Design and Control Implementation of Industrial Boiler

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***Abstract*—Manage of heat in boiler is a present troubleshoot problem in the power plants, because the process are difficult to control in presence of nonlinear and long dead time. The running situation may well differ in excess of a broad variety when it under go noise. The temperature of the steam is prohibited by fuzzy controller by varying the percentage amount of valve opening of inlet pipe which passes water over the steam tube of the super heater. Use of fuzzy controller we can eliminate some unwanted disturbance which are faced by using normal controller like time delay and changing shifting procedure as load changes. This paper deal with control implementation to attain the target of controlled action of the super heater steam temperature and simple design. The fuzzy and rules are designed to reach full attainment of target action of controllers and simulated. Results are established and modulation of entire process is viewed through MATLAB simulation.**

Keywords—Superheater, Fuzzy Logic Control, Fuzzy rules, Memership function

I.INTRODUCTION

Accurate power of the steam temperature is very major part of enormously important to make certain generally effectiveness and security to manage the operating condition of power plant with necessary temperature in the boiler. The unwanted heat that makes steam temperature to higher values because it cause damage to the superheater and elevated pressure as chance to break turbines blades, or slower pressure will lower the competence of the plant. In totaling extreme variation in steam temperature be able to straight of enlarged tiredness in the turbine blades as well as increase in prevalence of loss in the boiler drum, as a result the superheater steam is maintained at constant with varying the flow of spray water to be in particular temperature range like±30ºC in the temporary states and ±10ºC at the steadystate. Improving the performance of boiler by decrease the fluctuations of water molecules in the boiler as it makes more comfortable condition to reach the peak efficiency of plant and also it reduce the stress that are super imposed makes some small cracks in the unit.

There are some of the parameter that change the accuracy of the boiler outlet steam get deviate to the other parameter some of these are like change in boiler feed water rate, rate of change in heat by increase of flue gas, and the pressure of the steam produced by the heat conversion system during heating process. In order to control over all process which makes very difficult process by normal controller, since they are non-linear process which may vary by time to time with in the fraction of second the entire system get collapse if this parameter are not controlled, for this purpose the normal controller not able to occupy this condition matching which leads to some of time delay and peak overshoot happens at the controller output with huge slow response, by this the system can't able to recognize what happening inside the process makes slow result to the output device of flow control valve. This non-linear process are well controlled if we use of fuzzy logic controller of intelligent control action are well accomplished with concept of crisp and membership set, the normal process which change the superheated steam temperature are well tuned by this proposed system, this fuzzy system play more accurate control action which is suitable to control superheater temperature. The dynamic and flexible range makes fuzzy logic is competent with little time consuming process but however it provide accurate control action, as some the fuzzy rules are mostly checked by trials and errors method, the neural networks not only contain the capacity to produce estimated nonlinear functions with random accuracy, but also provide different control data can be trained from experimental value. The accumulated valve is control by this rule and the steam temperature is reduced by spray water over the tube reduces the temperature and also provide change in steam pressure which is maintain based on load capacity of boiler. This process involves fuzzification of the input variable and process the system with the help of the rules and defuzzification over the output variable which makes plant to operate with accurate result. The modeling of the system are obtained by well tuning the fuzzy logic over the normal PID controller which makes dynamic operation of proposed system with more linear process incorporated and also experiences of the operator is used to control the superheated steam temperature. The fuzzy logic controller are designed with respect to the obtained data and implemented with the control action.

II.MODELLING OF SYSTEM

Modelling the system is very important process because based on the modellation we can find the possible error and make the correction according to the system inputs. In this system Black Box modeling is well thought-out which makes more structural information by trial and error method. During starting of the process it goes in normal structure and when it under goes to more complex structure of handling more number of parameter.

The Transfer function is the used to obtained the overall result of the system analyze mainly gives output to the input value response designed for the system at superheater with the help of Cohen Coon method
For superheater:-

$$G_s(s) = \frac{20}{s+1} \quad (1)$$

For desuperheater:-

$$G_d(s) = \frac{5}{s+2} \quad (2)$$

The overall transfer function is:-

$$G(s) = \frac{100}{(s+1)(s+2)} \quad (3)$$

III. TUNING OF PID CONTROLLER

Mainly controller is used to slow down the "error rate" which is produced by difference of process variable and set point variable. To minimize the error we use some of the tuning methods basically ZieglerNichols and Cohen-Coon methods are used because of their fast response and high stable operation. Proportion plus Integral plus Derivative gives companied action over the deviation of the output. When tuning of this we can eliminate unwanted disturbance occurred during operation of super heater by fast change in the pressure head of steam and slow variation of steam temperature leads to produce some of offset at controller output which is eliminated by tunning of the controller of operation
The Cohen and coon are used for open loop process in which the system don't operate in closed manner but they will not produce much accurate result when compared to the closed loop, the gain obtained are shown below by a formulae
For primary controller,

K_P=0.049490, K_i=0.059770, K_d=0.0077612 For secondary controller,

K_p= 83.0959, K_i = 0.010285, K_d= 0.10588

IV. CONTOL METHODS

4.1 BY NORMAL METHOD

In normal method the system operates without any controller and the operation mainly depends upon manual control over the superheater steam temperature by measuring the output steam temperature of superheater and adjusting the spray valve position to slow down the steam temperature. This method don't not produce exact output because it will deviate from the set point valve and constant operation can't be obtained when the plant operates for long period uses of this required continues monitoring of different process parameter.

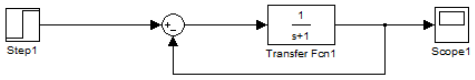

Fig.1Simulink using open method

4.2 BY CONTROL METHOD

This method is more stable than the previous method, here we use of normal PID controller. The superheater output steam temperature is more over constant to the set point but takes much settling time because it operate over the non-linear process it can be reduced by tuning the K_P, K_i, K_d values

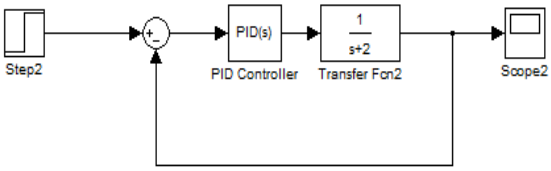

Fig.1Simulink using open method

4.3 THE PROPOSED FUZZY LOGIC CONTROL

The non-linearity of the steam temperature is reduce by the use of fuzzy logic controller which can be implemented in most of the plant operating in non-linearity condition. This system uses a closed loop feedback system along this rules are imposed over the fuzzy controller makes more comfortable zone for the operator to understand the process condition and the output obtained are more stable and constant to the process set point with less settling time.

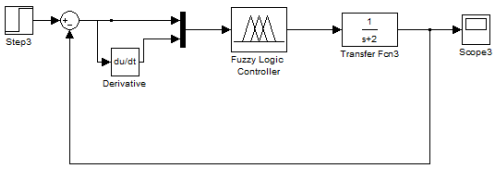

Fig.1Simulink using open method

4.4 FUZZY VARIABLES AND RULES

Two input variable error and error rate is created which is the difference of actual and desired steam temperature and one output variable which is used to control the spray valve. It uses of five triangular membership function gives most high response function when compared to other membership function. The fuzzy set for both input and output are use of following

PH(PressureHigh),PL(PressureLow),Z(Zero),SL(SteamLow),SH(SteamHigh

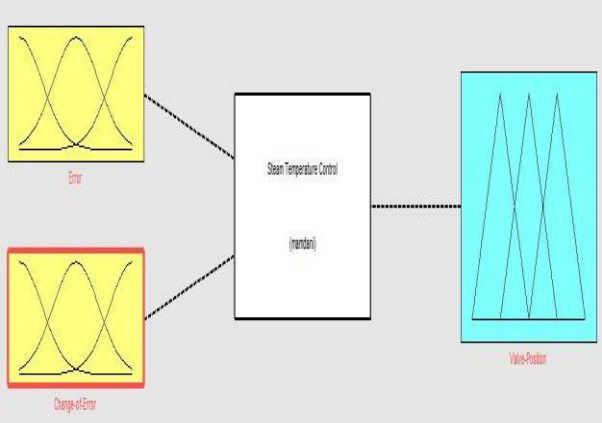

Fig.3-Block diagram of FLC controller

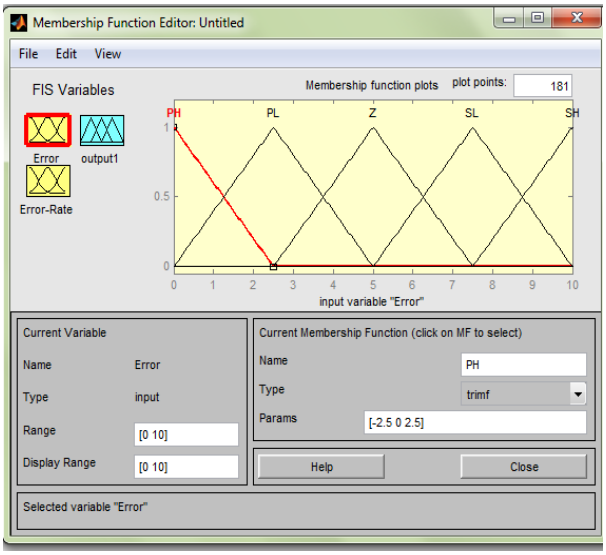

Fig.4-Input-1 membership functions

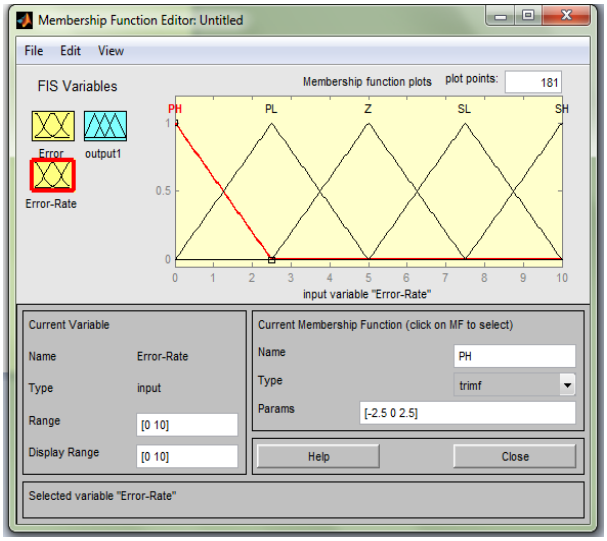

Fig.5-Input-2 membership functions

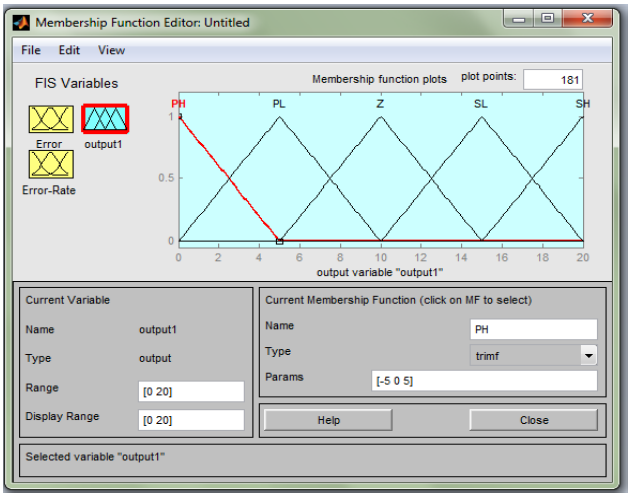

Fig.5-Output membership functions

Rules for Fuzzy Logic Controller

1. If (ERROR is SH) and (ERROR RATE is SH) then (CONTROL is SH).
2. If (ERROR is SH) and (ERROR RATE is SL) then (CONTROL is Z).
3. If (ERROR is SH) and (ERROR RATE is Z) then (CONTROL is PL).
4. If (ERROR is SH) and (ERROR RATE is PL) then (CONTROL is PH).
5. If (ERROR is SH) and (ERROR RATE is PH) then (CONTROL is PL).
6. If (ERROR is SH) and (ERROR RATE is PH) then (CONTROL is PL).
7. If (ERROR is SH) and (ERROR RATE is PH) then (CONTROL is PL).
8. If (ERROR is SH) and (ERROR RATE is PH) then (CONTROL is PL)

V. RESULT ANALYSIS

5.1 WITHOUT CONTROLLER

The system without controller as designed and simulated whose output response is viewed through simulink which not much nearer to the measured and set point variable due to the disturbance happen at steam outlet from the boiler.

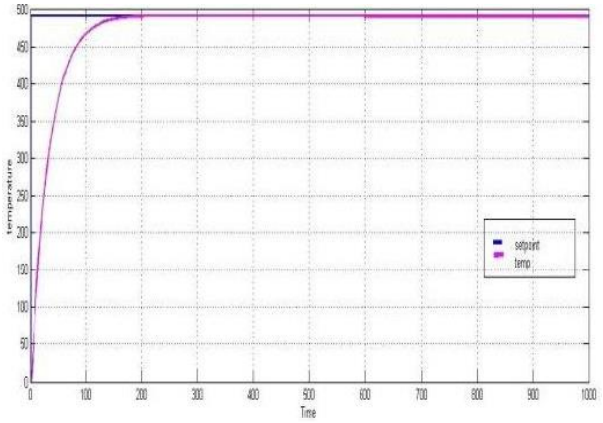

Fig 6- Output without control action

5.2 WITH PID CONTROLLER

The system with PID controller are designed and simulated whose output response are more over stable happen by variation of response from proportional to integral deviation of control action by tuning nearer to set point value and outputis viewed through simulink..

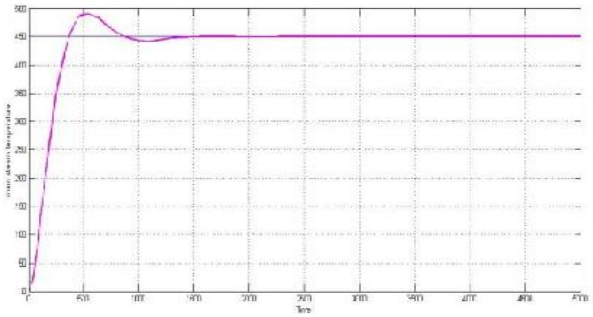

Fig 7- Output with PID controller design

5.3 FUZZY LOGIC CONTROLLER

By using the fuzzy logic controller we can eliminate the deviation which happen over the past control action and non linear control of steam are compensated to change of error. Fuzzy controller are designed with input crisp set of membership function with necessary logical rules based on steam variation and output membership function.

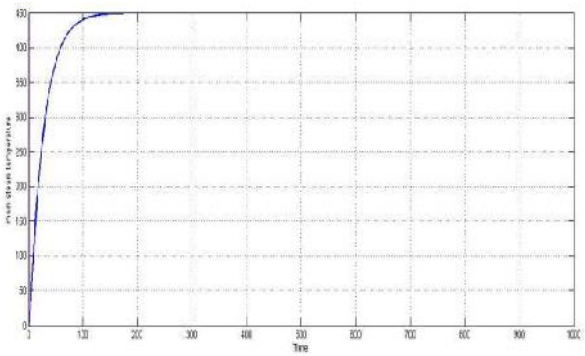

Fig 8- Output with fuzzy controller

VI. EVALUATION OF DIFFERENT CONTROL METHOD

Table 1-Comparison of results

Variables	***Without Controller***	***With PID Controller***	***With FLC***
Settling time(sec)	800	520	122
Rise time(sec)	120	80	65
Overshoot (%)	9	5	2

VII. CONCLUSION

The super heater steam temperature is controlled by different control method based on this the most suitable process for controlling non-linear parameter uses a fuzzy logic controller it aims to produce more robustness and linear output to the system set point value. The superheated steam temperature is maintained at required specified rate by adjustment of spray valve based on the rules given to the fuzzy logic controller and tuning process are done to accomplish well trained output result.

REFERENCES

[1] Ray K.S, Majumder D.D,"Fuzzy logic control of a nonlinear multivariable steam generating unit using decoupling theory"IEEE Transactions on Systems, Man, and Cybernetics, Volume: SMC-15, Issue: 4, PP.539 – 558,26 September 2012

[2] Meng Joo Er, Ya Lei Sun,"Hybrid fuzzy proportional-integral plus conventional derivative control of linear and nonlinear systems"IEEE Transactions on Industrial Electronics, Volume: 48, Issue: 6, PP.1109 – 1117, 07 August 2002

[3] Zhiqiang Gao, Trautzsch T.A, J.G. Dawson,"A stable self-tuning fuzzy logic control system for industrial temperature regulation"IEEE Transactions on Industry Applications Volume: 38, Issue: 2, PP. 414 – 424,07 August 2002

[4] Liu X.J,Chan C.W,"Neuro-Fuzzy Generalized Predictive Control of Boiler SteamTemperature"IEEE Transactions on Energy Conversion, Volume: 21, Issue: 4, PP.900 – 908,13 November 2006

[5] Wei Wang, Han-Xiong Li, Jingtao Zhang,"Intelligence-based hybrid control for power plant boiler" IEEE Transactions on Control Systems Technology,Volume: 10, Issue: 2,PP.280 – 287, 07 August 2002

[6] Matsumoto H, Ohsawa Y, Takahasi S,"Startup optimization of a combined cycle power plant based on cooperative fuzzy reasoning and a neural network"IEEE Transactions on Energy Conversion, Volume: 12, Issue: 1, PP.51 – 59, 06 August 2002

[7] Humphrey H.A,Buist D.M, Bansall J.W,"The steam and electric power plant of Imperial Chemical Industries, Ltd., at Billingham"Journal of the Institution of Electrical Engineers, Volume: 68, Issue: 406, PP.1233 – 1275, 29 January 2010

[8] Jianhua Zhang,Shuqing Zhou, Mifeng Ren,"Adaptive neural network cascade control system with entropy-based design"IET Control Theory & Applications, Volume: 10, Issue: 10, PP.1151 – 1160, 16 June 2016

[9] Subodh Panda, Ajit Kumar Patro, Dr. (Mrs.) Sarada Baboo, "Adaptive Neuro-Fuzzy Controller For Thermal Power Plant Optimization", International Journal Of Emerging Trends & Technology In Computer Science , Vol.2, Issue 6, 2013

[10] Subodh Panda, Ajit Kumar Patro, Dr. (Mrs.) Sarada Baboo, "Adaptive Neuro-Fuzzy Controller For Thermal Power Plant Optimization", International Journal Of Emerging Trends & Technology In Computer Science , Vol.2, Issue 6, 2013

[11] S. Goto, M. Nakamura, and S. Matsumura, "Automatic realization of human experience for controlling variable pressure boilers," *Contr. Eng.Pract.*, vol. 10, no. 10, pp. 15–22, 2000.

[12] G. Pellegrinetti and J. Bentsman, "Nonlinear control oriented boilermodeling—A benchmark problem for controller design," *IEEE Trans.Contr. Syst. Technol.*, vol. 4, no. 1, pp. 57–64, Jan. 1996.