Modeling of the production size using Fuzzy-Mamdani Logic to support green engineering: A zinc sheets industrial case study

S Mangngenre, S Bahri, F Mardin, R Hanafi, S Asmal and M F Fasra
The Department of Industrial Engineering, Engineering Faculty, Universitas Hasanuddin, Makassar, Indonesia
Email: saiful.ti@gmail.com

Abstract. Production planning is a tactical scheme in the supply chain management of product that aims to provide optimal solutions based on the inventory stock of the company in terms of fulfilling the production demand. The variable of demand, supply, and production amount is used in this research as an input to determine the production by the implementation of Fuzzy-Mamdani Logic (FML). This research aims to obtain the optimal production and supply planning for several periods, which later comparing the total cost through the Fuzzy-Mamdani Logic implementation with the method used by the company. The objects for this research are the 7’ and 10’ big-corrugation types of zinc sheets manufactured by PT Y, which is the highest demand product of the company. The result shows that the implementation of FML outlined as an appropriate solution for the decision making to determine the production amount. The amount production itself for the 7’ and 10’ big-corrugation type of zinc sheets during June 2017 - May 2018 were 663,700 and 640,400 quantities for each model, while production in June 2017 was only 18,100 and 32,800 quantities.

1. Introduction
The increasing of the competition in the industrial world nowadays gives the implication of industrial management development, specifically the optimal services for the customer, as well as optimizing the company profit. This condition will affect the development of the company in terms of market competition. Generally, the manufacturer companies implement the Make to Stock (MTO) concept as the strategy in fulfilling the customer demand. The companies with this strategy have the finished product in the inventory for direct-delivery when there is an order from the customer [1]. However, the implementation of this strategy occurs some problems, particularly in the inventory issue.

Vollmann [2] defines production planning as a tactical scheme, which aims to provide optimal solutions, based on the inventory stock of the company in terms of fulfilling the production demand. Production planning has a methodology that needed in planning the production amount, known as aggregate. That aggregate used to obtain the response to demand planning. The aggregate scheme is a process of planning the quantity and time of the certain period through the adjustment of the high level of production, supply, and other controlled variables.

Inventory is a collective term to show the supply stock as the anticipation for fulfilling the demand. It is defined as the product that stocked, which later will be used to sell at a specified period. Companies sometimes facing the uncertain demand of the product during the fulfilling period, thus need the extra amount of quantity which often known as safety inventories and appropriate production planning. Hence, the company should develop rational plans to show how they will respond to the
market [3]. This activity of production planning starts from creating the forecast to find out the type of product and the quantity for future production. However, most of the companies could not be able to adjust their production level with real demand. Thus, in terms of determining the production amount, it needs the appropriate forecast related to customer demand [4].

Fuzzy defines as unclear, blur, or uncertain. The Fuzzy Set is a subsidiary of the oldest mathematical system, which studies the process of random numeric, such as probability theory, mathematical statistics, information theory, and others. The problem solving by using the set of fuzzy is more convenient compared with the probability theory [5].

The fuzzy set defined by the component function. The component function is a curve that shows the dots map of the data as the value of the components [6]. One of the methods that can be used to get those values is by the function approach. Nasr et al. [7] stated that the fuzzy function and the Mamdani model, also known as a min-max method.

PT Y is a zinc sheets production company. The production decision in the company implements the Fuzzy Logic (FL) since this method able to mapping from the input into the output with the involvement of the variables [7]. This FL will be flexible and tolerant with the available data. It will create a model from a system which able to estimate the production amount. The factors that affect the decision of the production amount in FL are the supply and the demand. The objective of this study was to obtain the optimal production planning of zinc sheets for several periods.

2. Methods
The object of this research is the zinc sheets produced data by PT Y, which consists of small-corrugation, medium-corrugation, and plate types. Only big-corrugation type come with 7' (0,20x762x2134 cm) and 10' (0,20x762x3048 cm) and will be selected as the samples.

The method of FML used for data processing has steps as followed: creating the fuzzy Set; implicating the function; forming the composition, and defuzzification.

3. Results
3.1. Data set
Data collected for designing the decision of production amount were monthly data from January 2016 to May 2017, as presented in table 1 and table 2.

| Period        | 7' (Sheets) | 10' (Sheets) |
|---------------|-------------|--------------|
|               | Supply      | Production   | Supply      | Production   |
| January 2016  | 16.072      | 113.525      | 14.775      | 74.440       |
| February 2016 | 63.936      | 77.988       | 12.472      | 96.981       |
| March 2016    | 95.080      | 89.663       | 52.965      | 85.856       |
| April 2016    | 124.702     | 124.242      | 74.251      | 47.875       |
| May 2016      | 200.749     | 27.484       | 73.744      | 59.928       |
| June 2016     | 186.053     | 36.969       | 90.769      | 36.982       |
| July 2016     | 199.951     | 57.829       | 91.820      | 84.592       |
| August 2016   | 198.303     | 61.472       | 119.821     | 101.313      |
| September 2016| 214.325     | 63.959       | 166.324     | 42.588       |
| October 2016  | 213.987     | 62.320       | 148.922     | 79.512       |
| November 2016 | 186.309     | 1.496        | 137.171     | 20.355       |
| December 2016 | 104.799     | 82.179       | 79.486      | 81.862       |
Table 2. Supply and production in 2017

| Period       | 7 '(Sheets) | 10 '(Sheets) |
|--------------|-------------|--------------|
|              | Supply      | Production   | Supply      | Production   |
| January 2017 | 108.552     | 41.462       | 80.487      | 70.414       |
| February 2017| 100.681     | 57.125       | 106.131     | 107.758      |
| March 2017   | 76.196      | 64.508       | 150.092     | 43.890       |
| April 2017   | 62.653      | 51.555       | 114.015     | 23.972       |
| May 2017     | 64.384      | 42.177       | 85.298      | 4.751        |

3.2. Modeling

Forecasting the demand for the period between June 2017-May 2018 (table 3) was conducted using the demand between January 2014-May 2017.

Table 3. Demand forecast of the product June 2017-May 2018

| No. | Period     | Product (Sheets) |
|-----|------------|------------------|
|     |            | 7 ft.   | 10 ft.   |
| 1   | June 2017  | 35.002  | 44.072  |
| 2   | July 2017  | 39.124  | 39.227  |
| 3   | Augustus 2017 | 42.254 | 50.250  |
| 4   | September 2017 | 68.630 | 64.386  |
| 5   | October 2017 | 90.811 | 82.037  |
| 6   | November 2017 | 94.676 | 93.517  |
| 7   | December 2017 | 85.602 | 79.553  |
| 8   | January 2018 | 56.725 | 55.515  |
| 9   | February 2018 | 38.944 | 40.555  |
| 10  | March 2018  | 47.487  | 45.359  |
| 11  | April 2018  | 40.684  | 43.326  |
| 12  | May 2018    | 35.908  | 33.541  |
|     | Total       | 675.847 | 671.340 |
| Mean Error | -1.225    | -344   |
| MAD      | 12.788     | 11.585 |
| MAPE     | 20%        | 18%    |
| RSFE     | -16.228    | 6.667  |

The first step to obtain the decision of the production amount using FML in this study was creating the Fuzzy Set. In the Mamdani method, both input and output variables divided into one or more fuzzy sets, as shown in table 4.

Table 4. The Fuzzy Set

| Variable      | Type | Range (Sheets) |
|---------------|------|----------------|
| Demand        | 7’   | [23.071 – 89.998] |
|               | 10’  | [35.931 – 91.263] |
| Supply        | 7’   | [16.072 – 214.325] |
|               | 10’  | [12.472 – 166.324] |
| Production Amount | 7’ | [1.496 – 124.242] |
|               | 10’  | [4.751 – 107.758] |

The second step was forming of component function aims to represent the variables of demand, supply, and production amount, as presented in table 5 and table 6.
Table 5. The Fuzzy set domain of 7' Type

| Fuzzy Set | Range (Sheets)       | Domain (Sheets)       |
|-----------|----------------------|-----------------------|
| Small     | [23.071 – 89.998]    | [23.071 – 99.998]     |
| Medium    | [16.072 – 214.325]   | [16.072 – 214.325]    |
| Large     | [1.496 – 124.242]    | [1.496 – 124.242]     |

Table 6. The Fuzzy set domain of 10' Type

| Fuzzy Set | Range (Sheet)       | Domain (Sheet)       |
|-----------|---------------------|----------------------|
| Small     | [35.931 – 91.263]   | [35.931 – 91.263]    |
| Medium    | [12.472 – 166.324]  | [12.472 – 166.324]   |
| Large     | [4.751 – 107.758]   | [4.751 – 107.758]    |

The next step was to form the rules. Based on the available data, it could be formed the rules for this study, as shown in table 7 and table 8.

Table 7. The fuzzy rules of 7'

| No | Demand | Supply | Production | No | Demand | Supply | Production |
|----|--------|--------|------------|----|--------|--------|------------|
| 1  | Small  | Small  | Medium     | 7  | Medium | Large  | Small      |
| 2  | Small  | Medium | Small      | 8  | Medium | Very Large | Small    |
| 3  | Small  | Large  | Small      | 9  | Large  | Small  | Large      |
| 4  | Small  | Very Large | Small   | 10 | Large  | Medium | Large      |
| 5  | Medium | Small  | Large      | 11 | Large  | Large  | Medium     |
| 6  | Medium | Medium | Medium     | 12 | Large  | Very Large | Small    |

Table 8. The fuzzy rules of 10'

| No | Demand | Supply | Production | No | Demand | Supply | Production |
|----|--------|--------|------------|----|--------|--------|------------|


The last step was defuzzification. This step was conducted using Matlab R2016a software and tools fuzzy logic function. Figure 1 shows the result of defuzzification with demand and supply of products between June 2016-May 2017.

![Defuzzification result](image)

Figure 1. Defuzzification result

Base on FML with the optimal supply result, the rules from defuzzification could be accepted. With the demand based on forecast between July 2017-May 2018 as the input, it obtained decisions of production amount for the upcoming 12 month-periods as presented in table 9.

### Table 9. Production decision based on the FML

| Period       | Production Amount (Sheet) |
|--------------|---------------------------|
|              | 7’                        | 10’                       |
| June 2017    | 18.100                    | 32.800                    |
| July 2017    | 40.600                    | 18.600                    |
| August 2017  | 40.200                    | 52.400                    |
| September 2017 | 62.100                  | 58.600                    |
| October 2017 | 92.300                    | 76.600                    |
| November 2017 | 92.500                  | 93.500                    |
| December 2017 | 91.300                  | 69.700                    |
| January 2018 | 61.900                    | 66.200                    |
| February 2018 | 38.100                   | 42.200                    |
| March 2018   | 50.100                    | 46.400                    |
| April 2018   | 36.400                    | 42.400                    |
| May 2018     | 40.100                    | 41.000                    |
| **Total**    | **663.700**               | **640.400**               |

### 4. Conclusions

The implementation of FML can be minimized or eliminating the supply cost through the modification of rules compositions by using the Matlab R2016a software based on the input of demand, supply, and
production amount of the company. The determination of the production amount of zinc sheets through the FML is more optimal than the previous method implemented by PT Y with the difference of production amount between 9,553 for 7’ and 2,789 for 10’ type during the period between January 2016-May 2017.

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