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A Study on Dual Fuel Engine: Opportunities for Development of Non-Polluting and Efficient I.C. Engine

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Abstract-The fuel used in most of the transport vehicles used in cities and villages as well as pumps used in farms is diesel. The use of diesel in engines causes environmental pollution and harmful effects on living beings by emitting harmful poisonous gases. It also aids global warming. Fuel crisis leads to an increase in demand to search for an alternate fuel. Compressed Natural Gas (CNG) is the best alternate fuel for India. Presently CNG can be easily used in petrol engine by using a CNG kit and minor modification. But it is difficult to use CNG in diesel engines. Research has been done to run diesel engines on CNG and three methods have been found successfully which are:1.Spark Ignition of CNG 2.Direct Injection of CNG in the inlet manifold in Dual Fuel Mode 3. Premixing of CNG and air in pre-mixer in Dual Fuel Mode.

***Key words*- CNG, Dual fuel mode, diesel engine, pre-mixer.**

I. INTRODUCTION

Dual Fuel engines operate on both diesel and natural gas simultaneously. Diesel fuel acts as a 'spark plug' as it auto ignites under compression and then ignites the gas. Natural Gas can be introduced to the combustion chamber by either mixing it with the airflow or injecting it into the manifold/chamber. In the Fumigation process, the gas is blended with air proportionately and the mixture enters the inlet manifold during the suction stroke. The dual fuel operation does not involve any major engine modification, only a pre-mixer is attached on the inlet manifold. In dual fuel engines, at low loads when the gaseous fuel concentration is low, ignition delay period of the pilot fuel increases and some of the homogeneously dispersed gaseous fuel remains unburned and results in poor performance. A concentrated ignition source is needed for the combustion of the induced fuel at low loads.

Further the injection timing of the pilot fuel, injector opening pressure, pilot fuel quantity and intake temperature are some of the important variables controlling the performance of dual fuel engines at high loads. This process has the advantage of instant switchover to diesel-only operation, in case natural gas is unavailable. The degree of diesel replacement by natural gas depends on - the engine operating conditions and the engine design to some extent, typically varying from 60% to 70%. The dual fuel technology has been much more successfully used in engines with slow variation of load, where the engine speed varies in a small range. The use of diesel fuel allows the retention of the diesel compression ratio and its efficiency while the natural gas contributes to economy and is responsible for lower emissions.

II. EXPERIMENT SET UP

This study used 6.5 hp water-cooled four-stroke single-cylinder engines, with one intake and one exhaust valve, shown in Figure 1. In this engine, the auto ignition of a small quantity of diesel pilot fuel injected into the combustion chamber before the piston reaches top dead center, initiates the combustion. The burning diesel fuel then ignites the gaseous fuel. The pilot fuel was ultra low-sulfur (<10ppm) diesel.

Fig.1 shows that a CNG kit is provided to supply of correct fuel quantity during operation. It contains a CNG cylinder having capacity 4 kg and a pressure reducer to reduce the pressure as well as control quantity of CNG which is directly connected to the pre-mixer. Electronic digital weighing scale is used to calculate supply rate of CNG during operation on dual fuel mode. Pyrometer and thermometer are used for measuring the exhaust gas temperature and inlet/outlet cooling water temperature respectively. An air box with a small orifice is used for constant air supply. U-tube manometer is attached to the air box to measure the air supply by measuring the pressure head. Band brake dynamometer is used to apply brake torque to the engine shaft for measuring the brake power of engine at specific RPM. Portable digital tachometer is used to measure RPM of engine output

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shaft. For measuring fuel (diesel) consumption a calibrated burette is used. Readings are recorded after idling the engine for 15 minutes.

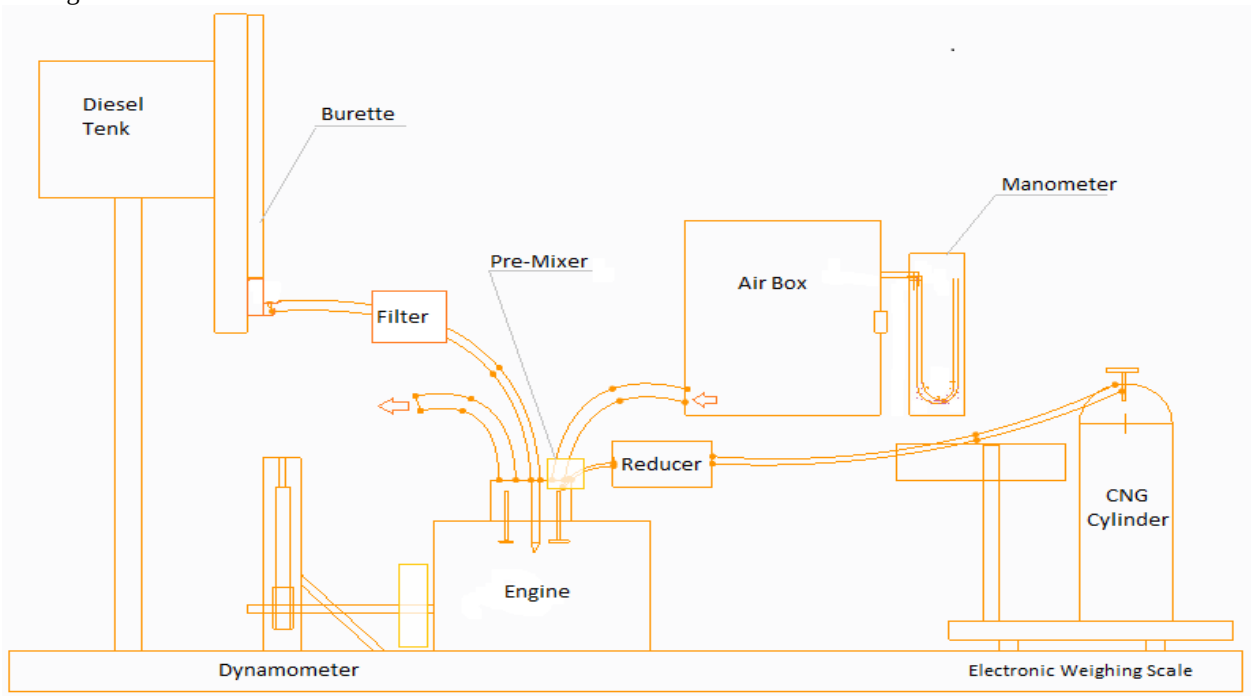

Fig. 1 Experimental Setup

III. RESULTS

1. *Comparison of fuel mass flow rate*

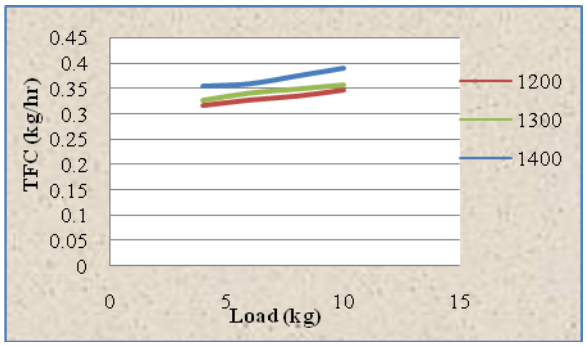

Fig.2 Total fuel (Diesel) consumption

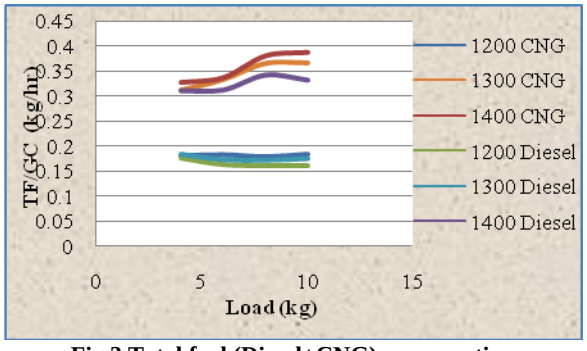

Fig.3 Total fuel (Diesel+CNG) consumption

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Fig.2 and Fig.3 shows the variation in diesel consumption during normal mode and combined fuel consumption during dual fuel mode with respect to load at different engine RPM. In normal working of engine the average diesel fuel used in kg/hr at 1200, 1300 and 1400 RPM are 0.332, 0.345 and 0.370 respectively. During dual fuel mode consumption of the diesel decreases to average 0.167 kg/hr and its substitute by CNG in kg/hr at 1200, 1300 and 1400 RPM are 0.314, 0.324 and 0.342 respectively. This substitution value is approximately 67.34% of total fuel consumption.

2. Comparison of A/F ratio

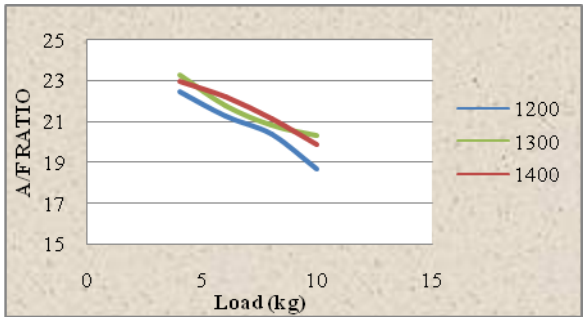

Fig.4 Air-Fuel ratio on Diesel mode

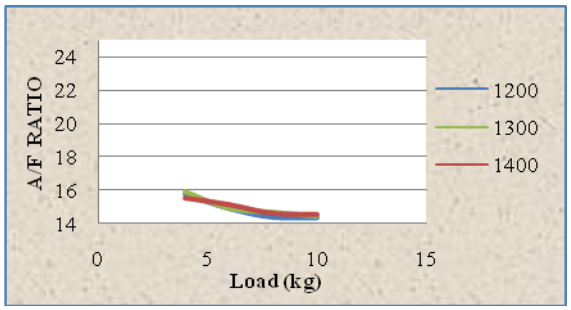

Fig.5 Air-Fuel ratio for dual fuel mode

Fig.4 shows that while engine is working on only diesel fuel the average A/F ratio at 1200, 1300 and 1400 RPM are 21.54, 21.23 and 20.08.This means that approximately 30-35% more air is going inside the combustion chamber. On other hand in DF mode (Fig.5) average A/F ratio at different RPM are 15.16, 14.94 and 14.75 which are very near to theoretical A/F ratio for combustion of fuel. Based on this, we can predict that in dual fuel mode complete combustion of fuels, CNG and diesel occurs which reduces the pollutants and harmful gases from exhaust. It is also reduces heat loss due to high pressure ratio.

3. Compression of Efficiency

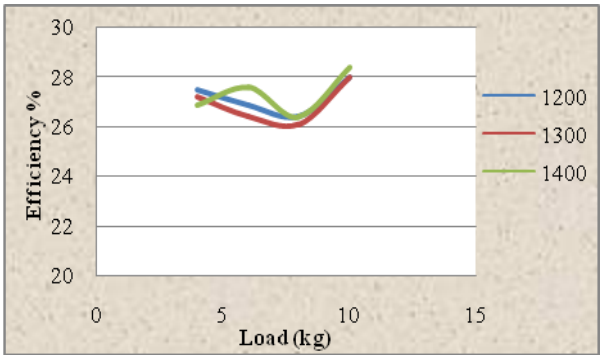

Fig.6 Efficiency of Diesel Engine

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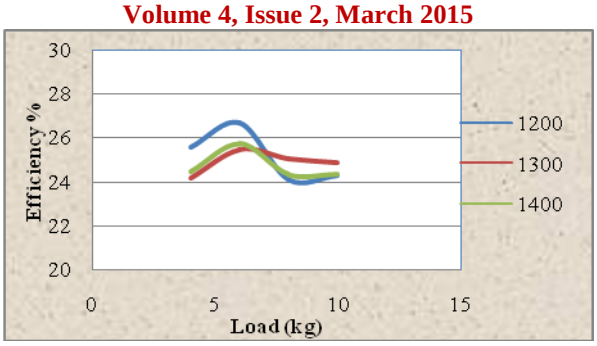

Fig.7 Efficiency of Dual Fuel engine

As shown in Fig.6 average efficiencies of diesel engine are 26.90%, 27.29% and 27.14%. These readings are taken in normal operating conditions. Fig.7 shows that efficiency on dual fuel operating mode. Average efficiencies are 24.88, 24.72 and 24.92 which is quite less than diesel mode because of uncontrolled and partial combustion of fuel. These are inevitable consequences of fuel governing mechanism which automatically controls the quantity of diesel according to engine speed. As load increases on engine from dynamometer, the brake power produced by engine also increases. In this condition the consumption of diesel in normal mode increases. But in dual fuel mode quantity of pilot diesel fuel remains same and the supply of the CNG increases to fulfill load demand. So at part load and full load condition the use of CNG is sufficient as primary fuel.

IV. CONCLUSION

A comprehensive experimental study on the performance measurement of diesel engine and to convert it to dual fuel engine with the help of CNG kit has been carried out successfully. The results obtained during experiment shows that the feasibility of dual fuel engine to replace conventional diesel engine are very high as it reduces the major pollutants such as nitrogen oxides, smoke and carbon dioxide. It has been observed that dual fuel has shown a better overall performance and reduction of NOX.

In experimentation, dual fuel engine works approximately on theoretical A/F ratio (14.75-15.16) which is most desirable operating condition for any kind of engine. These point to lowering the emissions and decreases heat loss. Efficiency is approximately same for both modes, around 26-28%. But it substitutes high cost diesel to low cost CNG and 67.34% substitution is possible in this experiment. So dual fuel mode reduces running cost of engine.

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