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STUDY OF PERFORMANCE AND COMBUSTION CHARACTERISTICS OF A STRATIFIED CHARGE SPARK IGNITION ENGINE

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ABSTRACT

The main target of developing the spark ignition engines is to reduce the hazard exhaust products emitted from these engines. It also aims to increase their thermal efficiency which in turns require the increment of compression ratio. The latter can't achieved in the conventional engines due to the abnormal combustion. There are many ways to accomplish this goal such as applying the stratified charge technique.

Among the techniques of stratification is the use of divided-chamber system which fulfills to some degree the two basic requirements of stratified charge engines: (1) the inhibition of mixing prior to ignition to achieve stratification, and (2) rapid mixing just before combustion and expansion for complete combustion.

Surveying of the available literature establishes the need for furthers research into the combustion characteristics of the stratified charge engines. The optimization of some of the controlling operating and design parameters are still a matter of controversy.

Therefore an experimental set-up was established with the objective of studing the combustion process in divided-chamber stratified charge engine by the injection of different fuels in the pre-chamber followed by oxygen injection with each type of the fuels. therefore the study focused on the effects of the degree of stratification, the pre-chamber volume, and the time of fuel and oxygen injection upon the engine performance and combustion characteristics at different compression ratios and speeds.

Tests were run on a Ferryman A30 marine water-cooled engine with 95 mm cylinder bore and 82 mm stroke. The engine is modified to be a divided chamber stratified charge engine and it was prepared with different facilities to obtain maximum possible flexibility both in the

range over which engine design and operating parameters. These facilities give the following features; variable pre-chamber volume, variable ignition timing, variable pre-chamber injection timing, variable injection of fuel type in the pre-chamber and variable compression ratio.

Instrumentation for measurements of speed, torque, fuel and air consumption, exhaust temperature, water inlet and outlet temperatures, and coolant flow rate were installed. Gasoline, propane and oxygen were injected separately in the pre-chamber. Gasoline was injected by an injection pump through an injector into the pre-chamber. Propane fuel was compressed by a gas compressor and injected through a nozzle into the pre-chamber. The oxygen was injected directly from oxygen container through a nozzle into the pre-chamber. Each injection system was equipped with a control system for injection pressure and timing.

The pre-chamber is cylindrical in shape, and its volume can be varied from 5.0 to 20.0 percent of the engine clearance volume by varying the thickness of the annular spacer fitted between the injector and the pre-chamber body. The Pre-chamber and the main-chamber are connected by a duct of 8 mm opening diameter.

The engine is directly coupled to an electrical dynamometer. This is also used to start the engine and to turn the engine for friction power tests. The experimental results were also supported by theoretical analysis model and computer program for this type of engines. The principle measured pressures for computer simulation purposes traces used to study the combustion characteristics and to interpret the trends in engine performance.

The reported results showed that the optimum pre-chamber volume is approximately 10 % of the total clearance volume. It also showed that the

LIST OF FIGURES

optimum time of starting fuel injection is 50 - 60^{o} BTDC during the compression stroke and ends up at 5^{o} from the beginning of the expansion stroke. Oxygen injection in the beginning of compression with a concentration of 30 % in the used air enhances the engine performance and combustion characteristics.

The results of the study indicated that the stratified charge engines can be operated by injecting different fuels at high compression ratios without problems which in turns leads to increase the thermal efficiency.

The results also showed that the stratified charge engine can be operated at lean mixture with equivalence ratio of 0.55, which couldn't be achieved with the conventional engines. The operation with lean mixture leads to the decrease of NO concentration emitted with the exhaust products.

The obtained results indicated that the charge stratification in a divided chamber has the ability to run at leaner overall equivalence ratios. Equally, in practice, it might well be that faster combustion rates could be achieved with charge stratification. In addition, lower pollutant emission levels are predicted for stratified charge combustion process. Charge stratification is clearly a worthy topic for further experimental work. It is considered that the model reported in this thesis is most useful in providing an understanding disappointing performance of divided chamber (stratified and non-stratified) engines. It might well be possible to incorporate a finite burning rate expression into the theoretical model, perhaps based on the observed flame propagation and pressure rises noted in the experimental work.