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METHANOL AS ALTERNATIVE FUEL IN HIGH COMPRESSION RATIO TWIN SPARK IGNITION SI ENGINE

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ABSTRACT

The experiments have been carried on the effect of methanol- gasoline blends on the engine performance and combustion characteristics. 4-stroke cylinder digital twin spark ignition engine is used in performing tests at different loads for the blends like M0, M20, M40, M60, M80, as well as for pure methanol also at 26^{o}BTDC for one spark plug and 24^{o}BTDC for the other one. As methanol is more volatile than gasoline, the results depicts good enhancement in physical properties due to the addition of methanol. As per the results obtained through experiments it shows that there is an increase in both brake thermal efficiency and fuel consumption with the increase of methanol content in blends. From the results it is also observed that there is a decrement in the emission of CO, UBHC, NO_x.

Key words: DTSi, Gasoline, Methanol, UBHC, SI, HC, CO.

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1. INTRODUCTION

There is a huge need for finding an alternative to fossil fuels as the threat for the issues like global warming, environmental degradation and energy security is increasing day-to-day. Despite with the fact that the fossil fuels are being used safely, it has a lot of side effects on environment by incrementing the global warming. So this creates a need for the usage of renewable energy fuels. Alcohols are recommended for SI engines [1, 2] as they are known for their low global warming potential. Methyl Alcohol (CH_3OH), popularly known as methanol is derived from organic compounds called alcohols. Methanol can be produced from synthesis gas, gasification of coal, biomass and many more ways. Methanol can be easily produced as these raw materials are found in plenty amounts [3, 4].

Now-a-days many researches are conducted on the consumption of methanol or methanol gasoline for Spark Ignited engine as a fuel. There is a decrement in HC and CO emissions and increment in the engine torque, brake power and volumetric efficiency while using low content rates of alcohol gasoline (methanol and ethanol) when compared to the operation with pure gasoline[5]. As the methanol content in the fuel blend increases there is a decrement observed in the emissions of CO and NO_x when consuming 10, 20, 85% methanol-gasoline blends in SI engines [6]. When the engine is tested with methanol and ethanol as substitute fuels there is increment in thermal efficiency and decrement in the NOx and CO emissions [7]. Many researches were conducted on the emissions in SI engine consuming methanol-gasoline blends by the addition of ethanol as a co-solvent depicts an increment in HC emission for M25 (gasoline having 6 vol % ethanol and 19 vol % methanol) and decrement in the emission of NO_x when compared with those of gasoline and M10(gasoline having vol % ethanol and 8.5 vol% methanol) for various loads of engine. The CO emission was lower using methanol-gasoline blend than gasoline, for low and medium loads. But for higher loads, that of M25 was higher[8]. The studies in comparison with two flex-fuel depicts decrement in the emissions of CO and NO_x while consuming methanol [9].

In this work the usage of gasoline-methanol blends as well as neat methanol as fuel is experimented in digital twin spark ignition engine. In the comparison with single spark plug engine, the combustion will be much efficient because of the two spark plugs which are fixed at the two ends of cylinder head improves the combustion by reducing the flame travel distance. The performance parameters like brake power, Indicated power, friction power, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, total fuel consumption brake specific fuel consumption are assessed. The emission characteristics were also performed using the engine. The observation of results depicts an increment in brake thermal efficiency. There is also a decrement in the percentage of CO and UBHC.

2. EXPERIMENTAL INVESTIGATION

The work was done using a single cylinder four stroke variable compression ratio engine. The spark plugs are fixed at two ends of the cylinder head. The engine was able to operate under different compression ratios varying from 4.5 to 10.5. The experiment was conducted using the engine at fixed compression ratio 12. The blends which were prepared on volume basis are poured into fuel tanks using measuring burette. There is small modification done in carburettor main jet to increase the rate of flow of fuel as the calorific value of methanol is lesser than that of gasoline. The excess air ratio was fixed by adjusting air adjustment screw.

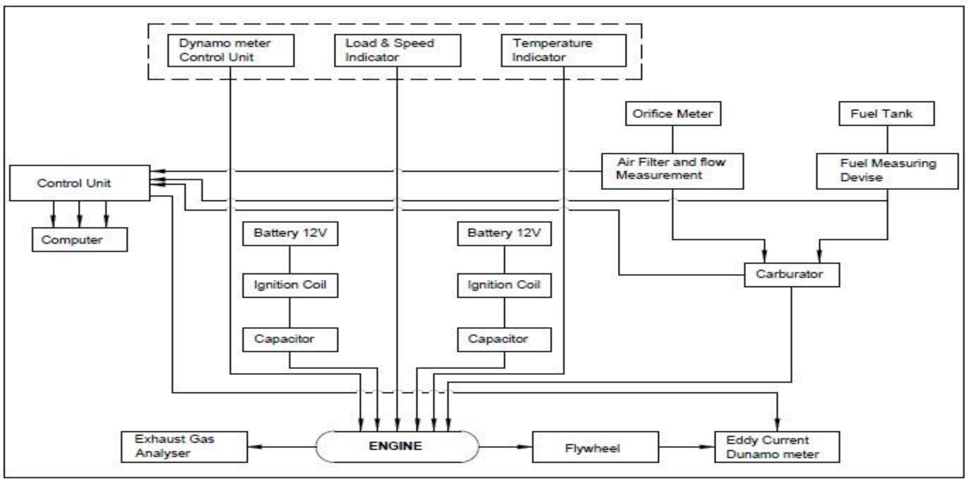

Figure 1 Schematic diagram of Engine setup

3. RESULTS AND DISCUSSIONS

3.1. Engine Performance

During the engine operation there will be a good combustion rate as the gasoline-methanol blends has methanol which provides oxygen as it is an oxygenated fluid. As the percentage of methanol in the blend increase the better results are obtained for it. With the increase of methanol content the flash point, fire point, viscosity is reduced significantly. The variation of TFC with respect to different load is presented in the figure 2. The graph depicts that fuel consumption is increased for all blends when compared to gasoline. This is well known that calorific value of gasoline is higher than methanol. To overcome that power loss flow rate of fuel has been increased. However it shows improvement in brake thermal efficiency. Experiments were conducted at different loads with fixing crank angle 26^{o} BTDC for one spark and 24^{o} BTDC for the other one. The emission parameters are determined with the help of gas analyser. The Figure 1 shows the schematic diagram of test engine.

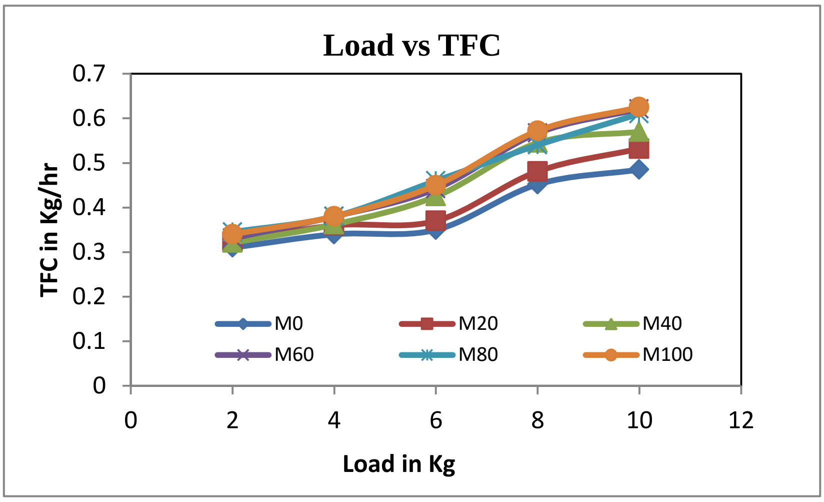

Figure 2 TFC with respect to Load

The effect of gasoline and gasoline-methanol blends on engine power can be observed in Fig.3. The power obtained with gasoline is 2.22KW at maximum load. Power obtained for blends varies from 2.31KW to 3.48KW. The engine power is increased by about 36% at the minimum load. There are many reasons to consider for increasing power using methanol blends is explained in brake thermal efficiency discussion. The increase in torque is an important reason for increasing the power. The effect of gasoline and methanol fuels on brake thermal efficiency at different loads is shown in fig.4. The maximum brake thermal efficiency obtained by gasoline is 23.65%. With the usage of methanol-gasoline the value of brake thermal efficiency is gradually increased. The maximum BTE obtained when methanol as fuel is 28.24%. The increase in brake thermal efficiency is about 19.4%. The higher laminar flame speed of methanol than most of the hydrocarbons can be a reason for increased thermal efficiency [10, 11]. Therefore maximum heat is utilised inside the combustion chamber before it loses due to the higher flame velocity leads to increase thermal efficiency. The presence of higher oxygen in methanol helps to get complete combustion by reducing the emission is a second reason for increasing efficiency. The reduction in work during the compression stroke due to high heat of vaporization of methanol can be a third reason for increasing thermal efficiency.

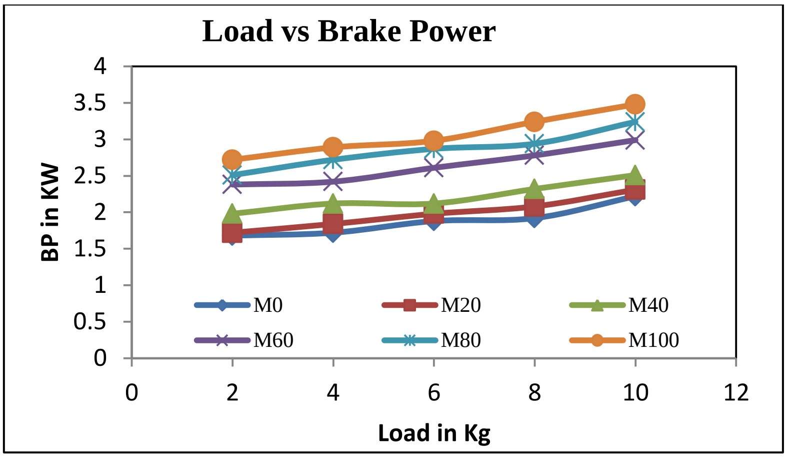

Figure 3 Brake Power with respect to Load

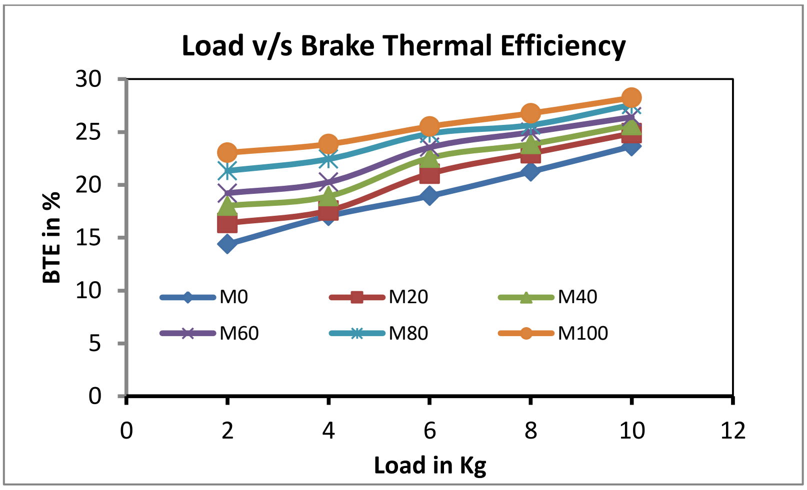

Figure 4 BTE with respect to Load

The indicated thermal efficiency improved for different blends of gasoline – methanol can be observed in the figure 5. The indicated thermal efficiency is increased about 26.15% when methanol is used as fuel at the higher load. The higher octane number and flame speed leads to get complete combustion increases the efficiency when methanol is used as fuel.

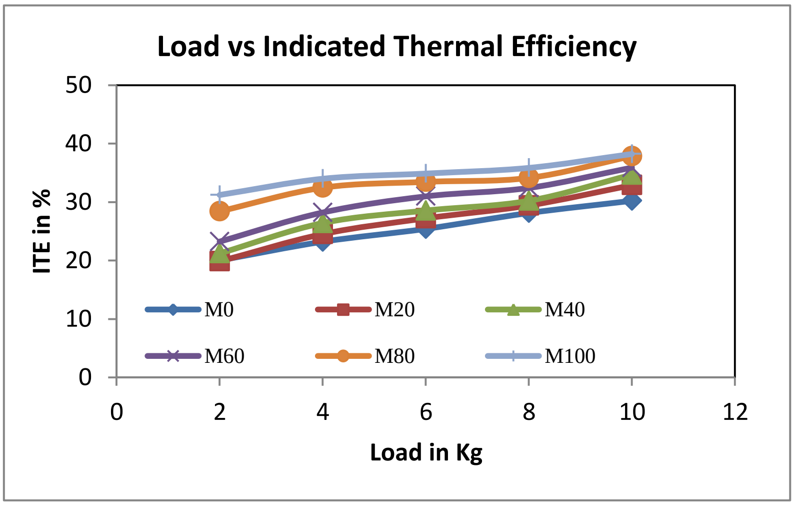

Figure 5 ITE with respect to Load

3.2. Exhaust Emissions

The figure 6 describes the carbon monoxide emission for different percentages of methanol with respect to load. The carbon monoxide is decreasing by increasing the methanol percentage in blends. The reduction in CO is about 26.2% at lower load and about 22.16% at the higher load. It is also observed that CO is decreasing by increasing the load. The combustion chamber temperature is increasing by increasing the load can be a reason for reduction in CO. The figure also reveals that CO is decreasing by increasing the methanol content in blends. The oxygen enrichment and higher operating temperature helps to reduce the CO emission [10, 12,15].

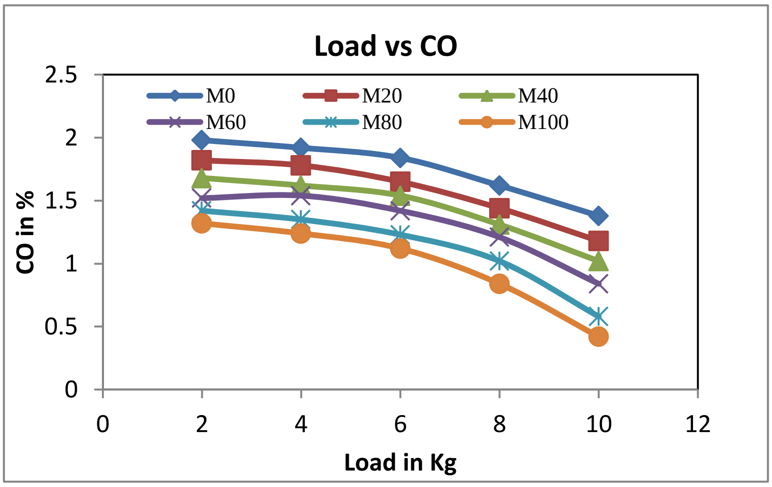

Figure 6 CO with respect to Load

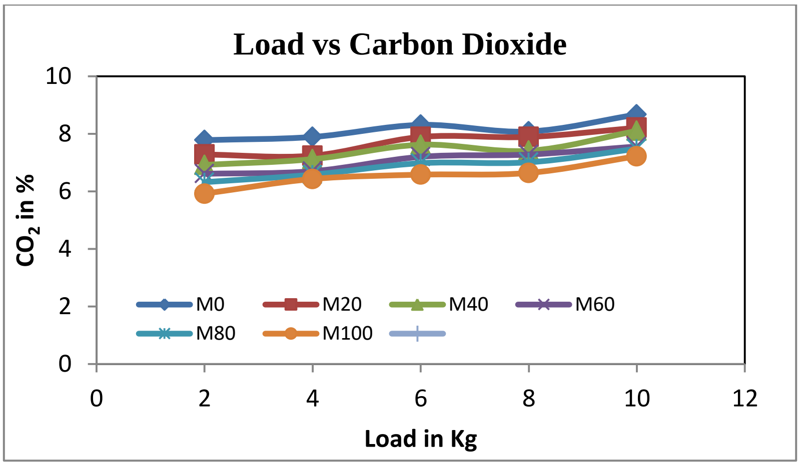

Figure 7 CO_2 with respect to Load

The variation of CO_2 with respect to load and different gasoline – methanol blends elaborated in the figure 7. The CO_2 with respect load showing decreasing trend by increasing the methanol percentages in the blend. The decrease in CO_2 is about 17.8% at the higher load. The emission of CO_2 is mainly dependent on C/H ratio of the fuel [12, 13]. The less C/H ratio of methanol leads to decrease the CO_2 emission. The blends show less CO_2 emission because of less C/H ratio and C content in methanol when compared to gasoline. The presence of excess oxygen in the methanol compared to gasoline is the second reason for decreasing carbon dioxide emission.

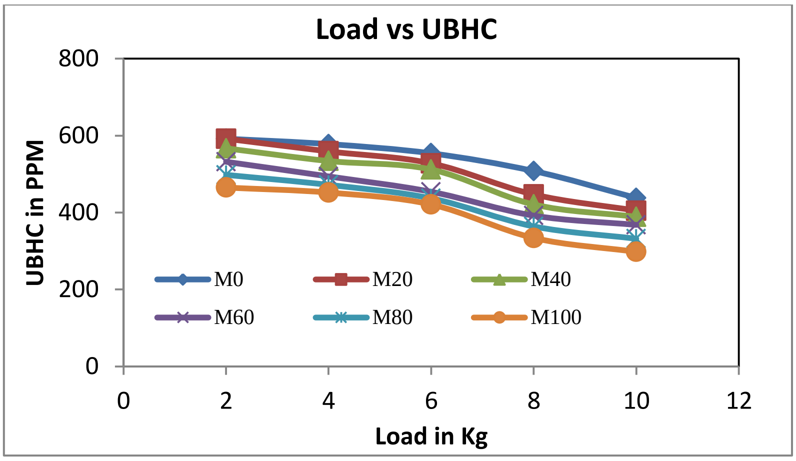

Figure 8 UBHC with respect to Load

The reasons for unburned hydrocarbon emission are improper combustion, misfires, valve overlapping, exhaust valve leakage, lubricating oil leakage to the combustion chamber due to warn out piston rings and crevices [13]. The emission of UBHC with respect to load for different blends is plotted in the figure 8. The HC emission is decreasing by increasing the methanol percentages as well as load. There is a significant reduction in HC is about 41.2% at the higher load. Due to the higher operating temperature at higher load helps to achieve complete combustion may decrease the HC emission. The higher oxygen present in the methanol leads to decrease the HC emission by complete combustion.

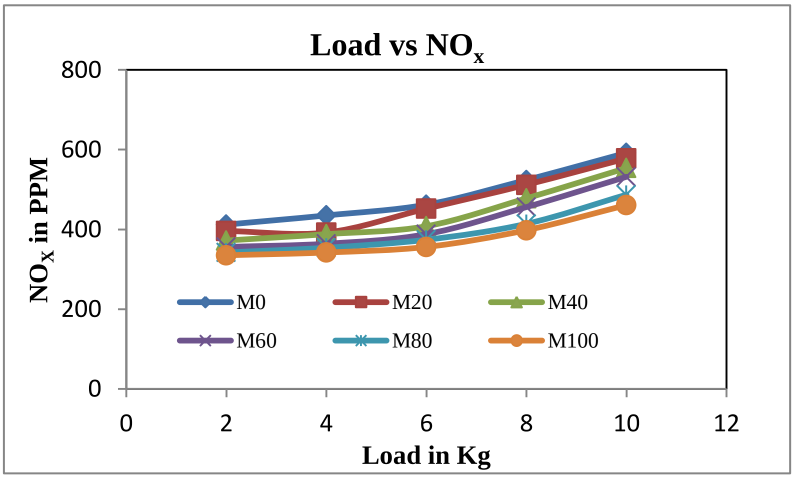

Figure 9 NO_x with respect to Load

The comparison of NO_x emission at different gasoline – methanol blends is shown in the figure 9. NO_x emission is continuously decreasing by increasing the methanol content in the blends. The decrease in NO_x is about 23% at the higher load and about 26% at the lower load. It is also observed that NO_x is increasing by increasing the load on engine. However it is reducing with increase in methanol percentage in the blend. The reason for increasing in NO_x at higher loads is due to the increase in temperature by increasing the load. Methanol has higher heat of vaporization reduces the combustion chamber temperature is important reason for decreasing NO_x emission.

4. CONCLUSIONS

The effect of methanol on performance and emission was assessed experimentally in a single cylinder 4-stroke variable compression ratio twin spark ignition SI engine. The experimental results revealed that, fuel consumption is increased due to the lower energy value of methanol by increasing the methanol content in the fuel. However thermal efficiency is increased. The increase in fuel consumption is compensated by increase in thermal efficiency. The emission of carbon monoxide, carbon dioxide, unburned hydrocarbons and NO_x were reduced by increasing methanol percentage.

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