

Research Article

Study of Multiple Spark Ignition Engines with Single Spark Ignition Engines on the Basis of Engine Efficiency and Emission Characteristics Size

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Abstract

This paper describes some results of the research in the area of multiple spark ignition engines. Dual spark ignition system has proved their potential in improving the performance of the engines and improved emissive characteristics as compared with the single spark plug ignition system. Recently a new type engine has been introduced which uses triple spark plugs at different location, controlled by an advanced electronic control unit. This advanced electronic control unit uses three different ignition timings with variable spark plug number. Experiments were conducted at different load conditions and different types of engines has proved that dual spark plug ignition engines are surely better than a single spark plug engine, but triple spark ignition engines has proved their potential. The current paper investigates the effect of multiple spark plugs to single spark plug on the basis of engine performance and their respective emissive characteristics. The result has shown that there is a considerable performance improvement in power output, increase in thermal efficiency and reduced maintenance due to lower emission of BSFC, HC and CO emission in triple spark plug mode of operation as compared to single and dual spark plug mode of operation..

Keywords: Spark Ignition, Emissive Characteristics, Engine Performance, Thermal Efficiency.

1. Introduction

Fossil fuels are the majorly used type of fuel from decades and due to their rapid usage caused the increase in greenhouse gases, degradation of air quality and shortage of fossil fuels. All these have encouraged the development of new technologies with reduces the engine emissions and its fuel efficiency without compromising its power. Such advancement in technology is dual or twin spark ignition technology and one of its kind digital triple spark technology developed by Bajaj auto. The main idea behind introducing more than one spark plug per engine cylinder is to complete the combustion process as fast as possible. In SI engines fuel should be ignited exactly at end of compression stroke and before the power stroke, which gives very less time for the flame initiation process (M.L. Mathur, et al, 2006). Introducing multiple spark plugs at different location creates multiple flame fronts, thus reducing the time and effective distance travelled by the flame front in combustion chamber. Bajaj auto has claimed that introduction of triple spark system has reduced the spark ignition timing by 15°. The ignition process is further improved by DTS-I technology, TRIIC-iii and intelligent CDI to control no. of spark plugs working at a time and vary their sparking timing according to load(throttle), engine rpm and engine temperature.

TRIIC-III controls the power and torque requirement which is constantly changing, depending on whether the rider is cruising, accelerating or is running at max speed. TRIIC systems quickly adapt ignition timing according to riding characteristics. The Intelligent Capacitor discharge Ignition or Intelligent CDI works by using a microprocessor, which senses different speeds and load on engine and alters the ignition timing for best combustion performance.

Studies done by Narsimha Bailkeri (Baikeri ,et al, 2013) has shown that introduction of dual spark ignition has considerably increased the performance of the engine by increasing efficiency & power and reducing its exhaust emissions. Same results can also be seen in the study done by Ajay K. Singh (Ajay K. Singh, et al ,2013) which proved that dual spark ignition system is better for improving ignition process even in 2-stroke engines. Thus reviews and studies have clearly indicated that use of multiple spark ignitions can increase the rate of combustion by rapidly completing the process. Thus, generating more power, increased the engine efficiency and lower the exhaust emissions.

In this work various performance parameters and emissive characteristics are analyzed in detail for single spark ignition, twin spark ignition and triple spark ignition engines. Following this section is the instrument and experimental setup used to measure the different engines performance is described. Next is the result and

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discussions, followed by conclusions and suggestion made for future work.

2. Experimental Setup and Test Procedure

Experiments were conducted on 4-stroke petrol engines with single spark plug, twin spark plug and triple spark plug carried out at a constant speed of 3000 rpm. The engine specifications are given in table 1. Components used to perform the experiments are: air cooled single cylinder single spark ignition petrol engine, air cooled single cylinder twin spark ignition petrol engine, liquid cooled single cylinder triple spark ignition petrol engine, dynamometer, exhaust gas analyzer, fuel consumption device and digital tachometer.

Table 1 Engine Specification

Maker's Name	Hero Motocorp	Bajaj Auto Ltd.	Bajaj Auto Ltd.
Model Name	Hunk	Pulsar 150	Pulsar 200NS
Type of engine	4-stroke single cylinder	4-stroke single cylinder	4-stroke single cylinder
cooling	Air cooled	Air cooled	Water cooled
Displacement volume	149.2 cc	149.01 cc	199.5 cc
Compression ratio	9.1 : 1	9.5 : 1	11:01
Maximum torque	12.80 Nm @ 6500rpm	11.25 Nm @ 6500rpm	18.3 Nm @ 8000rpm
Maximum power	14.4 Ps @ 8500rpm	13.02 Ps @ 8500rpm	23.5 Ps @ 9500rpm
Ignition system	CCVI	I-CDI	I-CDI

3. Results and Discussions

3.1 Flame Propagation

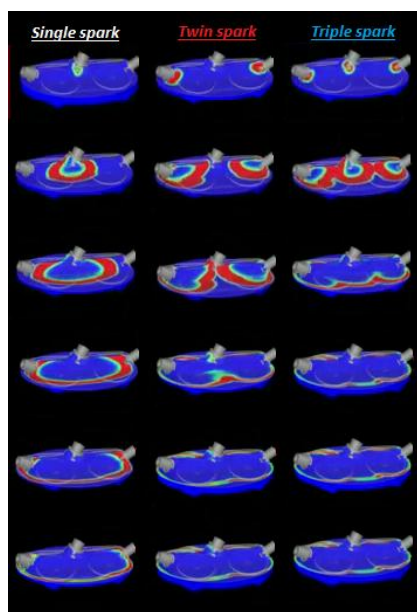


Figure 1 Flame Propagation

Fig. 1 shows flame propagation in single spark, twin spark and triple spark ignition conditions. In single spark ignition the spark plug is centrally located to achieve best possible flame propagation for combustion process; In dual or twin spark mode the plugs are located at some distance from diametrical ends; In triple spark ignition mode one primary plug is centrally located and other two secondary plugs are located similar to twin spark ignition mode in the cylinder head. The following observation can be made by it:

- Combustion process takes place faster in twin spark plug mode and fastest in triple spark plug mode as compared to single spark plug mode.
- Combustion is about 27% faster in triple spark as compared to twin spark and 50% faster as compared to single spark.

3.2. Brake thermal efficiency v/s load

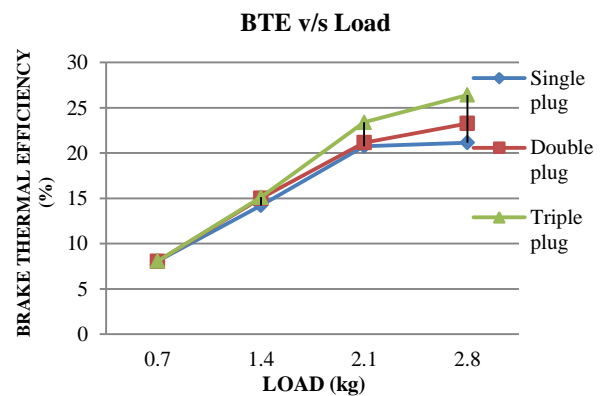


Fig. 2 Variation of brake thermal efficiency with load for single plug, twin plug and triple plug mode

Following observation can be made from it:

- Brake thermal efficiency is maximum for triple spark mode
- Variation increases more the increase in load.
- Similar trend can also be seen in dual plug mode but variation is lesser than triple plug mode.

3.3. Brake specific fuel consumption v/s load

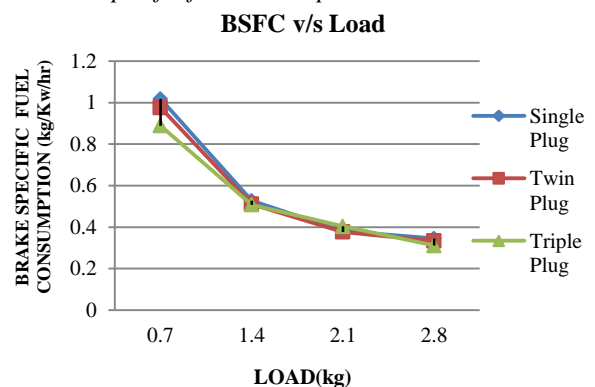


Fig. 3 Changes in brake specific fuel consumption with load for single plug,twin plug and triple plug modes.

Following observation can be made from it:

- BSFC is very high at the initial stage for all three engines.
- It is maximum for single spark engine and minimum for the triple spark engine.

3.4. Volumetric Efficiency v/s Load

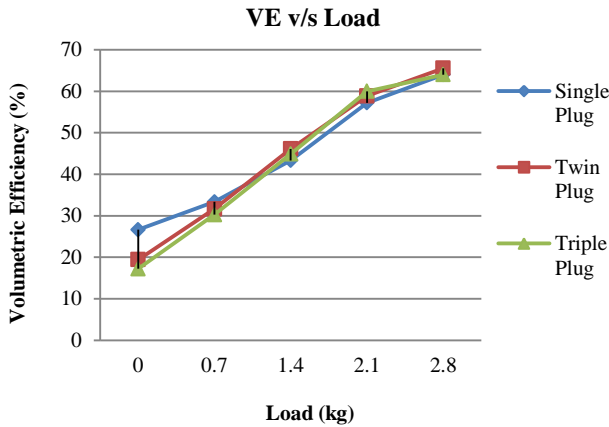


Fig. 4 Changes in Volumetric Efficiency with load for single plug, twin plug and triple plug modes.

Following observation can be made from it:

- Initially volumetric efficiency is maximum for single spark engine and minimum for triple spark engine.
- In all the cases it increases with the increase in the load.

3.5. Unburnt Hydrocarbon emission v/s Load

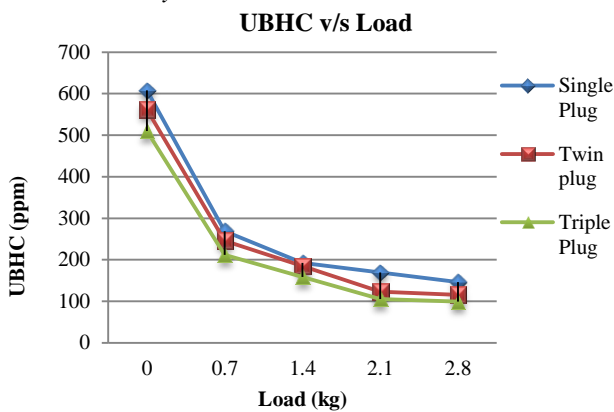


Fig. 5 Changes in unburnt hydrocarbon with load for single plug, twin plug and triple plug modes.

Following observation can be made from it:

- UBHC emissions are higher in single spark engine because of incomplete combustion.
- Triple spark engines have lesser and better UBHC emission due to better and faster completion of combustion.

3.6. CO emission v/s Load

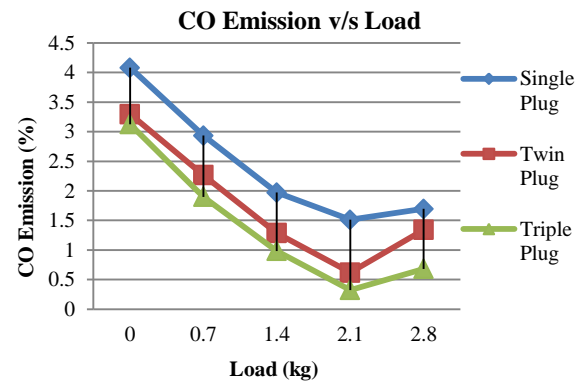


Fig. 6 Changes in CO emission with load for single plug, twin plug and triple plug modes.

Following observation can be made from it:

- CO emissions are highest for the single spark engine due to incomplete combustion.
- It is least for the triple spark engine.
- CO emissions decrease with load in all three conditions because at high temperature CO gets oxidized.

3.7. NOx Emission v/s load

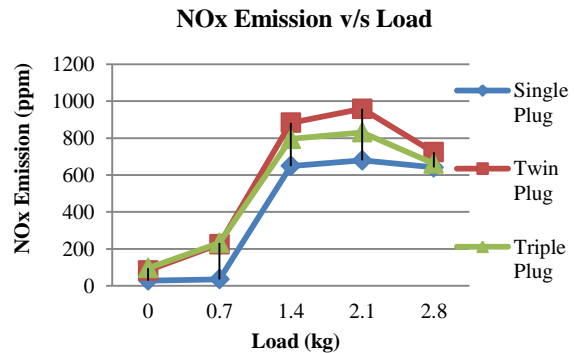


Fig. 7 Changes in NOx emissions with load for single plug, twin plug and triple plug modes.

Following observation can be made from it:

- NOx emissions are higher for twin and triple Plug engine at initial conditions.
- It increases with the load till 2.1kg in all three engines.
- Curve of triple plug engine tends to approach minimum value due to liquid cooling.

Conclusions

Following conclusions are made according to experimental results:

- 1) Combustion process in triple spark engine takes place 27% faster than twin spark and 50% than single spark engine due to faster flame propagation.
- 2) Brake thermal efficiency of twin spark engine is 5.1% higher and BTE of triple spark engine is about 13% higher than single spark engine.

- 3) Volumetric efficiency of triple spark engine is about 3.63% lesser and it is about 1.3% less for twin spark engine as compared to single spark engine.
- 4) The UBHC emission in triple spark engine is reduced by 29% and in twin spark engine it is reduced up to 13% as compared to the single spark engine.
- 5) The CO emission in triple spark engine and twin spark engine are also reduced to a great extent.
- 6) NOx emissions are increased by 3.3% in triple spark engine and 13% in twin spark engine as compared to single spark engine at full load.

It is observed experimentally that triple spark engine is clearly a winner amongst all the three types, which gives max performance in terms of efficiency and exhaust emissions. So it is suggested that triple spark and twin spark technology should be preferred in comparison with single spark technology.

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