Abstract

The impact of energy crisis and growing concern for the environment has put more thrust on internal combustion engines, gas turbines and rocket motors to perform as more efficient and environment friendly ones. The present work has been made with this motivation to throw light on some specific aspects of atomizing nozzles and gas turbine combustors to optimize their performance parameters in achieving the desired goal of energy economy and clean environment. The Chapter 1 discusses the practical importance of the problem highlighting the state of art and the scope of present work. The work is then divided into three distinct parts and is described in the three remaining chapters of the thesis as follows :

I. **(Chapter 2) Hydrodynamics of Swirl Atomizers - Theory of Air Core Formation and Prediction of Performance Characteristics.**

II. **(Chapter 3) Modelling of Spray Combustion in a Gas Turbine Combustor - Influence of Inlet Air Swirl and Spray Parameters on Combustion and Emission Characteristics.**

III. (Chapter 4) Thermodynamics of Spray Combustion in a Gas Turbine Combustor - An Exergy Analysis and Comparison of Combustion and Second Law Efficiencies.

In part I (Chapter 2), numerical computations on hydrodynamics of swirling flow in a simplex type pressure atomizer have been made. The central theme of the work lies in the theoretical prediction of air core diameter, and important atomizer performance characteristics of a simplex atomizer from the computation of a swirling turbulent flow through the atomizer. The diameter of the central air core inside the atomizer has been predicted from a hydrodynamic situation that yields the minimum resistance to the flow in the atomizer at given operating conditions. The atomizer performance characteristics, namely, the coefficient of discharge and spray cone angle have been evaluated from the predicted velocity distribution at the discharge plane of the orifice and the total pressure drop in the atomizer. The influences of the pertinent input parameters , namely, the liquid flow rate through the atomizer and the geometrical dimensions of the atomizer on air core diameter, coefficient of discharge and spray cone angle have been established. The predicted results have been compared with the available relevant information in the literature.

In part II (Chapter 3), a numerical model of a typical diffusion controlled spray combustion in a gas turbine combustor has been made. The numerical model is based on the two phase separated flow approach. The gas phase chemical reaction between the fuel vapour and the oxidizer has been considered as a single-step, irreversible, finite rate controlled one. The mean reaction rate is determined either by Arrehenius model or by eddy-dissipation combustion model depending upon the relative magnitude of kinetic and turbulent diffusive speeds of reaction. The emission of thermal NO_x is predicted from the kinetics of Zeldovich mechanism. A radiation model for the

gas phase, based on modified first order moment method, has been adopted in consideration of the gas phase as gray absorbing-emitting medium. The basic objectives of the work are as follows :

- To predict the influences of inlet air swirl at different combustor pressures on combustion and emission characteristics like combustion efficiency, wall and exit temperature distributions and exit NO_x distribution.
- To predict the influences of spray parameters like mean drop diameter and spray cone angle on combustion and emission characteristics as stated above.
- To develop an indigenous numerical model of spray combustion in a gas turbine combustor in providing a tool to guide the direction in which the experiments are to be performed in designing a gas turbine combustor for its optimum performance in relation to fuel economy and clean emission at specified operating parameters.

In part III (Chapter 4), an exergy balance, on the basis of flow availability, in the process of spray combustion in a typical can type gas turbine combustor has been made to determine the thermodynamic irreversibilities of the process at various operating conditions and to compare the second law efficiencies with the combustion efficiencies at various operating conditions. The velocity, temperature and species concentration fields within the combustor required for the purpose are obtained from the numerical solution of the transport processes carried out in part II.