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TITLE OF THE THESIS: EFFECT OF OPERATING VARIABLES ON THE PERFORMANCE OF COMBINED CYCLE POWER PLANT

ABSTRACT

The concept and development of combined cycle is originated from the utilization of waste heat of thermal power plant. A combined cycle as the name implies is the combination of two cycles operating at different temperature, each of which could operate independently. The heat rejected by the higher temperature cycle is recovered and is used by lower temperature cycle to produce additional power to realize an improved overall efficiency. For the combination the separate cycle must operate on separate fluids. Energy conservation concept (or the first law of thermodynamics) does not give the detailed analysis of the losses in power plant components. It is necessary to pinpoint the exergy losses. Exergy analysis enables one to determine the maximum work that can be expected from energy device or process; this is possible because the second law expresses the quality of energy. The purpose of this work is to analyze the performance of a combined power plant according to the second law of thermodynamics using the exergy analysis. The critical review of literature in this field helps in finding the major research gap involved till date, which encourages investigating the effect of major operating variables on the performance of combined cycle situated in Indian climatic condition. In this thesis work the detailed thermodynamic analysis is carried out for different components of combined cycle power plant (NTPC Dadri, Gas Unit) in association with different operating variables, which consists of a gas turbine unit, heat recovery steam generator without extra fuel consumption, and steam turbine unit. The results pinpoint that more exergy losses occurred in the gas turbine combustion chamber reaching 35% of the total exergy losses, while the exergy losses in other plant components are between 7% and 21% of the total exergy losses at 1400 ºC turbine

inlet temperature and pressure ratio 10. This work also considered the effect of the pressure ratio, turbine inlet temperature, pressure drop in combustion chamber, and heat recovery steam generator on the exergy losses in the plant. There are clear effects in the exergy losses when changing pressure ratio and turbine inlet temperature. The effect of pinch temperature on combined cycle efficiency and exergy destruction in different components is reported. The results show that both first and second law efficiency of combined cycle decreases as pinch point temperature increases. The variation in exergy destruction of topping cycle components is almost constant and increases with pinch temperature but variation in bottoming cycle components is different and also increases with pinch temperature. Also the effect of ambient temperature on combined cycle efficiency, gas turbine cycle efficiency, exergy destruction in different components, exergy loss via exhaust and air fuel ratio at lower and higher turbine inlet temperature is reported. The results show that the net decrease in combined cycle efficiency is 0.04% and the variation in exergy destruction of different plant components is up to 0.35% for every $^{\circ}$C rise in ambient temperature. Finally this second law based investigation clearly finds the site of maximum exergy destruction with associated variables which further gives the improvement in this field and special care to the researcher.