001	11,440,884	0	0	10	2,736,006	0.28%	78.6%	A	1	R	AR	Not Stock
9	CARBIDE INSERTS UZM3PTS2N16-T3 2P0017	2P0017	156,670	16	5	240	2,525,904	0.26%	80.2%	B	5	F	BF	Stock
10	CAULKING COPE C PO-04106A-013A-CAA 5P2002	5P2002	1,244,125	2	1	9	1,997,053	0.21%	82.9%	B	3	M	BM	Stock
11	3rd PIERCER AB-BPR5EAL-3D5 10P430	10P430	1,073,370	2	1	34	1,634,080	0.17%	85.7%	B	3	M	BM	Stock
12	GUIDE 3BE PM-00506-036-3BE 3P1302	3P1302	455,314	3	0	11	1,589,266	0.16%	86.1%	B	1	R	BR	Not Stock

Table 4: PT. XYZ FMEA Analysis Results
Source: data processed 2022

All spare parts that should be stocked based on the FMEA method's calculation results.

C. ABC-FMR Analysis

The classification of spare parts will help warehouse inventory planning so that the company's inventory level is not too high and exceeds production needs, but also not too low and causes production machines to stop (healthy stock).

No	Spare Part Number	Failure Mode	Effect	Severity	Causes	Occurence	Prevention	Detection	RPN	Recommendation (Stock/Not)
1	1st DIE D7EA AB-D7EA-1D2 10P002	Pressure Indicator Error	Machine Stop	7	O-Ring leakage	7	Visual	7	343	Stock
2	CARBIDE TIP UZM3PTK2C1-T4 2P0025	Speed and Press Mat'L unstable	Machine Stop	7	Bearing broken	7	Visual	7	343	Stock
3	ELECTRODE BAR C PM-00505-019-014 3P1202	Mold Not Clamping	Machine Stop	7	O-Ring leakage	7	Visual Indicator Pressure Gauge	7	343	Stock
4	INSERT PUNCH HOLDER PMR7A AB-PMR7A-3P2 10P502	Oil leakage	Dirty	10	Piping leakage	7	Visual Check Once	4	280	Stock
5	CARBIDE INSERTS UZM3PTK2B-0-T4 2P0016	Mold Can Not Heat Up	Machine Stop	7	Heater disconnected	7	Visual Monitor	4	196	Stock
6	C.F. REAMER C 7 HA AG-WR-613N30-5 2P1029	Barrel not warm	Machine Stop	7	Heater disconnected	7	Visual Alarm	4	196	Stock
7	METAL SHELL PRESSER C PM-23207-040-002 3M2018	Nozzle difficult to release	No material out	7	Nozzle Unclean condition	7	Visual Check Once	4	196	Stock
8	MANDREL B-S AG-SM-M03 2P5001	Hydrolic not working	Machine Stop	7	Pompa error	7	Visual	4	196	Stock
9	CARBIDE INSERTS UZM3PTS2N16-T3 2P0017	Hard Sliding	Machine Stop	7	Roller broken	7	Visual	4	196	Stock
10	CAULKING COPE C PO-04106A-013A-CAA 5P2002	Machine Not On	Machine Stop	7	Fuse disconnected	7	Visual	4	196	Stock
11	3rd PIERCER AB-BPR5EAL-3D5 10P430	Off, Shut Down	Mesin Tidak Bisa Panas	7	Relay bur nout, Life Time, Electrical Short	4	Visual	7	196	Stock
12	GUIDE 3BE PM-00506-036-3BE 3P1302	Burn out	Machine Stop	7	Life Time , Electrical Short	4	Visual	7	196	Stock

Table 5: PT. XYZ ABC-FMR Analysis Results
Source: data processed 2022

Based on the results of the ABC-FMR analysis, 9 spare parts are recommended for stock, while the remaining 3 do not need to be stocked in the warehouse.

D. Final recommendation of spare parts

The next step was to determine which spare parts should be stocked in the warehouse using FMEA and ABC-FMR analysis. The condition applied was if the outcomes of the two analyses were similar. If one of the analysis results is different, there is no need to keep the spare parts stocked.

No	Nomor Spare Part	Rekomendasi FMEA (Stok/Tidak)	Rekomendasi ABC-FMR (Stock/Tidak)	Keputusan Akhir (Stok/Tidak)
1	1st DIE D7EA AB-D7EA-1D2 10P002	Stock	Stock	Stock
2	CARBIDE TIP UZM3PTK2C1-T4 2P0025	Stock	Stock	Stock
3	ELECTRODE BAR C PM-00505-019-014 3P1202	Stock	Stock	Stock
4	INSERT PUNCH HOLDER PMR7A AB-PMR7A-3P2 10P502	Stock	Stock	Stock
5	CARBIDE INSERTS UZM3PTK2B-0-T4 2P0016	Stock	Stock	Stock
6	C.F. REAMER C 7 HA AG-WR-613N30-5 2P1029	Stock	Stock	Stock
7	METAL SHELL PRESSER C PM-23207-040-002 3M2018	Stock	Not Stock	Not Stock
8	MANDREL B-S AG-SM-M03 2P5001	Stock	Stock	Stock
9	CARBIDE INSERTS UZM3PTS2N16-T3 2P0017	Stock	Stock	Stock
10	CAULKING COPE C PO-04106A-013A-CAA 5P2002	Stock	Stock	Stock
11	3rd PIERCER AB-BPR5EAL-3D5 10P430	Stock	Not Stock	Not Stock
12	GUIDE 3BE PM-00506-036-3BE 3P1302	Stock	Not Stock	Not Stock

Table 6: PT. XYZ Final Recommendation of Spare Parts
Source: data processed 2022

According to the data in the table above, only 9 of the 12 spare parts utilized as research material are recommended for warehouse inventory. The other 3 spare parts, on the other hand, do not require stocking. As a result, the percentage of items that must be in stock is 75%. As seen in the table below, the final inventory number is:

No	Part Name	Local Code	Weekly Demands (Units/Weeks)	Yield (Weeks)	PLT (Weeks)	Batch Size (Units)	CTI (Weeks)	CTI Stock (Units)	std dev	Service level	SS Stock (Units)	SS (Weeks)	PLT Stock (Units)	Kmax MAX KANBAN (Units)	Kmin MIN KANBAN (Units)	TRIGGER POINT (Units)	Max Value	Min Value	On Hand Value
1	1st DIE D7EA AB-D7EA-1D2 10P002	10P002	0	1	16	1	1	1	0.25	0.25	1	0	5	8	7	7	117,456,432	102,774,378	337,687,242
2	CARBIDE TIP UZM3PTK2C1-T4 2P0025	2P0025	8	1	16	1	0	1	0.25	0.25	1	8	125	127	126	126	46,410,083	46,044,649	18,271,686
3	ELECTRODE BAR C PM-00505-019-014 3P1202	3P1202	2	1	16	1	1	1	0.25	0.25	1	2	27	30	29	29	49,950,000	48,285,000	118,215,000
4	INSERT PUNCH HOLDER PMR7A AB-PMR7A-3P2 10P502	10P502	1	1	16	1	1	1	0.25	0.25	1	1	17	20	19	19	31,317,191	29,751,332	128,400,484
5	CARBIDE INSERTS UZM3PTK2B-0-T4 2P0016	2P0016	4	1	16	1	0	1	0.25	0.25	1	4	66	69	68	68	25,868,662	25,493,754	18,745,407
6	C.F. REAMER C 7 HA AG-WR-613N30-5 2P1029	2P1029	1	1	16	1	1	1	0.25	0.25	1	1	19	21	20	20	26,094,227	24,851,645	54,673,619
7	CARBIDE INSERTS UZM3PTS2N16-T3 2P0017	2P0017	4	1	16	1	0	1	0.25	0.25	1	4	64	67	66	66	10,496,882	10,340,192	37,600,699
8	CAULKING COPE C PO-04106A-013A-CAA 5P2002	5P2002	0	1	16	1	2	1	0.25	0.25	1	0	6	9	8	8	11,197,127	9,953,002	11,197,127
9	3rd PIERCER AB-BPR5EAL-3D5 10P430	10P430	0	1	16	1	3	1	0.25	0.25	1	0	6	9	8	8	9,660,329	8,586,959	36,494,576

Table 7: PT. XYZ Inventory Needs Calculation
Source: data processed 2022

According to the table above, the total inventory cost for the 9 spare components is IDR 761,285,841. However, if it is used in conjunction with the results of the replenishment inventory calculation, the number of spare parts that must be kept in stock in the warehouse can be minimized, lowering the inventory value automatically. Thus, the inventory value is between IDR 306,080,911 and IDR 328,450,913, with a minimum of IDR 306,080,911 and a maximum of IDR 328,450,913. As a result of implementing the replenishment pull system, IDR 432,834,927 was saved, representing a 56.86% decrease over the previous situation.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Based on the results of the preceding analysis, it can be inferred that there are four primary factors that influence the use of FMEA in inventory management: there are no substitutes for the spare parts, the lead time for acquiring spare parts is rather lengthy (or long), the machine failure rate is high, and there is a total halt to the machine's operation. The use of FMEA is very useful in determining essential spare parts and the amount that needs to be stocked to keep inventory management in good health (no shortage nor abundance). Monitoring the utilization of spare parts and performing regular inspections of the amount of inventory in the warehouse, as well as updating FMEA, are all improvements that must be made in relation to the implementation of FMEA in inventory management.

B. RECOMMENDATIONS

The combination of the FMEA method with inventory management systems is highly successful and has an impact on inventory calculations. It is hoped that further research would incorporate more methodologies and connect them to planned maintenance, which is one of the pillars of total productive maintenance (TPM).

For companies, FMEA can be used in the manufacturing sector to identify possible defects so that the number of defects can be minimized and production quality increased, which will lead to the increasing of customer satisfaction. The FMEA is a living document, which implies that companies must update their FMEA implementation whenever the process or materials utilized change, for the FMEA to be beneficial to the company.

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