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ABSTRACT

This thesis presents investigations on thermodynamic modeling and evaluation of effects of irreversibilities in advanced 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 1. Second-law based thermodynamic performance analysis of an indirect intercooled reheat regenerative gas turbine cycle with inlet air cooling and evaporative aftercooling of the compressor discharge has been carried out using exergy balance approach in chapter 2. It is shown that maximum exergy is destroyed in the combustion chamber; it represents over 60% of the total exergy destruction in the overall system. The work output of the cycle increases with pressure ratio but the first-law efficiency of the cycle increases sharply up to the pressure ratio (r_p = 36), and further increase in pressure ratio causes significant reduction in first-law efficiency. The second law efficiency behaves similar to first-law efficiency with the pressure ratio but it is found to be lower than the first-law efficiency. The net work output increases with the increase in ambient relative humidity. The first-law efficiency decreases with the increase in ambient relative humidity for the value (ϕ = 40%-60%).

Exergy analysis of a regenerative gas turbine cycle using absorption inlet cooling and evaporative aftercooling has been carried out in chapter 3. It is shown that maximum exergy is destroyed in the combustion chamber. The exergy destruction in combustion chamber, evaporative aftercooler and WH increases significantly with the increase in pressure ratio. But the exergy destruction in regenerative heat exchanger decreases as pressure ratio increases. The net work output and thermal efficiencies decreases with the increase in CIT. The first and second-law efficiency increases initially with the increase in ambient relative humidity but further increase in ambient relative humidity (φ =40%-60%) causes significant decrease in the first and second-law efficiencies.

An energy and exergy analysis is also carried out for gas turbine for cogeneration applications in chapter 4. The effects of overall pressure ratio, overall temperature ratio, and percentage pressure drop on the system performance parameters have been investigated and are compared with gas turbine cogeneration system without regenerator. It is found that the exergy destruction in each component of the cycle is significantly affected by the overall pressure ratio and turbine inlet temperature and very less affected by the increase in percentage pressure drop in heat transfer devices. The maximum exergy is destroyed during the combustion process; which represents about 70% of the total exergy destruction in the overall system. The first-law efficiency, power to heat ratio, and second-law efficiency of the cycle are significantly influenced by the overall pressure ratio and temperature ratio, and small variation were observed in these parameters with variation in percentage pressure drop in heat transfer devices.

Combined first and second-law analysis for a cogeneration system having intercooled reheat regeneration in gas turbine as well as inlet air cooling and evaporative aftercooling of the compressor discharge is carried out in chapter 5. Thermodynamic analysis indicates that exergy destruction in each component of the cycle is significantly affected by the overall pressure ratio and turbine inlet temperature and not at all affected by the ambient relative humidity. It also indicates that the maximum exergy is destroyed during the combustion process. The first-law efficiency, power to heat ratio, and second-law efficiency of the cycle are significantly varies with the change in the overall pressure ratio and TIT, but the change in ambient relative humidity shows small variation in these parameters.