ISSN(p) 1693-8232
ISSN(e) 2723-1585

ANALYSIS OF PRODUCTION CAPACITY OF NOBU PINK CERAMIC TYPE USING CAPACITY REQUIREMENT PLANNING METHOD AT PT ARWANA CITRAMULIA TBK PLANT I

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ABSTRAK

PT Arwana Citramulia Tbk merupakan perusahaan manufaktur dengan produk yang dihasilkan adalah keramik. Perusahaan ini memiliki permasalahan dalam hal mengatasi permintaan yang cenderung fluktuatif, hal ini membuat perusahaan kesulitan dalam mengatur perencanaan kapasitas produksi yang efektif. Adapun tujuan penelitian ini untuk mengetahui kapasitas produksi yang ideal keramik tipe Nobu Pink. Analisis kapasitas produksi keramik tipe nobu pink dilakukan di PT. Arwana Citramulia Tbk Plant I dengan menggunakan metode Capacity Requirement Planning (CRP) dengan perhitungan kapasitas diperlukan menggunakan metode bill of labor (BOL). Dari hasil penelitian menunjukkan kapasitas produksi keramik tipe nobu pink ukuran 25 x 25 cm adalah 633 pcs/jam atau 15.192 pcs dalam satu hari. Hasil perbandingan kapasitas tersedia dengan kapasitas yang diperlukan terjadi kekurangan kapasitas pada stasiun kerja Kiln di setiap periode. Usulan yang dapat diterapkan oleh perusahaan adalah dengan penambahan jam kerja lembur selama 3 jam di hari sabtu, maka akan memenuhi kekurangan kapasitas.

Kata kunci : *production capacity; capacity planning; capacity requirement planning (CRP); bill of labor (BOL);* jadwal induk produksi

ABSTRACT

PT. Arwana Citramulia Tbk is a manufacturing company that produces ceramics. The company faces challenges in managing fluctuating demand, making it difficult to effectively plan production capacity. The objective of this research is to determine the ideal production capacity for the Nobu Pink ceramic type. The analysis of the production capacity for Nobu Pink ceramics was conducted at PT. Arwana Citramulia Tbk Plant I using the Capacity Requirement Planning (CRP) method, with capacity calculations performed using the bill of labor (BOL) method. The research results indicate that the production capacity for 25 x 25 cm Nobu Pink ceramics is 633 pieces per hour or 15,192 pieces per day. A comparison of available capacity with required capacity shows a shortage of capacity at the Kiln workstation in each period. A proposed solution for the company is to add 3 hours of overtime work on Saturdays, which would meet the capacity shortage.

Keywords : production capacity; capacity planning; capacity requirement planning (CRP); bill of labor (BOL)*;* master production schedule

INTRODUCTION

In the effort to meet consumer needs, manufacturing companies will face various challenges, especially the limitations of production factors such as raw materials,

machinery, production methods, capital, and human resources. With these factors in mind, manufacturing companies can also calculate the minimum and maximum production capacities within the constraints present. By understanding production capacity, companies can make plans for production scheduling. Optimal product capacity is highly beneficial when implemented, as it considers minimal production costs.
PT Arwana Citramulia Tbk. Plant 1 is a company that manufactures ceramics, operating 24 hours a day with a division of 3 shifts for each day, and is one of the companies engaged in ceramic production, particularly the production of floor ceramic products sized 25 x 25 cm with various motifs according to orders. Below is a comparison of the Demand Data and Ceramic Production Data from the top 5 highest sales.

Table 1. Demand Data and Production Data

Ceramic Types	Month	Demand Data	Production Data
Akashi Brown	January	11.500	10.995
	February	11.500	11.1624
	March	11.500	9.643
	April	11.500	11.505
	May	5.400	0
	June	11.500	11.433
	July	11.500	11.795
	August	5.750	8.332
	September	5.750	6.800
	October	11.500	12.895
	November	11.500	12.450
	December	5.400	6.922
Total		114.300	114.394
Kansai Blue	January	11.500	12.280
	February	11.500	12.743
	March	6.450	8.795
	April	6.450	6.873
	May	6.450	5.400
	June	11.500	11.592
	July	6.450	6.500
	August	6.450	6.227
	September	11.500	11.688
	October	11.500	12.704
	November	11.500	11.597
	December	11.500	11.302
Total		112.750	117.701

Table 1. Demand Data and Production Data (cont'd...)

Ceramic Types	Month	Demand Data	Production Data
	January	5.750	5.854
	February	11.500	10.672
	March	11.500	8.643

Nobu Pink	April	5.750	5.463
	May	11.500	11.597
	June	11.500	5.470
	July	0	0
	August	11.500	8.224
	September	11.500	11.595
	October	11.500	11.302
	November	11.500	8.795
	December	11.500	12.452
Total		126.500	100.067
Orient Blue	January	11.500	10.725
	February	11.500	12.703
	March	11.500	11.054
	April	11.500	11.592
	May	5.400	6.325
	June	11.500	11.974
	July	5.400	5.585
	August	11.500	11.050
	September	11.500	12.205
	October	11.500	11.725
	November	11.500	11.597
	December	5.400	0
Total		119.700	116.535
Nobu Blue	January	5.400	5.466
	February	5.400	5.850
	March	11.500	11.595
	April	5.750	5.500
	May	11.500	12.004
	June	11.500	11.503
	July	5.750	8.795
	August	11.500	8.590
	September	11.500	10.723
	October	11.500	11.595
	November	11.500	12.450
	December	5.750	5.955
Total		108.550	110.026

Source: PT Arwana Citramulia Tbk. Plant 1

From the table above of demand data and production data for 5 types of ceramics, a graph is created as shown below.

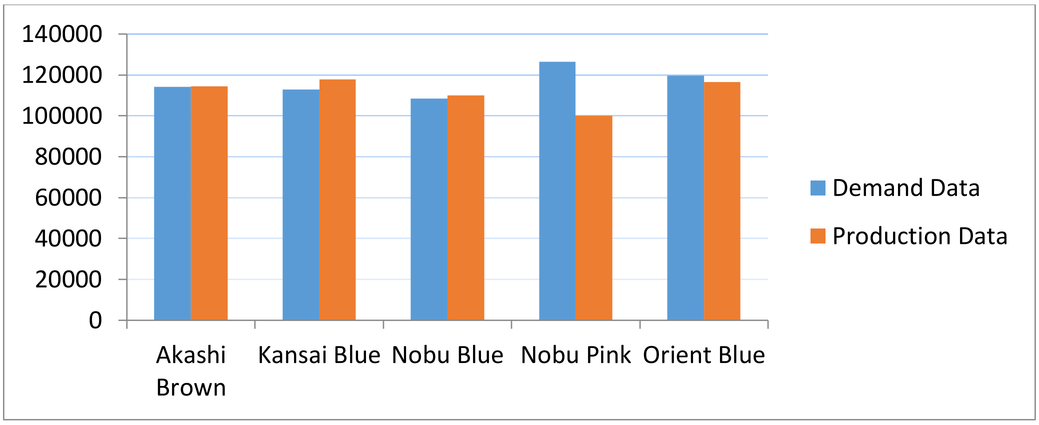

Figure 1. Graph of Demand Data and Production Data for the Top 5 Highest Sales (source: PT Arwana Citramulia Tbk. Plant 1)

The company faces challenges in managing fluctuating demand, as seen in the table above, making it difficult to effectively regulate production capacity. Therefore, effective capacity planning is needed for successful manufacturing planning and control. If the company lacks capacity, it will inevitably lead to a domino effect of problems, such as failure to meet production targets, resulting in delayed product deliveries to customers, leading to loss of trust from customers, potentially damaging the company's reputation, or even causing its loss altogether. Hence, there is a need for a realistic production plan, integrating production and capacity planning to ensure that customer demand is consistently met by the company. Based on the background description, the research problem focuses on the production capacity of the Nobu Pink ceramic type with dimensions of 25 x 25 cm, which is not yet known. This type is chosen because it has the largest difference between demand data and production data.

MATERIALS AND METHODS

Capacity

Capacity often determines capital requirements, thus influencing a significant portion of fixed costs. Capacity also determines whether demand can be met or if existing facilities will be underutilized. If the facilities are too large, some of them will remain idle, incurring additional costs charged to existing production. If the facilities are too small, customers and the overall market will be lost. Therefore, with the goal of achieving high utilization rates and high returns on investment, determining the size of facilities is crucial (Kurniasih & Suri, 2015).

Santoso & Heryanto (2020) define capacity as the level at which a productive system (workforce, machinery, workstations, departments, factories) can produce. Capacity is determined in terms of output units per unit of time. According to Orlicky (1975) as cited in Fatmawati & Wiwi (2013), capacity measures the ability of a production facility (work center, department, or other facility) to achieve a certain amount of work within a specific time frame and is a function of the amount of resources available.
Handoko (1995) in Ruswantoro & Herwanto (2021) states that capacity is the level of output of a quantity of output within a certain period and represents the highest possible output quantity during that period. According to Handoko (1995) in Ruswantoro & Herwanto (2021), the types of capacity are divided into:

1. Design Capacity: the level of output per unit of time for which the factory is designed.
2. Rated Capacity: the level of output per unit of time indicating that the facility theoretically has the capability to produce it.

3. Standard Capacity: the level of output per unit of time set as the operating target for management, supervisors, and machine operators, and can be used as a basis for budgeting.
4. Actual/Operating Capacity: the average output level per unit of time during past periods.
5. Peak Capacity: the output quantity per unit of time (possibly lower than rated, but greater than standard) that can be achieved through maximizing output, and may be achieved through overtime work, additional labor, eliminating delays, reducing break times, etc.

Capacity Planning

Mcleavy, et al. (1995) in Fatmawati & Wiwi (2013) define capacity planning as the process of determining the required number of people (workers), machines, and physical resources to determine the production objectives of an organizational company. According to Santoso & Heryanto (2020), capacity planning is a function of determining the required capacity level to meet production schedules (required capacity), comparing it with available capacity, and planning adjustments required in capacity level or schedule. If the capacity is insufficient to meet production schedules, the following possibilities may occur:

1. Shortage
2. Failure to achieve production targets
3. Late delivery to customers
4. Production managers becoming frustrated
5. Loss of confidence in the formal system

Conversely, if the provided resources exceed the required ones, it will result in low resource utilization, manufacturing inefficiency, high costs, and reduced profit margins. Ideally, the required capacity for scheduling production would be equal to the available capacity.

Capacity planning aims to integrate production factors to minimize production facility costs. In other words, decisions regarding production capacity should consider the economic factors of the production facility, including its efficiency and utility. The factors influencing the formation of effective capacity include product design, quality of materials used, attitude and motivation of the workforce, maintenance of machines/facilities, and job design (Hendra Kusuma, 2009).

Capacity Requirement Planning (CRP)

Capacity Requirement Planning (CRP) is a function to determine, measure, and address the level of capacity or process to determine the amount of labor and machine resources needed to execute production. According to Gasperz (2005) as cited in Ruswantoro & Herwanto (2021), CRP is used to ensure, measure, and regulate capacity levels or processes to ensure the required amount of labor and machine energy resources needed for production. Capacity Requirement Planning (CRP) determines the capacity needed to create material requirement plans (Santoso & Heryanto, 2020).

Baroto (2002) in Ruswantoro & Herwanto (2021) states that the main objective of CRP is to show the comparison between the load assigned to work centers through existing work orders and the capacity of each work center over a certain period. Through the identification of overloads or underloads, if there are any, replanning actions can be attempted to eliminate this situation in order to achieve a balance between load and capacity (balanced load). If the flow of incoming orders exceeds capacity, the load will increase, indicated by inventory located in the work queue. Conversely, if the flow of incoming orders is less than the available capacity, the load (orders waiting to be processed) will decrease.

CRP allows us to balance the load against capacity. There are five basic actions we may take when there is a difference/imbalance between available capacity and required load (Gasperz, 2011) as cited in the journal (Ruswantoro & Herwanto, 2021):

1. Increasing capacity
2. Reducing capacity
3. Increasing load
4. Reducing load
5. Redistributing load

Forecasting

Forecasting is the prediction or estimation of something that has not yet occurred. Forecasts are typically based on past data analyzed using specific methods. Forecasting aims to minimize the impact of uncertainty, in other words, to obtain forecasts that can minimize forecast errors, which are usually measured with metrics like Mean Absolute Deviation, Absolute Error, and so on. Forecasting is a crucial tool in effective and efficient planning..

Sofyan (2013) states that forecasting is an activity of estimating or predicting future events, of course with the help of prior planning, where this plan is made based on the capacity and demand/production capabilities that have been conducted in the company. According to Kushartini & Almahdy (2016) as cited in Lusiana & Yuliarty (2020), forecasting is the process of estimating future needs, including needs in terms of quantity, quality, time, and location required to meet the demand for goods or services. Forecasting is an estimate of the demand level for one or more products over several future periods (Kusuma, 2009).

Master Production Schedule

The Master Production Schedule (MPS) provides an overview of the planning period for demand, including forecasts, backlogs, supply plans, final inventory, and promised available quantities. The MPS is based on aggregate production planning and serves as a key link in the planning and control chain. MPS is related to marketing, distribution planning, production planning, and capacity planning..

Sinulingga (2013) defines the Master Production Schedule (MPS) as a statement of what final products or items are planned to be produced and how many of those products or items will be produced in each period throughout the planning horizon.

RESULT AND DISCUSSION

The data used consists of observation data and company data. Observation data were obtained from stopwatch time studies on the production floor. Observation data were also obtained from direct interviews with company personnel. The historical data used are data obtained from the company.

Table 2. Demand Data and Production Data for Nobu Pink Ceramic Type

Month	Demand Quantity (Box)	Production Data (Box)
January	10.900	5.854
February	11.500	10.672
March	11.500	8.643
April	9.874	5.463

May	11.500	11.597
June	11.500	5.470
July	11.500	0
August	11.500	8.224
September	11.500	11.595
October	11.500	11.302
November	11.500	8.795
December	11.500	12.452

Based on the observations, it was found that there are 3 shifts of working time. Each shift works for 8 hours per day plus 4 hours of work on Saturdays. Here are the number of workers at each workstation.

Table 3. The number of workers at each workstation

Process	Machine (Unit)	Workers
Milling	4	8
Spry Dryer	1	3
Press	2	6
Horizontal Dryer	3	9
Glazing Line	2	6
Kiln	2	6
Packing	2	9

Source: PT Arwana Citramulia Tbk. Plant 1

Forecasting

Based on the forecast calculation for Nobu Pink ceramic demand using exponential smoothing method (alpha 0.4), the results are as follows:

Table 4. Result of Forecast Calculation

Month	Demand Quantity (Box)	ES 0,4
January	11.500	-
February	10.900	11.500
March	11.500	10.900
April	11.500	11.140
May	9.874	11.284
June	11.500	10.720
July	11.500	11.032
August	11.500	11.219
September	11.500	11.332
October	11.500	11.399
November	11.500	11.439
December	11.500	11.464
January	11.500	11.478

Master Prodction Schedule

The preparation of the master production schedule for the next 12 months based on the forecast results is as follows:

- Gross requirements are taken from the forecasted demand for January - December.
- Project On Hand (POH) represents the inventory on hand.
- The initial POH is 952 crates, obtained from the final production in December last years, which was 12,452 Box be diminished the demand quantity of 11,500 Box. Hence, the inventory on hand is only 952 units.
- Net requirements are obtained by subtracting the POH from the gross requirements.

Table 5. Master Production Schedule

Periode	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Agst	Sept	Okt	Nov	Des
Gross Req.	11.500	10.900	11.140	11.284	10.720	11.032	11.219	11.332	11.399	11.439	11.464	11.478
POH*	952	0	0	0	0	0	0	0	0	0	0	0
Nett Req.	10.548	10.900	11.140	11.284	10.720	11.032	11.219	11.332	11.399	11.439	11.464	11.478

Working Time Measurement Example

The working time measurement is conducted to determine the various time components required to produce a product, or in other words, to ascertain the standard time for the ceramic manufacturing process. The work time measurement is conducted using the Stopwatch Time Study method through repetitive observations.

- The Adequacy of Data Test

  The adequacy of data test is conducted to determine whether the observed data we have collected is sufficient or not. The data is considered sufficient if the value of N' is less than the value of N or the number of observations.

Table 6. Working Time Data of Horizontal Dryer Process (minute)

No	X	X^2
1	10-24	104.858
2	11.01	121.220
3	11,09	122.988
4	12.14	147.380
5	11.87	140.897
6	10.9	118.81
7	10.22	104.448
8	10.30	106.09
9	11.80	139.24
10	10.22	104.448
Total	109.79	1,210.379

Given the value of (k = 2) or 95%. The value (k) represents the confidence level where the researcher uses a confidence level of 95%. (s = 5%). The value (s) represents the error value that may arise in processing this data. If the researcher uses a confidence level of 95%, then the value of (s) or the error value is 5% (95% + 5% = 100%), and N = 10 (number of observations).

Based on the obtained results, the value of (N) is greater than (N') or (N' < N), which is 6.631 < 10. Therefore, the data is considered sufficient.

- Test Data Uniformity

  The test for data uniformity is conducted to determine whether the collected data is uniform or not. It means the data has entered within the control limits. Data is considered uniform if it does not exceed the upper control limit (UCL) and does not fall below the lower control limit (LCL). The mathematical calculation is as follows: Based on the calculation results, the upper control limit (UCL) is obtained as 12.469, while the lower control limit (LCL) is 9.489.

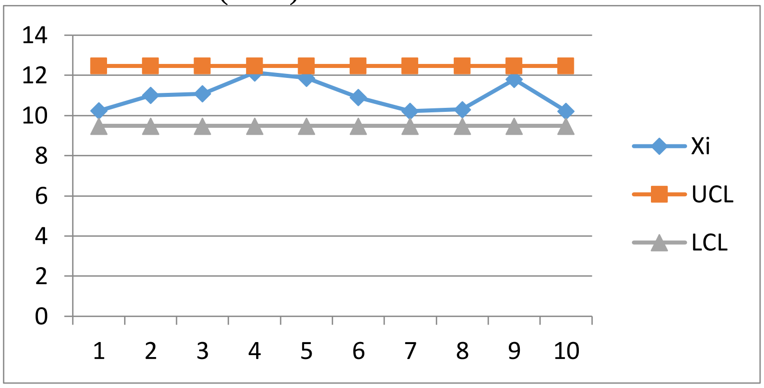

Figure 2. Uniformity Data Control Chart of Horizontal Dryer Process

Based on the graph above, it is known that the data is within control limits because there are no data points exceeding the upper control limit (UCL) and no data points falling below the lower control limit (LCL). Since the data is within control limits, the observed data is considered to be uniform. This can be observed from the blue line graph where there are no points exceeding the control limits.

Standard Time Calculation Example

After conducting the data processing test, the next step is to determine the normal time, cycle time, and standard time in order to calculate the capacity of each machine.

Before determining the standard time, it is necessary to determine the adjustment factor and the allowance factor. In this study, the adjustment factor uses the Westinghouse approach. Assessment is carried out by the production manager, considering the assessment based on categories according to the Westinghouse approach. The data for the adjustment of the horizontal dryer process is as follows:

- Horizontal Dryer Process

Table 7. Adjustment Factor for Horizontal Dryer Process

No	Factor	Class	Symbol	Adjusment
1	Skill	Good	C1	+0.06
2	Effort	Average	D	0.00
3	Work Condition	Average	D	0.00
4	Consistency	Fair	E	-0.02
		Total		+0.04

Based on the table above, the adjustment factor for the horizontal dryer is P = 1 + 0.04 = 1.04.

After assessing the adjustment factor, the next step is to assess the allowance factor. The assessment is carried out by the production manager based on the actual conditions and situations in the production area. The data for the allowance of the horizontal dryer process is as follows:

Table 8. Allowance Factor for Horizontal Dryer Process

No	Factor	Explanation	Point
1	The exerted force	Medium	12
2	Work posture	Standing on two feet	2
3	Work movements	Normal	0
4	Eye fatigue	Continuous viewing with changing focus	12
5	Workplace temperature	High	10
6	Atmospheric conditions	Good	0
7	Good environmental conditions	Very noisy	2
8	Personal needs	Men	1
	Total		39

After determining the adjustment value and the allowance value, the cycle time, normal time, and standard time can be calculated.

a. Cycle time = 10.979 minute/6 pcs (1 Box)
b. Normal time = 11.418 minute/6 pcs (1 Box)
c. Standard time = 18.781 minute/6 pcs (1 Box)

Below is the table for calculating the standard time for the entire ceramic manufacturing process.

Table 9. All Process Standard Time

Process	Standard Time (mnt)	Standard Time (Hrs)	Standard Time (1 pcs)
Horizontal Dryer	18.718 minute	0,312 hrs/6 pcs	0,052 hrs
Glazing Line	5.767 minute	0,096 hrs/6 pcs	0,016 hrs
Kiln	105.567 minute	1,759 hrs/48 pcs	0,036 hrs
Packing	2.559 minute	0,043 hrs/16 pcs	0,007 hrs

Calculation of Required Capacity

The calculation of required capacity is done using the Rough Cut Capacity Planning (RCCP) method with the Bill of Labor approach. The calculation involves multiplying the master production schedule matrix by the standard time matrix, then dividing by the number of workers.

- Horizontal Dryer Process

  $C = \sum \left(\frac{A \times B}{W}\right)$

  Legend:

  C : Capacity Required

  A : Standard Time

  B : MPS Quantity

  W : Numbers or workers

  $C_{January} = \left(\frac{0.052 \times (10.548 \times 16)}{9}\right)$

  $C_{Januari} = 975{,}104 \text{ jam/bulan}$

- Glazing Line Process

  $C_{January} = \left(\frac{0.016 \times (10.548 \times 16)}{6}\right)$

  $C_{Januari} = 450{,}048 \text{ jam/bulan}$

- Kiln Process

  $C_{January} = \left(\frac{0.036 \times (10.548 \times 16)}{6}\right)$

$C_{January} = 1.012{,}608 \text{ jam/bulan}$

- Packing Process

$C_{January} = \left(\frac{0.400 \times (10.548 \times 16)}{9}\right)$

$C_{January} = 131{,}264 \text{ jam/bulan}$

The table below is a summary of the required capacity results in hour units.

Table 10. Summary of the Required Capacity Results in Hour Units

Process / Month	*Horizontal Dryer*	*Glazing Line*	*Kiln*	*Packing*
January	975,104	450,048	1.021,608	131,264
February	1.007,644	465,067	1.046,400	135,644
March	1.029,831	475,307	1.069,440	138,631
April	1.043,143	481,451	1.083,264	140,423
May	991,004	457,387	1.029,120	133,404
June	1.019,847	470,699	1.059,072	137,287
July	1.037,153	478,686	1.077,043	139,617
August	1.047,536	483,478	1.087,826	141,014
September	1.053,766	486,354	1.094,296	141,853
October	1.057,504	488,079	1.098,177	142,356
November	1.059,747	489,114	1.100,506	142,658
December	1.061,093	489,735	1.101,904	142,839

Calculation of Available Capacity

Available capacity is used to compare the required production time with the existing production time in the company for one month. Based on the observations, it was found that the production process is carried out in 3 shifts. With 5 working days plus half a working day on Saturday, here are the detailed data on the working hours and days of the employees.

From field observations and time measurements, the following data were obtained:

- Milling Process
  - In the milling process, the time needed to process 1 Ballmill is 6 hours with a capacity of 13.5 tons. 1 Ballmill = 13.5 tons or 13,500 kg
  - Monday-Friday:
  - 1 day = (24 hours) / (6 hours) = 4 Ballmill (1 Ballmill is loaded once, during 24 hours it's loaded 4 times)
  - Ballmill machine capacity for 1 day = 13.5 x 4 = 54.0 tons
  - Saturday:
    1 day = (12 hours) / (6 hours) = 2 Ballmill (1 Ballmill is loaded once, during 12 hours it's loaded 2 times)
  - Ballmill machine capacity for 1 day = 13.5 kg x 2 = 27.0 tons
  - Ballmill machine capacity for 1 month with 8 hours / shift = 54.0 tons x 22 days = 1,188 tons/month or 1,077,735 kg/month
  - Ballmill machine capacity for 1 month with 4 hours / shift = 27.0 tons x 4 days = 108 tons/month or 97,976 kg/month
  - Total capacity in 1 month = 1,077,735 + 97,976 = 1,175,711 kg/month
- Spry Dryer Process

For the spray dryer process, the machine can hold 23 kg every 10 seconds.

- Capacity for 1 hour = 3,600/10×23kg = 8,280 kg/hour
- Capacity for 1 day (8-hour shift) = 8,280 kg x 24 hours = 198,720 kg
- Capacity for 1 month (8-hour shift) = 198,720 kg x 22 days = 4,371,840 kg/month
- Capacity for 1 day (4-hour shift) = 8,280 kg x 12 hours = 99,360 kg
- Capacity for 1 month (4-hour shift) = 8,280 kg x 4 days = 33,120 kg/month
- Total capacity for 1 month = 4,371,840 kg + 33,120 kg = 4,404,960 kg/month

- Press Machine

For the press machine, the cycle per minute is 12 times. Each press produces 4 ceramic pieces. There are 2 press machines that print ceramic pieces sized 25 x 25 cm, so the area per ceramic is 0.0625 m2.

- Ceramic area = side x side = 25 x 25 = 625 cm2 = 625/10,000 = 0.0625 m2
- Capacity for 1 minute = 12 x 4 pieces = 48 pieces
- Capacity for 1 minute = 48 pieces x 0.0625 = 3 m2
- Capacity for 1 hour = 3 x 60 minutes = 180 m2
- Capacity for 1 day for an 8-hour shift = 180 m2 x 24 hours = 4,320 m2/day
- Capacity for 1 month for an 8-hour shift = 4,320 m2/day x 22 days = 95,040 m2/month
- Capacity for 1 day for a 4-hour shift = 180 m2 x 12 hours = 2,160 m2/day
- Capacity for 1 month for a 4-hour shift = 2,160 m2/day x 4 days = 8,640 m2/month
- Total capacity for 1 month = 95,040 + 8,640 = 103,680 m2/month
- Capacity for 1 month (2 machines) = 103,680 x 2 = 207,360 m2/month

- Horizontal Dryer Process

The horizontal dryer work station operates for 8 hours on regular days, 4 hours on Saturdays, and stops for 5 minutes (0.083 hours) for setup to ensure the machine works properly.

- Actual working hours (Monday-Friday) = Effective working hours - prepare to go home hours = 8 hours - 0.25 hours = 7.75 hours
- Actual working hours (Saturday) = 3.75 hours
- Utilization = (actual working hours) / (available hours) × 100% = 11.5/12×100% = 0.96
- Standard hours obtained by the machine = actual hours - ((actual hours) / (standard working hours setup time + setup time)) × setup time = 11.5 - (11.5/(8+0.083))×0.083= 11.382
- Efficiency = (standard hours) / (actual hours) × 100% = 11.382/11.5×100 = 0.99
- Machine working hours on Monday-Friday = hours/day x days/month = 24 x 22 = 528 hours/month
- Machine working hours on Saturday = hours/day x days/month = 12 x 4 = 48 hours/month
- Total machine working hours = 528 + 48 = 576 hours/month
- Available capacity = Number of machines x Machine working hours x Utilization x Efficiency = 3 x 576 x 0.96 x 0.99 = 1,642.291 hours/month
- The number of ceramics in one process is 6, and the time for one process is 10.979 minutes. The time used for one ceramic is 1.83 minutes.
- Capacity for 1 hour = 60/10.979×6 = 33 pieces

- So, for 1 month producing ceramics = 1,642.291 x 33 pieces = 54,195 pieces/month.

- Glazing Process

  The glazing line work station operates for 8 hours on regular days, 4 hours on Saturdays, and stops for 5 minutes (0.083 hours) for setup to ensure the machine works properly.
  - Actual working hours (Monday-Friday) = Effective working hours - prepare to go home hours = 8 hours - 0.25 hours = 7.75 hours
  - Actual working hours (Saturday) = 3.75 hours
  - Utilization = (actual working hours) / (available hours) × 100% = 11.5/12×100% = 0.96
  - Standard hours obtained by the machine = actual hours - ((actual hours) / (standard working hours setup time + setup time)) × setup time = 11.5 - (11.5/(8+0.083))×0.083= 11.382
  - Efficiency = (standard hours) / (actual hours) × 100% = 11.382/11.5×100 = 0.99
  - Machine working hours on Monday-Friday = hours/day x days/month = 24 x 22 = 528 hours/month
  - Machine working hours on Saturday = hours/day x days/month = 12 x 4 = 48 hours/month
  - Total machine working hours = 528 + 48 = 576 hours/month
  - Available capacity = Number of machines x Machine working hours x Utilization x Efficiency = 2 x 576 x 0.96 x 0.99 = 1,094.860 hours/month
  - The number of ceramics in one process is 6, and the time for one process is 3.009 minutes.
  - Capacity for 1 hour = 60/3.009×6 = 120 pieces/hour
  - So, for 1 month producing ceramics = 1,094.860 x 120 pieces = 131,383 pieces/month.

- Kiln Process

  The Kiln work station operates for 8 hours on regular days, 4 hours on Saturdays, and stops for 5 minutes (0.083 hours) for setup to ensure the machine works properly.
  - Actual working hours (Monday-Friday) = Effective working hours - break hours = 8 hours - 0.25 hours = 7.75 hours
  - Actual working hours (Saturday) = 3.75 hours
  - Utilization = (actual working hours) / (available hours) × 100% = 11.5/12×100% = 0.96
  - Standard hours obtained by the machine = actual hours - ((actual hours) / (standard working hours setup time + setup time)) × setup time = 11.5 - (11.5/(8+0.083))×0.083= 11.382
  - Efficiency = (standard hours) / (actual hours) × 100% = 11.382/11×100 = 0.99
  - Machine working hours on Monday-Friday = hours/day x days/month = 24 x 22 = 528 hours/month
  - Machine working hours on Saturday = hours/day x days/month = 12 x 4 = 48 hours/month
  - Total machine working hours = 462 + 48 = 576 hours/month
  - Available capacity = Number of machines x Machine working hours x Utilization x Efficiency = 2 x 576 x 0.96 x 0.99 = 1,049.860 hours/month
  - The number of ceramics in one process is 48 pieces, and the time for one process is 29.324 minutes.

- Capacity for 1 hour = 60/29.324×48 = 98 pieces/hour
- So, for 1 month producing ceramics = 1,049.860 x 98 pieces = 107,296.28 pieces/month.

- Packing Process

The packing work station operates for 8 hours on regular days, 4 hours on Saturdays, and stops for 5 minutes (0.083 hours) for setup to ensure the machine works properly.

- Actual working hours (Monday-Friday) = Effective working hours - break hours = 8 hours - 0.25 hours = 7.75 hours
- Actual working hours (Saturday) = 3.75 hours
- Utilization = (actual working hours) / (available hours) × 100% = 11.5/12×100% = 0.96
- Standard hours obtained by the machine = actual hours - ((actual hours) / (standard working hours setup time + setup time)) × setup time = 11.5 - (11.5/(8+0.083))×0.083= 11.382
- Efficiency = (standard hours) / (actual hours) × 100% = 11.382/11×100 = 0.99
- Machine working hours on Monday-Friday = hours/day x days/month = 24 x 22 = 528 hours/month
- Machine working hours on Saturday = hours/day x days/month = 12 x 4 = 48 hours/month
- Total machine working hours = 462 + 48 = 576 hours/month
- Available capacity = Number of machines x Machine working hours x Utilization x Efficiency = 2 x 576 x 0.96 x 0.99 = 1,094.860 hours/month
- The number of ceramics in one process is 16 pieces, and the time for one process is 1.516 minutes.
- Capacity for 1 hour = 60/1.516×16 = 633 pieces/hour
- So, for 1 month producing ceramics = 1,094.860 x 633 pieces = 693,046 pieces/month.

Below is a table of Comparison of Required Capacity with Available Capacity.

Table 11. Comparison of Required Capacity with Available Capacity

Month	**Capacity**	**Process**			
		Horizontal Dryer	***Glazing Line***	***Kiln***	***Packing***
Jan	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	975,104	450,048	1.012,608	131,264
	Remaining Capacity	418,420	478,968	-83,592	797,752
Feb	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.007,644	465,067	1.046,400	135,644
	Remaining Capacity	385,880	463,949	-117,384	793,372
Mar	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.029,831	475,307	1.069,440	138,631
	Remaining Capacity	363,693	453,709	-140,424	790,385

Table 11. Comparison of Required Capacity with Available Capacity (cont'd...)

Month	Capacity	Process			
		Horizontal Dryer	***Glazing Line***	***Kiln***	***Packing***
Apr	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.043,143	481,451	1.083,264	140,423
	Remaining Capacity	350,381	447,565	-154,248	788,593
May	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	991,004	457,387	1.029,120	133,404
	Remaining Capacity	402,520	471,629	-100,104	795,612
Jun	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.019,847	470,699	1.059,072	137,287
	Remaining Capacity	373,677	458,317	-130,056	791,729
Jul	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.037,153	478,686	1.077,043	139,617
	Remaining Capacity	356,371	450,330	-148,027	789,399
Aug	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.047,536	483,478	1.087,826	141,014
	Remaining Capacity	345,988	445,538	-158,810	788,002
Sept	Availability Capacity	1.393,524	929,016	929,016	929,016
	Required Capacity	1.053,766	486,354	1.094,296	141,853
	Remaining Capacity	339,758	442,662	-165,280	787,163
Oct	Availability Capacity	1,393.524	929.016	929.016	929.016
	Required Capacity	1,057.504	488.079	1,098.177	142.356
	Remaining Capacity	336.020	440.937	-169.161	786.660
Nov	Availability Capacity	1,393.524	929.016	929.016	929.016
	Required Capacity	1,059.747	489.11	1,100.506	142.658
	Remaining Capacity	333.777	439.902	-171.490	786.358
Dec	Availability Capacity	1,393.524	929.016	929.016	929.016
	Required Capacity	1,061.093	489.735	1,101.904	142.839
	Remaining Capacity	332.431	439.281	-172.888	786.177

Based on the calculation results, the available capacity for the horizontal dryer workstation is 1,642.291 hours/month, while for the glazing line, kiln, and packing workstations it is 1,094.860 hours/month. Considering the final production output of ceramic type nobu pink, the production capacity achieved is 633 pcs/hour, resulting in 15,192 pcs/day. Upon comparing the available capacity with the required capacity, it's evident that there is a capacity shortage at the kiln workstation throughout the entire period. Below are alternative steps to address the capacity shortage issue at the kiln workstation.

An alternative to address the capacity shortage issue is by implementing overtime (extra hours). The calculation of the number of overtime that can be added to the kiln workstation in January is as follows:

The number of overtime = (the amount of capacity shortage (hours) / (number of machines (operators)) = 83,592 / 6 = 14 hours/operator

Therefore, the total overtime that need to be added in January is 14 hours per operator. To meet the capacity shortage, the company can only extend overtime for 3 hours on Saturday, making the working hours on Saturday to be 7 hours.

Table 12 Calculation of Overtime at the Kiln Workstation

Period	Shortage Capacity (Hrs)	Number of Operator	Total Overtime (Hrs)
January	83,592	6	14
February	117,384	6	20
March	140,424	6	23
April	154,248	6	26
May	100,104	6	17
June	130,056	6	22
July	148,027	6	25
August	158,810	6	26
September	165,280	6	28
October	169,161	6	28
November	171,490	6	29
December	172,888	6	29

To fullfill the capacity shortage, an additional of overtime for 14 hours are required for the January period. The proposed overtime is an additional 3 hours on Saturdays, making the working hours initially 4 hours extended to 7 hours. With three shifts, the total overtime for one day are 9 hours, and the overtime for one month are 36 hours. This approach is applied to each period to ensure the capacity shortage is met. Below are the capacity analysis results with overtime alternative in each period.

Table 13 Capacity Analysis with Alternative Addition of Overtime

Period	Availability Capacity	Required Capacity	Remaining Capacity
January	1.163,289	1.012,608	150,681
February	1.163,289	1.046,400	116,889
March	1.163,289	1.069,440	93,849
April	1.163,289	1.083,264	80,025
May	1.163,289	1.029,120	134,169
June	1.163,289	1.059,072	104,217
July	1.163,289	1.077,043	86,246
August	1.163,289	1.087,826	75,463
September	1.163,289	1.094,296	68,993
October	1.163,289	1.098,177	65,112
November	1.163,289	1.100,506	62,783
December	1.163,289	1.101,904	61,385

With the addition of a maximum of 36 overtime/month in each period, there is an increase of capacity as indicated in Table 13 above.

CONCLUSION

Based on the analysis of production capacity using the Capacity Requirement Planning (CRP) method, the available capacity for the horizontal dryer workstation is 1,642.291 hours/month, while for the glazing line, kiln, and packing workstations it is 1,094.860 hours/month. The research results indicate that the production capacity of ceramic type nobu pink is 633 pcs/hour, and the production capacity of ceramic type nobu pink in one day is 15,192 pcs.

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