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DEVELOPMENT OF DIRECT METHANOL INJECTION FOR A TWO-STROKE SI ENGINE FOR OPTIMUM PERFORMANCE

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ABSTRACT
Two stroke engines have the advantages of low specific weight, simplicity of production and less cost. However it has the inherent drawbacks of poor scavenging and relatively high exhaust emissions.
Due to increasing in demand on petroleum fuel and the threat of environmental pollution, the current designs of two stroke engines need upgradation to eliminate drawbacks of improper scavenging. In addition alternative fuel has to be investigated in order to counteract the rapidly depleting petroleum reserves. Two stroke engine with direct fuel injection and fueled on a renewable fuel like methanol is an alternative in this regard.
In the present work a two-stroke SI engine is fitted with a low-pressure injection system for direct methanol injection. Various compression ratios, and injection pressure are considered for optimization studies and the performance characteristics are studied with regard to brake thermal efficiency, exhaust emissions, equivalence ratio at constant speed.

Key words: Two-stroke SI engine, Direct injection, Methanol

1. INTRODUCTION
Two-stroke S.I. Engine has the advantages of low specific weight, compactness and simplicity in the design, low production cost and low maintenance cost. However this type of engine has two serious drawbacks

- Poor fuel economy
- High-unburned hydrocarbon emission.

These drawbacks will restrict the future use of the two-stroke engine unless substantial improvements in its performance are required, as the current emphasis is on improved economy and lower exhaust. The fuel loss through short-circuiting could be minimized. One method of approach, which is receiving more and more attention, is the application of in-cylinder fuel injection in place of carburetion[1-3].
In the present study a two-stroke spark ignition engine is fitted with a low-pressure injection system for direct methanol injection. The performance of the engine is studied to optimize the system parameters.

2. METHANOL AS ALTERNATIVE FUEL
The world is rapidly dwindling petroleum supplies, their rising cost and the growing danger of environmental pollution from these fuels have led to an intensive search for alternative fuels. The use of methanol as petrol substitute in small two-stroke engine vehicle has now assumed greater importance because of their large population and phenomenal growth rate. Methanol is well established as a good alternative fuel for SI Engines due to its high octane rating, high latent heat of vapouration and wider inflammability limits. If the two-stroke engine could be redesigned for direct fuel injection and fuelled on a cleaner fuel such as methanol, it may be the most desirable small engine of the future[4-6].

3. ARRANGEMENT FOR IN-CYLINDER FUEL INJECTION
The present work is carried out on a commercial two-wheeler engine working on two-stroke principle. Specifications of the engine are given in table 1.
A separate cylinder head is cast in order to accommodate the fuel injector with the existing configuration of the combustion chamber. The volume of the combustion chamber is maintained in such a way as to keep the compression ratio the same. Fins are welded over the head for effective dissipation of heat. A simple pintle type nozzle with single conical spray is used in present study. The spray angle is measured from its photograph and is crosschecked by geometrical calculation on taking its impression on a sheet from a known distance from the injector tip. It is found to be 15 degree.
Special attention is given to the location of fuel injector with respect to spark plug. Spark plug is located as in the original design and using the spray angle as reference, the injector is located opposite to the spark plug in such a way that the most part of the spray from

the nozzle passes at a distance of about 5 mm, below the spark plug tip, in order to avoid wetting of the plug point. This also ensures proper stratification without causing any over rich spot at the plug point, which might otherwise cause unreliable initiation of combustion or even misfiring. The dimensional details of the spray configuration used in the present experimental set up are shown in Fig.1. A copper washer is used as seating for the injector so as to get a leak proof fit.

The fuel pump and camshaft are mounted on a separate rigid foundation with two bearings on either side. The drive for the camshaft is taken through chain and sprocket arrangement from the driver shaft threaded directly to the engine flywheel with a lock nut to tighten it. The other end of the driver shaft is supported by a bearing.

For piston lubrication a small hole is drilled in the intake manifold and the oil is dribbled through it. The oil flow is controlled at the rate of approximately 3% of fuel flow. For lubrication fuel pump with methanol 2% self-mixing castor oil are used as lubricants.

4. EXPERIMENTAL PROCEDURE

In order to study the performance characteristics of the engine with in-cylinder fuel injection experiments have been conducted for three compression ratio namely 6.60:1, 7.56:1, 8.95:1, and injection pressures (viz. 45, 60 and 80 bar) for constant speed at 2500 rpm. When the engine is running under steady state at the specified operating condition the following reading are taken.

1. The manometer reading in mm of water for calculating the airflow rate.
2. The load applied on the dynamometer in Newton's to calculate the brake power.
3. The dynamometer speed indicated by the hand tachometer.
4. Time taken for the consumption of 10 cc of fuel to calculate the fuel flow rate.
5. CO (%) and UBHC(ppm) readings from the automotive exhaust emission analyzer.

5. RESULTS AND DISCUSSION

5.1 Performance of The Engine With In-Cylinder Injection for Different Compression Ratios

With the different compression ratios (viz. 6.60:1, 7.56:1, 8.95:1) used for fuel injection it is observed that the best results are obtained for a compression ratio of 8.95: 1, which is associated with minimum fuel- air ratio (Fig. 2 to 5). The leaner mixtures also result in low CO and UBHC. The low UBHC emission levels are also partly due to higher exhaust temperatures, which tend to oxidize a fraction of the UBHC by acting as a thermal reactor. However at higher loads, at the tested speed the performance of the engine with higher compression ratio drops slightly. This is attributed to the onset of knocking which was observed during the course of experiments.

5.2 Performance of The Engine With In-Cylinder Fuel Injection for Different Injection Pressures

With different injection pressures [viz. 45, 60 and 80 bar] used for fuel injection it is observed that the best results are obtained at an injection pressure of 60 bar which is associated with minimum fuel–air ratio as shown in Figs. 6 to 9.

At lower pressures, due to improper automization fuel evaporation problems would arise resulting in lower combustion efficiency. At high injection pressures difficulty was experienced in setting fuel pump rack, since it becomes difficult to meter the fuel quantity at high injection rates, particularly in view of the fact that the fuel requirement for the present engine under consideration was as low as around 10-15 mm^3 per cycle. Therefore any small adjustment of fuel rack setting would result in deterioration of engine performance.

As regards to exhaust temperature and emission levels of UBHC and CO the general trend is that at optimum injection pressure they have reasonably low values as compared to other injection pressures at all loads and speeds.

6. CONCLUSION

Experiments are conducted on a single cylinder two-stroke spark ignited air-cooled engine with in-cylinder injection of methanol gave a wide spectrum of results from which the following conclusions are drawn.

1. The engine can be successfully operated with in- cylinder methanol injection up to the maximum speed of 2500 rpm.
2. Optimization tests shows that best performance is obtained when the fuel
3. Injection timing is set at 40^0 before exhaust port closed, at an injection pressure of 60 bar and compression ratio of 8.95:1.
4. Maximum break thermal efficiency of about 17.82% is realized when the engine speed is 2500 rpm and a BMEP of 2.58 bar.
5. In-cylinder methanol injection results in lesser emissions of UBHC and CO.

7. TABLE AND FIGURES

Table 1 Specification of the Engine

Type:	Single cylinder, air-cooled, Two stroke SI engine
Power:	6.5 BHP at 5300 rpm
Bore:	57 mm
Stroke:	58 mm
Displacement:	148mm
Compression ratio:	7:1
Ignition system	Magneto ignition system
Fuel:	Methanol

Table 2 Properties of Methanol

Chemical formula	CH_3OH
Molecular weight	32
Specific gravity	0.795
Lower calorific value	19,680 kJ/kg
Octane number	106
Latent heat of evaporation	1168 kJ/kg

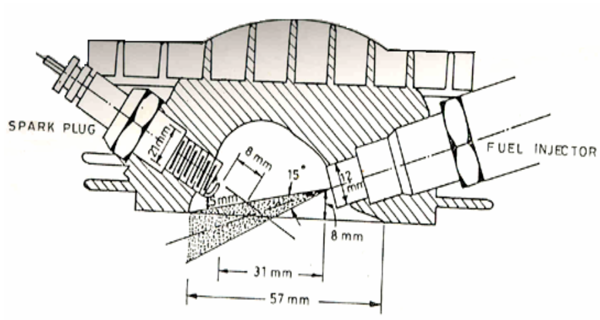

Fig. 1 Combustion chamber configuration

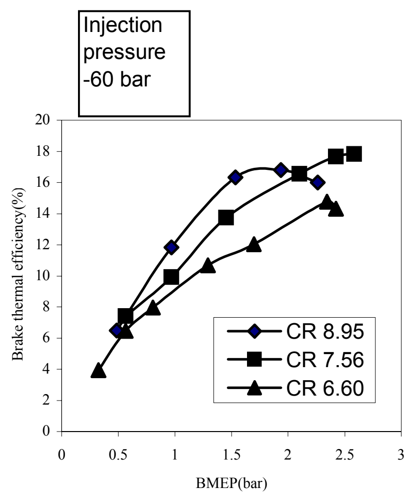

Fig. 2 Variation of Brake thermal efficiency with load

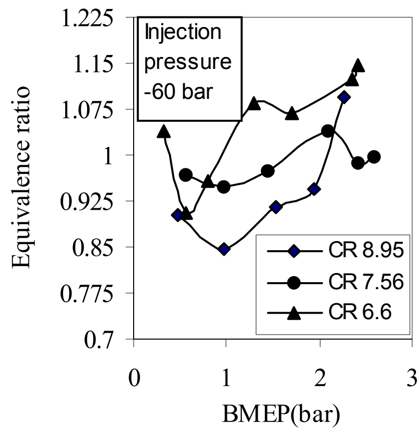

Fig.3 Variation of equivalence ratio with load

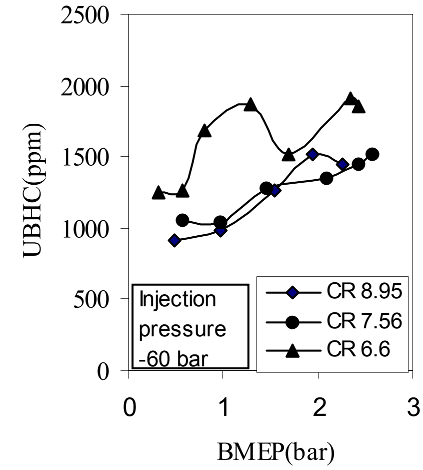

Fig. 4 Variation of UBHC with load

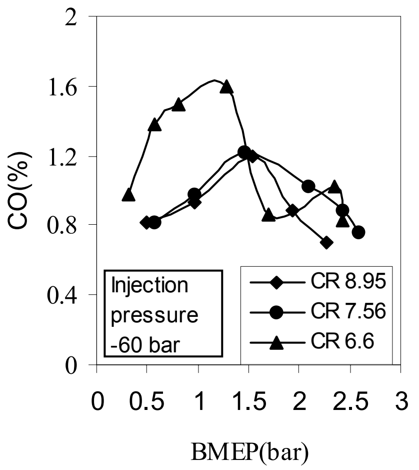

Fig. 5 Variation of CO with load

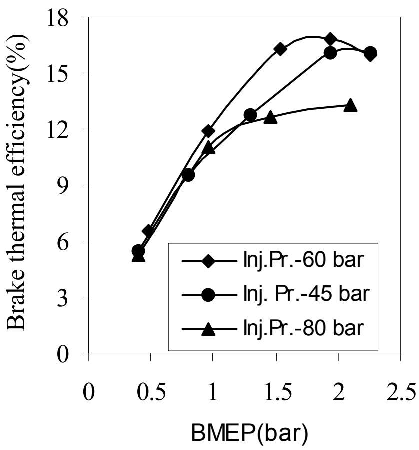

Fig. 6 Variation of brake thermal efficiency with load

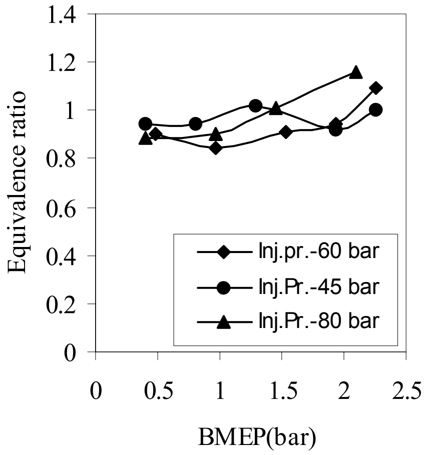

Fig.7 Variation of equivalence ratio with load

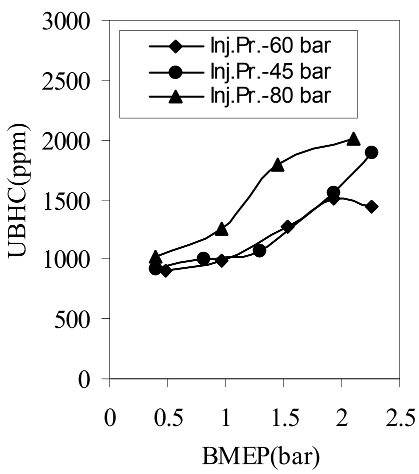

Fig. 8 Variation of UBHC with load

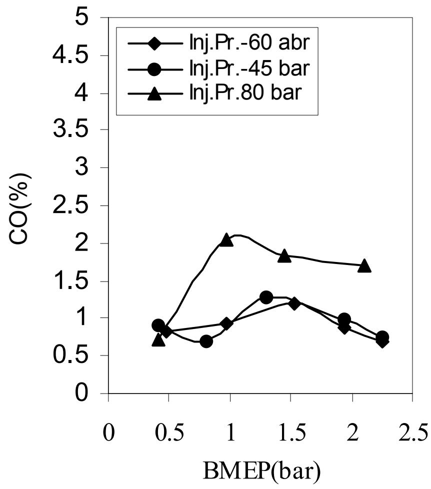

Fig. 9 Variation of CO with load

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