

Implementation Of Economic Production Quantity (EPQ) Method in Controlling Brick Production at UD SM Edi-Mardiana Serdang Bedagai

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Abstract. Currently, business competitors are facing challenges, especially in the industrial sector. In achieving its goals, the company will face certain obstacles so that the company must have good management. Because without good management the company will experience a shortage of production (shortage) or excess production (over stock) which results in losses for the company. UD. SM Edi Mardiana Serdang Bedagai is a business that produces bricks which is experiencing problems in the form of excess production inventory. Therefore, a policy is needed to control the amount of production by adjusting consumer needs so as not to cause losses for the company. One method that can be used is the Economic Production Quantity (EPQ) method which can determine the optimal production level, the optimal time interval to minimize inventory costs. From the results of calculations using the EPQ method, the optimal level of brick production for each production period is 4.326.589.75 seeds with an interval of 6,79 months and the total cost of procuring production with the EPQ method is Rp313.532.065,95.

Keyword: Economic Production Quantity (EPQ), Bricks, Inventory Control, Inventory, Production

Abstrak. Pada masa kini, pesaing usaha menjalani tantangan terutama di sektor industri. Dalam mencapai tujuannya perusahaan akan menghadapi kendala tertentu sehingga perusahaan harus memiliki manajemen yang baik. Karena tanpa adanya manajemen yang tepat perusahaan akan mengalami kekurangan jumlah hasil produksi (shortage) atau kelebihan hasil produksi (over-stock) yang mengakibatkan kerugian pada perusahaan. UD. SM Edi Mardiana Serdang Bedagai adalah sebuah usaha yang memproduksi batu bata yang mengalami permasalahan berupa kelebihan persediaan produksi. Oleh karena itu diperlukan kebijakan untuk mengendalikan jumlah produksi dengan menyesuaikan kebutuhan konsumen agar tidak menimbulkan kerugian pada perusahaan. Salah satu metode yang dapat digunakan adalah metode Economic Production Quantity (EPQ) yang dapat menentukan tingkat produksi optimal, interval waktu optimal untuk meminimumkan biaya persediaan. Dari hasil perhitungan menggunakan metode EPQ, tingkat produksi optimal Batu Bata setiap periode produksi adalah 4.326.589,75 biji dengan interval waktu 6,79 bulan dan total biaya pengadaan produksi dengan metode EPQ sebesar Rp313.532.065,95.

Kata Kunci: Economic Production Quantity (EPQ), Batu Bata, Pengendalian Persediaan, Persediaan, Produksi

Received 4 October 2022 | Revised 11 November 2022 | Accepted 20 December 2022

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1. Introduction

At present, business competitors are facing challenges, especially in the industrial sector. I get profit is the main goal of the company. In achieving its goals, the company will certainly experience several obstacles, Therefore, the company must have proper governance to control the activities carried out by the company in order to operate efficiently and the company will get optimal profit. Production is one of the jobs that produce goods or to be carried out by the company.

Inventory is one of the most important aspects in a company to meet consumer demand from time to time[1]. Inventory management is very important for companies, because without good management, a company will have problems in the process of meeting consumer needs, whether in the form of goods or a service produced .

A company must be proficient in the problem of determining the amount of production produced, because without good governance the company will experience a shortage of manufactured goods (shortage) which results in unfulfilled consumer demand, so that the profits obtained by the company will be reduced or excess production (over-stock) and cause the company to incur undue costs such as construction costs, loss costs, costs of damage to goods due to long-term storage and the possibility of shrinkage in production.

UD S M While Berdagai is a business that produces bricks. This trading business is located in Karang Rejo Village, Serdang Berdagai Regency, which has been established since 2003. The production results of this business have spread to the North Sumatra Province, such as Pematangsiantar, Pematang Raya, Sidamanik, Siborong-borong and Tarutung. UD. SM Serdang Berdagai often experiences problems in the form of excess production stock which causes losses due to increased storage costs and shrinkage of bricks. Therefore, a policy is needed to control the amount of production by adjusting consumer needs so as not to cause losses to the company.

The Economic Production Quantity (EPQ) method is an evolution of the inventory control method. The EPQ method aims to determine the optimum production results in the right time and with the lowest production costs. Production results in this method must be more than the required amount. This means that before the stock runs out, the production process must be carried out. Inventory will gradually decrease and increase to meet demand. Therefore, EPQ can be used to calculate the optimal production quantity with optimal time and cost so that the company can control production inventory.

2. Literature Review

2.1. Inventory Control

An inventory control is the company's expertise to control all needs, be it raw materials, or semi-finished products even for finished products, ensuring that they are always available adequately in a balanced and fluctuating market condition. Inventory control is a very common model used in solving problems related to efforts to manage inventory of raw materials and finished materials in a company activity. If the company does not have enough inventory, the costs for emergency procurement will increase. In general, an inventory control will facilitate and speed up the work of factory companies, which need to be carried out sequentially in producing goods, storing them in warehouses and sending them to consumers. Inventories are goods that are stored for use or sale in the future or period to come. The purpose of supplies are [2]

Inventory control is a commodity that has been collected and stored and can then be used to fulfill demand at any time. The demand is in the form of raw materials, components, semi-finished goods, spare parts, and so on [3]. The purpose of inventory control is as follows [4]:

1. Preventing production activities from stopping as a result of running out of inventory in a company.
2. Preventing spending in a company is not excessive.
3. Preventing a company from buying goods/products in a small way so that the cost of the order is not too large.

2.2. Lilliefors Test

In the process of inventory control, in statistics a can be used to establish and determine distribution patterns. In this distribution pattern can also be calculated by testing the normality of the observed data. This test was carried out using the Lilliefors Normality Test. The definition of normality test is a method used to see whether the data comes from a population that is normally distributed or has a normal distribution [5].

Suppose there is a sample with data values $x_1, x_2, x_3, \dots, x_n$. Hypothesis testing is carried out based on this sample, namely:

1. Hypothesis (H_0): The sample comes from a normally distributed population.
2. Hypothesis (H_1): The sample comes from a population that is not normally distributed.

1. To test the hypothesis, the steps taken are as follows: The data values x_1, x_2, \dots, x_n are used as numbers in standard z_1, z_2, \dots, z_n form by using the formula:

$$z(i) = \frac{x_i - \bar{x}}{s} \quad (1)$$

description:

- \bar{x} = sample mean value
 s = sample standard deviation The formula used to calculate the sample mean:
 i = 1, 2, 3, ..., n

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n} \quad (2)$$

The formula used to calculate the standard deviation:

$$S = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{X})^2}{n - 1}} \quad (3)$$

2. Calculates the probability $F(Z_i) = P(Z \leq Z_i)$ value using a standard normal distribution list.
3. Calculating the ratio $Z_1, Z_2, Z_3, \dots, Z_n$.

If the ratio is denoted by $S(Z_i)$, then:

$$S(Z_i) = \frac{\text{Total } z_1, z_2, z_3, \dots, z_n \leq z_i}{n} \quad (4)$$

4. Calculate the difference $F(Z_i) - S(Z_i)$, with the formula , namely:

$$|F(Z_i) - S(Z_i)| \quad (5)$$

5. Finding the maximum value between the absolute values of the difference $|F(Z_i) - S(Z_i)|$ and make it as L_{count} or L_0 ie:

$$L_{0(count)} = \max\{|F(Z_i) - S(Z_i)|\} \quad (6)$$

For $i = 1, 2, 3, \dots, n$

6. The determining criterion is the comparison L_{count} with the value L_{table} or $L_{\alpha(n)}$. If:
 $L_{count} \leq L_{table}$; then H_0 accepted so that the data distribution is normal.
 $L_{count} > L_{table}$; then it is H_0 rejected then the data is not in the form of a normal distribution which $L_{\alpha(n)}$ is a critical point to perform the Lilliefors Normality Test with a significant level α and a lot of data n.

2.3. Economic Production Quantity

The EPQ method is an evolution of the inventory method which mass-produces the procurement of raw materials for certain spare parts and uses them only as product sub-parts. The definition of EPQ or what is often known as the optimal production level is a method for minimizing the total inventory cost of production set-up and storage costs[6].

The EPQ method assumes that an inventory is added gradually and is carried out continuously during the production period. Therefore, production and inventory do not increase during the production period. Where is the Unit in production is taken from storage or purchased from

suppliers. If an item is purchased from a supplier, pricing is the responsibility of the purchasing department. When an item is produced in a factory, there is a production cost per unit.

The assumptions contained in the EPQ Model are described as follows.

1. Production runs continuously with a production rate of P units per unit time.
2. During production (t_p), the level of inventory fulfillment is equal to the level of production minus the level of demand ($P-D$).
3. When production stops at one point, the inventory will decrease at a rate D per unit time.
4. Inventory levels are the same for each production cycle.
5. The lead time is constant.
6. Deterministic demand with a known demand rate.
7. There is no stock-out

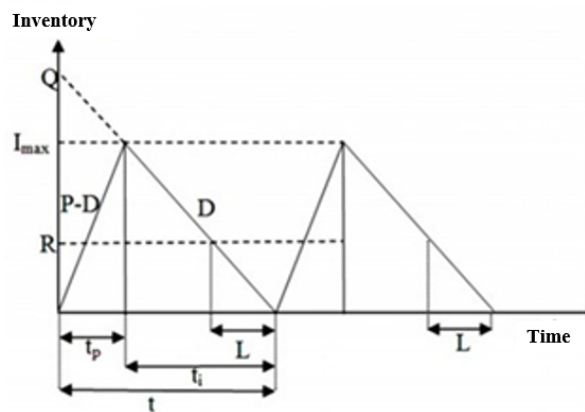


Figure 1. EPQ Inventory Chart

Information:

- Q : The amount of production in one round of production.
 I_{max} : Maximum inventory level.
 P : Average production per unit time.
 D : Average distribution per unit time.
 R : Inventory is running out.
 L : Back production process time.
 t_p : The time of the production process is done.
 t_i : The production process stops.
 t : Time of one production cycle

From Figure 1 it can be seen that the amount of production per round must meet the demand for D during time t , or denoted $Q = D.t$. Production is carried out at period t_p with the production level P at the same time as the fulfillment of demand. When the inventory reaches its maximum at period t_p , namely $I_{max} = t_p(P - d)$, then the production process stops.

Average inventory will be equal to:

$$t_p = \left(\frac{P-D}{2} \right) \quad (7)$$

To meet the inventory of Q , it takes time t_p with a level of increase in inventory of P , then the equation:

$$Q = t_p P \quad \text{or} \quad t_p = \frac{Q}{P} \quad (8)$$

At period t_i the production process has stopped and there is a reduction in inventory with level D . If the inventory has reached level R , then a production procurement must be held whose duration depends on L (lead time).

Substitute equation (7) into equation (8), then the average inventory will be:

$$\begin{aligned} \frac{Q}{P} \left(\frac{P-D}{2} \right) &= \frac{Q(P-D)}{2P} \\ &= \frac{Q}{2} \left(1 - \frac{D}{P} \right) \end{aligned} \quad (9)$$

For each time the inventory is stored, the holding cost h is required, then:

$$\text{Carrying cost} = \frac{Q}{2} \left(1 - \frac{D}{P} \right) h \quad (10)$$

Since the number of production cycles is $\frac{D}{P}$ with $Q > D$ and $D \neq 0$ required procurement costs k , then:

$$\text{procurement costs} = \frac{D}{Q} k \quad (11)$$

The amount of Total Inventory Cost (TIC) is obtained from the sum of the set-up costs (procurement costs) and holding costs (storage costs) as follows:

$$TIC = \text{set-up cost} + \text{holding cost} \quad (12)$$

Substitute equation (10) and (11) into equation (12)

$$TIC = \frac{D}{Q} k + \frac{Q}{2} \left(1 - \frac{D}{P} \right) h \quad (13)$$

Equation (13) is differentiable to Q so it can minimize the set-up cost and holding cost, which is

called EPQ and will be denoted as Q_0 . Then obtained as follows:

$$\begin{aligned}\frac{\partial TIC}{\partial Q} &= -\frac{D}{Q^2}k + \frac{1}{2}\left(1 - \frac{D}{P}\right)h = 0 \\ \frac{D}{Q^2}k &= \frac{1}{2}\left(1 - \frac{D}{P}\right)h \\ Q_0 &= \sqrt{\frac{2DK}{\left(1 - \frac{D}{P}\right)h}}\end{aligned}\quad (14)$$

From equation (19) Q_0 is used to find the optimal time interval for each production cycle, as follows:

$$t_0 = \frac{Q_0}{D} \quad (15)$$

To calculate the minimum TIC_0 , it is obtained by substituting Q_0 into equation (13), so we get:

$$TIC = k\frac{D}{Q_0} + \frac{Q_0}{2}\left(1 - \frac{D}{P}\right)h \quad (16)$$

with:

- Q : The amount of production in one round of production.
- Q_0 : Optimal production rate per one production cycle.
- D : The rate of distribution of production per unit time.
- P : Production rate per unit time.
- C_s : Set-up cost or procurement cost for each production cycle.
- C_c : Holding cost or storage cost per unit per unit time.
- TIC : Total inventory cost
- TIC_0 : Total minimum cost of production inventory.
- I_H : Average inventory
- I_{max} : Maximum stock
- t_0 : Optimal time of one production cycle.
- t : Time of one production cycle.

3. Methodology

The procedure in this study is described by a flowchart as shown is Figure 2.

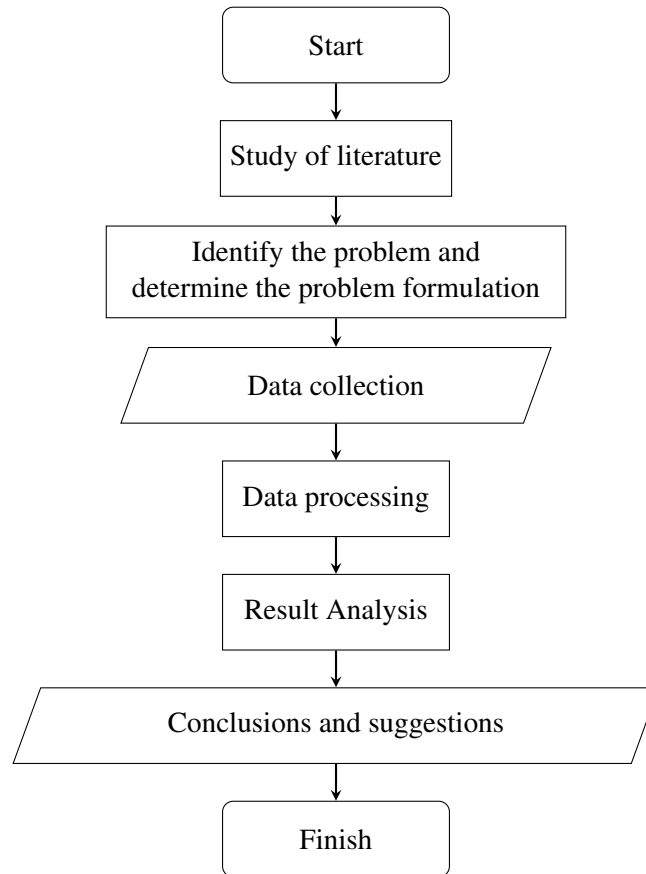


Figure 2. Research Prosedure

This initial stage examines the theory of inventory and the EPQ (Economic Production Quantity) method or what is often known as the optimal production level to minimize the total inventory cost. Studies sourced from several reference books and research journals that support the EPQ method can minimize production costs.

Then data collection where this stage requires production data, distribution data, production procurement costs and tapioca flour storage costs by UD SM Serdang Berdagai in the 2020-2021 period. Then the data processing is carried out quantitatively including the normality test of the distribution data with the Liliefors Normality Test and then using the EPQ method to calculate the optimal production level, interval time and minimum inventory cost.

Next is the analysis of the results. At this stage, quantitative data are obtained in the form of production levels, interval time and optimal minimum inventory costs after being processed by the EPQ method. Previously, normality data was obtained after testing the data with the Liliefors test. Finally, by determining conclusions and suggestions. After researching through data collection, data processing and analysis of the results, it can be concluded that the EPQ method can be a solution to save or minimize tapioca flour production costs at PT Bumi Sari Prima Pematangsiantar. Then recommend the company to apply the EPQ method in operational policies.

4. Results and Discussions

4.1. Data Normality Test with Lilliefors

The data for the distribution of bricks in 2020 and 2021 were tested for normality using the Lilliefors Normality Test to see if the data obtained had a normal distribution.

1. The steps for testing brick distribution data in 2020 are as follows:

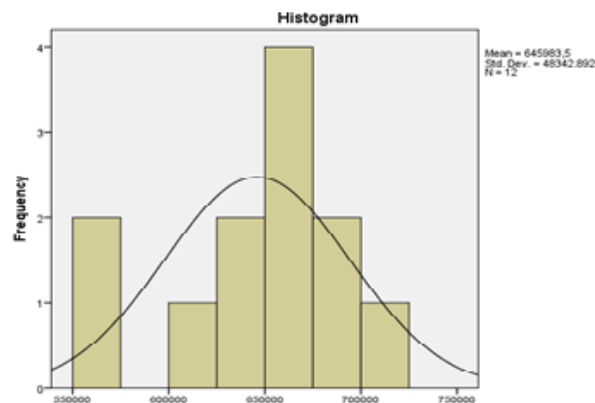


Figure 3. Bricks Distribution Histogram 2020

Hypothesis:

H_0 : Distribution of bricks in the period January – December 2020 is normally distributed.

H_1 : Distribution of bricks in the period January – December 2020 is not normally distributed.

Table 1. Normality Test of Data Distribution of Bricks in 2020

x_i	Z_i	$F(Z_i)$	$S(Z_i)$	$ F(Z_i) - S(Z_i) $
650623	0.10	0.5398	0.5000	0.0398
611649	-0.71	0.2420	0.2500	0.0080
698310	1.08	0.8599	0.9167	0.0568
564358	-1.69	0.0455	0.0833	0.0378
671107	0.52	0.6985	0.7500	0.0515
695700	1.03	0.8485	0.8333	0.0152
625841	-0.42	0.3372	0.3333	0.0039
663050	0.35	0.6368	0.5833	0.0535
565637	-1.66	0.0485	0.1667	0.1182
664340	0.38	0.6480	0.6667	0.0187
711229	1.35	0.9115	1.0000	0.0885
629958	-0.33	0.3707	0.4167	0.0460

From Table 1 obtained the values:

$$L_{0(count)} = \text{Max}|F(Z_i) - S(Z_i)| = 0.1182$$

$L_{table} = L_{\alpha(n)}$, obtained from the Lilliefors Normality Test table with a significant level $\alpha = 0,005$ and $n=12$.

$L_{\alpha(n)} = L_{0,05(12)} = 0,2420$ Because $L_{0(count)} < L_{table}$, it is H_0 accepted, meaning that the brick distribution data from January to December 2020 is normally distributed. Therefore, the calculation in inventory control can use the EPQ method.

2. The steps in testing brick distribution data in 2021 are:

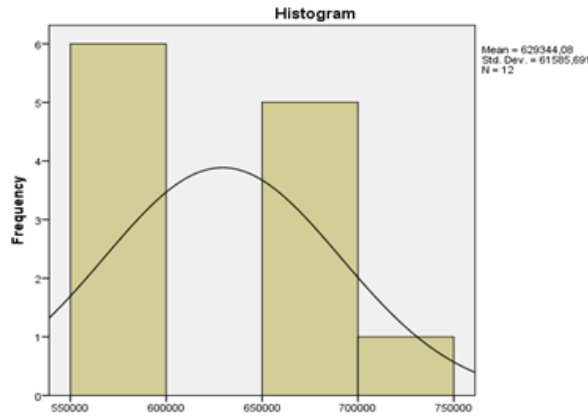


Figure 4. Bricks Distribution Histogram 2021

Hypothesis:

H_0 : Distribution of bricks in the period January – December 2021 is normally distributed.

H_1 : Distribution of bricks in the period January – December 2021 is not normally distributed.

Table 2. Normality Test of Data Distribution of Bricks in 2021

x_i	Z_i	$F(Z_i)$	$S(Z_i)$	$ F(Z_i) - S(Z_i) $
574027	-0.90	0.1841	0.3333	0.1492
564392	-1.05	0.1469	0.1667	0.0198
691959	1.02	0.8461	0.9167	0.0706
550023	-1.29	0.0985	0.0833	0.0152
657088	0.45	0.6736	0.5833	0.0903
676988	0.77	0.7794	0.8333	0.0539
740830	1.81	0.9649	1.0000	0.0351
593877	-0.58	0.2810	0.4167	0.1357
570953	-0.95	0.1711	0.2500	0.0789
596588	-0.53	0.2981	0.5000	0,2019
661468	0.52	0.6985	0.6667	0.0318
673936	0.72	0.7642	0.7500	0.0142

From Table 1 obtained the values:

$$L_{0(count)} = \text{Max}|F(Z_i) - S(Z_i)| = 0.2019$$

$L_{table} = L_{\alpha(n)}$, obtained from the Lilliefors Normality Test table with a significant level $\alpha = 0,005$ and $n=12$.

$L_{\alpha(n)} = L_{0,05(12)} = 0,2420$ Because $L_{0(count)} < L_{table}$, it is H_0 accepted, meaning that the brick distribution data from January to December 2021 is normally distributed. Therefore, the calculation in inventory control can use the EPQ method.

4.2. Calculation with EPQ Method

Based on the normality test of the data using the Lilliefors test, it was found that the data from the distribution of bricks in UD. SM Serdang Berdagai comes from a population that follows a normal distribution pattern from 2020-2021.

4.2.1. Optimal Production Rate (Q_0)

Based on data obtained from UD. SM Serdang Berdagai, then it can be calculated:

1. The average number of bricks produced each month is:

$$\begin{aligned} P &= \frac{\text{amount of production in 2020} + \text{amount of production in 2021}}{24} \\ &= \frac{8.418.507 + 8.545.894}{24} \\ &= 706.850,04 \end{aligned}$$

So the average number of bricks production every month is 706,850.04 seeds.

2. The average number of brick distributions per month is:

$$\begin{aligned} D &= \frac{\text{The number of distributions in 2020} + \text{The number of distributions in 2021}}{24} \\ &= \frac{7.751.802 + 7.552.129}{24} \\ &= 637.663,79 \text{ pcs} \end{aligned}$$

Then the average number of distribution of bricks every month is 637,663.79 seeds.

3. The average cost of producing bricks per month is:

$$\begin{aligned} k &= \frac{\text{total production cost 2020} + \text{total production cost 2021}}{24} \\ &= \frac{1.052.313.375 + 1.068.236.750}{24} \\ &= Rp 88.356.255,21 \end{aligned}$$

So the average cost of brick production that must be spent is RP 88,356,255.21 every month.

4. Average brick storage cost per seed

The calculation of storage costs (h) is based on the cost of bricks in 2020 and 2021, where the storage cost per brick is based 15% on the price of bricks, which is equal to:

$$\begin{aligned} h &= 15\% \frac{\text{brick prices in 2020} + \text{brick prices in 2021}}{2} \\ &= 15\% \frac{400 + 420}{2} \\ &= 61.5 \end{aligned}$$

Note: Storage fee = 15% of brick price (company policy)

Furthermore, the optimal production level (Q_0) in each production cycle using the following equation:

$$\begin{aligned} Q_0 &= \sqrt{\frac{2Dk}{(1-D/P)h}} \\ &= \sqrt{\frac{(2)(637.663,79)(88.356.255,21)}{\frac{1-637.663,79}{706.850,04}(61,5)}} \\ &= 4.326.589,75 \end{aligned}$$

Then the optimal level of production for each round of production is 4.326.589,75 seeds.

4.2.2. Optimal Time Interval for each Production Round

The optimal time interval obtained for each production cycle is:

$$\begin{aligned} t_0 &= \frac{Q_0}{D} \\ &= \frac{4.326.589,75}{637.663,79} \\ &= 6,79 \text{ month} \end{aligned}$$

So, the most optimal time interval for each production cycle is 6.79 months.

4.3. Minimum Inventory Cost (TIC_0)

The calculation to determine the minimum cost of brick production inventory is follows:

$$\begin{aligned} TIC_0 &= k \frac{D}{Q_0} + \frac{Q_0}{2} \left(1 - \frac{D}{P}\right) h \\ &= (Rp\ 88.356.255,21) \frac{637.663,79}{4.326.589,75} + \frac{4.326.589,75}{2} \left(1 - \frac{637.663,79}{706.850,04}\right) (61,5) \\ &= Rp\ 26.044.338,83 \end{aligned}$$

The cost of inventory received is equal to Rp 26.044.338,83 each month, so that the minimum cost for each round of production is obtained, namely:

$$\begin{aligned} TIC_0 \times t_0 &= Rp\ 26.044.338,83 \times 6,79 \text{ month} \\ &= Rp\ 176.712.510,42 \end{aligned}$$

From the calculation results, it is found that the optimal production amount has the lowest cost in one production cycle. Then the number of rounds of brick production is calculated, the time interval, the period of machine operation for each production cycle which is calculated in two

periods and one period, as follows:

1. Number of production cycles in two periods

$$\frac{T}{t_0} = \frac{24}{6,79} = 3,54$$

Then the number of production cycles in each period is $3,54/2=1,77$ times.

2. Minimum inventory cost in two periods

$$\begin{aligned} TIC_0 \times t_0 \times \frac{T}{t_0} &= Rp176.712.510,42 \times 3,54 \\ &= Rp 625.064.131,89 \end{aligned}$$

Then the minimum inventory cost in one period is $Rp 625.064.131,89/2=Rp 312.532.065,95$

The minimum inventory cost in one month is $Rp 312.532.065,95 /12=Rp 26.044.338,83$

Then the minimum inventory cost of brick production in two periods is $Rp 625.064.131,89$, one period is $Rp 312.532.065,95$ and one month is $Rp 26.044.338,83$.

4.4. Calculation Based on Company Condition

Calculations are the results of research based on production conditions at the company, namely:

1. The rate of production of bricks every month.

$$P = 706.850,04$$

2. Distribution rate of bricks every month.

$$D = 637.663,79$$

3. The machine operates for two periods.

$$\begin{aligned} t &= \frac{\text{number of distributions 2020} + \text{number of distributions 2021}}{\text{rate of production}} \\ &= \frac{7.751.802 + 7.552.129}{706.850,04} \\ &= 21,65 \text{ month} \end{aligned}$$

Thus, the length of time the machine operates for two periods is 21.65 months.

Therefore, the calculation to determine the cost of brick production inventory borne is:

$$\begin{aligned} TIC_0 &= \frac{D}{Q}k + \frac{Q_0}{2} \left(1 - \frac{D}{P}\right) h \\ &= \frac{637.663,79}{706.850,04} (Rp 88.356.255,21) + \frac{706.850,04}{2} \left(1 - \frac{637.663,79}{706.850,04}\right) (61,5) \\ &= Rp81.835.451,15 \end{aligned}$$

So in two periods at the same time the cost of procuring production is the total cost of procurement of supplies multiplied by the time interval that has been obtained, namely:

$$\begin{aligned}TIC \times t &= Rp\ 81.835.451,15 \times 21,65\ month \\ &= Rp\ 1.771.810.177,36\end{aligned}$$

The cost of procurement of bricks production inventory in one period is:

$$\begin{aligned}TIC &= \frac{Rp\ 1.771.810.177,36}{2} \\ &= Rp\ 885.905.088,68\end{aligned}$$

And the cost of procurement of brick production supplies in one month is $= (Rp\ 885.905.088,68) / 12 = 73.825.424,06$

So in two periods the cost of supplying bricks production supplies is Rp 1,771,810,177,36 and for one period is Rp 885,905,088.68.

5. Conclusion

Based on the results of research and data processing conducted at UD SM Serdang Berdagai, the following conclusions can be drawn the Data Normality Test (Lilliefors Normality Test) it is known that the brick distribution data in January 2020 - December 2021 is normally distributed. The optimal production level of bricks using EPQ Method is 4.326.589,75 seeds with a production time interval of 6.79 months for each production period. So the optimal number of bricks production every month is 637.663,80 seeds, while according to company policy is 706,850.04 seeds so that the control of brick production every month is 69,186.24 seeds. The EPQ method can reduce production costs. The total cost of procuring production according to company policy is Rp 885.905.088,68, while the EPQ method is Rp 313.532.065,95.

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