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Self Tuning Based Adaptive Fuzzy Logic Controller in Lab view for Sterilizing Equipments

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ABSTRACT

In this paper, temperature monitoring of sterilizing equipment system was established with the help of fuzzy and self tuning Adaptive fuzzy logic controller designed in Lab VIEW software. It combines the advantages of both fuzzy logic and self tuning Adaptive fuzzy logic controller. The implementation attempts to rectify the errors between the measured value and the set point which helps to achieve efficient temperature control. The Adaptive fuzzy controller uses defined rules to control the system based on the current values of input variables and temperature errors. The simulation results presented in order to evaluate the proposed method. The result shows that self tuning Adaptive fuzzy logic controller was tolerant to disturbance and the temperature control is most accurate.

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1. INTRODUCTION

Fuzzy logic control system, transforms the linguistic information and expert knowledge into control signals which are currently used in wide variety of engineering applications. The fuzzy logic provides an inference structure that enables appropriate human reasoning capabilities. The main advantage of the fuzzy logic was its simplicity in designing over other type of controllers. Even if it is more advantageous than conventional controllers, it also has some drawbacks which include the complexity in developing the rules lead to increase the complexity of the process. Process control system is a group of electronic devices and several kind of equipment's which provides the stability and accuracy. In this paper the thermal disinfection was recommended for reprocessing of anesthetic equipment and apparatus. A disinfection process was intended to significantly reduce the number of pathogenic micro organisms on instruments by removing and/or killing them.

2. SYSTEM DESCRIPTION

The sterilizing system generally consists of the following description. The desired temperature was given to the system through keyboard. The actual temperature was sensed by sensor and converted to digital signal by the A/D converter. The computer reads the actual temperature and compares with desired temperature. If it finds any difference then it sends signal to switch ON/OFF the relay through D/A converter and amplifier. Then the LabVIEW software acts as a controller which corrects the error. Thus the system automatically corrects any changes in output. Since there are more complexity it also provide simple procedure to obtain output.

The sterilizing process consist of several things mainly water tank, sensor, data acquisition system, computer, LabVIEW controller and heater. For the distribution of the heat the stirrer was used.

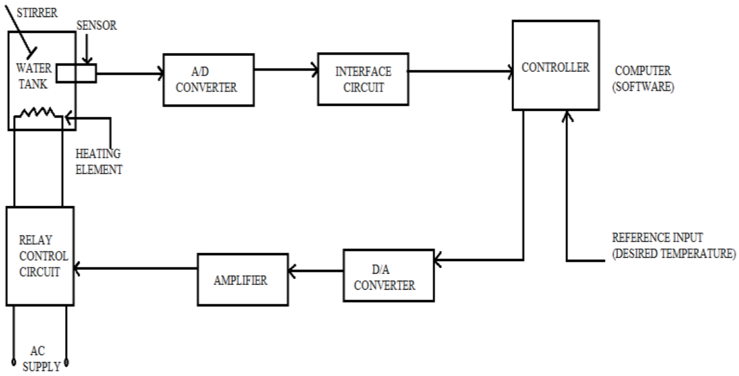

Figure 1. Block diagram of the sterilizing system

The Sensor used was thermocouple. DAQ was used for inter connection between sensor and controller as well as controller and driver circuit. The thermo-couple output was in the range of milli volt so we use an amplifier circuit for increasing the voltage range. The working of the system was described as, when the temperature was measured by the thermocouple was converted into the voltage, which was going to the controller through DAQ. The differences between the set point and actual value were applied to the controller, nothing but error. The PWM signal was produced corresponding to the output voltage of the sensor.

2.1. Thermal Disinfection

Thermal disinfection achieves high level of sterilization. Disinfection when surface was in contact with heated water for an appropriate length of time. Shorter times are required at high temperatures. Draft international standards will precipitate changes to conditions required for disinfection by thermal means using circulating hot water in a mechanical cleaning machine. Sterilizing was done very consciously so that the disinfection will be so accurate which will not lead the patient to cause sick again. AS 4187 will include the following instrument surface temperature and times for disinfectors:

a. 70˚c for 100 minutes, or
b. 75˚c for 30 minutes, or
c. 80˚c for 10 minutes, or
d. 90˚c for 1 minute

2.2. System Identification

System identification was done by using MATLAB system identification tool box. Here sterilizing system was a single input single output system. So the order of the system is one. When we apply the input to the system, the process will take some time for heating process. When the system is switched off, it will take some time to come to the initial condition.

3. DESIGN PROCEDURES

The process variable is the system parameter that is to be controlled, such as temperature and the set point is the desired value for the parameter you are controlling. A fuzzy controller determines a controller output value, such as the heater power. The controller applies the controller output value to the system, which in turn drives the process variable toward the set point value.

3.1. FLC

Fuzzy logic was more effective in feedback control system. The FLC processes are stated as user-defined rules governing the system, the changes can be modified easily to show the flexible nature of the controller. With the help of rule based operation, the system can be easily designed for any numbers of inputs. The nonlinear functions can be modeled with the help of fuzzy logic controller. Despite of the advantages, there was a complexity in developing the rules with increase in complexity of process. Sterilizing system was nonlinear to some extent. But nonlinear system theories were limited and difficult to design; therefore the nonlinear system should be linearized. The adjustment of the linear control of nonlinear systems requires. The sterilizing system uses the two-dimensional fuzzy controller model. Designing a controller for a linearized model is not an issue but ensuring that this controller will work for operating conditions outside the linearization region was trivial.

3.2. Fuzzification

It was the process of transforming a crisp set to a fuzzy set or a fuzzy set to a fuzzier set, i.e., crisp quantities are converted to fuzzy quantities which translates accurate crisp input values in to linguistic variables. In a real life world, the quantities that we consider may be thought of as crisp, accurate and deterministic, but actually they are not so, they possess uncertainty within themselves. The uncertainty may arise due to vagueness, imprecision or uncertainty. Generally three types of fuzzifiers that are used for the fuzzification process; they are:

a. Singleton fuzzifier
b. Gaussian fuzzifier
c. Trapezoidal or triangular fuzzifier

3.3. Defuzzification

Defuzzification is a mapping process from a space of fuzzy control action defined over an output universe of discourse into a space of crisp (non fuzzy) control actions. This required because in many practical application of crisp control action are needed to actuate the control. It is the process that produces a non fuzzy control action. There are many defuzzification methods but the most common methods are as follows:

a. Center of gravity (COG)
b. Bisector of area (BOA)
c. Mean of maximum (MOM)

3.4. Membership Function

Membership function defines the fuzziness in a fuzzy set irrespective of the elements in the set, which are discrete or continuous. These are generally represented in graphical form. There are several ways to characterize fuzziness; in similar way there are many way of describing membership function. The membership function defines all the information contained in a fuzzy set. There are several ways to assign membership values to fuzzy variables in comparison with the probability density function to random variables. Various methods for assigning membership value are as follows:

a. Intuition
b. Inference
c. Rank ordering
d. Angular fuzzy sets
e. Neural network
f. Genetic algorithm
g. Inductive reasoning

3.5. Formation of Rules

Decision making logic was, simulating a process of human decision, where fuzzy control obtained from the knowledge of the control rules and linguistic variable. The rules are in “If Then” format and the If side was called the conditions and the Then side was the conclusion. The relationships between the input and the output linguistic variables are described by the rules. The total number N of possible rules for a fuzzy system were as:

$$N=P_1\times P_2\times\ldots\ldots\times P_n \quad (1)$$

Where, p_n was the number of linguistic terms for the input linguistic variable n. If the linguistic terms are same in the input linguistic variable has the same number of linguistic terms; the N possible rules are defined as:

$$N = p^m \quad (2)$$

Where p denotes the number of linguistic terms for each input linguistic variable and m denotes the number of input linguistic variables. Detecting problems in large rule bases was difficult.

Table 1. Rule base for FLC and self tuning FLC

	U(t)	e(t) NB	NM	NS	ZO	PS	PM	PB
Δe(t)	NB	NB	NB	NB	NB	NM	NS	ZO
	NM	NB	NB	NB	NM	NS	ZO	PS
	NS	NB	NB	NM	NS	NS	PS	PS
	ZO	NB	NM	NS	ZO	ZO	PM	PM
	PS	NM	NS	ZO	PS	PS	PB	PB
	PM	NS	ZO	PS	PM	PM	PB	PB

For fuzzy systems with many number of controller inputs, the cascading fuzzy system is used to avoid large rule bases. Likewise the rules can be formed.

3.6. Self Tuning Adaptive Fuzzy Logic Controller

The adaptive controller was being composed of two loops. The loops were differentiated by their process. The inner loop consists of process and an ordinary feedback controller. The outer loop adjusts the parameter of the controller parameter, which was made of a recursive parameter estimator and a design calculation. Sometimes without introducing probing control signal it was not possible to estimate the process parameters. The system can be viewed as an automation of process modeling and design, for each sampling period the process model and the control design are updated.This construction type of the controller was called a self-tuning regulator to prove that the controller automatically tunes its parameter to obtain the desired output of a closed loop system**.**

4. SIMULATIONS AND RESULTS

The performance of the self tuning Adaptive fuzzy logic controller overcomes the drawbacks of the common fuzzy logic controller. The maximum overshoot and the settling time are very low as compared with the common fuzzy logic controller.

Then errors were minimized. From the simulation result of the AFLC controller, found the variation of input scaling factors and output scaling factors variation for various set points. Three methods for designing self-tuning Adaptive fuzzy logic controller are:

a. Varying the shape of membership function
b. Change the tuning Rules
c. Change the scalar Gains.

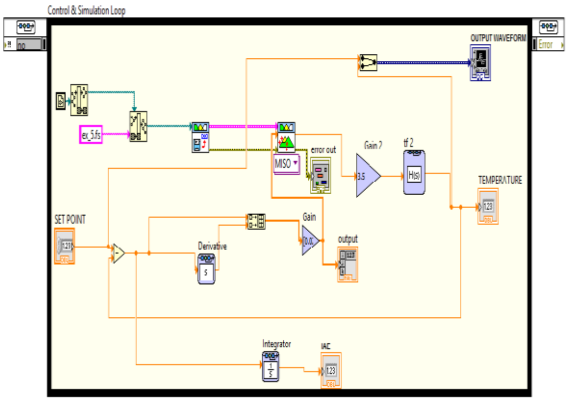

Figure 2. Simulation Block diagram of fuzzy logic controller

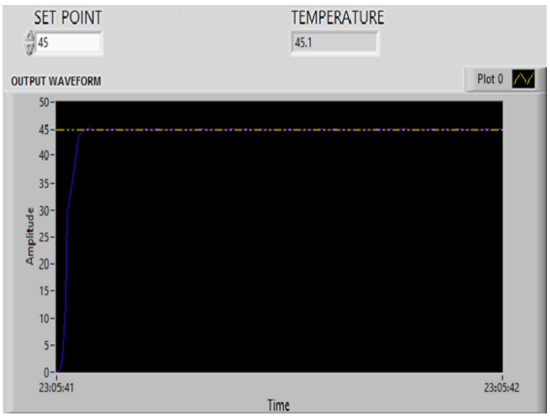

Figure 3. Output response of the FLC

Then the simulation of the self tuning was performed, here the output which derived from the fuzzy loop corrected inevitably. Thus it provides better simulation results.

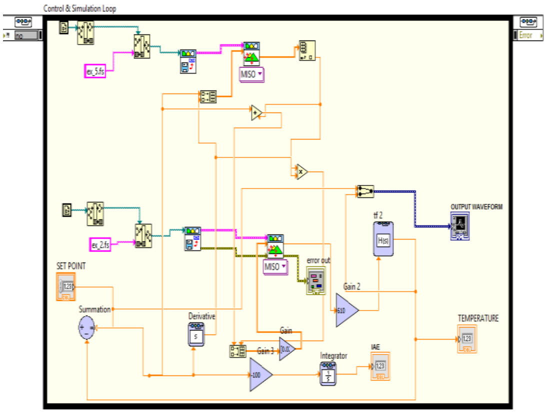

Figure 4. Simulation Block diagram of Self-tuning FLC

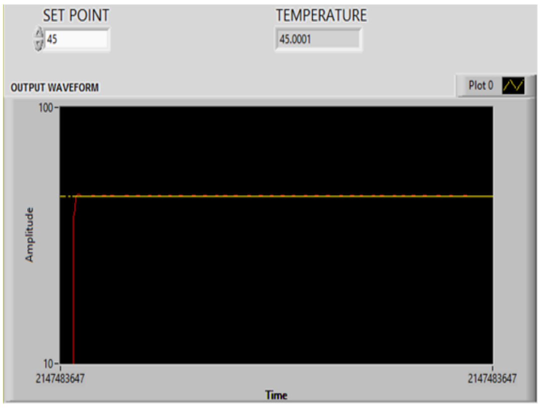

Figure 5. Response of the self tuning FLC

Then the simulation of the self tuning was performed, here the output which derived from the fuzzy loop corrected inevitably. Thus it provides better simulation results. The output which comes out from the fuzzy comes out with a minute errors thus the self tuning Adaptive Fuzzy controller automatically corrects the output to the desired values.

5. CONCLUSION

In this paper, the design of a self tuning Adaptive fuzzy logic controlled for the temperature control was presented. It has been shown that in the proposed scheme, the self tuning Adaptive fuzzy logic controller was performing better than a common fuzzy logic controller when both controllers were subjected to the same operating conditions. LabVIEW software was used to simulate the controller models. The simulation results and the performance of the controller show that the self tuning Adaptive fuzzy logic controller has fewer errors than normal fuzzy logic controller. Then the final value was more close to the desired value. Future work includes, adding more parameters in the control process.

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