Enhancing Thermal Power Plant Efficiency Using Soft Computing

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Abstract

With the rising cost of fuel prices, industries that use steam boiler for heating or power generation are hard to operate at peak efficiencies.

While steam consumption, leakages and other heat transmission losses con contribute to the overall energy bill, this project article focuses on the heart of the steam generation- the boiler.

There are different way to improve bailer efficiency using conventional control theory based mathematical models that describe the dynamic behavior of he boiler process control. Due to lack of comprehensibility, conventional controllers are often inferior to the intelligent controller. Soft computing tech provide an ability to make decision and learning from the reliable data.

The main aim of this project work is to achieve optimal operation of thermal power plant, to improve its efficiency and to reduce the consumption of fuel.

Initially several common models of thermal power control are analyze , which use coordinated control system as well as local equipment Then the system structure, function and application described. At the end the structure and function of digital power plant is introduced with support of soft computing tech.

***Keywords**: optimization, PI controller, artificial neural network, Boiler efficiency, indirect losses*

Introduction

The power generating industry is currently undergoing an unprecedented reform. Artificial intelligence techniques offer one of the most potentially profitable usages in recent developments.

Artificial neural networks (ANNs) have been used in a broad range of applications optimization, prediction and automatic control. The boiler needs very precise control and measurement for its efficient operation. As we are aware that Boiler is main source of fuel consumption in any industry. It is a matter of great concern to all that boiler should run at its maximum efficiency with minimum indirect losses. For attaining maximum boiler efficiency, exact assessment of boiler efficiency and all indirect losses are very important. Boiler consumes measure chunk of fuel in any processing industry. Efficiency of any Boiler depends upon minimization of various indirect losses of the boiler so that amount of energy input in the boiler by burning the fuel can be maximum utilized for generation of steam and cost of steam can beminimized ultimately. The following indirect losses can be minimized for efficient boiler efficiency.

- Dry Flue Gas Loss
- Fuel Moisture Loss
- **Blow Down Losses**
- Incomplete Combustion Loss
- Air Moisture Loss
- Radiation and Convection Loss

After knowing the various heat losses it is possible to take action to improve boiler efficiency.

As mentioned earlier, insufficient blowdown may cause carryover of boiler water into the steam or the formation of deposits on boiler tubes. Excessive blowdown wastes energy, water and treatment chemicals. The blowdown amount required is a function of boiler type, steam pressure, chemical treatment program, and feedwater quality. The optimum blowdown amount is typically calculated and controlled by measuring the conductivity of the boiler feedwater. Conductivity is a viable indicator of the overall total dissolved solid concentrations. Typically, blowdown rates range from 4 – 8 percent of boiler feedwater flow rate, but can be as high as 20 percent with extremely poor quality feedwater.

1. Need of work

There are two types of boiler blowdowns: manual and automatic. Plants using manual blowdown must check samples many times a day or according to a set schedule, and adjust blowdown ccordingly. With manual boiler blowdown control, operators are delayed in knowing when to onduct blowdown or for how long. They cannot immediately respond to the changes in feedwater onditions or variations in steam demand. An automatic blowdown control constantly monitors boiler water conductivity and adjusts the blowdown rate accordingly to maintain the desired water chemistry. A probe measures the conductivity and provides feedback to the controller driving a modulating blowdown valve. An automatic blowdown control can keep the blowdown rate uniformly close to the maximum allowable dissolved solids level, while minimizing blowdown and reducing energy losses.

Changing from manual blowdown control to automatic control can reduce a boiler's energy use by 2 – 5 percent and reduce blowdown water losses by up to 20 percent.

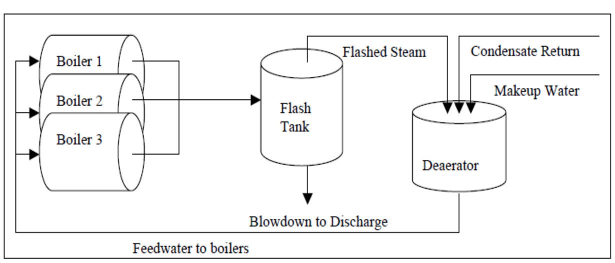
Blowdown Heat Recovery Units

In addition to proper blowdown practices, including the use of automatic blowdown control, reducing cost and heat loss associated with boiler blowdown can also be achieved through recovering the heat/energy in the blowdown.

The blowdown water has the same temperature and pressure as the boiler water. Before this high-energy waste is discharged, the resident heat in blowdown can be recovered with a flash tank, a heat exchanger, or the combination of the two. Any boiler with continuous surface water blowdown exceeding 5 percent of the steam generation rate is a good candidate for blowdown waste heat recovery.

Flash Tank System

The flash tank system shown in the figure below can be used when expense and complexity must be reduced to a minimum. In this system, the blowdowns from the boilers are sent through a flash tank, where they are converted into low-pressure steam. This low-pressure steam is most typically used in deaerators or makeup water heaters.



Schematics of a Flash Tank System
fig.(1)

Conventional Flash Tank – Heat Exchanger System monitoring

The system shown below consists of a flash tank and a heat exchanger. The temperature of the blowdown leaving the flash tank is usually still above 220°F. The heat of this flash blowdown can be used to heat makeup water by sending it through the heat exchanger, while cooling the blowdown at the same time. Heating boiler makeup water saves on fuel costs. An additional advantage of cooling blowdown is in helping to comply with local codes regulating the discharge of high temperature liquids into the sewer system.

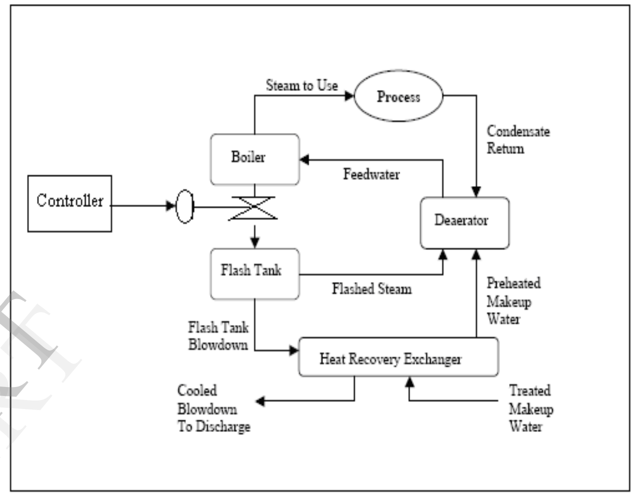
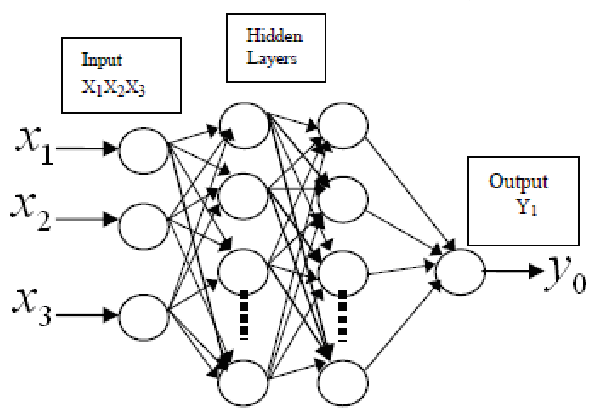


Fig.2 Conventional method of contorl

2. Artificial Neural Network

Artificial neural networks are powerful tool that have the ability to identify underlying highly complex relationships from input–output data only. Over the last 15 years,



ANN architecture for the feed control station
Fig.3

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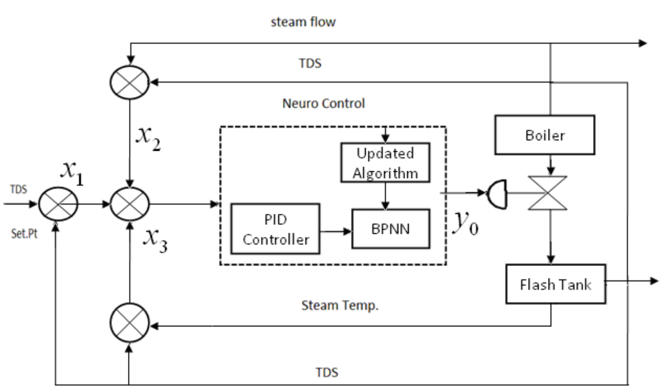
ANNs have been extensively studied to present process models, and their use in industry has been rapidly growing. The main advantage of ANN is the ability to model a problem by the use of data associated with process, rather than analysis of process by some standard numerical methods. In this model the system's output error is propagated back through the plant using its partial derivatives at an operating point. In a set of actual system, outputs are selected as training data and provided as input to the ANN during its training period. By comparing the output of the ANN with the desired system output, the network's output error is computed, which is then used to train the neural network. After the neural network is well trained, its input is switched to the desired system output. Then, the ANN acts as the inverse of the plant and its output will drive the system to reach the desired value.

3. Proposed Neural Network Model

There are many ANN architectures for which the choice depends on the type of problem and may require experimentation of different algorithms. One of the most popular architecture is a multilayer perceptron with the back propagation (BP) algorithm. BPNN (Back propagation neural network) is applied for the prediction of TDS in flash tank It is proved that a four-layer (with two hidden layers) perceptron can be used to approximate any continuous function with the desired accuracy. BP has been used successfully for pattern classification, though its original development placed more stress on control applications. A controller is usually connected serially to the controlled plant under consideration. For a multilayer perceptron, the weights of the network need to be updated using the network's output error. For an ANN-controller, the output is the control command to the system. However, when the ANN is serially connected to a controlled plant, the network's output error is unknown, since the desired control action is unknown. This implies that BP cannot be applied to control problems directly. Thus, one of the key problems in designing a neural network controller is to develop an efficient training algorithm. Fig. 4 shows the ANN architecture for the TDS control station of the power plant. This is used to control the blow down of the of the Boiler. In this model, there are three inputs: TDS level, temperature of steam on flash tank, steam flow and one output is of opening of the pneumatic valve in the blow down control system. The valve regulates the excess water in the blow down system. Trials are performed using two hidden layers with the number of neurons one hundred in each of hidden layer, three neurons in the input layer and one in the output layer. Training the ANN is an important step for developing a useful network.



Blow down control with BPNN
Fig.4

If we determine that the maximum effective operating range is between 4500 μmhos and 5000 μmhos, then we can set the controller to control blowdown at that range (as shown below). Below 4500 μmhos we are wasting water, chemical, and fuel. While above 5000 μmhos we are risking the generation of wet steam.

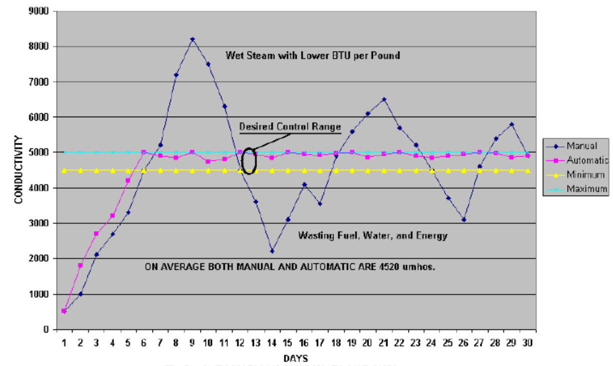


Fig.5 AUTOMATIC VS MANUAL BLOWDOWN

Conclusions

The proposed back propagation 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 that can reduce indirect losses .the tripping of the boiler during load fluctuations. Focusing on process control systems, a new direct adaptive controller using 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 ANN controller attractive for process-control applications.

By proper use of this ANN technique it is possible to increase boiler efficiency and also consistency of boiler efficiency can also be maintained. This may serve as an important tool for the management to exercise effective energy conservation and cost control measures. In order to compete with international products, there is no other alternative but to go for automation in near future. This approach may act as a precursor to that.

An approach to design a ANM 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.

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