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A Relevant Study on Comparison of Performance Combustion and Emission Valves of CI Engines

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ABSTRACT

An experimental set up was configured with necessary instruments to evaluate the performance, emission and combustion parameters of the compression ignition engine at different operating conditions. A single cylinder air-cooled four-stroke direct injection diesel engine (Kirloskar Engine) compression ratio of 17.5:1, developing 4.4 kW at 1500 rpm was used for this work. Experiments were conducted for the selected oils. The engine was operated with five different blend ratios Viz. B20, B40, B60, B80 and B100 (% volume). The optimal values for performance, combustion and emission were determined for each and particular oils.

Keywords: ***Charge amplifier, CI engine, Combustion, Cylinder, Emission valves, Meters, Oils, Optimal valves.***

1. INTRODUCTION

There is a realization throughout the world that the petroleum resources which are non-renewable, are limited and are being consumed at an alarming rate. The growing demand for energy and gradual extinction of fossil fuels has lead to an energy crisis. Most of the power in industries and transportation is derived from oil and coal. Special mention is needed for automobiles where almost all of the fuels for combustion engine today are derived from petroleum, a non renewable source of energy, which is nearing its end at an unprecedented pace. The grave name of the energy problem was sharply brought into focus by the oil crisis of 1973. Since then, several price hikes have taken place, upsetting economy of most of the nation. The globe today uses about 147 trillion kWh of energy which is expected to rise in the coming future, the expected rise in the world consumption of energy up to 2030. A major chunk of this rise will be due to the developing countries, which are bound to grow by leaps and bounds.

Thus to overcome, the magnitude of the present fuel crisis in India and the significant increase of fuel consumption rate in the transportation and rural agriculture sector over the last few decades as well as due to steep increase in crude oil prices.

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Diesel engines are widely used in the agricultural sector as in tractors and irrigation pump sets.

For the present work, the tests were conducted on a single cylinder, four strokes, naturally aspirated, air-cooled diesel engine coupled with electrical dynamometer test rig. The detailed technical specifications of the engine are given in Table 3.1. Figure 3.1 shows the schematic diagram of the experimental set-up.

2. TRANSESESTERIFICATION PROCESS, FUEL CHARACTERIZATION, ENGINE PERFORMANCE, COMBUSTION AND EXHAUST EMISSION ANALYSIS

Balusamy et al. [2007] have investigated methyl ester of Thevetia peruviana seed oil (TPSO) and blended with diesel fuel, has been tested in naturally aspirated single cylinder diesel engine at rated speed of 1500 rpm. Brake thermal efficiency increases with increasing brake power for all fuels. At maximum load, BSFC of B20 (3.4%) and B100 (10.3%) are higher than that of diesel due to higher density and viscosity of the fuel blends. Mechanical efficiency increases with increasing brake power for all fuels. The performance and emission parameters like brake thermal efficiency, brake specific fuel consumption, CO, HC, NOx, CO_2, O_2, smoke and exhaust gas temperature are measured, analyzed, and compared with that of diesel. Engine performance with TPSO has been found comparable to that of diesel and CO, HC emissions are less but NOx and smoke are slightly higher than that of diesel.

2.1 ENGINE TESTS WITH ESTERS

Gonzalez Gomez et al. [2000] were evaluated the exhaust emission and performance characteristics in a Toyota van, powered by a 2l indirect injection (IDI) naturally aspirated diesel engine, operating on vegetable based waste cooking oil methyl ester (WCOME). Exhaust emission results showed that lower levels of CO, CO_2, smoke (approximately 64%, 7.5% and 48% respectively) and SO_2 can be attained with WCOME. On the other hand, NOx emissions were higher (approximately 20%) for WCOME. Engine performance was satisfactory for WCOME. The power developed by WCOME was higher (approximately 9%) than that for mineral diesel fuel at low speeds although it was lower at higher speeds. It seems that WCOME had better performance characteristics than mineral diesel fuel at low speeds. Polymerization of the lubricating oil did not occur. The viscosity was still in grade at the end of the trial. The wear metals were higher when the trial finished. WCOME is a good option as alternative fuel due to the similarities with mineral diesel fuel and its improvement in exhaust emission levels. However, it is certain that further research into the reduction of NO emissions is needed.

3. EQUIPMENT AND INSTRUMENTATION

The magnitude of the present fuel crisis in India is going to worsen in the foreseeable future due to significant increase of fuel consumption rate in the transportation and rural agriculture sector over the last few decades as well as due to steep increase in crude oil prices. Diesel engines are widely used in the agricultural sector as in tractors and irrigation pump sets.

For the present work, the tests were conducted on a single cylinder, four strokes, naturally aspirated, air-cooled diesel engine coupled with electrical dynamometer test rig. The detailed technical specifications of the engine are given in Table 3.1. Figure 3.1 shows the schematic diagram of the experimental set-up.

3.1 SELECTION OF ENGINE

Table.3.1 Engine specifications

Engine Type	Four stroke, stationary, constant speed, direct injection, diesel engine
Make	Kirloskar
Model	TAF1
Maximum Power	4.4 kW @ 1500 RPM
Maximum Torque	28 N-m @ 1500 RPM
Bore	87.5 mm
Stroke	110 mm
Compression Ratio	17.5:1
Injection Timing	23.4^0 bTDC
Loading Type	Electrical Dynamometer

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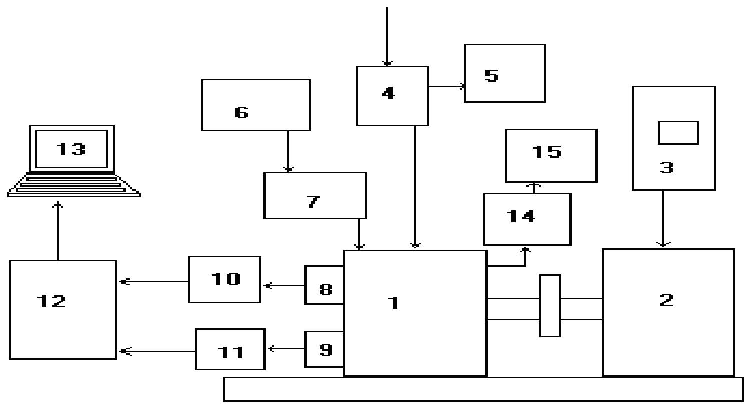

1. Diesel engine
2. Swinging field electrical dynamometer
3. Dynamometer controls
4. Air box
5. U-tube manometer
6. Fuel tank
7. Fuel measurement flask
8. Pressure pick up
9. TDC position sensor
10. Charge amplifier
11. TDC amplifier circuit
12. A/D card
13. Personal computer
14. Exhaust gas analyzer
15. AVL smoke meter

Fig. 3.1: Layout of engine test rig

3.2 DYNAMOMETER

Electrical swinging field dynamometer is used for measuring the brake power of the engine. This dynamometer is coupled to the engine by flexible coupling. This electrical dynamometer consists of a 5 KVA AC alternator (220V, 1500rpm) mounted on the bearings and on the rigid frame for the swinging field type loading. The output power is directly obtained by measuring the reaction torque. Reaction force (torque) is measured by using a strain gauge type load cell. A water rheostat is used to dissipate the power generated. A panel board consisting of ammeter, voltmeter, switches and fuse, load cell indicator, digital rpm readout etc, is also provided. Figure 4.2 shows pictorial view of engine and dynamometer

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Fig. 3.2: Engine and dynamometer

3.3 EXHAUST GAS EMISSIONS

3.3.1 INVISIBLE EMISSIONS

MRU delta 1600 L Exhaust Gas Analyzer was used to measure HC and CO emissions. The emissions of CO (carbon monoxides) and HC (hydrocarbons) were measured by means of infrared measurement. NO_X emissions are measured by using CRYPTON 295 5- gas analyzer. The pictorial views of exhaust gas analyzers are shown in figures 3.3 and 3.4.

Fig. 3.3: MRU delta 1600 L exhaust gas analyzer

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Fig. 3.4: CRYPTON 295 5- gas analyzer

3.3.2 VISIBLE EMISSIONS

AVL 415 Variable Sampling Smoke meter was used to measure the particulate matter in the exhaust. The part of the exhaust gas flow was sampled by means of a probe in the exhaust line and drawn through a filter paper. The resultant blackening of the filter paper was measured by a reflect meter and hence the soot content in the exhaust gas was determined. The pictorial view of smoke meter is shown in fig.3.5.

Fig. 3.5: AVL 415 Variable sampling smoke meters

3.4 COMBUSTION CHAMBER PRESSURE

Engine cylinder pressure is the basic parameter, necessary for any type of engine combustion analysis. Cylinder pressure changes with crank angle as a result of cylinder volume change, combustion, heat transfer to the walls, flow into and out of the crevice regions and leakage. The combustion rate information can be obtained from accurate pressure data.

3.4.1 PRESSURE TRANSDUCER

Cylinder pressure is measured using AVL pressure transducer. The pressure transducer is located in a hole drilled through the cylinder head into the combustion chamber. The sensing element consists of metal diaphragm, which deflects under pressure. This deflection is converted into voltage, which is proportional to pressure. The pictorial view of pressure transducer is shown in fig.3.6. The pressure transducer is fitted in to the combustion chamber through the cylinder head as shown in fig.3.7.

Make : AVL

Model : GH12D
Miniature Pressure Transducer

Measuring Range : 0...250 bar (25 Mpa)

Sensitivity : 15 pC/bar (150 pC/Mpa)

Temperature Range : up to 400°C

The soot deposits occur on the surface of pressure transducer diaphragm is lead to an error margin of upto 10%. In order to avoid this, it is necessary to clean the transducer after every 10 hours of operation. 10% - 15% solution of caustic soda (NaOH) is used as cleaning solution and non-ionic tansies are used as cleaning agent. The transducer is immersed in the bath for 5-8 hours and then dried in an oven at 40°C to 50°C to remove the vapors.

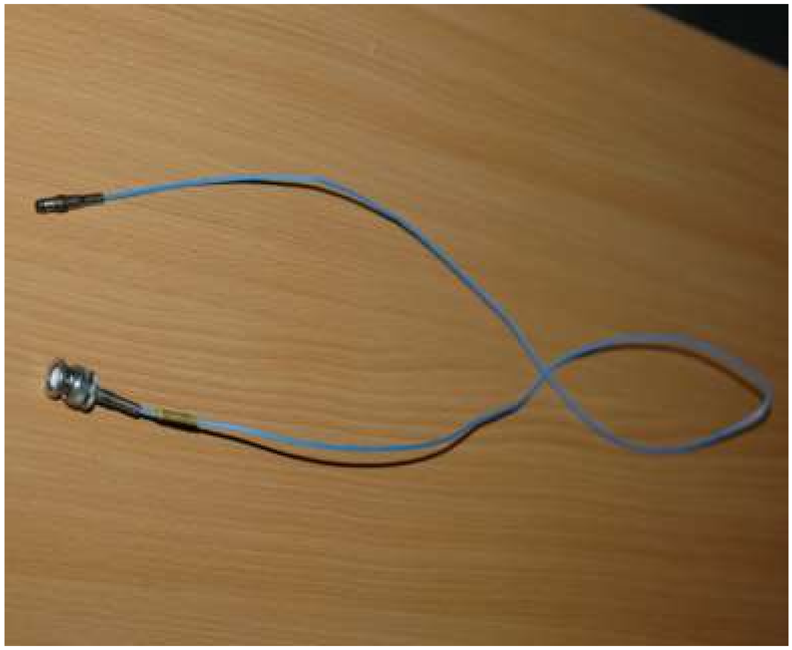

Fig. 3.6: Pressure transducer

Fig. 3.7: Pressure transducer in mounted position

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3.4.2 ANGLE ENCODER

Angle Encoder is used to convert the analog value of angle into digital, electrical signal. Counters, microprocessors or data processing equipment can be connected to the encoder to evaluate these electrical signals and determine the angular position and the speed of revolution. This is fitted carefully on the crankshaft and CDM conditioner (AVL 3016a01) in conjunction with encoder is intended to trigger signal and crank marker conditioning. CDM conditioner is prepared for conditioning 600 input pulses per revolution. The angle encoder in mounted position is shown in fig.3.8.

Make : AVL

Model : AVL 364 angle encoder

Measuring Range : 10 … 15000 min^{-1}

Resolution : 0.5 deg. CA

Temperature Range : -30°C to +100°C for encoder at mounting surface

Fig. 3.8 : Angle encoder

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3.4.3 CHARGE AMPLIFIER

The charge amplifier is used to convert the electrical charge output of the pressure transducer into the proportional voltage. It consists of an operational amplifier with a feedback through a variable capacitor, which is changed according to the range selected. This combination acts as an integrator for the current inputs from the transducer and the integral of the change variations appears as the output voltage. This voltage output is proportional to the total charge at any instant. The photographic view of the charge amplifier setup is shown in fig.3.9. To ensure the accuracy of the pressure measurement, the charge amplifier should be allowed to warm up for four hours before the measurements are to be taken.

Make : AVL
Model : AVL3066A02
Piezo Charge Amplifier
Adjustment : BNC socket on front panel
Measurement Range : 1600 pC / V
No of channels : Two
Output Voltage : 0 … □ 10V at load □1.5 kOhm.

Figure 3.9: Charge amplifier

3.4.4 COMBUSTION ANALYSER

In this work, AVL 615 Indimeter system was used to analyse combustion chamber pressure data. AVL Indimeter consists of A/D card to convert analog signal into digital signals. These digital signals form the input to the AVL Indimeter software. This software analyses the data and is capable of producing pressure-crank angle diagram, log p-v diagram and heat release rate.

3.5 TEST PROCEDURE

Before starting the experiments, all the equipments were calibrated according to the manufacturers' guidelines. The engine was started by hand cranking and was allowed to warm up at no load condition. The engine was fueled with methyl ester, traditional diesel and blends containing 20 percent, 40 percent, 60 percent and 80 percent of methyl ester. For every fuel change, the fuel lines were cleaned, and the engine was left to operate undisturbed for at least 30 minutes to stabilize on the new conditions. The following measurements were made at various loads (0%, 25%, 50%, 75% and 100% of rated load).

1. Fuel consumption
2. Air flow rate
3. Engine output
4. In cylinder pressure data
5. Engine emissions

3.6 ERROR ANALYSIS

The errors associated with various primary experimental measurements and the calculations of performance parameters are detailed. The summary of estimated uncertainties is given in Table.3.2.

Table 3.2 Summary of estimated uncertainties

Parameters	Uncertainty (%)
Reaction temperature	0.249
Exhaust gas temperature	0.41
Pressure	2.0
Brake thermal efficiency	0.31
HC	5.0
CO	5.0
NOx	5.0
Smoke intensity	5.0

4. CONCLUSION

The details of the experimental setup and the different instruments used for the evaluation of performance and measurements of emission are also discussed with the co-workers and colleagues.

The optimum blend for each of the oils tested and the various emission levels are reported. It also provides the scope for further work.

Thus, an experimental set up was configured with necessary instruments to evaluate the performance, emission and combustion parameters of the compression ignition engine at different operating conditions. Where, a single cylinder air-cooled four-stroke direct injection diesel engine (Kirloskar Engine) compression ratio of 17.5:1, developing 4.4 kW at 1500 rpm was used for this work. *As we said above, e*xperiments were conducted for the five di*fferent vegetable oils selectively. The engine was run* with five different blend ratios Viz. B20, B40, B60, B80 and B100 (% volume). The optimal values for performance, combustion and emission were determined for each of the oil.

5. FUTURE SCOPE

The power used in the agricultural and transportation sector is based on diesel fuel and hence it is essential to develop alternatives for diesel. A number of steps have been taken for promoting the conservation of petroleum products. These include improving energy efficiency of refineries and increasing fuel efficiency in the transport sector. Moreover the engine exhausts accumulate the pollution into the atmosphere. Alternative fuels especially for diesel are needed to diminish the impacts of exhaust gas pollution on the environment and depleting fossil fuel reserves. Such alternatives should be compatible with existing engines, associated equipments like fuel injector etc. and fuel transportation, storage and delivery. There are some important properties to be considered while deciding alternative fuel for the existing engines.

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