# Effect of increasing of number of spark plug on SI engine performance and exhaust emission.

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**Abstract— Conventional spark ignited system is in use since 1860 with single spark plug and with the recent advancement in technology with research an development in the field of automotive industry more than one spark plug is introduced in the combustion chamber for various outcomes. The main goal is to increase the performance and reduce the exhaust emissions. The main motive to increase number of spark plug is to make process of combustion instantaneous and increase the rate of flame propagation. Which in result provide stronger performance, greater fuel efficiency, increased efficiency and reduced emissions. In this paper we will practically compare single spark plug, dual spark plug and triple spark plug spark ignited engines.**

**Index Terms— Brake specific fuel consumption, Exhaust emission, Flame propagation, Spark ignited engines, Volumetric efficiency.**

## 1. Introduction

The spark-ignition engine is the universal engine for all fuels of low inflammability, especially gasoline (a mixture of several hydrocarbons), but also **liquefied petroleum gas** (LPG), **liquefied natural gas** (LNG), methanol and ethanol (alcohols), and hydrogen. The **thermal efficiency** depends mainly on the compression ratio ε, which is limited by the knock tendency.
The ignition of the fuel mixture is achieved by an electric spark which is generated through a spark plug which transfers electric current from the ignition coil to the combustion chamber.

### 1.1 Spark plugs

A spark plug is device which delivers electric current from an ignition coil to the combustion chamber of a S.I. engine to ignite the compressed air-fuel mixture by the help of an electric spark while containing pressure within the engine.

### 1.2 Single spark plug engine

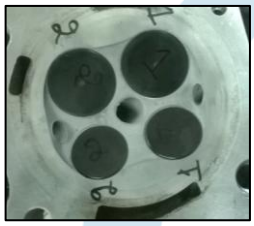
A single spark plug or conventional engine employs a single single spark plug which is placed at the centre of the cylinder head and the combustion is achieved through it only.

### 1.3 Two spark plug engine

A dual spark plug engine employs two spark plugs to ignite the air-fuel mixture alternatively so as to increase the flame diameter and burn the fuel instantaneously. This process of firing the spark, coupled with the swirl caused in the air-fuel mixture results in incomplete combustion. The Digital Twin Spark Ignition system controls this process electronically.
The two spark plugs are fixed on opposite ends of the combustion chamber, creating efficient and speedy combustion. It has two plugs per cylinder and has the combustion chambers, and piston heads positioned to produce a broad and fast flame front to ignite the air-fuel mixture.

### 1.4 THREE SPARK PLUG ENGINE

The Triple Spark Technology uses three same spark plugs to ignite the fuel. However, instead of a single spark plug in the conventional petrol engine design, this engine uses three plugs.The three spark plug technology provides fast and optimal combustion under part-load conditions. Thus, it helps in achieving better fuel efficiency and lower emissions.



### 1.5 FLAME PROPAGATION

Flame propagation is defined as the progress (spread) of the flame inside the engine cylinder (combustible environment) outward from the point at which the combustion started. Flame generally propagates spherically. The rate of radial propagation of flame is known as flame speed. It is typically measured in m/s. It gives an idea about how rapidly fame propagates from a reference point. The flame speed determines the ability of a fuel to undergo controlled combustion without detonation.


## 2. EXPERIMENTAL SETUP

Table 1: single spark plug engine specification

| | |
|---|---|
| **Make and model** | Yamaha FZ S FI (V 2.0) |
| **Engine** | Single cylinder, 4 stroke, air cooled, SOHC |
| **Power** | 13.2 PS @ 8000RPM |
| **Torque** | 12.89NM @ 6000 RPM |
| **Displacement** | 149 CC |

Table: 2 Two spark plug engine specification

| | |
|---|---|
| **Make and model** | Bajaj Pulsar 150 |
| **Engine** | 4-Stroke, 2-Valve, Twin Spark BSVI Compliant DTS-i FI Engine |

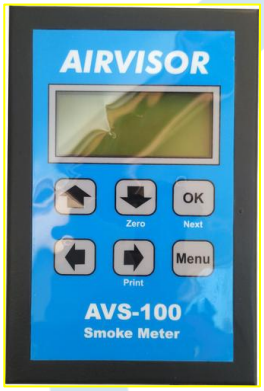
| | |
|---|---|
| **Power** | 14 PS @ 8500 RPM |
| **Torque** | 13.25 @ 6500 RPM |
| **Displacement** | 149 CC |

Table 3: Three spark plug engine specification

| | |
|---|---|
| **Make and model** | Pulsar RS200 |
| **Engine** | Ingle cylinder, liquid cooled |
| **Power** | 24.5 PS @ 9500 |
| **Torque** | 18.74 NM @ 8000 RPM |
| **Displacement** | 200 CC |

## 3. EXPERIMENT

### 3.1 EXHAUST EMISSION




The AVG-500 is intended to use for measurement of emission gases i.e. Carbon Monoxide, Carbon Dioxide, Hydro-Carbons, Oxygen through tail pipe of internal combustion engines running on fossil fuels like Petrol / CNG / LPG. Proper filtration of exhaust sample is recommended during measurements.

### 3.2 ENGINE PERFORMANCE

PRONY BRAKE : - The prony and the rope brakes are the two types of mechanical brakes chiefly employed for power measurement. The prony brake has two common arrangements in the block type and the band type. Block type is employed to high speed shaft and band type measures the power of low speed shaft.

BAND TYPE PRONY BRAKE DYNAMOMETER: - The band type Prony brake consists of an adjustable steel band to which are fastened wooden block which are in contact with the engine brake-drum. The frictional grip between the band the brake drum can be adjusted by tightening or loosening the clamp. The torque is transmitted to the knife edge through the torque arm. The knife edge rests on a platform or communicates with a spring balance.

## 4. OBSERVATION

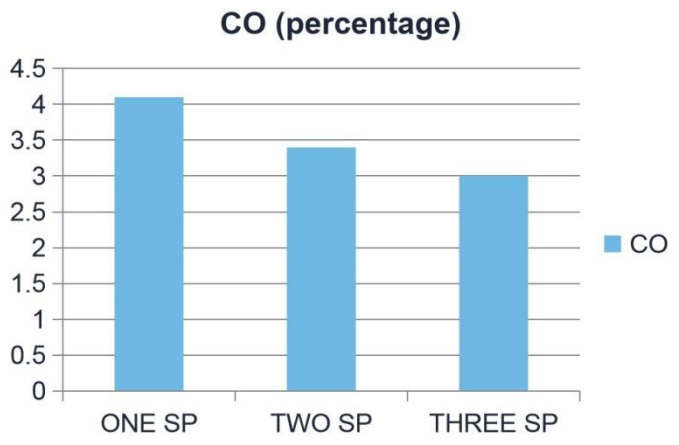
### 4.1 EMISSIONS

Air pollutant emissions emitted by motor vehicle exhausts include:
1. carbon monoxide (CO),
2. nitrogen oxides (NOx),
3. particulate matter (PM); and
4. Un-burnt Hydrocarbons (UBHC)

In our experiment we have calculated the amount of carbon monoxide. Nitrogen oxides and un-burnt hydrocarbons.

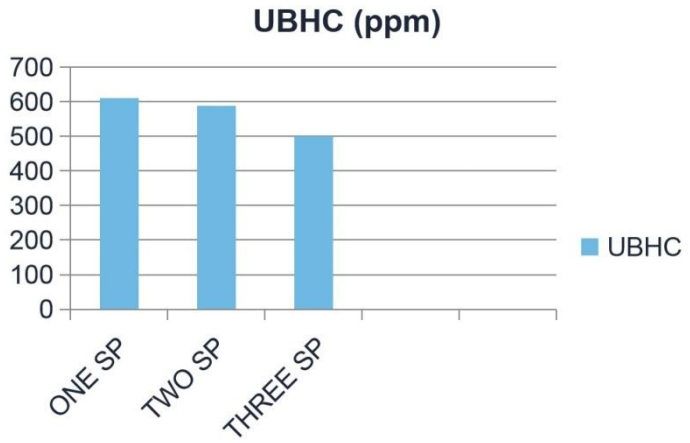
*4.1.1 Carbon Monoxide*

Carbon monoxide (CO) is a colorless, odorless gas. It results from the incomplete combustion of carbon-containing fuels such as natural gas, gasoline, or wood, and is emitted by a wide variety of combustion sources, including motor vehicles, power plants, wildfires, and incinerators.



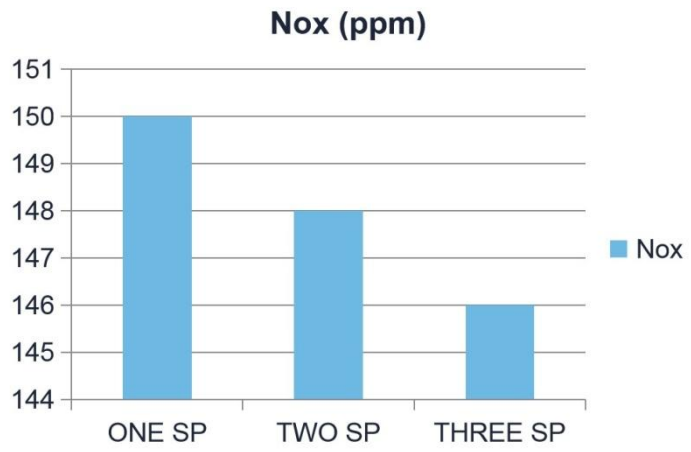

*4.1.2 Un-burnt Hydrocarbons*

Unburned hydrocarbons (UHC) are typically an output of incomplete combustion due to unfavorable engine design, low fuel quality or failure in the control system. UHC exists in both SI and CI engines, while in the latter one, the HC compounds contain higher molecular weight due to the higher boiling point of the diesel fuel spray




4.1.3 *Nitrogen Oxides*

Nitrogen Oxides are a family of poisonous, highly reactive gases. These gases form when fuel is burned at high temperatures. NOx pollution is emitted by automobiles, trucks and various non-road vehicles (e.g. construction equipment, boats,etc.)

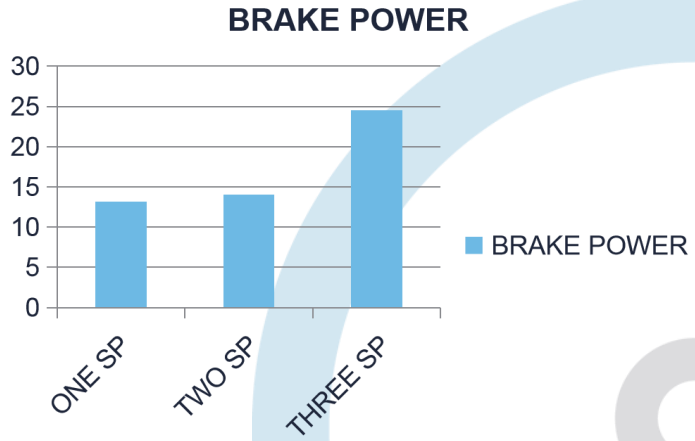


### 4.2 Engine Performance

Engine performance is often characterized by the engine operating behavior in the speed–load domain, for example, the behavior of emissions, fuel consumption, noise, mechanical and thermal loading.
In our test we have calculated the Brake Power and Torque Output.

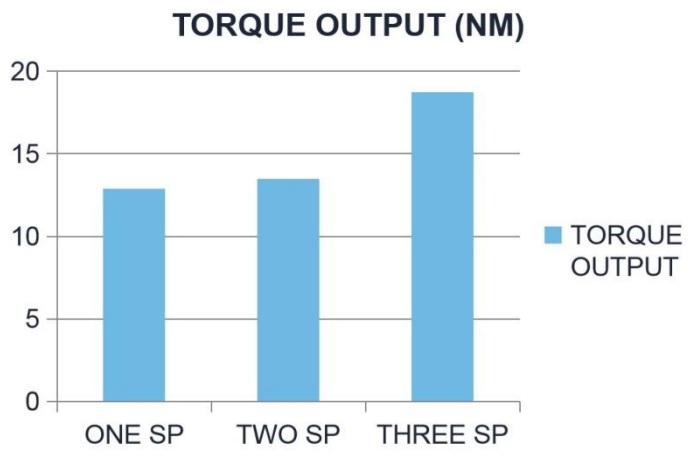
4.2.1 *Brake Power*

The brake power (briefly written as B.P.) of an IC Engine is the power available at the crankshaft. The brake power of an I.C. engine is, usually, measured by means of a brake mechanism (prony brake or rope brake).




### 4.2 Torque output

In physics, the definition of torque is a force that acts on a body through a lever arm.
Applied to internal combustion engines or electric motors, torque indicates the force to which the drive shaft is subjected.
Torque is expressed in pound-feet (lb-ft) or newton-meters (Nm).
The interaction of torque and engine speed (rpm) determines the engine power.




## 5. Conclusion

With the help of data collected and experiments conducted we can conclude that the advancement in automotive technology which gave birth to introduction of more that one spark plug per combustion chamber have increased the engine performance and decreased the level of exhaust emissions.In our study we found that with the increase of number of spark plug the percentage emission of Carbon Monoxide decreases. For single spark plug it is 4.07%, for dual spark plug it is 3.47% and for triple spark plug it is 3%.Similarly quantity of Un-burnt Hydrocarbons also decreases, for single spark plug it is 610PPM, for dual spark plug it is 590PPM and for triple spark plug it is 500PPM.There is a similar case for nitrogen oxides emission also, for single spark plug the NOx emission is 150 PPM, for dual spark plug it is 148PPm and for triple spark plug it is 146PPm.Opposite to this the engine performance increases with the increase of number of spark plugs. We have compared the engine performance on the basis of Brake power produced per cubic centimeter and Torque Output per cubic centimeter volume of engine.Brake power output for single spark plug is 13.2PS, 14Ps for dual spark plug and 24.5 PS for triple spark plug.Similarly torque output also increases with

increase in number of spark plugs which is 12.89NM for single spark plug. 13.25 NM for dual spark plug and 18.74NM for triple spark plug.Hence, increased number of spark plug results in better engine performance and environment friendly.

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