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# Boiler Performance Optimization Using Process Neural Network

KEYWORDS: Process neural network, blow down, Indirect losses , soft sensor, Heat exchanger, Neurocontrol. Flash steam, feed water

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**ABSTRACT** *The important issue in the modern thermal power plant is to develop methodology concept algorithm technologies for designing a control system which must be able to evolve, self develop. self organized and self evaluated and to self improve. Although linear model can provide acceptable performance for many systems they may be unsuitable for non linearity. So it is highly required for a model that reflect the non liner relationship between cause and effect variable. Implementation of soft sensor in neural network estimate process data using self organizing neural network. Here basic requirement of design an neuron control with soft sensor are the knowledge of fundamental relationship of process variable and the parameter in the question .It is called a process neural network which is an extension of traditional neural network in which the input and output are time variant. So the data processing is better than traditional neural network so it is highly suitable to minimize heat loss at blow down station and increase its ability by operating at peak.*

**1:-INTRODUCTION**

The process of in corporating process neural network in the power plant to ahead of the limits of conventional technique and to improve the existing tools by optimizing the dynamical performance of process such as blow down station in power plant .The soft sensor, know also as virtual sensor are soft ware tools capable of calculating quantities that can not be measure or that are difficult to measure. They are based on technology that provide an estimatimation of measurements by creating a mathematical model for real data. The increase the potential of neural network with this support we can design a neural control where the actuating signal at the input to the plant is generated by neural network based control. The properly trained neural network act as controller and appropriate actuating signal for the plant is directly available at the networks output. . The main propose of this research work is to use this technique in thermal power plant for increase its efficiency through reducing various indirect losses. When water is converted to steam, the dissolved solids are left behind in the boiler water. As steam is continually produced, evaporated, and replaced with new water, the amount of solids in the boiler continues to increase indefinitely. These will inevitably collect in the bottom of the boiler in the form of sludge, and are removed by a process known as bottom blow down. Insufficient blow down may lead to carryover of boiler water into the steam, or the formation of deposits. Excessive blow down will waste energy, water, and chemicals. The optimum blow down rate is determined by various factors including the boiler type, operating pressure, water treatment, and quality of makeup water. Table1: Model Report Format for Boiler Efficiency and Indirect Losses System

**CODE: AL1 DATE: 19/12/12 12:00 AM FUEL: OIL**

| | |
|---|---|
| **BOILER EFFICIENCY** | **69.35** |
| **INDIRECT LOSSES** | **30.65** |
| **(I) DRY FLUE GAS LOSS** | **7.42** |
| **(II) FUEL MOISTURE LOSS** | **6.31** |
| **(III) BLOW DOWN LOSSES** | **14.77** |
| **(IV) INCOMPLETE COMBUSTION LOSS** | **0.00** |
| **(V) AIR MOISTURE LOSS** | **0.00** |
| **(VI) RADIATION & CONVECTION LOSS** | **2.15** |

*COURTESY:- THERMAX BOILER,J.K.PAPER,RAYAGADA*

2: NEED OF WORK:- Although reducing blow down results in substantial fuel savings, this function cannot be eliminated entirely. A boiler operating on high quality feed water needs very little blow down, while equipment using feed water containing solids, alkalinity or silica requires a much higher rate, may be even continuous discharge. A comprehensive energy conservation program, apart from ensuring correct amount of blow down must include the use of flash tanks and heat exchangers to reclaim some of the energy wastage in boiler blow down.

**2.1 Flash Steam Recovery**

Flash steam heat recovery is a method for recovering at least 85% of the blow down heating value. About half of the heat contained in the blow down water is recovered in the form of flash steam by discharging the flow to a flash tank, usually operated at 5 psig. A portion of the blow down flashes to steam at the lower pressure and is available for use in Flash steam recovery is calculated using the formula:

$A = (H - W) / L$

Where:

- A = Flash steam %
- H = Boiler blow down water heat content, Btu/lb
- W = Water heat/content at flash pressure, Btu/lb
- L = Steam latent heat content at flash pressure, Btu/lb

Assuming, a flash tank is added to a boiler operating at 235 psig

**2.2 Blow down heat recovery**

Heat exchangers can reclaim the sensible heat from the blow down that goes into sewerage for heating boiler makeup water and the like. In most cases, the heat exchanger is designed to reduce the temperature of the blow down water to within 120 °F of the temperature of the makeup water. Additional heat recovered is calculated from the following formula:

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M = J x (1- A) x (W – P)

Where:

- M = Additional daily heat recovery, Btu

- P = Water heat content at exchanger outlet, Btu/lb

The system shown below consists of a flash tank and a heat exchanger. The temperature of the blow down leaving the flash tank is usually still above 220°F. The heat of this flash blow down can be used to heat makeup water by sending it through the heat exchanger, while cooling the blow down at the same time. Heating boiler makeup water saves on fuel costs. .Fig 1

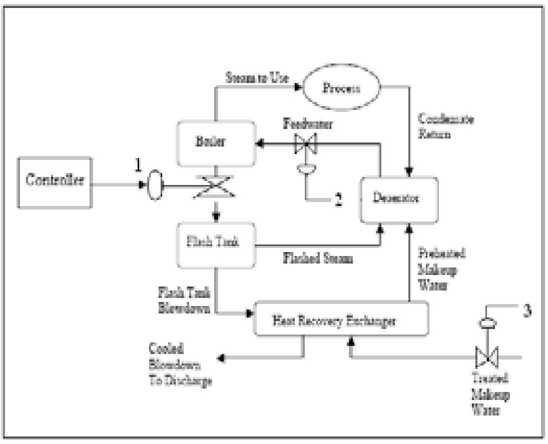



Fig. 1 conventional method of control of Colled Blowdown on discharge

**3: PROPOSE MODEL:-**

**3.1 Introduction**

The generic non-linear solution to the system like Blow down monitoring can be provided through process neural network (PNN). It is so as the dynamic relationship between various causes and effect variable is capable through artificial neural network (ANN). ANN has the benefit of being capable to capture non-linear relationships. As we know the performance of process manufacturing and control algorithm are dependent upon the precession of the model associated with it. The required potential to provide benefit to these algorithms can be achieved through PNN when it is applied to non-linear system.

**3.2 Components And Working**

In linear model the existing neural network provide a clear view of relationship between effect variable and its causes. The real benefit of using ANN in all linear modes is that they can provide better modeling of non-linear relationship. For this system there are various ANN structure but they process some common features. They are generally composed up numerous processing elements called as nodes which are arranged together to form a network. The commonly used processing element is one which weights the input signal and than sum them with a bias assigned to it. The summed weighted inputs are passing through a non-linear activation function such as the hyperbolic tangent and this is the output of neurons. The model approximation for blow down optima ion is gradual learning based on the observation of the blow down loop input/output data in real time.The functioning of blow down station describe with the differential equation

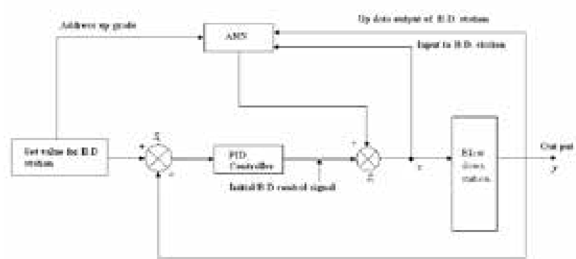
Y(K+1)=a Y(K) +b X(k)

Y(k) and X(X) are output and input to BD respectively.

K is the time step number and a,b are constant coefficient as per design of BD station with soft sensor in neural network (PNN) as shown in fig.2Here the control signal X(K) for actuating control value is determined by a pair of value y(k) and y(k+1) which are the present and next blow down station output(TDS, Drum level , BD temp.)The sequences value of y(k) for k=1,2,3,………… is assumed to be known and is provided by the reference blow down output (TDS, drum level, Blow down temp.) generator. The conventional controller initially produce the control signal x (k). The controller hear in use is _Ve feedback configuration. The reference blow down output generator inputs the present output value of thee station to summing node S1. Due to the close loop condition system between the reference plant output to the summing node S1 and the ui nit plant output .To fulfill this condition the close loop control l system must have classical controller, plant & node S1 be in stable and it is definite high gain conventional controller. At the initial training state the neuro control provides little or no input to the summing node S2.The neural controller associated with soft sensor hear is memory based. It is not initially trained and its initial output is zero to S2. There for the dominant components of the total Actuating signal (k) is the output of traditional controller. The control signal produced by PID controller in each control step x(K) is generated in PNN of y(K), y(K+1), which is due to the learning

rules of w(K+1)=WK + $\alpha$ [X(K)W(K)]

In this weight adaption $\alpha > 0$ is a small +ve learning constant, K denots learning step number and also the number of the control step, The initial weight value are set to zero. Which corresponds to setting the entire characteristic surface to zero at the beginning of training .The conventional controller build the weight W (k) can now be interpreted as updated control signal value (K) . At the learning value W, the learning end up and x (k) the averaged value over number neuro control learning steps.



PNN frunctioning at process station

**Fig 2**

**4. APPLICATION OF PNN BLOW DOWN MANITORING.**

The Process Neural Network which describe above can be use successfully at BD STATION for its optimization. Here the present measure valu of TDS of boiler drum water can compare with set valu , at the same time to have a successful drum level control to support the lode required by the system we have to consider the steam flow as parameter hence dischargeing BD and its monitoring is dependable to steam flow also.To reduse the heat lossess in this system ,to utilize the maximum amount of heat for heating feed water, Blow down water temp. is a parameter for feed water control which effect the boiler drum and at the end steam flow that gives required TDS in discharge water.

The required algorithm regulate the error for minimization to have a control signal to

Pneumatic control valve placed at three different point in BD station..The valves regulate the excess water in the blow down system and feed water line for monitoring TDS and Feed Water temp.

The systematic use of PNN in BD station for its optimization

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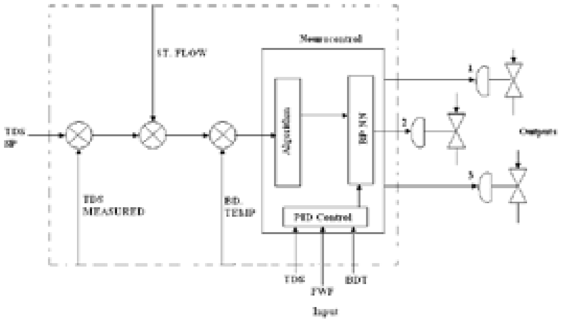
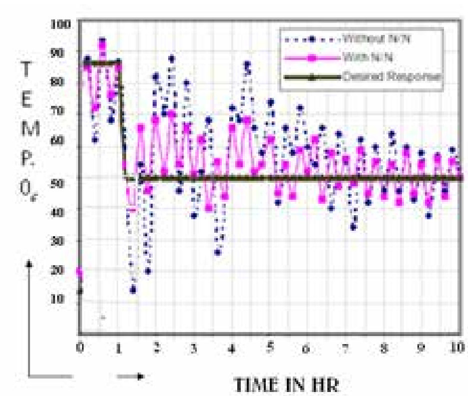
is shown in the fig(3 )



Application of PNN in Blow down station

## 5. RESULT AND DISCUSSION

The blow down losses of the Boiler is one of the most sensitive parameter involved in all Thermal Power Plants. This parameter is directly related to the control of the temp. of feed water and the control of the TDS. A careful study was done on the existing PI controller system in the Power plant and compared with the designed PNN model.. The results obtained with the proposed neural network of the boiler plant shows that soft sensor can converge the neural network to improve performance. fig. 4 shows comparison of neural network results with desired blow down control and percentage of deviation of BD monitoring without neural network. It has been clearly proved that the PNN model is more accurate and efficient making the system robust and reliable as compared to the former..



Blowdown temp control with PNN

Fig. 4

The results of PNN are very sensitive to number of neurons. Increasing the number of neurons in hidden layer will decrease the number of calculation steps with subsequent decrease in summed squared error. The proposed PNN controller can replace a conventional controller, and is shown to overcome most of the problems mentioned above. A training algorithm is derived based on BP, enabling the neural network to be trained with system output errors, rather than the network-output errors. In the BP algorithm, weights need to be modified by using the network-output error that is not known when a multilayer perception is applied directly to the controlled plant. Therefore, the proposed algorithm enhances the NN's ability to handle control applications. The only a priori knowledge about the controlled plant is the direction of its response, which is usually easy to determine. The proposed PNN controller has been applied to the BD control in a thermal power plant and extensive simulations conducted show promising results. As per Fig.5 we determine that the maximum effective operating range is between 4500 μ mhos and 5000 μ mhos, then we can set the controller to control blow down at that range (as shown below). Below 4500 μmhos we are wasting water, chemical, and fuel. While above 5000 μ mhos we are risking the generation of wet steam.

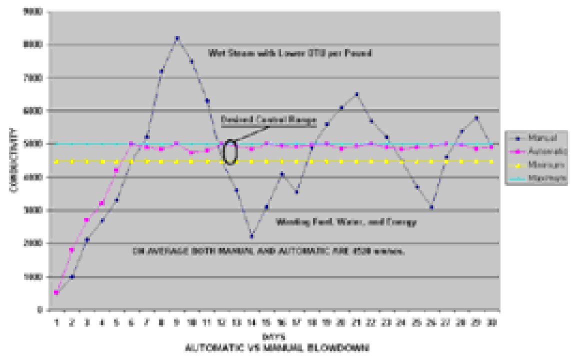


Fig.5

This shows that inadequate treatment of boiler water can waste as much as 15-18% of energy and can even result in plant damage. Feed water if not properly treated shall result in scale buildup which can reduce boiler efficiency by as much as 10-12% and can even result in plant damage .It is important to maximize condensate return an additional is to 18% of boiler energy from the steam is needed to re-heat each pound of coal makeup water.

## 6. CONCLUSION

The proposed process neural network proves to be an efficient modeling system for calculation and optimization of the Blow down. It significantly reduces the frequency of deviations and the degree of deviation of the TDS, F .W temp. that can reduce indirect losses .the tripping of the boiler during load fluctuations. Focusing on process control systems, a new controller using soft sensor in neural networks has been designed and tested for the Blow down control in a thermal power plant. For such a control system, the negative effects of a long system response delay and nonlinear elements are the main obstacles in designing a high performance controller and fine-tuning its parameters. Good performance, a simple structure and algorithm, and the potential for fault tolerance make the proposed PNN controller attractive for process-control applications.By proper use of this PNN technique it is possible to increase boiler efficiency and also consistency of boiler efficiency can also be maintained by reducing losses.. Hence an approach to design a PNN controller used for the blow down control optimization in the process of a power plant boiler has been presented. The optimization of the BDC will reduce the in direct losses and improve the efficiency in the boiler system.

## REFERENCE

• Dukelow, S. G. (2001), The Control of Boilers 2nd Edition, Instrument Society of America, USA | • Lab VIEW (1998), User Manual, National Instrument Liptak, Béla G. (1999), optimization of Industrial Unit Processes, CRC Press LLC, USA | • [1] P. J. Werbos, "Backpropogation through time: What it does and how to do it", proceedings of the IEEE, Vol. 78, No. 10, October 1990. | • [4] L. Fausett, Fundamentals of Neural Networks, New Jersey: Prentice-Hall, 1994. | • [11] S. N. Sivnandan, S. Sumpathi, and S.N. Deepa, "Introduction to Neural Networks using MATLAB 6.0", The Mc Graw Hill Publication, New Delhi | • University. Boiler Efficiency Institute. Auburn, Ala. 1991. | • "Minimizing Boiler Blow down." Steam Tip Sheet #9. Department of Energy. Office of Industrial Technologies. Energy Efficiency and Renewable Energy. June 2001. | • Thermal power plants efficiency optimization using back propagation neural network ____ Subodh Panda and Bikash Swain, ATCIT, 40-43, ISBN NO:978-93-83060-00-9 | • Introduction to Artificial neural system jacek M .ZURADA ISBN, 81-7224-650-1 | • Subodh Panda and Bikash swain. Enhancing thermal plant efficiency using soft computing. IJERT, Issn 2278-018, Vol2issue 3, March-2013 | • Preetie. Manke& sharad tembhurne. Application of back propagation neural network to drum level control in thermal power plant IJCSI, vol9 issue2. no 1 march-2012. Issn -1694-0814 | • Subodh Panda, Bikash Swain, Sandeep Mishra, Blow down Losses Control in thermal power plants using neural Network. International journal of Advancements in Research & Technology, Volume2, Issue5, May-2013 ISSN 2278-7763. | • Improving energy efficiency of boiler system, A. Bhatia. CED Engineering.com. |