Inventory policy for relining roll spare parts to minimize total cost of inventory with periodic review (R,s,Q) and periodic review (R,S) (Case study: PT. Z)

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Abstract. PT. Z is a company that focus on steel industry in Indonesia. This company produces steel plates and coil. Relining roll is one kind of spare parts. The function is to reduce thickness of steel. Relining roll used in almost of machines in cold rolling mill. However, there is a problem in supply of spare parts called overstock in January-December 2017. The effect of overstock is high cost on holding inventory. The result of ABC analysis, there are seven spare parts with A category which are four spare parts with slow moving demand, two spare parts with erratic demand, and one spare parts with lumpy demand. Spare parts with slow and erratic demand use periodic review (R,s,Q) policy and spare parts with lumpy demand use periodic review (R,S) policy. The result of calculation of using periodic review in proposed condition is 99,98%. And the result of calculation of total cost inventory using periodic review (R,s,Q) and periodic review (R,S) is Rp 3.019.768 or 90,31% lower than actual condition.

1. Introduction
The steel industry in Indonesia is growing rapidly which is marked by the increasing demand of steel. The fact is demand of steel in 2017 reached 14 million tons, but the domestic steel industry only can produce 8 million ton. PT. Z is a company that focus on steel industry in Indonesia. The company has eleven machines and the output are steel plate and coil. Relining roll is one kind of spare parts that exist in almost all machines at the factory. The function is to reduce thickness of steel. There are 28 SKU of relining roll spare parts.
Based on Figure 1, it is known that the inventory of relining roll spare parts exceeds demand. The average inventory rate is 49.23% more than total demand every month in 2017. It can be an indication that the inventory is overstock.

Based on Figure 2, it is known that most of relining roll exceed the maximum level of inventory that applied by the company. It can be concluded that there is a problem with inventory of relining roll called overstock.
Figure 3. Comparison of Holding Cost to Total Cost of Inventory in 2017

Based on Figure 3, it shows that 80.75% total cost of inventory is holding cost. This is caused by a lot of inventory so the amount of holding cost is high. Thus, the objective in this research is to determine inventory policy for relining roll spare parts so that can minimize total cost of inventory.

2. Literature Review

2.1 Inventory

Inventory consist of all materials that are stored and will be used in the future by a company. Inventories are classified into five types, there are raw material, work in progress, finished goods, spare parts, and consumable [1].

2.2 Total Cost of Inventory

Total cost of inventory is all expenses and losses incurred because of an inventory for certain period. The components of total cost of inventory include ordering cost, holding cost, shortage cost, and systemic cost [2].

\[
\text{Total cost of inventory} = \frac{AD}{Q} + \left(\frac{Q}{2} + k\sigma_{R+L}\right)r + c_{\sigma_{R+L}G_u(k)D} \quad (1)
\]

\[
\text{Service Level} = 1 - \left(\frac{\sigma_{R+L}G_u(k)}{\mu}\right) \times 100\% \quad (2)
\]

2.3 ABC Analysis

The purpose of ABC analysis is to determine the importance of items and thus allowing different levels of control based on the relative importance of items [3].

2.4 ADI-CV Analysis

Average Demand Interval and Coefficient of Variance (ADI-CV) are used to classify demand pattern of spare parts based on the interval between demand and the diversity of demand size [4]. With N is the number of positive demand periods, \( \mu \) is average demand and \( \sigma \) is standard deviation.

\[
ADI = \frac{\sum_{i=1}^{N} t_i}{N} \quad (3)
\]

\[
CV = \frac{\sigma}{\mu} \quad (4)
\]
ADI = 1.32

| Erratic | Lumpy |
|---------|-------|
| Slow   | Intermittent |

**Figure 4.** Classification of ADI-CV

### 2.5 Periodic Review (R,s,Q)

In the system (R,s,Q), the inventory level will be review every interval period (R) and if inventory level is lower than reorder point (s) then the order will be occur with specific order quantity (Q) so the inventory level passes through the reorder point. With demand (D), ordering cost (A), holding cost (h), shortage cost (c), and expected demand over lead time and review interval (μ), so the model periodic review (R,s,Q) [5]:

\[
Q_0 = \sqrt{\frac{2DA}{r}} \tag{5}
\]

\[
P(s) = \frac{qr}{c_sD} \tag{6}
\]

\[
μ = D(R + L) \tag{7}
\]

\[
n(s) = μP(s) - sP(s + 1) \tag{8}
\]

Next step is find new Q with:

\[
Q_1 = \sqrt{\frac{2D(A + c_s n(s))}{r}} \tag{9}
\]

Then recalculate P(s) and n(s) with new Q. If the value of R is still consistent, then the calculation is completed with the last value of s and Q.

### 2.6 Periodic Review (R,S)

In the system (R,S), the inventory level will be review every interval period (R) and if inventory level is lower than order up to level (S) then replenishment order is placed to raise inventory position to the maximum level inventory (S). Periodic Review (R,S) can compress the overstock because it does not determine the specific reorder point [6]. If the value of μ is lower than 20 then the standard deviation equal to square root of mean [7]. With expected demand (\(\bar{x}_{R+L}\)) and standard deviation (\(σ_{R+L}\)) over lead time and review interval, so the model periodic review (R,S) [8]:

\[
P_u > (k) = \frac{qr}{dc_s} \tag{10}
\]

\[
\bar{x}_{R+L} = D(R + L) \tag{11}
\]

\[
S = \bar{x}_{R+L} + kσ_{R+L} \tag{12}
\]

### 2.7 Sensitivity Analysis

Sensitivity analysis can be used to measure amount of tolerable change from the optimum solution [9]. If the optimal solution changes due to parameter changes, then it can be said that the parameter is sensitive [10].
3. Result and Analysis

3.1 ABC Analysis
ABC analysis is used to assist in grouping of parts so that each category group has different treatment according to the criteria of the category of spare parts category. Here is the result of ABC analysis.

| Table 1. Result of ABC Analysis |
|---------------------------------|
| Category | Amount | Percentage of Total Cost Inventory |
|----------|--------|-----------------------------------|
| A        | 7      | 81.23%                            |
| B        | 7      | 14.15%                            |
| C        | 14     | 4.62%                             |
| Total    | 28     | 100%                              |

Spare parts with A category or seven SKU spent 81.23% of the total cost of inventory relining roll on PT. Z. This causes A category spare parts to be more closely watched in their inventory control compared to categories B or C. Therefore, this study is conducted only for spare parts with category A.

3.2 ADI-CV Analysis
Based on the calculation of ADI and CV2 values for all rolling relining spare parts, the following results are obtained:

| Table 2. Result of ADI-CV Analysis |
|-----------------------------------|
| Category   | Amount | Percentage |
| Slow Moving | 9      | 32.14%     |
| Intermittent| 0      | 0.00%      |
| Erratic     | 7      | 25.00%     |
| Lumpy       | 12     | 42.86%     |
| Total       | 28     | 100%       |

Total amount of relining roll in this study is 28 SKU. Periodic review (R, s, Q) is used for spare parts with slow moving and erratic demand whereas periodic review (R, S) is used for spare parts under the lumpy demand (Wang & Xia, 2015).

3.3 Periodic Review (R,s,Q)
With equation (5) to (9), here is the result of periodic review (R,s,Q).

| Table 3. Result of Periodic Review (R,s,Q) |
|------------------------------------------|
| No | Roll Name | R | s | Q  |
|----|------------|---|---|----|
| 1  | Separator  | 2 | 28| 33 |
| 2  | Wringer (S)| 2 | 12| 10 |
| 3  | Bridle 1   | 2 | 4 | 1  |
| 4  | Support    | 2 | 20| 19 |
| 5  | Wringer    | 2 | 30| 23 |
| 6  | Wringer EC2| 2 | 6 | 6  |

The optimal solution for Separator are 28 units as reorder point and order size Q is 33 unit with interval of review (R) every 2 weeks. If at review intervals once every two weeks the inventory position of the Separator is less than equal to 28 units, then there will be orders of 33 units or multiples so that it can exceed the reorder point.

3.4 Periodic Review (R,S)
With equation (10) and (11), here is the result of periodic review (R,S).
Table 4. Result of Periodic Review (R,S)

| No | Roll Name | R | S |
|----|-----------|---|---|
| 1  | Snubber 1 | 2 | 5 |

The optimal solution for Snubber 1 are 5 units as order up to level (S) with interval of review (R) every 2 weeks. If at review intervals once every two weeks the inventory position of the Snubber 1 is less than equal to 5 units, then replenishment order is placed to raise inventory position maximum level inventory.

3.5 Total Cost of Inventory

With equations (1) and (2), here is a comparison total cost of inventory in actual condition with proposed condition.

Figure 5. Comparison of Total Cost of Inventory In Actual and Proposed Condition

Figure 5 shows that proposed total cost of inventory is Rp 3,019,768 or 90.31% lower than actual condition. This is caused by the amount of inventory in the warehouse has decreased so that the holding cost is not generated at the time of actual condition. Based on the result of Permatasari’s research, with these two methods can even reduce total cost of inventory until 92%.

Here is a comparison of service level in actual conditions and proposed conditions.

| Table 5. Service Level |
|------------------------|
| Service Level          |
| Actual | Proposed |
| 100%   | 99.98%    |

Service level in proposed condition is 99.98%. Service level can be influenced by the number of shortage or stock out so that the incoming demand cannot be fulfilled.

3.6 Sensitivity Analysis

Ordering cost, holding cost, shortage cost, and demand will be used as parameters in sensitivity analysis.
Figure 6 shows that there is a fluctuation in total costs of inventory in case of changes in ordering cost, holding costs, shortage cost, and demand. If there is any change of ordering cost and holding costs, then the resulting pattern is linear, meaning the higher ordering cost or holding cost, the greater the total cost of inventory incurred. Although there are several changes in the shortage cost, it is not change total cost of inventory significantly. If the number of demand increased by 5% then the total cost of inventory will decrease because the maximum inventory amount for some SKUs increases, thus reducing the frequency of ordering. Therefore, ordering cost, holding cost, and number of demand are sensitive parameters while the shortage cost is a parameter that is not very sensitive to total cost of inventory.

4. Result and Analysis
Based on research on inventory control of relining roll spare parts, it can be concluded that:
1. Problems that occur at PT. Z is the high amount of inventory or overstock that causes the total cost of inventory to be very large. To solve the problems that occur in the company then used the periodic review policy.
2. Based on ABC analysis result, there are seven types of spare parts with A category including four spare parts having slow moving demand pattern, two spare parts have erratic demand pattern, and one spare part has lumpy demand pattern. The periodic review policy (R, s, Q) is used for erratic and slow-moving parts while the periodic review policy (R, S) is used for lumpy parts.
3. Periodic review (R, s, Q) and periodic review (R, S) resulted service level of 99.98%. Total inventory cost obtained is Rp 3,019,768 or 90.31% less than in actual condition.

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