Name : ROHIT VERMA
Name of Supervisor : Dr. Abdul Khaliq
Department : Mechanical Engineering
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ABSTRACT

This thesis presents investigations on thermodynamic modeling and evaluation of the effects of external and internal irreversibilities in thermal power generation systems using the concept of finite time thermodynamics. Finite time thermodynamic study of Rankine cycle, Joule Brayton cycle, Ericsson & Stirling cycle and Dual cycle has been carried out. Detailed parametric studies have been carried out & numerical results are presented. The study includes the effect of heat source/sink thermal reservoir temperatures, effectiveness of the heat exchangers on source/sink heat capacitance rates of external fluids and internal irreversibility parameter on the efficiency, working fluid temperatures and various heat transfer rates to and from the systems. The internal irreversibility parameter is introduced and its effect is seen on the performance of these systems taking into account the finite heat capacitance rates and finite time heat transfer processes.

Finite time thermodynamic optimization has been applied to the endoreversible Rankine power cycle for its generalized power optimization. A generalized expression for its maximum power output as well as efficiency at maximum power is obtained and is compared with observed efficiencies of actual power plants.

A finite time thermodynamic analysis based on a new kind of optimization criterion has also been carried out in chapter 3 for an endoreversible and regenerative Joule-Brayton power cycle coupled with variable temperature thermal reservoirs. Power output increased significantly with increasing hot-cold side temperature ratios. Moreover, the thermal efficiency at maximum ecological function is less than the average of the finite time or maximum power efficiency and reversible Carnot efficiency.

The finite time thermodynamic analysis based on the ecological optimization criterion has also been reported in chapter 4 of the thesis for an irreversible and finite heat capacity rate Joule Brayton power cycle model which includes three types of irreversibilities : finite rate heat transfer, heat leakage, and internal irreversibility. The power output, thermal efficiency, and the exergetic efficiency increases as the turbine irreversibility parameter increased. Results can be used as an important criterion in the design of Joule-Brayton heat engines.

The investigations on finite time thermodynamic evaluation of Ericsson and Stirling power cycles are also presented. The power output and thermal efficiency of both cycles has been optimized, including finite heat capacitance rates of the heat source and sink reservoirs external fluids, finite time heat transfer, regenerative heat losses and direct heat leak losses from source to sink reservoirs.

An ecological performance analysis for an irreversible dual-cycle cogeneration system has been performed in chapter 6. The general and optimal performances of the irreversible dual-cycle cogeneration system, having a finite-rate of heat transfer, heat leak and internal irreversibilities based on the EPC objective function have been investigated. The analyzed results of the dual-cycle cogeneration system considered, working at maximum EPC conditions, have a significant advantage in terms of entropy-generation rate and can be used for the selection of optimal design parameters.