International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-03, June 2018

Comparative study on Performance and Emission of Single and Twin spark Ignition Gasoline Engine

[1]Basavaraj Kambale, [2]Dr. Antony A J

[1]Department of Mechanical Engineering, Moodlakatte Institute of Technology, Kundapura, India

[2] Principal, Bearys Institute of Technology, Mangalore, Karnataka, India.

Abstract: Spark timing is one of the major controlling parameters which remarkable effects the combustion temperature, torque, performance and emission characteristics. Present demand for strong performance and better fuel efficiency is not possible to attain by single spark plug engines due to various losses in combustion chamber and other design parameters. Twin spark ignition is one of the alternative solutions investigated by most of the researchers to improve the performance and reduce the emissions. In this system two spark plugs are located at different positions initiating the sparks at various crank angles. This article presents the performance and emission parameters of single cylinder four stroke spark ignition engine is for both single and twin spark plugs. Experimental results revealed that, performance parameters have been increased for twin spark ignition engine compared to single spark system. The exhaust emission such as CO and UBHC decreased significantly with increase in CO_2 and NO_x.

Keywords: Twin Spark, CO, CO_2, NO_x, UBHC

I. INTRODUCTION

Improvement in engine performance by effective burning of air-fuel mixture and reduction in emissions at the exit can be achieved by doubling the spark plugs. Two spark plugs initiated the spark at two ends of the combustion chamber have increased the combustion efficiency [1]. In order to understand the benefits of twin spark ignition system over single spark ignition, a detailed performance and emission study is carried out on test engine in this article. The effects of number of spark plugs are the major objective of this work. The performance and emission characteristics have been studied experimentally at the constant speed of 1600 RPM.

During the twin spark ignition system, engine was equipped with two spark plugs over the engine head in opposite direction. The efficiency of the small engines can be improved with increased power output by increasing the number of fuel ignition elements. The engine will be able give higher power with lesser emissions compared to conventional engine which is working with single spark plug [2].

II. EXPERIMENTATION

In this work, the emissions and combustion behaviour of single and twin spark ignition engine is studied to understand the advantages of twin spark ignition system over single spark ignition. Experiment is carried out at the fixed compression ratio 6:1 for both single and twin spark ignition operation. During experimentation on single spark plug system, spark was initiated at 26° BTDC. In case of twin spark ignition the sparks were generated at an angle 32° BTDC and 26° BTDC.

Table 1. Engine Specification

Engine	Kirloskar
Rated Power	5 HP
Bore Dia.	87.5 mm
Stroke length	110 mm
Connecting rod length	234 mm
Rated Speed	1500 RPM
Compression Ration	6 – 10
Cooling	Water Cooled
Mode	Dual Fuel

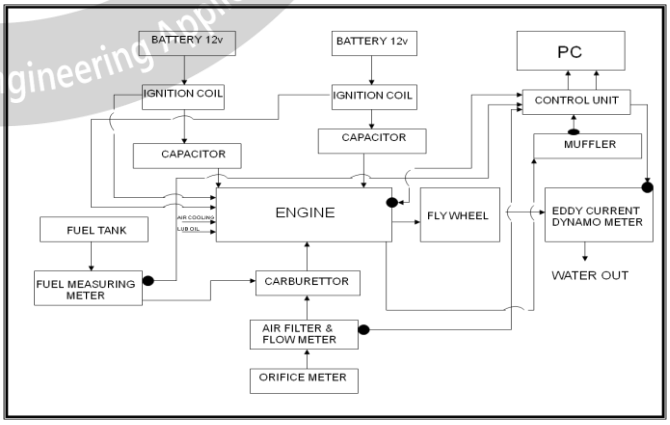

Fig. 1. Layout of engine test rig.

III. PERFORMANCE STUDY

Fig. 2 elaborates the brake specific fuel consumption for single and twin spark ignition system at different load conditions. It is observed from the figure that, fuel

 DOI : 10.18231/2454-9150.2018.0299

consumption decreases for both single and twin spark ignition systems at all load conditions.

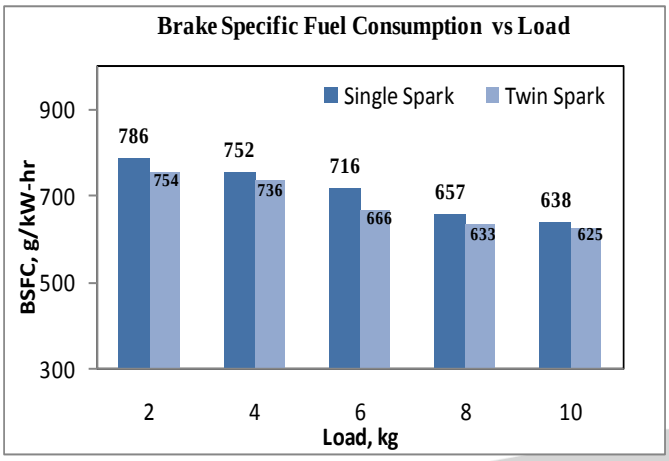

Fig.2. Variation of BSFC with respect to load.

The decrease in fuel consumption for twin spark ignition system over single spark ignition at lower engine load was found to be 18.01% and it was 2.05% at the higher load. The increase in combustion efficiency due to initiation of spark at two different directions at two intervals might be the reason for reduction in fuel consumption for twin spark ignition engine.

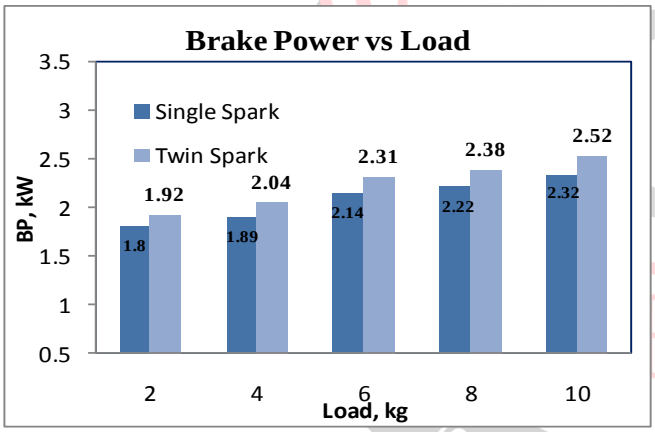

Fig. 3. Variation of Brake power with respect to load.

The effect of number of ignition elements on brake power at different load conditions is presented in the Fig. 3. As the load increases from 2 to 10 kg, brake power increases for both single and twin spark ignition systems. The increase in brake power for twin spark ignition over single spark ignition was found to be 8.12% at lower engine load and 8.68% at the maximum engine load. The maximum brake power was found to be 2.52 kW for twin spark ignition system at the maximum engine load condition. The improvement in brake power might be due to reduction in fuel consumption and increased combustion efficiency.

The variation of brake thermal efficiency and Indicated thermal efficiency of twin spark ignition and single spark ignition system at different engine condition is plotted in the Fig. 4 and Fig. 5. At lower engine load, the indicated thermal efficiency was found to be 13.11% and 14.62% foe single and twin spark ignition systems respectively. There is 25.12% increasing in thermal efficiency observed for twin spark ignition engine while single spark ignition shows around 22.34% increase by varying the engine load from 2 kg to 10 kg. The TSI engine has shown 6.74% and 8.99% increases in BTE with respect to 2kg and 10kg engine load respectively. It is also clear from the experimental results that, ITE of the TSI system significantly increases during all load conditions. The increase in ITE for TSI compared to SSI was found to be 12.03% and 3.68% at the minimum and maximum engine load. There are two reasons can be accounted for increasing thermal efficiency of twin spark ignition engine, one is decrease in fuel consumption and second one is increase in cylinder temperature [3].

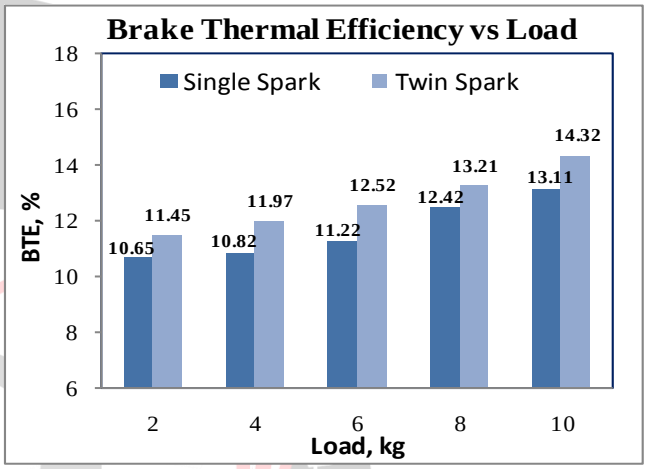

Fig. 4. Variation of BTE with respect to load.

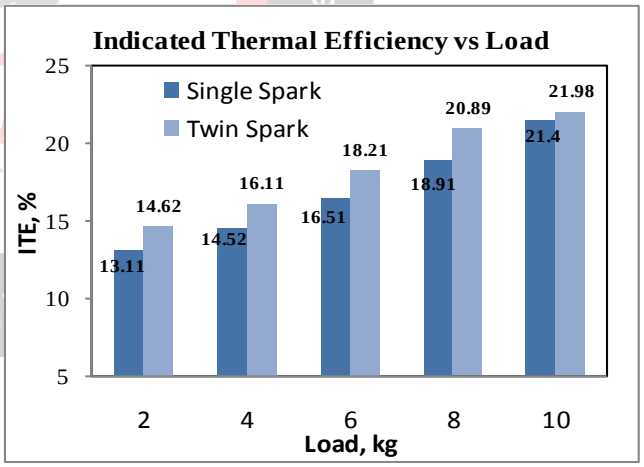

Fig. 5. Variation of ITE with respect to load.

IV. EMISSION STUDY

The figure 5 and 6 elaborates the effect of number of ignition elements on CO and CO_2 emissions at different engine load conditions. It is observed that, carbon monoxide emission decreases by increasing the engine load. Combustion temperature plays an important role in CO and UBHC emissions. The reduction in CO emission was found to be 21.97% and 17.28% for SSI (Single spark ignition) and TSI (Twin spark ignition) engine by varying

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the engine load from 2kg to 10kg. It is also observed that, CO_2 emission has increased for varying the engine load from 2 to 10 kg. There was 13.17% and 15.47% increase in CO_2 for SSI and TSI while engine load was varied from 2kg to 10kg.

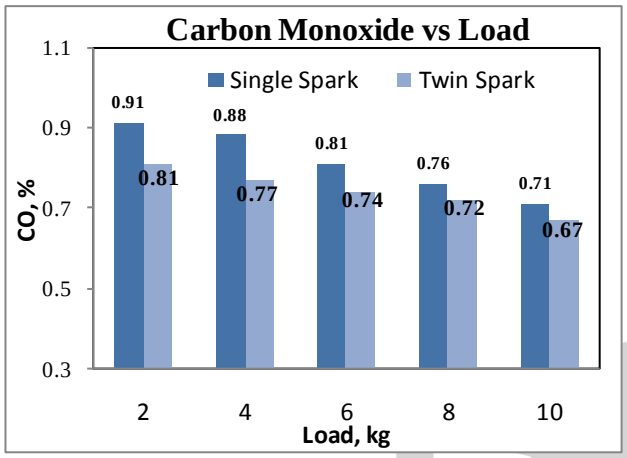

Fig. 6. Variation of CO with respect to load.

There is 5.3% reduction of CO for twin spark ignition observed at maximum load. The increase in CO_2 emission for twin spark ignition at the same engine load was found to be 6.69%. The reduction in CO emission and uniform combustion in twin spark ignition might be the reasons for increase in CO_2 emission.

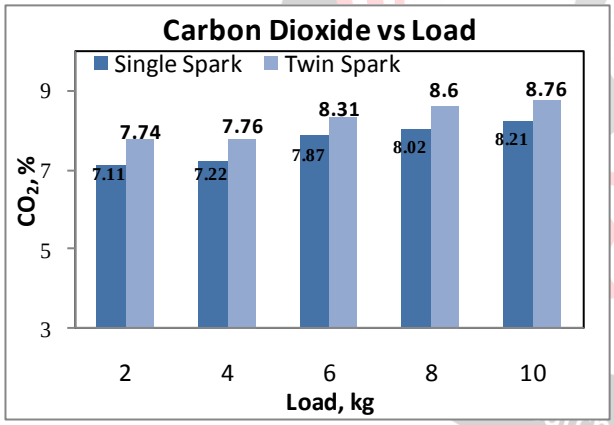

Fig. 7. Variation of CO2 with respect to load.

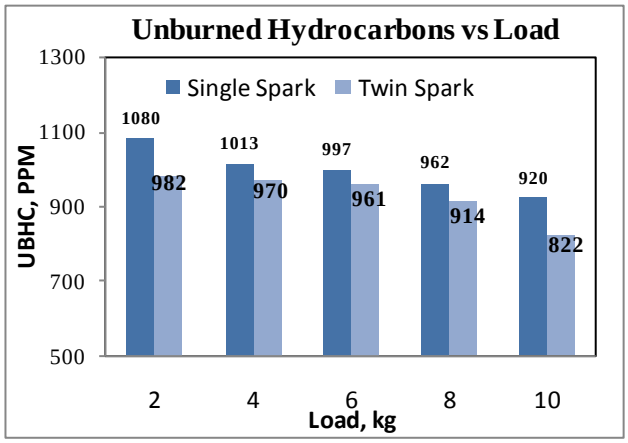

Fig. 8. Variation of UBHC with respect to load.

Improper mixing, lower combustion temperature and lower flame speed are the main reasons for UBHC emissions [4 - 7]. The Fig. 8 clearly differentiates the emission of unburnt hydrocarbons for twin and single spark ignition systems at different load conditions.

It is very clear from the results that, unburnt hydrocarbon emission reduces with increase in engine load for both twin spark and single spark ignition engine. As the load varied from 2 to 10 kg, the reduction in UBHC emission is 14.81% and 16.82% for twin spark ignition and single spark ignition respectively. At 2 kg engine load, reduction in unburnt hydrocarbons for twin spark ignition over single spark ignition system was found to be 9.07%. During the maximum load conditions, reduction in hydrocarbon emission is 10.65%. Increased combustion chamber temperature in twin spark system might be the reason for reduction in hydrocarbon emissions [8].

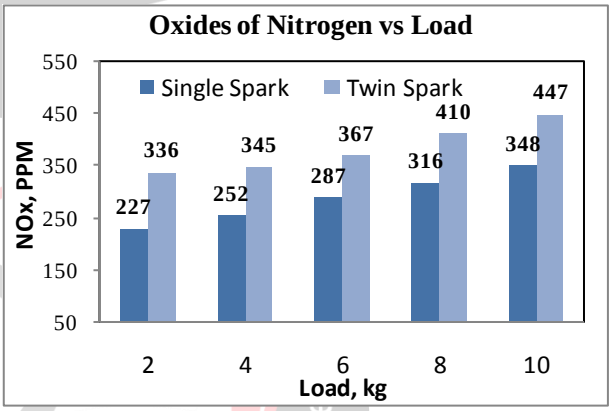

Fig. 9. Variation of NOx with respect to load.

The effect of number of spark plugs on NO_x emissions at load conditions is elaborated in the Fig. 9. As the engine load increased from 2 kg to 10 kg NO_x emission has increased for both single and twin spark ignition combustion. Increase in engine load increases combustion chamber temperature leads to increase the NO_x emission. At lower load, increase in NOx emission for twin spark ignition system over single spark ignition was found to be 36%. At the maximum engine load, it was found to be 26.15%. The increase in cylinder temperature in twin spark ignition engine is directly impacted on NO_x emission [2].

V. CONCLUSIONS

The performance and emission characteristics of single and twin spark ignition combustion system are discussed thoroughly in this article. Twin spark ignition has shown decreased fuel consumption compared to single spark ignition. This might be due to the enhanced combustion rate in twin spark ignition. The reduction in fuel consumption and increased cylinder temperature has showed improvement in engine power. Hence thermal efficiency of the engine also increases significantly. It is well known that, shortage of oxidation temperature at the later part of the combustion is one of the main reason for CO emission.

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This might be rectified by twin spark ignition combustion mechanism. By comparing overall experimental results, it is very clear that twin spark ignition engine can provide more power and less exhaust emission.

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