Inventory Management Improvement at PT Inalum, Kuala Tanjung, Sumatra Utara

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ABSTRACT
This research aimed to analyze the inventory issue in PT Inalum. The method used in this research is a quantitative method to collect inventory historical data from January 2022 to December 2022 obtained from the company’s ERP SAP. The data contains information of 6028 items of the MRO inventory. The collected data was analyzed using Economic Order Quantity (EOQ), Reorder Point (ROP), Safety Stock (SS) and Average Inventory Level (AIL). By using Fixed Order Quantity model, the MRO inventory is calculated to compare the ideal and actual average inventory levels. From the analysis, the researcher found that the MRO inventory in Kuala Tanjung, PT Inalum, has a service level of 0.52, which is still far below the service level target of 0.95. At the same time, PT Inalum has the potential to reduce inventory by USD 5,402,389 or 58.2% of the inventory value. This research aims to provide guidance for the management of PT Inalum in making inventory policies that can increase service levels as well as minimize inventory costs.

Keywords: Average inventory level, Economic Order Quantity (EOQ), Inventory policy, Service level.

1. INTRODUCTION
PT Inalum has been operating for more than 40 years with an average aluminium production of 225,000 tons per year. To maintain the consistency of the annual production output, the availability and reliability of equipment is required to support aluminium production. To achieve this goal, PT Inalum implements a preventive maintenance strategy for maintenance activities. In order for preventive maintenance activities to run smoothly, the availability of spare parts is crucial. The division responsible for ensuring the availability of spare parts in the warehouse is the Commercial & Supply Chain Management (GCM), which includes the Logistics & Material Management (ILG) and Procurement & Category Management (IPM). However, the GCM has faced the same problem over the years in trying to meet the service level of spare parts availability in a timely manner according to the needs of the maintenance department.

As shown in Fig. 1, the average service level achieved by GCM is only 46.5% in the period 2018~2022, which is far below the management minimum target of 95%.

Besides the GCM has performed low performance of service levels in inventory management, the GCM also faces the problem of high stock value from year to year due to uncertainty of spare parts demand. This can be seen in Fig. 2, where the inventory value consistently increased from 2018 to 2020 until it exceeded USD 35 million. Although there has been a significant decrease in 2021 and 2022, this was caused by a management policy to force the maintenance team to consume spare part inventory immediately to prevent excessive inventory. These inventory value consist of about 18,000 SKU number.

Under the dynamic conditions of spare parts demand by maintenance users, it is difficult for companies to estimate how many spare parts will be needed in the future and when they will be consumed. The company needs to find the optimum stock level. Too much inventory can lead to overstocking, which disrupts the company’s financial liquidity because there are too many company assets in the form of MRO inventory, while too little inventory can lead to the possibility of parts stockouts, which can cause maintenance users to be unable to carry out maintenance planning on schedule. Therefore, determining ordering timing and quantities is essential for managing stock in inventory management. As mentioned earlier, an appropriate and efficient inventory policy is required to achieve the company’s service level target of 95% with the lowest possible inventory value. According to Samanta (2014),
inventories are stored items, waiting for storage or manufacturing experience. Inventory can be found across all economic sectors. Observing almost any company balance sheet shows that inventory accounts for a significant portion of its assets, including inventories of raw materials, components, and subassemblies in the manufacturing process and finished goods. Inventory can also be defined within a supply chain as all raw materials, processes, and finished goods. Inventory occurs in the supply chain due to the incompatibility between supply and demand. As a consequence, inventories are kept to reduce costs or increase the availability of goods (Chopra & Meindl, 2001). Therefore, inventory management is a very important function to determine the supply chain health of company. With inventory management, a company could maintain the optimum inventory to be able to meet its requirements and avoid understock and overstock conditions (Samanta, 2014). Inventory management of inventory control is a way to achieve two objectives at the same time. Management has to control the customer satisfaction towards the availability of goods at the time of purchase and they also should minimize the inventory costs due to inventory unstructured (Stevensos, 2002). A more in-depth analysis of inventory management is therefore required.

2. Materials and Methods

The first step is the literature review. Literature Review is a stage that aims to determine which theories should be used in this research. Theories related to the business issue raised by the author are those related to inventory management. Based on literature about inventory management (Jacobs et al., 2014), there are two general types of multiperiod inventory systems: fixed order quantity models (EOQ model) and fixed time period models (P model). Fixed order quantity models attempt to determine the specific point or Reorder Point (ROP) at which an order will be placed and the optimum size of that order, which is called Economic Order Quantity (EOQ). Meanwhile, the fixed time period model is only counted at particular times and is generated by order quantities that vary from period to period depending on usage rates. It is possible that some large demand will draw the stock down to zero after an order is placed. This condition could go unnoticed until the next review period. Generally, fixed time period requires a higher stock level and higher probability of stockout than fixed order quantity system. And the average inventory level will be known and what it means to the business issue are being discussed and finding a solution. After learning references from Jacobs et al. (2014), the researcher prefers Fixed order quantity model (EOQ-model) over the other models due to the following:

a) The fixed order quantity model can result in a lower average inventory level because this model uses EOQ system (minimizing inventory cost).

b) The fixed order quantity model is more appropriate for monitoring items that are more responsive to minimizing the probability of stockout because this model uses ROP system (increasing service level).

Also, reference from (Rizkya et al., 2018) that it has been known that the fixed order quantity model for the automotive industry inventory system can reduce total inventory cost by 53.89%, which is much higher than the fixed time period model only reduces total inventory cost by 27.53%. By learning from these two references, the researcher will choose fixed order quantity model as the best alternative solution in this research.
At this stage, all the necessary data will be collected so that this research can be carried out. Data is obtained in the form of secondary data, where all data is obtained from ERP SAP. The data period used in this research is from January 2022 to December 2022.

Based on the flowchart of the analysis method in Fig. 3, the researcher analyzes the data after gathering them to solve the problem on the basis of a literature review. The first step is downloading the historical consumptions (D) per month of each material that are consumed in 2022. Some other variables, such as Service level (SL), Lead Time (LT), Ordering Cost (S), and Holding Cost (H), are determined based on the company’s data or other references. Based on those data of historical consumption, the researcher will calculate the average of that consumption and their standard deviation. Standard deviation itself is a statistical measure that describes the amount of variation or dispersion in a set of values. The Safety Stock Calculation is used to calculate the possible stock to prevent the items out of stock (Heizer & Render, 2011). This calculation will affect to Reorder Point and Inventory Level. Reorder point is a point that calculates when to order the items. The Reorder Point is determined by average demand and lead time (Hansen & Mowen, 2005). In this research, this method is used to know the best time to order the items. The Economic Order Quantity is used to know the optimum level for ordering the items (Heizer & Render, 2011). This calculation also can be used to evaluate the inventory level of the company. In this research, Average Inventory Level (AIL) is to analyze the inventory level. Ideal Average Inventory level (AIL ideal) will be calculated by using variables of EOQ and SS that has been calculated previously. This AIL ideal is ideal condition of average inventory level that should be reached by warehouse management to achieve the target of service level with minimum cost. At the same time, Actual Average Inventory Level (AIL actual) based on data of inventory per month from January 2022 until December 2022 also need to be calculated. These data will be calculated to have the average value of them. After AIL actual has been determined, the researcher will make comparison between AIL ideal and AIL actual. This gap between them will be analyzed whether the condition of items is in understock condition, overstock condition or normal stock condition. Overstock condition occurs when AIL actual is more than AIL ideal, while understock condition occurs when AIL actual is less than AIL ideal. For overstock condition, the researcher will try to calculate potential saving that company can get if the inventory policy of EOQ model is applied. Meanwhile, for understock condition, the researcher will try to calculate estimated average service level that company has obtained. After that, researcher try to make comparison between total ideal AIL and total actual AIL based on value of money to know whether generally the company is facing the understock condition or the overstock condition. After determining recommended inventory model to be applied at PT Inalum, the researcher will propose new business process to management of PT Inalum. After get approval from management, this new business process will be executed by inventory team and the result will be monitored based on timeline of implementation.

EOQ can be calculated for each item by using the following formula:

\[
EOQ = \sqrt{\frac{2 \times D \times S}{H}}
\]  

where:

- \(D\) = yearly consumption
- \(S\) = Ordering Cost for each order
- \(H\) = Holding Cost per unit per year

By assuming lead time is constant while demand variability exists, safety stock can be calculated by using this formula below:

\[
Safety\ Stock = Z \times \sqrt{LT} \times \sigma_d
\]

where:

- \(Z\) = Service Level
- \(LT\) = Lead Time (months)
- \(\sigma_d\) = Standard deviation of demand/consumption

To calculate the ROP, use the formula below:

\[
ROP = d \times LT + Safety\ Stock
\]

where \(d\) = monthly consumption.

To determine the Average Inventory Level (AIL), apply the formula shown below:

\[
AIL = \frac{EOQ}{2} + Safety\ Stock
\]

Considering the goal of MRO inventory is to ensure that an organization has the necessary materials, tools, and supplies to support its day-to-day operations, maintenance, and repair activities. Low consumption rates may result in an overstock and high inventory cost, while high consumption rates may cause a shortage and low service level. Therefore, there must be a balance between ordering quantities and consumption. To achieving a balance, it is crucial to forecast the amount of future consumption based on trend and characteristics of consumption. For more simplicity, historical consumption data can be collected and make statistical analysis to determine ordering quantities and safety stock. Nevertheless, according to Simchi-Levi and Philip (2000) which can be seen on Table I, even though we fail to predict future consumption precisely, the changes in ordering quantities between predetermined order quantities and optimum order quantities have a relatively small impact on total inventory cost due to total inventory cost is insensitive to order quantities. For example, if the decision maker orders 20% more than the optimal order quantity then the increase in total inventory cost is no more than 1.6%.

Based on historical data from January 2022 to December 2022, there are 6028 SKU numbers that consumed by the maintenance team from warehouse of MRO inventory, Kuala Tanjung. The researcher will use these materials data as inventory analysis in this research. Based on data obtained from the ILG and IPM departments, the real condition of the material purchase data at the MRO inventory warehouse, Kuala Tanjung, is shown in Table II.
Inventory Management Improvement at PT Inalum, Kuala Tanjung, Sumatra Utara

Ardiananta and Basri

Fig. 3. Flowchart of analysis method (source: Author).

TABLE I: SENSITIVITY ANALYSIS OF ORDER QUANTITIES (SOURCE: DAVID SIMCHI)

<table>
<thead>
<tr>
<th>Order ratio ( \left( \frac{Q_{\text{predetermined}}}{Q_{\text{optimal}}} \right) )</th>
<th>0.5</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
<th>1.1</th>
<th>1.2</th>
<th>1.5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in cost</td>
<td>25%</td>
<td>2.5%</td>
<td>0.5%</td>
<td>0</td>
<td>0.4%</td>
<td>1.6%</td>
<td>8.9%</td>
<td>25%</td>
</tr>
</tbody>
</table>

TABLE II: FIXED VARIABLES OF MRO INVENTORY

<table>
<thead>
<tr>
<th>Fixed variable</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead time</td>
<td>300 days</td>
<td>Company's data</td>
</tr>
<tr>
<td>Holding cost</td>
<td>26% of unit price</td>
<td>Heizer and Render (2011)</td>
</tr>
<tr>
<td>Ordering cost</td>
<td>USD 49</td>
<td>Company's data</td>
</tr>
<tr>
<td>Service level</td>
<td>95%</td>
<td>Company's target</td>
</tr>
</tbody>
</table>

3. DISCUSSION

In order to find the real problem of this case, the researcher tries to analyze the root cause of the problem by using Current Realty Tree (CRT). CRT will help to determine the root cause by starting from the undesirable effect and defining the intermediate effect until it reaches the root cause of the problem.

Fig. 4 shows that overstock of MRO inventory occurs due to purchasing spare parts in over quantity. Overstock condition occurs when amount of spare parts usage for maintenance is lower than amount of purchasing. This overstock condition will result in high inventory costs. Conversely, Stockout condition occurs when amount of spare parts usage is higher than amount of purchasing. This stockout condition will result in low service level.

The error in determining the amount of spare parts purchased occurs because the company did not apply a statistical analysis approach to historical consumption in the previous years. By adopting this statistical analysis approach, the company is expected to be able to predict spare parts consumption more accurately in the future while still allowing for estimation error in the form of safety stock. In addition, PT Inalum currently does not set Reorder Point (ROP) so that there is no replenishment when stocks are running low below ROP. All the problems that occur in terms of inventory management at PT Inalum are because PT Inalum has not implemented an appropriate inventory policy. The other root cause is a delay in the procurement process, which is an inherent risk that PT Inalum is struggling to mitigate in order to minimize the occurrence of delays in procurement in the future.

By knowing all the root cause of problems that occurs in PT Inalum’s inventory, the researcher, as a Logistics & Materials Management Dept. (ILG) team, will propose the inventory policy to management as an effort to mitigate the risk of low achievement of service level and high inventory costs. However, the factor of delay in procurement process...
will be excluded from this research because this is the Procurement Management Dept. (IPM)’s matter to solve this problem.

4. Findings/Results

After knowing the results of the Average Inventory Level (AIL) ideal from the calculation for all materials using the fixed quantity order model, the comparison between the Average Inventory level of the proposed model (EOQ Model) and the actual/current system can be made. The comparison between the Average Inventory Level ideal and actual can be seen in Table III.

Table III shows a comparison between AIL ideal and actual for 10 items. Researchers divided it into two kinds of comparison, which are the quantity (unit) and the value of money (USD). For those comparisons will be known the inventory status whether the status is understock, overstock or normal stock.

Based on Table III, it can be seen that Sawdust wood has a value of USD 5,874 whereas the ideal value is USD 12,759. This condition occurs because Sawdust wood has more demand than the available stock in the warehouse. The gap for this item is −54%. This situation is similar with paper manila, lubricating oil Turalik, wood disused, brick SK26, castable HCAL, and log wood. These items are classified as understock items. Meanwhile, Steel shot has a value of USD 58,231, whereas the ideal value is USD 27,448. This condition occurs because steel shot has less demand than the available stock in the warehouse. The gap for this item is 112%. This situation is similar with Rivet blind. These items are classified as overstock items. Lastly, the Lubricating oil Rarus has a value of USD 5,062, whereas the ideal value is USD 4,669. Because the gap between the ideal and actual value is only 8% or not more than 10% (based on limitation that is determined by the company), this situation is classified as normal stock.

From Fig. 5, we can see that there are 1,485 item materials (24.64% of total items) were understock items where the value is USD 5,829,251 (37%), 151 item materials (2.5%) were normal stock items where the value is USD 419,227 (3%) and 4,392 item materials (72.86%) was overstocking items where the value is USD 9,274,743 (60%) in MRO inventory, Kuala Tanjung for period 2022.

Based on value of money (United States Dollar), for overstock status, MRO inventory Kuala Tanjung potentially saves USD 5,402,389 (58.2%) of inventory value. On the other hand, for understock status, MRO inventory Kuala Tanjung spent USD 9,965,060 below the theoretical ideal inventory value (−171%). And lastly, for normal stock status, MRO inventory Kuala Tanjung potentially saves USD 18,891 (5%) of inventory value. For the total actual AIL, MRO Inventory Kuala Tanjung spent USD 4,543,780 (−29%) below the ideal total AIL. This situation describes that generally, MRO inventory in Kuala Tanjung is facing an understock situation. The comparison is shown in the Table IV and Fig. 6.

From Fig. 7, estimated average service level for 4,392 understock items were 0.52 which is far below target set by management. While for 1,485 overstock items were nearly 1 which exceed target set by management. This is what we call inventory mismatch because MRO inventory Kuala Tanjung should be able to allocate abundant spending of USD 5,402,389 for 1,485 overstock items to purchase 4,392 understock items, which need an additional budget of USD 9,965,060 instead. Thus, MRO inventory only needs to increase budget by USD 4,543,780 to reach the ideal inventory value condition in order to achieve an average service level of 0.95 for all items. And lastly, only 151 normal stock items successfully achieve the target service level of 0.95.
TABLE III: AIL COMPARISON

<table>
<thead>
<tr>
<th>No</th>
<th>Material number</th>
<th>Material description</th>
<th>Unit</th>
<th>Purchase cost/unit (USD)</th>
<th>AIL ideal (Unit)</th>
<th>AIL actual (Unit)</th>
<th>Gap (Unit)</th>
<th>AIL ideal (USD)</th>
<th>AIL actual (USD)</th>
<th>Gap (USD)</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>150102001635</td>
<td>SAWDUST, WOOD, FINE AND DRY; STANDARD</td>
<td>kg</td>
<td>0.02</td>
<td>524226.03</td>
<td>241335.25</td>
<td>−282890.78</td>
<td>12758.61</td>
<td>5873.61</td>
<td>−6884.99</td>
<td>−54% Understock</td>
</tr>
<tr>
<td>2</td>
<td>150102001385</td>
<td>PAPER, MANILA, 3X100X50MM-LIGHT BROWN STEEL SHOT, 140-1.4 MM-45—50 HRC-1000 KG/DR</td>
<td>SHT</td>
<td>0.33</td>
<td>60870.19</td>
<td>15822.58</td>
<td>−45047.61</td>
<td>19979.73</td>
<td>5193.53</td>
<td>−14786.20</td>
<td>−74% Understock</td>
</tr>
<tr>
<td>3</td>
<td>150402000052</td>
<td>LUBRICATING OIL, TURALIK 43-209 L/DR WOOD DISUSED, 120X1000MM-EXCEPT PINUS</td>
<td>kg</td>
<td>2.39</td>
<td>11469.77</td>
<td>24333.33</td>
<td>12863.57</td>
<td>27447.95</td>
<td>58231.37</td>
<td>30783.42</td>
<td>112% Overstock</td>
</tr>
<tr>
<td>4</td>
<td>150402000017</td>
<td>LUBRICATING OIL, RARUS-427-208L/DR-MOBIL</td>
<td>L</td>
<td>2.69</td>
<td>1405.61</td>
<td>1882.00</td>
<td>476.39</td>
<td>4668.70</td>
<td>5062.49</td>
<td>393.79</td>
<td>8% Normal stock</td>
</tr>
<tr>
<td>5</td>
<td>140111000046</td>
<td>BRICK, SK26-65X107X114X30MM-ST</td>
<td>EA</td>
<td>3.03</td>
<td>20054.68</td>
<td>13546.33</td>
<td>−6508.35</td>
<td>60719.27</td>
<td>41014.04</td>
<td>−19705.23</td>
<td>−32% Understock</td>
</tr>
<tr>
<td>6</td>
<td>140111000130</td>
<td>CASTABLE, HCA/MATRILO-34ACX</td>
<td>kg</td>
<td>2.48</td>
<td>13493.51</td>
<td>6979.17</td>
<td>−6514.34</td>
<td>33445.62</td>
<td>17298.87</td>
<td>−16146.74</td>
<td>−48% Understock</td>
</tr>
<tr>
<td>7</td>
<td>150102001135</td>
<td>LOG, WOOD, 20X40X4000MM-M-KAYU SEMBARANG LUBRICATING OIL, RARUS-427-208L/DR-MOBIL</td>
<td>EA</td>
<td>1.23</td>
<td>18003.48</td>
<td>2466.67</td>
<td>−1533.81</td>
<td>22121.87</td>
<td>3030.93</td>
<td>−19090.94</td>
<td>−86% Understock</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

The researcher will provide new Material requirement Planning (MRP) business process that will replace the current MRP business process in accordance with the inventory policy that will be implemented. The comparison between current business process and proposed business process can be seen in Fig. 8.

Fig. 8 shows comparison the business process of MRP in the SAP ERP system that is being used at PT Inalum and the proposed business proposed that will be applied in the future. The person in charge who will execute that business process from start until finish is inventory team from ILG Department. The MRP process starts from running the MRP system to find out the required planned order quantities. The planned order is then converted into a purchase requisition (PR) that will be sent to the procurement system. The red dashed line shows the additions and changes from the previous business process. The difference between the current business process and the proposed business process can be seen in the following Table V.
AIL Theory vs AIL Actual

Fig. 6. Comparison of AIL based on the value of money.

Estimated Service Level

Fig. 7. Estimated service level.

Fig. 8. Comparison between current and proposed MRP business process (Source: Author).
5. Conclusions

From the research, it can be seen that PT Inalum has the potential to save the inventory as much as USD 5,402,389 (58.2%) from the inventory value of overstock items. At the same time, PT Inalum also faces the very low service level condition in inventory management. It can be seen from the calculation of the estimated average service level of understock items is 0.52. This is still far below from ideal service level of 0.95. If we make a total AIL comparison between the ideal and actual AIL, we find that the total AIL actual is USD 4,543,780 (−29%), much less than the total AIL ideal, which means that the understock condition is much more dominant than the overstock condition. By doing inventory management with fixed order quantity model, PT Inalum can increase service level of 95% while maintaining minimum inventory cost.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

References


