Comparison of Control Simulation on Cornstarch Dryer using Mamdani and Sugeno Fuzzy Logic

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Abstract: Corn is an important commodity for Indonesia. According to BPS data, Indonesia's maize production increased by 2.81% annually. The abundance of corn productivity was making Techno Park Grobogan innovated corn noodle. However, cornstarch is long dried and requires a lot of power to make its own loss in this business. Fuzzy logic is one of the control algorithms that can streamline the working of the tool. The weakness of previous researchs were using triangle membership function in the form. The purpose of this study to applied a trapezoid-triangle membership function on the fuzzy logic simulation of Mamdani and Sugeno method then comparing them in. The design of device to be simulated consists of input temperature and humidity and the regulated output is heater, heat blower, and moisture blower. The simulation results showed the Mamdani method is more efficient in using heat and power. While the mamdani method is efficient in the dissemination of heat and time used.

1 INTRODUCTION

Several innovations to increase the selling value of corn have been done. An innovation well developed that is making corn noodles from Grobogan Techno Park (Pusat Teknologi Agroteknologi. 2017). Corn has the greatest carbohydrate content number 2 after rice that is equal to 73,4% (Masniah and Syamsuddin. 2013). Making corn noodle can not be separated from the main ingredient that is corn flour. The better the corn flour used is the better quality corn noodles. The quality of corn flour based on Indonesian National Standard (01-3727-1995) has a smell, taste, and normal color with a maximum water content of 10% (Badan Pengkajian and Pengembangan Kebijakan Perdagang. 2016). Good dried corn flour is used with moisture content of 14-18% (Resmisari, 2014) (Wylis, et al. 2014). Good flour is obtained through temperature and humidity settings to avoid browning in the drying process. Temperature required 50-55 ° C with 50% humidity (Sacchetti, G., et al. 2004) (Ahmed, et. al. 2010).

This research purposed to simulate the efficient control of efficient corn flour automatic control system. In previous flour-drying innovations like, cabinet dryer, rack dryer, and the latest is the rotary dryer (Mentari, 2015). However, the control system used has not been optimally consequently making the drying time to be long, and the power used is large. This research use fuzzy logic control method. Fuzzy logic control has advantages over other frequently used control methods such as *Proportional Integral Derivative* (PID) and *Artificial Neural Network* (ANN). Fuzzy control is more robust than PID controllers, since fuzzy controls cover a wider area of operation than a PID controller. Fuzzy can worked with many disturbing environments(Arief, et. al. 2015). The study was conducted by comparing the simulation of Mamdani fuzzy method with Sugeno method.

Fuzzy Logic Research is widely used in the field of automatic control. Several studies on control systems have developed fuzzy logic of temperature and humidity in the dryer. Research conducted (Benvenga, et al. 2010) showed good drying results with a temperature of 54 ° C and humidity of 43%.

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Fuzzy logic has high experimental and predictive values, so it is effective for designing and building a control system on the dryer (Farzaneh, et al. 2016) (Al-Mahasneh, et al. 2016). Other research got good results after applying fuzzy logic to the dryer system (Nugroho, et al. 2017) (Kumar, et. al., 2013) (Mansor, H., et al. 2010). The research is still use the triangle membership function. The model has its weaknesses, namely the integral squared error is quite high, as a result the time to reach the setpoint is long enough (Suratno, et al. 2011).

This research was carried out innovation on member function form and treatment of output control on rule base. The member function used is trapezoid-triangular. Member functions from one input and another input also have the same form. This study uses a combination of member function forms between triangles and trapezoidal. The combination of membership functions in the form of a trapezoid and a triangle is the best form combination (Barua, et al. 2007) (Coupland, 2007) (Butt, et al. 2004) (Zhao, et al. 2002). The combination of trapezoid and triangle gives fuzzy variables with sharp input. This combination shows the difference between the linguistic set points. The combination expresses the signal measured by the sensor properly

2 METHOD

2.1 Basic Stucture of Product

The basic structure of the design of the device to be simulated consists of heater, and 2 blowers with fuzzy logic control. A good algorithm control is created through an overview of the system to be controlled. The system is designed with 2 inputs of the DHT 22 sensor form temperature and humidity. The DHT 22 sensor will detected the temperature and humidity present in the drying chamber. The input is processed by microcontoler Atmega328 using fuzzy logic. The output of a microcontroller is a PWM signal to regulated the output of this system. The heater in this scheme serves as a drying temperature controller. The temperature in the space will be propagated by the hot wind blower. While the other blower serves to provide a moist air flow from outside the dryer room.

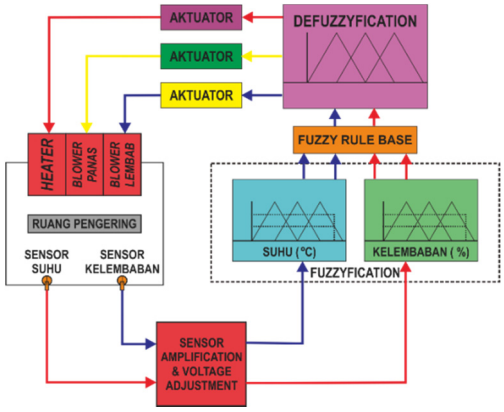


Figure 1: Dryer Block diagram.

2.2 Design of Fuzzy Logic Algorithm

The test is performed by performing a comparison analysis of fuzzy logic control simulation of Mamdani and Sugeno method using Matlab application. Fuzzy logic itself consists of 4 stages that is, *Fuzzifier*, *Rules*, *Inference*, dan *Deffuzifier* (Khaur, et al. 2012) (Singhala, et al. 2014)(Chaudhari, et al 2014). The input of DHT22 sensor will be used to design the fuzzifier, inferences engine, Rule Base, then in the defuzzifier to achieve the quality and quantity on the machine used (Abbas, et al 2011).. This work design using trapezoidal membership function for input temperature with a range of 0 ° C-100 ° C. While the input humidity has a membership function in the form of a triangle with a range of 0% -100%. Every input is grouped into three conditions as in Table 1 for temperature and Table 2 for humidity.

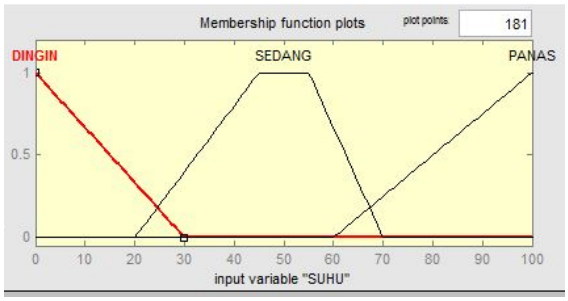
Table 1: Temperature Membership Group

Specification	Fuzzy Level	Index
0-30	Dingin	D
20-70	Sedang	S
60-100	Panas	P

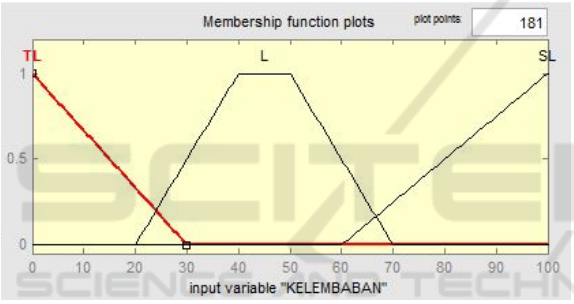
Table 2: Moisture Membership Group

Specification	Fuzzy Level	Index
0-30	Tidak Lembab	TL
20-70	Lembab	L
60-100	Sangat Lembab	SL

Each input variable has three membership functions can be seen in **Figure 2a** and **Figure 2b**. The temperature membership function consists of, “dingin”, “sedang”, dan “panas”. As for the membership function of humidity consists of, “tidak lembab”, “lembab”, dan “sangat lembab”



(a)



(b)

Figure 2: Plot of Membership Function (a) The Temperature Variable, (b) The Humidity Variable.

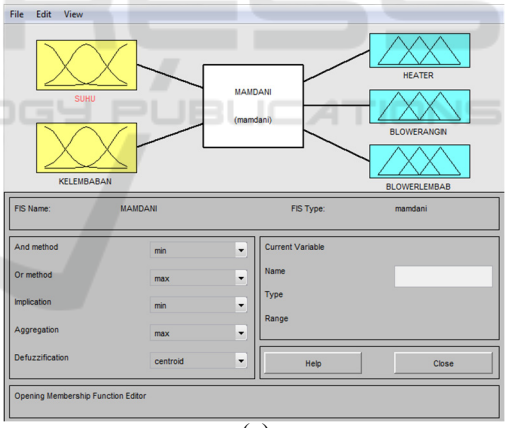
The input is then received by the machine inference with the AND logic operator. After that, input will processed microcontroller using fuzzy logic rule base. The number of Rules Base of the system can be searched by the formula m^n, with m = the maximum number of members is 3. While n = the number of inputs that is 2. So, the number of rule base used a number of 9 rules. The details are as follows:

Table 3: Rule Base Of Control Fuzzy Logic.

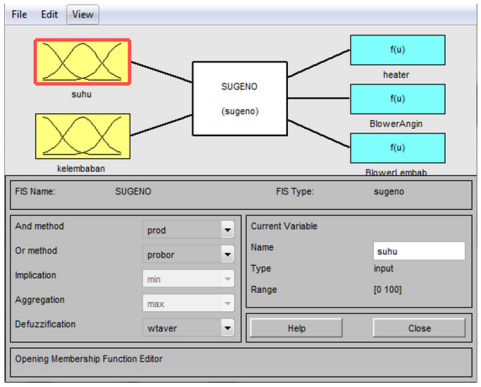
Tempera-ture	Humi-dity	Heater	Blower 1	Blower 2
Dingin	TL	P	K1	SP2
Dingin	TL	P	K1	P2
Dingin	TL	P	K1	K2
Sedang	L	H	P1	SP2
Sedang	L	H	P1	P2
Sedang	L	H	P1	K2
Panas	SL	M	SP1	SP2
Panas	SL	M	SP1	P2
Panas	SL	M	SP1	K2

3 RESULT AND DISCUSSION

The result of simulation test is done using Matlab (Matrix Laboratory) R2014a application. Matlab has ability to simulate various mathematical calculations. This test phase uses two methods of fuzzy logic namely Mamdani, and Sugeno. The test is done by setting the system input. Each method will be compared to the simulation result.



(a)



(b)

Figure 3: Display Logic Fuzzy (A) Mamdani Method, (B) Method Sugeno.

Each fuzzy method in this test will see the output response generated. Each method is given input, form *member function*, and same *rule base*. So, we can see the difference of working system by them. The defuzzification process of Mamdani method using *centroid* method. While, Sugeno method using *wtaver* method. After going through the defuzzification stage will be known output produced.

The following is the comparative test result:

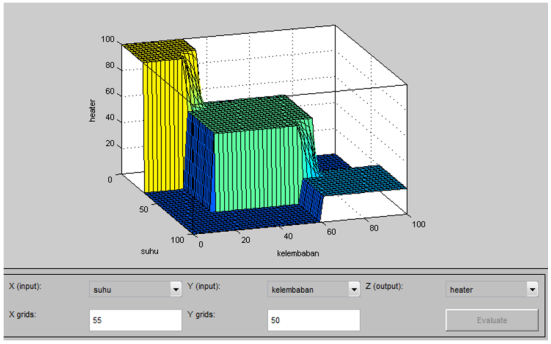
Table 4: Simulation Result Of Mamdani Method.

Dry Room		Fuzzy Output		
Tempera-ture	Humi-dity	Heater	Warm Blower	Moist Blower
35	30	55	20	24.7
35	40	55	20	24.5
35	50	55	20	24.5
35	60	55	20	24.7
40	30	55	20	24.7
40	40	55	20	24.5
40	50	55	20	24.5
40	60	55	20	24.7
45	30	55	20	24.7
45	40	55	20	24.5
45	50	55	20	24.5
45	60	55	20	24.7
50	30	55	20	24.7
50	40	55	20	24.5
50	50	55	20	24.5
50	60	55	20	24.7
55	30	55	20	24.7
55	40	55	20	24.5
55	50	55	20	24.5
55	60	55	20	24.7
60	30	55	20	24.7
60	40	55	20	24.6
60	50	55	20	24.6
60	60	55	20	24.7

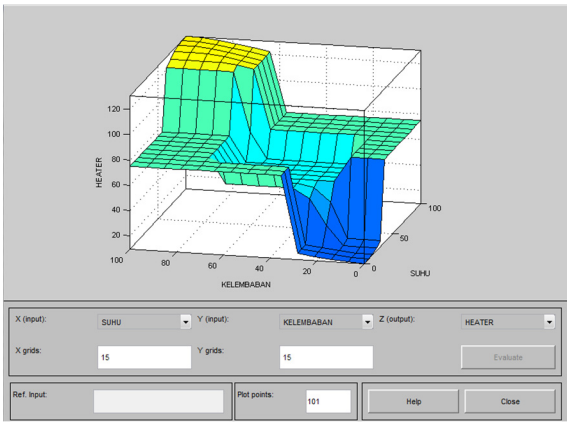
Table 5: Simulation Result Of Sugeno Method.

Dry Room		Fuzzy Output		
Tempera-ture	Humi-dity	Heater	Warm Blower	Moist Blower
35	30	60	30	30
35	40	60	30	30
35	50	60	30	30
35	60	60	30	30
40	30	60	30	30
40	40	60	30	30
40	50	60	30	30
40	60	60	30	30
45	30	60	30	30
45	40	60	30	30
45	50	60	30	30
45	60	60	30	30
50	30	60	30	30
50	40	60	30	30
50	50	60	30	30
50	60	60	30	30
55	30	60	30	30
55	40	60	30	30
55	50	60	30	30
55	60	60	30	30
60	30	60	30	30
60	40	60	30	30
60	50	60	30	30
60	60	60	30	30

Results from the simulation table obtained fuzzy logic mamdani and sugeno method can keep the output to still maintain the conditions specified. The mamdani method can optimize the temperature of heater and the power used is not large. However, it takes quite a long time than the sugeno method. While the sugeno method is able to use the heater efficiently with high temperatures. Drying time is relatively fast. But the power needed is great. The difference will be more clear on the graphs produced by each method.



(a)



(b)

Figure 4: Graphic Result (a) Mamdani Method, (b) Sugeno Method

Mamdani method commonly known as *min-max* method. The antecedents of the mamdani method have a minimum form, while the combined consequences have the maximum shape. Every rules in the mamdani method is *implication* (causal). In addition, the rules set of mamdani method are also independent of each other (Setiadji, 2009). Thus, in the resulting graph shown input from temperature and humidity is small then the heater will work optimally to supply heat.

The sugeno method is a *fuzzy inference* method with representation of IF-THEN-shaped rules. The outputs generated at the *rule base* stages are constants or linear equations (Syarif, 2016) (Wachdani, 2010). Collection and correlation between rules will shape the inferences. Then, in the *defuzzification* stage will be searched the average value (Kusumadewi,2010). The resulting output is crisp.

4 CONCLUSIONS

The result of the simulation shows that there is no significant difference. The mamdani method is efficient in the use of electrical power with average system workability. So, the drying time will be slightly longer than sugeno method. While the method sugeno able to make the system work in incentives with the resulting power consequences will be higher. Therefore, the use of fuzzy logic control method mamdani or sugeno will be better if adjusting the goals and desires to be achieved. If you want fast time use the Sugeno method. But, if you want to save power, it is better to choose mamdani method.

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