Fuzzy Logic Control System Implementation on Solar and Gas Energy Dryers

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Abstract: Savings in the use of power sources in tools receive special attention, for example by using hybrid power, namely using two or more power sources to drive a device. The purpose of this research is to produce a prototype control system that can be applied to a hybrid system using sunlight and LPG gas to keep it stable and continuous with fuzzy logic method. The method used is fuzzy logic control program language using codevision AVR program and matlab software. Parameters measured in the dryer test include air temperature, air flow velocity, LPG gas energy consumption and material weight reduction. The measurement results are used to calculate drying energy, dryer efficiency and moisture content. The use of hybrid power, the dryer can save energy, small overshoot and stable temperature.

1 INTRODUCTION

Energy sources are getting depleted, energy savings in tools or equipment receive special attention, for example by using hybrids, namely using two or more power sources to drive a tool. In this modern era, energy sources are running low, saving on the use of energy in tools or equipment needs special attention and treatment. By using hybrid power, namely using two or more power sources to drive a tool. The requirement for hybridization energy for equipment is renewable energy (water, wind, solar) with sustain energy such as fossil energy (coal, gas or oil). The aim of using hybridization energy is to sustain the performance of the driven tool which it does not decrease and in order to fossil energy can be saved.

Combining two or more energy sources in the system can cause the system to become multivariable, non-linear, erratic, complex, uncertain or fuzzy. According to (Negnevitsky 2005) a fuzzy system can only be controlled by applying intelligent systems such as neural network systems, experts, or fuzzy logic.

(Azis and Sinadia, 2018) conducted studies related to hybrid solar energy and LPG gas, namely the design of a fuzzy-expert system on a solar and LPG hybrid powered food control device with one input and one output, (Satria et al., 2015) namely designing a temperature control system on a hybrid dryer using the fuzzy logic method, and (Arikundo and Hazwi, 2014) designing a logic - based temperature and humidity control system for drying hybrid nutmeg (myristica sp.) using solar energy and biomass.

Nowadays, on the one hand, the hybrid energy system is unusual to implement because this kind of technology has not fully ready yet. Moreover this technology is quite expensive, so most of people still using one the energy existed. On the other hand, all existing energy are very limited. For this reason, it is necessary to explore and to investigate the hybrid energy system for innovate the sources energy revolution.

2 RESEARCH METHODS

The materials used to make the dryer instrument include U 13 mm mild steel, 0.9 mm thick aluminum sheet, glass wool, 5 mm acrylic glass, screws, bolts, rivets, pipes, glass glue, lighters, 3 inch Blawer, 3 inch paralon pipe, stainless steel doof plate, gas stove, elbow iron, electronic components, microcontroller, coax cable, electrical cable, PCB, gas hose, 3 kg LPG gas, electronic lighter and solenoid. The material used to test the performance of the dryer is sago.

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The tools used to manufacture the dryer are workshop equipment, solar power meter (0.1W/m²), anemometer (0.1 m/s), digital scale (0.01g), data logger, and software (Matlab, Codevision).

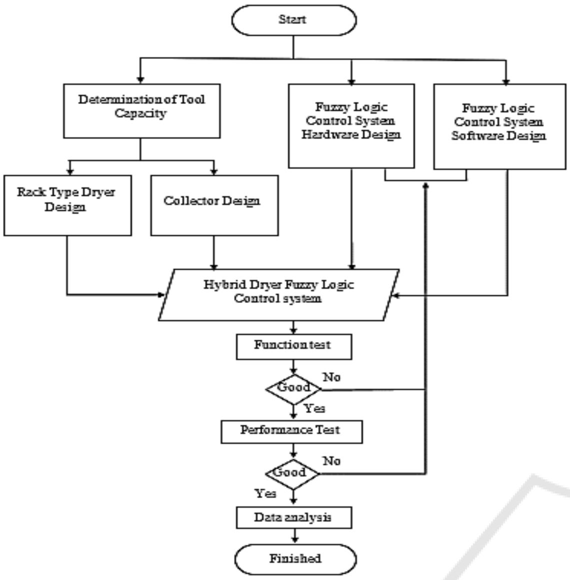


Figure 1: Research Diagram.

2.1 Determination of Tool Capacity

This tool is designed with a capacity of 40 kg. The drying equipment in this study used an existing drying chamber, consisting of 20 shelves with a capacity of 2 kg per shelf. The wait is located at the bottom of the Dryer chamber. Energy requirements are needed to find out how much energy or power is needed in waiting for the heater.

In this study, the type of collector used is a data plate solar collector which has several main components such as cover, acrylic, insulation, and absorber.

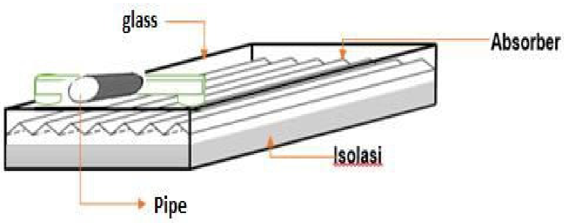
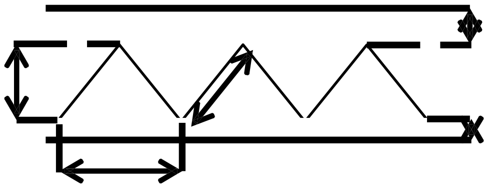


Figure 2: Flat Plate collector design.

The corrugated type (V) on the data plate collector is more widely used because of its higher efficiency against the sun.



description:
Ta = collector top surface height
Tb = collector area
Tc = width between collector cross sections
Ta = collector bottom surface height

Figure 3: Flat Plate collector design.

2.2 Fuzzy Hardware Control System Design

The design of fuzzy-based gas valve control hardware whereas the gas valve (solenoid) is assembled into a series and parallel circuit, so it can supply various power for the energy needs of the drying chamber. To produce power 0 to maximun power, fuzzy control is used, and its use uses a baypass on the solenoid.

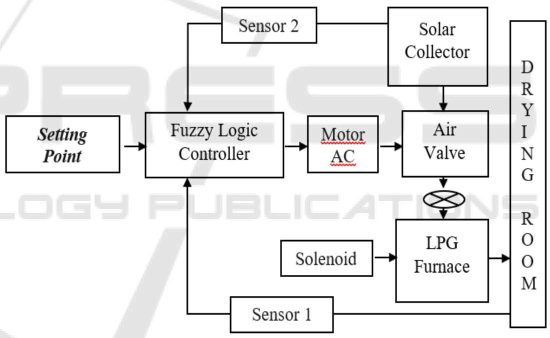


Figure 4: Fuzzy Logic Control System Design.

The design of the valve control hardware is shown in Figure 3, where the valve drive motor gets a control signal from the microcontroller and its action will move the air valve. The air rate of the collector depends on the valve opening (0^0, 45^0, 90^0). Motor drive used for the force acting on the valve leaf. The driving motor used in this study is an AC motor whose torque is caused by air in the valve.

2.3 Designing Fuzzy Control Software

2.3.1 Defining Input-Output

In developing a multivariable fuzzy logic control system, so a fuzzy control method should be designed, namely 2 inputs and 2 outputs. The 2-

input system consists of Dryer Room Temperature (T1) and Collector Temperature (T2). While the output is power (W) and valve opening (^{0}).

2.3.2 Defining the Universe of Speech and Values

In this study, the input temperature of the collector used ranges from 25^{O}C to 90^{O}C, at the input of drying room temperature 30^{O}C to 60^{O}C. This range is the actual condition of the collector temperature and drying chamber temperature. The universe talks about fuzzy singleton output in the range of 0 – max watt for power and 0^O to 90^O for opening and closing the valve.

2.3.3 Determining the Membership Function and Fuzzy Set

The function used for input is a triangular function and a set of three fuzzy sets for each input variable. For membership function. The system has two inputs and two outputs of fuzzy sets, the drying chamber input temperature (T1) is defined as r1 = low, s1 = medium, t1 = high. For the fuzzy set, the input collector temperature (T2) is defined as r2 = low, s2 = hot, t2 = high.

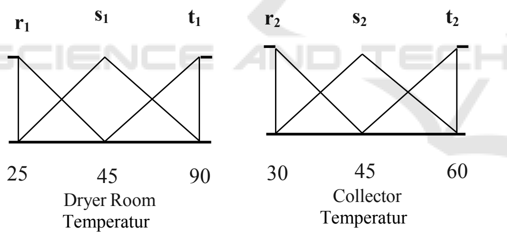


Figure 5: Temperature input membership function (^{O}C).

Mean while, the power output fuzzy set for the hybrid system is defined as kc=small, ak=rather small, sd=medium, bs=large, and sb=very large. The fuzzy set of valve open output is tt=close (0^0), bs=open (45^0) and bk=open (90^0)

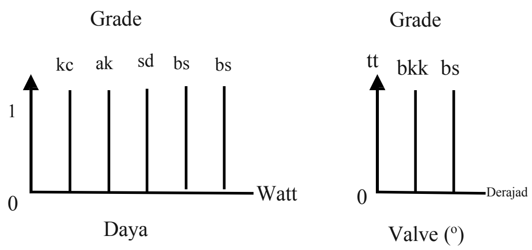


Figure 6: Output membership function.

2.3.4 Formulation of Conversational Rules

In this study, the rules are arranged based on the loop system that is in accordance with the desired conditions. The following are the results of the compilation of the rules for the 2 input 2 output system proposed by (Y Wang at al., 1997) in Figure 19. The results are as follows:

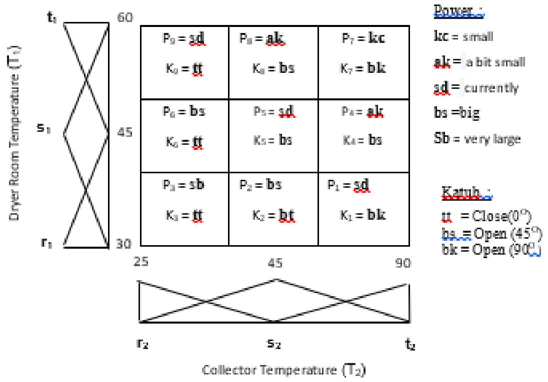


Figure 7: Fuzzy control matrix for hybrid systems.

The rules made from the control matrix are:

R1 : if (T1 is **r1**) and (T2 is **t2**) then (K1 is bk) (P1 is sd)
R2 : if (T1 is **r1**) and (T2 is **s2**) then (K2 is bt) (P2 is bs)
R3 : if (T1 is **r1**) and (T2 is **r2**) then (K3 is tt) (P3 is sb)
R4 : if (T1 is **s1**) and (T2 is **t2**) then (K4 is bs) (P4 is ak)
R5 : if (T1 is **s1**) and (T2 is **s2**) then (K5 is bs) (P5 is sd)
R6 : if (T1 is **s1**) and (T2 is **r2**) then (K6 is tt) (P6 is bs)
R7 : if (T1 is **t1**) and (T2 is **t2**) then (K7 is bk) (P7 is kc)
R8 : if (T1 is **t1**) and (T2 is **s2**) then (K8 is bs) (P8 is ak)
R9 : if (T1 is **t1**) and (T2 is **r2**) then (K9 is tt) (P9 is sd)

2.4 Instrument Examining

Testing of the tool aims is to determine whether the results of the hardware design and fuzzy rules can run a hybrid solar and gas system simulation tool in accordance with the expected function and it cand produce good performance. The implementation of this testing is carried out in two stages, namely functional testing and performance testing

3 RESULTS AND DISCUSSION

3.1 Dryer Machine Description

The hybrid system dryer consists of a collector, an LPG furnace, a dryer box and a control system. As seen in the image below.

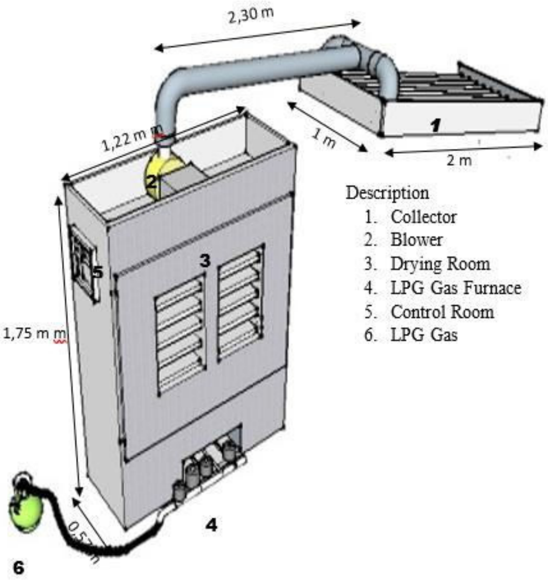
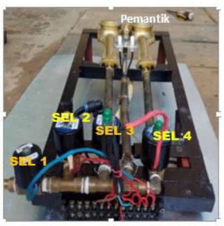


Figure 8: Hybrid Dryer.

Figure 9: Dryer Control Point.

The figure above is the control panel of the drying machine which is controlled automatically using fuzzy logic solar energy is the main source while LPG gas is an alternative source that is used if sunlight cannot reach room temperature.



	SOLENOID				Daya (Watt)
	SEL 1	SEL 2	SEL 3	SEL 4	
Condition	Open	Close	Close	Close	300
	Open	Open	Close	Close	1300
	Open	Close	Open	Close	2300
	Open	Open	Close	Open	3300
	Open	Close	Open	Open	4300

Figure 10: LPG Gas Stove Design.

The figure above is an LPG gas stove design which uses a selenod as an LPG flame regulator, adjusted for use with the temperature of the drying room.

Drying machine specifications can be seen in the table below:

Table 1: Specification of Dryer Machine with Fuzzy Logic Control System.

Kategori	Keterangan
Tool Capacity	20 rack
Dryer Dimensions	122 cm x 57 cm x 175
Collector Dimension	122cm x 244 cm
Collector Efficiency	79,24 %
material	*Steinless stell*
Blower	3 inci
Driving force	Listrik 220 V, 2,5 A
Spower source	LPG dan Surya
Control System	*Fuzzy Logic*

3.2 Functional Test Tool

This test is carried out by heating the temperature sensor at a temperature of 30 ^{0}C to 60 ^{o}C and observing which gas solenoid is working. The solenoid valve is used to supply energy from LPG, there are 4 solenoids that are installed with the markings Solenoid 1, Solenoid 2, Solenoid 3 and Solenoid 4. Solenoid 1 will continue to provide gas supply to keep the fire burning while solenoid 2, solenoid 3 and solenoid 4 will lights up depending on the energy requirements calculated by fuzzy. The test results in table 2 show that when the temperature is between 29^{0}C and 50^{0}C the power required is large to increase the temperature in the drying chamber, while at a temperature > 50^{O}C the power will decrease according to the energy requirement until it reaches the desired temperature.

Table 2: Solenoid Valve Test Results Against Temperature and Power.

Solenoid Valve				Temperature (^{O}C)	power (Watt)
I (300)	II (1000)	III (2000)	IV (2000)		
open	close	open	open	30 -34	4300
open	open	close	open	35-41	3300
open	close	open	close	42-50	2300
open	open	close	close	51-55	1300
open	close	close	close	>56	300

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3.3 Simulation Results of Fuzzy Control Rules 2 Inputs, 2 Outputs in the Matlab Program

To ensure that the rules made are correct, it is necessary to look at the surface results in Matlab as shown in Figure 34. Figure 34 shows that the decrease in gas power (LPG) decreases gradually so that the rules that have been made are as desired. The above rules are the basis for developing a fuzzy logic control program language using the AVR codevision program.

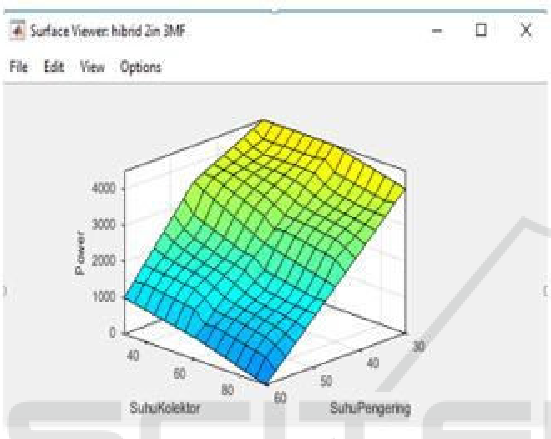

Figure 11: Fuzzy Surface Display in Matlab.

3.4 Tool Performance Test

Performance tests were carried out to determine the performance of the tool when drying sago using solar energy sources, LPG gas, and hybrids. Parameters observed were drying chamber temperature, drying time, moisture content and energy use.

3.4.1 Using Solar Energy

The temperature in the drying chamber using solar energy is strongly influenced by weather conditions. conducted for 2 days from 10.00 AM to 15.00 PM. The test results can be seen in Figure 12. The figure shows that on the first day the highest air temperature in the collector was 62^0C (12.00 PM) and the highest air temperature in the drying room was 46^0C (12.30 PM), while on the second day the highest temperature in the collector was 68^0C. (13.00 PM) and the highest temperature in the drying room is 51^0C (13.00 PM).

The difference between the collector air temperature and room temperature is caused by the loss of energy in the air duct and the mixing between the air temperature and the collector temperature. In the picture, the temperature looks unstable, the air temperature in the room ranges from 30^0C to 51^0C on the second day of drying.

3.4.2 Using LPG

From the observations it is proved that the fuzzy control system can control the temperature based on the setting point, the time is quite short, the offer shoot is 64^0C minutes and it does not exceed 69^0C, and it could running well because at that temperature gelatinization will occur (Cecil et al. 1982). Although there is an offset of 58^0C (3% of the setting point) but it is smaller than 5%, according to (Ogata et al., 1996) that the system offset occurs between 2% - 5%.

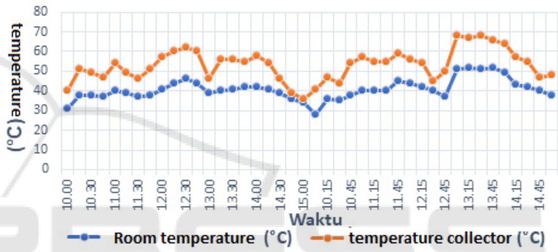

Figure 12: Dryer Room Temperature Response to Solar Intensity.

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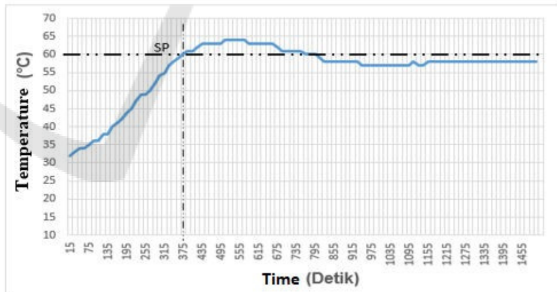

Figure 13: Dryer Room Temperature Response to Time Using LPG.

While the observation of the temperature in the drying room during the drying process can be seen in Figure 13. It can be seen in the figure that the temperature reaches the Setting Point (60^0C) in 6.75 minutes and overshoot occurs at 4^0C for 11.5 minutes after that the temperature is constant at 58^0C.

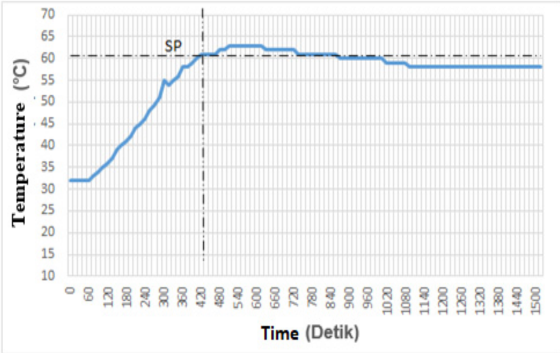

Figure 14: Dryer Room Temperature Response to Time Using Hybrid Power.

To meet the water content of sago from the Indonesian national standard, in this study, the water content of 6% was taken. This aims to extend the shelf life of sago flour, because the moisture content is less than 7%, the microbiological damage is much slower. According to (Winarno, 1992) the water content of the material between 3% to 7% will achieve optimum food stability.

4 CONCLUSIONS

Based on this research that has been done on the hybrid powered dryer, it can be concluded that:

1. A multivariable control system has been successfully designed that works with the expected results, such as relatively small overshoot, stable temperature and relatively small offset.
2. The drying time using the hybrid and non-hybrid methods (LPG gas) is same, but the use of the solar energy method is longer.
3. The dryer can save 50% of LPG gas with the hybrid method in varying sunlight conditions (cloudy).

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