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Thermodynamic analysis of 120 MW thermal power plant with combined effect of constant inlet pressure (124.61 bar) and different inlet temperatures

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ABSTRACT

The thermal power plants are used to generate power. The thermal power plants are designed based on required conditions, but actually inlet conditions are not as per the designed conditions. Variations in the power outputs from power plant are always a matter of disputes. So correction curves for power and heat rate are generated. In this paper, the thermodynamic analysis of 120 MW thermal power plant has been done at particular inlet pressure (124.61 bar) and at different inlet temperatures (507.78 °C, 517.78 °C, 527.78 °C, 537.78 °C, 547.78 °C, 557.78 °C, and 567.78 °C). The correction curves for power and heat rate have been generated for combined effect of inlet pressure and different inlet temperatures. These curves indicate that if inlet pressure is 124.61 bar and inlet temperatures vary, then power output and heat rate also vary.

1. Introduction

This paper is based on 120 MW thermal power plant and a thermal power plant consists of five major components – **(1) boiler, (2) steam turbines** – high pressure turbine, intermediate pressure turbine and low pressure turbine, **(3) condenser, (4) feed water pump** – pump after condenser and pump after deaerator and **(5) feed water heater** – one feed water heater for high pressure turbine, two feed water heater for intermediate pressure turbine and three feed water heater for low pressure turbine.

In the boiler, water converts into high pressure and temperature steam by the constant pressure heating process. Then high pressure and temperature steam enters into a high pressure steam turbine, in which steam expands and some amount of steam extract for feed water heating process. Then steam enters into an intermediate pressure turbine, in which steam expands and some amount of steam again extract for feed water heating process. And finally steam enters into a low pressure turbine, in which steam expands and some amount of steam again extract for feed water heating process. After passing through the low pressure turbine steam is converted into saturated water. Then water enters into the boiler with the help of a pump [1].

Sukrii et al. [2] worked on condenser optimization in steam power plant. Sharda and Batra [3] worked on super thermal power station to improve the performance of the plant by distribution control system technology. Richard and Fritz [4] worked on modernization of turbine and condenser for improving the performance of power plant. Prabhakar and Dinesh [5] applied six sigma DMAIC methodologies in thermal power plants. Vosough et al. [6] worked on condenser to improve the efficiency of power plant. Mateen and Roa Nageswara [7] did structural and thermal analysis of the condenser by finite element analysis. Carvalho and Cristiani [8] analyzed the corrosion in condenser tubes. Claude [9] worked on step-by-step approach to the evaluation and life

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Nomenclature

Ex_i	extraction quantity from HP, IP and LP turbines at different stages (kg/s)
FF	flow function
h_i	enthalpy of steam at different stages (kJ/kg)
L_1	steam used for reducing pressure difference b/w 1st & last stage of HP turbine (kg/s)
L_2, L_3 and L_4	leakage before entering steam in HP turbine (kg/s)
L_5 and L_6	leakage after steam expand in HP turbine (kg/s)
L_7 and L_8	leakage before entering steam in IP turbine (kg/s)
L_9	leakage before entering steam in LP turbine (kg/s)
P	pressure of steam for 120 MW power plant (design condition) (bar)
Q_1	heat addition in boiler (kJ/kg)
Q_2	heat addition in superheater (kJ/kg)
V	specific volume of steam for 120 MW power plant (design condition) (m^3/kg)
W	mass flow rate of steam for 120 MW power plant (design condition) (kg/s)
W'	mass flow rate generated in boiler at different conditions (kg/s)
W_i	mass flow rate of steam at different stages (kg/s)

extension of feed water heaters. Riley et al. [10] worked on a feed water heater. Andreas et al. [11] worked on power plant to improve the performance by an elaborate design process. Rene et al. [12] worked on a simulation of the components of a thermal power plant. Rainer et al. [13] worked on operational flexibility and improve efficiency of the plant. Cheng et al. [14] worked on cascade shell and tube type feed water heater. Bryan and Richard [15] worked on life management and its applications on a feed water heater. Roth [16] worked on the efficiency of thermal power plants. Kaupp [17] published a paper on thermal power plant. John and Terrence [18] explained the complementary fired combined cycle plant design concept and compared its plant performance characteristics with conventional duct fired plants. Michael and Christof [19] worked on modernization of steam turbine. Jeffrey et al. [20] worked on retrofit design and operation for large steam turbine. Jaroslav et al. [21] worked on the reheat concept by biomass fuel to increase efficiency of the plant. Mateen and Roa Nageswara [22] did structural and thermal analysis of the condenser by finite element analysis. Vora et al. [23] worked on performance evaluation of the turbo generator system of a thermal plant by the use of probabilistic approach. Sharma and Singh [24] worked on the thermodynamic evaluation of waste heat recovery boiler for its optimum performance. This work deals with the generation of correction curves for different inlet pressures and inlet temperature conditions. These curves help as a reference or as a document to prove the design of thermal power plant. A layout of 120 MW thermal power plant [26] (Fig. 1).

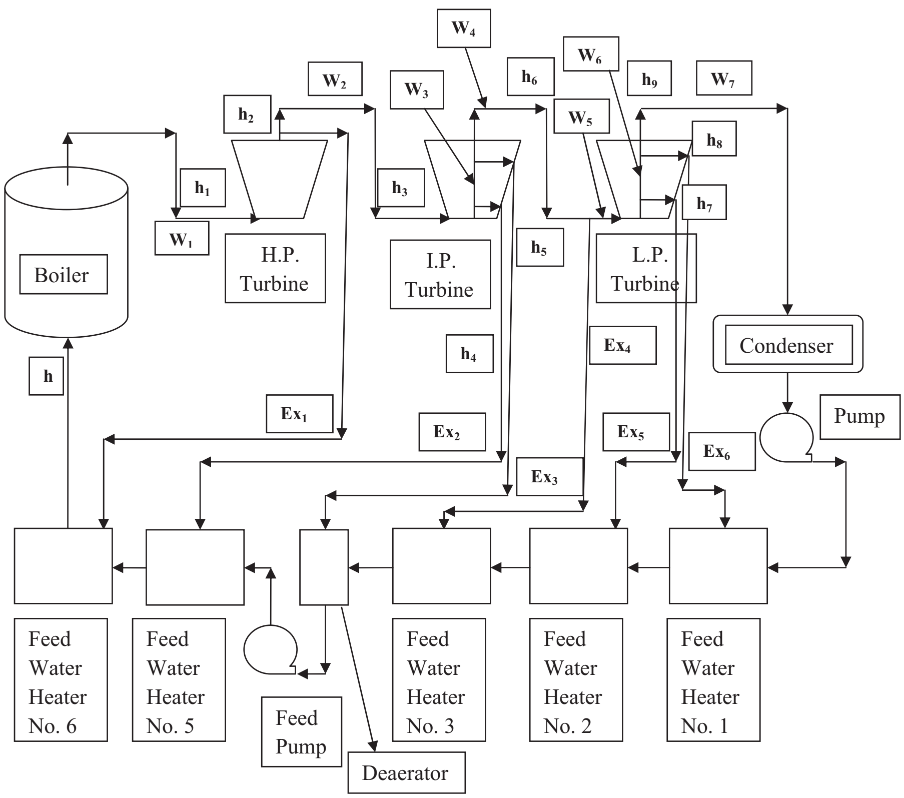

Fig. 1. Layout of 120 MW thermal power plant.