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Inventory Policy for Cutting Tools with Maximum Allowable Lifespan to Minimize Total Inventory Cost using Tools Procurement Policy Algorithm

(Case Study: PT EFG Bandung)

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Abstract. Cutting tools inventory management is essential for manufacturing company, especially for Machining Department PT EFG in supporting the production process to run smoothly. If cutting tools are not available when production is going on, resulting in loss of production. On the other hand, having too many tools in the crib so that cutting tools are not being used and also incurs more monetary investment in tool inventory which is not acceptable either. High inventories of cutting tools that are not followed by a comparable number of tool requests caused overstock conditions at the tool crib. Effective cutting tools inventory management will be able to decrease total inventory cost of tools. Thus, this study constructs an inventory model which involves cutting tools used in the milling process and included in A items as many as 15 SKU with also involve distribution of lifespan in designing an optimal inventory policies for cutting tools using Tool Procurement Policy algorithm. Application of this policy on inventory systems able to generate a lower total cost inventory with an optimal order quantity and optimal lifespan. With inventory calculation parameter of Tools Procurement Policy algorithm, the total cost of inventory is able to be pressed by 78.22% lower than its current state.

Keywords: Cutting Tools Inventory Management, Tool Procurement Policy algorithm, Lifespan Distribution

1. INTRODUCTION

Inventory represent a detailed list of movable items in the form of raw material, in-process or finished products, which are needed in the manufacture of goods or to maintain the machinery and equipment in good working condition. It is an essential part of an organization (D. K. Singh *et al*. 2013).

In manufacturing company, inventory is a must, since it is impossible to predict the demand or supply of goods precisely because there is fluctuation in it. Inventory is used to absorb fluctuations which disturb the production schedule of the enterprise. By managing inventory, a company can be assured that the production will run smoothly. Besides that, inventory also used to comply service level to customers.

PT EFG is the first aircraft industry in Indonesia. The main business activities of this company is a manufacture, market, sell and distribute the products. Moreover, it also provides aircraft services, logistics support, and serve for the improvement of aircraft both domestically and abroad. In the production of aircraft components, PT EFG needs raw material, supporting component, machinery, etc. Inventory of those thing are very crucial, if stock of goods are not enough when needed, it will result in loss of production. On the other hand, if inventory of goods are too much, it will cause higher holding cost, which is also not permitted.

This research was being conducted in Machining Department which provides several components for manufacturing processes. Cutting tool is one of the most important supporting components in this department because production process can only be run effectively if cutting tools available with the right amount and at the right time. However, it was found excessive inventory of cutting tools which always occur in tool crib. The excess inventory of cutting tools during the period from March – December 2015 can be seen in Figure 1.

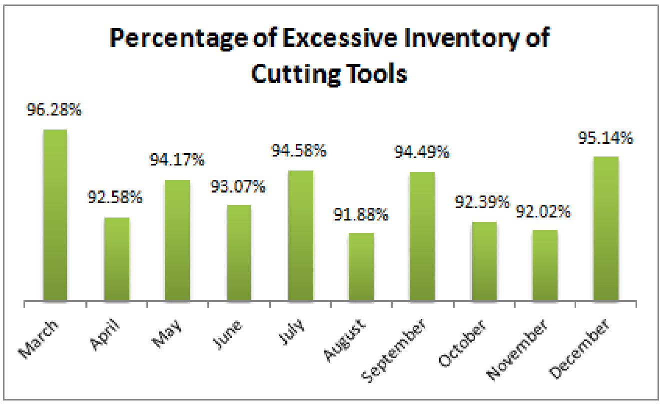

Figure 1: Percentage of excessive inventory of cutting tools

The excessive inventory in the crib reached more than 90 percent during period March to December 2015 as shown in Figure 1. The excessive inventory of cutting tools cause many items are not being used and incurs more monetary investment in tool inventory. The percentage of excessive inventory of cutting tools indicate the inventory policy of cutting tools is not conducted properly, both in terms of order size and the time of purchase the cutting tools.

Based on the observation, this issue can be caused by order planning of cutting tools have not been well planned yet. Actual conditions occurring in inventory management for cutting tools in PT EFG is currently using the models available on the company's ERP system, which is min-max system with best practice approach. Determination of the parameters is determined by planner experience. Order process of cutting tools will be made when inventory level reaches the lower limit (min level) with an order size form the differences between min and max level of inventories. However, this does not always happen. Sometimes before the inventory level reaches the reorder point, ordering new cutting tools has been done with the order size exceeds the value of min-max differences. As a result, inventory levels tend to be higher. Whereas, by ordering cutting tools with an optimal order size, it can decrease an inventory cost of cutting tools so the excess money can be used elsewhere for other useful purposes.

Hence, this research constructs an inventory model which involves cutting tools for milling process as many 15 SKU included in A items based on ABC Analysis to design Tool Procurement Policy (TPP) for storing optimal number of cutting tools. Since the lifespan of cutting tools has a significant impact on the whole quantity of procurement, it will also included in calculation to determine an optimal procurement policy for cutting tools lifespan distribution.

Application of this policy on inventory systems able to generate a lower total inventory cost. The calculation by using Tool Procurement Policy (TPP) was able to press the total inventory cost by determining the amount of order quantity, optimum allowable lifespan of cutting tools, and procurement cycle time.

2. CUTTING TOOLS MANAGEMENT

Inventory management for cutting tools in production, is an activities to ensure appropriate productivity, means on time available of tools and at the minimum cost. Appropriate cutting tool management, in financial terms, means decreasing the inventory cost for a certain period of time (G. Svinjarević *et al*. 2007). Replacement of cutting tool is important in manufacturing fields. If a tool is replaced too early, it can cause the cutting tools remaining unused or piling up in the crib and may increase ordering cost because the changes occur frequently. On the other hand, if a tool is replaced too late, the probability of tool failure might be increased (D. Ganeshwar Rao *et al*. 2011). In this proposed tool inventory model, considering on the maximum allowable lifespan of cutting tools in estimate the optimal order size and procurement cycle time.

2.1 Model Formulation

2.1.1 Assumptions

As the procurement issue of cutting tools is quite complex, for the purposes of this research, several assumptions are taken into account during the formulation of cost-minimization process. The following assumptions are necessary to model this research:

1. Involving cutting tools lifespan in determining ordered quantities.
2. A failure of a cutting tool causes potential damage of work piece, thus results in a penalty cost.
3. Tool vendor is located nearby resulting in negligible tool supplying time.
4. Consumption of tools per period is can be deemed as a deterministic inventory model.
5. Total working time in a period is fixed

2.1.2 Decision Variables

Q^* Optimal procurement quantity per cycle
T_m^* Optimal stopping time of tools (time-unit)
T_{cyc}^* Optimal procurement cycle time (time-unit)
TC^* Total inventory cost (in rupiah)

2.1.3 Parameters

T_u Average unit processing time per product
T Lifespan of cutting tools (time-unit)
Dp Demand rate of products (product/year)
C_f Fixed cost for every order (IDR/tool)
c_h Unit holding cost (IDR /tool)
c_p Unit penalty cost (IDR /tool)
c_u Unit penalty cost (IDR /tool)
$E(T)$ Expected lifespan (time-unit/tool)

2.1.4 Cost function components and intermediate variables

TC_{PC} Purchasing cost
TC_{PT} Expected total penalty cost
TC_i Expected annual holding cost
D_T Demand of tool required per year
T_w Total working time needed per year
TC Total cost

2.2 Lifespan of Cutting Tool

The lifespan of cutting tools is the time from the beginning of its first using to its blunt. According to Taylor's formula, several factor which affects lifespan are cutting speed (V), feed (f) and machining depth of cut (d). In this research, those factors are determined from the actual work piece processing. The lifespan of cutting tools related to three things, which are: procurement policy, penalty cost estimation, and demand of cutting tools.

2.2.1 Lifespan of Cutting Tool Related Procurement Policy

Procurement policy discuss about when the inventory for cutting tools be replenished, because, as mentioned before, replacement tool has its own importance in the manufacturing field. If a tool is replaced too early, it can cause the cutting tools remaining unused or piling up in the crib and may increase ordering cost because the changes occur frequently. On the other hand, if a tool is replaced too late, the probability of tool failure might be increased (D. Ganeshwar Rao *et al*. 2011). Furthermore, procurement policy also talks about how many should be ordered when the inventory for cutting tools is replenished. Since lifespan of cutting tools is taken into consideration, procurement policy also talks about how long the optimum lifespan for cutting tools in the resulting minimum cost.

2.2.2 Lifespan Dependent Penalty Cost Estimation

Penalty cost defined as costs to be incurred if the cutting tool is broken or fails before its maximum allowable usage time T_m. As explained in previous research about cutting tools inventory management (Bhaba R. Sarker *et al*. 2014), cutting tools have an expected lifespan, $E(T)$, around its mean value which is depicted in Figure 2. Hence, because the total working time per year is fixed, longer working time for a cutting tool may reduce the quantity of cutting tools to be ordered so it will decrease holding cost and purchasing cost. However, prolonged usable time increase the risk of tool failure so it will results in increasing penalty cost. On the other hand, shortening of working time of cutting tools to avoid tool failure may decrease the failure loss, but a new tool is then needed to replace the one currently being used, and that will incur an extra tool cost. As a result, shorter usable time of T_m will potentially increase the holding cost and purchasing cost for higher order quantity, however, that will decrease the penalty cost.

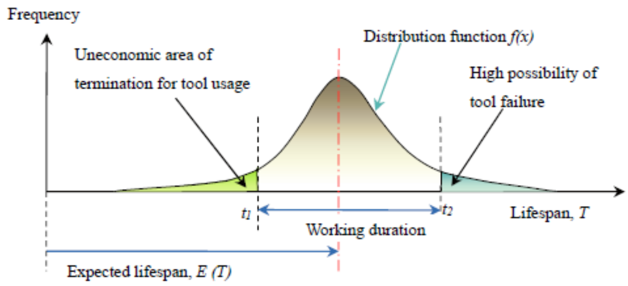

Figure 2: Different effects of possible cost depending on lifespan (Source: (Bhaba R. Sarker *et al*. 2014))

The maximum allowable usage time could be also termed as stopping time since the starting time of all tool lifespan is assumed to be zero. If T_m is the maximum allowable usage time for a cutting tool, then the expected lifespan for the tool populations can be divided into two groups: group A for cutting tools which has actual lifespan $0 \le T \le T_m$ and group B for tool which has lifespan $T_m < T \le \infty$. Penalty cost depends on the allowable maximum stopping time. As shown in Figure 3, tool fails in group A will result in penalty cost. The probability of fail before T_m is $F(T_m)$, which is the cumulative probability while the tool life $T \le T_m$. The expected penalty cost, *Cp*, can be calculated as,

$$C_p = c_p F(T_m) = c_p \int_{-\infty}^{T_m} f(T)dT \qquad (2)$$

2.2.3 Expected Lifespan Dependent Demand

In manufacturing process, total demand for product per year is approximately steady. A product has demand rate Dp (products/year) with average machining time per product T_u (hours/product). From this data, total manufacturing time for product in a year T_w can be computed as $T_w = T_u\,Dp$ hours/year. For an expected lifespan of a cutting tool, $E(T)$, the total demand of cutting tools, D_T (tools/year), can be expressed as $D_T = T_u Dp/E(T)$, where the tool lifespan T follows a normal distribution $f(t)$.

If a stopping policy is implemented, the upper bound in earlier distribution will changes from $-\infty \leq T \leq \infty$ to $-\infty \leq T \leq T_m$. For group A, with $T \leq T_m$, as shown in Figure 3, the expected lifespan of all tools in the range $T \leq T_m$ can be expressed as,

$$E(T)|_{T=T_m} = \int_{-\infty}^{T_m} T f(T)dT \qquad (3)$$

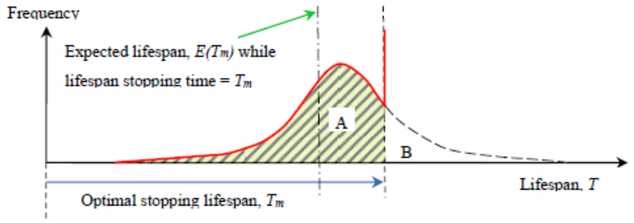

Figure 3: Depiction of expected lifespan and tool stopping time (Source: (Bhaba R. Sarker *et al*. 2014))

For group B in Figure 3, the lifespan of the tools exceeds the maximum allowable usage time $T > T_m$; thus the lifespan of all these tools are practically Tm. So, the expected lifespan for these tools in group B is defined as

$$E(T_m) = T_m \int_{T_m}^{\infty} f(T)dT = T_m[1 - F(T_m)] \qquad (4)$$

where $f(T)$ follows normal distribution.

Since the total population of the tools is comprised of two groups, *A* and *B* as explained above, each group of tools has different weighted usable expected lifespan as defined in equations (3) and (4), respectively. The term 'weighted' is to emphasize that the lifespan of a group is weighted by its population proportion and the word 'usable' indicates the actual or usable life length of a tool. Thus, the total expected lifespan of both groups as

$$E(T)_{A+B} = E(T)|_{T=T_m} + T_m[1 - F(T_m)] \qquad (5)$$

From equation (3) and (4), the total demand per can be calculated as

$$D_T = \frac{T_u D_p}{E(T)|_{T=T_m} + T_m[1-F(T_m)]} \qquad (6)$$

2.3 TPP Model Construction for Cutting Tool

The objective of TPP model is to determine an optimal procurement quantity of machining tools per cycle and an optimal stopping time of machining tools to obtain the minimum total inventory costs during the planning horizon. The total cost for a purchasing cycle, TC_c can be expressed as:

$$TC_c = C_f + TC_I + TC_{PC} + TC_{PT} \qquad (7)$$

a) Replenishment ordering cost, C_f
The replenishment ordering cost of cutting tools is the cost incurred for each ordering process.

b) Holding cost, TC_I
The average inventory holding cost is a geometry-based value obtained as $\bar{I} = T_c Q/2 = Q^2/(2D_T)$ thus, the holding inventory cost (TC_I) in one cycle can be calculated as

$$TC_I = c_h \bar{I} = \frac{c_h Q^2}{2D_T} \qquad (8)$$

c) Purchasing cost, TC_{PC}
The purchasing cost of cutting tools per each purchasing process is the multiplication between the order size with the price per unit of cutting tools. The purchasing cost can be expressed as,

$$TC_{PC} = c_u Q \qquad (9)$$

d) Penalty cost, TC_{PT}
Penalty cost depends on the maximum allowable stopping time T_m. As shown in Figure 4, the tool fails in group A will result in penalty cost. The probability of cutting tool fails before its maximum allowable stopping time is $F(T_m)$, which is the cumulative probability while the tool life $T \leq T_m$. Total penalty cost for tool failure TC_{PT} per cycle can be obtained as

$$TC_{PT} = Qc_p F(T_m) \qquad (10)$$

Therefore, collecting all these segmental cost, we can express the total cost per cycle, TC_c, as

$$TC_c = C_f + \frac{c_h Q^2}{2D_T} + c_u Q + Qc_p F(T_m) \qquad (11)$$

Therefore, the average annual cost, TC, for D_T/Q cycles per year is obtained as

$$TC(Q, T_m) = \frac{C_f D_T}{Q} + \frac{c_h Q}{2} + c_u D_T + D_T c_p F(T_m) \qquad (12)$$

Combined with equation (6), equation (12) can be rewritten as

$$TC(Q, T_m) = \frac{\frac{C_f T_u D_p}{Q} + [c_u + c_p F(T_m)]T_u D_p}{E(T)|_{T=T_m} + T_m[1-F(T_m)]} + \frac{c_h Q}{2} \qquad (13)$$

3. Numerical Analysis

3.1 ABC Analysis

Machining Department provides 91 types of cutting tools to support production processes at PT EFG. Each type of cutting tools has a different amount of usage on each month and also have different price for each type of cutting tools.

In order to make the control easier, Machining Department classify cutting tools based on the investment value of each cutting tools, this categorization method is called ABC analysis. ABC analysis divides cutting tools into three parts, which are A, B, and C items. According to (Edward A. Silver *et al*. 1998), it stated that A items contributed 80 percent of investment were given by 20 percent of the total number of cutting tools; B items comprise roughly 30 percent of the cutting tools, but represent 15 percent of the investment; and C items comprise roughly 50 percent of the cutting tools, but represent only 5 percent of the investment.

Table 1: ABC Analysis

Category	Total Investment	% of Investment	Number of Item
A	€ 317,761.10	79.50%	15
B	€ 61,288.81	15.33%	27
C	€ 20,655.81	5.17%	49
Total	€ 399,705.72	100%	91

Table 1 shows the classification results using the ABC analysis for all types of cutting tools located in the Tool Crib Machining Department. Based on Table 1 can be seen that A items make up 15 types of cutting tools, but represent 79.5 percent of investment. While B items comprise 27 types of cutting tools, but represent 15.33 percent of investment. The highest number of cutting tools is involved in C items, which make up 49 types of cutting tools, but only represent 5.17 percent of investment.

3.2 Algorithm for TPP

Development of a model algorithm for TPP was conducted to accommodate the actual conditions in the system but has not been implemented by the company, which is the development of inventory model which consider the cutting tools lifespan distribution. The tool lifespan have a great impact on procurement policy in determining procurement cycle time, optimal order quantity per cycle, and optimal usage time of cutting tools. The following solution procedure for determining the optimal order quantity and procurement policy (Bhaba R. Sarker *et al*. 2014).

Step 1: Initiative values of parameters T_u, D_p, C_f, c_u, c_p, and c_h and distribution of lifespan for T is obtained from the company's data described in the data collection. However, data lifespan of cutting tools is then needed to get the value of mean and standard deviation.

Given:

Mean (μ)	=	3.55	hours
Standard deviation (σ)	=	1.62	
Replenishment cost (C_f)	=	1642.3	per order
Unit penalty cost (c_p)	=	1068629.5	per tool
Unit holding cost (c_h)	=	946.99	per tool
Unit purchasing cost (c_u)	=	98.37	per tool
Average unit processing time per product (T_u)	=	9.99	hours
Demand rate (D_p)	=	122	products

In determine the boundaries of T and Q, carried out by trying some values. In the first trial, put the value of T begin with the number 2, then plus one so that T values are 2, 3, 4, 5, and 6. While for the value of Q, start from the number 20 to 60. It has different value for each cutting tools, based on its parameters.

Step 2: In initialize objective value TC^*, Q^* and T^*, calculation of optimal order quantity using Economic Order Quantity is used. For example,

Given,

C_f = Rp1,642.271062 per order

$D_T = T_u D_p / E(T)$ = 291 tools

c_h = Rp 946.99 per tool

Then,

$$Q^* = \sqrt{\frac{2\, C_f D_T}{c_h}} = \sqrt{\frac{2\,(Rp\ 1{,}642.271062)(291)}{Rp\ 946.99}} = 32 \text{ tools}$$

From the calculation results, it can be known that the optimal order quantity is around 31.769 tools. So, this results is then used to find the optimal procurement quantity and stopping time using algorithm for TPP.

Step 3: Data lifespan of cutting tools follows normal distribution, so cumulative distribution probability $F(T)$ can be computed by using equation (15). For example, T_m= 4 hours, μ_T= 3.549 hours, σ= 1.62. So, $F(T_m)$ = 0.60939. If the calculation process is done by using Microsoft Excel, it can be easily computed by input this formula: =NORMDIST(x, mean, standard deviation, cumulative), x is the value of T, mean and standard deviation is the same value with step 1, while cumulative is a logical value that determines the form of the functions. If cumulative is true, input value 1, it means NORMDIST returns the cumulative distribution function (area under the curve). And if false, input value 0, it returns the probability mass function.

The value of cumulative distribution function, $F(T)$, have been obtained. Furthermore calculate expected lifespan, $E(T)$, using equation (3), for example, $E(T)|_{T=4} =$

$\int_{-\infty}^{4} Tf(T)dT$ = 2.62608 hours. For expected lifespan for cutting tools in area B, using equation (4), $4[1 - F(4)]$ = 1.456241 hours. Thus, total expected lifespan $E(T)_{A+B}$ = 4.18849 hours.

Table 2: Cumulative Distribution Function and Expected Lifespan

T_m	2	3	4	5	6
$F(T_m)$	0.16983	0.36747	0.60939	0.81434	0.93451
$E(T)$	1.69712	2.001	2.62608	2.83927	3.31848
$T_m[1-F(T_m)]$	1.66033	1.89756	1.56241	0.92826	0.39288
$E(T)$ *total*	3.35745	3.89856	4.18849	3.76753	3.71137

Step 4: By using value of parameters in step 1, calculate inventory total cost, for example,

$$TC(32,4) = \frac{\frac{c_f T_u D_p}{32} + [c_u + c_p F(4)]T_u D_p}{E(T)|_{T=4} + 4[1 - F(4)]} + \frac{32c_h}{2}$$

Table 3: Computational result of total cost for normally distributed lifespan

Order Size (Q)	Lifespan Tm (Hours)				
	2	3	4	5	6
20	1359067825.95	1236466525.97	1226108547.88	1433961879.44	1497833889.05
30	1359062624.37	1236462703.56	1226105317.81	1433957759.40	1497829635.02
32	1359062329.30	1236462580.89	1226105269.17	1433957599.52	1497829458.39
40	1359062391.06	1236463159.84	1226106070.25	1433958066.86	1497829875.49
50	1359064145.06	1236465327.58	1226108415.70	1433960145.32	1497831913.74
60	1359066892.70	1236468351.06	1226111557.65	1433963109.27	1497834850.90

When T follows normal distribution, the computational results by running the programmed algorithm for TPP are shown in Table 3.

Step 5: Repeat Steps 3 and 4 until both upper boundaries are reached. If both upper boundaries are reached, for procurement order quantity and stopping time, the optimal total inventory cost is then obtained from intersection of both variables.

Step 6: Based on computational results shown in Table 3 the approximate optimal results are:

1. Optimal procurement order quantity, 32 tools per order
2. Optimal stopping time of tools is 4 hours
3. Minimum total cost, is IDR 1,226,105,269.17
4. Optimal procurement cycle time, T_{cyc}^* = 41 days

4. Discussion

The development of inventory model TPP algorithm based on research that have been done by Bhaba R. Sarker *et al.* (2014), this policy effectively applied to cutting tools which have a maximum allowable lifespan, thus, in determining an optimal order quantity and procurement cycle time, necessary to consider the lifespan distribution of cutting tools (Bhaba R. Sarker *et al*. 2014). Besides that, based on common assumptions about demand patterns and costs, TPP algorithm can generate a lower total cost of inventory than the company's current policy. Result of the adoption algorithm for TPP in the inventory management system of cutting tools in Machining Department PT EFG able to decrease total cost of inventory at IDR 37,393,317,759.53 or its about 78.22 percent within a horizon planning. The comparison of total inventory cost between current and proposed state can be seen in Figure 4.

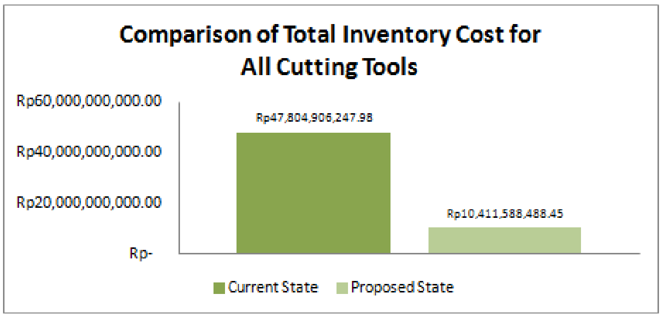

Figure 4: Comparison of Total Inventory Cost between Current and Proposed State

4.1 Comparison of Inventory Cost Component

Total cost includes all cost components, which is replenishment cost, holding cost, purchasing cost, and penalty cost.

1) Replenishment ordering cost

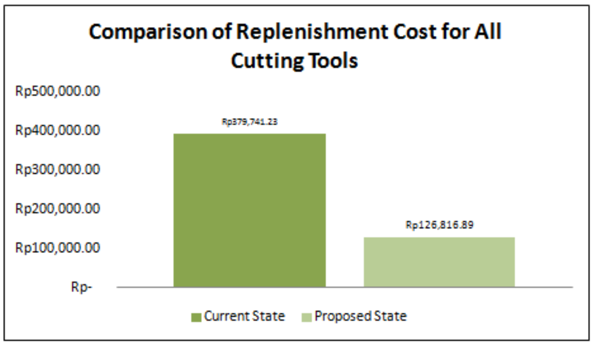

Figure 5: Comparison of Replenishment Order Cost between Current and Proposed State

In detail, Figure 5 shows that the implementation of TPP algorithm able to decrease procurement order cost about 67.69 percent from IDR379,741.23 become IDR 126,816.89. This leads to a reduction in total inventory cost to be incurred by the company in procuring a number of cutting tools required for production process.

The main factors affecting decrease or increase in the cost of storage on each cutting tools is a change in a parameter procurement order quantity (Q) and demand of cutting tools (D_T), because those two parameters indicates how frequently the procurement order process is made.

2) Holding cost

The total holding cost for all types of cutting tools decreased after implementation of algorithm for TPP as shown in Figure 6.

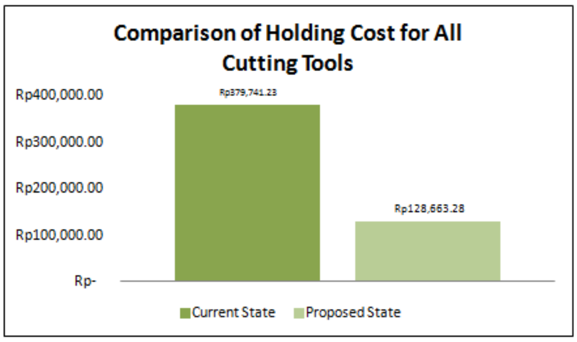

Figure 6: Comparison of Holding Cost between Current and Proposed State

Total holding cost of proposed model is IDR 128,663.28 while total holding cost of actual condition is IDR 379,741.23. There is 66.12 percent decreasing on total holding cost. The main factors affecting decrease or increase in the holding cost for each cutting tools is a change in a parameter procurement order quantity (Q).

3) Purchasing cost

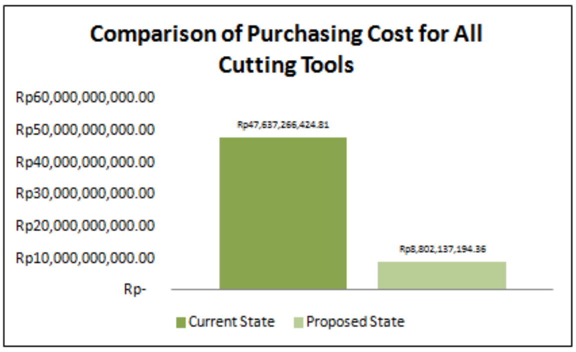

Figure 7: Comparison of Purchasing Cost between Current and Proposed State

Figure 7 shows the comparison between purchasing cost in current state and proposed state for all types of cutting tools. Total purchasing cost of proposed model is IDR8,802,137,194.36 while total purchasing cost of actual condition is IDR47,637,266,424.81. There is 81.52 percent improvement on purchasing cost. This is happened because the demand of cutting tools in current state are always more than the demand of tools in proposed state.

4) Penalty cost

Figure 8 shows the comparison between penalty cost in current state and proposed state for all types of cutting tools. Total penalty cost of proposed model is IDR1,609,195,813.93 while total penalty cost of actual condition is IDR7,611,827,535.30. There is 78.86 percent improvement on total penalty cost.

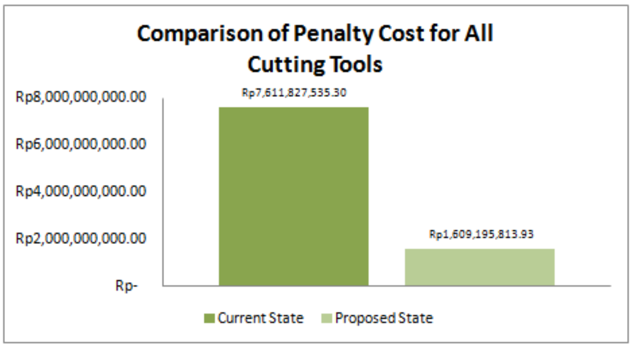

Figure 8: Comparison of Penalty Cost between Current and Proposed State

Penalty cost per cycle in equation (10), will be multiplied by D_T/Q to get the total penalty cost for one year. So from the total penalty cost in a year, $TC_{PT} = D_T c_p F(T_m)$, it can be concluded that the decreasing on penalty cost in proposed state is because the total demand of cutting tools in current state are always higher than the demand of cutting tools in proposed state.

4.2 Sensitivity Analysis

In this section, penalty cost (c_p) and holding cost (c_h) are analyzed for their impact on T^*, Q^*, T^*_{cyc}, and TC^*. It shows an example of the sensitivity analysis process for both penalty cost and holding cost by using data cutting tools Slot Drill Short-Carb for AL-K10 with cutter dimension 25X45X121-2F.

4.2.1 Sensitivity Analysis of Penalty Cost

The unit penalty cost is penalty amount if a machining tool fails usually along with the work piece damaged or broken. A sensitivity analysis of the penalty cost is conducted by decreasing and increasing penalty costs to certain range until its impact on the other variables can be seen. Sensitivity comparison of T according to different value of penalty cost and its influence to T^*_{cyc}, TC^*, T^*, and Q^* can be seen in Table 4. The unit penalty cost has an impact on T^*_{cyc}, and TC^* when the optimal value of T^* and Q^* are decided. Table 4 shows the penalty cost c_p has an impact on the total cost, TC^*, changes in costs or sensitivity itself shown in the increase in penalty cost by 20%.

Table 4 Sensitivity comparison of T according to different value of c_p

	Unit penalty cost, c_p	T_m^* (Hours)	Q^* (Tools)	TC^* (Rp)	T_{cyc}^* (Days)
Decrease 30%	Rp 748,040.66	4	32	Rp 1,169,776,325.09	41
Decrease 25%	Rp 801,472.13	4	32	Rp 1,179,255,786.54	41
Decrease 20%	Rp 854,903.61	4	32	Rp 1,188,735,247.99	41
Decrease 15%	Rp 908,335.09	4	32	Rp 1,198,214,709.44	41
Decrease 10%	Rp 961,766.56	4	32	Rp 1,207,694,170.89	41
Decrease 5%	Rp 1,015,198.04	4	32	Rp 1,217,173,632.35	41
Increase 5%	Rp 112,060.99	4	32	Rp 1,236,132,555.25	41
Increase 10%	Rp 1,175,492.46	4	32	Rp 1,245,612,016.70	41
Increase 15%	Rp 1,228,923.94	4	32	Rp 1,255,091,478.15	41
Increase 20%	Rp 1,282,355.42	2.916	33	Rp 1,261,075,331.10	39
Increase 25%	Rp 1,335,786.89	2.916	33	Rp 1,266,927,409.55	39
Increase 30%	Rp 1,389,218.37	2.916	33	Rp 1,272,779,488.00	39
Increased 100%	Rp 2,137,259.02	2.5	34	Rp 1,353,049,306.27	38

The mainly influences the adoption of decision variables T_m^*. On the contrary, if value of T_m^* and Q^* are not decided to be the optimal value, total cost TC^* fluctuates dramatically with the fluctuation of c_p. However, there is little influence on the time of ordering cycle.

4.2.2 Sensitivity Analysis of Holding Cost

Sensitivity analysis of the holding cost is conducted by decreasing and increasing penalty costs to certain range, in this case, the range is between 5 and 30 percent. Sensitivity comparison of T according to different value of holding cost and its impact to T_{cyc}^*, TC^*, T^*, and Q^* can be seen in Table 5.

Table 5 Sensitivity comparison of T according to different value of c_h

	Unit holding cost, c_h	T_m^* (Hours)	Q^* (Tools)	TC^* (Rp)	T_{cyc}^* (Days)
Decrease 30%	Rp 662.89	4	38	Rp 1,226,648,177.93	48
Decrease 25%	Rp 710.24	4	37	Rp 1,226,649,062.50	47
Decrease 20%	Rp 757.59	4	36	Rp 1,226,649,918.62	46
Decrease 15%	Rp 804.94	4	34	Rp 1,226,650,747.20	43
Decrease 10%	Rp 852.29	4	33	Rp 1,226,651,552.12	42
Decrease 5%	Rp 899.64	4	33	Rp 1,226,652,333.39	42
Increase 5%	Rp 994.34	4	31	Rp 1,226,654,836.31	39
Increase 10%	Rp 1,041.69	4	30	Rp 1,226,654,563.49	38
Increase 15%	Rp 1,089.04	4	30	Rp 1,226,655,273.73	38
Increase 20%	Rp 1,136.39	4	29	Rp 1,226,655,965.34	37
Increase 25%	Rp 1,183.74	4	28	Rp 1,226,656,648.85	36
Increase 30%	Rp 1,231.09	4	28	Rp 1,226,657,311.74	36
Increased 100%	Rp 1,893.98	4	22	Rp 1,226,665,567.26	28

The unit holding cost (c_h) has impact on the total cost TC whenever there is inventory of tools in stock. Table 5shows fluctuation of the unit holding cost (c_h) resulting in the change of T^*, Q^*, T_{cyc}^*, and TC^*. The smaller for unit holding cost, the bigger for order size, and this can minimize the total cost TC^*. Compare with the decrease of unit holding cost, increasing unit holding cost incures bigger order size and results in raising of TC^*. The change of c_h also has significant impact on the time of ordering cycle along with the change of Q^*.

5. Conclusion

This paper studies the inventory policy problem, especially for cutting tool inventory management system in Machining Department PT EFG, which is an overstock condition in tool crib so it cause high total inventory cost. Problems concerning inventory management for cutting tools can be solved by using algorithm for Tool Procurement Policy (TPP) which can control the accurate procurement of cutting tools. Proposed model algorithm for TPP, is a inventory model which considers cutting tool lifespan to design an economic tool crib policy for storing optimal number of tools because lifespan have a great impact on procurement policy.

Calculation results of total inventory cost using TPP algorithm showed that there is a decreasing in the cost of 78.22 percent from IDR47,804,906,247.98 become IDR 10,411,588,488.45.

The impact of decision variable to total inventory cost is the higher quantity of tools should be ordered, the higher total inventory cost incurred. However, there is an optimal value which intersection between order quantity and lifespan of cutting tools that represent an optimal inventory cost should be paid by the firm. The increasing of order quantity resulting longer procurement cycle time.

For further study, research dealing with an uncertainty demand of product that will alter total working time of tools needs to be explored. Besides that, considering machining time per unit for several product. Study different cutting tools lifespan distribution also an interested topic, whether uniformly distributed lifespan or other distribution.

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