Production Planning and Control in Furniture Company at PT. Lion Metal Works

by Lina Gozali


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12:00 – 1:45 pm, MONDAY — Case Studies — Room 2

Session Chair: Goh Ying Soon, Universiti Teknologi MARA, 54000 Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, Malaysia

ID 776 Marketing Communication Strategy of the Tourism and Culture Office of Langkat Regency in Increasing Tangkahan Tourist
Nina Siti Salmaniah Siregar, Armansyah Matondang, Ilma Saakinah Tarell and Abdul Harls, Communication Science Study Program, Faculty of Social and Political Sciences, Universitas Medan Area, North Sumatera, Indonesia
Beby Mashito Batubara and Agung Suharyanto, Public Administration Study Program, Faculty of Social and Political Sciences, Universitas Medan Area, North Sumatera, Indonesia
Evi Yunita Kurniaty, Governmental Science Study Program, Faculty of Social and Political Sciences, Universitas Medan Area, North Sumatera, Indonesia

ID 772 Does Digital Marketing Platforms affect Business Performance? A Mini-Review Approach
Mohamad Arfiman Yosep, Monizaihasra Mohamed, Mohd Yusoff Yusliza, Jumadil Saputra and Zikri Muhammad, Faculty of Business, Economics and Social Development, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

ID 774 2013 Curriculum Implementation in Physical Learning
Tri Kurnia Badu, Syafa Lisaholit, Vivi Rahim Hentihu, Siti H Lollatu, and Suraya Mukaddar, Universitas Iqra Buru, Namlea, Indonesia
M Chairul Basrun Umanailo, Department of Agricultural and Forestry, University of Iqra Buru, Namlea, 97571, Indonesia

ID 769 Conceptualizing the Role of Patient Satisfaction in the Relation between Services Quality and Patient Loyalty in Jordan Public Hospitals
Salahaldeen Alkawamleh, Puspa Liza Ghazali, Rosilda Abdul Razak, Juliana Arifin and Erl Norein Mohmad Zain, Faculty of Business and Management, Universiti Sultan Zainal Abidin Unisza, 21300 Kuala Nerus, Malaysia
Sukono,Universitas Padjadjaran, Bandung. West Java. Indonesia
Rini Cahyandari, UIN Sunan Gunung Djati Bandung, West Java. Indonesia
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ID 861 Capital Investment Analysis of New Business Unit Education Technology at PT Berau Coal
Cahyo Andrianto, Executive MBA Student, School of Business and Management Institute of Technology Bandung, Bandung
Yunieta Anny Nainggolan, Lecturer of Business Risk and Finance Interest Group, School of Business and Management Institute of Technology Bandung, Bandung, Indonesia

ID 879 The Influence of Digital Folktales on the Students' English Vocabulary Mastery of SMP Negeri 9 Buru
Abd. Rahman, Universitas Iqra Buru, Maluku, Indonesia

ID 969 The Constructiveness of Online Learning in Mandarin Course During COVID-19 Pandemic Season
Nurul Ain Chua Binti Abdullah, Che Mohd Zaid, Rozwati Abdul Rahid, Mazlina Ahmad and Azlina Musa, Center for Foundation and Continuing Education, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia
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Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

12:00 – 1:45 pm, MONDAY — Operations Management — Room 3

Session Chair: Lina Gozali, and Frans Jusuf Daywin, Lecturer of Industrial Engineering, Tarumanagara University, Jakarta, Indonesia

ID 079 The importance and satisfaction of location decision factors of South African manufacturing and service SMMEs: An Exploratory Factor Analysis
Alice Kabamba Lumbwe, Eveth Nwobodo-Anyadiegwu, and Charles Mbohwa, Department of Quality and Operations Management, University of Johannesburg, Johannesburg, South Africa

ID 589 The Power of Hypothesis Parameters Testing on Geometric Distributions and Its Simulation
Budi Pratikno, and Evita Luaris Wulandari, Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Soedirman, Purwokerto, Indonesia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

ID 049 Influence of Substrate Temperatures on Morphological TiO2 Nano-layers Properties
Bedoud Khouloud, Merabet Hichem, Graine Redouane, Alimi Latifa, and Drici Djalel, Research Center in Industrial Technologies (CRTI), Cheraga, Algeria

ID 451 Modeling and configuration management of Reconfigurable Manufacturing Systems (RMS)
Jesus Vital Kombaya, Nadia Hamani and Lyes Kermad, Department of Industrial Engineering, University of Paris 8, Paris, France and University Picardie Jules Verne, Saint Quentin, France

ID 370 Developing a Multi Criteria Decision Making Framework to Select the Most Suitable Production System in Apparel Firms: Use of ANP Method
Wijayanayake A.W., Thalagahage N.T.H, and D.H.H. Niwunhella, Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka

ID 458 Production Planning and Control in Furniture Company at PT. Lion Metal Works
Lina Gozali, and Frans Jusuf Daywin, Lecturer of Industrial Engineering, Tarumanagara University, Jakarta, Indonesia
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This is to certify that

Lina Gozali, Frans Jusuf Daywin, Andri Tan Wijaya

Tarumanagara University, Jakarta, Indonesia

Delivered an Oral Presentation entitled "Production Planning and Control in Furniture Company at PT Lion Metal Works" at the Eleventh Annual International Industrial Engineering and Operations Management Conference Virtually via Zoom.

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Production Planning and Control in Furniture Company at PT. Lion Metal Works

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ABSTRACT

Production planning and control that is not executed properly can make it difficult for a company to determine the demand needed to make its products. This happened to PT. Lion Metal Works. Production planning and control are things that need to be done for every manufacturing company in regulating its production activities so that it stays on target. This research requires request data from January 2017 to 2019, and other supporting data to carry out the forecasting method and then proceed with disaggregated aggregates, rough-cut capacity planning, material requirement planning, and capacity requirement planning. The results of the best forecasting calculations were using neural networks, aggregate and disaggregated planning in the form of a mixed shift and overtime scheduling totaling Rp. 3,837,237,500, rough-cut capacity planning does not have a lack of resources, material requirement planning using the silver meal method and the Wagner Within algorithm with the result is IDR 11,110,385,953 for 15 materials during the 2020 period, and in capacity, requirement planning there is a shortage of 9.9% for painting machines and 9.8% for packaging. The best solution for the problem of lack of painting and packaging machines is to add overtime hours with a total cost of Rp. 389,170,000 and 498,750,000.

Keyword: *Forecast, Aggregate, Disaggregate, RCCP, MRP, CRP*

1. Introduction

The industry is an economic activity for profit by producing various products which will then be distributed to consumers. However, there are many challenges in marketing its products to consumers, both from internal and external challenges such as competitors. Therefore, in order to compete with competitors, the industry is currently trying to always make developments in many aspects.

PT. Lion Metal Works has problems in determining the demand needed to make its products. This is because the demand from consumers is always fluctuating or uncertain every year. As a result, PT Lion Metal Works often experienced a production shortage, and other problems, some products that were made were piled up because they were not sold. The problem that arises from piling up unsold items is that the goods are damaged because they have been stored in the warehouse for too long. The problems that exist in PT. Lion Metal Works caused many losses to the company. Therefore, it is necessary to improve the planning and control of production. The aim of this research to make a planning production and inventory control with software for PT. Lion Metal.

2. Literatur Review

2.1. Forecasting

Forecasting is an art and science in predicting future events [Heizer, 2015]. Appropriate forecasting in a company will give a good effect in company in determining the production amount. There are following methods used:

1. SMA (*Simple Moving Average*)

$$F_{t+m} = \frac{\sum_{i=1}^{t-N+1} Xi}{N}$$

2. DMA (*Double Moving Average*)

$$F_{t+m} = a_t + b_m \text{ ....(2a)}$$
$$a_t = S'_t + (S'_t - S"_t) \text{ ....(2b)}$$
$$b_t = \frac{2}{N-1}(S'_t - S"_t) \text{ ....(3c)}$$

3. WMA (*Weighted Moving Average*)

$$F_{t+1} = \alpha X_t + (1-\alpha)F_t$$

4. SES (*Single Exponential Smoothing*)

$$F_{t+1} = \alpha X_t + (1-\alpha)F_t$$

5. DES (*Double Exponential Smoothing*)

$F_{t+m} = a_t + b_t .m$ .... (5a)
$a_t = 2S'_t - S''_t$ .... (5b)
$b_t = \frac{\alpha}{1-\alpha} . (S'_t - S''_t)$ .... (5c)
$S'_t = \alpha A_t + (1 - \alpha) S'_{t-1}$ .... (5d)
$S''_t = \alpha S'_t + (1 - \alpha) S'$ .... (5e)

6. Regresi Linear

$Y'(t) = a + b (t)$ .... (6a)
$b = \frac{n \sum x y - \sum x \sum y}{n \sum x^2 - (\sum x)^2}$ .... (6b)
$a = \frac{\sum y - b \sum t}{n}$ .... (6c)

7. Kuadratik

$Y'(t) = a + bt + ct^2$ .... (7a)
$b = \frac{\gamma\delta - \theta\alpha}{\gamma\beta - \alpha^2}$ .... (7b)
$c = \frac{\theta - b\alpha}{\gamma}$ .... (7c)
$a = \frac{\sum Y(t) - b \sum t - c \sum t^2}{n}$ .... (7d)

8. Siklik

$Y'(t) = a + b \sin \frac{(2¶t)}{N} + c \frac{(2¶t)}{N}$ .... (8a)
$a = \sum Y(t) / N$ .... (8b)
$b = \sum Y(t) \sin \frac{(2¶t)}{N} / N$ .... (8c)
$c = \sum Y(t) \cos \frac{(2¶t)}{N} / N$ .... (8d)

9. Artificial Neural Network
Artificial Neural Networks is a processing system that has characteristics similar to a biological neural network [Siang,2005]. The formula used is

$$\text{Normalisasi data} = \frac{X - Xmin}{Xmax - Xmin}$$

2.2. Forecasting Verification

The purpose of forecasting verification which checking the forecasting function that should represents existing data. Forecasting method that would be selected should have the smallest error value. Three of most frequently formula used is [Sunarmintyastuti, et.al, 2015]:

1. *Mean Absolute Deviation* (MAD)
The method for evaluating forecasting methods uses the sum of absolute errors.
$$MAD = \frac{|Xi - Fi|}{n}$$
2. *Mean Squared Error* (MSE)
The method the produces moderate errors that are likely to be better for small and large scale error
$$MSE = \frac{(Xi - Fi)^2}{n}$$
3. *Mean Absolute Percentage Error* (MAPE)
MAPE is average absolute difference between the values and predicted in that period.
$$MAPE = \frac{100 \frac{|Xi - Fi|}{Xi}}{n}$$

2.3. Aggregate and Disaggregate Planning

Aggregate planning is one of the calculation methods that can find the production planning schedule. The purpose of aggregate planning is the first step to determine production activities, resources, stabilization of production, and assignment labor to fulfill the fluctuations demand.

Disaggregate is a model for obtaining the production planning for each type of product in each product group from the aggregate plan [Vincent, 2004}. The aggregate planning only provides a production plan for the entire product, so the calculation must be continued to disaggregate production planning into several products for each type of product. Before discussing the disaggregate grouping procedure, it must be understood about the definition of product grouping. Manufacturing companies with many types of products usually grouping their products into product groups or families. The grouping is base on the similarity of the technology process, similarity demand patterns, similarity function, etc.

2.4. Master Production Schedule

Capacity Planning determines the level of capacity needed to do a production schedule that consists of the available capacity and necessary adjustment to the capacity level of a production schedule. Capacity Planning calculation can be seen in MPS [Eddy, 2007]. MPS (Master Production Schedule) is a production planning that describes how many amounts each type of product is needed. The function of MPS is the schedule of production items, which the guidance of Material Requirement Planning and Rough Cut Capacity Planning (RCCP).

2.5. Rough Cut Capacity Planning

RCCP (*Rough Cut Capacity Planning*) is a long-term planning. RCCP is used to determine the capacity requirments needed to implement in MPS. Basically, there are four step needed to implement RCCP that is [Eunike, et.al., 2018]:

1. Get information about production planning from MPS.
2. Get Information about product structure and lead time.
3. Determine *bill of resources*.
4. Calculate specific resource requirements and make RCCP report.

RCCP used in this research is use three methods, CPOF (Capacity Planning Overall Factor), BOLA (Bill of Labour Approach), and RPA (Resource Profile Approach). The formula used in RCCP is:

1. Capacity Machine: Available Time x Total Machines
2. Total Production Time: Amount of Production x Standart Time

The value of total time production must be less than capacity machines. Based on 3 RCCP methods used this is the formula:

1. Capacity Planning Overall Factor (CPOF)
   a. Calculate historical value of machine:
      HM = Total Standart Time: Standart Time
   b. Calculate total capacity requirement:
      TCR = Total Standart Time x Amount of Production
   c. Calculate time needed each machine:
      Waktu Produksi Permesin = HM x TCR
   d. Comparing the production time needed for each machine with the capacity of machines. The value of production time required must less than capacity of machines.
2. Bill of Labour Approach (BOLA)
   a. Calculate time production each machine:
      Machine Production Time = amount of production x standart time
   b. Comparing the production time needed each machine with the capacity of machines
3. Resource Profile Approach (RPA)
   a. Calculate time production each machine:
      Machine Production Time = amount of production x standart time
   b. Comparing the production time needed each machine with the capacity of machines

2.6. Material Requirment Planning

MRP (Material Requirement Planning) is an information system that can translate the master production schedule for finished goods into several stages of production needs [William, 2012; Gozali, 2020a]. The concept of production management is a need for raw material for production planning. The purpose of the MRP system which controlling the inventory levels, determining priorities items, calculating the inventory planning in the production system. The following methods are used:

1. LFL (*Lot For Lot*)
   The *lot for lot* (LFL) method is a method to minimize the inventory level based on providing inventory as needed at the exact time. The cost for this method just calculates the order cost
2. EOQ (*Economic Order Quantitiy*)
   This method which based on of best ideal number of raw material to book:

$$EOQ = Q^* = \sqrt{\frac{2DS}{H}}$$

3. POQ (*Periodic Order Quantitiy*)
   This method is similar to EOQ, but the difference is there are some modification that used for discrete period requests

$$\mathrm{EOI} = \frac{\mathrm{EOQ}}{\mathrm{R}} = \sqrt{\frac{2\mathrm{C}}{\mathrm{RPh}}}$$

4. LUC (*Least Unit Cost*)
   The Methods that observe the cost of inventory level for each unit

$$(L) = \frac{s + (h \sum_{t=T}^{L} [(t - dT)dt]}{J}$$

5. AWW (*Algoritma Wagner Within*)
   Method that provides optimum solutions for deterministic ordering problems over a certain period of time

$$\boldsymbol{O_{en}} = \mathbf{A} + \boldsymbol{h} \sum (\mathbf{q_{en}} - \mathbf{q_{et}}) \quad \text{(5a)}$$
$$\boldsymbol{f_n} = \boldsymbol{Min}\ [\boldsymbol{O_{en}} + \boldsymbol{fe-1}] \quad \text{(5b)}$$
$$f_N = O_{en} + f_{e-1} \quad \text{(5c)}$$
$$f_{e-1} = O_{ve-1} + f_{v-1} \quad \text{(5d)}$$

6. *Silver Meal*
   This method is based on the cost period.

$$\frac{TRC(T)}{T} = \frac{C + \text{Total biaya simpan hingga akhir perioda } T}{T} \quad \text{(6a)}$$
$$\frac{TRC(T)}{T} = \frac{C + Ph \sum (K-1) Rk}{T} \quad \text{(6b)}$$

MRP need to calculate value of safety stock of raw material. Formula used for safety stock number is:

$$SS = Z\ x\ \sigma\sqrt{L}$$

Z = standart normal (from distribution normal table)
σ = standart deviation
L = lead time

2.7. Capacity Requirement Planning

Capacity planning shows how many labor, machines, and resources are needed to fulfill production. [Gozali, et.al.,2020b; Lefta, 2020a; Lefta, 2020b; Wijaya, 2020]. CRP is a capacity calculation technique required by material requirement planning. The formula used in CRP is similar RCCP method, but the difference is there is have efficiency.

a. Capacity Machine: Available Time x Total Machine x Efficiency
b. Total Production Time: Total Production x Standart Time

3. Methodology Research

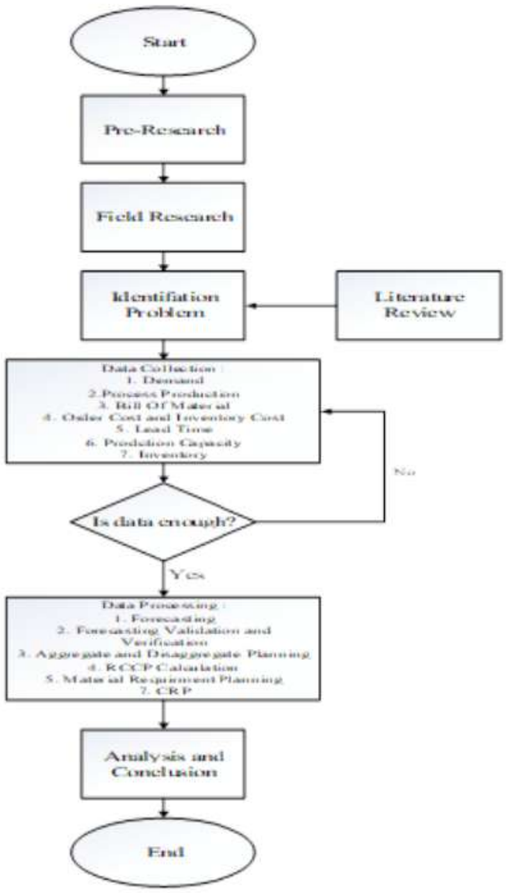


Figure 1. ***Flowchart*** **Research Methodology**

The first step, finding and identifying the problem. After that, find the method for solving the problem that is owned by PT. Lion Metal Works systematically. This research uses the forecasting method, aggregate and disaggregates planning, rough-cut capacity planning (RCCP), material requirement planning (MRP), and capacity requirement planning (CRP). The Data will use demand for each product in January 2017 until December, labor costs, overtime costs, inventory costs, lead time, production capacity, and bill of material. The forecasting method uses an artificial neural network method and verification error with MAD, MSE, and MAPE. After forecasting for the following year, it can continue to calculate the aggregate and disaggregate method. The option for aggregate and disaggregate planning is shift strategy, overtime strategy, and mix shift overtime strategy. Then, RCCP calculation for getting availability of machines with 3 methods that is BOLA, RPA, and CPOF. Material requirement planning calculates getting the smallest cost for each material by using LFL, EOQ, POQ, LUC, Silver Meal, and AWW. Finally, the CRP method to calculate machine availability. The Final result shows the conclusion and suggestions for PT. Lion Metal Works. A flowchart of the research methodology can be seen in figure 1.

4. Result and Implementation

Based on this research methodology, the first method used is forecasting. Forecasting using 3 years' demand data from January 2017 to December 2019. The demand data can be seen in table 1

Table 1. Demand Data From Januari 2017 – Desember 2019

Month	Demand	Month	Demand	Month	Demand
Jan-17	2798	Jan-18	3552	Jan-19	3736
Feb-17	3144	Feb-18	3049	Feb-19	2099
Mar-17	4108	Mar-18	4708	Mar-19	2784
Apr-17	4483	Apr-18	3272	Apr-19	2236
May-17	3603	May-18	5655	May-19	2469
Jun-17	2212	Jun-18	1922	Jun-19	1671
Jul-17	3775	Jul-18	6779	Jul-19	1714
Aug-17	3516	Aug-18	2177	Aug-19	2830
Sep-17	3364	Sep-18	3640	Sep-19	2296
Oct-17	3946	Oct-18	3319	Oct-19	2917
Nov-17	3976	Nov-18	3498	Nov-19	2749
Dec-17	1565	Dec-18	2708	Dec-19	2107

Table 2 Normalization Demand Data

No	L-31K	L-33	L-33A	L-33AK	L-44	L-44E	L-552	L-553	L-554	L-556
1	0,594	0,474	0,087	0,324	0,235	0,144	0,111	0,258	0,053	0,552
2	0,445	0,384	0,196	0,440	0,297	0,130	0,345	0,282	0,215	0,282
3	0,594	0,595	0,354	0,466	0,404	0,239	0,489	0,272	0,236	0,737
4	0,422	0,400	0,146	0,569	0,482	1,000	0,107	0,239	0,125	1,000
5	0,648	0,423	0,065	0,302	0,386	0,353	0,363	0,315	0,403	0,259
6	0,391	0,186	0,000	0,264	0,162	0,185	0,155	0,054	0,254	0,190
7	0,313	0,538	0,152	0,469	0,344	0,216	0,556	0,087	0,262	0,672
8	0,672	0,387	0,171	0,653	0,351	0,265	0,305	0,317	0,131	0,345
9	0,406	0,603	0,543	0,276	0,347	0,090	0,241	0,151	0,151	0,750
10	0,617	0,856	0,534	0,531	0,431	0,172	0,134	0,281	0,147	0,692
11	0,570	0,641	0,457	0,823	0,380	0,269	0,105	0,345	0,543	0,306
12	0,000	0,142	0,012	0,000	0,123	0,124	0,000	0,000	0,344	0,000
13	0,391	0,443	0,255	0,478	0,274	0,468	0,250	0,369	0,339	0,297
14	0,258	0,410	0,193	0,267	0,299	0,154	0,272	0,497	0,302	0,086
15	0,711	0,569	0,245	0,394	0,431	0,208	0,728	0,300	1,000	0,664
16	0,672	0,373	0,022	0,422	0,282	0,197	0,496	0,127	0,354	0,241
17	1,000	0,792	0,149	0,594	0,412	0,920	0,586	0,967	0,573	0,506
18	0,203	0,200	0,043	0,274	0,194	0,039	0,041	0,045	0,219	0,067
19	0,703	1,000	1,000	1,000	1,000	0,382	0,579	1,000	0,420	0,317
20	0,484	0,000	0,186	0,189	0,000	0,000	0,526	0,095	0,435	0,328
21	0,453	0,310	0,028	0,336	0,259	0,046	0,828	0,104	0,926	0,302
22	0,359	0,386	0,093	0,273	0,159	0,035	0,884	0,276	0,208	0,494
23	0,586	0,648	0,283	0,636	0,224	0,175	0,143	0,477	0,521	0,293
24	0,758	0,496	0,078	0,363	0,084	0,019	0,580	0,002	0,059	0,362
25	0,313	0,263	0,289	0,255	0,214	0,090	1,000	0,159	0,843	0,274
26	0,305	0,241	0,258	0,286	0,161	0,019	0,084	0,062	0,278	0,170
27	0,523	0,384	0,137	0,124	0,118	0,061	0,307	0,435	0,549	0,418
28	0,414	0,124	0,130	0,310	0,088	0,033	0,433	0,114	0,000	0,384
29	0,852	0,219	0,078	0,255	0,304	0,109	0,141	0,118	0,002	0,332
30	0,180	0,189	0,065	0,047	0,083	0,128	0,035	0,172	0,157	0,071
31	0,508	0,096	0,065	0,099	0,066	0,154	0,157	0,069	0,020	0,166
32	0,656	0,297	0,161	0,524	0,280	0,066	0,136	0,130	0,481	0,213
33	0,688	0,438	0,186	0,189	0,117	0,017	0,204	0,163	0,199	0,198
34	0,492	0,332	0,366	0,392	0,420	0,049	0,081	0,201	0,195	0,252
35	0,367	0,324	0,127	0,361	0,234	0,137	0,078	0,601	0,158	0,297
36	0,133	0,102	0,078	0,260	0,079	0,148	0,290	0,196	0,145	0,190

After having 3 years of demand data, the calculation of neural networks starts with normalizing the data. The result calculation of data normalizing can be seen in table 2.

The data normalization will proceed with MATLAB software to obtain the architecture neural network. The result of the architecture neural network after conducting a training parameter using activation tansig function as the hidden layer and logsig as the output layer is the 12-4-1 pattern of the neural network. Pattern 12-4-1 can be interpreted as the neural networks needed 12 input data named X1-X12. X1-X12 are the input demand data from month 1 until 12. By using tansig function as a hidden layer, X1-X12 will be formed into 4 hidden layers, which are given symbol Z1-Z4. After that, Z1-Z4, by using logsig function, will be formed into 1 output, it is given the symbol Y1 (Wijaya, 2020). This Y1 is the result of the forecast for next month. The network architecture can be seen in figure 2.by using logsig function will be formed into 1 output it is given the symbol Y1. This Y1 is the result of the forecast for next month. The network architecture can be seen in figure 2.

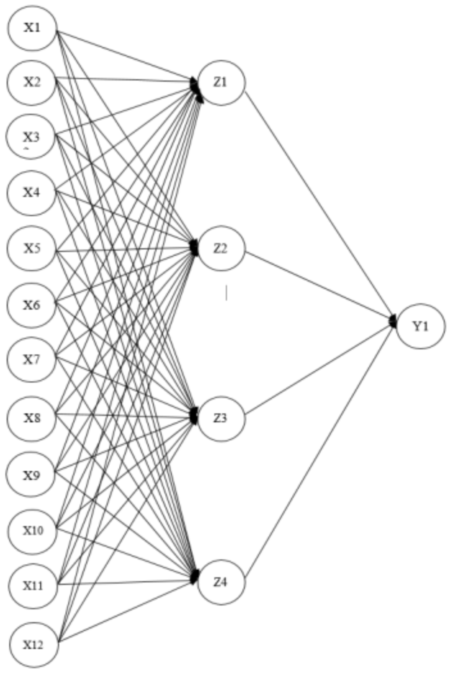


Figure 2 Neural Network

The result of MATLAB software for the forcast data normalization for next 12 month can be seen in table 3.

Table 3 Result Normalization Forecast

No	L-31K	L-33	L-33A	L-33AK	L-44	L-44E	L-552	L-553	L-554	L-556
1	0,667	0,111	0,066	0,480	0,639	0,128	1,000	0,128	0,994	0,172
2	0,995	0,110	0,071	0,217	0,365	0,080	1,000	0,200	0,028	0,194
3	0,188	0,147	0,083	0,116	0,081	0,053	0,106	0,138	1,000	0,343
4	0,569	0,199	0,168	0,242	0,176	0,037	0,198	0,335	0,001	0,262
5	0,497	0,181	0,968	0,221	0,132	0,063	1,000	0,281	0,990	0,320
6	0,090	0,123	1,000	0,526	0,913	0,134	0,053	0,288	0,217	0,218
7	1,000	0,263	0,658	0,232	0,773	0,157	0,034	0,230	0,999	0,216
8	0,156	0,125	0,068	0,295	0,174	0,130	0,109	0,136	0,002	0,185
9	0,512	0,082	0,065	0,469	0,068	0,033	1,000	0,165	0,002	0,236
10	0,992	0,069	0,065	0,090	0,077	0,014	0,035	0,183	0,006	0,265
11	0,017	0,049	0,088	0,440	0,986	0,056	0,037	0,131	0,020	0,260
12	0,603	0,047	0,367	0,068	0,990	0,145	0,371	0,235	0,463	0,163

The error result of calculation each product can be seen in table 4

Table 4. Result Calculation of Error Value.

Jenis Eror	L-31K	L-33	L-33A	L-33AK	L-44	L-44E	L-552	L-553	L-554	L-556
MAD	0,0025	0,02	0,04	0,02	0,39	0,12	0,23	0,06	0,1	0,1
MSE	**0,001**	0,012	**0,0029**	**0,0024**	0,26	**0,09**	0,22	**0,01**	**0,02**	**0,02**
MAPE	0,0037	**0,01**	0,05	0,0043	**0,08**	0,11	**0,07**	0,04	0,09	0,09

The next process is doing a denormalization data forecast next month for each product for getting the real value of unit production. The result of calculation denormalization forecast data can be seen in table 5.

Tabel 5. Result of Denormalization Data

No	L-31K	L-33	L-33A	L-33AK	L-44	L-44E	L-552	L-553	L-554	L-556
1	96	301	57	499	1500	179	1183	94	623	100
2	138	301	59	320	958	130	1183	135	99	110
3	35	331	63	252	399	102	167	100	627	179
4	84	373	90	337	584	85	272	213	84	142
5	75	359	348	323	499	112	1183	182	621	168
6	22	311	358	530	2041	186	108	186	202	121
7	139	426	248	330	1764	210	85	153	626	120
8	31	313	58	373	581	182	171	98	85	106
9	76	277	57	491	371	81	1183	115	85	129
10	138	267	57	234	390	61	86	126	87	143
11	13	251	64	471	2185	105	89	96	95	140
12	88	248	154	219	2192	198	468	156	336	95

The next process is doing the aggregate and disaggregate planning method. This method is to regulate the amount of production by calculating the smallest cost of production (Lefta, 2020; Gozali, 2020). Cost production is inventory cost, labor fee, and overtime cost. The method has 3 types that are shift, overtime, and mix strategy shift overtime. After calculating the lowest cost is the mixture strategy. The result of aggregate mixed strategy can be seen in table 6

Table 6. Result of Aggregate Planning Mixture Strategy

Period	Average Production/hours	Total Days/Month (Monday-Friday	Total Days/Month (Saturday)	Total Production	Demand Forecasting (Unit)	Produktion Reguler Time (Unit)	Start Inventory	Overtime	Produktion Over Time (Unit)	End Inventory	Production RT+OT (Unit)	Overtime Cost	Labor Cost	Inventory Cost	Total Cost
Jan-20	18	22	4	348	4.632	6.264	1.632	0	0	1.632	6.264	Rp -	Rp 504.000.000	Rp 40.800.000	Rp 544.800.000
Feb-20	18	19	5	158	3.433	2.844	1.043	0	0	1.043	2.844	Rp -	Rp 252.000.000	Rp 26.075.000	Rp 278.075.000
Mar-20	18	21	4	167	2.255	3.006	1.794	0	0	1.794	3.006	Rp -	Rp 252.000.000	Rp 44.850.000	Rp 296.850.000
Apr-20	18	21	4	167	2.264	3.006	2.536	0	0	2.536	3.006	Rp -	Rp 252.000.000	Rp 63.400.000	Rp 315.400.000
May-20	18	12	5	109	3.870	1.962	628	0	0	628	1.962	Rp -	Rp 252.000.000	Rp 15.700.000	Rp 267.700.000
Jun-20	18	21	4	167	4.065	3.006	-431	33	446	15	3.452	Rp 63.642.857	Rp 252.000.000	Rp 362.500	Rp 316.005.357
Jul-20	18	22	4	174	4.101	3.132	-955	72	972	18	4.104	Rp 138.857.143	Rp 252.000.000	Rp 437.500	Rp 391.294.643
Aug-20	18	18	5	151	1.998	2.718	738	0	0	738	2.718	Rp -	Rp 252.000.000	Rp 18.437.500	Rp 270.437.500
Sep-20	18	22	4	174	2.865	3.132	1.005	0	0	1.005	3.132	Rp -	Rp 252.000.000	Rp 25.112.500	Rp 277.112.500
Oct-20	18	20	5	165	1.609	2.970	2.366	0	0	2.366	2.970	Rp -	Rp 252.000.000	Rp 59.137.500	Rp 311.137.500
Nov-20	18	21	4	167	3.509	3.006	1.863	0	0	1.863	3.006	Rp -	Rp 252.000.000	Rp 46.562.500	Rp 298.562.500
Dec-20	18	21	4	167	4.154	3.006	715	0	0	715	3.006	Rp -	Rp 252.000.000	Rp 17.862.500	Rp 269.862.500
Total												Rp 202.500.000	Rp 3.276.000.000	Rp 358.737.500	Rp 3.837.237.500

After getting the aggregate result with the total cost of Rp. 3.837.237,500, then continuing with disaggregate calculation for getting the production planning detail in every month. This method uses disaggregate percentage techniques. The result of disaggregate can be seen in table 7.

Table 7. Result of Disaggregate Planning

Periode	L - 44	L -33	L -33AK	L-552	L-554	L-553	L-556	L-44EE	L-33A	L-31K
Jan-20	2029	408	675	1105	491	128	0	243	78	130
Feb-20	794	250	266	981	83	112	64	108	49	115
Mar-20	532	442	336	223	836	134	239	136	84	47
Apr-20	776	496	448	362	112	283	189	113	120	112
May-20	253	183	164	600	315	93	86	57	177	39
Jun-20	1733	265	451	92	172	158	103	158	304	19
Jul-20	1766	427	331	86	627	154	121	211	249	140
Aug-20	791	426	508	233	116	134	145	248	79	43
Sep-20	406	303	537	1294	93	126	142	89	63	84
Oct-20	720	493	432	159	161	233	264	150	106	255
Nov-20	1872	216	404	77	82	83	120	90	55	12
Dec-20	1587	180	159	339	244	113	69	144	112	64

The next step calculates the production capacity from the total available capacity machines in PT. Lion Metal Works. The method is RCCP with Planning Using Overal Factor (CPOF), Bill of Labour (BOLA), and Resource Profile (RPA). The data needed are the number of machines, MPS, each machine's capacity, and the production process.

The result shows the same finding based on the calculation with CPOF, BOLA, and resource profile. The result of rough-cut capacity planning needed to fulfill all production planning can be seen in table 8.

Table 8. Result of Rough Cut Capacity Planning in Minutes

Total Proses	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Total
Punch	145948,62	70228,6907	76520,9842	82376,1909	44510,9	108475	122985	79026,7	70458,557	83058	98759,28	90625,1	1072973
Bending	87039,777	44073,13	47420,9482	55276,1645	30156,4	61869,9	68840,8	51687,9	52648,037	57339,2	51395,6	45265,1	653012,9
Spot Welding	96514,312	49461,5706	57352,3125	61168,561	34420,6	66947	77581,1	57090,5	57989,144	62633,8	57316,7	52137,9	730613,5
Welding	15654,868	9039,5081	9421,82955	11670,1477	7332,26	10601,7	11350,5	10193,1	13134,851	12458,3	6858,103	6037,35	123752,6
Painting	8860,005	4562,943	4957,491	5127,3915	3166,32	6109,83	7014,2	4795,21	5096,6685	5023,79	5298,909	5044,69	65057,45
Packing	59614,38	31215,45	33495,42	35761,425	21457,6	40807,9	47783,1	32643,6	34810,335	36451,6	34958,07	33590,2	442589,1

In order to know the available time of each machine, the calculation of available time for each machine should be found first. The result of capacity time for each machine can be seen in table 9.

Table 9. Capacity of Machines.

Mesin	Total Machines	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
Punch	21	438480	199080	210420	210420	137340	211113	220752	190260	219240	207900	210420	210420
Bending	11	229680	104280	110220	110220	71940	110583	115632	99660	114840	108900	110220	110220
Spot Welding	11	229680	104280	110220	110220	71940	110583	115632	99660	114840	108900	110220	110220
Welding	5	104400	47400	50100	50100	32700	50265	52560	45300	52200	49500	50100	50100
Painting	1	20880	9480	10020	10020	6540	10053	10512	9060	10440	9900	10020	10020
Packing	4	83520	37920	40080	40080	26160	40212	42048	36240	41760	39600	40080	40080
Total Capacity Req		1106640	502440	531060	531060	346620	532809	557136	480180	553320	524700	531060	531060

From the RCCP calculation, there are some problems in the packing department in June and July because the production time needed less than a machine capacity. This problem needs a solution and can be seen in CRP planning (Lefta, 2020a}.

Next is the MRP method with Lot for Lot (LFL), Economic Order Quantity (EOQ), Period Order Quantity (POQ), Least Unit Cost (LUC), Silver Meal, dan Algoritma Wagner Within (AWW) techniques. The result of MRP methods is the total cost of each raw material. The result of MRP can be seen in table 10.

Table 10. Result of MRP in Total Cost

	Bahan Baku							
Metode	Coil	Baut	Kunci	Plastik	Sticker	Dus	Cat	River
LFL	Rp 22.078.483.101	**Rp 27.365.821**	Rp 18.582.467	Rp 1.738.401	Rp 1.598.812	Rp 1.738.401	Rp 57.075.638	Rp 27.163.382
EOQ	Rp 38.318.988.155	Rp 117.577.290	Rp 52.771.200	Rp 6.286.090	Rp 5.266.817	Rp 6.286.090	Rp 187.067.572	Rp 224.761.420
POQ	**Rp 10.880.568.436**	Rp 43.326.121	Rp 27.577.247	Rp 3.417.711	Rp 2.609.393	Rp 3.417.711	Rp 100.408.399	Rp 36.078.782
LUC	**Rp 10.880.568.436**	**Rp 27.365.821**	Rp 17.503.327	Rp 1.797.701	Rp 1.630.375	Rp 1.797.701	Rp 58.782.076	Rp 27.163.382
Silver Meal	Rp 12.412.052.812	**Rp 27.365.821**	**Rp 10.478.104**	**Rp 1.735.286**	**Rp 1.540.910**	**Rp 1.735.286**	**Rp 56.145.181**	**Rp 24.899.767**
AWW	**Rp 10.880.568.436**	**Rp 27.365.821**	Rp 16.410.107	**Rp 1.735.286**	Rp 1.559.743	**Rp 1.735.286**	**Rp 56.145.181**	Rp 27.163.382
Metode	Sliding Door Lock	Door Glasses	Sliding	Engsel	SP Washer	Spring	Handle	Welding Electrodes
LFL	Rp 16.671.668	Rp 46.446.439	Rp 16.862.362	Rp 18.838.144	Rp 17.310.029	Rp 14.713.496	Rp 20.222.864	Rp 1.738.401
EOQ	Rp 15.003.040	Rp 85.170.530	Rp 44.880.660	Rp 51.003.730	Rp 32.198.760	Rp 25.540.685	Rp 53.421.780	Rp 6.286.090
POQ	Rp 8.371.428	Rp 50.745.039	Rp 23.413.522	Rp 31.561.944	Rp 19.612.609	Rp 14.556.356	Rp 23.905.964	Rp 3.417.711
LUC	Rp 6.457.118	Rp 36.565.959	Rp 15.925.602	Rp 18.119.388	Rp 13.416.229	Rp 9.950.736	Rp 20.378.284	Rp 1.797.701
Silver Meal	**Rp 5.975.478**	Rp 31.639.479	Rp 15.069.802	Rp 17.347.564	**Rp 12.027.669**	Rp 9.075.416	Rp 19.273.084	**Rp 1.735.286**
AWW	**Rp 5.975.478**	**Rp 31.631.949**	**Rp 11.794.662**	**Rp 16.991.804**	Rp 12.064.569	**Rp 8.746.596**	**Rp 18.749.004**	**Rp 1.735.286**

The result shows that each raw material has a different technique due to the lowest cost output. The coil's lowest cost using POQ, LUC, and AWW and screw using LFL, LUC, silver meal, and AWW.

CRP method is the final method. Just like the RCCP method, but CRP has differences with using efficiency rate, utilization rate, and allowance. The result of CRP can be seen in table 11

Table 11 Result of CRP Method

Machines	Product Type											
	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
Punch Avaible Time	395728,2	179670	189904	189904,05	123949	190529,483	199229	171710	197864	187630	189904	189904
Punch Requirement Time	145948,6217	70228,7	76521	82376,19093	44510,9	108474,822	122985	79026,7	70458,6	83058	98759,3	90625,1
Bending Avaible Time	207286,2	94112,7	99473,6	99473,55	64925,9	99801,1575	104358	89943,2	103643	98282,3	99473,6	99473,6
Bending Requirement Time	87039,77713	44073,1	47420,9	55276,16447	30156,4	61869,899	68840,8	51687,9	52648	57339,2	51395,6	45265,1
Spot Welding Avaible Time	207286,2	94112,7	99473,6	99473,55	64925,9	99801,1575	104358	89943,2	103643	98282,3	99473,6	99473,6
Spot Welding Requirement Time	96514,31195	49461,6	57352,3	61168,56095	34420,6	66946,9918	77581,1	57090,5	57989,1	62633,8	57316,7	52137,9
Welding Avaible Time	94221	42778,5	45215,3	45215,25	29511,8	45364,1625	47435,4	40883,3	47110,5	44673,8	45215,3	45215,3
Welding Requirement Time	15654,86825	9039,51	9421,83	11670,14765	7332,26	10601,7324	11350,5	10193,1	13134,9	12458,3	6858,1	6037,35
Painting Avaible Time	18844,2	8555,7	9043,05	9043,05	5902,35	9072,8325	9487,08	8176,65	9422,1	8934,75	9043,05	9043,05
Painting Requirement Time	15704,83833	8183,78	8914,66	9110,474833	5739,82	10675,6678	12347,6	8434,3	9208,67	8891,54	9226,41	8894,53
Packaging Avaible Time	75376,8	34222,8	36172,2	36172,2	23609,4	36291,33	37948,3	32706,6	37688,4	35739	36172,2	36172,2
Packaging Requirement Time	61200,48	32062,1	34398,1	36664,725	22047,7	41844,435	49016,7	33460,5	35751,4	37343,5	35861,4	34493,5

The result of CRP method in graph can be seen in figure 3.

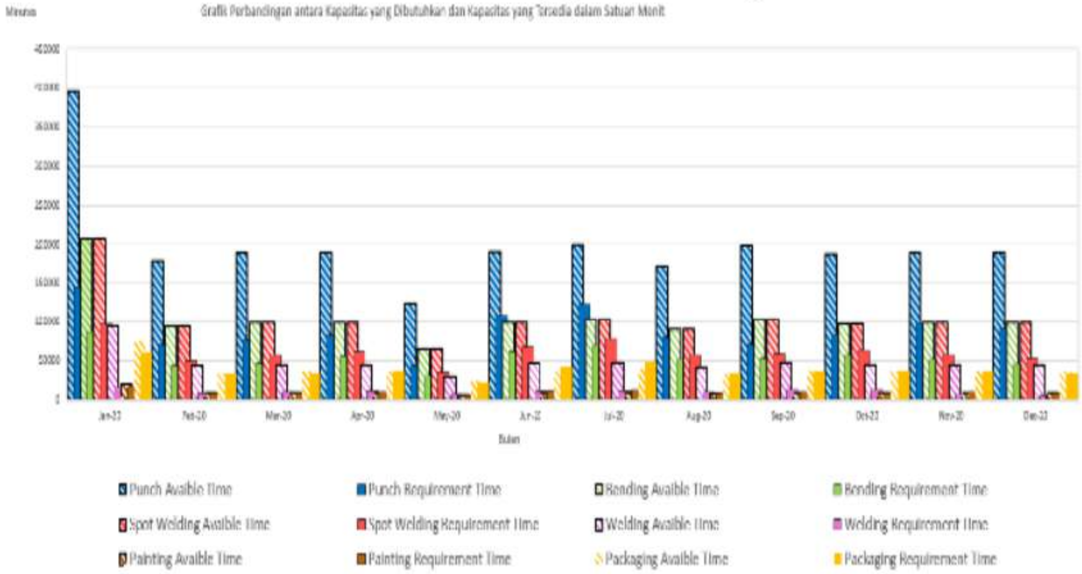


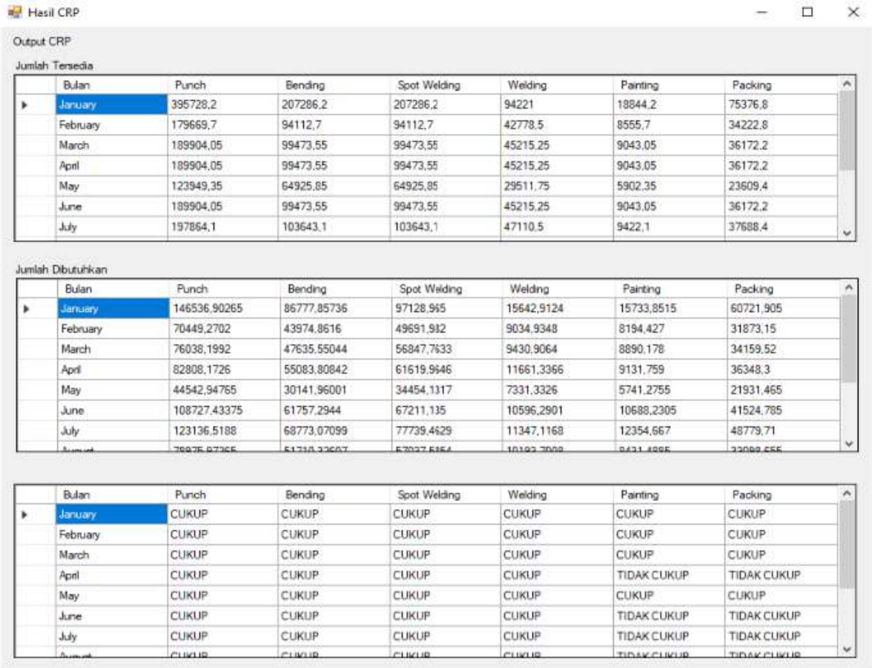
Figure 3 Comparasion of Available Time Machines with Total Time Production Needed

The result shows a shortage of machines in the painting department in April, June, July, August, and November and packing in April, June, July, and August. This problem needs a solution by calculating the lowest cost with options such as overtime, add a shift, reduce shift, add machines, add a shift, and reduce machines. The best option is the lowest cost result. The result of problem-solving can be seen in table 12.

Table 12. Result of Total Cost Each Option

Solution	Punch	Bending	Spot Welding	Welding	Painting	Packing
Add Shift	Rp 3,130,195,000.00	Rp 1,539,265,000.00	Rp 1,549,685,000.00	Rp 4,582,350,000.00	Rp 445,520,000.00	Rp 1,246,650,000.00
Reduce Shift	Rp 2,749,435,000.00	Rp 1,151,065,000.00	Rp 1,182,185,000.00	Rp 3,802,470,000.00	Sufficient	Sufficient
Overtime	Sufficient	Sufficient	Sufficient	Sufficient	Rp 398,655,000.00	Rp 730,380,000.00
Add Machine	Sufficient	Sufficient	Sufficient	Sufficient	Rp 2,751,015,000.00	Rp 6,408,667,500.00
Reduce Machine	Rp 481,285,000.00	Rp 342,485,000.00	Rp 373,625,000.00	Rp 139,420,000.00	Sufficient	Sufficient

The result for the punch machines should reduce the number of punch machine because available time machine is too much with the total cost is Rp. 481.285.000,00, and should reduce the bending machine too with the total cost Rp. 342.485.000,00, the reduction of the spot-welding machine with total cost Rp. 373.625.000, the reduction of the number of welding machine with total cost Rp. 139,420,000, painting machines and packing should be added the overtime production planning because there is a deficiency with total cost Rp. 398,644.000,00 and Rp. 730.380.000,00



Jumlah Tersedia

Bulan	Punch	Bending	Spot Welding	Welding	Painting	Packing
January	395728,2	207286,2	207286,2	94221	18844,2	75376,8
February	179669,7	94112,7	94112,7	42778,5	8555,7	34222,8
March	189904,05	99473,55	99473,55	45215,25	9043,05	36172,2
April	189904,05	99473,55	99473,55	45215,25	9043,05	36172,2
May	123949,35	64925,85	64925,85	29511,75	5902,35	23609,4
June	189904,05	99473,55	99473,55	45215,25	9043,05	36172,2
July	197864,1	103643,1	103643,1	47110,5	9422,1	37688,4

Jumlah Dibutuhkan

Bulan	Punch	Bending	Spot Welding	Welding	Painting	Packing
January	146536,90265	86777,85736	97128,965	15642,9124	15733,8515	60721,905
February	70449,2702	43974,8616	49691,982	9034,9348	8194,427	31873,15
March	76038,1992	47635,55044	56847,7633	9430,9064	8890,178	34159,52
April	82808,1726	55083,80842	61619,9646	11661,3366	9131,759	36348,3
May	44542,94765	30141,96001	34454,1317	7331,3326	5741,2755	21931,465
June	108727,43375	61757,2944	67211,135	10596,2901	10688,2305	41524,785
July	123136,5188	68773,07099	77739,4629	11347,1168	12354,667	48779,71

Bulan	Punch	Bending	Spot Welding	Welding	Painting	Packing
January	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP
February	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP
March	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP
April	CUKUP	CUKUP	CUKUP	CUKUP	TIDAK CUKUP	TIDAK CUKUP
May	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP	CUKUP
June	CUKUP	CUKUP	CUKUP	CUKUP	TIDAK CUKUP	TIDAK CUKUP
July	CUKUP	CUKUP	CUKUP	CUKUP	TIDAK CUKUP	TIDAK CUKUP

Figure 4. The Output of Production Planning and Inventory Control Software

The software for Production Planning and Inventory Control has been developed for PT Lion Metal, Which can be seen in figure 4.

5. Conclusion

In best forecasting method for 10 type products PT. Lion Metal Works is an artificial neural network method. This method has the smallest error value than other methods. The best method for Aggregate and Disaggregate planning is a mixture of overtime and shift strategy because this method has the smallest total cost for the amount of Rp 3.837.237.500. The result of RCCP techniques by using CPOF, BOLA, and Resource Profile technique shows that the packing department has a deficiency in June and July.

The result of CRP planning shows in the painting department in April, June, July, August, and November, with a 9,8% deficit. The solution for painting machines is to add overtime with a total cost is Rp. 389.170.000. The Packaging department has a deficiency in April, June, July, and October with a percentage of 9,9%. Solution for packaging adds overtime with the total cost is Rp. 498.750.000

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Biographies

Lina Gozali is a lecturer in the Industrial Engineering Department at Universitas Tarumangara since 2006 and a free-lance lecturer at Universitas Trisakti since 1995. She got her Bachelor's degree at Trisakti University, Jakarta - Indonesia, then she graduated Master's Degree at STIE IBII, Jakarta – Indonesia, and graduated with her Ph.D. at Universiti Teknologi Malaysia, Kuala Lumpur – Malaysia in 2018. Her apprentice college experience was in paper at Kertas Bekasi Teguh, shoe at PT Jaya Harapan Barutama, automotive chain drive industry at Federal Superior Chain Manufacturing. She teaches Production System and Supply Chain Management Subjects and her Ph.D. research about Indonesian Business Incubator. She actively writes for almost 40 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 been worked at PT. Astra Otoparts Tbk as International Business Development Department for 4 years, Citibank, N.A as customer service for 1 year, PT. Pandrol as assistant marketing manager for 1 year. PT. Texmaco as a merchandiser for 3 years.

Frans Jusuf Daywin, lecturer in the Department of Agricultural Engineering at Faculty of Agricultural Technology Bogor Agricultural University since 1964, conducted teaching, research, and extension work in the field of farm power and machinery and became a professor in Internal Combustion Engine and Farm Power and retired as a professor in 2007. In 1994 up to present as a professor in Internal Combustion Engine and Farm Power at Mechanical Engineering Program Study Universitas Tarumanagara, directing and supervising undergraduate students' theses. From 2016 up to the present, teaching undergraduate courses of introducing concept technology, research methodology, and seminar, writing a scientific paper and scientific communication, and directing and supervising undergraduate student’s theses in Industrial Engineering Program Study at the Faculty of Engineering Universitas Tarumanagara. He got his Ir degree in Agricultural Engineering, Bogor Agricultural University Indonesia in 1966, and finished the Master of Science in Agricultural Engineering at the University of Philippines, Los Banos, the Philippines 1981, and got the Doctor in Agricultural Engineering, Bogor Agricultural University Indonesia in 1991. He joined 4-month farm machinery training at ISEKI CO, AOTS, Japan in 1969- and 14-days agricultural engineering training at IRRI, Los Banos the Philippines, in March 1980. He received the honors “SATYA LANCANA KARYA SATYA XXX TAHUN” from the President of the Republic of Indonesia, April 22nd, 2006, and received appreciation as Team Jury from the Government of Indonesia Minister of Industry in Industry Start-Up 2008. He did some research and survey in farm machinery, farm mechanization, agricultural engineering feasibility study in-field performance and cost analysis, land clearing and soil preparation in secondary forest and alang-alang field farm 1966 up to 1998. Up to the present, he already elaborated as a conceptor of about 20 Indonesia National Standard (SNI) in machinery and equipment. He joins the Professional Societies as a member: Indonesia Society of Agricultural Engineers (PERTETA); Indonesia Society of Engineers (PII); member of BKM-PII, and member of Majelis Penilai Insinyur Profesional BKM-PII.

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