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Gas Turbine Modeling for Load Frequency Control

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Abstract: ***As most of the daily life requirements are getting automated. One of such automated system is the automation of Gas temperature controller. There are number of traditional approaches to control the Gas temperature. One of the most common approach is the automation system with static threshold value. According to this system the Gas start Powering up and as the temperature level goes to required level the Powering process will be terminated. But the Modern Gas Temperature Controller which are highly complex and non-linear demand both based on boiler capacity and the required temperature strength with in time limit. In this present work we have defined the parametric analysis dynamically and the dynamic rule set is being generated by the fuzzy controller to control the Gas temperature. The parameters we have considered are the Gas hardness, earlier temperature and the quantity of the Gas. The work also includes the concept of Power exchanger. The Power exchange process is been performed respective to the Gas Power as well as the boiler Powering. It means as the some Powered Gas included it will perform the Power exchange to balance the Gas Power. The proposed system is the fuzzy based dynamic Gas temperature controller to control the Gas Powering. The obtained results show the presented system is far effective and error prone.***

Keywords: gas turbine, fuzzy logic, gas temperature control, performance error & rate of temperature change

I. Introduction

Gas power: Gas power is one of the developed and reliable energy source. The use of the Gas power is been increased in all kind of small, medium or large.In this present work we have defined the stability factor for a small Gas firm. A high level power plant is a system that transfers and distributes power from one or more power plants to residential commercial and industrial consumers for space power, Gas power and industrial processes [3].The Power carrier in the power distribution system can be either Gas or steam. The Gas in the distribution system can be generated in power-only boiler plants, in combined power and power production plants, from industrial waste power recover, refuse incineration plants or sometimes from geothermal sources. The Power is transmitted from production plants to clients as Gas in a closed network consisting of two pipes (flow and return pipes). Power pipes are laid in the ground, usually at a depth of 0.5 to 1 metre. The pipes have effective thermal insulation. The Gas circulating in the flow pipes releases its power to clients via power exchangers.[4] Clients receive the power in the substation, which includes the power exchangers for power and service Gas and possibly a power exchanger also for air conditioning, control devices, pumps, expansion and safety equipment, thermometers and manometers and shut-off valves and energy metering. [4]The amount of power consumed in the building is measured. The components of the Power meter are: a flow sensor, a temperature sensor pair, and a calculator.[4]
Temperature Control: The boiler, the temperature sensor, the data acquisition card and the proportional valve make together control circuit.

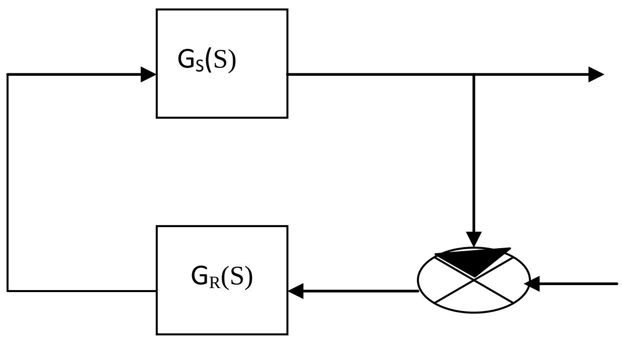

Figure: 1 Temperature Control

We already know: temperature is controlled by the PI controller by means of voltage u(t) on the proportional valve on the basic of calculated control error e(t) between required temperature $y_w(t)$ and the real value y(t) of temperature of service Gas. The transfer function $G_S(s)$ which describes in the system. [9]

Fuzzy Control: Fuzzy control is based on variable fuzzy set theory, fuzzy language and a computer digital control on fuzzy logic. Fuzzy control is a non-linear control. It does not depend on the precise mathematical model of the controlled object, especially for complex system or process control, and control method is a simple and robust well. The control diagrams are as follows (for fuzzy controller with virtual box):

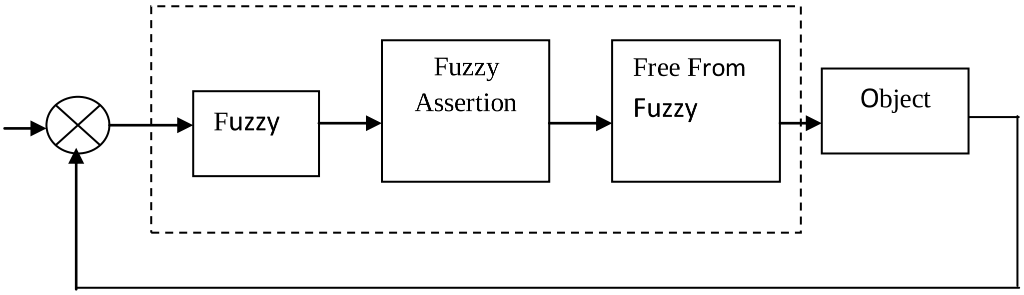

Figure: 2 Fuzzy Control

In the cooling Gas temperature control system of fuel cell, when fuzzy control strategy used alone cannot meet the requirements of precision. Due to the controlled object model parameters is nonlinear and time variability, so a separate PID control is not ideal too. In order to make the lack of control in two ways, we used the way to make up for each other's deficiencies and to make the organic combination of two control methods.

Reliability: Supply of power is very reliable. On an average, in large DH-systems operation interruptions resulting from damages in the Power network and the consequent repair work leave the individual client without power as an average for only one hour a year. Thus, the reliability of supply in power is nearly 100%. [4]

II. Proposed Work

In this, the fuzzy logic based gas based temperature controller is being proposed. The presented system is a dynamic system that will analyze the properties of the boiler as well as the gas dynamically and respective to that it will set the parameters for the controller system. The work is not only about the gas level controller but it also include the concept of heat exchanger also.

A. Problem statement

- The scheme Includes the definition of fuzzy based Gas based temperature controller.
- The work is based on the fuzzy logic in which the fuzzy parameters are decided dynamically
- The presented system is the automated system that will first study the characters of the Gas and the boiler and based on these the decision making will be performed about the requirement in increase of the based temperature.
- The presented system is designed for the Gas heating as well as the Gas cooling characteristics based on the parametric settings.
- The work also includes the concept of heat exchange in which the basic parameter of the Gas will be distributed over the system so that the benefit of existing can be taken while deciding the based temperature level.

B. Significance of Work

- The main aim of this dissertation is to present a dynamic Gas heating system. That will perform the Gas heating under defined constraints.
- The work is not only about the heating or improving the heating respective to the time span. The work is about to control the gas heating. It means even after the time span there will be small change in heat under the defined constraint.
- The fuzzy system is implemented to control the gas heating.
- Complete system and the system parameters are dynamic and fuzzy controlled.

C. Objectives

The objectives of the proposed system is given as under

- Design of a Gas Heating System
- Define the parameters respective to heating system i.e. Time Span, Quantity and Error Rate
- Define a Fuzzy Rule Set to control the gas Based temperature
- Analysis of Result using Graph

D. Sources of Data

In this present work the data is required in terms of information regarding the different parameters that can be considered while controlling the Gas based temperature. This information can be collected from both the primary sources as well as the secondary sources. For the primary sources the data can be collected from some Gas boiling plant and the values considered by those plants can be used here to decide the decision vector for the heating process. In this work we have collected the data from the secondary sources. This data is collected from the research done by the earlier researchers. We have driven the same parameters used by some earlier researcher.

E. Research Methodology

The main implementation is done in the MATLAB version(7.8.0) Stands for Matrix laboratory. It is a software package used to perform scientific computations and visualization. Its capability for the analysis of various scientific problems, flexibility and powerful graphics makes it very useful package. It provides a integrated development environment (IDE) for programming with numerous predefined functions, user defined functions, can also be included which can be used just like any other built in function.

The dimensions of the proposed system are

- Based temperature
- Time Span
- Gas quantity

III. Theoretical Analysis

FL is a problem-solving control system methodology that lends itself to implemen- tation in the system ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both.

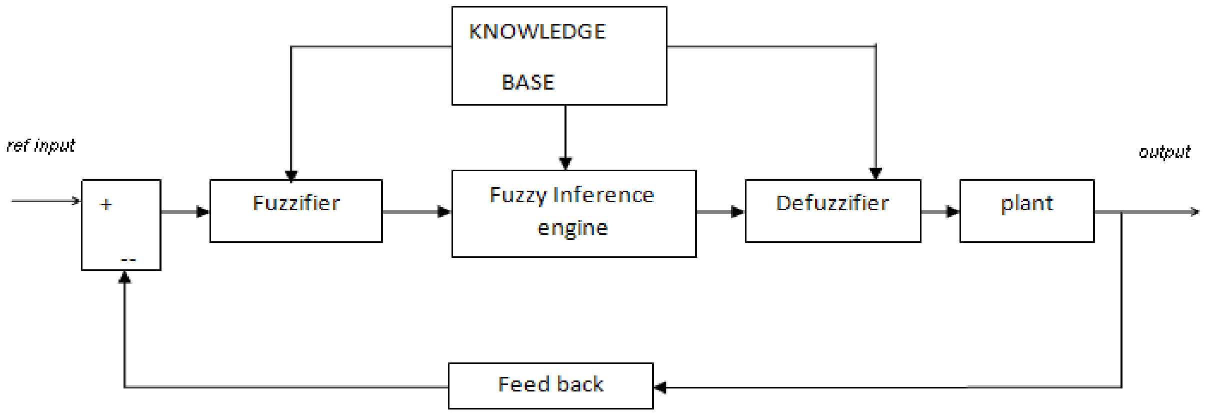

Figure 3: Block Diagram of Fuzzy logic Controller

The steps in designing the controller are:

1. Identify the variables (inputs, states and outputs of the) of the plant.
2. Partition the universe of discourse or the internal spanned by each variable into a number of fuzzy subsets, assigning each a linguistic label.
3. Assign or determine a membership function for each fuzzy subset.
4. Assign the fuzzy relationship between the inputs or states, fuzzy subsets on the one hand and the outputs fuzzy subsets on the other hand, thus forming the rule base.
5. Choose appropriate sealing factors for the input and output variables in order to normalize the variables to the [0,1] or [-1,1] interval.
6. Fuzzify the inputs to the controller.
7. Use fuzzy approximate reasoning to infer the output contributed from each rule.
8. Aggregate the fuzzy outputs recommended by each rule.
9. Apply defuzzification to form a crisp output.

Thus based upon these rules fuzzy logic controller is designed and can be suitable for any kind of control applications.

A. Characteristics of FL

- In FL, exact reasoning is viewed as a limiting case of approximate reasoning.
- Everything is a matter of degree.
- Any logical system can be fuzzified
- Knowledge is interpreted as a collection of elastic or, equivalently, fuzzy constraint on a collection of variables
- Inference is viewed as a process of propagation of elastic constraints.

B. Key Benefits of Fuzzy Design

- Simplified and reduced development cycle
- Ease of implementation
- Can provide more “user-friendly” and efficient performance

C. Applications of Fuzzy Logic

- Control (robotics, automation, tracking, consumer electronics)
- Information systems (DBMS, info. Retrieval)
- Pattern recognition (image processing, machine vision)
- Decision support (adaptive HMI, sensor fusion)

IV. Results

The presented work is implemented on Gas boiler system that is under the fuzzy control. Results are here presented in different cases that vary because of the parametric values.

Case 1: In the first the parameters that are being used for the analysis of the system are defined along with values

- Total Quantity: 2000
- Time Span: 10 Seconds
- Hydrolic Cofficient : 0.6006

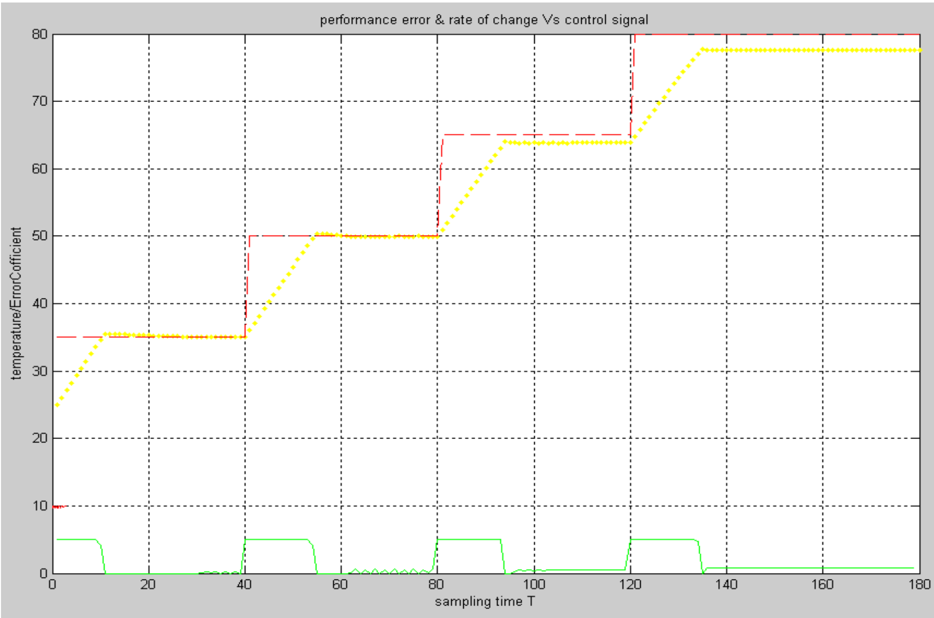

Figure 4: Performance Error and Rate of Temperature Change

Performance Error and Rate of Temperature Change: As we can see in Figure 4 the analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature value. Here the Yellow line represents temperature change in proposed system. The red line is the standard temperature values according to existing system. Here the green line represents the control signal. As we can see the temperature value obtained here under the defined parameters is 78.6004 C.

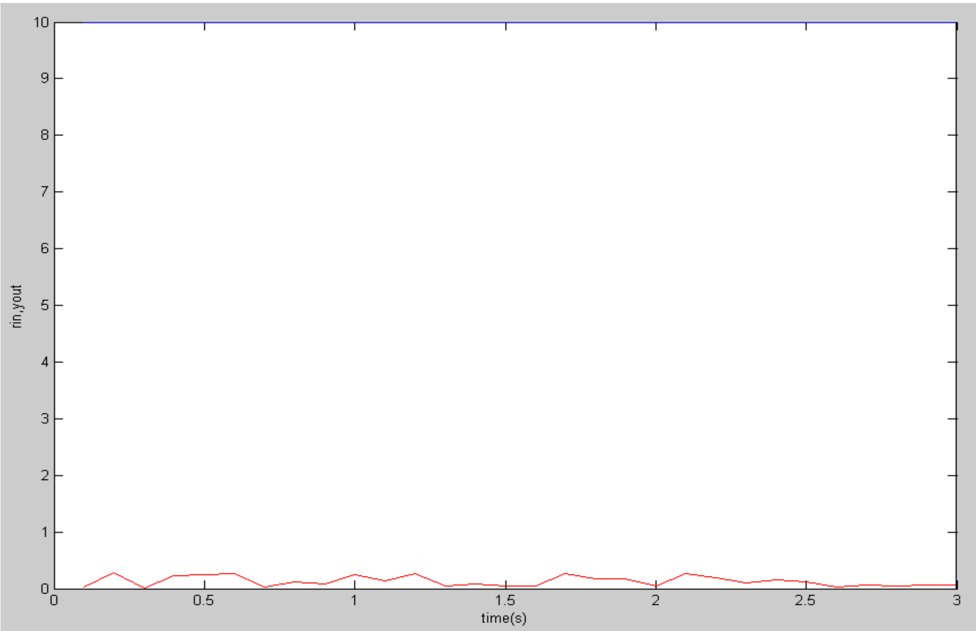

Figure 5: Error Rate

Error Rate: As we can see in Figure 5 the error analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature rate. Here the red line represents error rate in proposed system. The average error rate in this system is 0.9257.

Case 2 : In the first the parameters that are being used for the analysis of the system are defined along with values

- Total Quantity: 2000
- Time Span: 15 Seconds
- Hydrolic Cofficient : 0.6006

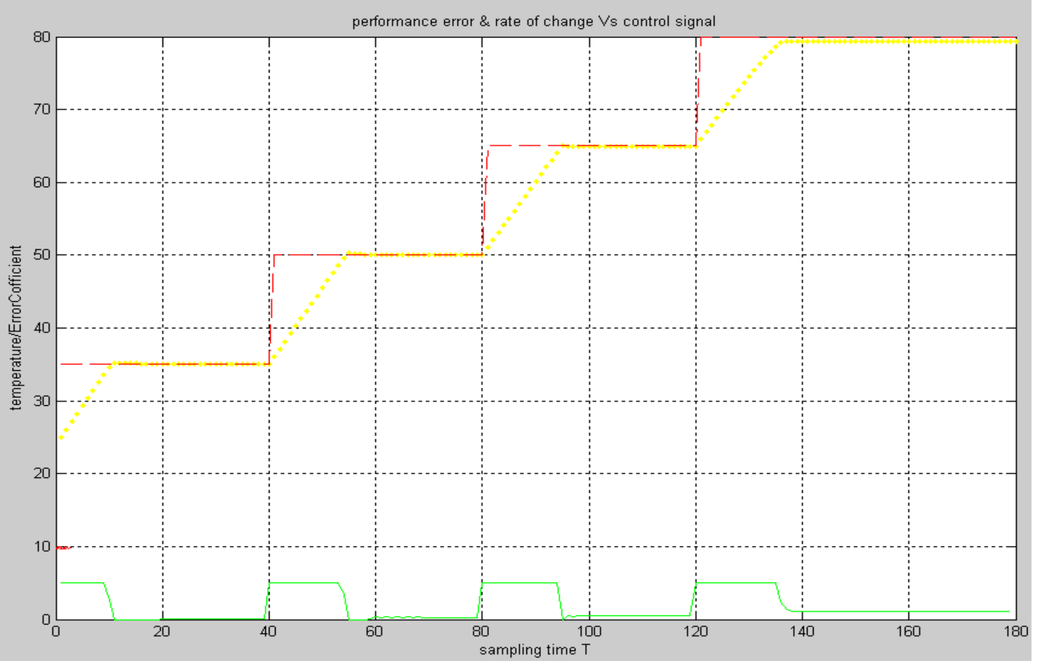

Figure 6: Performance Error and Rate of Temperature Change

Performance Error and Rate of Temperature Change: As we can see in Figure 6 the analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature value. Here the Yellow line represents temperature change in proposed system. The red line is the standard temperature values according to existing system. Here the green line represents the control signal. As we can see the temperature value obtained here under the defined parameters is 79.4051 C.

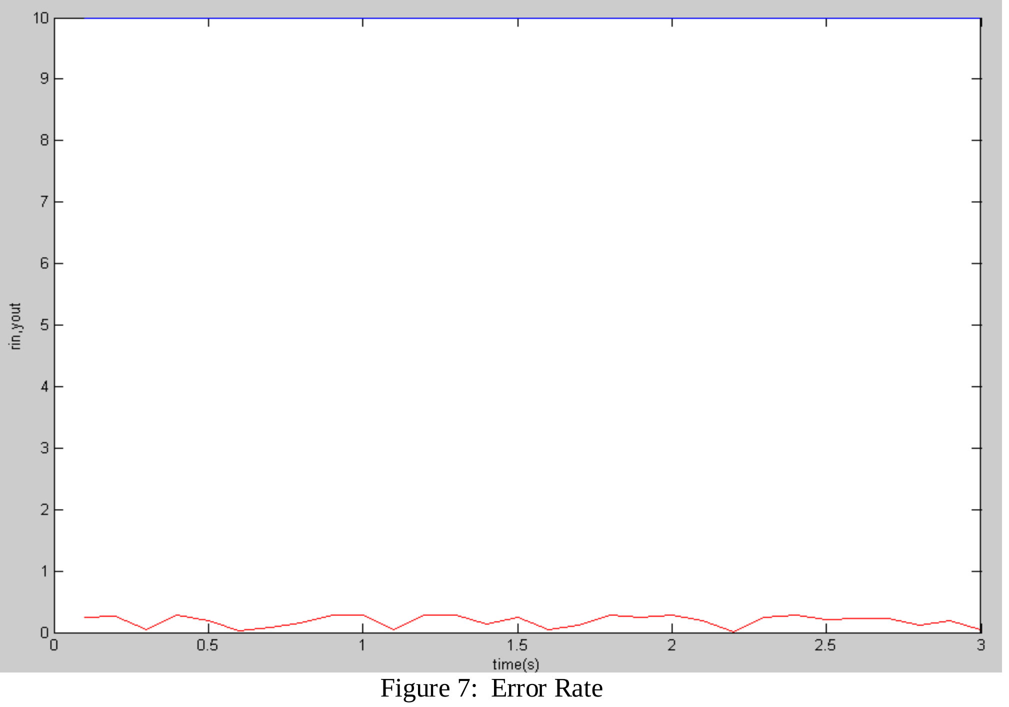

Figure 7: Error Rate

Error Rate: As we can see in Figure 7 the error analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature rate. Here the red line represents error rate in proposed system. The average error rate in this system is 1.0940.

Case 3: In the first the parameters that are being used for the analysis of the system are defined along with values

- Total Quantity: 2000
- Time Span: 20 Seconds
- Hydrolic Cofficient : 0.6006

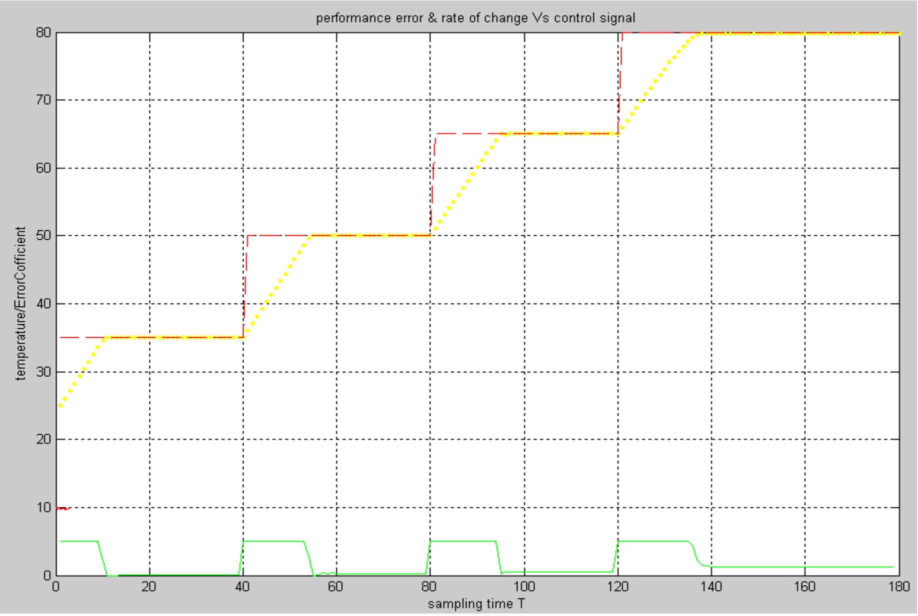

Figure 8: Performance Error and Rate of Temperature Change

Performance Error and Rate of Temperature Change: As we can see in Figure 8 the analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature value. Here the Yellow line represents temperature change in proposed system. The red line is the standard temperature values according to existing system. Here the green line represents the control signal. As we can see the temperature value obtained here under the defined parameters is 79.7282 C

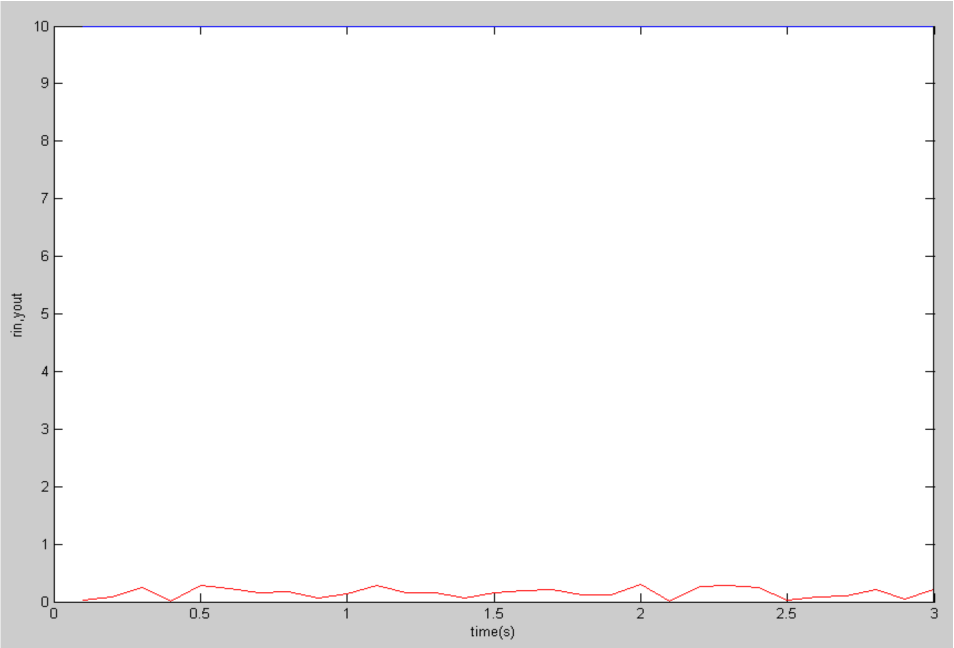

Figure 9: Error Rate

Error Rate: As we can see in Figure 9 the Error analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature rate. Here the red line represents error rate in proposed system. The average error rate in this system is 1.1827.

Case 4 : In the first the parameters that are being used for the analysis of the system are defined along with values

- Total Quantity: 2000
- Time Span: 25 Seconds
- Hydrolic Cofficient : 0.6006

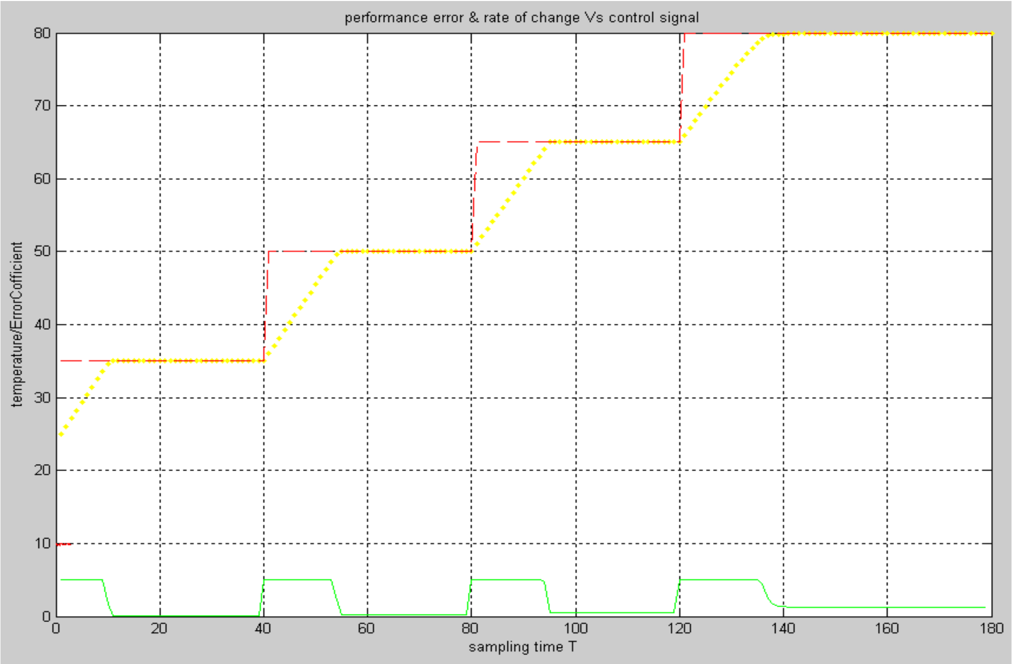

Figure 10: Performance Error and Rate of Temperature Change

Performance Error and Rate of Temperature Change: As we can see in Figure 10 the analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature value. Here the Yellow line represents temperature change in proposed system. The red line is the standard temperature values according to existing system. Here the green line represents the control signal. As we can see the temperature value obtained here under the defined parameters is 79.9615C

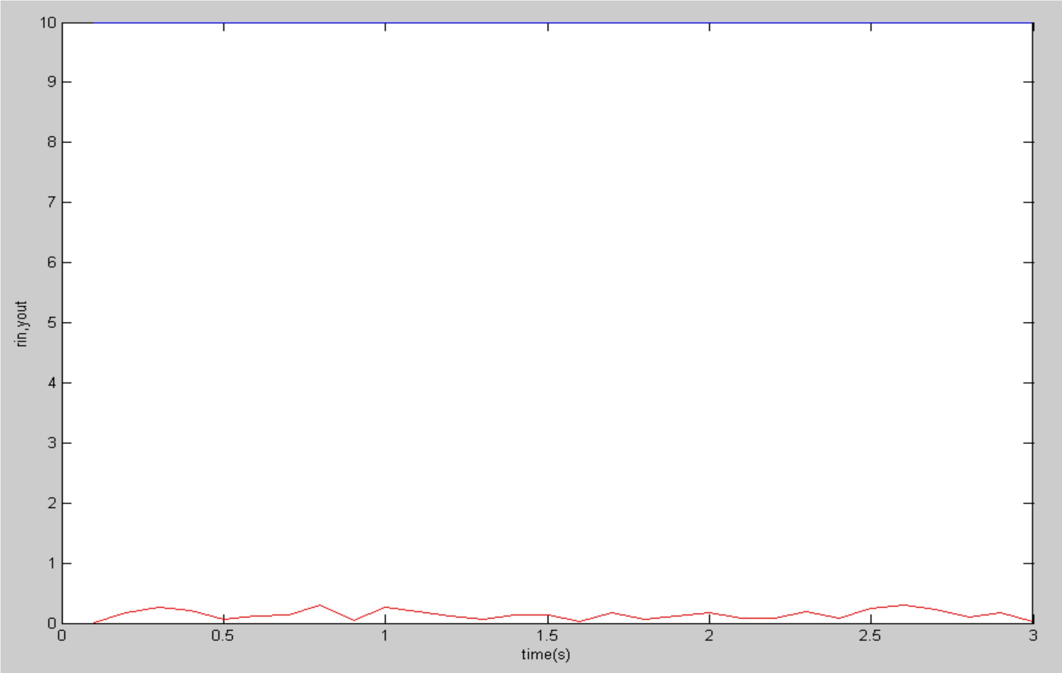

Figure 11: Error Rate

Error Rate: As we can see in Figure 11 the Error analysis of the proposed system. Here the x axis represents the sampling time. The y axis represents the temperature in rate. Here the red line represents error rate in proposed system. The average error rate in this system is 1.2247.

Result Analysis

Here the result analysis of the proposed work respective to different parameters is shown as

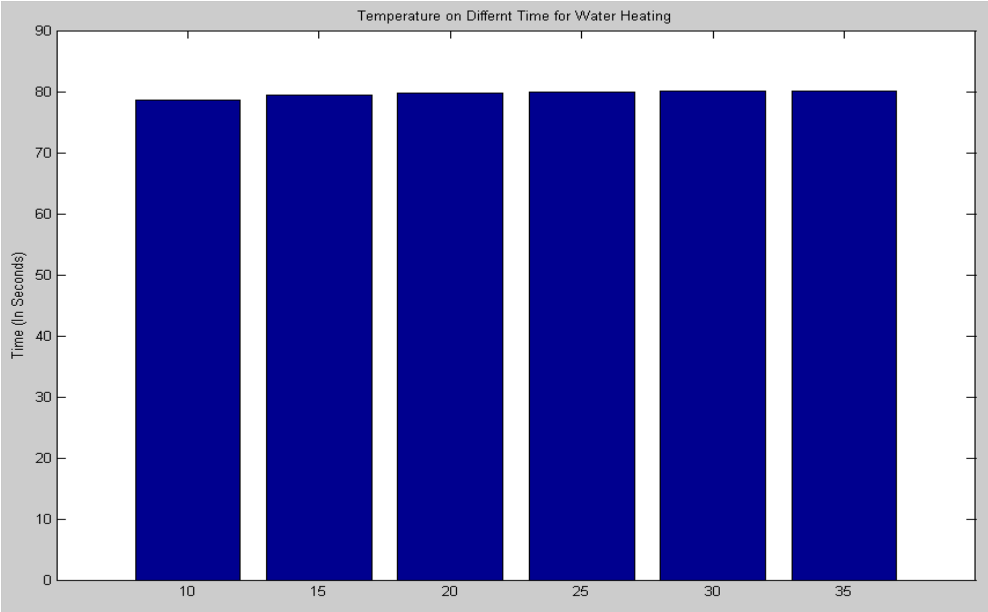

Figure 12: Result Analysis (Temperature Value)

As we can see in Figure 12 the analysis of the proposed system respective to different parameters of Gas temperature controller. As we can see the presented system is proving the stability in terms of temperature.

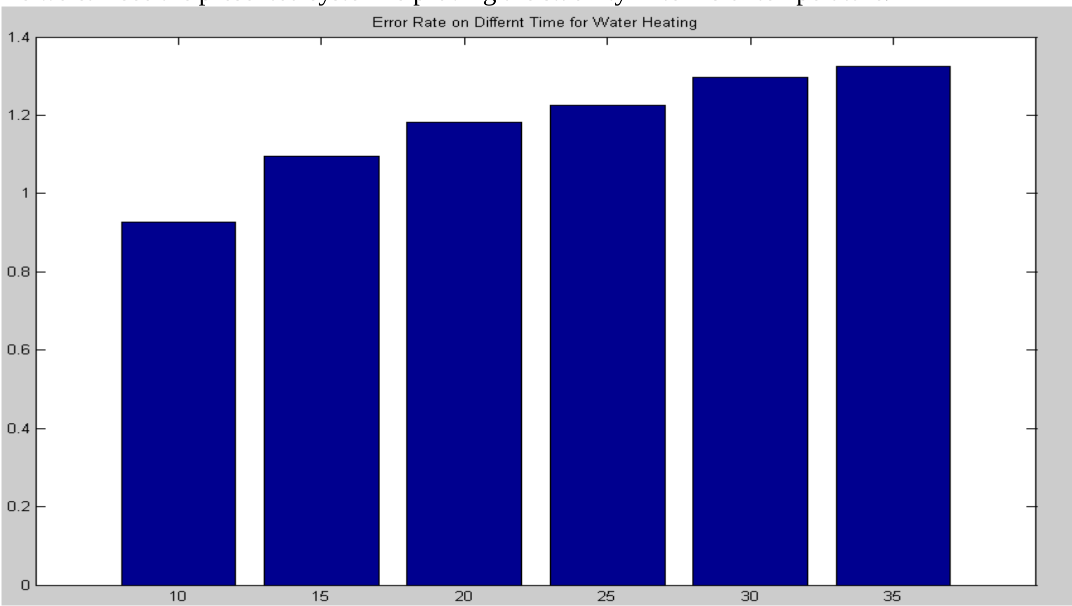

Figure 13: Result Analysis (Error Rate)

As we can see in Figure 13 the analysis of the proposed system respective to different parameters of Gas temperature controller. The result is presented in terms of error rate under different time intervals.

V. Conclusion

The use of sensor based system to control the Gas plant is the one of the basic requirement in a plant to automate the Gas boiler. There are number of such controller system exist that define some threshold value for the Gas temperature controlling and as the temperature raise upto that level the heating process is terminated. The present work is the improvement of the same controller system with two concepts. The present work is about to control the Gas temperature along with concept of heat exchange. An intelligent fuzzy based Gas temperature controller is defined in this present work. The system is defined with some parameters these parameters are basically the decision parameters based on which it will identify the boiling requirement of the Gas. The parameters are defined in terms of temperature requirement, time constraint etc. These parameters are influenced with one more factor of heat exchange. According to this if heated Gas or the boiler is being used the controller will analyze and perform the change in the controller dynamically. It itself will change the values of the parameters of Gas based temperature controller. As the parameter match the system will stop itself. More over the comparative analysis is performed of this fuzzy based system with existing system that is the simple Gas temperature controller and identify the gain driven from the system.

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