INVESTIGATION ON IRREVERSIBILITIES DUE TO HEAT TRANSFER AND FLUID FLOW IN THERMAL POWER CYCLES

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ABSTRACT

This thesis present investigation on thermodynamic modeling and effects of irreversibility's in thermal power cycles using the concept of exergy analysis and entropy generation. Detailed literature review on exergy analysis of thermal power cycles is reported in chapter I. first and second law analysis of steam power cycle, gas turbine cycle, combined Brayton / Rankine power cycle, indirect fired air turbine multi stage reheat cogeneration power cycle, and the gas turbine cycle combined with vapour compression refrigeration system, have been carried out. Detailed parametric study has been done and results are presented. This study include the effect of pressure ratio, cycle temperature ratio, number of reheat stages, pressure drop in heat transfer devices, and the refrigeration temperature on the performance parameters of thermal power cycles.

Second-law based performance assessment of regenerative-reheat steam power cycle has been carried out in terms of irreversibility analysis in chapter II. The reduction in irreversible losses with the addition of backward, cascade type feed water heater and a reheat option are compared with the conventional first law assessment. The second law indicates that maximum exergy is destroyed in the boiler and that these thermodynamic losses are significantly reduced by the incorporation feed water heater. The incorporation of feed water heating results in the reduction of the total irreversibility rate of the plant by 18%. The corresponding improvement in thermal efficiencies is 12%. These two values are enhanced to 24and 14% respectively, by the incorporation of reheat to regeneration.

Thermodynamic analysis of gas-turbine cycle based on first and second law analysis has been carried out in chapter III. It is found that the exergy destruction in combustion process dominates the exergy destruction picture as expected; it represents over 50% of the total exergy destruction in the overall system. As the pressure ratio increase, the exergy destruction in combustion chamber and reheater increase significantly. The result further indicates that the exergy destruction in all the components of the plant is more or less independent of pressure losses in combustion chamber and reheater.

Second-law based thermodynamic performance analysis of multistage reheat combined Brayton/rankine power cycle has been carried out in chapter IV using exergy balance approach.

Expressions involving the relevant variables for specific power output, first-law and second-law efficiency of gas turbine cycle, steam turbine cycle, and combined power cycle, exergy destruction in the components of combined cycle have been derive. Maximum exergy destruction was observed in combustion chamber and least in compressor for a given cycle pressure ratio and temperature ratio.

The study has been extended in chapter V to the performance evaluation of an indirect fired air turbine cogeneration system wit multistage reheat, based on first and second-law

analysis. The effect of various operating parameters on the thermodynamic performance of indirect fired air turbine cogeneration system has been studied. A comparative study between no reheat and multistage reheat shows that there is a significant improvement in electrical power output, process heat production, fuel utilization efficiency, the second law efficiency due to reheat, but the power to heat ratio decreases with reheat.

Exergy analysis is also carried out in chapter VI for the gas turbine cycle combined with vapour–compression refrigeration system. Expressions involving exergy destruction due to irreversibility’s during compression, combustion, expansion, superheating and throttling processes are derived, and examine for the evaluation of its thermodynamic performance. Parametric study shows that the interaction between the combustion irreversibility’s and the throttling losses is dominant in governing the system efficiency with various temperature and refrigeration temperature.