Experimental Investigation on Twin Spark Ignition Engine using Methanol Fuel at Different Spark Timing Combinations

[1] Dr. Antony A. J, [2]Divakar Shetty S
[1] Principal, Bearys Institute of Technology, Mangalore, Karnataka, India.
[2] Department of Mechanical Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Bengaluru, India.

Abstract: Higher octane number and clean burning ability of the renewable energy sources attracted the researchers as alternative for petrol. Many researchers have studied the effect of methanol and gasoline – methanol blends as fuel for spark ignition engine and showed better results for methanol in case of performance and exhaust emissions. The potential to use gasoline – methanol blends as fuel is due to improved performance and reduction in CO, CO_2, UBHC and other pollutants. In this work, effect of spark timings on engine performance and emissions is studied at four different spark ignition combinations. The experimentation carried out on single cylinder four stroke twin spark ignition engine for both gasoline and methanol under full throttle condition at the fixed engine speed of 1600 RPM. The experimental results revealed that, fuel consumption increased for methanol compared to gasoline. However efficiency of the engine increased for methanol fuel due to the higher octane number and laminar speed of methanol with decrease in CO, CO_2, UBHC and NOx.

Index Terms **- Manifold, LPG, Gasoline, CO, CO_2, NO_x, UBHC.**

I. INTRODUCTION

The alternative fuels that quite resemble gasoline are derives from organic chemicals namely alcohols .The compounds like methanol and ethanol sound like good candidates to substitute the former since they have almost similar and better combustion characteristics compared to gasoline [1]. The alcohols namely methanol and ethanol are organically produced by the fermentation and distillation of live-stocks rich in starch content. Synthesis gas for the production of crude methanol can be obtained from the gasification of coal, wood, straw, garbage, plant stalks. The synthesis gas can also be got from decomposing biomass which currently is a major source of methanol and ethanol [2]. Another organic method of producing methanol is the gasification of rice husk under partial oxidation.[3]. The keen interest lies in the fact that methanol as well as ethanol has profound higher octane number, higher oxygen ratio, low carbon to hydrogen ratio, high flammability limit for combustion in IC engines. Minute changes to these fuels can enable them to be used as fuels for combustion engines [4, 5]. The ignition time gap is very important in proper combustion and is to be set very carefully. Use of two spark plugs in this work initiates the sparks in two different directions leading to an increase in the combustion efficiency by uniform combustion in the combustion chamber. The more ignition advance may increase the cylinder pressure rapidly but increases the work required to make piston travel in the upward direction. If the spark initiates too late, the combustion ends with improper combustion with lower cylinder pressure [6-10]. In this work spark timing is adjusted by electronic circuit instead of mechanical linkages to avoid the inertia and friction losses. The optimal spark timings have been found out by testing the engine at five different spark ignition combinations.

II. METHODOLOGY

The performance and emission characteristics were performed on a computerized, four stroke single cylinder engine with variable compression ratio. The specifications of the mentioned engine are enlisted in table 1. The test rig was also provided with variable spark timing and dual spark plugs facility. The schematic diagram of engine setup used in this work is depicted in the Fig. 1. As enshrined by earlier work done by researchers, it has been duly noted that usage of methanol increases the fuel consumption of the engine. So it was important to maintain adequate fuel flow rate by adjusting carburetor main jet for methanol to prevent from stalling under maximum load conditions. This work is aimed at achieving homogeneous combustion in SI engine and improves the performance with reduction in emission. This was achieved by developing twin spark ignition and tried with the different combination. A secondary spark plug to facilitate dual ignition was accommodated by a hole drilled on the other side of the engine head. The test engine was set to run under full throttle condition at the constant speed of 1600 rpm. The layout of experimental setup is shown in the Fig. 2.

Table 1. Engine Specifications.

Particulars	Details
Engine	Kirloskar
Type	4-Stroke, single cylinder, water cooled
Bore	76 mm
Stroke	72.6 mm
Displacement	330 cc
Fuel tank capacity (petrol)	4.5lit
Rated power (kW)	6.02, 1800 RPM
Cooling	Water Cooling
Compression Ratio	6:1 – 12:1
Connecting rod length	190 mm
Spark plug size	12 mm x 1 mm

Fig. 1. Schematic diagram of experimental test rig.

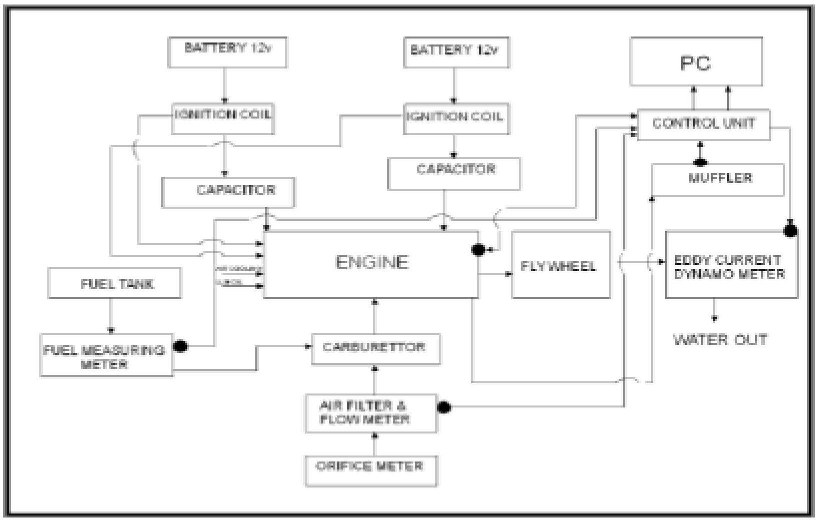

Fig. 2. Layout of Experimental setup.

III. ENGINE PERFORMANCE

Fig. 3. Clearly explains the brake power produced for different spark ignition combination. Comparing the results obtained at different combinations while gasoline is used as a fuel the minimum brake power obtained is 3.62 kW at 22o BTDC – 20o BTDC. The maximum brake power 5.19 kW is obtained using methanol as a fuel at 26o BTDC – 24o BTDC. The brake power has increased for first two combinations but reduced for 26o – 26o BTDC and 22o – 20o BTDC. The initiation of spark simultaneously in two different direction reduced combustion efficiency which can be observed in the experimental result. The increase in engine knocking due to collision of two pressure waves created at two different directions might be the reason for decrease in power at 26o – 26o BTDC. Early start of combustion can increase the work required to move the piston in the upward direction which will reduce power. Initiating the spark near to TDC by delaying spark timings also gives adverse effect due to insufficient time for complete combustion since the piston already travelled down before completion of the combustion.

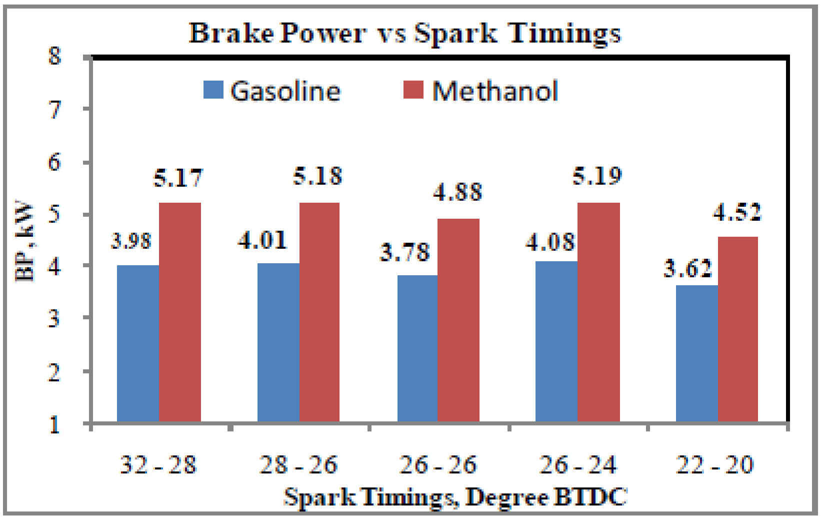

Fig. 3. Variation of brake power verses Spark timings.

The indicated thermal efficiency of engine at different spark timings is elaborated in the Fig. 4. Using gasoline as a fuel maximum efficiency was found to be 23.88% at 26o – 24o BTDC combination. Increase in power increases the thermal efficiency of the engine. Using gasoline as a fuel, maximum indicated thermal efficiency (ITE) was found to be 28.64% at 26o – 24o BTDC spark combination.

The minimum thermal efficiency obtained using methanol as a fuel is 26.02%. Oxygen enrichment, higher laminar flame speed and higher heating value of methanol are the reasons for increased thermal efficiency [11-13]. By comparing the experimental results 26o – 24o BTDC can be considered at optimum spark timing combination.

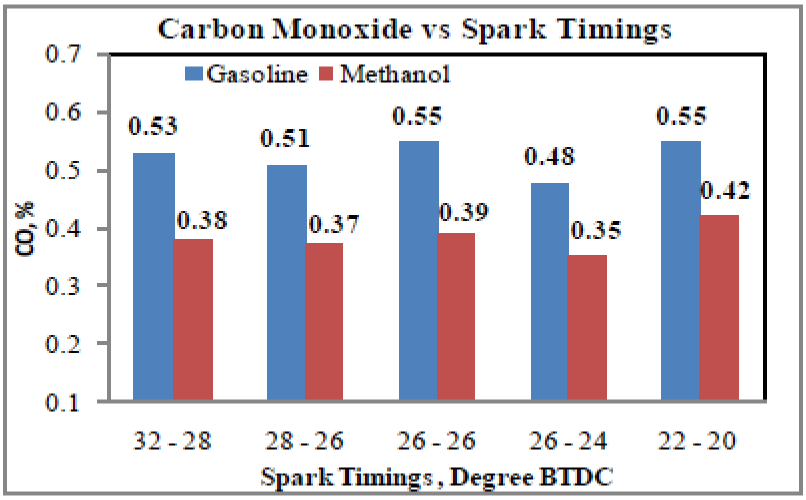

Fig. 4. Variation of ITE verses Spark timings.

The variation of brake thermal efficiency at different spark ignition combination is presented in the Fig. 5. The engine has showed better thermal efficiency for methanol at all spark timing combinations. By comparing the experimental results, the maximum thermal efficiency is found to be 23.46% at 26o – 24o BTDC. Using gasoline as a fuel, minimum thermal efficiency obtained is 17.92% at 22o – 20o BTDC. Uniform combustion, high laminar speed, increased brake power might be the reasons for increase in thermal efficiency.

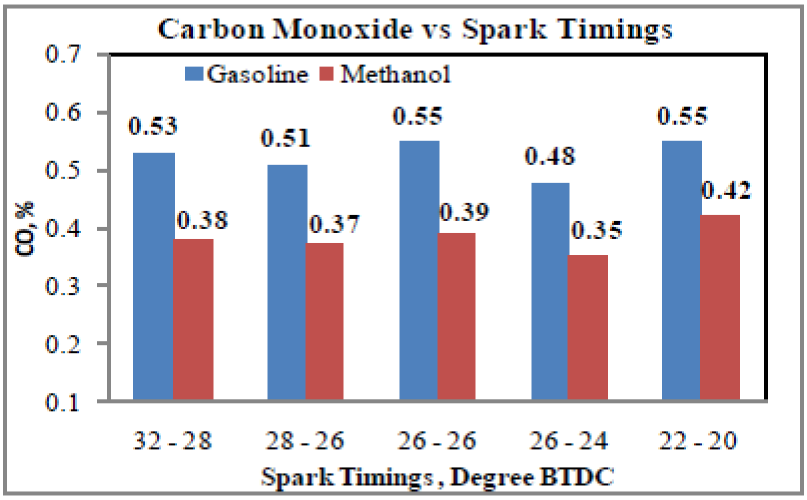

Fig. 4. Variation of ITE verses Spark timings.

The CO emissions decrease considerably when the engine operates close to its stoichiometric ratio[13-15]. The engine compression ratio of the fuel also effects the CO emission. Emission of carbon monoxide for different combination spark timings is described in the Fig. 6. The lowest CO emission was found to be 0.35% at 26o – 24o BTDC using methanol as a fuel. It can be observed from the figure that CO emission decreased for first, second and fourth combinations and showed higher value for third and fifth combinations. Increase in engine knocking due to sudden increase in engine temperature at the latter part of the combustion increases CO emission, which is experienced in 22o – 20o BTDC.

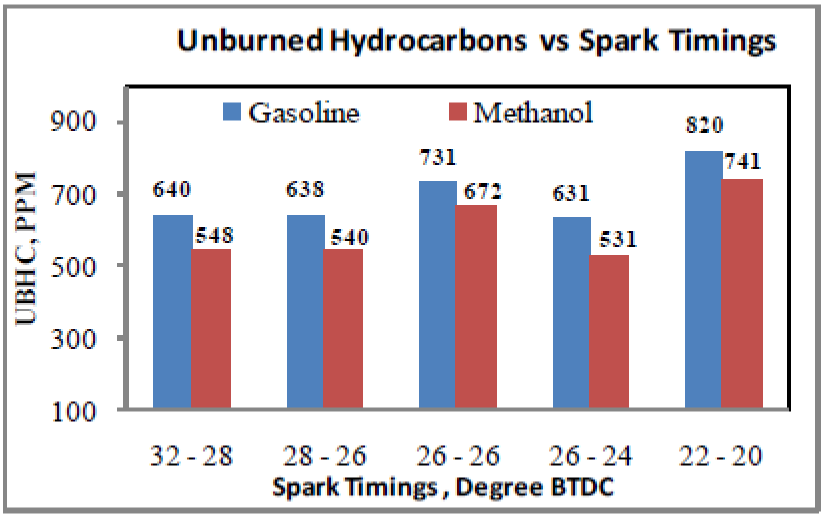

Fig. 7. Variation of UBHC verses Spark timings

Fig.7 shows the variation of UBHC with different spark timing combinations. The maximum and minimum hydrocarbon emissions can be observed in the fifth and third combinations respectively. Initiating sparks at 22o – 20o BTDC provides a short time for combustion of fuel mixture and the temperature starts reducing in the next stroke leading to increased HC emission. Addition of methanol to gasoline showed decline in HC emission for all combinations compared to gasoline. Advancing ignition timing reduces UBHC emission due to earlier start of combustion with respect to TDC. It is also observed that 26o – 26o BTDC showed higher HC emission compared to other combinations. Initiating the sparks at same time tends to increase cylinder temperature rapidly, it also increases the cylinder wall temperature and ends with engine knock increasing the HC emission. Comparing the experimental results in the figure, the spark ignition combination 26o – 24o BTDC can be considered as optimum spark ignition time.

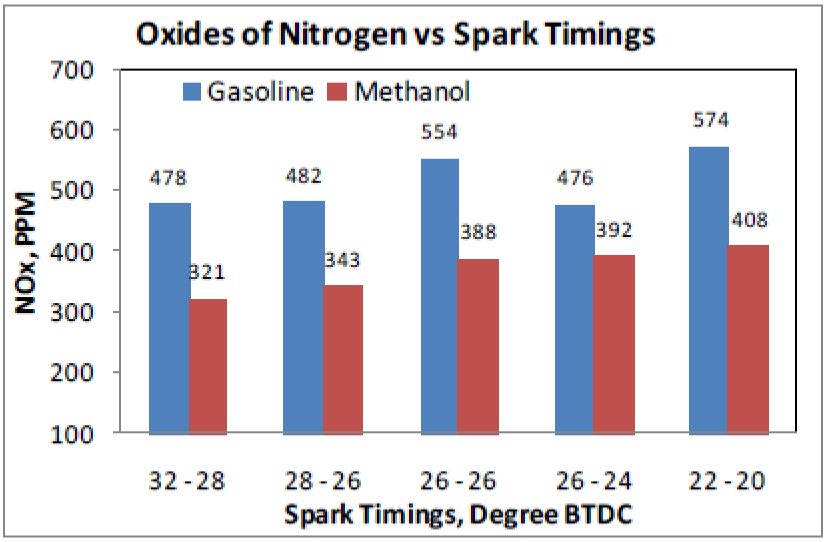

Fig. 8. Variation of NOx verses Spark timings

The influence of spark timings on NOx emission is presented in the Fig. 8. It can be observed from the experimental results that, NOx emission increased remarkably for third and fifth spark ignition combinations. However it showed less for methanol in all combinations compared to gasoline due to high heat of vaporization of methanol [12]. Initiating spark simultaneously from two spark plugs may increase cylinder temperature rapidly in the third combination and might be the reason for increase in NOx emission. Initiating sparks near the top dead center also increases the combustion temperature to higher extent which tends to increase the NOx emission.

CONCLUSION

The effect of spark timings on different engine parameters is studied at five different combinations. Engine performance and emission parameters is observed better for 32o – 28o BTDC and 28o – 26o BTDC with low exhaust emission, but not continued during 26o – 26o BTDC. The engine was tested with other combinations of spark timing such as 26o – 24o BTDC. During the experimentation engine performance is enhanced with lower exhaust emissions. But this trend did not sustain when the engine was tested with 22o – 20o BTDC combination. By comparing the results obtained, 26o – 24o BTDC can be considered as best optimum spark timing with improved performance and lower emission. However, further measures are necessary in engine exhaust handling system to reduce NOx emission.

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