International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 08, August 2026)

Overall Plant Efficiency by the Utilisation of Feed Water Heaters in A Thermal Power Plant

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***Abstract*— It is a well known fact that the addition of feed water heater increases the feed water temperature at the inlet of the boiler. This simultaneously reduces the work of the turbine resulting in reduction in fuel consumption for the same operating parameters of the power plant. The performance analysis with base power plant and with using feed water heaters is done. The over all plant efficiency is increased by the addition of six feed water heaters**

***Keywords*— Feed water heater, Plant Efficiency, Fuel consumption, Mass Balance, Extraction**

I. Introduction

The steam generators are designed for producing steam at a predefined temperature and pressure meaning that the thermal energy is accounted by the use of fuel consumption. Steam power plants are nowadays notable mechanical power producers worldwide [1].

The thermal power plant over all efficiency lies in how the generated thermal energy produced is utilised effectively in the conversion of electrical energy. Conversion of steam energy to electrical energy in conventional steam power plants, all produced mechanical power is used for electricity generation [2].

This paper analysis shows that the provision of feed water heaters and thus the extraction cycle increases the plant overall efficiency.

II. Description Of The Base Power Plant

FigureNo.1 shows the schematic of the base thermal power plant which consists of the four thermodynamic process detailed below.

Process 1-2:

Superheated steam is expanded in the steam turbine doing mechanical work.

Process 2-3:

Heat transfer from the exhaust steam at constant pressure to the condenser is rejected.

Process 3-4 :

The Boiler feed pump raises the pressure of the working fluid from the condenser to the boiler pressure.

Process 4-1:

The heat transfer to the feed water at constant pressure is done to convert it to superheated steam.

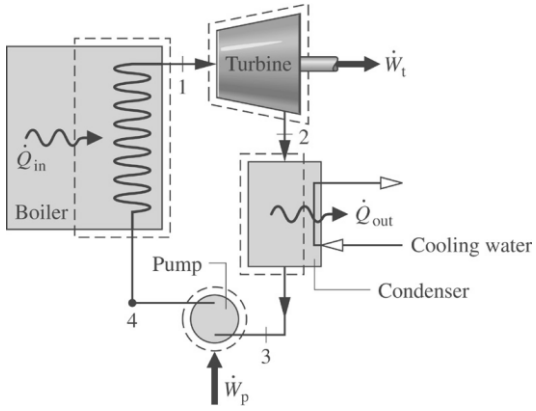

Figure No.1 Schematic of the base thermal power plant

III. Various Heat Zones of Steam in T-S plot

The heat energy in the steam is entering in to different heat modes at different points as shown in the Figure 2.

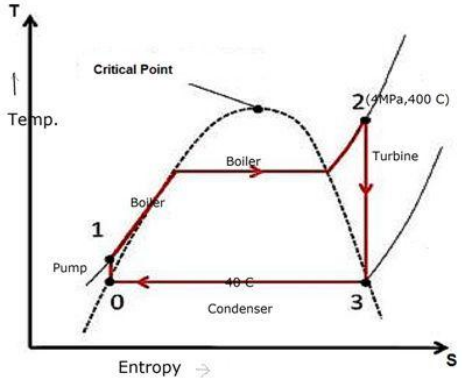

Figure No.2 Temperature (T)-Entropy (S) plot below of a base thermal power plant

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A. Work is produced by the Turbine and given by

$Wt = h_2 - h_3$

B. Heat is rejected in the condenser as

$Q_r = h_3 - h_4$

C. Work input is given to feed pump and is given by

$W_p = h_1 - h_4$

D. Heat is Supplied in the boiler and is equal to

$Q_s = h_2 - h_1$

E. Plant efficiency =

$$\frac{\text{Net work output}}{\text{Heat Supplied}}$$

IV. Feed Water Heater

Feed water heater is a heat exchanger which pre-heats the water delivered to the boiler. Regenerative heaters are placed between the main condenser and the steam generator, while each regenerative heater uses extracted steam from the turbine with the aim of condensate/feed water heating [3,4].

By the process of reheating, the feed water reduces the amount of energy needed to make steam and thus reduces in turn plant operation costs. This improves the thermodynamic efficiency of the system. Regardless of the steam power plant's final purpose, the regenerative heating system is one of the essential parts inside such plants [5].

V. Extraction Cycle

The figure No. 3 shows the schematic of the extraction process in a thermal power plant with Low Pressure (LP) and High Pressure (HP) Heaters used in the extraction cycle of a thermal power plant.

The steam is supplied to these heaters from the extraction point of the turbine. These heaters are provided with a by-pass protection on the feed waterside to protect them from burning out during starting and shut down of the boiler.. Feed water flows through the tube spirals and is heated by steam around the tubes in the shell of the heaters.

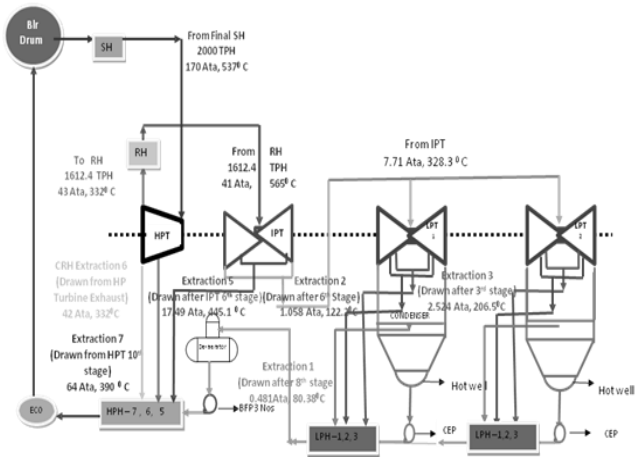

Figure No.3 Extraction Cycle of a Thermal Power Plant

The superheated steam form the boiler expands in the HP turbine and the expanded steam enter into Re-heater and then expands in the IP turbine. The are three heaters in the High Pressure side and three heaters in the low pressure side cascaded as shown above.

Low pressure heater is a vertical or horizontal shell-tube heat exchanger .The bleeding-off steam from turbine is used to heat condensate water from condensate pump. Condensate in tube pass absorbs the heat released from steam in shell pass.

VI. Conclusion

In any steam power plant, regenerative heaters reduce cumulative fuel consumption and increase overall plant efficiency [6,7]. It is necessary to optimise the number of feed heaters located and the position of them. The amount of extraction of bled steam from the high, intermediate and low pressure turbine is also to be mass balanced in order to achieve overall increase in plant efficiency. By the use of feed water heaters, the cumulative increase in feed water heater temperature reduces in fuel consumption considerably.

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