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Analysis of Emission characteristics on Compression Ignition Engine using Dual Fuel Mode for Variable Speed

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Abstract:- Rapid depletion of conventional energy sources, along with increasing demand for energy is a matter of serious concern for the mankind. The factor that petroleum based fuels will neither be available in sufficient quantities nor at a reasonable price in future, has revived interest in exploring the use of alternative fuels. It is essential that these alternative fuels for engine should be drive from indigenous sources and preferable renewable energy sources.
In this work, experiments are conducted by varying quantity of pilot fuel and speed with engine load constant
In the present work, the emission characteristics of CI engine are computed using CNG as the main fuel and diesel as the pilot fuel of dual fuel mode. From the experimental investigations, it is concluded that the emissions like NOx, HC, CO and CO_2 are lower compared to diesel engine.

Keywords:- CNG, CI Engine, Emission Characteristics

I. INTRODUCTION

India's energy needs are growing with economic development and growing population. The indigenous energy resources may not be sufficient in the long run to sustain the process of economic development of 9% of Gross Domestic Product. The country's energy supply system continues to be dependent on fossil fuels, which are finite. The oil and gas share in the energy consumption has reached a level of about 45% and is expected to remain so. Globally also the share of oil is expected to remain at the same level in future also.

The industrial growth of any country is measured by the amount of energy generation as well as its consumption. The fuel-air mixture before combustion and the burned products after combustion are the actual working fluids. The work transfers which provide the desired power output occur directly between these working fluids and the mechanical components of the engine. Because of their simplicity, ruggedness and high power-to-weight ratio, the Internal Combustion engines have found wide range of applications in agriculture, transportation and power sectors.

The reasons are driven by two factors: the environmental effects from petroleum based fuel. With more than one billion vehicles around the world, vehicle pollution is becoming the most significant source of air pollution [2]. The World Health Organization (WHO) estimated that approximately 460,000 people die prematurely each year as a result of exposure to particulate matter in the air [1]. Moreover, the air pollution also contributes to negative health impacts such as respiratory symptoms, chronic bronchitis, asthma exacerbation and the deficit in growth of lung function.

From these facts, the CNG has been chosen as one of the promising alternative fuel due to its substantial benefits compared to gasoline and diesel [6]. The main objectives of this project is to study the effects of using CNG as an alternative fuel as a replacement for diesel in compression ignition engines[4]. In the present work, diesel is used as the pilot fuel to ignite CNG and CNG as the main fuel. The impact of injection pressure is to be observed at constant and variable loads with different engine speeds to study the emission characteristics. In the present work, comparison analysis is to be carried out with diesel and dual fuel operation.

II. EXPERIMENTATION

The experimental setup consists of a single-cylinder, four-stroke, vertical water cooled, direct injection, natural aspirated, diesel engine connected to water brake dynamometer for loading of the engine. Experiments were conducted with pure diesel and dual fuel mode (diesel+CNG) at different engine speeds ranging from 800 rpm to 1300 rpm [3, 5]. Provision is also made for interfacing air flow, fuel flow, temperatures and speed measurement. The emphasis is on comparison of the engine performance and emissions with Diesel alone and dual fuel mode (diesel + CNG). The layout of experimental set up is shown in figure 1.

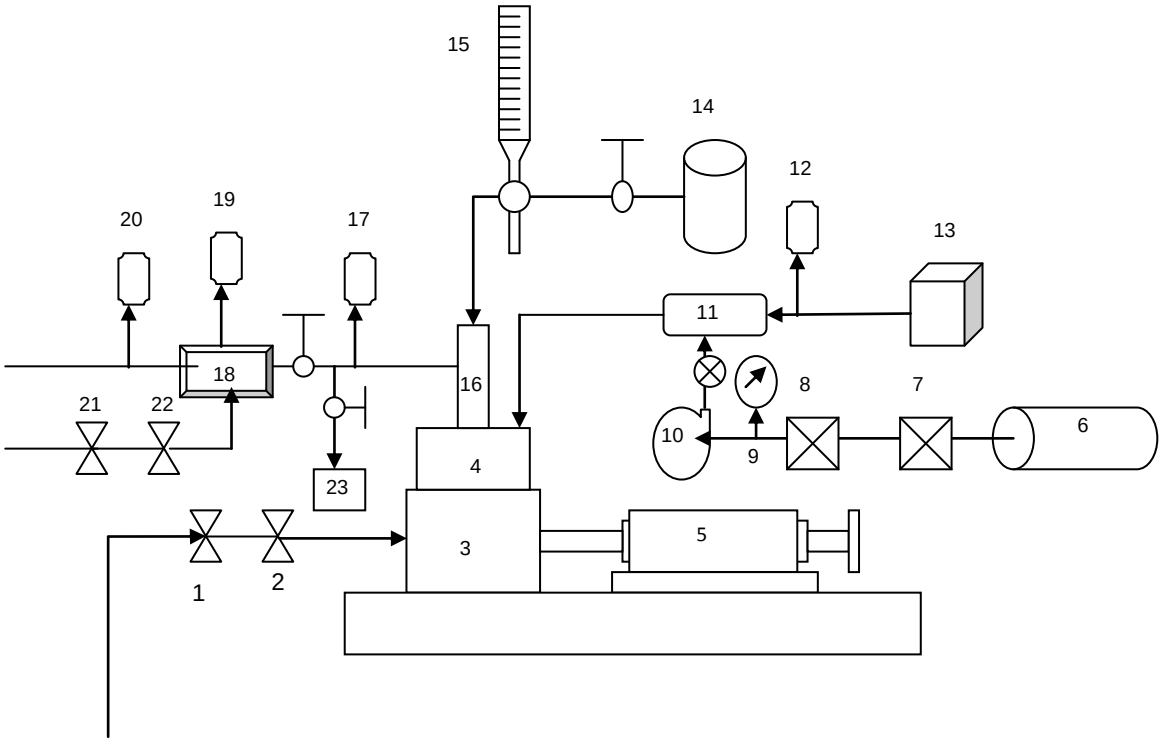

Fig: 1 Layout of Experimental Set up

[1. Cooling Water flow meter 2. Inlet water temperature Sensor 3. Engine block 4. Cylinder head 5. Hydraulic Dynamo meter 6. CNG cylinder 7. ON/OFF Valve 8. Solenoid valve 9. Pressure gauge 10. Regulator 11. Gas-air mixer 12. Manometer 13. Air box 14. Fuel tanks 15. Diesel flow measuring unit 16. Fuel injection system 17. Exhaust gas temperature sensors at inlet calorimeter 18. Calorimeter 19. Calorimeter outlet water temperature sensors 20. Temperature at outlet calorimeter 21. Calorimeter water flow meter 22. Calorimeter inlet water temperature sensor 23. Emissions analyzer point].

III. RESULTS AND DISCUSSION

The results from the experiments performed on the single cylinder, four-stroke, direct injection diesel engine operating at maximum load are shown from fig 2 to 5 and discussed below.

As observed from Figure 2, the NOx level for dual-fuel operation is considerably lower than conventional diesel fuel for engine under maximum load conditions. The formation of NO_X is largely dependent on the peak temperature in the combustion chamber as well as the concentration of oxygen and nitrogen gas from the intake air.

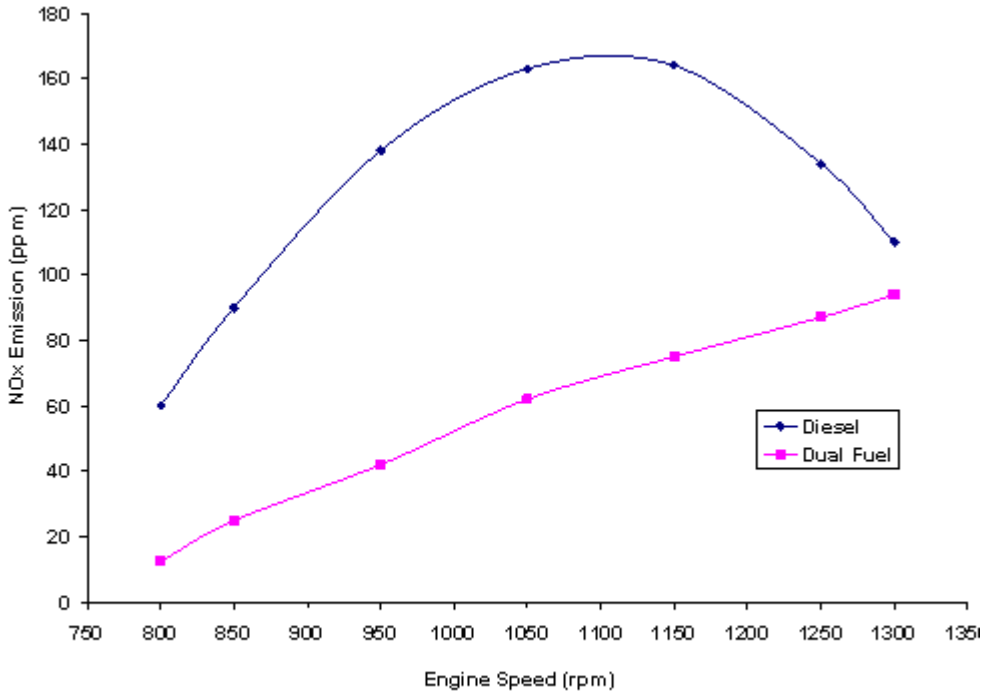

Fig. 2 Engine Speed vs NOx Emission with Dual Fuel Operation

The concentration of O_2 is reduced in the chamber due to the presence of gaseous natural gas fuel, which will displace an equal amount of air.

From the Figure 3, the emission level of HC for dual-fuel operation is substantially higher than diesel fuel. For diesel fuel, the level of HC emission records a slight increase with engine speed but is still at a much lower level than dual-fuel. With increasing load, the amount of HC produced in the emission will decrease since greater combustion efficiency can be achieved with increased temperature. From the graph, it can be observed that the level of HC for dual-fuel decreases with engine speed.

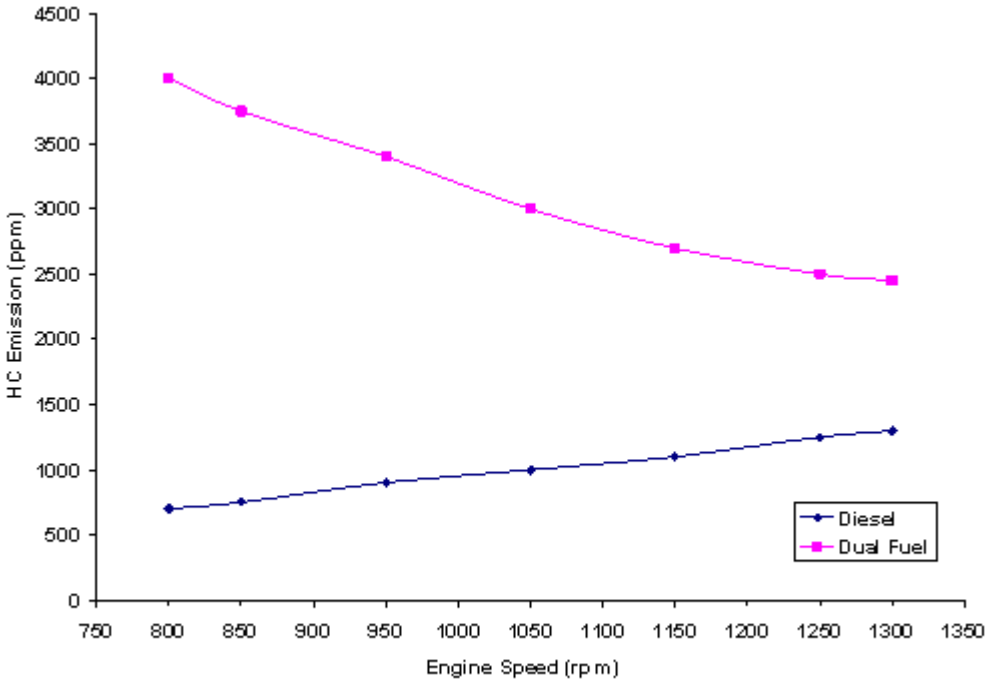

Fig 3 Engine Speed vs HC Emission with Dual Fuel Operation

Figure 4 shows the emission characteristics of diesel fuel and dual-fuel operation. As can be seen from the figure 4, a significant reduction in carbon monoxide emission can be achieved by running the engine with dual-fuel operation. It is observed that there is a decrease in CO emission for engine speeds ranging from 800 rpm to 1150 rpm with diesel. This

result is in agreement with the increasing exhaust temperature recorded for diesel fuel operation. At a high speed of 1300 rpm the CO emission becomes higher due to engine knocking which results in lower combustion efficiency. From the figure, it is observed that the Natural gas produces a greater combustion efficiency leading to lower amounts of CO since natural gas in its gaseous state usually contain less contaminants than diesel fuel.

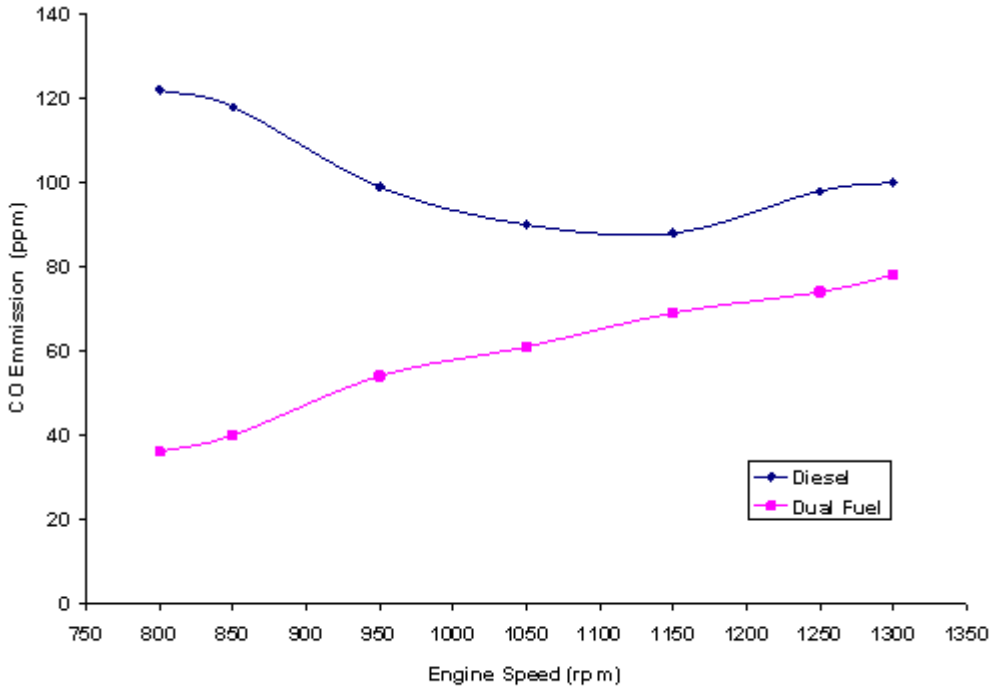

Fig. 4 Engine Speed vs CO Emission with Dual Fuel Operation

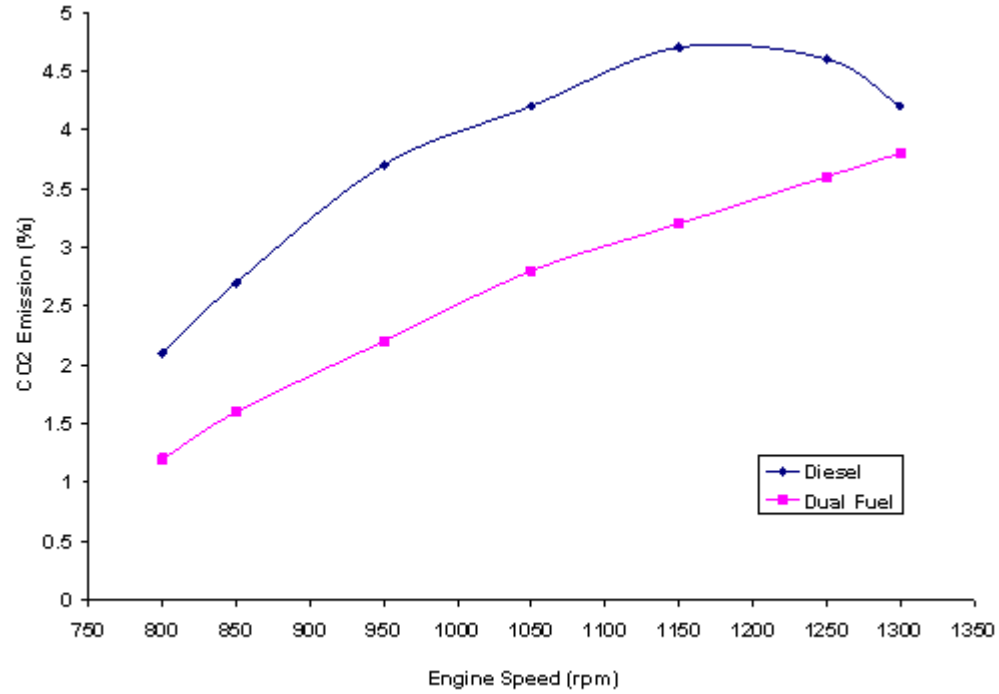

Fig. 5 Engine Speed vs CO_2 Emission with Dual Fuel Operation

From the figure 5, dual-fuel operation under maximum load operating condition produces less CO_2 compared to diesel by an average of 1.16%. The most significant reduction occurs at engine speed of 1100 rpm where dual-fuel provides reduction of 2.2% in CO_2 emission. From Figure 5, a trend in CO_2 emission is observed, an increase in engine speed will in turn cause the CO_2 level to rise gradually with both diesel and dual-fuel.

IV. CONCLUSIONS

The experiments are conducted at various speeds ranging from 800 rpm to 1300 rpm for maximum load and the conclusions obtained are given below.

- The emission characteristics for maximum operating load show a reduction in carbon monoxide, oxides of nitrogen and carbon dioxide. The level of unburnt hydrocarbon emission increased by almost two and a half fold when dual fuel is used.
- The unburnt hydrocarbon in dual-fuel operation for maximum load increases with increase in engine speed. This is a direct result of uncontrolled natural gas flow into the engine which produces methane gas accumulation in the exhaust.

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