# Forecasting and Production Planning, Inventory, Capacity, and Distribution Control in Y-Strainer Production in Metal Fitting Industry

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## Abstract

PT. DSG is a manufacturing company that produces metal fitting products, with Y-Strainer as the best-selling product. The company imports raw materials with a 2 to 3 weeks lead-time period. For the product demand is fluctuating, the quantity and schedule of ordering raw materials are also uncertain. The company also experienced delays in product delivery by 50% in the past year. Therefore, they need a proposed improvement plan for forecasting and planning production, inventory, and distribution to overcome these problems. This research requires demand data from April 2018 to March 2021 and other supporting data to perform a forecasting calculation. The forecasting method for this research is SMA, DMA, WMA, SES, DES, Cyclic, Linear, Quadratic, Decomposition, and ANN forecasting methods. The next calculation is aggregate planning by shift, overtime, mixed aggregate categories and rough cut capacity planning (RCCP) using CPOF, BOLA, and RPA methods. Material Requirement Planning (MRP) using EOQ, POQ, LFL, Silver Meal, LUC, and WWA lot-sizing and safety stock calculation. The final calculation continues with Capacity Requirement Planning (CRP) and Distribution Requirement Planning (DRP). As a result, the forecasting method chosen for the Y-Strainer product is ANN, for it has the smallest error compared to other methods. Mixed aggregate planning was chosen because it has the smallest total cost. The CRP calculation shows that the capacity is greater than the needs, meaning the company can meet customers' demand from April 2021 to March 2022 with their resources. The lot-sizing technique chosen for the MRP calculation is WWA that can save 22% and distribution planning using DRP can save 52% compared to the method PT. DSG uses now. The Odoo ERP system can help the company control business operations. It is more practical and efficient with data collection being carried out automatically, in real time, and stored in the ERP database. Thus, the delivery of information among departments runs quickly and accurately, which may lead the company to minimize errors.

## Keywords
Production Planning, Wagner Within Algorithm, ANN, DRP, ERP.

## 1. Introduction

Industrial has been growing rapidly in line with increasing needs from consumers, making the competition stronger. To continue developing and competing with competitors, a company must have a strategy to increase productivity to meet customer demand with the maximum profit possible. In addition, they are indirectly required to utilize their resources and maintain optimal product quality that leads to increased productivity. Thus, customers' increasing needs and demands make companies have to carry out good production and inventory control to manage costs to be the most optimum. In a manufacturing company with the make-to-order principle, the availability of raw materials is certainly important. Hence production planning and inventory control of raw materials are needed for production activities. Production planning and raw material inventory control have to be done based on accurate demand forecasting to make the production more effective and efficient.

PT. DSG is a manufacturing company that produces metal fitting products, such as strainers, drainers, and valves, on a make-to-order principle and has been competing in the metal fittings industry for the past 31 years. DSG is more in demand by foreign people which 60% of the company's market share is foreign consumers. The highest product demand that consumers often order is Y-Strainer.

Based on an interview with the head of the PPIC department of the company as the informant, they have an indefinite forecasting method. They usually order raw materials according to the production needs for customer orders. In order to fulfil customer demands with high quality, PT. DSG imports raw materials from abroad with a long lead time, which is 2 to 3 weeks. The product demand is volatile, so the quantity and schedule of ordering raw materials are also uncertain. In addition, the informant also informed that the company experienced a 50% delay in product delivery in the past year. In applying time and cost efficiency in an end-to-end production process, every company needs to implement information technology. The application of information technology causes changes to a set of tasks or processes, one of which is Enterprise Resource Planning (ERP). ERP as a computerized system, if used optimally in integrating every business process, will increase company efficiency. PT. DSG requires an information system that can cover all activities or business processes for each department in it. An ERP system will be very useful for the company, especially for the company's control and data collection process. Therefore, the company needs a proposed improvement plan for forecasting and planning for production, inventory, and distribution and ERP simulation to help companies overcome the problems that occurred.

### 1.1 Objectives
This study aims to determine the method of forecasting product demand, making production planning, determining the method of controlling raw material inventory, making machine capacity and the number of shifts planning, and the right distribution planning to be applied in PT. DSG to meet customer demands on time.

## 2. Literature Review
### 2.1 Forecasting
Forecasting is the process of estimating the future needs to come, including the size of quantity, time, and location to fulfil the demand for products or services (Nasution and Prasetyawan, 2008). Having upcoming demand can help the company decides which strategy is the most suitable for the next planning period (Gozali et al., 2013). The best suitable forecast method is the one with the smallest error. Forecasting calculation is done by using some methods such as: Single Moving Average (SMA), Double Moving Average (DMA), Weighted Moving Average (WMA), Single Exponential Smoothing (SES), Double Exponential Smoothing (DES), Linear Regression, Cyclic, Quadratic Regression, Decomposition, and Artificial Neural Network (ANN) method (Gozali et al., 2019; Lefta et al., 2020; Gozali et al., 2020).

The decision to choose the best forecasting methods has been made using some methods such as: Mean Error (ME); Mean Absolute Deviation (MAD); Sum of Squared Error (SSE); Mean Square Error (MSE); Standard Deviation of Error (SDE); Mean Percent Error (MPE); and Mean Absolute Percent Error (MAPE) (Gaszperz, 2004).

### 2.2 Master Production Schedule
MPS is a set of plans that describe how many will be made for each end item in a certain planning period (Gaszperz, 2001).

### 2.3 Aggregate and Disaggregated Planning
Aggregate planning is a method used in production planning to adjust production capabilities in order to face uncertain consumer demand by optimizing available resources (equipment and labour) to reduce the company's operational costs (Samuel et al., 2020).

Disaggregated planning is a model for obtaining production planning for each type of product in each product group based on the aggregate plan. The aggregate plan only provides a production plan for the entire product. It is necessary to do a disaggregated plan into the number of products for each type of product (product items) (Simanjuntak, 2017).

### 2.4 Rough Cut Capacity Planning
The RCCP determines the capacity requirements needed to implement the MPS. The steps required to implement the RCCP are as follows (Eunike, 2018).
1. Obtain information about the production plan from the MPS that have been made
2. Obtain information about product structure and lead time

3. Determine bill of resources
4. Calculate specific resource requirements and generate RCCP reports.

## 2.5 Safety Stock

Safety stock is additional inventory held to maintain the risk of the inventory shortage or also called stock out (Assauri, 1993:242).

## 2.6 Material Requirement Planning (MRP)

Material requirement planning can reduce lead time, inventory cost, improve inventory management and manufacturing efficiency and effectiveness by using accurate production planning (Herjanto, 2009:275). MRP is a technique that uses a list of material requirements, inventory, estimated revenue, and master production schedule to determine material requirements (Heizer and Render, 2009:648). The techniques used in this calculation are as follows (Christifan, 2021).

1. Economic Order Quantity (EOQ)
   EOQ is an inventory level that minimizes the total cost of storing inventory and ordering costs with fixed lot size (Herjanto, 2009).

2. Period Order Quantity (POQ)
   POQ is a technique that uses the logic of EOQ to get quantity orders that must be made for the interval of order period in one period (Hansa, 2015).

3. Lot for Lot (LFL)
   LFL or minimum inventory method is a technique that provides inventory in accordance with the needs at that time with the result that the only incurred cost is the ordering cost. Using LFL, if there is a delay in delivering goods, it will delay the production process (Diana, 2013).

4. Silver Meal Algorithm
   Silver Meal is a technique that aims to minimize the total cost of inventory per period. The criterion of this technique is that the lot size chosen must minimize the total cost per period. Demands with successive periods are accumulated into a tentative lot size until the lot's total carrying cost and setup cost is divided by the number of periods involved increase (Gozali et al., 2013).

5. Least Unit Cost (LUC)
   LUC is a lot-sizing technique that chooses the lowest cost per unit from certain periods by adding up total storage cost to ordering cost and then finding out the period with the lowest unit cost (Nisa, 2016). In the LUC technique, the size of the order quantity is determined by trial and error, namely by asking whether the lot size in one period should be the same as the net size or it is added to the next period. In the end, the decision is determined as per the lowest unit cost (sum of order and storage cost per unit) of each proposed lot size to be selected (Christifan, 2020)

6. Wagner Within Algorithm (WWA)
   WWA is a lot-sizing technique that minimizes inventory costs by using a variable cost matrix step (Gozali et al., 2013). This technique aims to obtain the optimal solution for a deterministic number of ordering units over a predetermined time horizon (Tersine, 1994).

## 2.7 Capacity Requirement Planning (CRP)

CRP is a detailed capacity calculation technique required by MRP. CRP verifies whether the available capacity is sufficient over the planning span (Wijaya, 2020).

## 2.8 Distribution Requirement Planning (DRP)

DRP is a method that handles stock replenishment in a multi-echelon distribution environment. It takes the point from independent demand to the point where forecasts must be made and establish requirements for supply sources.

### 2.9 Enterprise Resource Planning (ERP)

ERP is software that organizes and manages a company's business processes by sharing information between functional areas (Russel and Taylor, 2003). On the other hand, Odoo is a modern and complete set of ERP applications distributed in open source, including various business module programs.

## 3. Methods

First of all, observation is done by doing a field study to discover the actual problems. On the other hand, the literature review is also be done. After determining the problem, the purpose of the research is identified. Following this procedure, the data collection can be processed afterwards so that the result can be analyzed in the end.

Data processing is done to obtain a suitable production plan for PT. DSG. All of the methods in this research, such as: forecasting; Master Production Schedule (MPS); aggregate and disaggregated planning; Rough Cut Capacity Planning (RCCP); safety stock; Material Requirement Planning (MRP); Capacity Requirement Planning (CRP); Distribution Requirement Planning (DRP); and Enterprise Requirement Planning (ERP). Forecasting is done by using SMA (Single Moving Average), DMA (Double Moving Average), WMA (Weighted Moving Average), SES (Single Exponential Smoothing), DES (Double Exponential Smoothing), cyclic, linear, quadratic, decomposition, and Artificial Neural Network. The best forecasting method is determined based on ME (Mean Error), MAD (Mean Absolute Deviation), SSE (Sum of Squared Errors), MSE (Mean Square Error), SDE (Standard Deviation of Error), MPE (Mean Percent Error), and MAPE (Mean Absolute Percent Error). The best forecasting method chosen will be validated by using the tracking signal method.

RCCP techniques used in this observation are CPOF, BOLA, and resource profile. Material requirement planning lot-sizing techniques used in this observation are EOQ, POQ, LFL, Silver Meal Algorithm, LUC, and WWA. ERP simulation is done by using opensource ERP called Odoo. The research methodology flowchart is shown in Figure 1.

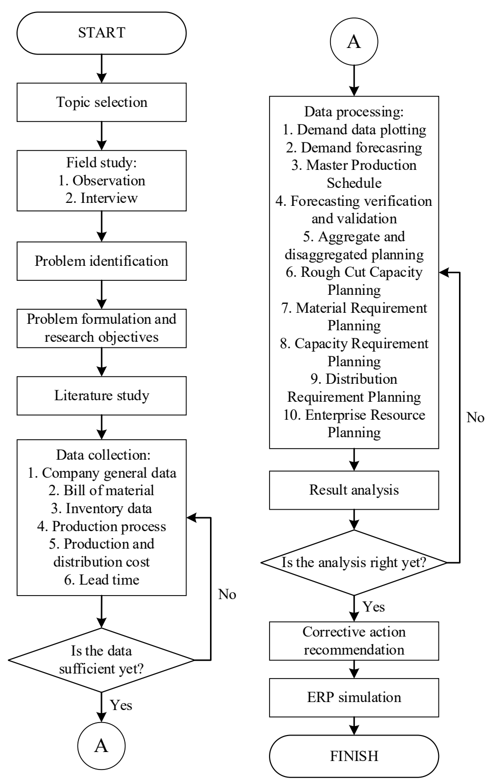


Figure 1. Research Methodology Flowchart

## 4. Data Collection

This research uses bill of material, product demand data from April 2018 until March 2021, order lead time and cost components, namely order and storage cost, and distribution data.

## 5. Result and Discussion

### 5.1 Forecasting Result

The most suitable forecasting method can be done by calculating the error of each method and choosing one of those with the smallest error. The smallest error for Y-Strainer production in PT. DSG based on the forecasting error calculation is the ANN method. The forecasting error calculation for the Y-Strainer product is summarized and shown in Table 1 below.

Table 1. Forecasting Error Summary for Y-Strainer Product

| Methods | MAD | MSE | SDE | MAPE | MPE |
|---|---|---|---|---|---|
| SMA (MA = 2 months) | 246.59 | 91,387.17 | 315.75 | 3,939.78 | 3,885.45 |
| SMA (MA = 3 months) | 249.21 | 92,681.27 | 309.16 | 4,733.29 | 4,680.76 |
| SMA (MA = 4 months) | 182.72 | 50,525.59 | 228.38 | 3,656.21 | 3,615.65 |
| SMA (MA = 5 months) | 250.29 | 93,390.61 | 310.65 | 5,171.10 | 5,126.37 |
| SMA (MA = 6 months) | 236.83 | 85,404.97 | 297.24 | 5,041.81 | 5,002.28 |
| SMA (MA = 7 months) | 227.24 | 81,807.86 | 291.08 | 4,924.77 | 4,887.32 |
| SMA (MA = 8 months) | 221.68 | 77,040.46 | 282.65 | 3,810.82 | 3,772.69 |
| SMA (MA = 9 months) | 217.74 | 74,745.89 | 278.6 | 2,854.26 | 2,815.51 |
| SMA (MA = 10 months) | 218.31 | 71,182.69 | 272.08 | 2,718.90 | 2,678.04 |
| SMA (MA = 11 months) | 217.84 | 72,415.76 | 274.65 | 2,603.71 | 2,562.27 |
| SMA (MA = 12 months) | 201.54 | 60,654.63 | 251.58 | 2,504.24 | 2,467.26 |
| SMA (MA = 13 months) | 198.17 | 61,418.26 | 253.4 | 2,482.03 | 2,444.26 |
| SMA (MA = 14 months) | 203.86 | 63,533.77 | 257.99 | 2,725.47 | 2,685.54 |
| SMA (MA = 15 months) | 212.29 | 67,744.00 | 266.7 | 3,036.39 | 2,994.87 |
| SMA (MA = 16 months) | 199.80 | 60,607.10 | 252.58 | 3,248.57 | 3,211.89 |
| DMA (MA = 2 months) | 322.00 | 176,330.02 | 426.43 | 5,577.04 | 5,543.39 |
| DMA (MA = 3 months) | 343.97 | 169,004.88 | 417.9 | 6,297.13 | 6,272.68 |
| DMA (MA = 4 months) | 320.34 | 155,180.27 | 400.9 | 7,855.86 | 7,832.18 |
| DMA (MA = 5 months) | 306.63 | 147,703.10 | 391.64 | 4,319.18 | 4,291.97 |
| DMA (MA = 6 months) | 266.20 | 113,920.23 | 344.48 | 3,957.10 | 3,928.55 |
| DMA (MA = 7 months) | 240.46 | 88,709.19 | 304.53 | 4,510.53 | 4,483.53 |
| DMA (MA = 8 months) | 252.40 | 117,970.06 | 351.95 | 7,016.47 | 6,979.34 |
| WMA (MA = 3 months) | 239.85 | 90,483.73 | 305.47 | 4,091.94 | 4,041.93 |
| WMA (MA = 4 months) | 243.16 | 89,220.28 | 303.48 | 4,581.60 | 4,532.80 |
| WMA (MA = 5 months) | 244.45 | 89,976.71 | 304.92 | 4,871.48 | 4,826.74 |
| WMA (MA = 6 months) | 237.37 | 86,474.90 | 299.09 | 5,030.19 | 4,989.58 |
| WMA (MA = 7 months) | 233.59 | 85,472.83 | 297.53 | 5,133.47 | 5,093.74 |
| WMA (MA = 8 months) | 224.71 | 80,793.79 | 289.46 | 3,877.98 | 3,838.20 |
| WMA (MA = 9 months) | 219.30 | 78,608.33 | 285.71 | 2,868.25 | 2,828.18 |
| WMA (MA = 10 months) | 218.04 | 77,941.73 | 284.71 | 2,913.19 | 2,872.15 |
| SES ($\alpha = 0.1$) | 211.97 | 68,252.49 | 265.07 | 3,475.76 | 3,434.38 |
| SES ($\alpha = 0.2$) | 220.34 | 72,272.63 | 272.76 | 3,879.16 | 3,837.40 |
| SES ($\alpha = 0.3$) | 225.31 | 75,849.03 | 279.43 | 3,990.67 | 3,947.78 |
| SES ($\alpha = 0.4$) | 227.74 | 79,053.97 | 285.27 | 3,919.03 | 3,875.33 |
| SES ($\alpha = 0.5$) | 230.09 | 82,271.46 | 291.02 | 3,723.05 | 3,677.16 |
| SES ($\alpha = 0.6$) | 232.94 | 85,610.71 | 296.86 | 3,456.73 | 3,409.30 |
| SES ($\alpha = 0.7$) | 236.71 | 89,267.91 | 303.14 | 3,148.79 | 3,099.36 |
| SES ($\alpha = 0.8$) | 242.17 | 93,570.57 | 310.36 | 2,823.01 | 2,768.71 |
| SES ($\alpha = 0.9$) | 247.63 | 98,521.74 | 318.46 | 2,484.94 | 2,425.69 |
| DES ($\alpha = 0.1$) | 221.74 | 73,766.15 | 275.68 | 4,168.15 | 4,129.74 |
| DES ($\alpha = 0.2$) | 234.56 | 84,749.15 | 295.5 | 4,467.25 | 4,424.30 |
| DES ($\alpha = 0.3$) | 246.94 | 95,881.53 | 314.3 | 4,126.68 | 4,075.55 |
| DES ($\alpha = 0.4$) | 262.74 | 107,739.15 | 333.17 | 3,478.13 | 3,404.12 |
| DES ($\alpha = 0.5$) | 274.26 | 121,332.62 | 353.57 | 2,750.36 | 2,553.49 |
| DES ($\alpha = 0.6$) | 295.15 | 137,928.97 | 376.97 | 2,986.96 | 1,693.95 |
| DES ($\alpha = 0.7$) | 320.50 | 158,165.21 | 403.68 | 3,204.80 | 840.56 |
| DES ($\alpha = 0.8$) | 342.79 | 185,749.74 | 437.47 | 3,267.15 | 62.9 |
| DES ($\alpha = 0.9$) | 368.97 | 223,234.21 | 479.58 | 3,427.91 | 647.66 |
| Cyclic | 200.61 | 59,018.28 | 246.38 | 3,184.62 | 3,152.09 |

| | | | | | |
|---|---|---|---|---|---|
| Linear | 201.80 | 59,583.16 | 247.56 | 3,331.74 | 3,298.85 |
| Quadratic | 246.94 | 95,881.53 | 314.3 | 4,126.68 | 4,075.55 |
| Decomposition | 90.20 | 20,565.66 | 128.27 | 61.45 | 41.73 |
| ANN | 0.146725 | 0.065726 | 0.267770 | 0.074275 | 0.012306 |
| **Minimum** | **0.146725** | **0.065726** | **0.267770** | **0.074275** | **0.012306** |

The best method in forecasting Y-Strainer product that is chosen is ANN method, therefore this method will be validated by using a tracking signal. The tracking signal result is shown in Figure 2 below.

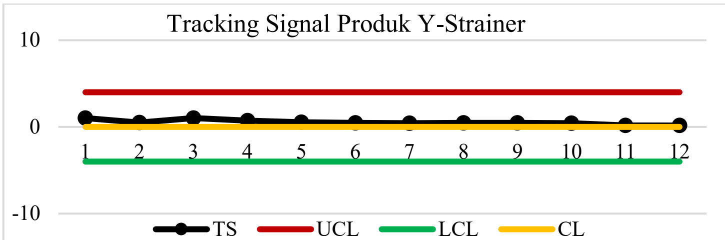


Figure 2. Tracking Signal Result

Based on the graph above, it can be concluded that the tracking signal value of the Y-Strainer product does not exceed the Upper Control Limit (UCL) of 4 and the Lower Control Limit (LCL) of -4 (Gunawan, 2021). Thus, the demand is under control, which means this method represents demand projecting for the upcoming year. The result of the forecasting above is shown in Table 2 below.

Table 2. Y-Strainer Product Forecast Using ANN Method

| **Period** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Quantity** | 39 | 15 | 1 | 11 | 332 | 832 | 832 | 524 | 41 | 14 | 5 | 1 |

## 5.2 Aggregate and Disaggregated Planning

In this study, the selected aggregate planning for the Y-Strainer product is a mixed aggregate planning of shift and overtime because it has the smallest total cost. The result of the mixed aggregate planning is shown in Table 3 below.

Table 3. Mixed Aggregate Planning Result

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.173 | 21 | 4 | 167 | 39 | 363 | 324 | - | - | 324 | 363 | - | 393.6 | 56.249 | 449.849 |
| 2 | 2.173 | 17 | 4 | 139 | 15 | 302 | 611 | - | - | 611 | 302 | - | 393.6 | 106.114 | 499.714 |
| 3 | 2.173 | 21 | 4 | 167 | 1 | 363 | 973 | - | - | 973 | 363 | - | 393.6 | 168.991 | 562.591 |
| 4 | 2.173 | 21 | 5 | 172 | 11 | 374 | 1,335 | - | - | 1,335 | 374 | - | 393.6 | 231.965 | 625.565 |
| 5 | 2.173 | 20 | 4 | 160 | 332 | 348 | 1,351 | - | - | 1,351 | 348 | - | 393.6 | 234.661 | 628.261 |
| 6 | 2.173 | 22 | 4 | 174 | 832 | 378 | 897 | - | - | 897 | 378 | - | 393.6 | 155.794 | 549.394 |
| 7 | 2.173 | 20 | 5 | 165 | 832 | 359 | 423 | - | - | 423 | 359 | - | 393.6 | 73.529 | 467.129 |
| 8 | 2.173 | 22 | 4 | 174 | 524 | 378 | 277 | - | - | 277 | 378 | - | 393.6 | 48.158 | 441.758 |
| 9 | 2.173 | 22 | 4 | 174 | 41 | 378 | 614 | - | - | 614 | 378 | - | 393.6 | 106.746 | 500.346 |
| 10 | 2.173 | 21 | 4 | 167 | 14 | 363 | 963 | - | - | 963 | 363 | - | 393.6 | 167.298 | 560.898 |
| 11 | 2.173 | 18 | 4 | 146 | 5 | 317 | 1,275 | - | - | 1,275 | 317 | - | 393.6 | 221.553 | 615.153 |
| 12 | 2.173 | 22 | 4 | 174 | 1 | 378 | 1,652 | - | - | 1,652 | 378 | - | 393.6 | 287.073 | 680.673 |
| | | | | | | Total | | | | | | - | 4,723.2 | 1,858.132 | 6,581.332 |

Remarks:
A : Month
B : Average Production Quantity/hour
C : Total Production Days (Monday-Friday)
D : Total Production Days (Saturday)
E : Total Production Hours
F : Demand Forecasting (in unit)
G : Production Quantity of Regular Time (in unit)
H : Initial Inventory
I : Overtime
J : Overtime Production (in unit)
K : Final Inventory
L : Total Production Quantity of Regular Time and Overtime (in unit)
M : Overtime Cost
N : Employee Cost (in a million rupiah)
O : Inventory Cost (in a million rupiah)
P : Total Cost (in million rupiah)

The result above shows the total cost of PT. DSG has to expend for mixed aggregate planning is Rp 6,581,332,303. This mixed aggregate planning method is made into disaggregate planning shown in Table 4 below.

Table 4. Disaggregated Planning on Y-Strainer

| **Period** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Quantity** | 339 | 278 | 339 | 344 | 324 | 354 | 328 | 354 | 354 | 339 | 293 | 354 |

## 5.3 Rough Cut Capacity Planning (RCCP)

Based on the prior calculation of CPOF, BOLA, dan RPA, they have the same result where the production capacity met the demand for the master production schedule. RCCP calculation result for the Y-Strainer product is shown in Figure 3 below.

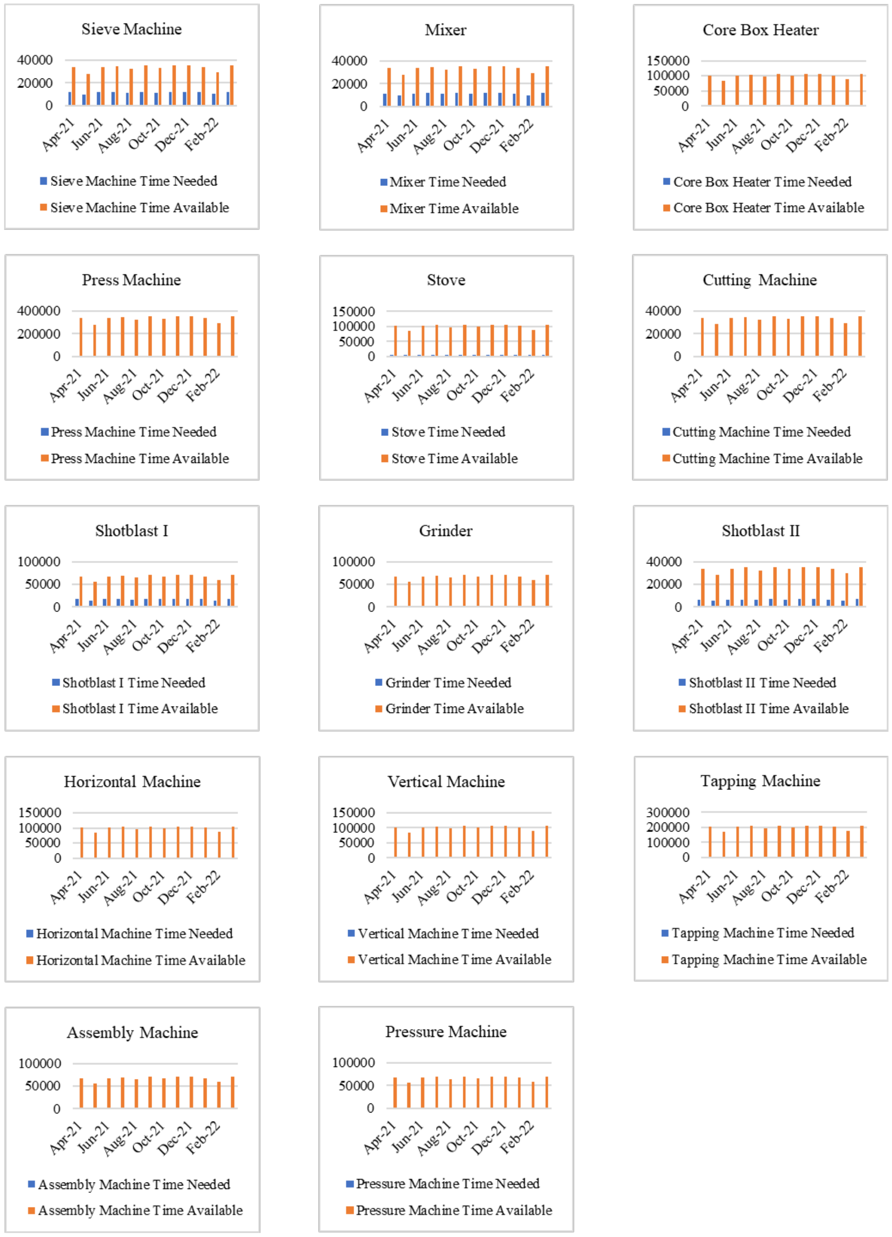


Figure 3. Comparison of Total Time Needed and Total Time Available

## 5.4 Material Requirement Planning (MRP)

The amount of safety stock for each raw material used to calculate the MRP of the Y-Strainer product is shown in Table 5 below.

Table 5. Safety Stock for Y-Strainer Raw Material

| **Raw Material** | **Imported Bronze Ingot 81%** | **Local Bronze Gram 81%** | **Seal Tape** | **Gasket** | **Mesh 20 Filter** |
|---|---|---|---|---|---|
| **Safety Stock** | 1 ton | 1 ton | 20 *roll* | 1 pc | 298 pcs |

A comparison of the cost needed for each Y-Strainer raw material of all lot-sizing techniques is represented in the table and graphic as shown in Table 6 below.

Table 6. Cost Comparison of Each Lot-Sizing

| Raw Material | Raw Material Procurement Cost | | | | | | |
|---|---|---|---|---|---|---|---|
| | PT. DSG Method | EOQ Lot-Sizing | POQ Lot-Sizing | LFL Lot-Sizing | Silver Meal Lot-Sizing | LUC Lot-Sizing | WWA Lot-Sizing |
| Imported Bronze Ingot 81% | Rp 1,500 | Rp 375 | Rp 375 | Rp 4,500 | Rp 1,759.81 | Rp 3,432.04 | Rp 805.34 |
| Local Bronze Gram 81% | Rp 37.50 | Rp 18.75 | Rp 18.75 | Rp 225 | Rp 60.23 | Rp 121.13 | Rp 15.66 |
| Seal Tape | Rp 56.25 | Rp 187.50 | Rp 112.50 | Rp 225 | Rp 191.63 | Rp 852.39 | Rp 142.49 |
| Gasket | Rp 18.75 | Rp 18.75 | Rp 18.75 | Rp 225 | Rp 110.80 | Rp 167.60 | Rp 56.03 |
| Mesh 20 Filter | Rp 4,375.00 | Rp 5,250 | Rp 5,250 | Rp 5,250 | Rp 4,725 | Rp 5,976.64 | Rp 3,675 |
| **Total Cost** | **Rp 5,987.50** | **Rp 5,850** | **Rp 5,775** | **Rp 10,425** | **Rp 6,847.48** | **Rp 10,549.79** | **Rp 4,694.53** |

Based on the comparison of total costs above, it is found that the WWA lot-sizing technique produces the smallest cost. Using WWA lot-sizing, the procurement cost of raw materials for Y-Strainer from April 2021 to March 2022 can save Rp 1,292,972 with a percentage of 22% compared to the procurement cost of the method currently used by PT. DSG.

## 5.5 Capacity Requirement Planning (CRP)

Based on the prior calculation, the time available is greater than the time needed in producing Y-Strainer. This figure shows that PT. DSG can meet customer demand from April 2021 to March 2022 with the available resources. The comparison of the above is shown in Figure 4 and Figure 5 below.

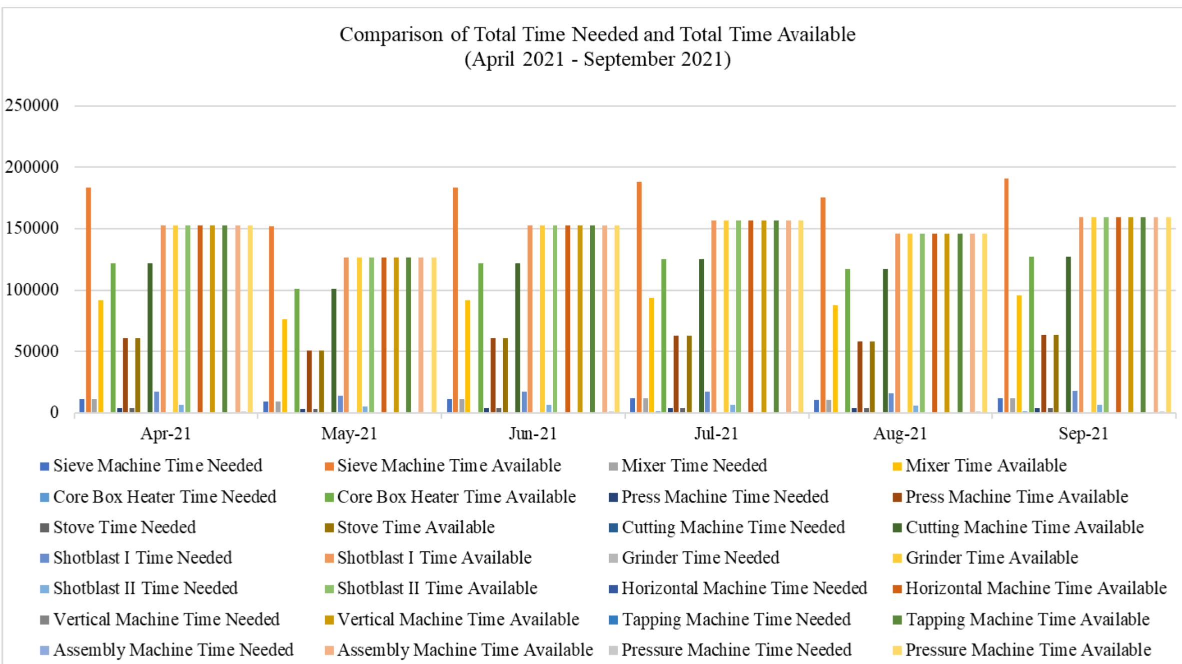


Figure 4. Comparison of Total Time Needed and Total Time Available from April 2021 to September 2021

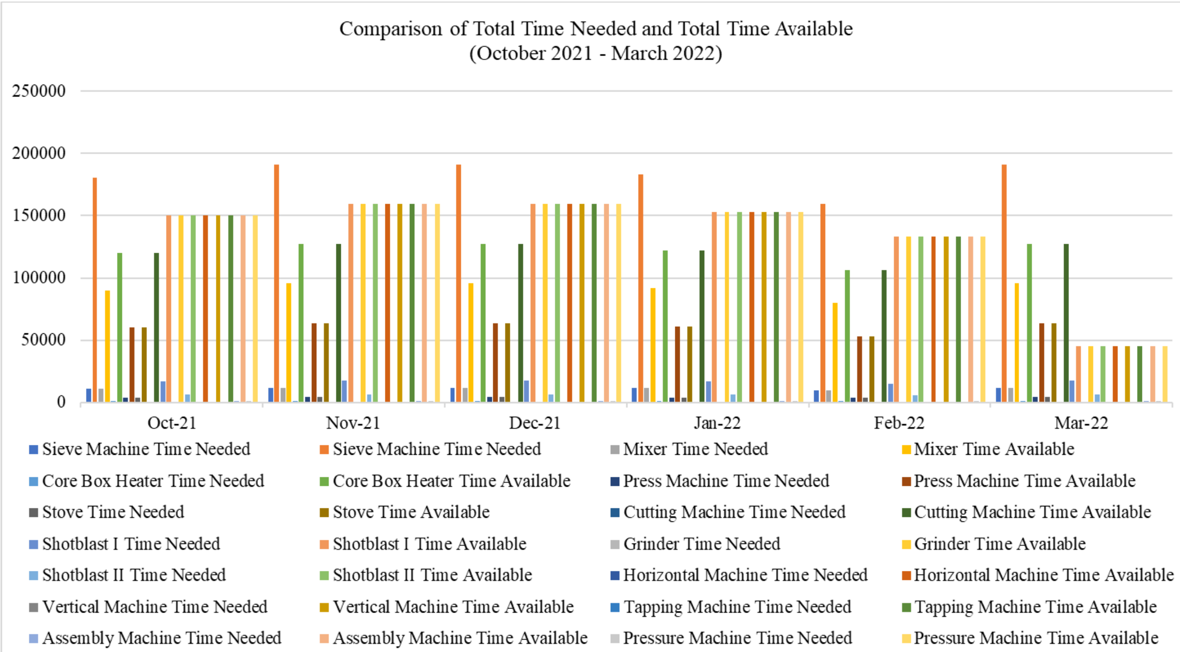


Figure 5. Comparison of Total Time Needed and Total Time Available from October 2021 to March 2022

Based on the calculation above, the production capacity meets the demand. Figures 4 and 5 show that PT. DSG can meet demand from April 2021 to March 2022 with the available resources.

## 5.6 Distribution Requirement Planning (DRP)

The cost comparison of the total distribution cost from all customers before and after the implementation of DRP is shown in Table 7 below.

Table 7. Cost Comparison Before and After DRP Implementation

| Total Cost | |
|---|---|
| **Before DRP Implementation** | **After DRP Implementation** |
| Rp 3,452,986 | Rp 1,663,709 |
| **Cost Savings** | |
| Rp 1,789,276 | |
| 52% | |

## 5.7 Enterprise Resource Planning (ERP)

ERP system display using Odoo for PT. DSG is as follows.

1. User Login

User login is a page where users input their email account and password to get into the ERP system. The user login display is shown in Figure 6 below.

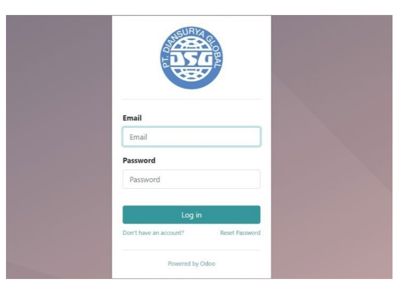


Figure 6. User Login

2. Odoo Module Menu
This menu is the main menu for selecting Odoo modules, where the number of Odoo modules can be added as needed. The menu display for the Odoo module is shown in Figure 7 below.

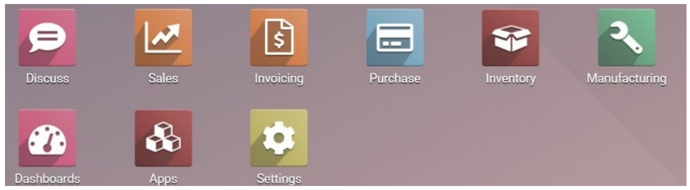


Figure 7. Odoo Module Menu

3. Inventory Menu
An inventory menu is a menu to control the stock of raw materials and products. The inventory menu display is shown in Figure 8 below.

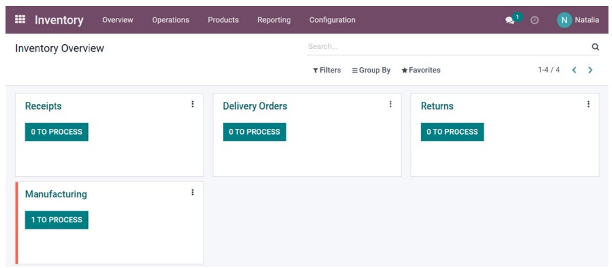


Figure 8. Inventory Menu

Inventory consists of raw materials and products sold, the distinguish them on the "products" menu, raw materials are marked with a "Can be Purchased" label, while products sold are marked with a "Can be Sold" label. The inventory menu displays for raw materials and products sold sequentially is shown in Figure 9 and Figure 10 below.

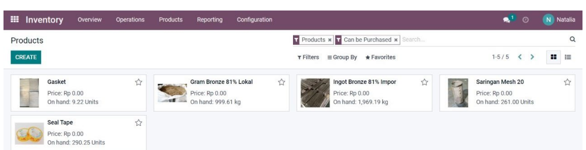

Figure 9. Inventory Menu for Raw Materials

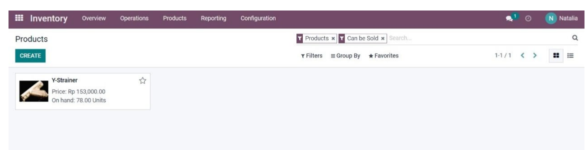

Figure 10. Inventory Menu for Products Sold

4. Sales Menu
The sales menu is a menu for inputting customers, quotations, and products sold. The sales menu display is shown in Figure 11 below.

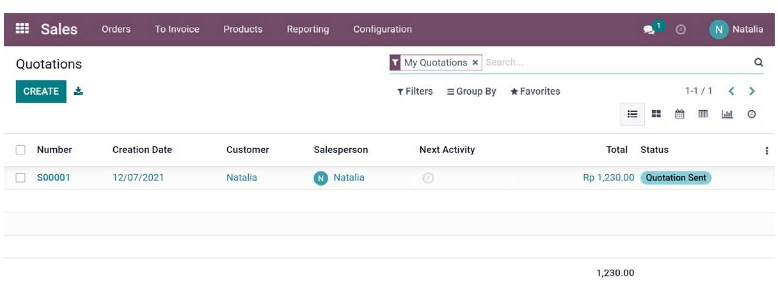


Figure 11. Sales Menu

5. Purchase Menu

The purchase menu is a menu for creating and controlling invoices such as sales and purchasing invoices, incoming and outgoing goods. The purchase menu display is shown in Figure 12 below.

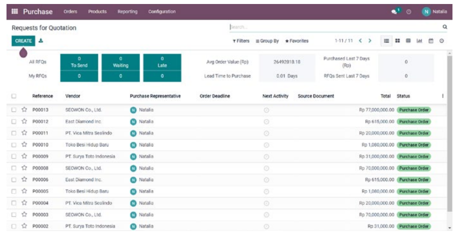

Figure 12. Purchase Menu

There is a list of company vendors (suppliers) on the purchase menu, which is shown in Figure 13 below.

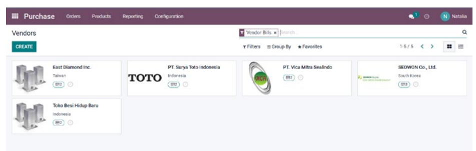

Figure 13. Vendor List on Purchase Menu

There is a feature on the purchase menu to send a purchase order to the vendor's email by clicking "Send PO by Email" marked with a green circle in Figure 14 below. Then if the company has received the raw materials, they can directly click on "Receive Products" marked with a red circle in Figure 14 below. The amount of stock on the inventory menu will increase automatically.

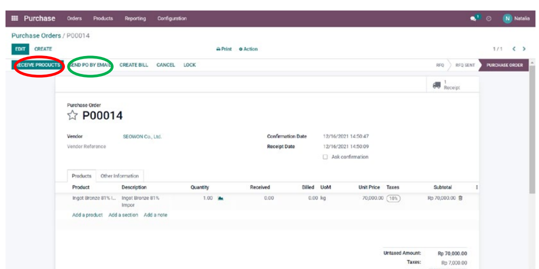

Figure 14. Purchase Order on Purchase Menu

6. Manufacturing Menu

The manufacturing menu is a menu for carrying out orders for the production process by creating a manufacturing order file. Before creating an order, the user has to enter the bill of material data. The bill of materials for the Y-Strainer product in the ERP system is shown in Figure 15 below.

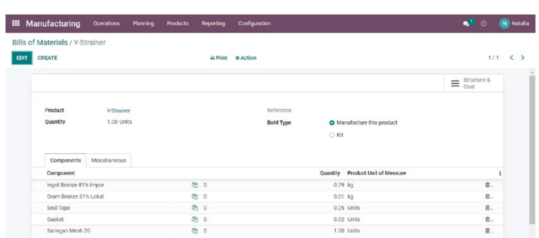

Figure 15. Bill of Material of Y-Strainer

If the order has been made, the stock of raw materials will be reduced automatically according to the number of raw materials in the manufacturing order needed for the production process. The manufacturing menu display is shown in Figure 16 below.

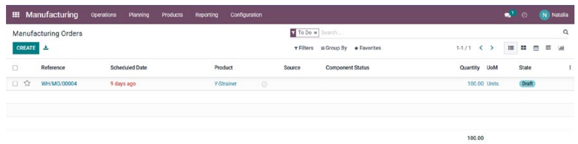


Figure 16. Manufacturing Menu

When creating a manufacturing order, the production department can also view the availability of raw materials needed for production by clicking "check availability". If raw materials are available, then the raw materials (components) color will change to black, as shown in Figure 17. In contrast, if raw materials are not available, the color of raw materials (components) will remain red.

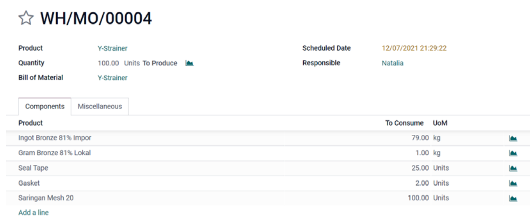


Figure 17. Raw Materials Availability Check on Manufacturing Order

Before and after the ERP system implementation is shown in Table 8 below.

Table 8. Comparison of Before and After the ERP System Implementation

| Before ERP System Implementation | After ERP System Implementation |
|---|---|
| Inventory data collection and raw material receipts are manually using Microsoft Excel | Inventory data collection and raw material receipts can be recorded automatically based on purchases made carried out by the purchasing department |
| Inventory of raw materials are manually using Microsoft Excel | Raw materials that have been received from suppliers will be updated automatically by the ERP system |
| The data collection of goods entering and leaving the warehouse is updated at a certain time manually using Microsoft Excel | Data collection of goods can be done automatically in real time because it is stored in the ERP database |
| Each department involved has its data, and information sharing is still limited | Each related department can view the required information automatically |
| Quotation, invoices, forms, manufacturing orders files, etc., are created manually. | Quotation, invoices, forms, manufacturing orders files, etc., are generated automatically in the ERP system and can be downloaded. |

## 6. Conclusion

The right forecasting method used for the Y-Strainer product is the Artificial Neural Network (ANN) method because it has the smallest error value compared to other forecasting methods. Aggregate planning chosen uses mixed aggregate planning of shift and overtime because the costs incurred are the smallest compared to other aggregate plans, which are Rp 6,581,332,303. RCCP calculation is done using CPOF, BOLA, and RPA techniques; the result shows that the production capacity meets the demand for the master production schedule. The CRP calculation shows that the capacity/availability is greater than the needs. Therefore, PT. DSG can meet customer demand from April 2021 to March 2022 with the available resources. The lot-sizing technique chosen for the MRP calculation is the Wagner Within Algorithm (WWA) method with a savings of Rp 1,292,972 with a percentage of 22% compared to the company's current method. Distribution planning using DRP can save Rp 1,789,276 with a percentage of 52% compared to the method currently used by the company. The Odoo ERP system can make it easier for companies to control business operations because it is more practical and efficient for the data collection can be done automatically in real time and stored in the ERP database.

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## Biographies

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**Lina Gozali** is a lecturer at the Industrial Engineering Department of Universitas Tarumangara since 2006 and a freelance lecturer at Universitas Trisakti since 1995. She graduated with her Bachelor's Degree at Universitas Trisakti, Jakarta – Indonesia, then she got her Master's Degree at STIE IBII, Jakarta – Indonesia, and she recently got her Ph.D. at Universiti Teknologi Malaysia, Kuala Lumpur – Malaysia in 2018. Her apprentice college experience was in paper industry at Kertas Bekasi Teguh, shoes industry at PT Jaya Harapan Barutama, and automotive chain drive industry at Federal Superior Chain Manufacturing. She teaches Production System and Supply Chain Management Subjects. She did a research about Indonesian Business Incubator for her Ph.D. She has written almost 70 publications since 2008 in the Industrial Engineering research sector, such as Production Scheduling, Plant Layout, Maintenance, Line Balancing, Supply Chain Management, Production Planning, and Inventory Control. She had worked at PT. Astra Otoparts Tbk before she became a lecturer.

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