MONITORING HOME SCALE SEMI HOT AIR COFFEE ROASTER MACHINE WITH MICROCONTROLLER

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ABSTRACT

Coffee roasting is one of the important thing in the coffee processing that will determine the quality of roasted coffee beans. The roasting process at the Kedai Kopi 92 requires two people who cause the labor cost of production is high. In the process penyangraian errors often occur in the size of the small fire power used several parameters namely time, temperature, moisture content, density and the number of roasted coffee. Solution that can be applied is to build a coffee roaster machine monitoring system that can monitor and also make decisions to control coffee roasting machine. Fuzzy Logic is implemented the use of decisions in the use of fire power, and the use of Arduino Microcontroller as a connector between coffee roasting machine and system that can also be done to control the roasting coffee machine that has input and output devices. The monitoring system that has been designed and implemented to the coffee roaster machine and tested for its functionality. From the result of the research, it can be concluded that the roasting machine monitoing system using arduino microcontroller and applying fuzzy logic can help to reduce production cost by reducing the amount of labor and can give decision during the process of penyangraian with fuzzy logic.

Keyword: Coffee Roaster, Microcontroller, Arduino, Fuzzy Logic, Sensor.

1. INTRODUCTION

Coffee roasting process is one of the important stages of coffee processing. In the roasting process this developing of taste and aroma of coffee that will determine the quality of coffee. To obtain good roasted coffee, the right variables are needed to determine the roasting process, such as the temperature of coffee beans, the moisture content, the roasting time, density of coffee and the quantity of roasted coffee.

The roasting process that happened in the production of household scale or coffee shop are still very low. In addition to the need for more labor that can increase the cost of production in the end. During the roasting process sometimes the use of amount fire power can cause too long or going too fast, which ultimately causes the results not as expected. Therefore, the roasting process on roaster engines needs to be monitored and controlled to handle the constraints

Based on the problems, then it is needed the system that can monitor and control the coffee roaster machine during the roasting process. The system should be able to monitor the roasting machine to obtain the temperature of the coffee beans and other variables can use a microcontroller that can integrate the roasting machine with the system so it can provide the temperature information of the coffee beans by using the temperature sensor in realtime. Due to the temperature of the coffee beans and the time obtained from the temperature sensor plus the density, the water content and the quantity of incoming coffee will be the determinant factor of the use of fire size in the roasting process. After obtaining these variables will be processed by applying Fuzzy logic as a decision-maker system, because Fuzzy logic has the ability to overcome the uncertainties that arise in decision making [1], which the uncertainty often arises in the process of penyangraian. Output or results from Fuzzy Logic will give commands to the microcontroller to set the amount power of the fire.

Therefore the microcontroller and Fuzzy logic can be the right solution to be used in a system of monitoring the coffee penyangraian who give the decision or what to do in the process penyangraian to get roast profile or desired maturity level.

1.1 Coffee Roasting

The coffee roasting process of penyangraian is the process to developing of flavor and aroma in coffee beans. When the coffee beans have uniformity in size, specific gravity, texture, moisture content and chemical structure [2], Then the roastinf process will be more easier to control. In fact, coffee beans have a huge difference, so the process of penyangraian is an art and requires the skills and experience as consumer demand.

The roasting process by using an initial high temperature. The roasting process is a pyrolysis process that will increase the temperature of the coffee beans from room temperature to 200^{o} to 230^{o} celcius usually takes 15 to 20 minutes. During roasting the coffee beans are stirred so that the water vapor is quickly carried out and heat is uniformly distributed throughout.

1.2 Coffee Roasting Machine

Coffee roasting machine is basically there are two types, drums roaster or called semi hot air and hot air. The roasted or semi hot air coffee roaster or indirectly heated drum machine has its own uniqueness in accordance with its manufacturer of aesthetics, price and so on, but all have the same function of heating coffee beans from room temperature to 230º C One of the most important parts of the roasting coffee machine is the roasted drum and also the airflow. The semi hot water roasting machine has a drum that rotates horizontally to stir the coffee beans. Usually this drum roaster machine gets its heat source from liquefied petroleum gas (LPG), and most heat sources are under a roasting machine drum.
There are several types of roaster engines that are commonly used today: Air Roaster and Drum Roaster

1.3 Microcontroler Arduino

Microcontroler Arduino or Arduino Board consists of hardware / microcontroller modules are ready to use and IDE software used to program the advantages of Arduino that we are not bothered with a minimum circuit system and programmer because it is built in on one board. [3].

1.4 Sensor

The sensor is a type of transducer used to convert mechanical, magnetic, heat, light and chemical quantities into voltage and electric current. Sensors are often used for detection when measuring or controlling. In this research, coffee roasting machine monitoring system uses several types of sensors such as temperature sensor using thermocouple K and MAX6675 module which serves to read the temperature of coffee beans, water content sensor with soil moisture and LM393 module to measure water content in coffee beans and heavy sensors By using load cell and HX7111 to measure the weight and density of coffee beans.

1.5 Servo Motor

Servo motor is a motor with a closed feedback system where the position of the motor will be informed again on the control circuit in the servo motor. The structure of the device consists of a motor, a series of gears, a potentiometer and a control circuit. Potentiometer serves to determine the angular boundary of the resulting rotation. While the angle of the servo motor axis is adjusted based on the width of the pulse sent through the signal foot that has been provided. Servo motors usually only move to reach certain angle only and do not move continuously like DC motor and stepper motor.

1.6 Fuzzy Logic

Fuzzy logic is an algorithm that contains an element of uncertainty, unlike the ordinary logic of strict logic, we only recognize two values, false or true, or 0 or 1. The Fuzzy set is a grouping of something based on the parameters and variables of language or linguistic variables, expressed in The membership function of a Fuzzy set is worth between 0.0 and 1.0 The Fuzzy set is based on the idea of extending the range of characteristic functions in such a way that the function will encompass real numbers at intervals [0,1].

2. RESEARCH CONTENT

2.1 Analysis

In the roasting process the is problems on the production penyangraian coffee requires more labor and higher wages. Sometimes also the result of whiteness not in accordance with the planned because of the precise determination of variables during the process penyangraian.
From the analysis of the problem above, it takes a system that can observe the roastering machine when penyangraian and also required fuzzy algorithm for which can determine the output of power or fire quantity when the process penyangraian
.

1. *Fuzzy Logic Analysis*

The workings of Fuzzy logic algorithm on coffee roasting machine monitoring system has 5 variables: Coffee Bean Temperature, Coffee Bean Density, Moisture of Coffee, Coffee Quantity, Length of Time of Penyangraian. Fuzzy logic algorithm applies 4 stages process namely Fuzzyfication, basic rule-making, reasoning and defuzzification. Here is a Fuzzy logic illustration obtained from 5 input variables can be explained in Figure 1

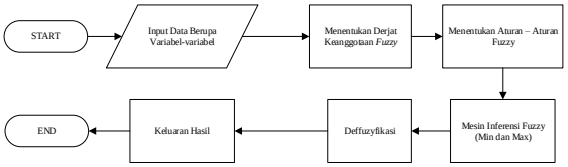


Figure 1 *Workflow Fuzzy Logic*

2. Data Input

The input data that required in this roasting machine monitoring system is in the form of variables. Fuzzy Logic input variables on this roasting machine monitoring system include coffee bean temperature, coffee bean density, coffee moisture content, coffee quantity and roasting time.

a. Bean Temperature

beans temperature obtained in realtime from coffee roasting machine through temperature sensor can be seen on Table 1

Table 1 Bean's Temperature

Bean's Temperature		
No	Parameter	Rentang
1	Sangat Rendah	90º-120ºC

2	Rendah	100º-160ºC
3	Tinggi	150º-210ºC
4	Sangat Tinggi	190º-230ºC

b. Beans Density

Coffee density is obtained by calculating the bulk density of coffee obtained in 1 liter volume can be seen on Table 2

Table 2 Bean's Density

Densitas Biji Kopi		
No	Parameter	Rentang
1	Very Low Density	550-625gr
2	Low Density	600-650gr
3	High Density	650-750gr
4	Very High Density	725-800gr

c. Moisture Content

Moisture content of coffee is assessed from the content of water content contained in coffee beans, coffee water content variables can be known by using the tool mouisture meter can be seen in the Table 3

Table 3 Moisture Content

Lama Waku Penyangraian		
No	Parameter	Rentang
1	Sangat Rendah	7%-10%
2	Rendah	9%-12%
3	Tinggi	11%-14%
4	Sangat Tinggi	13%-16%

d. Coffee Quantity

The quantity of coffee obtained from the amount of coffee that goes into the coffee roasting machine can be seen in Table .4

Table 4 Kuantitas Biji Kopi

Kuantitas Biji Kopi		
No	Parameter	Rentang
1	Sangat Sedikit	700-1000gr
2	Sedikit	800-1100gr
3	Banyak	1050-1350gr
4	Sangat Banyak	1200-1500gr

e. Roasting Time

Roasting time is the length or short time penyangraian can be seen in Table 5.

Table 5 Lama Waktu Penyangraian

Lama Waku Penyangraian		
No	Parameter	Rentang
1	Sangat Sebentar	6-9 menit
2	Sebentar	8-12 menit
3	Lama	11-15 menit
4	Sangat Lama	14-17 menit

3. Define Fuzzy Rule

The membership collection of the coffee bean set temperature, the density of the coffee beans, the water content of the coffee, the quantity of coffee and the roasting time are sought using the Fuzzy membership function.

Here's how to get the membership value based on the linguistic variables and numerical variables used

a. Bean's Temperature

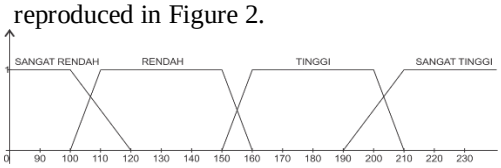
$$\mu SangatRendah\ [x] = \begin{cases} 1; & x \le 90 \\ \dfrac{120 - x}{120 - 100}; & 100 \le x \le 120 \\ 0; & x \ge 120 \end{cases}$$

$$\mu Rendah\ [x] = \begin{cases} 0; & x \le 150 \\ (x - 100)/(110 - 100); & 100 \le x \le 110 \\ 1; & 110 \le x \le 150 \\ (160 - x)/(160 - 150) & 150 \le x \le 160 \\ 0; & x \ge 160 \end{cases}$$

$$\mu Tinggi\ [x] = \begin{cases} 0; & x \le 150 \\ (x - 150)/(160 - 150); & 150 \le x \le 160 \\ 1; & 160 \le x \le 200 \\ (210 - x)/(210 - 200) & 200 \le x \le 210 \\ 0; & x \ge 210 \end{cases}$$

$$\mu SangatTinggi\ [x] = \begin{cases} 0; & x \le 190 \\ \dfrac{x - 190}{230 - 190}; & 190 \le x \le 230 \\ 1; & x \ge 230 \end{cases}$$

The membership function of the fuzzy set of temperature variables of coffee beans is reproduced in Figure 2.



Gambar 2 Bean's Temperature Membership Function

b. Beans Density

$$\mu VeryLowDensity[x] = \begin{cases} 1; & x \le 550 \\ \dfrac{625 - x}{625 - 550}; & 550 \le x \le 625 \\ 0; & x \ge 625 \end{cases}$$

$$\mu LowDensity\ [x] = \begin{cases} 0; & x \le 600 \\ \dfrac{x - 600}{650 - 600}; & 600 \le x \le 650 \\ \dfrac{700 - x}{700 - 650}; & 650 \le x \le 700 \end{cases}$$

$$\mu HighDensity[x] = \begin{cases} 0; & x \le 650 \\ \dfrac{x - 650}{700 - 650}; & 650 \le x \le 700 \\ \dfrac{750 - x}{750 - 700}; & 700 \le x \le 750 \end{cases}$$

$$\mu VeryHighDensity\ [x] = \begin{cases} 0; & x \le 725 \\ \dfrac{x - 725}{800 - 725}; & 725 \le x \le 800 \\ 1; & x \ge 800 \end{cases}$$

The membership function of the fuzzy set of beans density can be seen in Figure 3

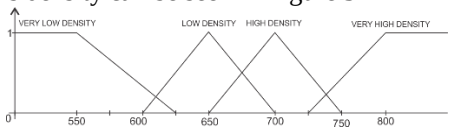


Figure 3 Membership Function Bean's Density

c. Bean's Moisture Content

$$\mu SangatRendah\ [x] = \begin{cases} 1; & x \le 7 \\ \dfrac{10 - x}{10 - 7}; & 7 \le x \le 10 \\ 0; & x \ge 10 \end{cases}$$

$$\mu Rendah\ [x] = \begin{cases} 0; & x \le 9 \\ (x-9)/(10-9); & 9 \le x \le 10 \\ 1; & 10 \le x \le 11 \\ (12-x)/(12-11) & 11 \le x \le 12 \\ 0; & x \ge 12 \end{cases}$$

$$\mu Tinggi\ [x] = \begin{cases} 0; & x \le 11 \\ (x-11)/(12-11); & 11 \le x \le 12 \\ 1; & 12 \le x \le 13 \\ (13-x)/(14-13) & 13 \le x \le 14 \\ 0; & x \ge 14 \end{cases}$$

$$\mu SangatTinggi\ [x] = \begin{cases} 0; & x \le 13 \\ \dfrac{x-13}{16-13}; & 13 \le x \le 16 \\ 1; & x \ge 16 \end{cases}$$

The membership function of the Fuzzy set of variables moisture content is reproduced in Figure 4

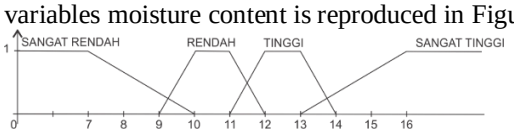


Figure 4 Membership Function Beans Moisture Content

d. Coffee Quantity

$$\mu Sedikit\ [x] = \begin{cases} 1; & x \le 700 \\ \dfrac{1000-x}{1000-700}; & 700 \le x \le 1000 \\ 0; & x \ge 1000 \end{cases}$$

$$\mu Sedang\ [x] = \begin{cases} 0; & x \le 800 \\ (x-800)/(900-800); & 800 \le x \le 900 \\ 1; & 900 \le x \le 1000 \\ (1100-x)/(1100-1000) & 1000 \le x \le 1100 \\ 0; & x \ge 1100 \end{cases}$$

$$\mu Banyak\ [x] \begin{cases} 0; & \\ \dfrac{(x-1050)}{1150-1050}; & x \le 1050 \\ & 1050 \le x \le 1150 \\ 1; & 1150 \le x \le 1250 \\ \dfrac{1350-x}{1350-1250} & 1250 \le x \le 1350 \\ 0; & x \ge 1350 \end{cases}$$

$$\mu SangatBanyak\ [x] = \begin{cases} 0; & x \le 1200 \\ \dfrac{x-1200}{1500-1200}; & 1200 \le x \le 1500 \\ 1; & x \ge 1500 \end{cases}$$

The Fuzzy membership function of Coffee Quantity variable is explain in Figure 5

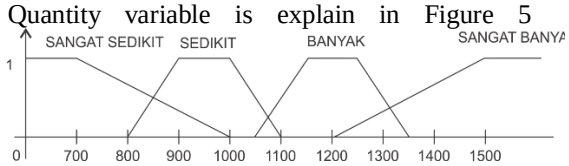


Figure 5 Membership Function Coffee Quantity

e. Roasting Time

$$\mu SangatSebentar\ [x] = \begin{cases} 1; & x \le 6 \\ \dfrac{6-x}{9-6}; & 6 \le x \le 9 \\ 0; & x \ge 9 \end{cases}$$

$$\mu Sebentar\ [x] = \begin{cases} 0; & x \le 8 \\ \dfrac{x-8}{9-8} & 8 \le x \le 9 \\ 1; & 9 \le x \le 11 \\ \dfrac{12-x}{12-11} & 11 \le x \le 12 \\ 0; & 12 \le x \end{cases}$$

$$\mu Lama\ [x] = \begin{cases} 0; & x \le 11 \\ (x-11)/(12-11); & 11 \le x \le 12 \\ 1; & 12 \le x \le 14 \\ (15-x)/(15-14) & 14 \le x \le 15 \\ 0; & x \ge 15 \end{cases}$$

$$\mu SangatLama\ [x] = \begin{cases} 0; & x \le 14 \\ \dfrac{x-14}{17-14}; & 14 \le x \le 17 \\ 1; & x \ge 17 \end{cases}$$

The membership function of the Fuzzy of time roasting variables is explained in Figure 6

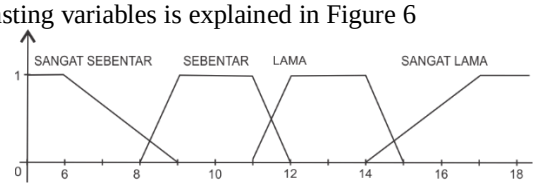


Figure 6 Membership Function Time Roasting

Example case, the roasting process of Arabica coffee with data that explained in Table 6

Table 6 Example Case of Coffee Roasting

No	Variabel	Nilai
1	Beans Temperature	195°C
2	Beans Density	666gram
3	Mositure Content	12,7%
4	Quantity	1303gram
5	Roasting Time	12:30

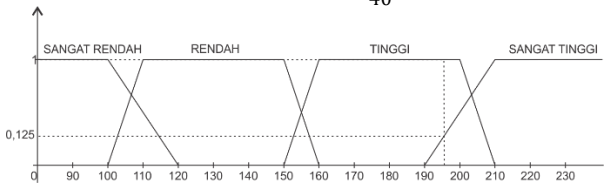
Here is an example calculation done to get the value of membership by using the example case in the table above:
Fuzzy set membership value*:*

Beans Temperature = 195°C

$$\mu Tinggi\ [195^oC] = \{1; \quad 160 \le 195 \le 200$$

$$\mu SangatTinggi\ [195^oC] = \begin{cases} \dfrac{195-190}{230-190}; & 160 \le 195 \le 200 \end{cases}$$

$$\mu SangatTinggi\ [195^oC] = \frac{5}{40} = 0{,}125$$

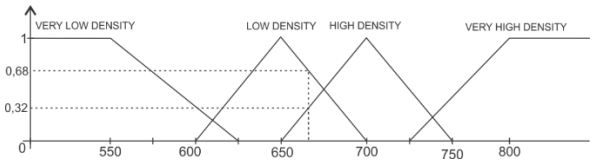


Gambar 6 Membership Function Beans Temperature 195°C

Beans Density = 666gr/Liter

$$\mu LowDensity\ [666] = \frac{700-666}{700-650}; \quad 650 \le x \le 700$$
$$= 0{,}68 \quad 650 \le 666 \le 700$$

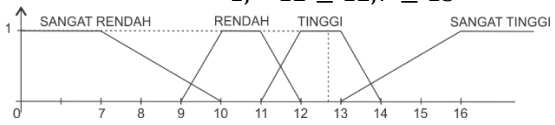
$$\mu HaighDensity\ [666] = \frac{666-650}{700-650}; \quad 650 \le x \le 700$$
$$= 0{,}32 \quad 650 \le 666 \le 700$$



Gambar 7 Membership Function Beans Density

Moisture Content = 12,7%

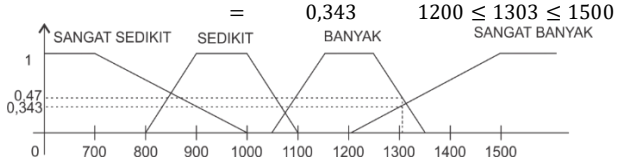
$$\mu Normal\ [12,7] = 1; \quad 12 \le x \le 13$$
$$= 1; \quad 12 \le 12,7 \le 13$$



Gambar 8 Membership Function Moisture Content 12,7%

Coffee Quantity = 1303gr

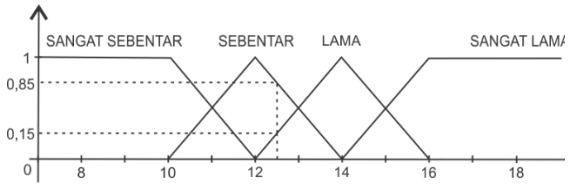
$$\mu Banyak\ [1303] = \frac{1350 - 1303}{1350 - 1250}; \quad 1250 \le x \le 1350$$
$$= 0,47 \quad 1250 \le 1303 < 1350$$
$$\mu SangatBanyak\ [1303] = \frac{1303 - 1200}{1500 - 1200}; \quad 1200 \le x \le 1500$$
$$= 0,343 \quad 1200 \le 1303 \le 1500$$



Gambar 9 Membership Function Coffee Quantity 1303gr

Time Roasting = 12:30

$$\mu Lama[12,5] = 1; \quad 12 \le x \le 14$$



Gambar 10 Fungsi Keanggotaan dari Variabel Lama Waktu Penyangraian 12:30

4. Define Rule Base

The determination of the basic rule or rule base is fulfilled after the determination of the membership function of the variable from the above case example. Based on existing data, can be established rules according to the conditions that are met as follows

a. IF Temperatur Biji Kopi Tinggi AND Densitas Low Density AND Kadar Air Tinggi AND Kuantitas Banyak AND Lama Penyangraian Lama THEN Power Rendah
b. IF Temperatur Biji Kopi Tinggi AND Densitas Low Density AND Kadar Air Tinggi AND Kuantitas Sangat Banyak AND Lama Penyangraian Lama THEN Power Tinggi
c. IF Temperatur Biji Kopi Tinggi AND Densitas High Density AND Kadar Air Tinggi AND Kuantitas Banyak AND Lama Penyangraian Lama THEN Power Tinggi
d. IF Temperatur Biji Kopi Tinggi AND Densitas High Density AND Kadar Air Tinggi AND Kuantitas Sangat Banyak AND Lama Penyangraian Lama THEN Power Tinggi

5. Inference Machine

At this stage the system consists of the collection and correlation between the rules that are met as follows:

a. [R1] **IF** Temperature Biji Kopi **Tinggi AND** Density Kopi **Low Densitys AND** Kadar Air **Tinggi AND** Kuantitas Kopi **Banyak AND** Lama Waktu Penyangraian **Lama THEN** Power **Rendah**

$$\alpha\text{-}pred_1 = \mu Tinggi\ n\ SoftBeans\ n\ KadarAir\ n\ KuantitasKopi\ n\ LamaWaktuPenyangraian$$
$$= MIN(\mu Tinggi[195];\ \mu LowDensity[666];\ \mu Tinggi[12,7];\ \mu Banyak[1303];\ Lama[12,5])$$
$$= MIN(1;0,68;1;0,47;1) = 0,47$$

b. [R2] **IF** Temperature Biji Kopi **Tinggi AND** Density Kopi **Low Densitys AND** Kadar Air **Tinggi AND** Kuantitas Kopi **Sangat Banyak AND** Lama Waktu Penyangraian **Lama THEN** Power **Tinggi**

$$\alpha\text{-}pred_1 = \mu Tinggi\ n\ SoftBeans\ n\ KadarAir\ n\ KuantitasKopi\ n\ LamaWaktuPenyangraian$$
$$= MIN(\mu Tinggi[195];\ \mu LowDensity[666];\ \mu Tinggi[12,7];\ \mu Banyak[1303];\ Lama[12,5])$$
$$= MIN(1;0,68;1;0,343;1) = 0,343$$

c. [R3] **IF** Temperature Biji Kopi **Tinggi AND** Density Kopi **High Density AND** Kadar Air **Normal AND** Kuantitas Kopi **Banyak AND** Lama Waktu Penyangraian **Lama THEN** Power **Tinggi**

$$\alpha\text{-}pred_1 = \mu Tinggi\ n\ HardBeans\ n\ KadarAir\ n\ KuantitasKopi\ n\ LamaWaktuPenyangraian$$
$$= MIN(\mu Tinggi[195];\ \mu HardBeans[666];\ \mu Normal[12,7];\ \mu Banyak[1303];\ Lama[12,5])$$
$$= MIN(1;0,32;1;0,47;1) = 0,32$$

d. [R4] **IF** Temperature Biji Kopi **Tinggi AND** Density Kopi **High Density AND** Kadar Air **Normal AND** Kuantitas Kopi **Sangat Banyak AND** Lama Waktu Penyangraian **Lama THEN** Power **Tinggi**

$$\alpha\text{-}pred_1 = \mu Tinggi\ n\ HardBeans\ n\ KadarAir\ n\ KuantitasKopi\ n\ LamaWaktuPenyangraian$$
$$= MIN(\mu Tinggi[195];\ \mu HardBeans[666];\ \mu Normal[12,7];\ \mu Banyak[1303];\ Lama[12,5])$$
$$= MIN(1;0,32;1;0,343;1) = 0,32$$

6. Rules Composition

From results of the implication function of each rule, used MAX method to perform the composition between all rules. The following is the fuzzy solution area obtained from the process of the implication function.

$$\mu_{sf}(z) = \mu Rendah(z), \mu Tinggi(z)$$
$$= \max\{0.47, 0.343, 0.32\}$$

Next is to determine the membership function of the Rendah and Tinggi Fuzzy set.

a. Rendah

If $\mu Rendah(z) = 0{,}343$ then Z reference to equation

$$\frac{z - 20}{30 - 20} = 0.343$$

Then Z = 23,43

If$\mu Rendah(z) = 0.47$, then Z reference to equation:

$$\frac{60 - z}{60 - 50} = 0.47$$

Then Z = 55.3

b. Tinggi

If $\mu SangatRendah(z) = 0.32$, then Z reference to equation:

$$\frac{z - 40}{50 - 40} = 0.32$$

Then Z = 43.2 and $\frac{80-z}{80-70} = 0.32$

Z = 76.8

Thus the membership function of the composition of rules is as follows:

$$\mu PowerApi = \begin{cases} 0.343; & 20 < z < 23.43 \\ \frac{60 - z}{60 - 50}; & 23.43 < z < 40 \\ 0.47 & 40 < z < 50 \\ \frac{80 - z}{80 - 70}; & 50 < z < 76.8 \\ 0.32; & 76.8 < z < 80 \end{cases}$$

7. Defuzzyfication

Defuzzyfication is a process where data that has been made fuzzy data changed back into the form of crips or firm values by using the Centorid method:

$$Z = \frac{\int_a^b Z_i \, \mu(z) dz}{\int_a^b \mu(z) dz}$$

Z= Nilai De*fuzzyfication*

$\mu(z)$= Value of membership

Zi= Value Domain from Linguistic Variable

Defuzzyfication:

$$Z = \frac{0.343\ z\ dz + \frac{60 - z}{60 - 50} z\ dz + 0.47\ z\ dz + \frac{80 - z}{80 - 70} z\ dz}{0.125\ dz + \frac{60 - z}{60 - 50}\ dz + 0.47\ dz + \frac{80 - z}{80 - 70} dz}$$

$= \frac{318{,}7261}{1}$ = 43,1630 Berada pada tingkat *power* Api (Tinggi)

The value obtained from deFuzzification is then used for the determination of the following rules:

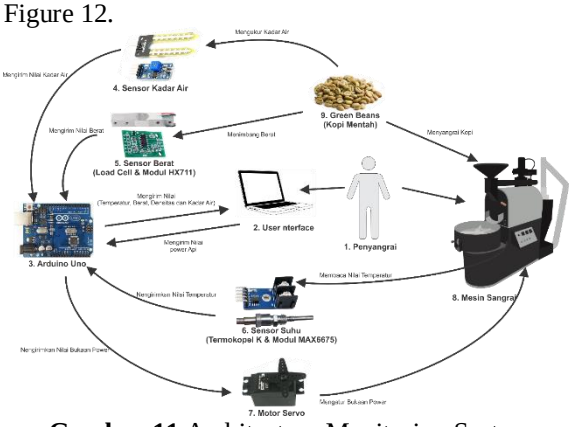
Table 7 Hasil Defuzzyfikasi Penyangraian Kopi

No	Hasil	Nilai
1	Sangat Rendah	10-30
2	Rendah	20-60
3	Tinggi	40-80
4	Sangat Tinggi	70-90

From table 7 it is explained that the result of the value of the defuzzyfication process to get the Z value using Centroid get the value 43.1630 and the value of 43.1630 which berate the use of fire power must be High

8. Analisis Arsitektur

The coffee roasting machine monitoring system built consists of three parts. First Personal Computer or laptop, as User Interface and also as control of the microcontroller used. Both Microcontroller is used as a liaison between User Interface or Personal Computer with Roasting Machine. The three Roasted Engines as objects monitored by Microcontroller can be seen in Figure 12.



Gambar 11 Architecture Monitoring System

2.2 Implementation

At this stage the form of the implementation results in this research is a prototype of Coffee Roasting Machine Monitoring System that is implemented in hardware and software described in Table 8

Table.8 Hardware Software Implementation

Nama Perangkat	Spesifikasi
Personal Computer / Notebook	CPU 2.1Ghz 2GB RAM *memory* 90GB *Free Space Hard disk*
Mikrokontroler	Arduino Uno tipe DIP (*Dual Inline Package*)
Sensor Suhu	*Thermocouple type K* Modul MAX6675
Sensor Berat	*Load Cell* 5Kg Modul HX711
Sensor Kadar Air	Soil Moisture Sensor LM393 chip
Motor Servo	MG946R RC *Metal Gear Servo*
Mesin Sangrai Kopi	Tipe *Drum Roaster* Kapasitas 2Kg
Kabel Koneksi USB	USB *type A to type B*
Windows 8	Sistem Operasi
Visual Studio 2013	Perangkat lunak untuk pengembangan aplikasi *windows form* pada *personal computer*
Arduino IDE	Perangkat lunak untuk program pembangun pada mikrokontroler arduino
WAMP Server	*Web server* / penyedia MySql

2.3 System Testing

Testing is done by comparing the process penyangraian using monitoring system with penyangraian process without using monitoring system.

The following test results comparison between penyangraian coffee using monitoring system with penyangraian coffee without using monitoring system

Tabel 9 Result of Testing System

	Roasting With Coffee Roasting Monitoring System		Roasting Without Coffee Roasting Monitoring System	
Time	Temperature	Fuzzy Value (Angle of Valeve)	Temperatur	Angle of valve
00:00	215	44,7728	215	75
00:30	132	71,7972	135	75
01:00	105	71,7972	107	75
01:30	108	71,7972	111	75
02:00	116	71,7972	120	70
02:30	125	71,7972	128	70
03:00	132	71,7972	135	70
03:30	139	71,7972	141	70
04:00	146	71,7972	147	70
04:30	152	71,7972	152	70
05:00	158	71,7972	158	70
05:30	163	71,7972	163	70
06:00	168	71,7972	167	70
06:30	172	71,7972	171	70
07:00	176	71,7972	175	60
07:30	180	71,7972	179	60
08:00	184	71,7972	183	60
08:30	187	71,7972	187	60
09:00	192	58,8048	191	45
09:30	196	51,5110	195	45
10:00	199	44,7728	197	45
10:30	202	44,7728	199	45
11:00	205	44,7728	201	45

The following comparison of power used during penyangraian between penyangraian by using monitoring and penyangraian system without using monitoring system that can be seen in Table 9

Tabel 10 Result of Comparasing

	Penyangraian Dengan Sistem Monitoring Mesin Sangrai	Penyangraian Tanpa Sistem Monitoring Mesin Sangrai
PC / Laptop	(19V x 3.42A) = 64,98 Watt = 0,6498 kWh	(19V x 3.42A) = 64,98 Watt = 0,6498 kWh
Arduino	(12V x 1A) = 12Wat =0,012 kWh	-
Cost kWh	Rp 1.467,28	Rp 1.467,28
Time Using	30 hari (6 jam/hari)	30 hari (6 jam/hari)
Cost/Week	(((0,6498 x 1.467,28)+(0,012 x 1.467,28)) x 6 x 30) = Rp 174.788,263	((0,6498 x 1.467,28) x 6 x30) =Rp 171.618,938
Labor Cost	1 Orang (Rp 1.250.000/bulan)	2 Orang (Rp 2.500.000/bulan)
Total	= Pemakaian Listrik + Upah = Rp 174.788,263 + 1.250.000 = Rp 1.424.788,263	= Pemakaian Listrik + Upah = Rp 171.618,938 + 2.500.000 = Rp 2.671.618,94

Based on the simulations that have been done, it can be concluded that penyangraian by using the system can take a decision on the use of the size of the fire power during the penyangraian process is not much different from penyangraian without using a monitoring system or manual. It can be concluded that the production cost of penyangraian using monitoring system can reduce the overall production cost almost 53% compared with penyapraian tapna using monitoring system.

3. CONCLUSION

Based on the results of experimentation and testing on fuzzy logic and microcontroller on roasting machine monitoring system can achieve the purpose of this research, it can be drawn conclusion:

a. The microcontroller can monitor and control the roasting machine during the roasting process, this helping to reduce labor cost by and pressing the overall production cost.
b. The system can give a decision or what to do in the process of penyangraian in setting the size of the fire power used, with the note of the use of water content sensors that can measure the water content in coffee.

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