Experimental Investigation of the Spark plug voltage on performance of IC engine

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Abstract: Internal combustion engines are used as source of mechanical power in thousands of applications but the most of the IC engines are employed for the transportation. The use of IC engines is going to be very difficult in future as depletion of fossil fuels and impact of engine emissions on environment are becoming very severe problems. In order to face these problems more fuel efficient engines with minimum emissions are needed, to achieve this aim many researchers are working in this field.
These problems can be faced with implementation of automotive sensors, better control mechanisms and turbochargers. Among the many techniques, the characteristics of spark plug also influence the performance of SI engines. The change in voltage supplied to the spark plug and its effect on operation of IC engine needed to be explored to explore the possibility of the use of spark plug voltage variation to control engine characteristics effectively. This work studies the effect of change in spark plug voltage on different engine characteristics and emissions.

Keywords: IC engines, Spark plug voltage, Performance control, emissions, Fuel efficiency.

Introduction:

For more than one hundred years, internal combustion engines have been used for propulsion. While in the early years of the development of IC engines air pollution and fuel consumption were of no interest, the situation has changed significantly overtime. And the research in the field of IC engines is more and more concentrated in pollution control and fuel efficiency. Different methods are employed to achieve this, like use of alternative fuels like LPG [1], Biodiesel [2] etc. Researchers are also working to improve power of the engine [3] and reduce knock in the engine [4].

The characteristics of spark plug also affects the performance of IC engine [5], the studies on effect of spark plug gap variation [6], effect of electrode erosion and wear [7][8], different shapes of spark plugs [9]. The present researcher's aim is to study the effect of voltage variation into the I.C. engine. To start the engine from idle position, it requires 10000 to 24000 volts. This voltage can be produced because of the primary winding and secondary winding ratio and due to the speed of the engine. Engine with higher compression ratio requires a higher voltage when pressure inside the combustion chamber is greater. Due to the variation of spark plug voltage, spark density also varies and due to that spark density variation performance of combustion and emission also varies. This research work is concentrated on the study of effect of the variation in the spark plug voltage intensity on the different performance parameters and emissions. In this work spark plug voltage is controlled with the help of spark intensity controller and performance of engine is studied for different spark plug voltages.

Ignition System:

In spark ignition engines, a device is used to ignite the compressed air fuel mixture to produce power. Ignition system is an electrical system which gives electrical supply to the spark plug, the voltage provided to spark plug generates spark. Ignition system consists of different components like battery, switch, distributor ignition coil, spark plugs and necessary wiring. This ignition system is capable of delivering voltages as high as up to 25000 volts, which is a requirement of spark plug in order to produce spark.

Spark Intensity Controller:

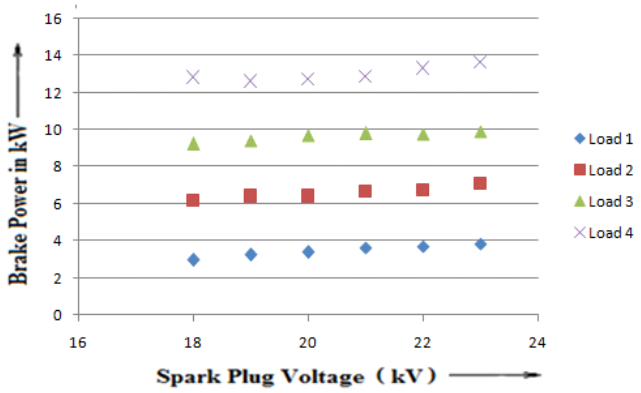
Pulse width modulation technique used in spark intensity controller in which supply voltage from ECM to ignition coil is controlled by using spark intensity controller which effect on secondary voltage, by using this technique it can be easy to step up or step down the ECM voltage signal supply to ignition coil.

Experimental Investigation:

This research work is done on an engine test rig which is available in I. C. Engine Laboratory of PVPIT, Budhgaon. The engine is used for this test rig is MPFI 4 stroke petrol engine of Indica ev2. It is incorporated with various kinds of sensors for sensing various performance parameters of engine i.e. cylinder pressure, temperature, speed etc. and communicating it with interfaced system.

Pulse width modulation technique used in spark intensity controller in which supply voltage from ECM to ignition coil is controlled by using spark intensity controller which affect the secondary voltage, by using this technique it can be easy to step up or step down the ECM voltage signal supply to ignition coil. In this work spark plug voltage is reduced from 24 kV to 18 kV and different characteristics of engine are studied, below 18 kV engines stops working.

Brake power Vs Spark Plug Voltage

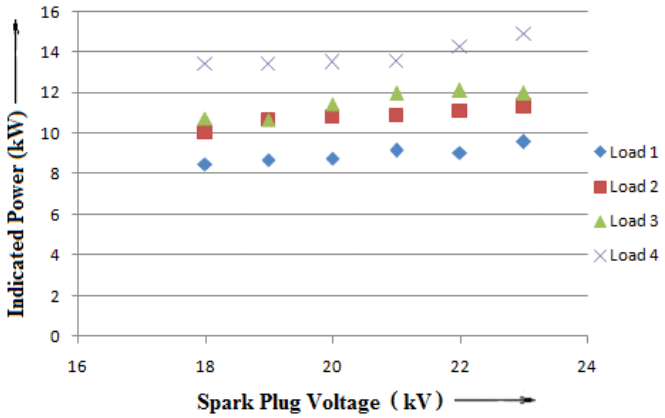


Graph 1: B.P. Vs Spark Plug Voltage

Graph 1 shows the Brake power of the IC engine with four different torque loading conditions (20 Nm, 40 Nm, 60 Nm and 80 Nm). This graph also shows the change in the brake power of the IC engine with increasing spark voltage from 18 kV to 23kV.When the spark plug voltage is decreased below the 18 kV then engine at 1500 rpm is stalled and it stops working hence observations below 18 kV cannot be recorded. As load on the engine shaft increases the engine develops more power as a response for this increase in load which results into increase in the brake power of the IC engine. For 18 kV supply for the spark plug, the brake power at 20 Nm load torque is 2.96 kW which increases upto 12.82 kW for 80 Nm. This increase in the brake power observed at all the voltages provided to the spark plug. Averagely increase in the Brake power for all the readings in this study from 20Nm load to 80 Nm load is 300%.

In this graph, spark intensity voltage is also changed from 18 kV to 23 kV and the performance of the IC engines is observed. This graph 1 also shows the change in brake power with increase in the spark plug voltage, in this graph it can observed that with increase in spark plug voltage brake power increases. As spark voltage decreases the stability of combustion reduces which leads to reduction in the brake power produced by the engine.

Indicated Power Vs Spark Plug Voltage

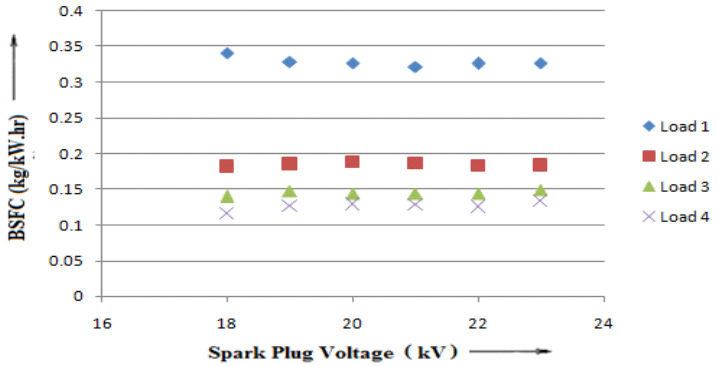


Graph 2: I.P. Vs Spark Plug Voltage

Graph 2 shows variations in Indicated power with increase in applied load on the engine shaft by dynamometer and spark plug voltage. This graph shows that the Indicated power of the IC engine increases with increase in the applied load. It also shows that with increase in the spark plug voltage Indicated power of the IC engine increases. The high spark plug voltage provides stable conditions for the production of good combustion. Hence at high spark plug voltage good combustion takes place which gives high mean effective pressure which finally gives high indicated power. When spark plug voltage decreases the combustion stability reduces and hence mean effective pressure and Indicated power reduces with it.

It can be observed from this graph that at 18 kV the Indicated power is 8.64 kW for 20 Nm load and 13.38 kW for 80 Nm load which increases to 8.69 kW and 13.41 kW for 19 kV and it again increases continuously upto 23 kV and reached to maximum value of 14.87 kW at 80 Nm load. The total Increase observed in the indicated power is 12% with increasing spark plug voltage from 18 kV to 23 kV.

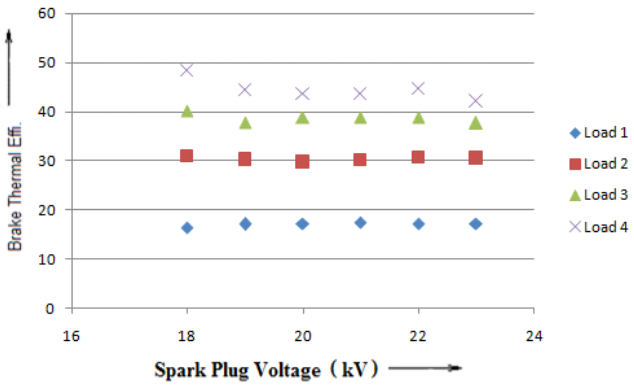
BSFCVs Spark Plug Voltage



Graph 3 BSFCVs Spark Plug Voltage

It is seen from graph 3 that brake-specific fuel consumption decreases when the load is increased for all voltages of the spark plug. And the brake specific fuel consumption of the IC engine increases with increase in spark plug voltage. As spark plug voltage decreases the combustion quality reduces hence fuel consumed in the combustion chamber also reduces. At 18 kV spark plug voltage the BSFC is 0.194 kg/kW.hr and as spark plug voltage decreases to 23 kV the BSFC is increased to 0.198 kg/kW.hr.

Brake Thermal Efficiency Vs Spark Plug Voltage

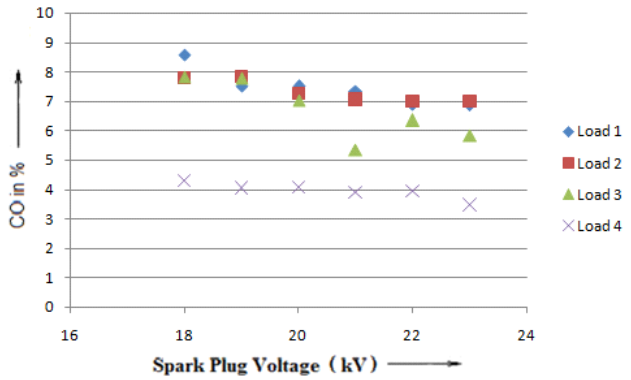


Graph 4 Brake Thermal Efficiency Vs Spark Plug Voltage

The variation of brake thermal efficiency with load for different spark plug voltages is presented in graph 4. In all cases, it increased with increase in load. This was due to reduction in heat loss and increase in power with increase in load. It can be observed that at 23 kV spark plug voltage the brake thermal efficiency is 19.7% at 20 Nm load and 42.84% at 80 Nm load and it decreases with increase in the spark plug voltage brake thermal efficiency increases to 16.45% at 20 Nm load and 48.35% at 80 Nm load. It is also observed that the brake thermal efficiency increases with increase in the load.

Emissions:

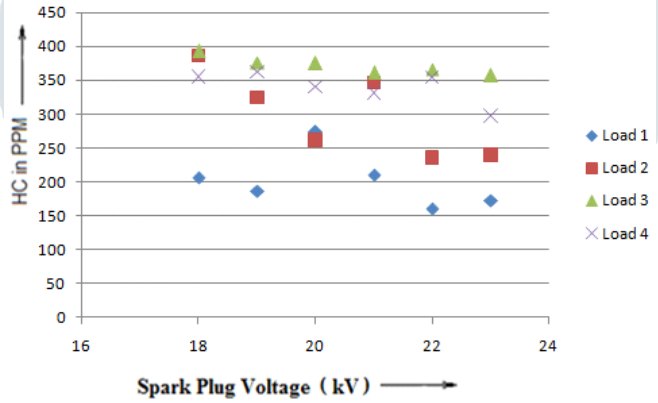
CO Vs Spark Plug Voltage



Graph 5 COVs Spark Plug Voltage

Graph 5 shows the CO % in exhaust emissions of the IC engine with increasing load and spark plug voltage. It can be observed in this graph that percentage of CO emissions decreases with increase in torque load applied on the engine shaft and it also decrease with increase in the spark plug voltage. It shows that at low spark plug voltage CO% is higher which means at low spark plug voltage combustion process is not good. As spark plug voltage is increased good combustion occurs and CO emissions are decreased. The CO % in exhaust of IC engine emissions is 8.57% and 4.27 % for 20 Nm load and 80 Nm load respectively at 18 kV and 6.87% and 3.47% at 23 kV spark plug supply voltage, this value increases to 7.11% when spark plug voltage is reduced to 18 kV.

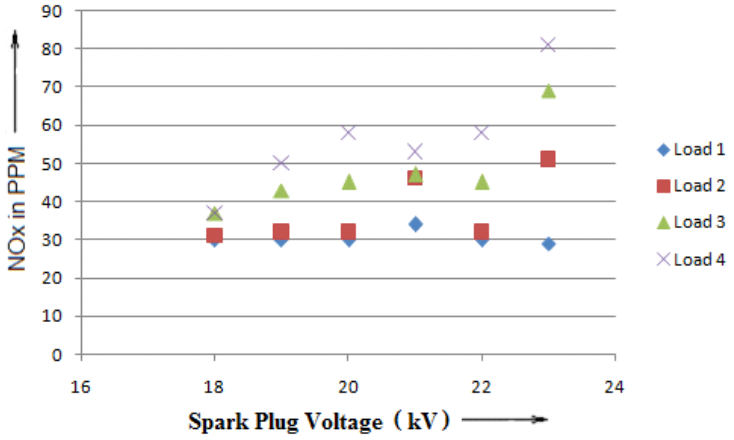
HC Vs Spark Plug Voltage



Graph 6 HC Vs Spark Plug Voltage

Graph 6 shows the variation of HC emissions plotted against the load. It is observed that the amount of HC emissions is increased with decrease in the spark plug voltage. The reduced amount of HC emissions indicates good combustion, at 23 kV spark plug voltage, combustion inside the combustion chamber occurs properly hence less hydrocarbon particles remain in the exhaust gas. The HC emissions at 23 kV are 173 ppm and 297 ppm for 20 Nm load and 80 Nm load respectively which is increased to 206 ppm and 305 ppm when spark plug voltage is decreased to 18 kV.

Vs Spark Plug Voltage



Graph 7 Vs Spark Plug Voltage

Graph 7 shows the nitrogen oxides emissions formed in an engine; these are highly dependent on combustion temperature, along with the concentration of oxygen present in combustion products. Due to decrease in the spark plug voltage the combustion quality decreases, hence combustion temperature also decreases this leads to reduced NO_X emissions at low spark plug voltages. It can be observed from this graph that with decreasing spark plug voltage from 23 kV to 18 kV the NO_X emissions present in the exhaust decreases and it also shows that with increase in load the NO_X emissions also increases. At 23 kV spark plug voltages the NO_X emissions are 29 ppm and 81 ppm and it decreases by 41.3% to 30 ppm and 37 ppm at 18 kV for 20 Nm and 80 Nm load respectively.

CONCLUSIONS

In this work it is observed that the brake power of the IC engine decreases with decrease in spark plug voltage. The maximum decrease observed in the brake power of engine with change in spark plug voltage from 23 kV to 18 kV is 5.5%. It is also observed that Brake specific fuel consumption of engine is increased with increasing spark plug voltage. The hydrocarbon emissions found in exhaust of IC engine are low at higher spark plug voltage. The hydrocarbon emissions increase by maximum value of 34.38% with reduction in spark plug voltage from 24kV to 18kV. Nitrogen oxide emissions are increased with increase in spark plug voltages. Due to decrease in the spark plug voltage the combustion quality decreases, hence combustion temperature also decreases this leads to reduced NO_X emissions at low spark plug voltages. With reduction in spark plug voltage the noise and vibrations in engine increases considerably and hence reduction in spark plug voltage increases knock detonation.

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