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Decision Support System for Determining the Quantity of Brick Production Using the Fuzzy Tsukamoto Method

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Abstract−Maximum profits are obtained from maximum sales. Maximum sales are those that can meet existing demands. There is a determination of the planned production amount to meet production levels to meet planned sales levels or market demand levels. Factors that need to be considered in determining production quantities include: the amount of inventory and the amount of demand. The amount of demand and supply is an uncertainty. Fuzzy logic is a science that can analyze uncertainty. One of the fuzzy rule methods is Tsukamoto, which is a method that is often used to build a system whose reasoning resembles human intuition or feelings. The calculation process is quite complex so it takes a relatively long time, but this method provides results with quite high accuracy. Ratu Batubata Refinery is a factory that produces large quantities every day. Therefore, planning the amount of brick production is very important. In order to meet market demand appropriately and in appropriate quantities. By using this application, it is hoped that the company can make it easy for the company to predict production quantities based on the amount of demand and existing inventory data, in order to achieve maximum profits.

Keywords: Method; Fuzzy; Tsukamoto; Supply; Factory; Brick;

1. INTRODUCTION

The rapid development of technology over time means that work carried out by humans can generally be completed quickly. Technology is a tool that is often used in human activities. The role of technology makes processing information easier because processing is very necessary so that the information produced can be useful for users[1]. Processing data and information quickly, precisely and efficiently is an important thing needed for every company or agency to increase work productivity, time and costs. As advances in information and communication technology develop, business competition in the industrial world is getting tougher. The number of companies is increasing and continues to make efforts and strategies to maintain their business[2][3]. A company's success in maintaining its business cannot be separated from the company's role in determining the amount of goods produced so that it can meet customer demand as much as possible. Companies that are able to control and manage their inventory well will be able to meet customer needs and of course be able to maintain business continuity in today's industrial world[4]. Inventory of goods in a business is important for a company, because from this inventory you can manage the stock of goods in the warehouse which will later be sold to consumers. Therefore, the entrepreneur or trader must be able to manage the inventory of goods effectively and efficiently to suit the company's objectives [5].

Currently the Ratu Brick Factory is faced with the problem of brick production, determining the best production composition. This requires brick factories to plan or determine production quantities, so that they can meet market demand on time, also in appropriate quantities, so that it is hoped that the profits of brick factories will increase. Basically, this production determination is planned to meet production levels to meet planned sales levels or market demand levels. Sometimes the amount of market demand is not proportional to the amount of production produced by the brick factory or vice versa, so uncertainty arises in determining the amount of production. Given the uncertainty, it is necessary to determine the optimum production amount. There are three things that are important considerations for the Ratu brick factory to determine the product[6]. First, the buyer's interest in the type of brick produced. Second, the trend of brick types that are more widely known to the public. Third, previous sales data becomes a reference for subsequent brick production. The three problems above are also experienced by the Ratu brick factory in producing its bricks, this arises due to disruptions during production resulting in unstable orders placed by consumers. Therefore, the brick factory must adopt a decision making strategy, because the decision making system can provide various benefits and advantages. The benefit that can be taken from a decision making system is expanding the decision maker's ability to process data/information for its users. Both decision making systems help decision makers provide considerations in making decisions about brick production [7].

This problem can be solved by developing an application in a decision support system. This decision support system has the ability to approach an expert with high accuracy and fast performance[8]. One technique that can be applied in developing a decision support system is the Tsukamoto fuzzy inference system. In the Tsukamoto fuzzy conclusion method, each consequence of a rule in the form of IF-THEN must be represented by a fuzzy set with a monotonous membership function. As a result, the output of inference from each rule is given explicitly (cnsp) based on α-predicate (fire strength)[9]. The final results are obtained using a weighted average. The application software in the decision support system will be developed using the Tsukamoto fuzzy method. This application software will be applied in determining production quantities. The results of Tsukamoto's fuzzy calculations will produce an output in the form of the number of goods to be produced so that the brick factory can minimize the losses it faces [10].

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There are three methods in the fuzzy inference system that can be used to determine production quantities, namely: the Tsukamoto method, the Mamdani method, and the Sugeno method[11]. The method that will be used in this research is the Tsukamoto method. This method was chosen because each consequence of a rule in the form of IF-THEN is represented by a fuzzy set with a monotonic membership function. As a result, the output of each rule is given strictly based on α (alpa), then the final result is obtained using a centered average [12]. The use of the Fuzzy Inference System (FIS) Tsukamoto method in a Decision Support System can provide a valid final value because changes in the number difference, no matter how small, in the survey value will affect the final value of the calculation. Input variables in the Tsukamoto method include the day production starts, production period, maximum inventory for a certain period, minimum inventory for a certain period, maximum demand for a certain period, minimum demand for a certain period, maximum production for a certain period, minimum production for a certain period, current demand, and current supply. Then the Decision Support System will process this data and display the output in the form of the number of goods to be produced[13].

2. RESEARCH METHODOLOGY

2.1 Stages Study

This research stage aims to identify the problems contained in the system and determine the needs of the system to be built. The stages start from problem analysis, system analysis, system requirements analysis, tool design, system design and system testing. There are steps or stages that must be taken in conducting research related to determining brick production. Figure 1 is the stages carried out to support the implementation of this research[14].

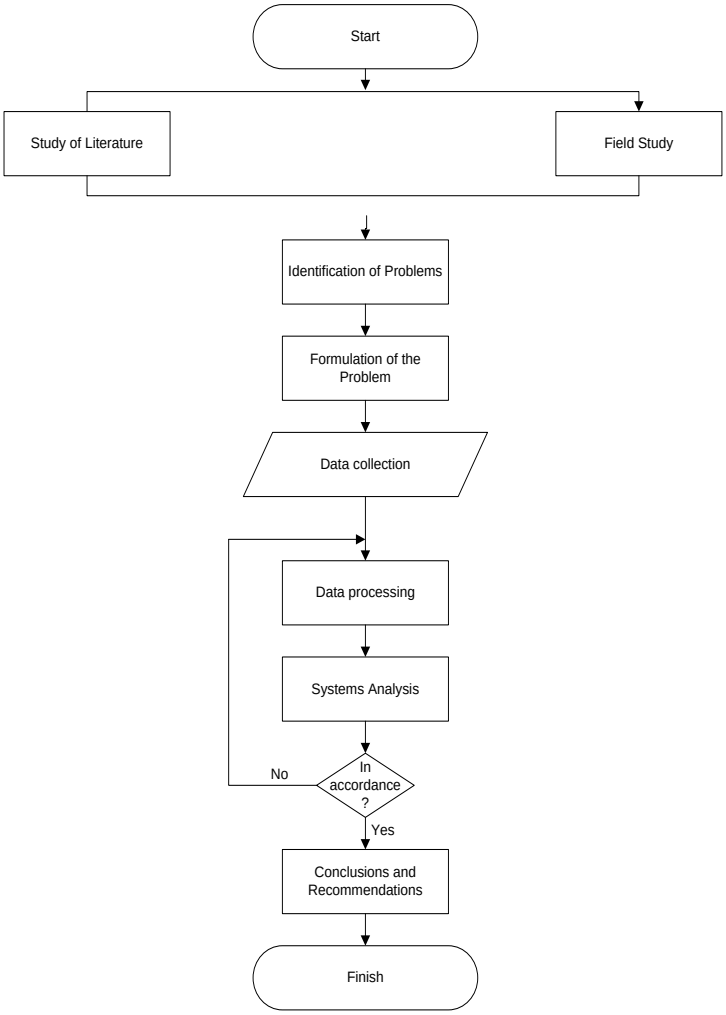

Figure 1. Research flow chat

There are several stages that need to be carried out to support research results well. The data collected were the names of brick factory production. The decision support system will carry out calculations and provide recommendations for brick factory production. The result of the recommendation is the production of goods determined based on criteria and preference weights [15]. The following stages are the steps that must be achieved in conducting research to determine brick factory production.

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a. Literature Study
   A literature study is a resource search carried out based on sources related to brick factory production. Learning can be obtained from books, journals or the internet in looking for materials related to this method.
b. Analysis
   Analysis is carried out to determine how to solve a problem. The design was carried out based on a case study that occurred in a brick factory which determined the production of brick factories.
c. Discussion
   The discussion was carried out by calculating a decision support system in providing recommendations for brick factory production. The results are obtained based on the criteria and preference weights that have been determined in the design of the criteria.
d. Implementation and testing
   Implementation and testing is the application of the results of the application program and the results of decision support system calculations in determining brick factory production.

3.2 Tsukamoto Fuzzy Inference System

Tsukamoto fuzzy inference system, the consequences of each fuzzy IF THEN rule are presented with a monotonous MF fuzzy set, so that the inference output of each rule is defined as a firm value which is induced by the power of the rule ignition. The overall output is the weighted average of each output rule. In its inference, the Tsukamoto method uses the following stages[16][17][18]:

a. Fuzzyfication, namely the process of changing system inputs that have firm values into linguistic variables using membership functions stored in a fuzzy knowledge base.
b. Formation of a fuzzy knowledge base (Rule in the form of IF...THEN), that is, in general the form of the Tsukamoto fuzzy model is IF (X IS A) and (Y IS B) and (Z IS C), where A, B, and C are sets fuzzy.
c. Inference engine, which is a process using the MIN implication function to obtain the α-predicate value for each rule (α1, α2, α3, … αn). Then each of these α-predicate values is used to calculate the output of the inference results strictly (crisp) for each rule (z1, z2, z3, ... zn).
d. Defuzzification, using the average method:

$$Z = \frac{\sum \partial 1.Z1}{\sum \partial 1} \quad (1)$$

3.3 Determining Variables

The variables used are demand variables , supply variables and production variables from the Ratu brick factory as in the following table[19].

Table 1. Fuzzy variables

Variable	Information
Request	X
Supply	Y
Production	Z

From the table 1 above, it is determined that the demand variable is symbolized by the letter X, the supply variable is symbolized by the letter Y and the production variable is symbolized by the letter Z.

3.4 Determining Fuzzy Sets

In determining the Fuzzy set, researchers used 2 sets as in the following table 2[20].

Table 2. Fuzzy Set

Variable	**Set**
Request	Increases and decreases
Supply	Many Little
Production	Many Little

From the table 2, it can be determined that the demand variable is set to increase and decrease, the supply variable is set to less and the production variable is set to less and more.

3. RESULT AND DISCUSSION

3.1 Data processing

The data taken in this research is presented in the form of data on minimum demand, maximum demand, minimum inventory, maximum inventory, minimum production, maximum production in the period from July to December 2024.

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Table 3. Ratu Brick Factory Production Data in a Period of 6 Months

No	Month	Request	Supply	Production
1	01-July	1674	1000	4000
2	16-July	2836	2540	4000
3	05-Aug	890	800	4500
4	10-Aug	4567	3567	4500
5	20-Aug	4000	3555	4500
6	21-Sept	3504	3345	3500
7	02-October	3633	3565	4000
8	02-November	5000	4567	5000
9	09-December	1754	1100	5000
10	15-December	2465	2120	5000

Source: Ratu Brick Factory

From the table 3, data on demand, supply and production from the Batubatu Ratu refinery, data taken from July to December 2024.

Table 4. Maximum Data and Minimum Data

Data	Amount
Maximum Request	5000
Minimum Request	890
Maximum Inventory	4567
Minimum Inventory	800
Maximum Production	5000
Minimum Production	3500

Furthermore, from the table 4, the maximum and minimum values for each demand, supply and production from the Ratu brick factory are determined.

3.2 Formation of Fuzzy Sets

In the Fuzzy Tsukamoto Method, both input and output variables are divided into one or more fuzzy sets. In determining the amount of brick production at the Batubata Ratu refinery based on supply and demand data, the input variables are divided into two, namely supply and demand variables. And one output variable, namely production. Determination of the variables used in this research.

Table 5. Universe talks For every fuzzy l variable

Function	Variable	Universe Talks
Inputs	Request	890 –5000
	Supply	800-4567
Outputs	Production	3500–5000

From variables that appear, then arranged fuzzy set domain. Based on this domain, the membership function of each variable is then determined, namely the design of fuzzy sets for determining production quantities:

Table 6 . Table fuzzy sets

Function	Name Variable	Set	Domain
Inputs	Request	Down	890 –5000
		Go on	890 –5000
	Supply	A little	800-4567
		Lots	800-4567
Outputs	Production	Reduce	3500–5000
		Increase	3500–5000

3.3 Rule Formation

Based on the previous formation of fuzzy sets and variables where there are input variables consisting of demand, supply and output variables consisting of production and there is also a fuzzy set divided into 2 variables, several rules can be formed as a calculation process which will be used as follows:
Rule1 : IF request Down AND supply Lots THEN Production Reduce
Rule2 : IF Request Down AND Supply A little THEN Production Reduce
Rule 3 : IF Request Ride AND Stock up Many THEN Productions Increase

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Rule 4 : IF Demand Increases AND Supply is Low THEN Production Increase

3.4 Process Calculation Fuzzy

Process calculation fuzzy consists from several stages that is:

a. Fuzzification
Variable modeling is carried out using linear representation membership functions, including :

1. Request, membership function of variables :

$$\mu\text{Bertambah(x)} = \begin{cases} 0 & x \leq 890 \\ \dfrac{x-890}{5000-890} & 5000 \leq x \leq 5000 \\ 1 & x \geq 5000 \end{cases}$$

$$\mu\text{Berkurang(x)} = \begin{cases} 1 & x \leq 890 \\ \dfrac{8000-x}{8000-5000} & 5000 \leq x \leq 5000 \\ 0 & x \geq 5000 \end{cases}$$

Membership values and Booking variables:

$$\mu\text{Bertambah}(7000) = \frac{6500-5000}{8000-5000} = 0{,}5$$

$$\mu\text{Bertambah}(7000) = \frac{8000-6500}{8000-5000} = 0{,}5$$

2. Inventory, membership function of variables :

$$\mu\text{Banyak(y)} = \begin{cases} 0 & x \leq 10000 \\ \dfrac{x-10000}{30000-10000} & 10000 \leq x \leq 30000 \\ 1 & x \geq 30000 \end{cases}$$

$$\mu\text{Sedikit(y)} = \begin{cases} 1 & x \leq 10000 \\ \dfrac{30000-x}{30000-10000} & 10000 \leq x \leq 30000 \\ 0 & x \geq 30000 \end{cases}$$

Membership values and booking variables:

$$\mu\text{Banyak}(25000) = \frac{25000-10000}{30000-10000} = 0{,}75$$

$$\mu\text{Sedikit}(7000) = \frac{30000-25000}{30000-10000} = 0{,}25$$

b. Formation of the Fuzzi Rule
In determining fuzzy rules, researchers used 4 fuzzy rules shown in the following table 7:

Table 7. *Fuzzy Rules*

Rules	Request	Supply	Production
1	Increase	A little	Lots
2	Increase	Lots	A little
3	Reduce	A little	A little
4	Reduce	Lots	A little

Based on the table above, it can be seen that, the fuzzy rules for each variable are concluded that when demand increases and supply is small then brick production must be large, if demand increases and supply is large then brick production is small, if demand decreases and supply is small then brick production is small and if demand is reduced and supplies are large then brick production will be small.

c. Inference process using the Tsukamoto method
Calculations to find α-predicate
Rule 1. If μ(x) = Increases and μ(y) = Slightly Then μ(z) = Slightly
α - predicate $_1$ = Min (0.5 ; 0.25)

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$0.25 = \frac{40000-x}{40000-15000}$

$0.25 = \frac{40000-x}{25000}$

40000 – x = 0.25 * 25000

40000 – x = 6250

-x = 6250 – 40000

-x = -33750

x = 33750

Rule 2. If μ(x) = Increase and μ(y) Increase Then μ(z) = Increase

α - predicate $_1$ = Min (0.5 ; 0.75)

$0.5 = \frac{x-15000}{40000-15000}$

$0.5 = \frac{x-15000}{25000}$

x - 15000 = 0.5 * 25000

x - 15000 = 12500

x = 12500 + 15000

x = 27500

Rule 3. If μ(x) = Decrease and μ(y) Increase Then μ(z) = Increase

α - predicate $_1$ = Min (0.5 ; 0.75)

$0.5 = \frac{x-15000}{40000-15000}$

$0.5 = \frac{x-15000}{25000}$

x - 15000 = 0.5 * 25000

x - 15000 = 12500

x = 12500 + 15000

x = 27500

Rule 4. If μ(x) = Decreased and μ(y) = Slightly Then μ(z) = Slightly

α - predicate $_1$ = Min (0.5 ; 0.25)

$0.25 = \frac{40000-x}{40000-15000}$

$0.25 = \frac{40000-x}{25000}$

40000 – x = 0.25 * 25000

40000 – x = 6250

-x = 6250 – 40000

-x = -33750

x = 33750

d. *Defuzzification*

$$Z = \frac{(0{,}25 * 33750) + (0{,}5 * 27500) + (0{,}5 * 27500) + (0{,}25 * 33750)}{0{,}25 + 0{,}5 + 0{,}5 + 0{,}25}$$

$$Z = \frac{8437{,}5 + 13750 + 13750 + 8437{,}5}{1{,}5}$$

$$Z = \frac{44375}{1{,}5} = 29583{,}33$$

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So, based on the calculations above, the Ratu brick factory can produce 29,583 bricks in the next transaction.

4. CONCLUSION

After conducting a theoretical discussion, implementation and testing, as well as test analysis The following conclusion can be drawn that the application of the Decision Support System with the Fuzzy Tsukamoto method has been made according to design and can used in determining the amount brick production with output of small bricks , medium bricks and large bricks . From the calculation results, the Fuzzy Tsukamoto Method can used to solve the problem, namely determining the amount of coal production at the Ratu brick factory for the next month which is more stable and can reduce the buildup of coal in the warehouse. Furthermore, the Decision Support System for determining the amount of goods produced using the Fuzzy Tsukamoto method has system performance that is able to run in accordance with functional requirements. This is proven by a comparison table between manual calculations and system calculations, which produces a correctness percentage of 96.91%. For further development, the decision support system can be developed in the Tsukamoto fuzzy calculation section, because in this research the system truth value is still 96.91% or not perfect. The use of the amount of data and rules in the decision support system influences the calculation results of the fuzzy method. This decision support system for determining production quantities would be better if it was developed for all brick factory business owners who experience excess stock or lack of stock at a certain time.

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