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Influence of Spark Timing on Performance and Emission Characteristics of Engine with Dual Spark Plug in Single Cylinder Using Gasoline and n-Butanol as Fuel

Ravikumar R[1], Antony A J[2]
[1]Assistant Professor, Department of Mechanical and Automobile Engineering, SoET, CHRIST (Deemed to be University), Bangalore, India, r.ravikumar64@gmail.com
[2]Professor, Mangalore Marine College and Technology, Mangalore, India

Abstract— *Greater octane number and complete burning ability of the non-conventional energy sources pull the researchers to engage in research activities on basis of alternatives for petrol. Many research peoples have thoughtful the causes of n-Butanol and gasoline – n-Butanol blends as fuel for Otto cycle engine and showcased superior results for n-Butanol in terms of performance and exhaust emissions. The probability to account for gasoline – n-butanol mixtures as fuel is due to an improvement in engine performance and reduction in CO_2, CO, HC, and other exhaust pollutants. In this current work, the outcome caused by different five sets of spark timings on engine performance parameters and exhaust emissions is studied. The investigation trails were carried out on four-stroke, single-cylinder, and dual spark plug ignition engines for both n-butanol and gasoline governed by the full-throttle condition at the constant engine speed of 3000 RPM. The investigation results disclosed that the consumption of fuel is highest for n-butanol compared to gasoline fuel. Although the efficiency of the engine enhanced for n-butanol fuel due to the rich octane number and laminar speed of n-butanol with gradually less in CO, CO2, HC, and NOx.*

Keywords— *CO, CO2, Gasoline, HC, LPG, Manifold, NOx.*

I. Introduction

The alternative fuels that quite be similar to gasoline are derived from organic chemicals namely alcohols. The derived n-butanol bang like a better competitor to replace, since they have almost alike and superior combustion characteristics as good as to gasoline [1]. The alcohol namely n-butanol is organically derived from the live-stocks rich in starch content by adopting fermentation and distillation process. The production of crude n-butanol by synthesis gas can be obtained from the gasification of wood, straw, coal, garbage, plant stalks, etc. The synthesis gas can also be obtained from the decomposing of natural biomass which is presently are a vital resource of n-butanol [2]. A distinct organic method of deriving n-butanol is the gasification of rice husk under partial oxidation also yields n-butanol [3].

The fine edge interest falls in the fact that n-butanol has a scholarly greater octane number, maximum oxygen ratio, turn down carbon to hydrogen ratio, rich flammability limit for combustion in IC engines. Minute changes to these fuels can enable them to be used as alternative fuels for combustion engines [4-7].

The ignition time interval is very essential in perfect combustion and is to be organized very cautiously. The use of twin spark plugs in this work initiates the sparks in two different angles headed to enhance the combustion efficiency by the uniform combustion process in the combustion chamber [8-11]. The greater ignition advance may enhance the cylinder average pressure quickly but increases the work needed to make the piston move in the up word direction. If the spark initiates too retort, the combustion process terminates with unlike combustion with minimum cylinder pressure [12-15]. In this effort, spark timings are controlled by an electronic circuit alternative for mechanical linkages to avoid inertia and friction waste. The optimal spark timings have been found out by testing the engine at five different spark ignition combinations.

II. Methodology

The performance parameters and emissions characteristics were executed on a computerized, four-stroke single-cylinder engine with an impermanent compression ratio. The specifications of the quoted engine are registered in table I.

TABLE I. Engine Specifications

Parameter	Description
Engine	4-Stroke, Oil Cooled, Single Cylinder
Engine Displacement (CC)	220 CC
Power-(PS @ rpm)	20.76 bhp @ 8500 rpm
Torque-(Nm @ rpm)	19.12 Nm @ 7000 rpm
Bore diameter	67 mm
Stroke length	62.4 mm
Rated Compression Ratio	9.5:1
Number of Valves	2
Valves arrangement	Overhead Camshaft
Fuel Supply System	Carburetor
Engine Cooling System	Oil Cooled and Air-Cooled
Fuel Type	Petrol
Ignition type	Twin Spark Ignition

The engine setup was also developed with impermanent spark timing and dual spark plugs arrangement. The above-said engine arrangement with all specifications is illustrated in schematic diagram Fig. 1. As treasured by earlier work done by different researcher scholars, it has been appropriately

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noted that usage of n-butanol enhances the fuel consumption of the engine. So it was very needful to control the required fuel flow rate by modifying the carburetor main jet for methanol to protect from stalling under higher load conditions. This work is aimed to attain a homogeneous combustion process in SI engines and developing the performance with decreasing in exhaust emission. This was accomplished by developing dual spark ignition and tried with the variable sets. The test engine was set to run under full throttle conditions at the constant speed of 3000 rpm at a fixed compression ratio of 9.5:1. The layout of the experimental setup has shown in Fig. 1.

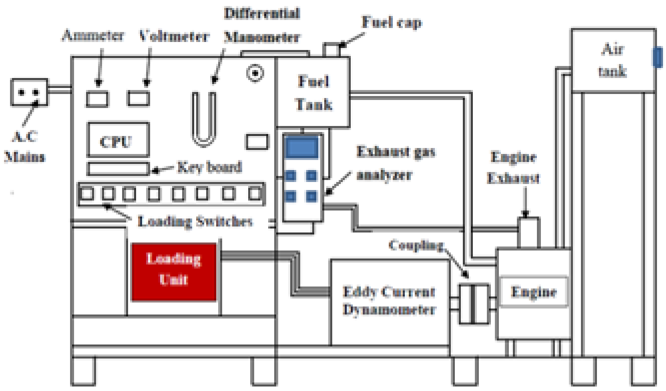

Fig. 1. The layout of the Experimental setup

III. Engine Performance

Chart-1 Illustrate the brake power produced by the engine for different spark ignition sets. Analyzing the obtained results at different sets of spark timings indicates that, maximum BP obtained while running the engine by adopting gasoline as a fuel is 2.76 kW at 24˚– 22˚ BTDC. The fuel n-butanol provides greater BP as 4.26kW while using it as an alternative fuel at the same pairs of spark timings. The results show brake power has maximum for the first two combinations but declined for 24˚ –24˚ BTDC and 20˚ – 18˚ BTDC.

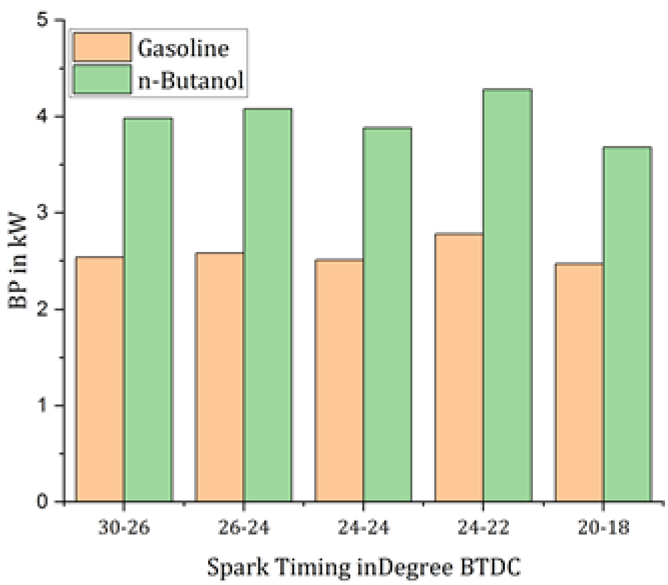

Chart -1: Variation of Brake Power v/s Spark Timings

There are many senses to be accounted for getting higher brake power at the combination 24˚–22˚ BTDC. Enhancement in combustion chamber temperature by beginning spark closer to the TDC is the primary reason for power growth. Scaling down in work required during the compression stroke by starting the combustion process closer to TDC might be the secondary reason for enhancing brake power. It is also evident from the obtained results that further advancing spark timing, minimize the engine power. Starting the spark by holding the spark angle further declines power due to the unavailability of time for the complete combustion of fuel.

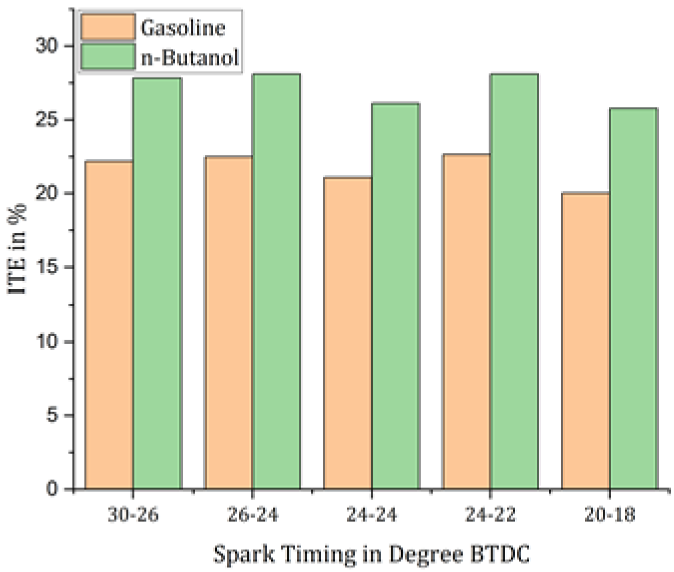

Chart -2: Variation of ITE v/s Spark Timings.

The variation of indicated thermal efficiency at different spark timings is concluded in the chart-2. Adopting gasoline as an alternative fuel, the greater efficiency was identified as 22.63% at 24˚ – 22˚ BTDC combination. An increase in power output enhances the thermal efficiency of the tested engine. By employing n-butanol as an alternative fuel, higher indicated thermal efficiency was determined as 28.09% 24˚ – 22˚ BTDC spark combination. The lesser thermal efficiency showed adopting n-butanol as fuel is 25.69%. Enrichment of oxygen, better heating value, and maximum laminar flame speed of n-butanol are the reasons for maximizing thermal efficiency. By comparing the obtained results, 24˚ – 22˚ BTDC can be accounted for as the optimum spark timing combination.

The changes in spark timing are affected on brake thermal efficiency of the engine test rig is represented in Chart -3. Proper mixing of n-butanol with air indicated the brake thermal efficiency is increased in all the combinations of spark timing. The highest thermal efficiency is given by the engine at 24˚–22˚ BTDC as compared to other respective combinations. Selecting gasoline as an alternative fuel, the least thermal efficiency shown by the engine is 13.09% at 20˚ – 18˚ BTDC. It can be witnessed that utilizing n-butanol as alternative fuel greatest efficiency obtained is 19.42% at 24˚ – 22˚ BTDC.

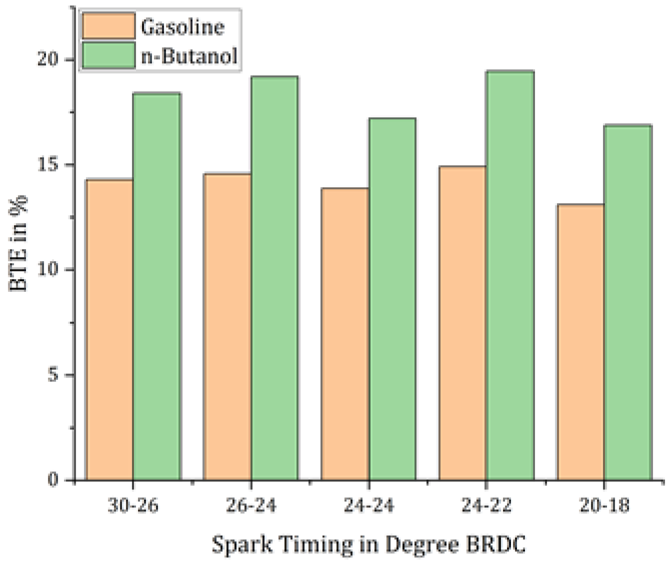

Chart -3: Variation of BTE v/s Spark Timings.

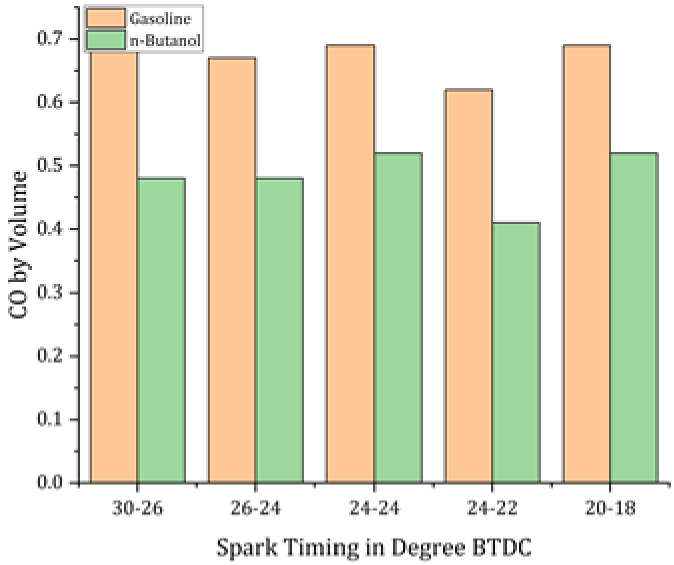

Chart -4: Variation of CO v/s Spark Timings.

Chart -4 illustrating the role of spark timings on carbon monoxide emission. It can be noticed that CO emission reduced for the first, second, and fourth set of spark timings. Showed greater value for the third and fifth set. The reasons to get a smaller value of CO emission are homogeneous combustion of fuel mixture and chemically correct A/F ratio. Commencement of sparks at 24˚–22˚ BTDC indicating lesser CO emission value 0.43% for n-butanol and 0.65% for gasoline fuels. The presence of rich oxygen in n-butanol fuel minimizes CO emission rate in all sets which can be witnessed in the chart. Post start of combustion process at 20˚–18˚ BTDC giving the greater value of CO compared to other sets of spark ignition time. Inadequate time grant for combustion process leads to higher in the CO emission in the fifth set of sparks timing.

Emission of HC comes into consideration for distinct spark timing combinations are ventilated in chart 5. Comparison of gathered experimental results is indicated that 24˚–24˚ BTDC and 20˚–18˚ BTDC pair of spark timings shows higher HC emission. An increase in combustion temperature with uniform heating inside the combustion chamber can reduce HC emission. The third pair may increase the temperature to a greater extent, but disappoint to get heating inside the combustion chamber in a uniform manner. Beginning the combustion process very nearer to the TDC is also not desirable because the demanded combustion chamber temperature will not be maintained when the piston begins to move in downward. Combined experimental results show the spark ignition pairs 24˚–22˚ BTDC can be advisable as optimum spark ignition time as results lower HC.

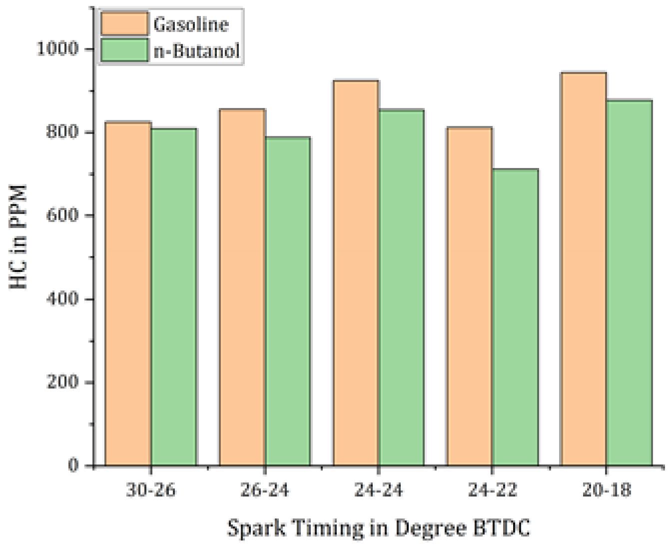

Chart -5: Variation of HC v/s Spark Timings.

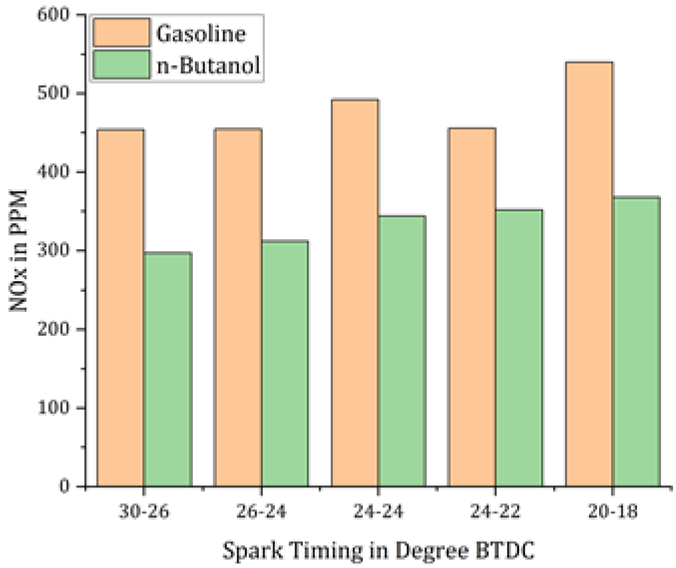

Chart -6: Variation of NOx v/s Spark Timings.

Fluctuation in NOx emission for the verity of spark timings is representing in chart 6. The laboratory results displayed that engine cylinder pressure increased for the variety of spark timing sets starting from 30˚–26˚ BTDC. The higher NOx emission was determined to be 535 PPM using gasoline as a fuel in 20˚–18˚ BTDC set. The fluctuation of

NOx emission formation for variable spark timings is presented in chart 6. The results obtained from the laboratory witnessed that cylinder pressure increased gradually for different spark sets beginning from 30˚–26˚ BTDC.

IV. CONCLUSIONS

The spark timings and their effects on different engine performance parameters and emission characteristics are studied at five variable sets. The engine performance parameters and emission characteristics are observed finer for 30˚–26˚ BTDC and 26˚–24˚ BTDC with little exhaust emission, but not extended during 24˚–24˚ BTDC. The existing engine test rig was trying out with another set of spark timing such as 24˚–22˚ BTDC. Through the experimentation engine performance is increased with decreasing exhaust emissions. But this movement did not carry out when the engine examines with a 20˚–18˚ BTDC combination. Comparing the results procure at 24˚– 22˚ BTDC can be account for as better optimum spark timing with enhanced performance and minimizing emission. Although, further investigations are requisites in engine exhaust administrate system to turn down the NOx emission.

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