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Fuzzy Logic based Industrial Control System Design

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Abstract: Fuzzy logic controller is an alternative modern control system that is easy because it does not need to look for a mathematical model of a system, but still effective because it has a stable response. The training module that has been designed using a DC servo motor and heater is controlled by an 89S52 microcontroller and the method of regulation used is fuzzy logic with a supervisory system using MMI software. The system created is a minimal system from SCADA because there is only one PC that is a data client. Fuzzy logic is designed to have two inputs (Err and ΔErr) and one output (Δton). Each membership function has 5 labels. Here used 25 fuzzy if-then rules consisting of 9 main rules, 10 additional rules and 6 supplementary rules. While the fuzzy logic process consists of fuzzyfication, evaluation rules, and defuzzyfication. The motor driver (motor driver) uses a PWM system (pulse width modulation) and the heater driver uses a proportional power control system. Input point setting is done through the SCADA software that is sent to the microcontroller via the computer's RS232 serial port. The system response testing is carried out on a number of setting point variations and load variations. From the data obtained shows that the system response is quite fast in pursuing the setting point value both in various variations, namely the load and setting point. Fuzzy logic is one of the redundant or fault tolerant control systems, which means the fuzzy logic controller can still work with a reduction in some rules, or if there are small errors in programming, without any significant changes.

Keywords:- Scada, fuzzy, serial port, RS232, DC Servo, microcontroller

INTRODUCTION

Control systems are needed to obtain high dynamical performance and more complex systems. Conventional PID is effective enough to correct error systems, but cannot be used for many parameters and systems that are not linear. Efforts to find systems that are able to provide data acquisition of a process parameter in real time with a minimum error-system (error and error rate) continue to be developed. One of them is controlling technique by using Fuzzy Logic Controller (FLC) application [1]–[4]. It is suspected that the performance of the FLC with the SCADA system has many advantages when compared to the classical control system (PID). Because of some of the above analysis it is necessary to make a module to prove, analyze, and implement a distributed control system on the network using Fuzzy Logic Controller (FLC) [5]–[8].

The problems to be resolved through this proposed research are: Modeling a SCADA system that is user friendly with students and lecturers. Design of the autotuning heating process system in an effort to stabilize the process temperature. FAM (Fuzzy Association Map) design for temperature controller and water level controller. Self-detection and resolution (autosolving) of disturbances (disturbance) contained in the plant and the target system. Data link / communication techniques used to communicate between plants and SCADA software. Changing membership degree data mapping to C language for the AT89S51 microcontroller. Design an accurate production data monitoring database. DC motor rotation speed settings with a pulse width adjustment or Pulse Width Modulation (PWM). Installation of control circuits and equipment safety is easier and simpler.

The purpose of this research activity is: Exploring, describing, explaining, proving, and obtaining / applying a concept, symptom or response produced by the fuzzy control system [9]–[14] which is very necessary in the Industry. Making a prototype module of data communication system both software (SCADA) and hardware (plant). Improve the learning process about industrial process control in Higher Education to be more relevant to the application. So that students are more familiar with the fuzzy logic control system [15]–[19].

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The benefits of this research for the future are: Providing an overview to the wider community, especially students and teaching staff working in the field of science about control systems with fuzzy logic algorithm. Providing an alternative to inexpensive control device products to the industrial world. As an inspiration for other students and science and technology development event in Indonesia.

METHOD

The method of completing this research is as follows: Gathering materials and reference data on the basis of SCADA theory and fuzzy logic. Design a job description of the system and determine and design the hardware that will be used in the system. Create a mechanical model of the plant frame and equipment layout on the plant and control panel. Record input and output addresses on the I / O pins of the DB25 port of the controller hardware. Designing a Man Machine Interface (MMI) Software to monitor the working status of a microcontroller via a serial link using Visual Basic 6.0. Designing a DC motor control system using PWM, calculating pulse timings, number of waves per second, calculating delay-time per millisecond on the microcontroller, making a program algorithm and changing the algorithm to the C programming language for the microcontroller [20]–[23]. Designing a heater adjustment system using the ON-OFF method with the ON time width and OFF time width parameters, making calculations of the ON time and OFF time of the total time ON and OFF time, making the program algorithm and changing the program into C programming language on the microcontroller [24]–[31]. Designing a Fuzzy Distributed Intelligent Control System program on a microcontroller using the C programming language. Testing the working of machines, controllers and MMI (communication lines). Analyzing the system and making reports.

Table 1. List of Materials and Research Equipment

1	Modul Mikrokontroller 89S52
2	ADC 0804
3	Sensor Suhu LM335A
4	WLC (Transistor 2N222 + Elektroda)
5	Flow Switch (Transistor 2N222 + Elektroda)
6	Kabel RS232
7	Kabel Data
8	CD Software Visual Basic 6.0
9	Driver Motor Pompa
10	Driver Heater
11	Driver Motor DC Servo (Agitator)
12	Driver Solenoid Valve
13	Motor Pompa
14	Heater
15	Motor DC Servo (Agitator)
16	Solenoid Valve
17	Kabel NYAF 15 cm dan Socket terminal
18	Peralatan Simulator

RESEARCH RESULTS AND DISCUSSION

System Response With 25 Rule

The system response to the fixed point setting is shown in Figure 1. The number of rules used is 25, namely 9 basic rules, 10 additional rules, and 6 supplementary rules with a load of 2 liters of substance.

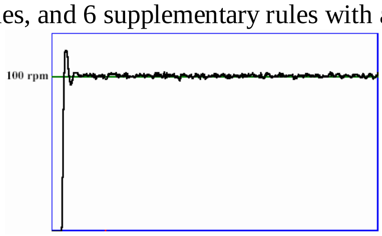

Figure 1. System Response to Fixed Point Settings

From the picture it can be seen that the system response has a very fast rise time of about 3-4 seconds with an over shoot of about 5-10 rpm. Steady State Error system response is also very small + 1 RPM. Figure 2 shows the system's response to a decrease in setting points. The setting point changes starting from 110 rpm and then reduced to 100 rpm, 90 rpm, and finally 80 rpm. Conversely in Figure 3 shows the system response to raising the Setting Point. From the picture it can be seen that it takes ± 2 seconds to reach each change of the Setting Point. With overshoot reaching 5-10 rpm.

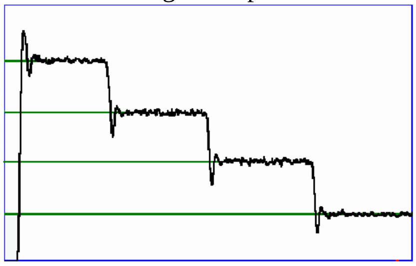

Figure 2. System Response to SP Variations with deceleration

From Figure 1, Figure 2 and Figure 3 can be seen that the system response with variations of Setting Points and load variations with basic rules and additional rules totaling 19, there was no significant change, although to achieve the desired setting point a slowdown of about ± 1 occurred. seconds. For Steady State Error of each image the same as Steady State Error on system response with rule number 25.

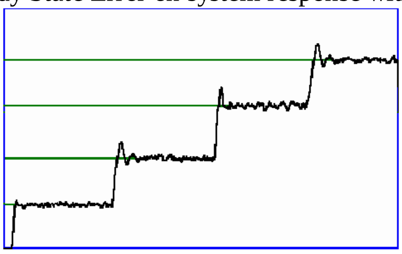

Figure 3. System Response to SP Variations with acceleration

Testing the response to the actual temperature stability generated by the heater. The first step of the Heater is tested by giving varying set points and different amounts of substances. Is it actually able to follow the desired set point. The second step is to find the speed of change or rise time by changing the set point quickly over and over again, then here is observed what is the speed of change that might be done by the actual.

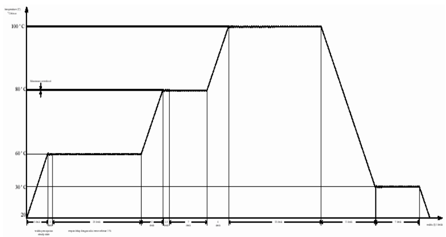

Figure 4 Characteristics of the response produced by the fuzzy training module on temperature control.

Data Testing Results Tool

The test is carried out in an Electrical Laboratory with the guidance of a Supervising Lecturer. In this test the output signal from the microcontroller [32]–[34] is observed based on the input provided and also the output of the agitator motor driver and heater driver. Fuzzy Controller Module Testing Equipment, DB25 connector cable, 24VDC motor with Shaft Encoder (absolute encoder), Heater 150W, 220VAC, Digital Osciloscope, Analog Osciloscope, Probe 10x, Connecting Cable, PC, ISP Microcontroller Programmer Cable, RS232 Serial Cable, Isolation Transformer , and Aquarium with water.

The output pulses are formed by Port 0.1 Microcontroller, where this port is connected to the DC motor driver. Testing is done by adjusting the pulse width with a sampling time of 50 mS. From the 0.1 microcontroller input port, the DC motor driver output voltage. This test is conducted to observe and analyze the output pulses formed by the Port 0.0 Microcontroller, where this port is connected to the heater driver. Testing is done by adjusting the pulse width with a sampling time of 100 mS. From the output port 0.0 the microcontroller will work on the heater driver. Fuzzy logic is the development of primitive logic that only recognizes two conditions, namely "yes" or "no". With the fuzzy logic, can recognize linguistic variables such as rather large, large, very large, and so on. Thus, the application of fuzzy logic will cause the system to be more adaptive.

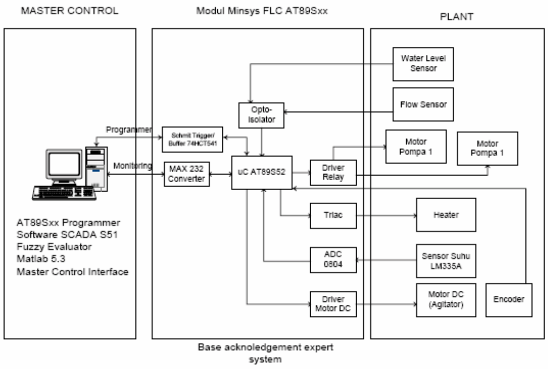

Figure 5. Block diagram of the fuzzy control system in the MMI training module

In determining control decisions, the control rules that are wanted are the rules that govern how the system should behave. In other words, these rules will determine once the performance of the desired control system. The basic rules of fuzzy controllers require a little code and memory and do not require heavy number-crunching or complex mathematical models to operate.

The language expression used in fuzzy logic can help define the operational characteristics of the system better. Language expressions for system characteristics are usually expressed in the form of "If - Then" rules. MCS '51 family microcontroller can be used as a fuzzy logic controller. Changing the algorithm is enough to change the program in the microcontroller which is relatively easier than changing the hardware. In this study we used the AT89S52 Microcontroller which is a family of MCS '51 [35]–[38].

In this study using 25 rules (rules) namely 9 basic rules, 10 additional rules, and 6 complementary rules with a load of 2 liters of substance. To maintain motor speed with variable loads, the voltage applied to the motor can be adjusted by using phase angle modulation or pulse width modulation techniques. While the temperature regulation by the heater is done using TRIAC. The purpose of each control system is to produce output from the input given. Here the system response will be tested with load variations and SP variations. Testing is also carried out by providing disturbances from outside in the form of additional friction and sudden increase in load. The manual testing procedure performed is as follows: Run MP1, MP2, Solenoid Valve, Heater and Motor Agitator manually from the hardware by pressing each push button each on the hardware. Running MP1, MP2, Solenoid Valve and Motor Agitator manually from the hardware by pressing each push button each of which is on the hardware.

The automatic testing procedure that is carried out is as follows: Give a load on the agitator motor of 2 liters of substance and the SP is set at a speed of 190 RPM and a temperature of 60 ° C. Give a load on the agitator motor of 4 liters and the motor rpm SP and SP temperature values vary. Give a load on the agitator motor of 2 liters and plus 2 liters of substance. Change the temperature value rises to 90 ° C, then observe the temperature rise that occurs. Change the temperature SP value down to 40 ° C, then observe again the changes in temperature that occur and record the time.

The system response is then displayed on the PC computer monitor screen with the help of the Data Acquitition facility contained in the MMI Software which can receive system response data from the 89S52 microcontroller system sent serially with 9600bps baudrate, startbit 1, stopbit 1, parity = none, data length 8 bit. The picture below shows the Man Machine Interface Software Program when operated.

CONCLUSION

Based on the results obtained, several conclusions can be drawn, among others: Fuzzy Logic Controller is a control system that is relatively easy to design, because no exact mathematical model of the system is needed. With a rule-based approach and common sense the system is designed and built. In this plant 9 basic rules are the basic rules used at the peak points, 10 additional rules are used to refine the system's response and 6 complementary rules are used when the system experiences extreme interference. Fuzzy Logic control has the nature of redundant and fault tolerant, where the reduction of the rule does not cause the system out of control. It can still be controlled by being degraded. With the help of MMI software that has been made, human interaction with plant machinery becomes easier and more practical. Appropriate and reliable serial data communication techniques are used in MMI systems, the effect of voltage drop factors is very small, efficient in wiring and components (does not require TTL ICs / buffers) but it is also capable of being used over very long distances.

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