Research Article

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Fuzzy Logic Control (FLC) for a Yarn Conditioning System

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Abstract: Conditioning machines have a wide use in the textile industry. For this reason, it is important to control the conditioning machines precisely. Fuzzy logic control (FLC) has found successful application areas in the control of electrical machines. In this study, FLC was used to control the conditioning system. In the computer aided conditioning experiment setup developed for this purpose, information is received via sensors, the measurement values are directly transferred to the computer, and the control of the system is done via the computer. Different experimental measurements were used to evaluate the reliability of FLC. In this study, 100% cotton selected in the most used number range in the market. Yarns in a vacuum environment with saturated steam at different pressures and temperatures. Measurements were taken one hour after conditioning 1 day then repeat after 1 week, after 2 weeks, and after 3 week. A fuzzy model of the yarn conditioning system was created using experimental data. Control of the conditioning machines with fuzzy logic controller has been done successfully. It has been observed that the fuzzy logic controller works very well, catches the desired set value in a short time and keeps the system at this value. During the operation, the desired pressure set value was reached in 5-6 minutes. With the effect of fuzzy logic controller, pressure and temperature values are stabilized in a short time.

Keywords: Fuzzy logic, Yarn, Conditioning, Control.

1. INTRODUCTION

Conditioning machines are widely used in the textile industry. This means that the control of conditioning machines must be precisely done. In recent years, fuzzy logic controllers draw attention with its successful used applications in the field of control of machinery. For this purpose, computer-aided conditioning experiment setup was designed. Developed computer-aided In the conditioning experiment setup, information is received through sensors. Measurement values are transferred directly to the computer. Fuzzy control of the system is done via computer [1]. One of the biggest problems encountered in control systems is the mathematical model of the mechanism is difficult to construct. Even if this model is created, it is very complex to perform the application with traditional logic. Fuzzy logic control systems don't need a mathematical model. control with the help of fuzzy logic linguistic variables create the mechanism. In the study, firstly, conditioning systems and general information about fuzzy logic hardware and mathematical fuzzy logic of the conditioning machine which is difficult and complex to model has been carried out [1-2].
Today, with the effect of spinning machines operating at high speeds and environmental conditions, the amount of moisture on the yarn decreases to 5%. This value is not enough

sufficient for problem-free operation of the yarn in the next processes. In order to increase this moisture content in the yarn, the yarns after spinning are subjected to conditioning. The main purpose of conditioning is the yarn. To eliminate internal stresses caused by mechanical stresses during production, to improve its physical properties and to reach the commercial humidity level of the yarn. The quality and quantity of these properties to be given to the yarn by conditioning depends on their shape. Many different methods are used in the conditioning of yarns. The most widely used of these methods is saturated in vacuum at low temperatures. It is a steam conditioning process. With this method, the yarns are homogeneously rouge can be given. In the conditioning process at low temperatures with saturated steam in a vacuum environment, errors arising from the process are usually caused by the temperature and the pressure cannot be kept constant and the vacuuming process is homogeneous arises due to its inability. The problem can be eliminated by doing this controlled process [3-4]. The nonlinear system is linearized into different operating points. Then, linear models corresponding to every operating point are established. The fuzzy model is described by a family of fuzzy IF-THEN rules where each one represents a linear input-output relation of the system. The global fuzzy model of the studied dryer was achieved by smoothly blending these linear models together through the fuzzy membership functions in order to give the overall nonlinear behavior of the dryer [5-11].

Kocakulak and Solmaz [12] modeled a regenerative braking system with a fuzzy logic control strategy. Vehicle speed, battery charge rate (SOC), brake pedal position and battery pack current values were taken as input parameters. The braking of the vehicle during its use is taken as the output of the modeled control system. It was concluded that instead of conventional regenerative brake, the use of regenerative brake controlled by fuzzy logic method provided energy savings of 4.8% in NEDC, 3.78% in ECE-15 and 5.44% in EUDC driving cycles. Öztürk et al. [13] proposed a fuzzy proportional integral derivative (PID - Proportional-Integral-Derivative) controller structure in microgrid. League championship algorithm (LSA), ant colony algorithm (CCA) and particle swarm optimization (PSO) algorithms were used to determine the most suitable controller parameters. At the same time, the cost function of the sum of time-weighted absolute error (ITAE - Integral Time-weighted Absolute Error) is used. As a result of the study, the performance of the proposed controller was compared with the classical PID controller. Özgüney et al. [14] modeled a two-wheeled self-balancing robot and only PID (proportional, integral and derivative) control and Fuzzy Logic-PID (Fuzzy Logic-PID) control were designed for this system. Fuzzy Logic-PID control responded faster than classical control. The simulation results obtained with PID and Fuzzy Logic-PID controls were compared. At the end of the study, it was understood that the Fuzzy Logic-PID control can adjust the control gains by itself and has a successful performance in reaching the desired speed and position. Asyauqi et al. [15] Fuzzy logic control is used to increase the energy efficiency of the washing machine and the cleaning behavior of the washing process. Matlab software was used for simulation. The mass of the material and the pollution level were selected as the input variables, and the engine speed was chosen as the output variable for washing the material. The material and pollution level increased the speed of the engine. Altınten et al. [16] the treatment of wastewater obtained from the cotton textile industry was carried out by electrocoagulation (EC) method. Simultaneous control of temperature, conductivity and pH was made using fuzzy control method to increase the efficiency of the treatment. MATLAB/Simulink program was used in control experiments. As a result, it has been revealed that the EC process is an effective method in the treatment of textile industry wastewater and the efficiency increases with the fuzzy control method.

In this study, 100% cotton selected in the most used number range in the market. Yarns in a vacuum environment with saturated steam at different pressures and temperatures.

Measurements were taken one hour after conditioning 1 day then repeat after 1 week, after 2 weeks, and after 3 week. There are studies on fuzzy logic applications in the textile industry. However, there is no fuzzy logic application for yarn conditioning systems in the literature. A fuzzy model of the yarn conditioning system was created using experimental data.

2. METHODOLOGY

In the experiments, yarns produced from 100 % cotton fiber with the following properties (yarn counts and twist counts) selected in the number range widely used in the market were used.

-Ne 16/1 carded woven ring yarn 521 tpm
-Ne 20/1 carded woven ring yarn 596 tpm
-Ne 30/1 carded woven ring yarn 597 tpm
-Ne 30/1 combed weaving ring yarn 562 tpm
-Ne 40/1 combed weaving ring yarn 599 tpm

The conditioning machine, which works with saturated steam in a vacuum environment, which is designed and manufactured, has a system that has the ability to reach the desired vacuum values and provides homogeneous temperature and vacuum distribution. With its easy-to-use programming, the machine is fully automatic and gives the same process values and standard production in all cases.

The conditioning machine working with saturated steam in a vacuum environment used in experimental studies is shown in Figure 1. The machine has a cylindrical structure with a diameter of 70 cm and a length of 145 cm. There is a vacuum meter and a mercury filled thermometer to be used in the control of vacuum pressure, temperature and indoor humidity in the manual control institution at the top of the conditioning machine. PLC, PID and fuzzy control of the produced conditioning machine is provided by a control program software with Visual Basic. In the developed computer aided conditioning boiler, vacuum pressure sensor and humidity-temperature sensors are used to monitor and control vacuum pressure, temperature and humidity values in the case of PID and fuzzy logic control. It has a humidity-temperature sensor display and can also be used in the case of manual control.

Figure 1. The designed conditioning machine.

The conditioning machines, which works with saturated steam in a vacuum environment, operates according to the indirect steaming system. That is, a separate system was not used for the supply of saturated steam to the system, and the water bath in the lower part of the boiler was not used.

It is obtained as a result of evaporation by heating with electric heaters after the conditioning boiler is evacuated under vacuum. The indoor temperature is also adjusted to the desired level by these electric heaters.

All the elements used during the experiment were visualized on the computer screen. The screenshot of the computer program written for the control of the conditioning machine is given in Figure 3.8. Experiment in the part of the vacuum pressure and temperature set values located at the top of the computer screen. For the desired vacuum pressure and temperature values (SET T2 and SET Vp) are entered. The written control program automatically saves the test results.

The conditioning system, which works with saturated steam in a vacuum environment, operates in three stages:

First stage: Clean water bath is adjusted into the boiler to the desired level, threads is placed and the lid of the boiler is tightly closed.

Second stage: The air in the conditioning tank is evacuated by vacuuming.

Third stage: Saturated steam supply for the system is performed. Saturated steam, the water bath at the bottom of the boiler, with electric heaters. It is obtained by heating and evaporation. The temperature of the environment these electric heaters adjusted to the desired level. Located in the main control panel control unit, with the setting values previously entered as information. By comparing the information coming from the boiler, the engine on the system and the control It manages the opening, throttling or closing operations of the valves at the desired rate. Operating steps of the system, pre-vacuum, heating, steaming, final vacuum and pressure consists of balancing steps. The system performs these steps automatically. Yarns are conditioned at different pressures, temperatures and waiting times with saturated steam in vacuum conditioning machine. All yarns used in the experiments have been subjected to conditioning with saturated stream in vacuum at 600 mmHg pressure at 50 ^oC, 60 ^oC, 70 ^oC and 80 ^oC, and at 70 ^oC in the conditioning machine at 650 and 700 mmHg vacuum pressure at temperature.

During the control of the conditioning machine, the signals received from the sensor are passed through an analog/digital (A/D) converter and made suitable for the computer environment. By comparing the signals coming to the software program with the desired value, the error value obtained is evaluated with the selected control methods, and control signals are obtained. The obtained control signal runs the motor according to the size of the control signal. Control is made using PID and fuzzy logic control methods.

3. CONTROLLING THE CONDITIONING SYSTEM WITH PID METHOD

The change in temperature and vacuum pressure values comes as analog information to the control program prepared by the sensors via the control box. The actual temperature and vacuum pressure values obtained during the experiment are compared in the control program written with the reference temperature and vacuum pressure values determined at the beginning of the experiment and which are required to be constant during the conditioning process. The resulting value is recorded as an error signal. The error signal Decodes the difference between the actual values at the time of measurement and the desired reference values. The obtained error signal is determined by the ratio, integral and derivative determined according to the characteristics of the selected control element. The control element is sent as an output signal by undergoing changes according to the control effects. In this study, the proportional, integral and derivative control effects were used together in the PID control method. In Figure 2, the system PID control block diagram is shown.

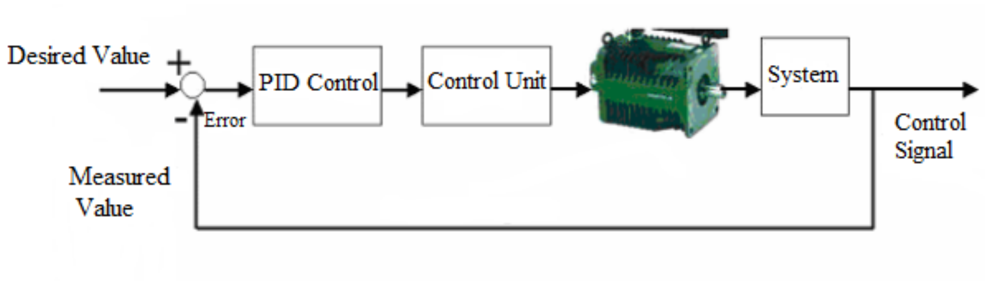

Figure 2. PID control block diagram

4. CONTROLLING THE CONDITIONING SYSTEM WITH FUZZY LOGIC METHOD

Reference pressure, temperature value and actual pressure obtained from sensors, temperature values are compared. The error value (e) obtained as a result of the comparison and the difference between the last value and the previous error value (ce). The input of the FLC method is taken as membership values. Obtained error and error change by fuzzy logic method in accordance with the rule base by using values control signal is obtained. According to the magnitude of the obtained control signal Control of the conditioning system was carried out. In Figure 3, the system fuzzy logic control block diagram is shown.

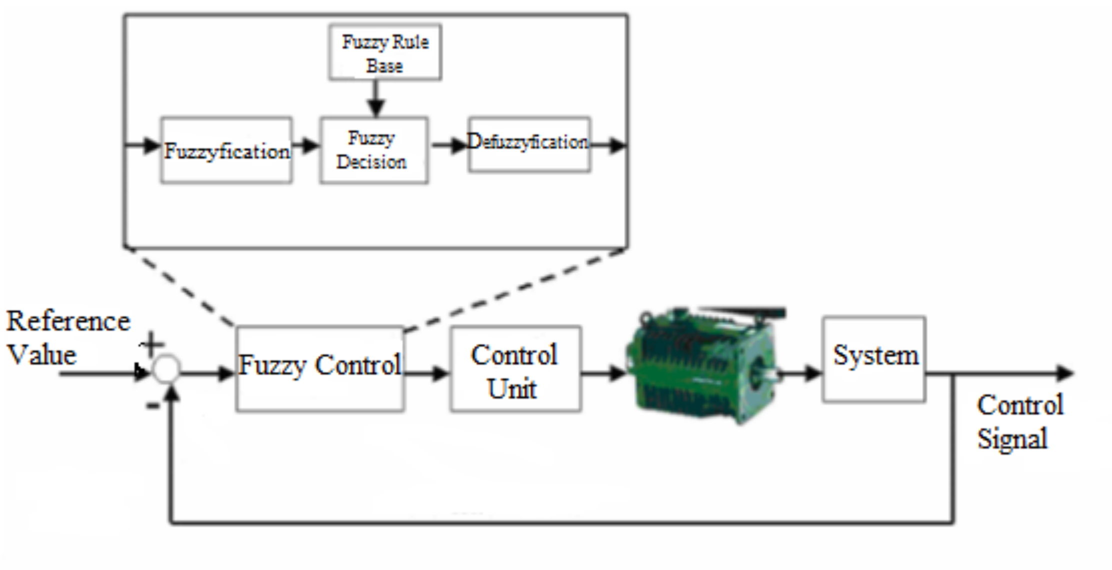

Figure 3. Fuzzy logic control block diagram

4.1. Designing the Fuzzy Logic Controller Unit

The fuzzy logic controller unit consists of input and output variables, blurring, fuzzy inference and rinsing sections. In order to control the conditioning system with fuzzy logic, it is necessary to determine the input membership functions. In this study, error and error modification are taken as input membership function in fuzzy logic control. In fuzzy logic control, error (e) is detected by taking the difference between the values measured during Deconditioning process and the reference values determined in advance. By comparing the obtained error with the previous error value, the error change (ce) value is also found.

4.2. Defining Fuzzy Logic Controller Input and Output Variables

The designed fuzzy logic controller unit;

Input variables: Error, Error_Change

Output variable: Control signal

Input Variable- Error (e)

it is found by taking the difference of the current ambient values from the desired ambient setting values and measuring elements.

Error = (desired state - current state)

H(e) = Reference - Actual

Input Variable- Error_Change (ce)

It is found by taking the difference of the current error value from the previous error value.

Error_Change = (current_error - previous_error)

Error_Change (ce) = H-Hö

Output Variable- Control Signal

This variable is the desired control signal (volt) in the conditioning process. Accordingly, the output variable of the fuzzy logic controller unit is obtained by Ks=f(e,ce). It is found by taking the difference of the current ambient values from the desired ambient setting values and measuring elements. The block diagram of the fuzzy logic controller unit used to generate the control signal is given in Figure 4.

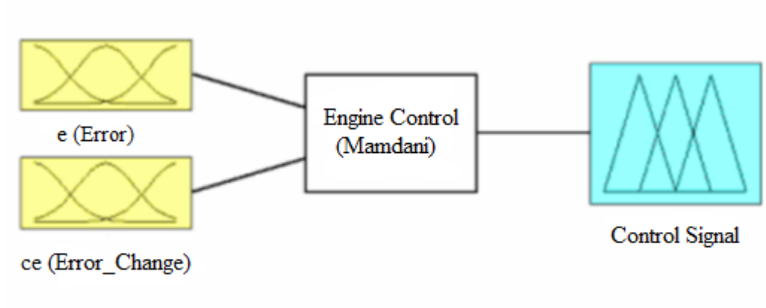

Figure 4. The block diagram of the fuzzy logic controller unit

Membership Functions of Input Variables

In this system, fuzzy subsets for input variables, triangle type membership defined as functions. Membership functions of input variables and foot spacings are shown in Figures 5. and Figure 6.

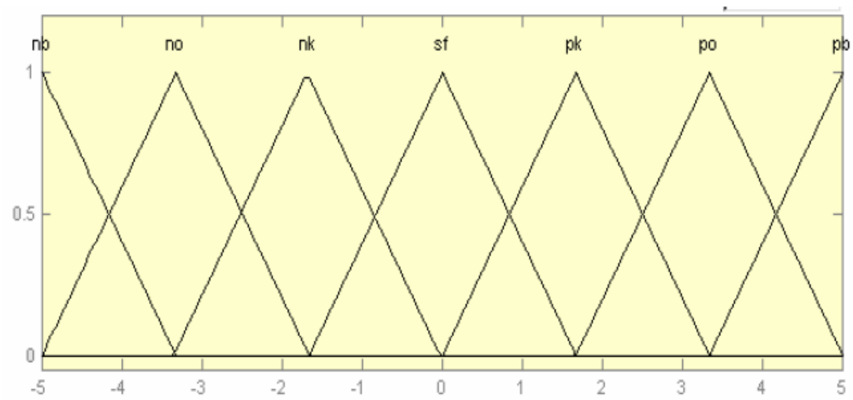

Figure 5. "Error (e)" Input membership function

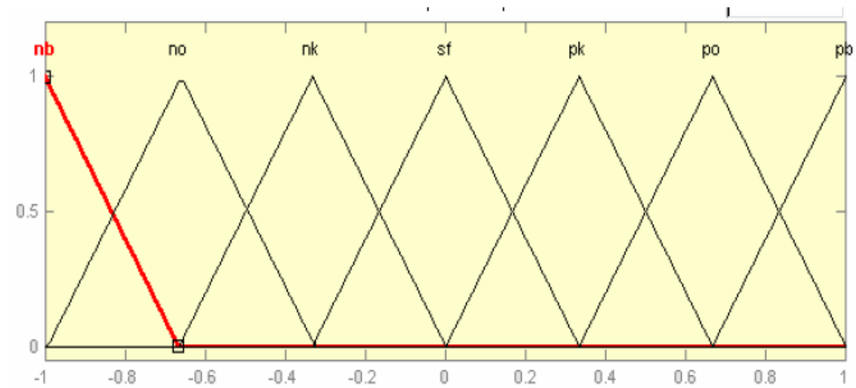

Figure 6. "Error_Change (ce)" Input membership function

Membership Function of Output Variable

The number of the "Control Signal" output membership function selected as the membership function of the fuzzy output variable and the leg widths are shown in Figure 7. In this system, fuzzy subsets for output variables are defined as triangle type membership functions.

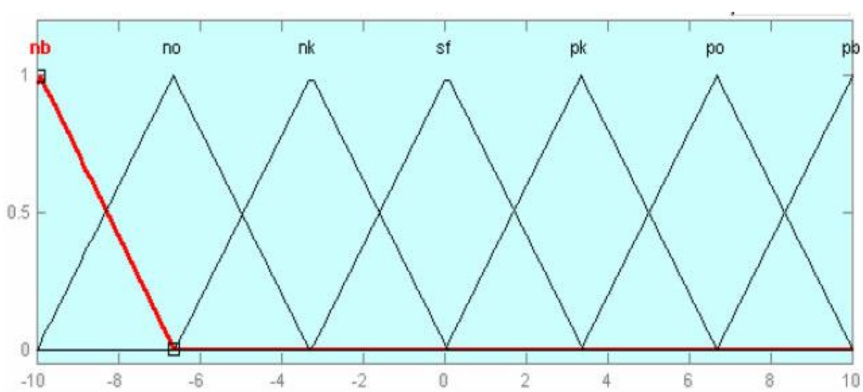

Figure 7. “Control Signal” output membership function

Fuzzy Inference

The relations between the determined membership functions are solved in the Matlab program with the rule base created by using the experimental data and expert opinions, and the necessary signals for the control are produced. Obtained solutions are given in Figure 8. Control signal decreased as error variation increased.

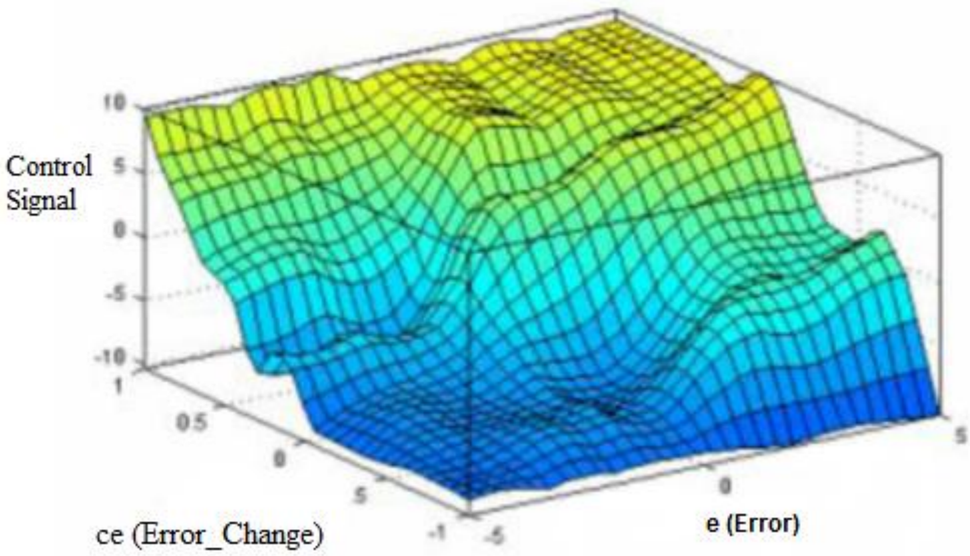

Figure 8. The result function obtained with the MATLAB program

3. CONCLUSIONS

Control of the conditioning machines with fuzzy logic controller (controller) has been done successfully. Fuzzy logic control (FLC) has found successful application areas in the control of electrical machines. The relations between the determined membership functions are solved in the Matlab program with the rule base created by using the experimental data and expert opinions, and the necessary signals for the control are produced. In this study, FLC was used to control the conditioning system. The computer aided conditioning experiment setup developed for this purpose, information is received via sensors, the measurement values are directly transferred to the computer, and the control of the system is done via the computer. Different experimental measurements were used to evaluate the reliability of FLC. It has been observed that the fuzzy logic controller works very well, catches the desired set value in a short time and keeps the system at this value. During the operation, the desired pressure set value was reached in 5-6 minutes. This is a very short time for the conditioning system. With the effect of fuzzy logic controller, pressure and temperature values are stabilized in a short time.

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