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The Innovation Breakthrough in Digital and Disruptive Era
Production Planning and Control of Flooring Using Aggregate Planning Method

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Abstract. PT. X is a private company engaged in the wood processing industry. To avoid production excesses or shortages in the company, production planning using the Aggregate Planning Method can be utilized to meet all consumer demands. The variables used include demand data, production costs, setup costs, and manufacturing time. Through this research, the company can fulfill consumer demands and minimize production costs by implementing aggregate planning. Additionally, the company can forecast future demand, enabling them to anticipate fluctuations in consumer demand. By using aggregate production planning, a total production time of 8657 hours can be scheduled to fulfill a demand of 7121 m². The cost savings achieved after implementing aggregate planning is IDR 1.383.921.682 and actual cost is IDR 1.477.900.968. So that the company can save production costs of IDR 93,979,286 or 6.35%. For the total production cost of the upcoming year 2023 by implementing aggregate planning based on the forecasting data, the cost is IDR 1.534.711.812.

1 Introduction

Currently, the industrial sector is experiencing rapid growth and development. This growth has led to an increase in demand for products in large quantities. Therefore, companies must adapt to these developments and follow current trends to ensure smooth production and business sustainability [1].

PT. X is a company operating in the wood processing industry. Its main activities involve manufacturing wooden flooring for houses and decking for ships, as well as various types of furniture. The company follows three stages of wood processing: sawmill for cutting the wood, kiln dry for drying, and moulding to shape the wood into desired products.

PT. X faces challenges due to the continuous increase in consumer demand, while the existing production cannot meet their needs. To address this issue, it is necessary to forecast future demand and develop strategies to reduce production costs, ensuring consumer demand is met with minimal production expenses. Employing aggregate planning in the production process can prevent overproduction or underproduction [2]. This way, the company strives to meet consumer demand with optimal production costs and proactively tackles the current challenges.

Aggregate Planning is an operational activity aimed at calculating the quantity and schedule of production for the future [3]. It can be defined as an effort to align supply and demand for a product or service by determining the appropriate quantities and schedules for input, transformation processes, and output [2].
The result of production planning is a production schedule that outlines the types of products, quantities, and production time schedules for a certain period [12]. Production planning is important to achieve a balance between supply and demand, avoid excess or shortage of inventory, and optimize the use of company resources. With good production planning, companies can improve operational efficiency, reduce production costs, and enhance customer satisfaction with timely and demand-driven products.

2.2 Production Control

The implementation of the planned production requires control to proceed according to the plans that have been made. Production plans are based on forecasts, which may not always be accurate [13]. Production control is a function carried out by staff and is not directly the responsibility of the company's management line. Production control can be carried out at every level of management, depending on the needs and characteristics of the factory [14].

Production Control is a management process that involves supervision and regulation of production activities to ensure that production proceeds in accordance with the plans and standards that have been set. The goal of production control is to achieve efficiency, productivity, and optimal quality in the production process [9].

Production control involves continuous monitoring and evaluation of production processes, including monitoring product quality, the use of raw materials and resources, production timing planning, and scheduling [15]. If there are differences between actual performance and established plans, corrective action will be taken to rectify the situation [16].

In controlling production, companies also seek to identify and resolve issues that may arise during the production process to ensure that production targets are achieved efficiently and effectively. Production control helps minimize the risk of production deviations from standards or meeting market demands, thereby maintaining customer satisfaction and business sustainability [17][18].

2.3 Forecasting

Forecasting is the process of projecting future needs, which includes information about the quantity, quality, time, and location of goods or services needed to meet demand [19]. Forecasting is used to estimate future demand for a company. By knowing the estimated future demand, companies can determine strategies and policies for material planning and scheduling that need to be done [20].

Demand forecasting is an estimation or projection of the expected level of demand for products that will occur within a specific period in the future [21]. Demand forecasting focuses on predicting demand for independent products or those not influenced by other factors, such as forecasting for finished products that are not dependent on the demand for other products [22].

Demand forecasting has certain common characteristics that must be considered in evaluating a demand forecasting process and the forecasting methods used [23]. The characteristics of demand forecasting are as follows:

- Causal factors that occurred in the past are assumed to remain relevant in the future.
- Forecasts are never perfect, meaning actual demand will always differ from the projected demand.
- The accuracy of forecasts will decrease over longer time spans.

These characteristics serve as important reference points in analyzing and evaluating the results of demand forecasting.

2.4 Aggregate Planning

Aggregate Planning is an operational activity aimed at calculating the quantity and schedule of production in the future [3]. Another definition of Aggregate Planning is an effort to match the supply and demand of a product or service by determining the appropriate quantities and schedules for inputs, transformation processes, and outputs [24]. In the process of Aggregate Planning, decisions are made to determine production, workforce requirements (staffing), inventory, and the level of unmet demand (backorder level) [25].

The process of aggregate planning includes determining the production level, required inventory, workforce levels, as well as backorder policies or customer order rejection policies. The ultimate goal is to achieve a balance between supply and demand in the most economical and efficient way [4].

In aggregate planning, companies need to consider various factors such as demand fluctuations, production costs, factory capacity, inventory, and labor [26]. By conducting effective aggregate planning, companies can avoid excess or shortage of inventory, minimize production costs, and enhance operational efficiency in their business.

3 Methodology

This research was conducted at PT. X, a company engaged in the wood processing industry. Variables can be interpreted as factors or concepts that have varying values and magnitudes. The variables used in the current problem are: demand data, production cost, set up cost, manufacturing time. If the collected data is complete, the next step is aggregate planning. In the forecasting process, the forecasting method will be determined based on the available data. The method used is the one with the smallest Mean Squared Error (MSE) value. After determining the method with the smallest MSE value, the next step is to perform forecast method testing.

Four forecasting methods are used from several available forecasting methods, including single
exponential smoothing with trend, linear regression, double exponential smoothing with trend. Select the best forecasting method using statistical tests to calculate the level of error for each forecasting method, specifically by calculating the smallest MSE value for each forecasting method.

\[
MSE = \frac{1}{N} \sum_{i=1}^{N} (y_i - \hat{y}_i)^2
\]  

(1)

\(MSE = \text{Mean Squared Error}\)

Verification test is conducted with the purpose of determining whether the method to be used is acceptable or not.

\[MR = \frac{1}{N} \sum_{i=1}^{N} (d_{i,t} - d_{i,t-1})\]  

(2)

\[d_{i,t} = \text{demand at } (t-1)\]

\[d_{i,t-1} = \text{forecast at } (t-1)\]

The purpose of knowing the average daily production is to determine the monthly production capacity. Calculating monthly production capacity based on working days. This calculation is done to determine the wood production capacity for one month based on the available working days. This production capacity consists of regular time production capacity and overtime production capacity.

The allocation of demand quantities with capacity based on the transportation model. The purpose of this allocation is to adjust the demand quantity according to the production capacity for month. The process can be accomplished by employing the matrix formulation of aggregate planning.

Table 1. The Matrix Formulation of Aggregate Planning

<table>
<thead>
<tr>
<th>Source</th>
<th>Demand Period</th>
<th>Idle</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 2 3 4</td>
<td>Pt_0</td>
<td>P_1</td>
</tr>
<tr>
<td>2</td>
<td>C_1 C_2 C_3</td>
<td>O_1</td>
<td>P_2</td>
</tr>
<tr>
<td>3</td>
<td>C_4 C_5 C_6</td>
<td>O_2</td>
<td>P_3</td>
</tr>
<tr>
<td>4</td>
<td>C_7 C_8 C_9</td>
<td>O_3</td>
<td>P_4</td>
</tr>
<tr>
<td>Forecast</td>
<td>Y_1 Y_2 Y_3</td>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>

4 Discussion

4.1 Product Demand Data

In this aggregate planning, only high-volume demands will be used in this research. The demand data used includes E2E, E4E, S2S, and S4S types of flooring.

Table 2. Demand Data Used in Aggregate Planning

<table>
<thead>
<tr>
<th>Months</th>
<th>E2E</th>
<th>E4E</th>
<th>S2S</th>
<th>S4S</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>50</td>
<td>60</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>February</td>
<td>45</td>
<td>50</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>March</td>
<td>65</td>
<td>80</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>April</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Machine name</th>
<th>Total</th>
<th>No.</th>
<th>Machine name</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Host</td>
<td>1</td>
<td>6</td>
<td>Single Rate</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>BandSaw</td>
<td>5</td>
<td>7</td>
<td>Multi Rate</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Pony</td>
<td>2</td>
<td>8</td>
<td>Planner</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Cross Cut</td>
<td>9</td>
<td>9</td>
<td>Moulding</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Boiler</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Machine Data

The costs incurred during the production process by PT. X are facilities that can be used for one type of product and another type of product with the same processing.

4.2 Calculation of Proposed Aggregate Planning

4.2.1 Determining Safety Stock Quantity

To determine the safety stock for each product type, the formula used is:

\[SS = k \cdot \sigma_D\]

Note:

SS = Safety stock
K = Safety factor for normal distribution = 1,645 (For a confidence level of 95%) 
\(\sigma_D\) = Standard deviation of the demand for each product type

\[\sigma_D = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}}\]

Note:

\(x_i\) = Forecasted demand adjusted for defect percentage
\(\bar{x}\) = Average demand adjusted for defect percentage
N = Total number of demand data

An example calculation for the E2E product type:

1. Total demand = 845 m³
2. Average demand = \(\frac{845}{12} = 70.42\) ≈ 70 m³/month

The machines used by PT. X consist of finished data, divided into Unit cost, Set-up Cost, and Holding Cost.

Table 4. Unit Cost Data, Set-Up Cost and Holding Cost

<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Unit Cost (IDR)/m³</th>
<th>Set-up Cost (IDR)/m³</th>
<th>Holding Cost (IDR)/m³/ month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E2E</td>
<td>IDR 2,025,430</td>
<td>IDR 110,786</td>
<td>IDR 1000</td>
</tr>
<tr>
<td>2</td>
<td>E4E</td>
<td>IDR 2,025,430</td>
<td>IDR 110,786</td>
<td>IDR 1000</td>
</tr>
<tr>
<td>3</td>
<td>S2S</td>
<td>IDR 1,535,260</td>
<td>IDR 64,507</td>
<td>IDR 1000</td>
</tr>
<tr>
<td>4</td>
<td>S4S</td>
<td>IDR 1,535,260</td>
<td>IDR 64,507</td>
<td>IDR 1000</td>
</tr>
</tbody>
</table>
3. Standard Deviation

\[
\text{Standard Deviation} = \sqrt{\frac{(56 - 70)^2 + (67 - 70)^2 + \ldots + (89 - 70)^2}{12 - 1}}
\]

\[
\text{Standard Deviation} = \sqrt{\frac{4,253}{11}} = 19,663
\]

4. Safety stock (pcs) = Safety factor x standard deviation

\[
\text{Safety stock} = 1,645 \times 19,663 = 32,34 = 32 \text{ m}^3
\]

The summary of safety stock calculations for each product type can be seen in Table 5, as follows:

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Total Demand (m³/year)</th>
<th>Average Demand (m³/month)</th>
<th>Safety Factor</th>
<th>Standard Deviation</th>
<th>Safety stock (SS) (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2E</td>
<td>845</td>
<td>70</td>
<td>1.645</td>
<td>19,663</td>
<td>32</td>
</tr>
<tr>
<td>E4E</td>
<td>857</td>
<td>71</td>
<td>1.645</td>
<td>18,193</td>
<td>30</td>
</tr>
<tr>
<td>S2S</td>
<td>906</td>
<td>75</td>
<td>1.645</td>
<td>15,806</td>
<td>26</td>
</tr>
<tr>
<td>S4S</td>
<td>861</td>
<td>72</td>
<td>1.645</td>
<td>14,488</td>
<td>24</td>
</tr>
</tbody>
</table>

4.2.2 Converting All Demands For Each Product Type Into Hours

The demand for each product type, which has been adjusted for defect percentage, is converted into hours using production time.

Formula :

\[D_{t} = W_{ij} \times D_{ij}, \ t\]

Note :

\[D_{ij}, \ t = \text{Demand} \]

\[W_{ij} = \text{Production Time}\]

\[D_{ij} = \text{Total demand in period t in hours}\]

The summary of the calculation results for the conversion of demand for each product type can be seen in Table 6.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Total Demand (m³/year)</th>
<th>Average Demand (m³/month)</th>
<th>Safety Factor</th>
<th>Standard Deviation</th>
<th>Safety stock (SS) (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2E</td>
<td>845</td>
<td>70</td>
<td>1.645</td>
<td>19,663</td>
<td>32</td>
</tr>
<tr>
<td>E4E</td>
<td>857</td>
<td>71</td>
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<td>30</td>
</tr>
<tr>
<td>S2S</td>
<td>906</td>
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<td>1.645</td>
<td>15,806</td>
<td>26</td>
</tr>
<tr>
<td>S4S</td>
<td>861</td>
<td>72</td>
<td>1.645</td>
<td>14,488</td>
<td>24</td>
</tr>
</tbody>
</table>

4.2.3 Total Production Requirement Calculation

The next step for the total production requirement is to sum up the demand with the safety stock. The total production requirement for the 12 planning periods is:

\[P_{t} = \sum (D_{t} + I_{t} - I_{t-1})\]

Note :

\[P_{t} = \text{Total production requirement for period t} \]

\[D_{t} = \text{Total demand for each product in period t} \]

\[I_{t} = \text{Inventory akhir pada periode} \]

\[I_{t-1} = \text{The initial inventory at period t-1 is converted into hours.}\]

An example for January 2022, the total production requirement for E2E is:

\[P_{t} = 379 + 165 = 507 \text{ hours}\]

The results of the calculation are as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>Demand (hours)</th>
<th>Safety stock</th>
<th>Total Production Requirement (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>37</td>
<td>165</td>
<td>507</td>
</tr>
<tr>
<td>1</td>
<td>339</td>
<td>165</td>
<td>339</td>
</tr>
<tr>
<td>2</td>
<td>487</td>
<td>165</td>
<td>487</td>
</tr>
<tr>
<td>3</td>
<td>364</td>
<td>165</td>
<td>364</td>
</tr>
<tr>
<td>4</td>
<td>501</td>
<td>165</td>
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<td>5</td>
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<td>6</td>
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<td>11</td>
<td>542</td>
<td>165</td>
<td>542</td>
</tr>
<tr>
<td>12</td>
<td>5141</td>
<td></td>
<td>5269</td>
</tr>
</tbody>
</table>

4.2.4 Planning for the Number of Workers

The total available working hours during the 12 production planning periods.

Total production time = 5269 hours (table 6.)

Number of working days = 297 days per year

Regular time = 7 hours/person/day

Over time = 4 hours/person/day

Absence rate = 10%

Total effective working hours:

\[(1 - 10 \%) \times 297 \times 7 = 1,871.1 \text{ hours}\]

Required workforce quantity = \[\frac{\text{Total Production}}{\text{Total effective working hours}}\]

\[\frac{5269}{1,871.1} = 2,815 \approx 3 \text{ persons}\]

4.2.5 Production Cost Calculation

The production cost processing calculated in this research includes:

a. Regular time labor cost: IDR 4,000 / hour / person

Regular time labor wage = 3 persons x IDR 4,000 = IDR 12,000 / hour

b. Overtime labor cost: IDR 4,200 / hour / person

Overtime labor wage = 3 persons x IDR 4,200 = IDR 12,600 / hour

c. Production cost for E2E / E4E products: IDR 2,025,430/m³. There are 15 pieces of wood in 1m³, so the production cost calculation is:

Production cost = IDR 2,025,430 / 15 = IDR 135,028 / pcs

For regular time production cost:

\[= \text{Production cost + regular time labor wage}\]

\[= \text{IDR 135,028 + IDR 12,000}\]

\[= \text{IDR 147,028}\]
For overtime production cost:
= Production cost + overtime labor wage  
= IDR 135.028 + IDR 12.600  
= IDR 147.628

d. Production cost for S2S/S4S products: IDR 1.535.260/m²

Production cost = IDR 1.535.260 / 15 = IDR 102.350

For regular time production cost:
= Production cost + regular time labor wage  
= IDR 102.350 + IDR 12.000  
= IDR 114.350

For overtime production cost:
= Production cost + overtime labor wage  
= IDR 102.350 + IDR 12.600  
= IDR 114.950

4.2.6 Determining the Capacity of Production Alternatives

The calculations for production requirements and capacity for aggregate planning can be seen in Table 8 as follows:

Table 8. Production Requirements and Capacity for Aggregate Planning

<table>
<thead>
<tr>
<th>Period</th>
<th>Demand (hours)</th>
<th>Safety stock (hours)</th>
<th>Total production requirement (hours)</th>
<th>Regular time days</th>
<th>Overtime capacity hours</th>
<th>Total demand (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>165</td>
<td>507</td>
<td>25</td>
<td>525</td>
<td>300</td>
<td>544</td>
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<tr>
<td>2</td>
<td>165</td>
<td>507</td>
<td>25</td>
<td>525</td>
<td>300</td>
<td>544</td>
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<td>487</td>
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<td>525</td>
<td>300</td>
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<td>4</td>
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<td>464</td>
<td>24</td>
<td>504</td>
<td>288</td>
<td>529</td>
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<td>496</td>
<td>25</td>
<td>525</td>
<td>300</td>
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</tr>
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<td>487</td>
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<td>546</td>
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<tr>
<td>8</td>
<td>464</td>
<td>464</td>
<td>24</td>
<td>504</td>
<td>288</td>
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</tr>
<tr>
<td>9</td>
<td>165</td>
<td>507</td>
<td>25</td>
<td>525</td>
<td>300</td>
<td>544</td>
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<td>546</td>
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<td>542</td>
<td>24</td>
<td>504</td>
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<td>707</td>
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<tr>
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<td>2017</td>
<td>4977</td>
<td>6237</td>
<td>3564</td>
<td>7121</td>
</tr>
</tbody>
</table>

4.2.7 Aggregate Planning Matrix

Based on the calculations of production requirements and capacity above, an aggregate planning matrix can be created using the transportation method for the 12 planning periods. From the production calculations in the aggregate planning matrix, the total production cost incurred is as follows:

Total Cost =
1. Period 1: (37 x 1000) + (507 x 261378) = IDR.329,155,746
2. Period 2: (165 x 1000) + (18 x 262378) + (321 x 261378) = IDR.88,790,142
3. Period 3: (165 x 1000) + (183 x 262378) + (304 x 261378) = IDR.127,639,086
4. Period 4: (165 x 1000) + (221 x 262378) + (143 x 261378) = IDR.95,527,592
5. Period 5: (165 x 1000) + (361 x 262378) + (140 x 261378) = IDR.131,476,378

6. Period 6: (165 x 1000) + (406 x 262378) + (90 x 261378) = IDR.130,214,488
7. Period 7: (165 x 1000) + (435 x 262378) + (52 x 261378) = IDR.127,891,086
8. Period 8: (165 x 1000) + (371 x 262378) = IDR.97,507,238
9. Period 9: (165 x 1000) + (123 x 263378) + (394 x 262378) = IDR.135,937,426
10. Period 10: (165 x 1000) + (131 x 263378) + (82 x 262378) = IDR.56,182,514
11. Period 11: (165 x 1000) + (443 x 263378) + (2 x 262378) = IDR.117,366,210
12. Period 12: (165 x 1000) + (460 x 263378) + (82 x 262378) = IDR.142,833,876

Total = IDR.1,383,921,682

So, the total proposed production cost using aggregate planning is IDR.1,383,921,682.

4.3 Existing Condition Aggregate Planning

The company implements production alternatives, including regular time and overtime work hours.

Table 9. Working Hours Data for January - December 2022

<table>
<thead>
<tr>
<th>Period</th>
<th>Regular Working Days</th>
<th>Working Hours/Day</th>
<th>Overtime Hours</th>
<th>Regular Working Hours</th>
<th>Overtime Working Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>7</td>
<td>4</td>
<td>168</td>
<td>96</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>7</td>
<td>4</td>
<td>168</td>
<td>96</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>7</td>
<td>4</td>
<td>182</td>
<td>104</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>26</td>
<td>7</td>
<td>4</td>
<td>182</td>
<td>104</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>175</td>
<td>100</td>
</tr>
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<td>7</td>
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<td>175</td>
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<tr>
<td>10</td>
<td>22</td>
<td>7</td>
<td>4</td>
<td>154</td>
<td>88</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>7</td>
<td>4</td>
<td>182</td>
<td>104</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>7</td>
<td>4</td>
<td>168</td>
<td>96</td>
</tr>
</tbody>
</table>

4.3.1 Production Capacity Based on Available Working Hours

An example calculation for Period 1 is as follows:
Total demand = 507 hours
Regular Time Production = 175
Overtime Production = 100
Production Shortage = Total demand - (regular time production + overtime production) = 507 - (175 + 100) = 232 hours
Production Surplus = (Regular time production + Overtime production) - Total demand = (175 + 100) - 507 = -232

Since the result is negative, it means there is a production shortage, so the production surplus is considered 0.

Here are the results of production capacity calculations based on available working hours, as shown in Table 10:

Table 10. Production Capacity Based on Available Working Hours

<table>
<thead>
<tr>
<th>Period</th>
<th>Total Demand (hours)</th>
<th>Regular Time Production</th>
<th>Overtime Shortage (hours)</th>
<th>Production Surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>507</td>
<td>175</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>507</td>
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</tr>
<tr>
<td>9</td>
<td>507</td>
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<td>100</td>
<td>0</td>
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<tr>
<td>10</td>
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<td>88</td>
<td>0</td>
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<tr>
<td>11</td>
<td>507</td>
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<td>104</td>
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</tr>
<tr>
<td>12</td>
<td>507</td>
<td>168</td>
<td>96</td>
<td>0</td>
</tr>
</tbody>
</table>
4.5 Aggregate Planning for January - December Based on Forecasting Data

The summary of production requirements and capacity calculations for aggregate planning can be seen in Table 13 as follows:

<table>
<thead>
<tr>
<th>Perio d</th>
<th>Demand (hours)</th>
<th>Safety (hours)</th>
<th>Total demand (hours)</th>
<th>Worki ng days</th>
<th>Regular (hours)</th>
<th>Overtime (hours)</th>
<th>Total demand (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>463</td>
<td>45</td>
<td>343</td>
<td>25</td>
<td>525</td>
<td>300</td>
<td>508</td>
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<tr>
<td>2</td>
<td>471</td>
<td>45</td>
<td>471</td>
<td>24</td>
<td>504</td>
<td>288</td>
<td>516</td>
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<td>476</td>
<td>45</td>
<td>476</td>
<td>25</td>
<td>525</td>
<td>300</td>
<td>521</td>
</tr>
<tr>
<td>4</td>
<td>483</td>
<td>45</td>
<td>483</td>
<td>24</td>
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<td>288</td>
<td>528</td>
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<tr>
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<td>45</td>
<td>496</td>
<td>26</td>
<td>546</td>
<td>312</td>
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<tr>
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<td>525</td>
<td>300</td>
<td>561</td>
</tr>
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<td>508</td>
<td>45</td>
<td>508</td>
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<td>546</td>
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<td>550</td>
</tr>
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<td>515</td>
<td>45</td>
<td>515</td>
<td>25</td>
<td>525</td>
<td>300</td>
<td>560</td>
</tr>
<tr>
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<td>45</td>
<td>524</td>
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<td>525</td>
<td>300</td>
<td>569</td>
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<tr>
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<td>45</td>
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<td>538</td>
<td>45</td>
<td>538</td>
<td>26</td>
<td>546</td>
<td>312</td>
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</tr>
<tr>
<td>12</td>
<td>548</td>
<td>45</td>
<td>548</td>
<td>24</td>
<td>504</td>
<td>288</td>
<td>593</td>
</tr>
<tr>
<td>Total</td>
<td>6054</td>
<td>705</td>
<td>5934</td>
<td>297</td>
<td>6237</td>
<td>3564</td>
<td>6594</td>
</tr>
</tbody>
</table>

Based on the calculations of production requirements and capacity above, an aggregate planning matrix can be created using the transportation method for the 12 planning periods. From the production calculations in the aggregate planning matrix, the total production cost incurred is as follows:

Total Cost = IDR 89,817,654

1. Period 1 : [(165 x 1000) + (343 x 261378)] = IDR 89,817,654
2. Period 2 : [(45 x 1000) + (182 x 262378) + (289 x 261378)] = IDR 123,336,038
3. Period 3 : [(45 x 1000) + (215 x 262378) + (261 x 261378)] = IDR 124,675,928
4. Period 4 : [(45 x 1000) + (264 x 262378) + (219 x 261378)] = IDR 126,554,574
5. Period 5 : [(45 x 1000) + (285 x 262378) + (211 x 261378)] = IDR 129,973,488
6. Period 6 : [(45 x 1000) + (335 x 262378) + (166 x 261378)] = IDR 131,330,378
7. Period 7 : [(45 x 1000) + (359 x 262378) + (149 x 261378)] = IDR 133,184,024
8. Period 8 : [(45 x 1000) + (397 x 262378) + (118 x 261378)] = IDR 135,051,670
9. Period 9 : [(45 x 1000) + (407 x 263378) + (117 x 261378)] = IDR 137,821,072
10. Period 10 : [(45 x 1000) + (408 x 262378) + (123 x 261378)] = IDR 139,244,718
11. Period 11 : [(45 x 1000) + (339 x 262378) + (199 x 261378)] = IDR 140,995,144
12. Period 12 : [(45 x 1000) + (347 x 262378) + (201 x 261378)] = IDR 143,627,144

Total = IDR 1,534,711,812

So, the total production cost for the upcoming year (2023) by implementing aggregate planning based on the forecasting data is IDR 1,383,921,682.
4.6 Cost Comparison

Based on the calculations using aggregate planning, the existing cost of the company can be compared to the proposed cost. A summary of the cost savings is as follows:

- Existing cost/Actual Cost = IDR 1.477.900.968
- Aggregate planning Cost = IDR 1.383.921.682
- Cost Savings = Actual Cost - Aggregate planning Cost
  = IDR 1.477.900.968 - IDR 1.383.921.682
  = IDR 93.979.286
  = 6.35 %

By using aggregate planning, the company can minimize production costs and effectively meet consumer demand. On the other hand, for the total production cost of the upcoming year 2023 by implementing aggregate planning based on the forecasting data, the cost is IDR 1.534.711.812.

5 CONCLUSION

By using aggregate production planning, a total production time of 8657 hours can be scheduled to fulfill a demand of 7121 m³. On the other hand, for the upcoming 12 periods, a production time of 5934 hours is needed to meet a demand of 6594 m³. The cost savings achieved after implementing aggregate planning. PT. X is encouraged to adopt aggregate planning for production to minimize production costs, which will ultimately lead to increased profitability.

The total proposed production cost using aggregate planning is IDR.1.383.921.682 and actual cost is IDR 1.477.900.968. So that the company can save production costs of IDR 93,979,286 or 6.35%. For the total production cost of the upcoming year 2023 by implementing aggregate planning based on the forecasting data, the cost is IDR 1.534.711.812. This approach will also enable the company to meet future consumer demands effectively.

For further research, can use the Interval Programming Approach for Multi-period and Multi-product Aggregate Production Planning. This approach is a mathematical optimization technique that can help efficiently plan production activities over multiple time periods and with multiple products, considering various constraints and objectives. It enables better decision-making in resource allocation, production scheduling, and cost optimization in a complex production environment.

References


