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# WIND TURBINE PRODUCTION PLANNING IN LOGISTIC SYSTEMS

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***Abstract***
*Production planning is very important in an industrial company as well as planning in Logistics. The purpose of implementing production planning in a company is to minimize costs incurred and maximize profits. This research is practicum-based research in the laboratory with the object of observation in the form of a wind turbine toy. This object will be processed through 5 stages in the production process starting from forecasting, RCCP (Rough Cut Capacity Planning), MRP (Material Requirement Planning), CRP (Capacity Requirement Planning), and Line Balancing. forecasting results are carried out with 12 future periods producing 232,888 units, RCCP balance between available capacity and required capacity, MRP using the lot sizing technique obtains the cheapest cost per unit Rp.142,179 with the LTC (Least Total Cost) method when compared to other MRP methods, namely LFL (Lot for Lot), POQ (Period Order Quantity), PPB (Part Period Balancing), EOQ (Economic Order Quantity), and LUC (Least Unit Cost), CRP by calculating the number of machines and working time, and line balancing which results in a decrease in track ineffectiveness from 42% to 22% and Smoothness Index from 476,662 to 189,703.*



***Keywords:***
*Logistics; production; planning; controlling; forecasting*

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## 1. Introduction

A company that acts as a manufacturer is not just producing a product. There are several stages that must be done by the company so that the products produced satisfy customers and obtain optimal profit. So to achieve the objectives of the observed companies, namely companies with Wind Turbine products, production planning and control are applied. The data obtained is secondary data from practicum-based research data regarding logistics planning and control. In fact, the logistics and the concept of the practicum will always go hand in hand [1]. Apart from delivering material, direct application related to the concept of production planning and control is also needed in order to gain a deep understanding from a theoretical or practical perspective [2]. Initially, the company will forecast the number of Wind Turbines that will be produced and determine the appropriate short-term forecasting method. The amount of demand forecast for the next 12 periods is the reference for the production target. Then the company estimates the amount of resources needed at each work station such as the number of working hours to process 1 unit in accordance with the purpose of making RCCP. RCCP will test the ability of resources in producing products in accordance with MPS. If it is not enough, MPS will be changed. Not only that, it also determines the cheapest lot sizing method for each element of the Wind Turbine through MRP as a planning stage for material availability in order to maintain a smooth production process. Everything the company does will be verified through CRP. At this stage, the final decision is made regarding *the lot sizing method* to be used and the lowest cost incurred for the revised elements in the MRP section. Eventually, the company will assemble the elements into *a Wind Turbine*. The assembly process takes place by weighing the balance of the production line. Therefore, the company will determine the number of work stations that can be functioned optimally by considering the efficiency of the track, the possibility of process delay, and how much interference occurs from the selected method. method. The problem is when planning & controlling the production of wind turbines from a logistical point of view. More detailed problems are in effort to work efficiency, save production costs and raw

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materials, and estimate the number of wind turbines to be produced. Stage by stage of planning and logistics control is carried out, so that the production process can run optimally and meet the target.

## 2. Methods

In planning and controlling production, there are several methods that must be done, namely Forecasting, rough Cut Capacity Planning (RCCP), Material Requirement Planning (MRP), Capacity Requirement Planning (CRP), and line Balancing. A more complete explanation is as follows:

### *A. Forecasting*

Forecasting is an attempt to estimate the level of demand in the coming period. Researchers use this method to make statement regarding the number of demands units in a certain period in the future according to several variables that play a role in the calculation process [3]. According to the time of forecasting, forecasting is classified in 3 parts:

1. Short-term forecasting
   Short-term forecasting is intended for making work schedules, short-term cash, and adjustments in the face of price changes.
2. Medium-term forecasting
   Medium-term forecasting is intended for making minor strategic decisions regarding business operations such as budgeting costs, determining the necessary staff, and planning production.
3. Long-term forecasting
   Forecasting with a long term is reserved for making key strategic decisions [2].

Forecasting data patterns are divided into 4 parts, namely:

1. Horizontal data pattern
   Horizontal data pattern occurs when the ups and downs of the data are around the average value and in a constant/stable condition.
2. Seasonal data patterns
   Seasonal data patterns occur when repetitive data movements are influenced by certain seasonal/period factors.
3. Cyclical data patterns
   This pattern occurs when the data is influenced by long-term economic fluctuations and occurs every few years.
4. Trend data patterns
   This pattern occurs in a long time and in the movement of data there is a gradual increase or decrease [4].

In forecasting there are 2 methods that can be used, namely:

1. Qualitative methods
   This method is used when there is no quantitative data and this method is considered better for long-term forecasting. There are several ways that can be used in completing the qualitative experience method, namely, delphi method, market research, historical analogy and consensus panel.
2. Quantitative Methods
   This method uses mathematical models to perform forecasting predictions. Mathematical models are derived from historical data which will then be used to predict the future. A good use for this method is in short-and medium-term forecasting. There are 2 techniques for solving quantitative methods, namely the periodic series technique (time series) and the explanatory/causal method [5].

### *B. Rought Cut Capacity Planning (RCCP)*

Rough Cut Capacity Planning (RCCP) is the determination of the level of resource availability planned to implement the MPS (Master Production Schedule) [6]. By that function, researcher use this method for comparing between the actual data and the amount of data that the company really need [7]. RCCP solutions use 3 techniques. This is due to a lot to do to achieve an approach to the resource profile. Before starting the RCCP technique, there are several inputs that must be considered, such as:

1. Demand forecasts and production plans that are the result of forecasting processes, aggregate planning, and disaggregation processes
2. Product structure and Bill of materials (BOM)
3. Set-up time and processing time of a product in the Department
4. The amount of economical production of products [8].

After that, the data is entered according to the needs of each RCCP technique. Here are the types of RCCP techniques:

1. Capacity Planning using Overall Factors

This technique uses historical data to calculate its capacity. Required inputs include:
- MPS
- Time required to produce / process resources
- The proportion of time for each resource

2. The Bill of Labor Approach

This technique uses the amount of Labor/time it takes to create an item. Required inputs include:
- MPS
- Standard time required to produce/process resources
- The proportion of time for each resource

3. Resource Profile Approach

This is a detailed RCCP technique. This technique divides labor needs based on time and takes lead time into consideration. Required inputs include:
- MPS
- Time required to produce / process resources
- The proportion of time for each resource
- Lead time for each resource [9]

*C. Material Requirement Planning (MRP)*

Material requirement planning (MRP) is a system of production planning, scheduling, and inventory control to organize the production process, this MRP is also a computer-based inventory control system to improve industrial productivity. Then this MRP is also used to estimate total of raw materials and schedule their availability [10]. Problems from research related to the model that produces the cheapest lot sizing costs with optimal total of lot sizing starting from raw materials to the whole can be observed through the application of RCCP. The optimalization of lot sizing as one of calculation element is used for minimizing the total of inventory which can affect the inventory cost [11]. MRP is used to achieve several goals that a manufacturing company wants to achieve. Here are the 4 objectives of MRP:
1. Reduce the amount of inventory
2. Reduce lead time in the production process and delivery of goods to customers
3. Prompt provision of information regarding delivery time
4. Improve the efficiency of the production operational system the production operational system runs more effectively because the flow of materials is controlled by MRP [12].

MRP creation has input data so that it can be processed. Here are the data required for the manufacture of Material Requirement Planning (MRP):
1. Master production schedule
2. Product structure (Bill of Materials)
3. Inventory record File [13].

There are several stages in conducting MRP, namely as follows:
1. Netting (net requirements), is to determine the net requirements based on the difference between the gross requirements (gross requirements) with existing inventory
2. Lotting (order quantity), is one of the MRP stages where the order quantity of each component is determined according to the net requirements resulting from the netting process
3. Offsetting (booking plan), is the stage where the planned booking time by considering the booking lead time of the supplier
4. Exploding is the stage where it is used to determine the amount of finished product needed by determining the bill of materials and the total gross requirement for each component [14].

*D. Capacity Requirement Planning (CRP)*

Capacity Requirement Planning (CRP) is a capacity requirement planning that organizes equipment, machinery, people, and other resources so that problems on demand can be met [15] CRP has more focused on total resources. The purpose of doing CRP is to show the comparison between the load set on the work center's capacity over a certain time period through the identification of overloads or underloads. If the calculation proves that an imbalance occurs, re-planning will be carried out [16].

In preparing the CRP, several inputs are needed, namely the following:
1. Bill Of Materials
2. Product master Data of each component

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3. MPS for each component Routing each component
4. Work Center Master File

The stages in preparing the CRP are as follows: [2]
a) Calculate the required capacity of each work Center.
b) Determine the load or load
c) Balancing capacity and load

*E. Line Balancing*

Line Balancing is balancing the working elements of an assembly line of work stations to minimize the number the total price of idle time at each work station to increase output [17]. The purpose of line balancing is to minimize the imbalance between the machines in order to meet the desired output of the production line (assembly line) and obtain effective work stations and improve work efficiency [18]. Inefficiencies can still be found in the path that affects the level of work effectiveness so that line balancing is being needed to measure it and helps the researcher to decide after knowing the condition. In line balancing there are several terms that are often used as follows:

1. Precedence Diagram

Precedence Diagram is an image sequence of work operations. The purpose of a precedence diagram is to control and plan production flow more easily. The following is the order of the number operations and work elements as depicted in Table 1 and is represented in the form of a precedence diagram as illustrated in Fig.1.

Table 1. Work Element

| WS | Operation Number | Work Element |
|---|---|---|
| 1 | 1 | Assemble the Generator and LED Assembly on the nacelle body |
| | 2 | Assemble the gear on the nacelle body using 2 small nuts [Nacelle Body Assembly] |
| | 3 | Assembling the Nacelle Cover with Body Nacelle using 4 medium nuts [Basic Nacelle Assembly] |
| 2 | 4 | Assembling 2 Bearings on the Basic Nacelle Assembly using 4 Medium Nuts [Nacelle Assembly] |
| 3 | 5 | Assembling the 3 rotor blades on the hub rotor using 3 medium nuts [Blade Assembly] |
| 4 | 6 | Assembling the tail boom on the nacelle assembly [boom assembly] |
| | 7 | Assemble the tail fin on the boom assembly |
| | 8 | Assembling the rotor hub on the boom assembly [wind turbine assembly] |
| | 9 | Assembling the tower on the wind turbine circuit using 1 medium nut |
| 5 | 10 | Assemble the 2 tower connectors on the tower base with the 4 bottom connector nuts |
| | 11 | Assemble Ground on tower connector with 1 bottom connector nut |

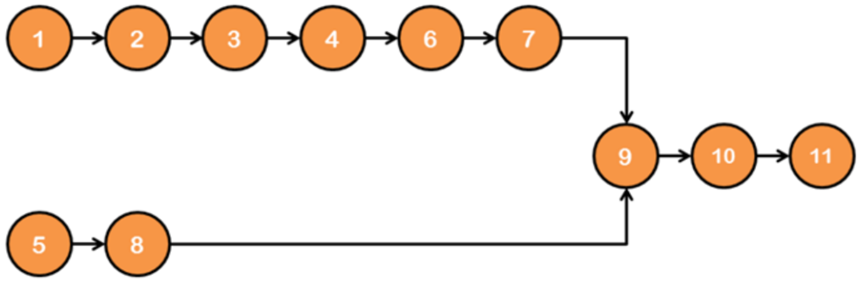


Figure 1. Precedence Diagram

2. Assemble Product
   Assemble Product is a product that passes through the sequence of work stations
3. Waiting Time (Idle Time)
   Idle Time is the waiting time of the operator or worker to perform the next process
4. Free Time Balance (Balance Delay)
   Balance delay is a measure of the inefficiency of a trajectory based on idle time due to less-than-perfect work allocation.
5. Work station Efficiency
   The efficiency of the work station is the ratio to the operating time. The work station is denoted Wi and the operating time of the largest work station is denoted Ws
6. Line Efficiency
   Line efficiency is the ratio of Total Work Station time divided by cycles multiplied by the number of work stations or can be calculated also by the number of work station efficiency divided by the number of work stations [19].

## 3. Result And Discussions

The Data in this study were obtained from secondary data in the practicum of Logistics Planning and control, namely data on demand for Wind Turbine logistics. Before forecasting, the data plot is done first which aims to determine the forecasting method to be used.

The graph of demand for wind Turbine logistics with calculations for 48 Periods is shown in Fig. 2.

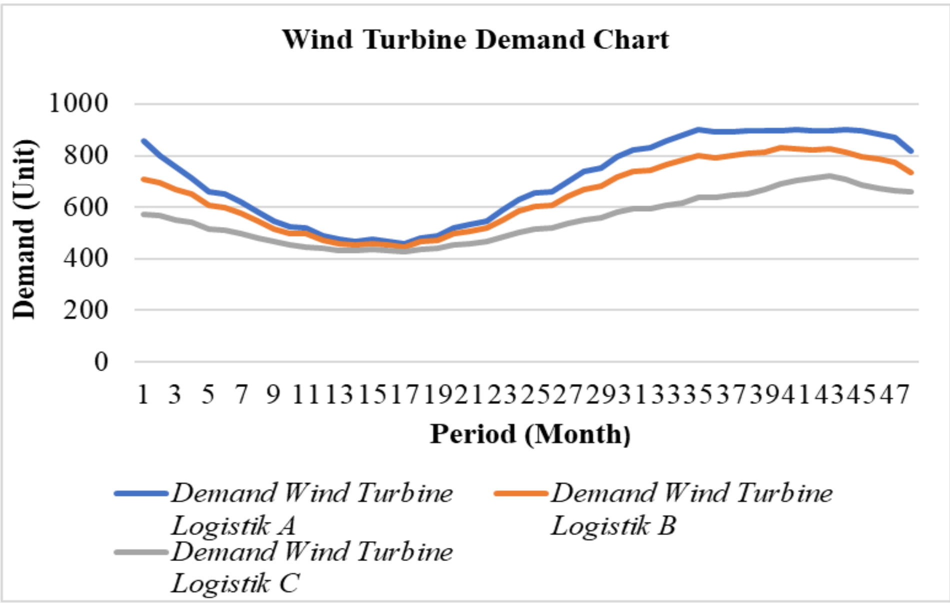


Figure 2. Chart of Logistic Wind Turbine

Data graph demand of Wind Turbine Logistic A, B, C is a cyclical data pattern due to the increase and decrease in demand for 48 Periods.

*A. Forecasting*

There are 3 types of demand data in Forecasting Wind turbine logistics, namely, Wind Turbine logistics A, B, and C for 48 Periods as shown in Fig. 3.

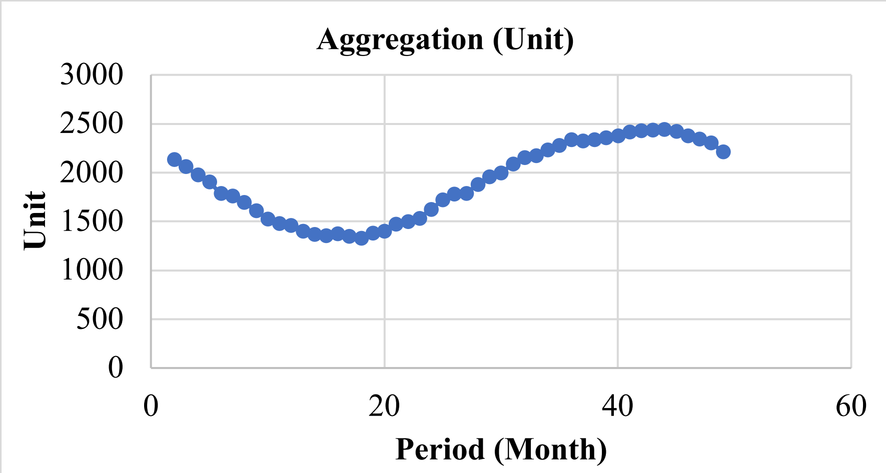


Figure 3. A, B, & C Logistics Wind Turbine Demand Aggregation

To get the right forecasting data calculated using the method that is closest to the chart pattern above. Based on the calculation analysis the closest method is a cyclical and cyclical trend. Then forecasting in the period 49-60 with both methods selected. After that, the calculation of the error of the actual data using the calculation error / Standard Error of Estimate (SEE). This calculation aims to decide the best method to be used. Based on the calculation in getting the cyclical Trend is the method chosen because it has the smallest error as can be seen in Table 2.

Table 2. SSE Recapitulation

| No | Method | SSE | Smallest SSE |
|---|---|---|---|
| 1 | Cyclic | 37007 | 27978 |
| 2 | Cyclic trend | 27978 | |

Then the number of demand forecasting on Wind turbine logistics for the next 12 Periods obtained as many as 232,888 units. Then the calculation of minimum production costs by Chase Strategy, Level Strategy, and Mix Strategy, the results obtained are given in Table 3.

Table 3. Total Cost Recapitulation

| **No** | **Method** | **Total Overall Cost** | **Selected Method** |
|---|---|---|---|
| 1 | *Chase Strategy* | Rp 1,561,310,000 | **Rp 1,399,151,040** |
| 2 | *Level Strategy* | Rp 1,639,852,080 | |
| 3 | *Mixed Strategy* | Rp 1,399,151,040 | |

After doing the calculations, the chosen method is the Mix Strategy method because it has the lowest total cost of Rp1,399,151, 040.

*B. Rough Cut Capacity Planning (RCCP)*

After forecasting, the next stage is RCCP which requires Master Production scheduling (MPS) as input. MPS obtained from module 1 practicum. There are 4 work stations (WS), namely smelting, forming, refining, and assembly. Each WS has its components for processing. In processing these components, then used in the calculation of processing time per work station to determine the Standard Hours per unit finished product, Bill of capacity per work station, Bill of capacity, Effective Daily Capacity by multiplying the number of machines, working hours, number of shifts, efficiency, and utility. After these steps, then calculate and analyze the RCCP of each work station. Fig. 4 is an example of the results of RCCP smelting station.

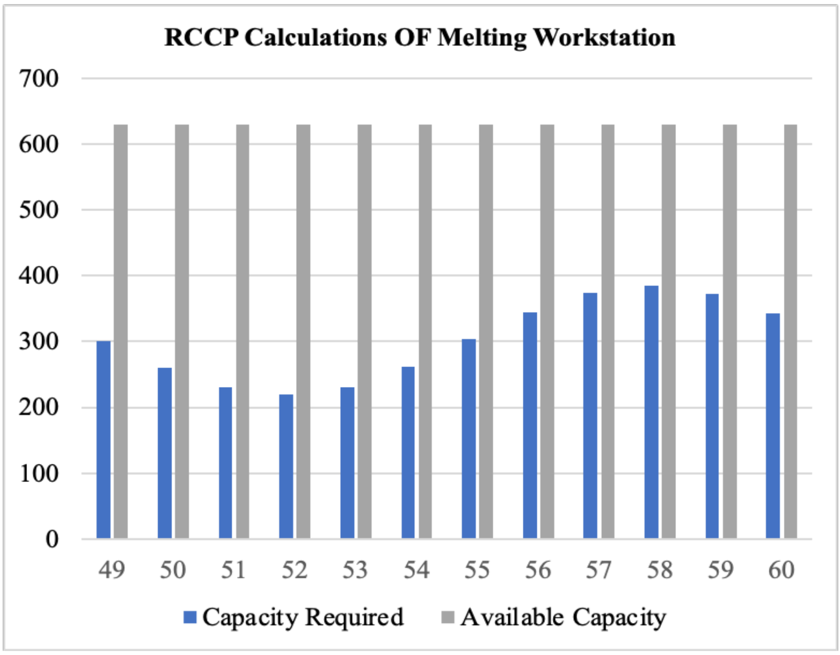


Figure 4. RCCP Calculation of Melting Stations

Based on the graph above, it explains that the needed capacity or production carried out is always available because the inventory capacity is still sufficient for production demand.

*C. Material Requirement Planning (MRP)*

Based on the master file inventory data, obtained requirements of each component, with input gross requirements, Schedule receipt, project on hand, and can be set requirements of the component. Level 0 gross requirement data is taken from MPS module 1 data, the next level is taken from the Gr of the Assembly before being multiplied by the amount and adjusted to the bill of materials. MRP calculation is done by several lotting methods, namely, Lot for Lot (LFL), Part Period Balancing (PPB), Period Order Quantity (POQ), Economic Order Quantity (EOQ), Least Unit Cost (LUC), Least Total Cost (LTC). In this study the lot sizing techniques used were the POQ, PPB, LUC, and LTC methods because these four methods were developments or modifications of the basic LFL and EOQ methods. Some of these methods are used to compare the minimum total cost of each component as given in Table 4.

Table 4. Total cost comparison of lot sizing components

| No. | Method | Total Cost |
|---|---|---|
| 1 | POQ | Rp 1.800.000 |
| 2 | PPB | Rp 1.753.950 |
| 3 | LUC | Rp 1.753.950 |
| 4 | LTC | Rp 1.753.950 |

*D. Capacity Requirement Planning (CRP)*

CRP is conducted to determine the amount of labor capacity and engineering resources to produce Wind turbine logistics. The CRP calculation used as provided in Table 5 is an effective working day of 21 days with 1 shift per day and the engine resources it has 5 smelting machines, 4 forming machines, 3 refining machines, and 2 assembly machines as engine resources. Calculation of planned input and planned output for the period 49-60.

Table 5. CRP Calculation of Melting Work Station

| Period (Month) | *Planned Input* | *Planned Output* |
|---|---|---|
| **49** | 339.034 | 628.320 |
| **50** | 360.319 | 628.320 |
| **51** | 365.937 | 628.320 |
| **52** | 285.132 | 628.320 |
| **53** | 218.469 | 628.320 |
| **54** | 127.460 | 628.320 |
| **55** | 31.819 | 628.320 |
| **56** | 0 | 628.320 |
| **57** | 0 | 628.320 |
| **58** | 0 | 628.320 |
| **59** | 0 | 628.320 |
| **60** | 0 | 628.320 |

After that, the calculation of raw material requirements that produce scrap percent of production. There are three types of materials, namely polyethylene l= 7 cm t=50 cm, polyethylene d=2 cm, and iron d=5 cm. Then perform the calculation of the total cost of the lotting method is the Period Economic Quantity (POQ), Part period Balancing (PPB), Least Unit Cost (LUC), and Least Total Cost (LTC). Some of these methods are used to compare the minimum total cost of each raw material. As shown in Table 6, the comparison of the total cost of lot sizing polyethylene l= 7 cm t=50 cm.

Table 6. Comparison of the Total Cost of Polyethylene lot sizes l= 7 cm t=50 cm

| No. | Method | Total Cost |
|---|---|---|
| 1 | POQ | Rp 169,904 |
| 2 | PPB | Rp 147,063 |
| 3 | LUC | Rp 147,063 |
| 4 | LTC | Rp 142,179 |

*E. Line Balancing*

In determining line balancing, work element data, priority diagram, allowance factor, and adjustment factor with 5 work stations are needed. The adjustment factor will be included in the normal time calculation and the allowance factor will be included in the standard time calculation. From the calculation of cycle time, normal time, standard time, WS efficiency, track efficiency, and balance delay obtained a production target of 920.79 seconds.

After that, line balancing calculations as given in Table 7 were carried out using two methods, namely RPW and region approach (RA). The selection of these two methods is based on the method studied in the laboratory.

Table 6. Recapitulation of Line Balancing Method

| | **Before** | ***Rank Position Weight*** | ***Region Approach*** |
|---|---|---|---|
| **Number of WS** | 5 | 4 | 4 |
| ***Balance Delay*** | 42% | 28% | 22% |
| **Line Efficiency** | 58% | 72% | 78% |
| **SI** | 476.662 | 249.965 | 189.703 |

From this recapitulation table, it is found that the most efficient method is the Region Approach method because this method has the smallest amount of WS and has a lower balance delay value than before using RPW and RA methods.

## 4. Conclusion

Based on the graph on the aggregate results, it is obtained that the forecasting method that will be used is the cyclical method and cyclical trend. Then the total demand forecasting for the next 12 periods is 23,288 units. Furthermore, the determination of the aggregate strategy with minimum production costs is obtained through a mixed strategy. In the calculation graph of the RCCP Wind Turbine smelting logistics work station, it can be seen that production capacity is always available because supply capacity is still sufficient for production demand and this also has the same results for the formation, refinement and assembly of WS. Then there are 6 lotting methods to calculate the optimum number of orders, in this study 4 methods were used, namely Period Economic Quantity (POQ), Part Period Balancing (PPB), Least Unit Cost (LUC), and Least Total Cost (LTC). Each component uses the lowest cost lotting options such as connecting bolts which can choose to use the PPB, LUC, or LTC method with a production cost of IDR 1,753,950. Each raw material uses a lotting option with the lowest cost, such as polyethylene, which can use the LTC method at a cost per unit of IDR 142,179.

Then to balance the assignment of task elements from a line to a work station and minimize idle time, line balancing is carried out. From the recapitulation table it is known that the most efficient line balancing method is the Region Approach (RA) method. The results obtained with RA were that previously there were 5 work stations, but with the Region Approach method, more effective results were obtained, namely 4 WS. The percentage measure of ineffectiveness of a fluency was also reduced from 42% to 22%. Track efficiency increased from 58% to 78%. The Smoothness Index (SI) fell from 476,662 to 189,703.

## References

[1] Utami, N., & Sitorus, O. F. (2015). Logistics Management at Giant Extra (Manajemen Logistik di Giant Ekstra). *Jurnal Untilitas, 1*(1), 92-102.

[2] Ruswandi, N., Herlina, R., Suri, F. K., Dianisa, P. A., Sandi, E., Sukarno, I., . . . Lusiani, M. (2021). Production Planning and Control in Logistics Systems (Laboratory Practicum Based Approach) (Perencanaan dan Pengendalian Produksi dalam Sistem Logistik (Pendekatan Berbasis Praktikum Laboratorium). *Jurnal Pendidikan dan Aplikasi Industri (UNISTEK), 8* (2), 139-148.

[3] O. P. Chukwulozie, A. O. Andrew, O. N. Celestine and S. J. Ebieladoh, "Analysis and Forecasting of The Production Quantity in A Manufacturing Industry Using Historical Data," *The International Journal of Engineering and SCience (IJES),* vol. 4, no. 10, pp. 7-17, 2015.

[4] W. Jobs, Wisdom Jobs e-university, 2021. [Online]. Available: https://www.wisdomjobs.com/e-university/marketing-management-tutorial-294/short-medium-and-long-term-forecasting-9586.html.

[5] Fani, E., Widjajati, F. A., & Soehardjoepri. (2017). Determining the Best Product Sales at Company X with the Winter Exponential Smoothing Method and the Event Based Method (Menentukan Penjualan Produk Terbaik di Perusahaan X dengan Metode Winter Exponential Smoothing dan Metode Event Based). *Jurnal Sains dan Seni ITS, 6*(1).

[6] Dewi, R. S. (2015). Forecasting (Peramalan). eprints Politeknik Negeri Sriwijaya, 2.

[7] Sugarindra, M., & Nurdiansyah, R. (2020). Production Capacity Optimization with Rough Cut Capacity Planning (RCCP). *IOP Conf. Series: Materials Science and Engineering.* Yogyakarta.

[8] Faizarteta. (2020). Understanding RCCP, MRP, Scheduling N Job M Machine (Pengertian RCCP, MRP, Penjadwalan N Job M Mesin). Retrieved 2020, from https://www.infoteknikindustri.com/2020/04/pengertian-rccp-mrp-penjadwalan.html

[9] Dimyanti, A, & Dimyanti, T.T. (2015). *persations Research:* Decisions Making Models (Model - Model Pengambilan Keputusan) . Bandung: Sinar Bagus Algesindo.

[10] Industri, L. S. (2017). Production Planning and Inventory Control (PPIC) & Production System Practicum Module (Modul Praktikum Production Planning and Inventory Control (PPIC) & Production System). Jakarta: Universitas Esa Unggul.

[11] Furqon, C., Sultan, M. A., & Pramudita, R. J. (2017). Analysis of Material Requirement Planning (MRP) Implementation on The Company. *2nd International Conference on Economic Education and Entrepreneurship.* Bandung.

[12] Khoiri. (2020). Definition and Function of Material Requirement Planning (MRP) (Pengertian dan Fungsi Material Requirement Planning (MRP). Retrieved from https://www.khoiri.com/2020/12/pengertian-dan-fungsi-material-requirement-planning-mrp.html.

[13] Kho, B. (2016). Industrial Management Science (Ilmu Manajemen Industri). Retrieved from http://www.ilmumanajemenindustri.com.

[14] Hidayat, A. R. (2021). Evaluation of the Application of the Material Requirement Planning System at PT. Indonesia Epson Industry (Evaluasi Penerapan Sistem Material Requirement Planning di PT. Indonesia Epson Industry). 1-87.

[15] Rahmah, A. (2021). MRP is (MRP adalah). Retrieved from https://rumus.co.id/mrp-adalah/

[16] Ruswantoro, A. Y., & Herwanto, D. (2021). Analysis of Capacity Requirement Planning on Fiber Laser Robotic Machines at PT. Kiyokuni Indonesia (Analisis Capacity Requirement Planning pada Mesin Robotic Fiber Laser di PT. Kiyokuni Indonesia). *Satuan Tulis Riset dan Inovasi Teknologi (STRING), 6*(1), 9-15.

[17] P, E. (2017). Optimal Production Time Capacity Planning Using the Capacity Requirement Planning Method at PT. SPI Surabaya (Perencanaan Kapasitas Waktu Produksi Yang Optimal Dengan Metode Capacity Requirement Planning di PT. SPI Surabaya). 31.

[18] Juwita, E. (2019). Analysis of Line Balance and Proposed Improvements Using the Line Balancing Method at PT. XYZ. Surakarta. (Analisis Keseimbangan Lini dan Usulan Perbaikan Menggunakan Metode Line Balancing di PT. XYZ). Surakarta.

p-ISSN: 2963-8577
e-ISSN: 2964-3511

[19] Khoiri. (2020). Purpose of Line Balancing and Examples of Its Application (Tujuan Line Balancing dan Contoh Penerapannya). (Khoiri.com) Retrieved from https://www.khoiri.com/2020/12/line-balancing-dan-bottleneck-di-industri.html.

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