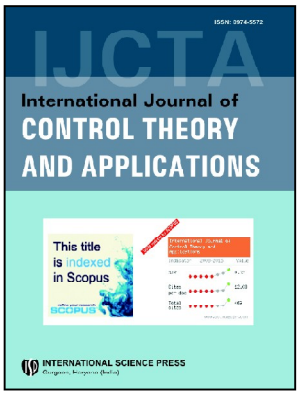

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Intelligent System Designing for Waste Heat Recovery in Efficiency Eancing of Thermal Power Plant

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Abstract: Many industrial heating processes generate waste energy; especially exhaust gas from the boiler at the same time reducing global warming. Waste heat found in the exhaust gas can be used to preheat the incoming gas. This is one of the basic methods for recovery of waste heat. Therefore, this article will present a study the way to recovery heat waste from boiler exhaust gas by mean of shell and tube heat exchanger. The present investigation has been carried out in order to increase the efficiency of the boiler. Methods for recovering the heat of flue gases from boilers were using Water preheated, Air preheated. This paper will focus on improving the performance of control circuits which is used in the heat exchanger. FuzzyPID controller will replace the PID and the Fuzzy controller to obtain the best solution. As a consequence, the overshoot ratio and the settling time. This paper looks in to performance evaluation of different conventional and intelligent controllers implemented with a clear objective to control the outlet fluid temperature of shell and tube heat exchanger system. First of all mathematical modeling of the process is performed using experimental plant data. After the mathematical modeling the control objective is set and different kind of controller are designed to meet the control objective. To control the temperature of outlet fluid of the heat exchanger system a conventional PID control can be used. Obtaining better settling time, rise time, and corresponding overshoot through proper tuning of practical problem. This timing parameter improvement is major challenges for engineers to have an optimal control over the process. Now a day's various intelligent systems as fuzzy logic, neural network, genetic control has a great role on process control. Some time togetherness of all this technique brings better results on timing parameters for non linear system also.

In this search work a suitable intelligent modeling through proper controller is proposed for improving operational beehive. It prove that over shoot is good in PID, settling time and overshoot both in fuzzy controller &further improvement can be obtained through neurofuzzy genetic controller.

Key words: Boiler Efficiency; Exhausts Gas; Heat Exchanger; Heat Recovery, fuzzy controller, Genetic controller, *Feedback and Feed-forward controller*,

INTRODUCTION

The process of heat recovered based on utilization of waste heat and its commercial outcome. Mostly flue gas takes out larger quantity of heat so a good amount of primary fuel can be saved if waste heat is recovered properly. The most important is the way heat recovered and how it can be utilized so that it contributes a large on operational efficiency of system. Here we have an example of flue gas at 200 deg cent., heat loss of 16.96% with boiler efficiency of 53.2% the out let temperature with flow rate of input parameters and flow rate of output element are basic controllable parameter. As per process need the outlet temperature must be regulated within the specified range. In initial set up PID(traditional controller) is used on this loop with feedback/feed forward condition and auto tuning provision are given. Next the PID has been replaced with intelligent system (fuzzy PID CONTROLLER) Heat loss due to moisture formed by burning is 11.55% and due to moisture in fuel is 14.22%. Boiler efficiency is 53.31%.So aim is to minimize heat losses through flue gas. The heat exchange is a very vital device in the industry. The shell & tube is a very common model used in industry for heating or cooling the fluid of the process. The essential parameters needed to be control the operation of heating or cooling the input temperature, the output temperature (set point), the process of heat recovered based on utilization of waste heat and its commercial outcome. Mostly flue gas takes out larger quantity of heat so a good amount of primary fuel can be saved if waste heat is recovered properly. The concept of intelligent control lies with the fact that human intelligence is imbibed in to the controller architecture so that human behavior can be emulated in the control decision. Human skilled knowledge is based upon heuristic information expanded in relation to the operation of the plant or process, and its intrinsic vagueness ("fuzziness") offers a powerful tool for the modeling of complex systems Altogether the system level simulation and design of suitable controller in this research work are packed out in Simulink. A comparative study of all the control performance is evaluated in this paper

LITEURE SURVEY

The heat loss from exhaust gas of boiler, due to blow down or from furnace is around 10 -40% and can be recovered for pre heating combustion air or preheating boiler feed water by an economizer system, required control system may be implement for proper utilization of waste heat to increase boiler efficiency up to certain level. Classical control methods different performance indices were calculated for feedback and feedback plus feed-forward control loops to achieve the desired robustness and system stability. Auto-tuning of PID controllers is also implemented and simulated in this paper. To achieve the desired control objective and implement human intelligence in controller architecture a fuzzy logic controller is designed and implemented. All the system level simulation and controller design in this paper are carried out in Simulink. Such method requires one closed-loop step set point response experiment similar to the classical Ziegler-Nichols experiment. However, in complex systems characterized by nonlinearity, large delay and time variance, the PID's are of no effect (Cao *et al*., 2008). The design of a PID controller is generally based on the assumption of exact knowledge about the system. Because the knowledge is not available for the majority of systems, many advanced control methods have been introduced. Some of these methods make use of the fuzzy logic which any system can be perfectly controlled through its chacteristic on settling time, rise time and magnitude of overshoot. The real expectation over optimal control is overshoot in desirable range; settling time must be shorter, less vibration. The convantation controller PID is proposed initially as it is widely use in industries. A Ziegler Nichols PID controller for higher order system is designed by Vaishakar and Khan 2007.Aproper tuning method which uses PID controller has been developed (Shamusuzzoha andSkogesstad, 2oo10). However the PID has no better effect over large delay and time variance in non linear system. Proper knowledge of the system is required to design PID control loop. The details mathematical model may not be feasible for all system hence other than this new concept of control has been develops. Some of this is intelligent system fuzzy neural with genetic control. Amplifies the control designing for complex models. Moreover, PID fuzzy controllers can be designed as power system stabilizer (Corcau and Stoenescu, 2007). The design of a fuzzy controller depends on the choice of membership functions.

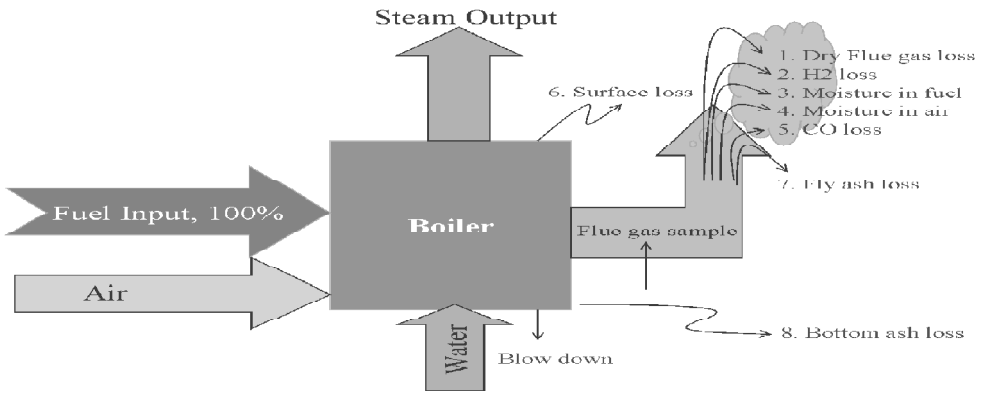
PROBLEM DEFINING & PROPOSED METHODOLOGY

The boiler operational efficiency decrease with in proper combustion regulation. on balancing heat transfer and unskilled or poor operation and maintenance. The reason for drifting out of boiler efficiency can be predicted through various efficiency test and its way of maintanance. Therefor any abnormality on process must throughly observed on the problematic point which needs immediate corrective action .So it is advisable to focused on present status of operation to maintain desired efficiency of boiler.

Boiler efficiency can be measured and enhance in the following two ways

1) Energy gain of working fluid (water & steam) is compared with the boiler fuel and all required operation & maintained for better control to express boiler efficiency directly

2) The different between total losses & energy) input for specified systematic operation also consider (various heat losses in boiler)



During direct method no proper action has been taken why the efficiency of the system is low .Also various losses accountable for this propose has to be neglected .Hence efficiency has to be improve easily by maintaining all the losses occurring in the boiler. We have concentrated much more on in directed as utilization of losses do not make significant changes in operation or modification on existing design .The principal reason for attempting to recover waste heat is economic. All waste heats that is Successfully recovered directly substitutes for purchased energy and therefore reduces the consumption of and the cost of that energy. A second potential benefit is realized when waste-heat substitution results in smaller capacity requirements for energy conversion equipment. Therefore, the use of waste-heat recovery can reduce the requirement for space heating energy. This permits a reduction in the capacity of furnaces or boilers used for heating the plant. In every case of waste-heat recovery, a gratuitous benefit is derived: That of reducing thermal pollution of the environment by an amount exactly equal to the energy recovered, at no direct cost to the recover.

METHODS TO INCREASE BOILER EFFICIENCY

SUMMARY OF HEAT BALANCE FOR COAL FIRED BOILER

Input/Output Parameter		kCal / kg of coal	% loss
Heat Input	=	3501	100
Losses in boiler			
1. Dry flue gas, L_1	–	275.88	7.88
2. Loss due to hydrogen in fuel, L_2	=	120.43	3.44
3. Loss due to moisture in fuel, L_3	–	206.91	5.91
4. Loss due to moisture in air, L_4		10.15	0.29
5. Partial combustion of C to CO, L_5	=	90.32	2.58
6. Surface heat losses, L_6	–	8.73	0.25
7. Loss due to Unburnt in fly ash, L_7	–	3.85	0.11
8. Loss due to Unburnt in bottom ash, L_8	–	61.27	1.77

Boiler Efficiency = $100 - (L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7 + L_8) = 77.77$ %

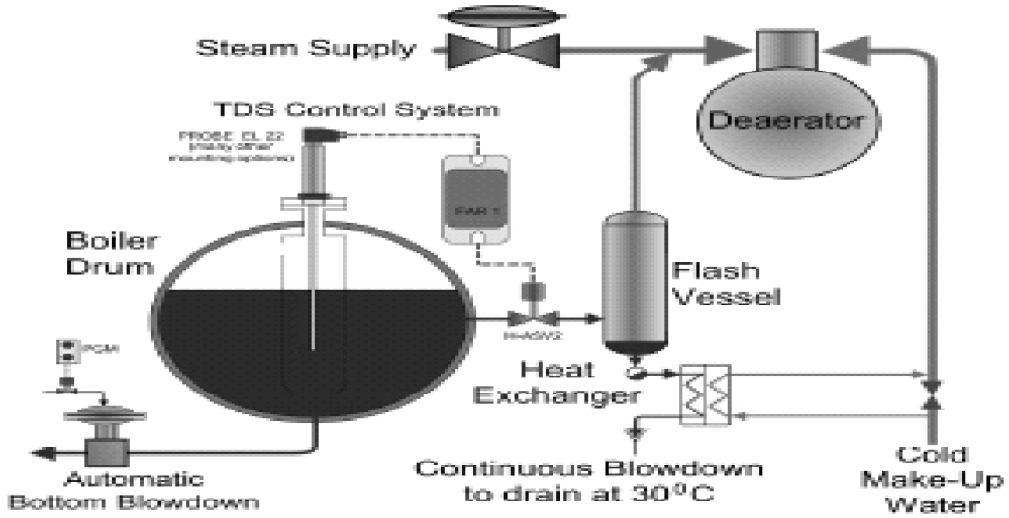
(a) Reduce Excess Air. (b) Preheat Combustion Air (c) Blow down Heat Recovery (d) Exhaust Heat Recovery (e) Replace Burners (g) Condensate Return

EXISTING HEAT RECOVERY SYSTEM (FEED WATER PREHEATED)

The power plant feed water heater useful for preheat the feed water in the process of steam making. This provides a remarkable cost saving and also support from thermal shock to boiler metal. It also allows feed water to goes up for saturation temperature level gradually.

A) Blow Down Heat Recovery

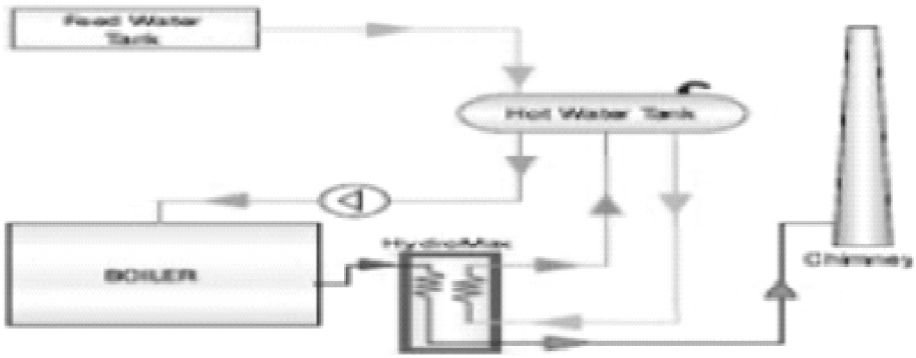
During blow down operation water and steam at high temperature are regularly discharge out. It can be passing through heat exchanger to raise the temperature of makeup water up to certain derired level. Now the blow down at lower temperature can further discharge out to drain or some other useful propose



(B) Exhaust Heat Recovery

In general the flue gas leaving boiler at 200 deg .cent to 300 deg.cent. So there is a lot of potential available for heat recovery. If this 200deg.cent flue gas comes contacts with 30 deg .cent feed water by heat balance (feed water temperature increase & flue gas temperature decrease)Now feed water raised to 100deg .cent and flue gas decrease to 125 de.,cent. With a flow rate of 3kg/s and heater effectiveness of 0.41

"m'w x Cpw x (Tw2-Tw1) = m'f x Cpf x (Tf2-Tf1) (1)"



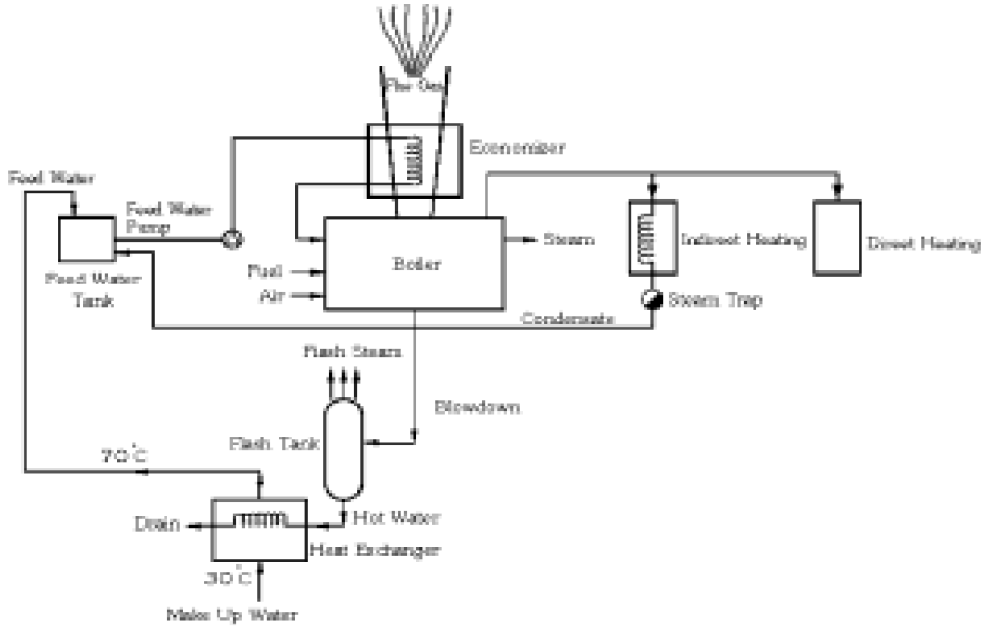
PROPOSED METHODOLOGY FOR HEAT RECOVERY

The main objective off the work is step wise represented in this way

1) As maintain earlier the possible heat recovery and utilization in thermal power plant operation based on indirect method of efficiency monitoring system.
2) Define system dynamic repose with controller
4) Present a systematic approach for designing PID, ANN, fuzzy based controller
5) Compare The Result o fall Controller to Investigate The superset of controller
6) Find out the benefit and outcome of the proposed model for heat recovery and its utilization

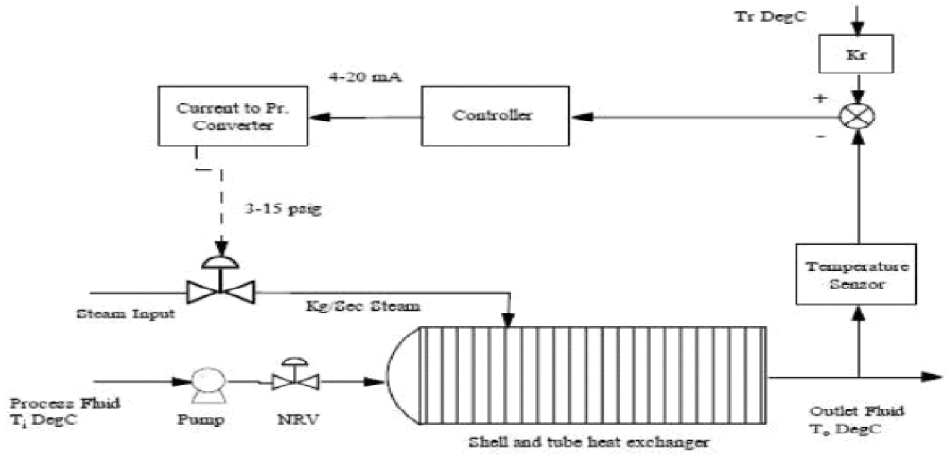
In this proposed method of utilization of recovered heat from flue gas and blow down is shown in fig ( )

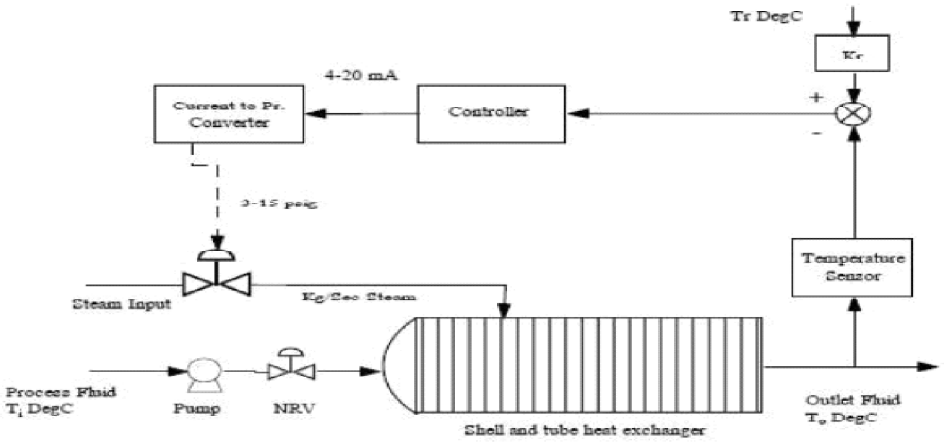
Here the maker of water at 30 deg bring back to around 70 deg through heat exchanger no1 where the blow down water/flash steam may be the process heat this feed water at this stage may be the input to next heat exchanger to utilize recovered heat of flue gas which can bring feed water more than 100 deg Hence a proper *regulation & control of this proposed model can add an amount of considerable amount of heat to feed water which directly save fuel cost ultimately with efficiency enhancing of the complete operation*



P-I DIAGRAM & OPERATION

In this control loop, reverse acting the controller , air to open (fail-close) type of valve used . thermocouple is a sensing element, this is provided in control architecture. out going fluid temperature is measured by the thermocouple. This thermocouple (voltage) is sent to the transmitter unit, that converts to a signal in the range of 4-20 ma. Controller unit is connected with output of the transmitter unit. The controller compares the output with the set point and then gives necessary command to the final control element through the actuator unit. Basically actuator unit is a I to P converter and the final control unit is an air to open valve. The actuator takes the controller output in the range of 4-20 ma and converts it in to pressure signal, i.e. in the range of 3-15 psig. The valve actuates according to the controller decisions.





Mathematical modeling of heat exchanger system

In this section mathematically modeled of the heat exchanger system, actuator, valve, sensor are developed with the available experiment data. The experimental process data's are summarized below.

The steam flow gain = 50c /kg/sec., Time constants = 30 sec.

Variation of process fluid flow gain = 1c/kg/sec., variation of process temperature gain = 3c/c.

Control valve capacity for steam = 1.6 kg/sec., Time constant of control valve = 3 sec.

Time range of temperature sensor = 50c to 150c., Time constant of temperature sensor = 10sec.

From the experimental data, transfer function and the gains are obtained as below.

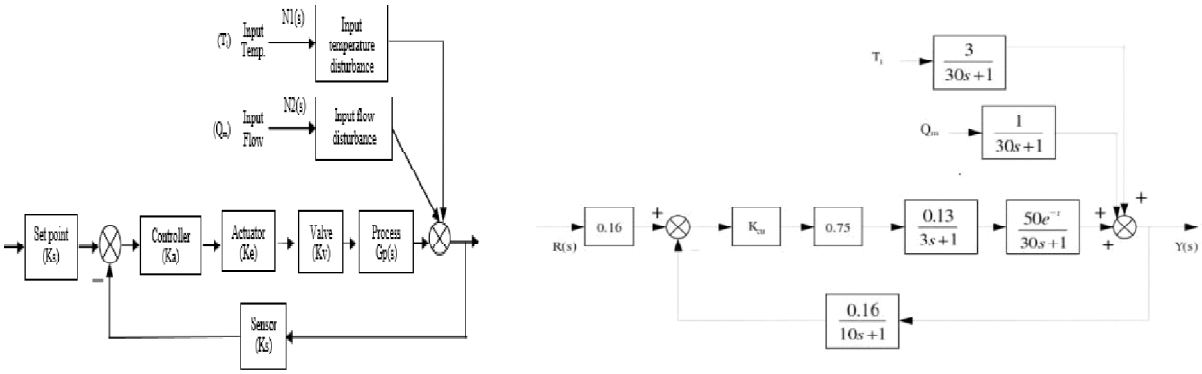
Transfer function of process = 50e^-s/ 30s+1. , Gain of valve = 0.13.

Transfer function of valve =0.13/3s+1. Gain of current to pressure converter = 0.75.

Transfer function of disturbance variables

1. Flow = 1/30s+1(dominant).
2. Temperature = 3/30s+1.

Transfer function of thermocouple = 0.16/10s+1.

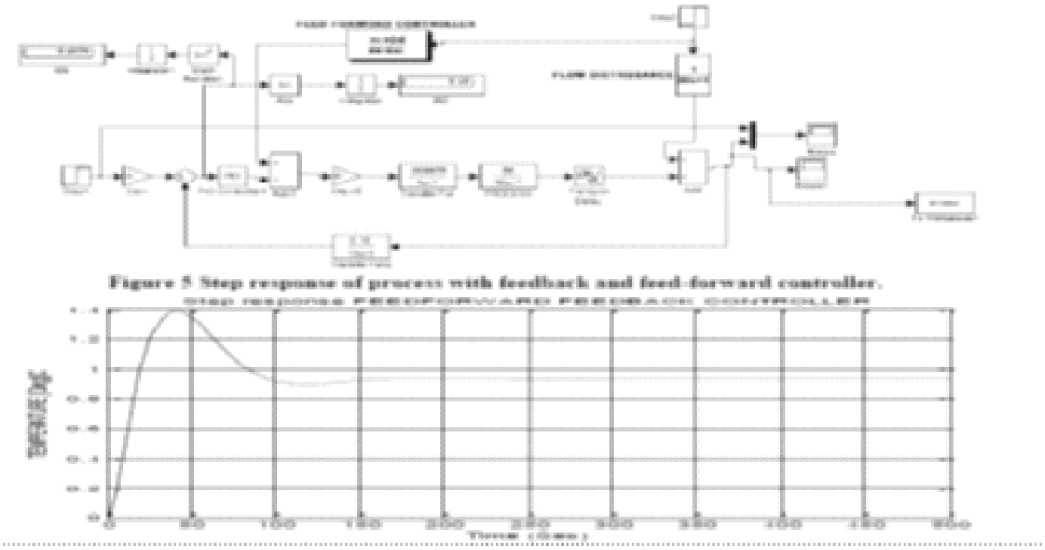


CONTROL METHODOLOGY FORMAKING SYSTEM INTELLIGENT

The proposed controller has to generate a control signal that maintains system parameter at predetermined value. This research work ultimately supports the following.

(a) A multivariable fuzzy controller for the human operating action B) An intelligent coordinator for the human decision making process. The various controllers starting from tradisational system to intelligent controller and its characteristic has been discussed deeply here

MODELING AND SIMULATION OF HEAT RECOVERY UNIT WITH PID ONTROLLER



MODELING AND SIMULATION OF HEAT RECOVERY UNITWITH FUZZY LOGIC CONTROLLER

Fuzzy logic is a thinking process or problem solving control methodology incorporated in control system engineering to control system when input tare either imprecise or the mathematical model are not present at all. Fuzzy fiction is process making a crisp quantity into the fuzzy. They carry considerable uncertain. If the form of uncertainty happens to be arising because of imprecision, ambiguity or vagueness then the variable is probably fuzzy and can be represented by membership function. Defuzzification is the conversion of fuzzy quantity to a

crisp quantity just as fuzzification is the conversion. There are many method of defuzzification out of which smallest of maximum method is applied in making fuzzy inference system .The fuzzy logic control consist of three main stages ,namely the fuzzification interface, the interface rules engine and defuzzification interface the fuzzy logic controller with error and change in error for this control as shown

Figure 6 Simulink model of fuzzy controller

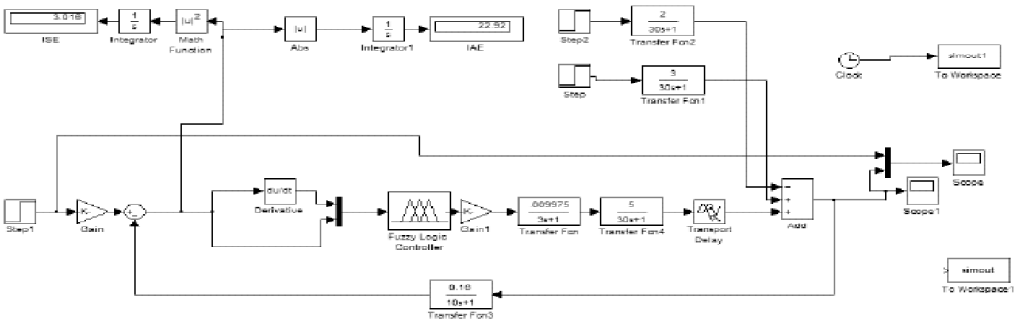
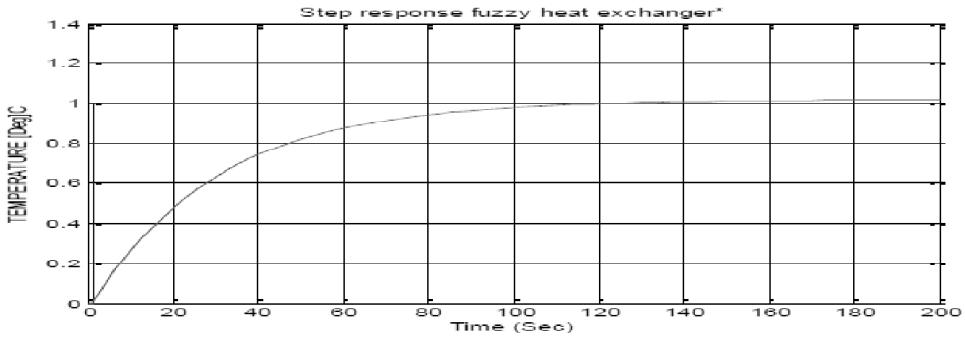
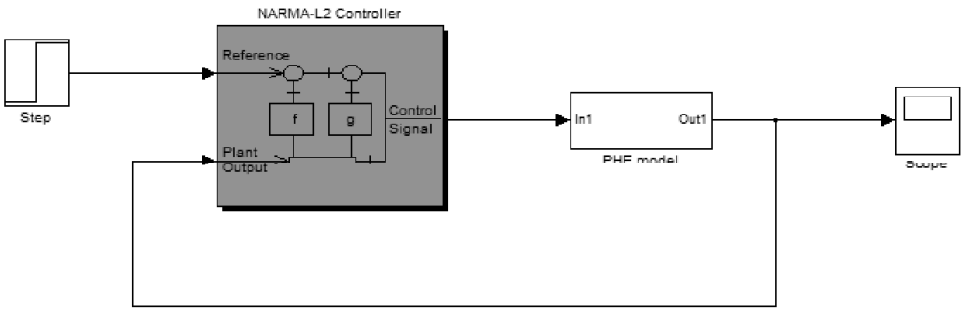


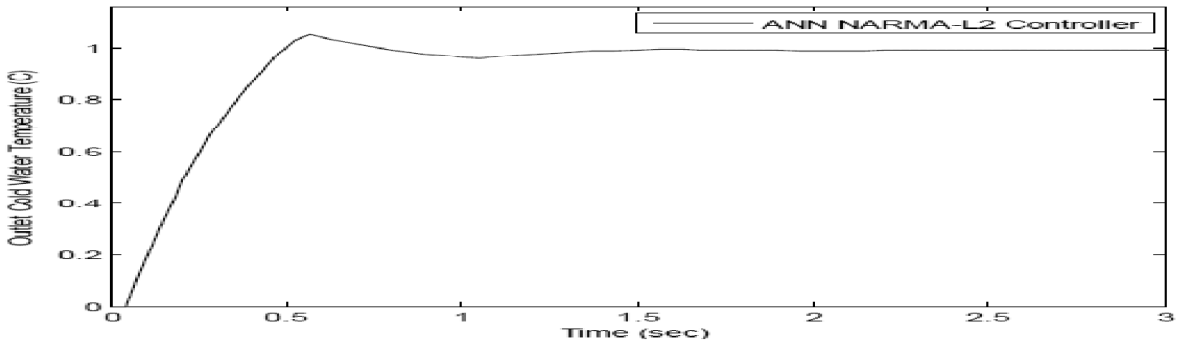
Figure 7 Step response of process with fuzzy controlle



MODELING AND SIMULATION OF HEAT RECOVERY UNIT WITH ANN CONTROLLER

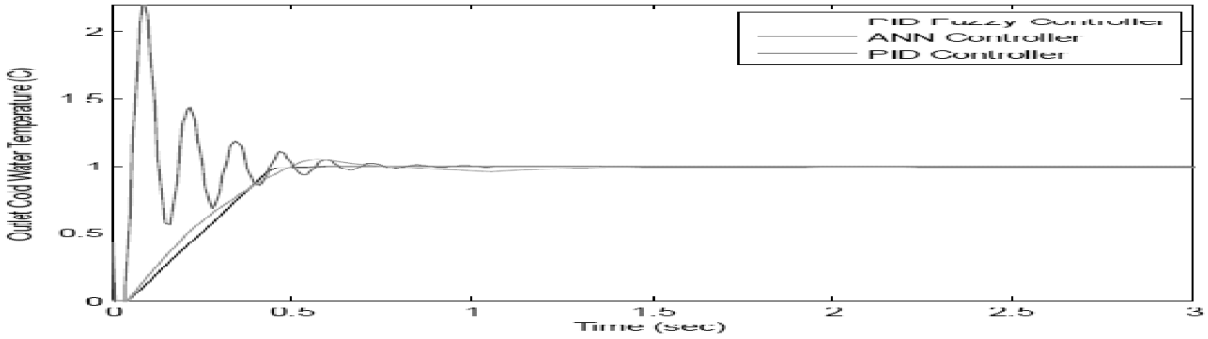
The ANN controller architecture employed here is a non liner auto regressive model reference adaptive controller .The controller is simply a rearrangement of the neural network plant model, which is trained of line in batch form .It consists of reference, heat exchanger output and control signal. The controller is adaptively trained to forced the plant output to track a reference model output The model network is use to predict the effort of controller changes on plant output which allow the updating of controller parameters .In this study the flue gas temperature, flow & temp of fed water with its flow be the ANN controller input .The output is control signal for pneumatic control valve. .Data required for controller training is obtained from the designing the reference model neural network and after a series of trial and error and modification the ANN architectecture provides the best performance .The proposed network has been trained by using the learning performance, learning algorithms courses the adjustment of the weights as that the controlled system gives the desired responses.





TESTING, OBSEVATION & RESULTS

The simulation result clearly shows that the fuzzy controller gives a much better control of temperature rather than ANN or PID controller .To evaluate the performance of the different controller we have considered two parameter of the step responses of the system .The first parameter is the maximum overshoot and the second parameter is the settling time .In all the three controller two parameter are evaluate and comparative study of their performance has been shown in fig. using this table the effective blow down operation and efficient heat utilization from flue gas save annual flue cost and increase the boiler effificiency up to certain extent through this proposed model which can be suggested for real time use in industry.



EFFICIENCY INCREASE

Table 1
Heat exchanger calculations

	Temperature (°C)		*Mass flow rate*	*Temperature fo flue gases (°C)*	
	In	*Out*	*(Kg/s)*	*In*	*Out*
Water preheater	30	100	3	200	125
Air prehenter	25	50	2.6	125	60

Table 2
Efficiency

	Before (%)	*After (%)*
Efficiency	53.31	61.73

CONCLUSION

This proposed model is comfortable controllable process with multidistributed parameter large time delay and immeasurable diatribuance. Through this how intelligent controller can be satisfactory fulfill all basic need of industry. In industry the experience operator could gain a better performance than the traditional PID to provide better and reliable performance an intelligent control system has to be developed to replace the manual control. In order to simulate function of information processing decision making and operating action of the experienced human operator an intelligent system frame is proposed .Intelligent system methodology is proposed to integrate machine level control and high level supervision properly for performance improvement of heat recovery and its utilization. The above proposed model of intelligent system is easy to implement without large modification to the original system. This been replace the human operator with traditional PID controller to gain robust performance. Efficiency of the boiler increase through reducing flue gas up to and

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