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Fuzzy Based Temperature Process Using LabVIEW

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Abstract: This project aims at designing and implementing a fuzzy controller for Multiple Input Single Output temperature process. Temperature control of water in the tank is achieved by varying current to the heating rod and inlet flow rate by a fuzzy controller. The system consists of a tank, MyRIO, SSR, temperature sensor placed inside a heating tank containing the heating rod, computer. Water is pumped into the tank from reservoir and RTD measures the current temperature. The signal from the temperature sensor is sent to the myRIO interfaced to the computer. LabVIEW software is used to acquire the input signal and send the output signal that is determined by the control algorithm. Fuzzy logic controller is designed in LabVIEW. Based on the set point temperature, the controller sets the appropriate current to the heating rod. If the required temperature is less than that sensed by the temperature sensor, the flow rate of water into the tank is controlled by a flowmeter. While conventional controllers are analytically described by a set of equations, the FLC is described by a knowledge-based algorithm. Thus this system is highly efficient in both heating and reducing the temperature of the tank. A fuzzy logic controller gives faster response, is more reliable and recovers quickly from system upsets. It also works well to uncertainties in the process variables and it does not require mathematical modelling.

Keywords: RTD, FLC, MyRIO, PID

I. INTRODUCTION

LabVIEW offers a graphical programming approach that helps you visualize every aspect of your application, including hardware configuration, measurement data and debugging. This visualization makes it simple to integrate measurement hardware from any vendor, represent complex logic on the diagram ,develop data analysis algorithms, and design custom engineering user interfaces.[1]

Nowadays, Proportional-Integral-Derivative (PID) control is the most common control algorithm used in industry and has been universally accepted in industrial control. The popularity of PID controllers can be attributed partly to their robust performance in a wide range of operating conditions and partly to their functional simplicity, which allows engineers to operate them in a simple, straightforward manner. As the name suggests, PID algorithm consists of three basic coefficients; proportional, integral and derivative which are varied to get optimal response. Closed loop systems, the theory of classical PID and the effects of tuning a closed loop control system are discussed in this paper. In order to make control loops work appropriately, the PID loop must be accurately tuned. The entire idea of this algorithm revolves around manipulating the error. The error as evident is the difference between the Process Variable and the Set point.[2]

The Cohen-Coon tuning rules are preferred next to the Ziegler-Nichols tuning rules. Cohen and Coon published their tuning method in 1953, eleven years after Ziegler and Nichols published theirs. The Cohen-Coon tuning rules work well on processes where the dead time is less than two times that of the time constant. The Cohen-Coon rules aim for a quarter-amplitude damping response.

Although quarter-amplitude damping-type of tuning provides very fast disturbance rejection, it tends to be very oscillatory and frequently interacts with similarly-tuned loops. Quarter-amplitude damping-type tuning also makes the loop to be unstable if the process gain or dead time doubles in its value. However, this can be minimized by reducing the controller gain into half of its value obtained [3].

In this paper, the major work is interfacing temperature trainer kit with a virtual instrumentation workbench named LabVIEW with the help of myRIO kit. The process variable is obtained from the temperature sensor and shared with the software via NI-myRIO. The obtained variable is processed with the three basic control strategies namely FUZZY, C-C. Even these had been implemented earlier by many researchers we worked out to calculate its efficiency in a virtual software or virtual instrumentation workbench.

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II. TEMPERATURE PROCESS

Temperature control is important in heating processes as it can disqualify materials in terms of their physical properties when not well performed. . Proportional-Integral- Derivative (PID) controllers are the workhorses of many industrial controllers , The frequently used method is Ziegler Nichols, often called as ZN. The need for improved performance of the process has led to the development of robust and optimal controllers. The objective of the project is to maintain the temperature of water in the liquid tank in a desired value. System identification of this temperature process is done by empirical method, which is notorious to be nonlinear and approximated to be a (First Order Plus Dead Time) FOPDT model. In this paper, the major process is to maintain the temperature in the desired value with a help of basic controller strategies and solid state relay

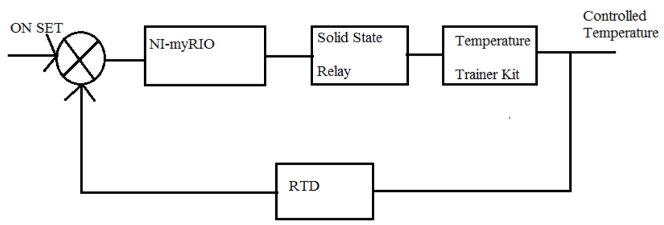

Fig 2.1 :General Block Diagram of Temperature Process

The real time temperature values is obtained through RTD sensor and fed to NI-myRIO were the signals are manipulated in the virtual instruments and output is feed to the control output using the solid state relay. In the process of controlling, the water is heated by a heater which is controlled by the controller

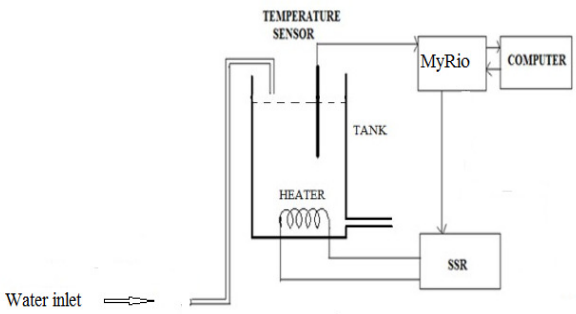

Fig2.2: Experimental Setup for Temperature Process

III. SYSTEM IDENTIFICATION

Empirical modeling is an useful approach for the analysis of different problems across numerous areas/fields of knowledge. As it is known, this type of modeling is particularly helpful when parametric models, due to various reasons, cannot be constructed. Based on different methodologies and approaches, empirical modeling allows the analyst to obtain an initial understanding of the relationships that exist among the different variables that belong to a particular system or process. In some cases, the results from empirical models can be used in order to make decisions about those variables, with the intent of resolving a given problem in the real-life applications. The most commonly used model to describe the dynamics of the industrial temperature process is general First Order plus Time Delay Process (FOPTD). And the FOPTD model structure is given in equation

$$G(s) = k/(\tau s+1)\, e^{-tds}$$

Where, td – Time delay, K – Process gain, τ - Time constant.

IV. CONTROLLER DESIGN

In the general controller, the set point **(r)** and process variable **(y)** is feed to the comparator and the variable ***(e)*** represents the tracking error. This error signal (**e**) is fed to the PID controller, and the controller computes both the derivative and the integral of this error signal with respect to time. The control signal (**u**) to the plant is equal to the proportional gain ($\mathbf{K_p}$) times the magnitude of the error plus the integral gain ($\mathbf{K_i}$) times the integral of the error plus the derivative gain ($\mathbf{K_d}$) times the derivative of the error.

This control signal (**u**) is fed to the plant and the new output (**y**) is obtained. The new output (y) is then fed back and compared to the reference to find the new error signal (**e**). The controller takes this new error signal and computes an update of the control input. This process continues while the controller is in effect.

The transfer function of a PID controller is found by taking the Laplace transform of Equation (1).

$$K_p + \frac{K_i}{s} + K_d s = \frac{K_d s^2 + K_p s + K_i}{s}$$

where $\mathbf{K_p}$ = proportional gain, $\mathbf{K_i}$ = integral gain, and $\mathbf{K_d}$ = derivative gain.

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A. Cohen-Coon Method

Perform a step test to obtain the parameters of a FOPTD (first order plus time delay) model Make sure the process is at an initial steady state, introduce a step change in the manipulated variable, Wait until the process settles at a new steady state.

Calculate process parameters: **t1, τ, τ** $_{del}$ **, K, r** as follows

$$t1 = t2 - \frac{(\ln(2))t3}{1-\ln(2)}$$

$$T = t3 - t1$$

$$T = t1 - t0$$

$$K = \frac{B}{A}$$

$$r = \frac{\tau del}{\tau}$$

Controller	***K***	***Ti***	***Td***	***Kp***
PID	**98.1**	**7.418**	**1.10**	**66.20**

V. LabVIEW

LabVIEW (Laboratory Virtual Instrument Engineering Workbench), a product of National Instruments , is a powerful software system that accommodates data acquisition, instrument control, data processing and data presentation. All LabVIEW graphical programs, called Virtual Instruments or simply VIs . But in this case the collection of the simple VIs are combined to form a project controller. The Interface between the Trainer kit and Virtual instrumentation is the NI-myRIO.

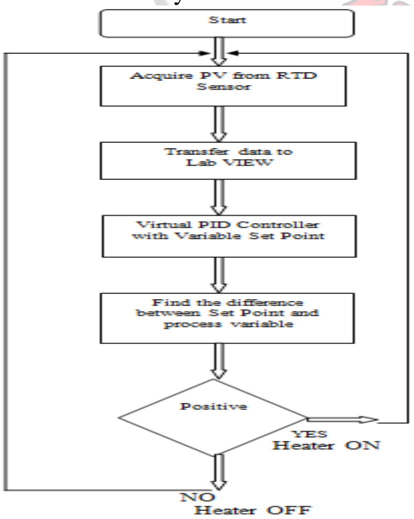

Fig:5.1 Flow chart for LabVIEW process

VI. FUZZIFICATION

Fuzzification is the process of changing a real scalar value into a fuzzy value. This is achieved with the different types of fuzzifiers (membership functions) Fuzzification. FuzzyLinguistic Variables are used to represent qualities spanning a particularspectrum. Fuzzification is the first step in the fuzzy inference process. This involves a domain transformation where crisp inputs are transformed into fuzzy inputs. Crisp inputs are exact inputs measured by sensors and passed into the control system for processing, such as temperature, pressure. Fuzzification is the process of making a crisp quantity fuzzy. We do this by simply recognizing that many of the quantities that we consider to be crisp and deterministic are actually not deterministic at all: They carry considerable uncertainty. If the form of uncertainty happens to arise because of imprecision, ambiguity, or vagueness, then the variable is probably fuzzy and can be represented by a membership function. In the real world, hardware such as a digital voltmeter generates crisp data, but these data are subject to experimental error.one possible range of errors for a typical voltage reading and the associated membership function that might represent such imprecision.

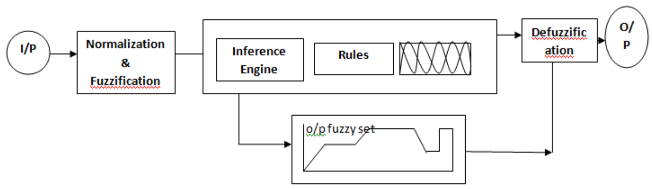

Fig:6.1 Block Diagram For Fuzzy Logic

VII. MEMBERSHIP FUNCTION

A membership function(MF) is a curve that defines how each point in the input space is mapped to a membership value between 0 and 1.The input space is sometimes referred to as the universe of discourse a fancy name for a simple concept. Mathematical function to grade the association of a value to a set. A function which for each fuzzy set assign a physical value on the abscissa to a truth value which describe to which extent this value belong to the set. An indicator function representing the degree of truth as an extension of valuation .Membership of the element of the base set in the fuzzy set. Membership functions return a value in the range of [0,1] indicating membership degree. A function that quantifies the grade of membership of a variable to a linguistic term. A function that describes the degree of an element's membership in a fuzzy set. A membership

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function quantifies the grade of membership of a variable to a linguistic term. It is a function that quantifies the grade of membership of a variable to a linguistic term. Reasonable functions are often piecewise linear functions, such as triangular and trapezoidal functions.

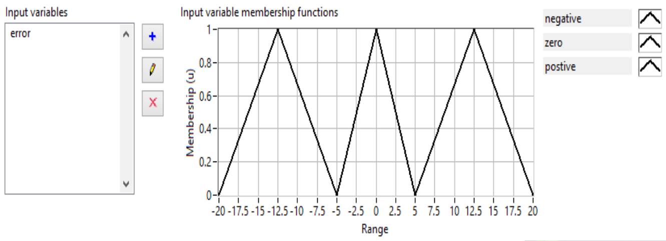

Fig:7.1 Input Variable Membership Function

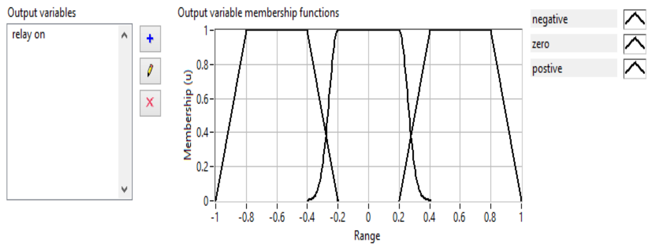

Fig:7.2 Output Variable Membership Function

An indicator function representing the degree of truth as an extension of valuation. The set of elements that have a non-zero membership is called the support of the fuzzy set. The function that ties a number to each element of the universe is called the membership function. Membership function indicates the collection of possible values that an object may have when it is defined as a factor of another object. For example tallness can be defined as low, medium, tall. by the help of membership function of tallness as a factor of low, medium and tall.

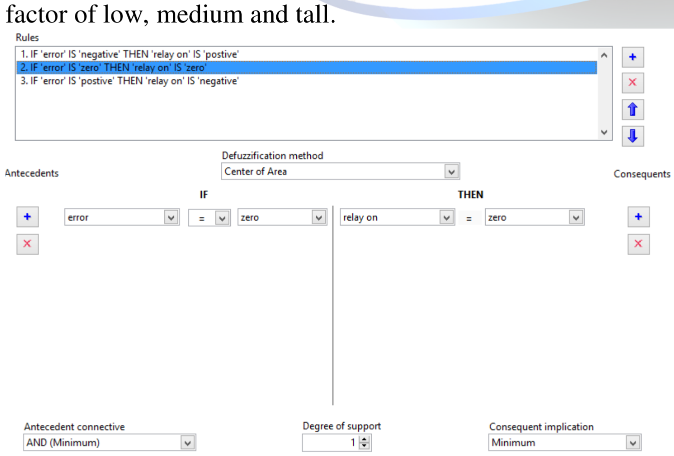

Fig:6.3 Rules for membership function

Rule Table:

error rate error	Negative	Zero	Positive
Negative	*Positive*	*Negative*	*Zero*
Zero	*Negative*	*Zero*	*Positive*
Positive	*Zero*	*Positive*	*Negative*

VIII. DEFUZZIFICATION

Fuzzy rule based systems evaluate linguistic if-then rules using fuzzification, inference and composition procedures. They produce fuzzy results which usually have to be converted into crisp output. To transform the fuzzy results in to crisp, defuzzification is performed. Defuzzification is the process of converting a fuzzified output into a single crisp value with respect to a fuzzy set. The defuzzified value in FLC (Fuzzy Logic Controller) represents the action to be taken in controlling the process.

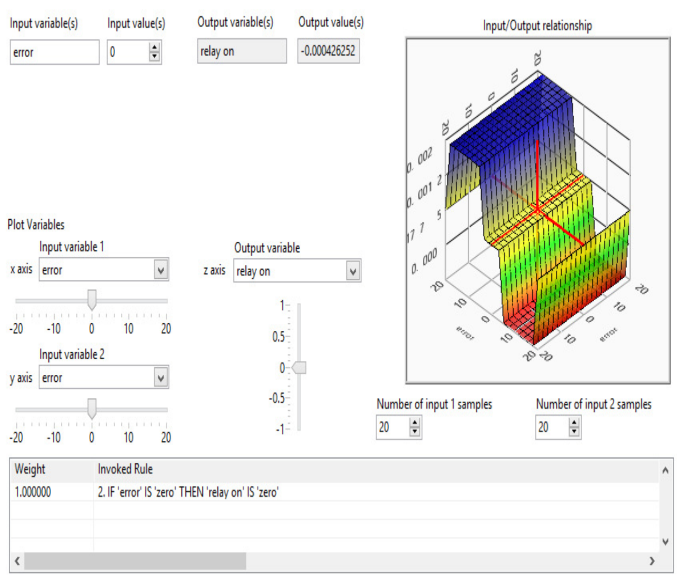

Fig:8.1 Test system in Fuzzy system Designer

Defuzzification is the process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. It is typically needed in fuzzy control systems. Some process of defuzzification is required to convert the resulting fuzzy set description of an action into a specific value for a control variable.

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IX. RESULT

The tuned values through the traditional pid as well as fuzzy logic techniques are analyzed for their responses to a unit step input, with the help of simulation and then the real time application for the liquid heating tank is presented. Because of the growing interest of the development of modern experiment for process control laboratory in Instrumentation and Control Engineering, the experimental setup of heat flow process for temperature control based on LabVIEW has been performed to give students a hands-on experience and view for process control design and computer-based laboratory that LabVIEW environment is accepted for implementation of local instrument control that a result of the response of temperature control system can be demonstrated by LabVIEW

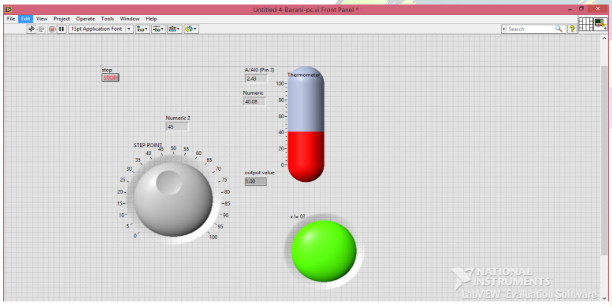

Fig:9.1 Result Window

X.CONCLUSION

The proposed project helps in efficient monitoring and control of water temperature with the help of fuzzy controller designed in LabVIEW software. This system attempts to correct the error between the measured temperature and the desired set point thus achieving efficient temperature control. The need for today industry is a real time monitoring and control of the various parameters in a simpler manner with easy identification and rectification of errors. As the existing system cooling process is time consuming, speeding up the cooling process is the need of the hour which the proposed system fulfills.

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