6. CONCLUDING REMARKS

The main objective of the present study was to develop a predictive procedure capable of predicting pressure, temperature and velocity at various locations of a small two stroke crankcase scavenged spark ignition engine and providing engine performance characteristics at the design stage. The focus of the present work was on the wave action phenomenon in engine piping system, particularly the exhaust system with divergent parts.

A numerical algorithm based on the method of characteristics reported by Zucrow-Hoffman (1977) has been employed for the solution of one-dimensional unsteady flow equations describing the flow in engine pipes in terms of the flow variables; pressure, velocity and density. The expressions of the boundary conditions needed for the simulation are derived in terms of the aforementioned variables. Models for the scavenging and combustion processes in engine cylinder are coupled with the wave action analysis in order to determine engine performance characteristics. The predicted pressure at various locations in the engine Husqvarna-250 with MK1 expansion chamber as well as the performance characteristics have been validated against the experimental data of Blair & Ashe (1976). Further, the predicted numerical results of Zucrow-Hoffman algorithm have been compared with the predictions of the existing algorithms, i.e., Benson algorithm and Modified algorithm. The comparisons are carried out for simple flow problems as well as for flow in engine piping system.

The studies carried out in the present work led to the following conclusions.

1. Zucrow-Hoffman algorithm, Benson algorithm and the Modified algorithm give similar results for wave action phenomenon when there is no temperature discontinuity in the flow. In the presence of thermal discontinuities, the predictions of Benson and the Modified algorithms deviate from those of Zucrow-Hoffman algorithm. Zucrow-Hoffman algorithm tends to attenuate and round off temperature and pressure
profiles due to the use of mesh method for integrating the pathline equations. On the contrary, Benson and the Modified algorithms retain the thermal discontinuity throughout the flow which results into higher amplitudes of the predicted pressure and discontinuous temperature profiles.

2. The numerical calculations for the engine Husqvarna-MK1 using the predictive procedure developed in the present work have shown that Benson and the Modified algorithms result into shock formation at diffuser entry and the solution becomes unstable. The shock was not predicted with Zucrow-Hoffman algorithm and it was possible to continue the engine calculations for any number of cycles.

3. Fairly good comparisons of predicted pressure with experimental data were obtained at various locations of the two stroke engine Husqvarna-MK1 using the predictive procedure based on Zucrow-Hoffman algorithm. No shock formation was predicted in the pressure-crankangle diagrams of the exhaust system which is in conformity with the experimental data.

4. The performance characteristics were found to be underpredicted when compared with the experimental data. Nevertheless, the correct trend for the performance characteristics with engine speed was obtained. However, it was not possible to examine the effects of various models of in-cylinder processes such as scavenging and combustion on performance characteristics in absence of the relevant experimental data.

Some other conclusions drawn in the present work during various investigations are:

1. Zucrow-Hoffman algorithm and the other two algorithms do not predict the shock (pressure discontinuity) as a true discontinuity but spread over several meshes. Increasing the number of corrections (ICOR) in Zucrow-Hoffman algorithm results into further increase in the spread of the discontinuity. While refining the mesh size reduces the spread of discontinuity.

2. Increasing the number of corrections ICOR in Zucrow-Hoffman algorithm
results into increase in the amplitude of the reflected pressure waves.

3. The three algorithms do not predict correct phasing of the suction wave in case of diffuser calculations and as the diffuser length increases the phasing further deteriorates.

4. For the case when there is no thermal discontinuity in the flow, Benson and the Modified algorithms give similar results. However, in presence of thermal discontinuities Benson algorithm results into pressure discontinuities if the number of pathlines per mesh is less than 2.

Suggestions for Future work

To improve the predictive capability of the prediction procedure in the present work, the following suggestions may be considered:

1. Detailed models of in-cylinder phenomenon are to be incorporated and validated against more comprehensive experimental data such as fraction of fresh charge in exhaust during the scavenging process and cylinder pressure diagram during the combustion process.

2. Measured coefficients of discharge of various ports are to be used for the direct flow as well as reverse flow situations.

3. Effects of released conditions, particularly temperature on pressure development in the exhaust system requires investigations.

4. Further validations of the carburettor boundary conditions are needed.