Abstract of Ph.D. Thesis

Flow processes in an internal combustion engine have a strong influence on the overall performance and efficiency of the engine. To design an engine cylinder for specific purposes, a design tool which can predict the performance of a given configuration of the engine cylinder is desirable. Nevertheless, the inherent complexities involved in the in-cylinder processes make a prediction tool difficult to develop and use. Many computer programs available in literature, capable of modelling and simulating realistic in-cylinder processes, require enormous computer storage and time, and can only be run on supercomputers. The present work is the first step in the development of a simple prediction tool, to suit the limited computing resources, using a novel method of formulation.

The new method proposed for solving flow problems in internal combustion engines involves dividing the problem into its global and local parts. The global part of the problem assumes the cylinder to be at a uniform pressure at any given time step and computes the mass and energy flows into and out of the cylinder through the ports. It also accounts for piston work and heat release due to combustion. The local part of the problem utilizes the results of the global part as boundary conditions to solve the governing equations of conservation of mass, momentum, energy and species masses, and obtains the flow field variables as a function of space and time.

A computer program called *CARE* has been developed for the **C***yclic* **A***nalysis of* **R***eciprocating* **E***ngines* on an axisymmetric plane. This computer program is applied to the multidimensional modelling of uniflow scavenging in an axisymmetric two-stroke engine. It is found that the initial thermodynamic state of the gases inside the cylinder at the beginning of scavenging has a strong influence on the scavenging characteristics of the engine. This fact has not been accounted for in the works reported in literature. The specification of the initial thermodynamic state in the cylinder has to be made based on the values of the engine parameters and geometry. It is proposed in this thesis that allowing the simulation to run over many crank cycles would alleviate the difficulty in specifying the correct initial state, as the solution finds its own initial state on repeated cycles. This gave rise to the name **Cyclic** *Analysis of Reciprocating Engines* for the computer program.

A parametric analysis has been made to study the influence of the engine parameters, namely, inlet port size, exhaust port size, inlet swirl angle, inlet inclination angle, engine speed, inlet manifold pressure, exhaust manifold pressure, and timing of exhaust valve closure, on the flow field and global quantities inside the cylinder, and the gas exchange efficiencies.

The results of the simulation are presented in the form of velocity vectors, fresh charge mass fraction contours and swirl velocity contours on the axisymmetric plane, at various crank angles. The variation of cylinder pressure, total cylinder mass, fresh charge mass and residual gas mass in the cylinder are plotted as a function of crank position during scavenging for various values of the engine parameters. The mechanism by which each parameter influences the gas exchange is discussed in detail. The various gas exchange efficiencies are also plotted as a function of the engine parameters. The results of the parametric analysis can be stated briefly as follows.

An increase in inlet port size, exhaust port size or inlet pressure, and a decrease in exhaust pressure or engine speed result in an increase in the mass flow through the inlet and exhaust ports, engendering an improvement in scavenging, delivery and charging, and a deterioration in trapping. Inlet swirl affects the efficiencies to a smaller extent, and the efficiencies are optimal for a certain value of the swirl angle. Inlet inclination angle also has only a minor influence on scavenging, and scavenging is better for positive inclination angles. Exhaust valve closure timing affects only the last phase of scavenging, and dictates the extent of short circuiting.