Application Of Artificial Neural Network In Coffee Roasting Process

Roza Susanti 1, Zas Ressy Aidha, Trisno Miswar2

1) Electronic Engineering, Electro Engineering Major, Politeknik State Of Padang, Limau Manis – Padang
E-mail: rozaaznir@gmail.com
2) Electrical Engineering, Electro Engineering Major, Politeknik State Of Padang, Limau Manis – Padang
E-mail: zasressya@gmail.com

Abstract—The temperature setting of roasting to the color of coffee beans aims to obtain coffee quality with water content according to SNI standards. Temperature settings to obtain a standard water grade value in the roasting process of robusta coffee beans using temperature sensors and MC. Monitoring temperatures in robusta coffee beans to get the appropriate grain color, the result of the coffee bean image then processed with Delphi7 program to get the RGB value. Proper temperature setting in the roasting process determines the quality of a robusta coffee powder that produces the typical aroma, color and flavor of coffee according to the standard. Circuit testing is done with LabVIEW software as virtual instrumentation as well as analysis of roasting result using Atifisial Neural Network method or reverse propagation JST, is a complex process modeling.

Keywords—Temperature control, roasting, arabica coffee and Artificial Neural Network

I. INTRODUCTION
A. Background
Indonesia is the fourth largest coffee producer after Brazil, Colombia and Ivory Coast. Most of the coffee plants in Indonesia are located south of the equator, such as in southern Sumatra Lampung, Bengkulu, Java, southern Sulawesi, Bali and Nusa Tenggara. While in South Sumatra coffee is a commodity produced after rubber and pepper commodities. And coffee is a drink or a lot of penyegaryang ingredients in public consumption, from the bottom to the upper class. Coffee became one of the world's top five commodities (Taylor, 2005).

Evaluation of the productive organoleptic products of roasting or roasting of coffee beans is traditionally dependent on the human senses. The human senses are usually unstable, depending on the physical or mental state involved at the time, and only qualitative measures can be set. To enable a continuous evaluation of coffee production flavors with high continuous reliability, electronic sensor systems that produce objective measurements can be used (Gopel, 1989).

The process of penyangraian is one of the important stages, but currently there is little data about how the proper penyangraian process to produce quality coffee products. Based on the above considerations, it is necessary to conduct research on the process of penyangraian coffee beans associated with the temperature used during penyangraian by using temperature sensors. Setting the temperature of the process of penyangraian based on the value of water content according to SNI standard (SNI.01-2983-1992). Roasting results determine the quality of coffee powder with the right temperature setting to produce the aroma, color and flavor of typical coffee maximum. Roasting color greatly affect the taste of the coffee powder, it is necessary to note the quality of color to improve the quality of coffee powder. Analysis of roasting result using Atifisial Neural Network method or reverse propagation JST, is a complex process modeling to identify the color of roasting result.

B. Aim
1. Design and make a system of coffee roasting system by setting temperature according to SNI standard.
2. Design and create a program to get the value of RGB roasted coffee beans.
3. Identify the color of roasted coffee beans by using the method of Atifisial Neural Network back propagation.

II. LITERATURE REVIEW
A. Coffee
Coffee is a commercial commodity known for several centuries, coffee beans can be tasted as delicious drinks. Coffee drinking has become a worldwide craze, especially in coffee-producing countries. Of the 40 types of coffee varieties present in the world, there are two main types of copies most widely traded, namely: 1. Arabica coffee, almost 75% of world coffee production is this kind of coffee (Indonesia contributes 10% of that amount). 2. Robusta coffee, produced about 25% of world production. Of these, Indonesia contributes 90%. In general they are two types of coffee cultivated in Indonesia, namely Robusta and Arabica coffee. Arabica coffee has better taste quality than Robusta coffee [7]. Figure 1 shows Arabica coffee beans.
Coffee making powder is generally divided into two namely Rooting (Roasting) and grinding (Blending). This is usually done by households and small industries. While large industries have additional stages to improve the guitar. In the roasting process the temperature setting should be noted because the loss of dry weight is closely related to the temperature of penyangraian. Based on the roasting temperatures used roasted coffee is distinguished into 3 groups namely light roast temperatures used 193 ° C to 199 ° C, medium temperature medium roast used 204 ° C and temperature dark roast used 213 ° C to 221 ° C. Light roast eliminates 3-5% water content, medium roast 5-8%, and dark roast 8-14% [8].

B. Roasting

This process is the stage of formation of aroma and typical flavor of coffee from within the coffee beans with heat treatment. Coffee beans naturally contain quite a lot of organic compounds of flavor-forming and typical coffee. The longer the roasting time, the color of roasted coffee beans approaching darkish brown [9]. The roasting process has been no common requirement Roasted coffee (SNI.01-2983-1992) can be seen in table 1.

<table>
<thead>
<tr>
<th>Kriteria</th>
<th>Satuan</th>
<th>Syarat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keadaan (bau, rasa)</td>
<td>-</td>
<td>Normal</td>
</tr>
<tr>
<td>Kadar air</td>
<td>%W/W</td>
<td>Maks 4</td>
</tr>
<tr>
<td>Kadar abu</td>
<td>%W/W</td>
<td>7-14</td>
</tr>
<tr>
<td>Kealkalian dari abu</td>
<td>1N NAOH/100 gr</td>
<td>80-140</td>
</tr>
<tr>
<td>Kadar kafein</td>
<td>%W/W</td>
<td>2-8</td>
</tr>
<tr>
<td>Cemaran logam</td>
<td>Mg/kg</td>
<td>Maks 30</td>
</tr>
<tr>
<td>Padatan tak larut dalam air</td>
<td>%W/W</td>
<td>Maks 0,25</td>
</tr>
<tr>
<td>Jumlah bakteri</td>
<td>Koloni/gram</td>
<td>Maks 300</td>
</tr>
</tbody>
</table>

C. Water content in coffee

One of the factors that influence the drying process is moisture content. Drying aims to reduce the water content of the material thereby inhibiting the development of decay organisms. The moisture content of a material affects the amount of evaporated water and the duration of the drying process (Taib et al., 1988) The moisture content of a material is the amount of water content of the weight of the ingredients expressed in percent wet base or in percent dry basis base). Wet basin moisture content has a theoretical maximum limit of 100%, whereas moisture content of dry bases is more 100%. Wet base water content (Mwb) is the ratio of the water weight present in the material to the total weight of the material.

The structure of the material can generally be based on the moisture content usually indicated in percentage moisture base of wet or dry base. Moisture base water content (Mwb) is widely used in market pricing while dry base water content (Mb) is used in engineering [10]. According to Brooker et al [11], the equation in the determination of dry water (dry base) applies the formula:

\[
\%MC_{db} = \frac{100MC_{wb}}{100 - MC_{wb}}
\]

Information:
\( MC_{db} \) = dry base water content (%)
\( Wa \) = Material Weight (g)
\( Wb \) = absolute dry matter weight (g)

Method of determination of moisture content can be done by two way that is direct method and indirect method. The direct method applies the oven method and the distillation method. In the oven method, the material sample is placed into the oven until a constant weight is obtained in the material. The determination of the moisture content of the oven method is based on the amount of water lost from the product.

D. Image Processing

Showing an image on the monitor screen needs more than just information about the location of the image-forming pixels. To obtain the right image also needs information about the colors used to describe a digital image. RGB color mode produces colors using a combination of three primary colors red, green, blue. RGB is a color model addition, which means that the primary colors are combined at a certain amount to produce the desired color. RGB begins with black color (the absence of all colors) and adds red, green, light blue to make white. Yellow is produced by mixing red, green; cyan color by mixing green and blue; magenta color of red and blue combination. Computer and television monitors use RGB. Electromagnetic waves produces red, green, blue combined signals to produce the various colors seen on the screen [12]. The RGB color combination can be seen in figure 2.
E. Artificial Neural Networks

In general, the process of ANN is divided into 2 parts, namely training and testing. Training is a learning process of the neural network system that regulates the value of input and how the mapping on the output until the appropriate model obtained while testing is the process of accuracy of the model that has been obtained from the training process. ANN Back Propagation trains networks to gain a balance between networking capabilities in recognizing patterns used during training and networking capabilities to provide the correct response to similar (but not identical) input patterns to the patterns used during the training. An example of a back propagation network with one hidden layer can be seen in the following figure:

III. RESEARCH METHODS

A. System planning

In the circuit design should be taken into account the economic value of the use of components. Before making the circuit and system, firstly planned block diagram which will have one purpose for the circuit that is made leads to the desired destination. As a controller using a microcontroller can be seen from block diagram 3.1:

Coffee beans in this study using Robusta coffee. Full motor using Aduino microcontroller. The color sensor of roasting machine uses 1 camera to get RGB image value, temperature setting and watering time based on the water content according to SNI standard (SNI.01-2983-1992). Screen testing is done with LabVIEW software as virtual instrumentation For the aroma quality using Electronic Nose and delphi7 software to get the value of RGB roasted coffee beans Roasting system analysis using the method of Atifissial Neural Network back propagation Artificial Neural Network (ANN) also called artificial neural network (ANN) is solving problems with complex process modeling.

B. Electronic Design

In this design the temperature setting in the process of penyangraian is very important. The roasting results determine the quality of the coffee powder by setting the right temperature and producing the most distinctive aroma, color and flavor of coffee. Roasting color greatly affect the taste of the coffee powder, it is necessary to note the quality of color to improve the quality of coffee powder.
IV. TESTING

A. Observation parameters

Parameters observed in this research are:
1. The temperature of roasting process
2. Water content of coffee beans
3. Color of coffee beans

B. Temperature And Water Content

Monitoring on the program is given delay (1000); which means sending data in arduino to labview every 1 second. As for the reception of data from arduino and to monitor temperature can be seen in the software display in Figure 6

Fig.6 Monitoring Temperature with Eagle Software

The result % reduction of water content dilalukan every temperature change by weighing weight before and after roasting, can be seen from table 2.

Table 2
Effect of temperature on water content

<table>
<thead>
<tr>
<th>Suhu (0C)</th>
<th>kadar air(%)</th>
<th>biji kopi yang hilang</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (190)</td>
<td>3.36</td>
<td></td>
</tr>
<tr>
<td>T2 (193)</td>
<td>5.45</td>
<td></td>
</tr>
<tr>
<td>T3(199)</td>
<td>5.59</td>
<td></td>
</tr>
<tr>
<td>T4 (200)</td>
<td>6.22</td>
<td></td>
</tr>
<tr>
<td>T5 (204)</td>
<td>6.80</td>
<td></td>
</tr>
<tr>
<td>T6 (213)</td>
<td>7.22</td>
<td></td>
</tr>
<tr>
<td>T7 (217)</td>
<td>7.79</td>
<td></td>
</tr>
<tr>
<td>T8(220)</td>
<td>8.10</td>
<td></td>
</tr>
<tr>
<td>T9(223)</td>
<td>8.20</td>
<td></td>
</tr>
</tbody>
</table>

Calculation of water content by using the theory of Brooker et al [10]. The equation in the determination of dry water content applies to the following equation.

\[
\%MC_{db} = \frac{100MC_{wb}}{100 - MC_{wb}} = \frac{W_a - W_b}{W_p}
\]

The steps taken at the measurement, with temperature, 190⁰ C -214⁰ C and using arabica dry coffee beans, with a time of 15 to 20 minutes, the loss of dry weight is closely related to the temperature of roasting. The roasting temperatures used in roasted coffee are distinguished into 3 groups: ligh roast temperature used 193⁰ C to 199⁰ C, medium temperature roast used 204⁰ C and dark roast temperature used 213⁰ C to 221⁰ C. Ligh roast eliminates 3-5% moisture content: medium roast, 5-8% dan dark roast 8-14% [8]. From the test the water content of coffee beans after penyangaian tends to decrease with increasing temperature and duration penyangaian. Pada temperature 193⁰ C and 199⁰ C (ligh roast) obtained average loss of water content of 4.52%, at 104⁰ C (medium roast) it was found that the average loss of 6.22% water content, and 213⁰ C-220⁰ C (dark roast) obtained an average loss of 7.06% water content.

C. Color of Roasted Coffee Beans

Testing is done by seeing the roasted beans coffee based on the color of roasted coffee. Here is a picture of roasted beans:

Fig.7 Result of some roasted coffee bean level

For this test used delphi7 software to process image image of roasted beans coffee. Here's the look of delphi7 software for image processing.

Figure 9. Image roasting color image processing panel
In the picture above can be seen several buttons that have their respective functions, including:

1. The "Start" button works to activate the camera if the initial capture the roasted beans coffee. Then select the camera port used.
2. "Black screen" to display the camera results.
3. "Open" is used to open the roasted coffee bean capture result.
4. 'Capture' This button serves to capture image that appears on the black screen where the camera results are displayed.
5. 'Save' this button to save the capture result.
6. 'Scan' is used to perform the scanning process where the scanning results will be displayed on the RGB panel. Then will get value from RGB on capture result of roasted coffee beans.
7. 'TChart' to display the scanning graph of the RGB obtained.

For the first test done by processing the color image at the Green coffee beans color level. Where in the panel there is the open button, then select the image or the image of the results. To see the RGB value in the photo / picture copy select "scan". To see the scan process can be seen in the picture below:

1. Temperature 100 ° C = 120 ° C

From the scanning process then get the RGB value as follows:

a. R = 7985005
b. G = 7169482
c. B = 4996040

2. Temperature 193°C – 199°C (light roast)
From the scanning process then get the RGB value as follows:

a. \( R = 7985005 \)
b. \( G = 7169482 \)
c. \( B = 4996040 \)

3. Temperature 104°C (medium roast)

Fig. 14 The process of scanning the coffee color of the third roast bean coffee

Scanning results are completed and will be displayed RGB value as shown below:

Fig. 15 The results of the third coffee scanning

From the scanning process then get the RGB value as follows:

a. \( R = 5339190 \)
b. \( G = 4437209 \)
c. \( B = 3450276 \)

4. Temperature 213 – 220 °C (dark roast)

Fig. 16 The process of color scanning coffee coffee roasted fourth beans

Scanning results are completed and will be displayed RGB value as shown below:

Fig. 17 The fourth coffee scanning result

Based on the test results can be seen RGB value for medium temperature roast smaller than the light roast temperature, and RGB value for dark roast temperature is also smaller than darisuhu medium, with darker color. The percentage value of RGB value of coffee beans can be seen from table 3, where the value of red is approximately 50%, green is approximately 25%, and blue is approximately 25%. The color value of roasted coffee beans influences the flavor and aroma typical of coffee. The longer the roasting time, the color of roasted coffee beans approaching darkish brown [9].
Table 3
Percentage Value of RGB Rice Roasted Coffee Beans

<table>
<thead>
<tr>
<th>% Color Value</th>
<th>Temperature 193°C – 199°C (light roast)</th>
<th>Temperature 104°C (medium roast)</th>
<th>Temperature 213 – 220°C (dark roast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R (Red)</td>
<td>46.99%</td>
<td>50.85%</td>
<td>48.78%</td>
</tr>
<tr>
<td>G (Green)</td>
<td>29.63%</td>
<td>26.15%</td>
<td>25.42%</td>
</tr>
<tr>
<td>B (Blue)</td>
<td>23.38%</td>
<td>22.99%</td>
<td>25.80%</td>
</tr>
</tbody>
</table>

The next stage is the process of identifying the type of coffee using ANN where the type of coffee to be achieved or the target results are as follows:
1. First Coffee Before Roast (Target: 0 0)
2. Coffee both Light Roast (Target: 0 1)
3. The third coffee Medium Roast (Target: 1 0)
4. The fourth Coffee Dark Roast (Target: 1 1)

This is the identification process for "First copy":
1. Enter RGB and target input data in the program
2. Press upload to arduino module to process the ANN data.
3. Display the results of identification.
4. From the identification process then get the same output with the target. For more details can be seen in the picture below:

Here is the identification process for "Second coffee":
1. Enter RGB and target input data in the program.
2. Press upload to arduino module to process the ANN data.
3. Display the results of identification.
4. From the identification process then get the same output with the target. For more details can be seen in the picture below:
This is the identification process for "Third copy":

1. Enter RGB and target input data in the program.
2. Press upload to arduino module to process the ANN data.
3. Display the results of identification.
4. From the identification process then get the same output with the target. For more details can be seen in the picture below:

This is the identification process for "Fourth Coffee":

1. Enter RGB and target input data in the program.
2. Press upload to arduino module to process the ANN data.
3. Display the results of identification.
4. From the identification process then get the same output with the target. For more details can be seen in the picture below:

REFERENCES