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Controlling Of Formation of Hot Spots in Si Engines by Altering the Material of Insulator Tip of Spark Plug

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Abstract: *In an era where energy conservation has become the latest topic of discussion not only among erudite but also among the ordinary responsible denizens where efficiency along with minimum pollutions has become the benchmark for any new automobiles. Due to the environment damage it causes to our planet, the aim of the engineers is to modify the engine components which produce fewer emissions and to get a greater performance.*

The project title as "Controlling of Formation of Hot Spots in Si Engines by Altering the Material of Insulator Tip of Spark Plug" is aimed to implement the less polluting vehicles and discussing about the performance of engine, reduction of emissions.

This present work discusses about the control of knocking, complete combustion, reduction of emissions by using "coated insulator tip of spark plug". Here, project work runs by the major problem of formation of hot spots is observed in the combustion chamber if the vehicle is made to operate for a long duration of time. The hot spots generally form at the spark plug and near the exhaust valve. Due to these hot spots the main effects are increase in tendency of knocking and also release of harmful emissions. The heat range of spark plug is affected by the construction of the spark plug: the type of material, the length of insulator and the surface area of the plug exposed within the combustion chamber.

The results indicated that the brake thermal efficiency, mechanical efficiency has gradually increased form usual spark plug to coated insulator tip of spark plug. In coated insulator tip of spark plug, emissions such as unsaturated hydrocarbon and carbon oxides decrease. The performance of coated insulator tip of spark plug has improved the combustion process which results in higher efficiencies.

KEY WORDS: Performance, IC Engine, Emissions, Spark plug, Coated Insulator tip of a spark plug.

1. INTRODUCTION

Since the development of internal combustion engines, inventions have been made to improve their efficiency. One of the primary aspects of which is to develop the understanding of the relationship between the engine and fuel that burns within it. In particular, the fuel's propensity to auto-ignite is an important characteristic which can dictate the ability of an engine to work to its full thermodynamics potential. Fuel is desired to ignite rapidly after injection into combustion chamber when working with the compression ignition (CI) engine. In a spark ignition (SI) engine, a high resistance to auto ignition is favored mainly to prevent knocking. Knocking is an unwanted ringing sound caused by auto-ignition of the fuel/air mixture ahead of the turbulent flame front. Effects of engine knocking range from inconsequential to completely destructive and acts as the main limiting factor of thermodynamic efficiency.

2. Coating of Tungsten and Copper Alloy

2.1Tungsten:-

The word tungsten means "heavy stone" in Swedish. The chemical symbol for tungsten is W which stands for wolfram. The name came from medieval German smelters who found that tin ores containing tungsten had a much lower yield. It was said that the tungsten devoured the tin "like a wolf". Pure tungsten metal was first isolated by two Spanish chemists, the de Elhujar brothers in 1783. Tungsten is a grayish-white lustrous metal, which is a solid at room temperature. Tungsten has the highest melting point and lowest vapor pressure of all metals, and at temperatures over 1650°C has the highest tensile strength. It has excellent corrosion resistance and is attacked only slightly by most mineral acids.

Tungsten belongs to the group of refractory metals. Refractory metals are metals that have a higher melting point than platinum (1 772 °C). In refractory metals, the energy binding the individual atoms together is particularly high. Refractory metals have a high melting point coupled with a low vapor pressure, high modulus of elasticity and good thermal stability. Refractory metals are also typically characterized by a low coefficient of thermal expansion and relatively high density.

Tungsten has the highest melting point of all metals as well as a remarkably high modulus of elasticity. In general, its properties are similar to those of molybdenum. The two metals are located in the same group in the periodic table. However, some of the properties of tungsten are more pronounced than they are in molybdenum.

Figure 1: Coated spark plug

Table 1.Properties of Tungsten:

S. no	Specification Or Units	Values
1	Atomic number	74
2	Atomic Weight	183.86
3	Group Number	6
4	Density @ 20 ºC (gm/cc)	19.3
5	Melting Point ºC	3410
6	Boiling Point ºC	5530
7	Thermal Conductivity @ 20 ºC (cal/cm/ºC/sec)	0.40
8	Specific Heat @ 20 ºC (cal/gram/ºC)	0.032
9	Temperature Coefficient of Electrical Resistivity Per ºC (0 – 100 ºC)	0.0046
10	Tensile Strength @ Room Temp., psi	100,000 – 500,000
11	Poisson's Ratio	0.284
12	Hardness (Brinell)	2570
13	Working Temperature, ºC	<1700
14	Recrystallization Temperature, ºC	1300 – 1500

Table 2.Properties of Tungsten and Copper alloy

Chemical Composition on (% by wt.)	**Copper**	20 ± 2
	Max. Addisivity	0.5
	Tungsten	balance
Density	**gr/cc Min.**	15.15
Conductivity	**IACS % Min.**	34
Resistivity	**μΩ*cm Max.**	5.0
Hardness	**HB Kgf/mm² Min.**	220
Bend Strength	**MPa Min.**	736

2. EXPERIMENTAL SETUP

Figure 2. Model of an engine

2.1ENGINE SPECIFICATIONS:

Engine Model	:	5 port model petrol engine
Make	:	Bajaj
Engine Type	:	Single cylinder, Two stroke, Water cooled spark ignition engine
Bore	:	57mm
Stroke	:	57mm
Speed	:	1500 rpm
Rated Power	:	3hp

2.2EXPERIMENTAL PROCEDURE:

The experimental set up consists of brand new BAJAJ make 5 port model petrol engine (kick start) of 3hp(2.2kw) capacity and is Air cooled. The engine is coupled to a Rope Brake Drum Dynamometer with spring balance for loading purposes. Coupling is done by an extension shaft in a separate bearing house and is belt driven.

1. Engine: The engine which is supplied by BAJAJ make 5 port model petrol engine (kick start) of 3hp (2.2kw) capacity and is Air cooled. The engine is coupled to a Rope Brake Drum Dynamometer with spring balance for loading purposes. Coupling is done by an extension shaft in a separate bearing house and is belt driven.

2. Dynamometer: The engine is coupled to a Rope Brake Drum Dynamometer with spring balance for loading purposes.

3. Thermocouples are provided at the appropriate positions and are read by a digital temperature indicator with channel selector to select the position

4. Engine speed at various conditions is determined by a digital RPM indicator.

5. Load on the engine is measured by means of spring balance.

6. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure different e is measure at the orifice is measured by means of an ACRYLIC manometer.

7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

8. The testing arrangement is mounted on an aesthetically designed self sustained study frame made of MS channels with anti vibration mounts.

9. The test rig comes with a separate control panel made of NOVAPAN board that houses all the indicators, accessories and necessary instrumentations at appropriate positions. The engine was coupled with a rope dynamometer to apply different engine loads. The engine was started on neat gasoline fuel and warmed up. Then parameters like the speed of operation, fuel consumption and load were measured. After the engine reached the stabilized working condition, emissions were measured using an exhaust gas analyzer. The engine performance and exhaust emissions were studied at different engine loads and constant engine speed, 1500 rpm obtained maximum torque.

2.3 EXHAUST GAS ANALYZER:

Figure 3. Exhaust gas analyzer

Engine exhaust gas analyzer can measure Oxygen (O2), Carbon Monoxide (CO), Carbon Dioxide (CO2), Nitrogen Oxide (NO),Nitrogen Dioxide (NO2), and Hydrocarbons (HC's).

Oxygen: Filtered ambient air enters the engine and forms part of the fuel mixture. Ambient air contains 20.9% O2. Ideally, in most engine types, this O2 should be consumed as the fuel is burned. Oxygen levels analyzed at the tailpipe indicate unburned O2, and represent a lean air/fuel mixture.

Hydrocarbons: The HC's channel is calibrated as hexane or propane depending on the vehicle type the analyzer is to be used on. The measurement itself represents unburned fuel and is measured in the ppm (parts per million). Modern automobiles in good running order frequently show 10ppm or less. Trucks and forklifts may have higher levels due to fuel type or engine style.

Carbon Dioxide: The level of CO2 is a product of combustion and represents the amount of fully burned fuel. Therefore, a higher CO2 level indicates higher engine efficiency. Many fuel injection engines will show approximately 15% CO2.

Carbon Monoxide: Partially burned fuel results in CO. High CO levels indicate a 'rich' fuel mixture. A perfect fuel mixture meters in exactly enough fuel to consume all of the O2 entering the engine. A perfect ratio is not sustainable in real-life operation. A fuel mixture that contains excess fuel is usually referred to as a 'rich' condition. A 'lean' condition refers to an excess of O2.

NOx: NOx generally refers to NO and NO2 (nitric oxide and nitrogen dioxide). This measurement is in ppm and represents the combustion products of burning nitrogen. This occurs at the higher engine temperatures associated with a lean fuel mixture or being under load. The NOx output of a typical engine, the NO component will usually make up the highest proportion. Diesel engines are generally associated with higher NOx and particulate emissions.

2.3 Procedure:

Switch on the power, the front panel is put on, the blank LED display reads. Then it displays the model number and version of the equipment. Leave the equipment for 60 seconds to worm up. After that zero settings is done automatically. Initialization part includes leak check. During leak check insert cap at the tip of probe and press CAL when cap is inserted. If leak check is done then instrument show waiting and installation OK. Now remove the cap to the probe and insert it in tail stock when engine is running. Engine emissions are displayed.

3. RESULTS AND DISCUSSION:

3.1 RELEVANT GRAPHS:

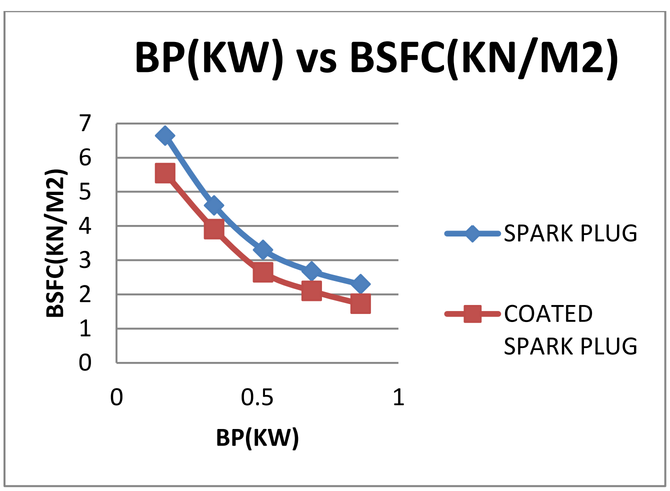

Chart -1: **BSFC Vs Brake power.**

Brake specific fuel consumption (BSFC) measures the amount of input fuel required to develop one-kilowatt power. The BSFC is an important parameter of an engine because it takes care of both mass flow rate and heating value of the fuel. As shown in Fig.6.1, the BSFC initially decreases with increasing of engine load until it reaches a maximum value and then increases slightly with further increasing engine load for all kind of fuels. From the observation of results in fig.(B.P. Vs BSFC) the brake specific fuel consumption of coated spark plug insulator tip is less than that of existing spark plug.

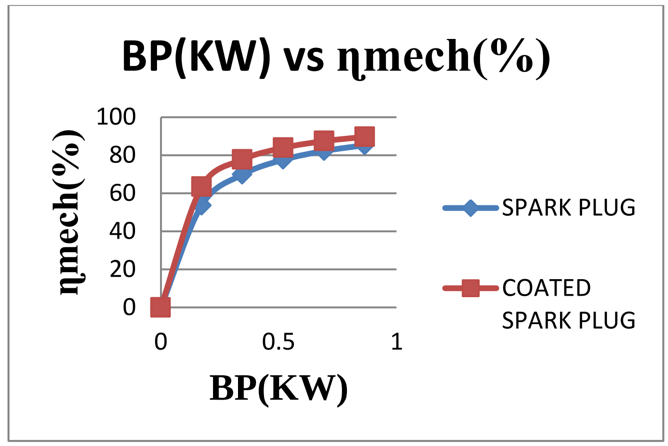

Chart -2: **Mechanical Efficiency Vs Brake Power**

Mechanical efficiency tells the performance of engine that is how much percent of input energy (indicated power) is converted to output energy (brake power).From the observation of results in fig. (graph B.P.Vs η_{mech})the mechanical efficiency of coated spark plug insulator tip is more than that of usual spark plug.

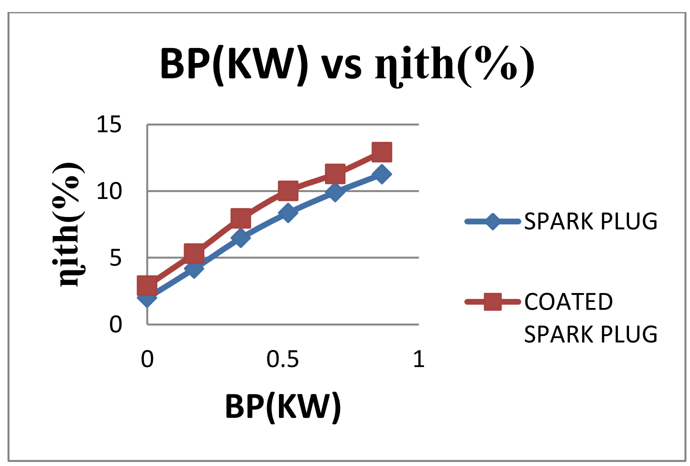

Chart -3: **Graph between B.P. Vs $\eta_{i.th.}$**

From the observation of results in fig.(B.P. Vs $\eta_{i.th.}$)the indicated thermal efficiency of coated spark plug insulator tip is more than that of usual spark plug.

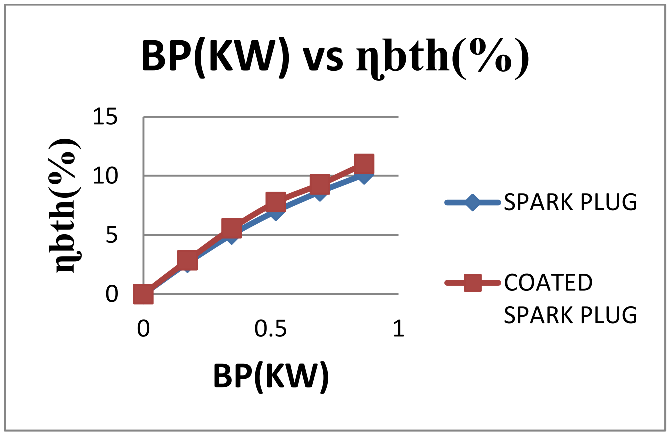

Chart -4: **Variation of brake thermal efficiency with respect to load.**

Thermal energy of an engine is defined as the ratio of output to that of the chemical energy input in the form of fuel supply. It may be based on brake or indicated output. It is the true indication of efficiency with which the thermodynamic input is converted into mechanical work. Brake thermal efficiency indicates how much amount of heat energy is converted into brake power. From the observation of results in fig (graph B.P. Vs η B.Th.) the brake thermal efficiency of coated spark plug insulator tip is more than that of usual spark plug.

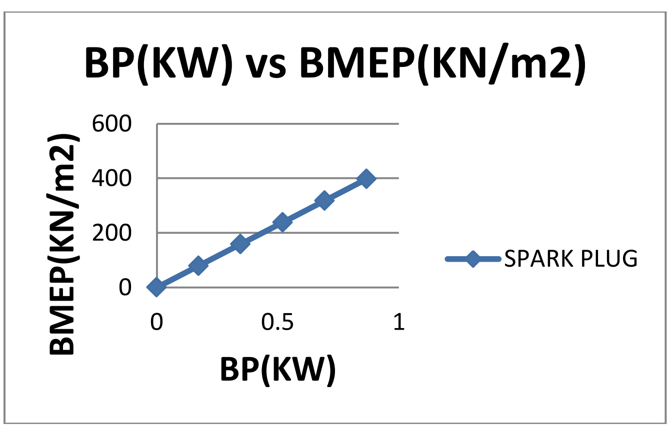

Chart -5: **Graph between B.P. Vs BMEP**

From the observation of results in fig.(B.P. Vs BMEP) BTE indicates the ability of the combustion system to accept the experimental fuel and provides comparable means of assessing how efficiently the fuel is converted to mechanical output. the pressures exerted for both is same for each particular output(for each particular load) hence the graph obtained is a straight line from zero to maximum output for all blends and for each brake power

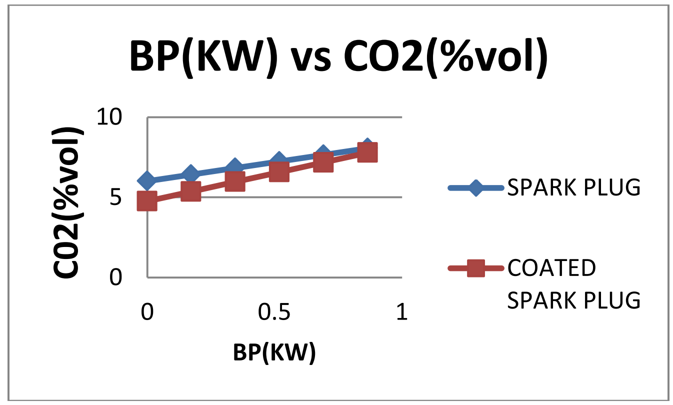

Chart -6: **Variation of CO_2 with respect to BP**

Compares the Carbon dioxide (CO_2) production per input energy for all kind of fuels at different output power. From Fig (BP Vs CO2) the CO2 emissions of coated spark plug insulator tip is quietly high when compare to usual spark plug resulting in a rich mixture and poor fuel economy leads to plenty of oxygen availability the unburned carbon reacts with oxygen leading to formation of CO2 Emissions.

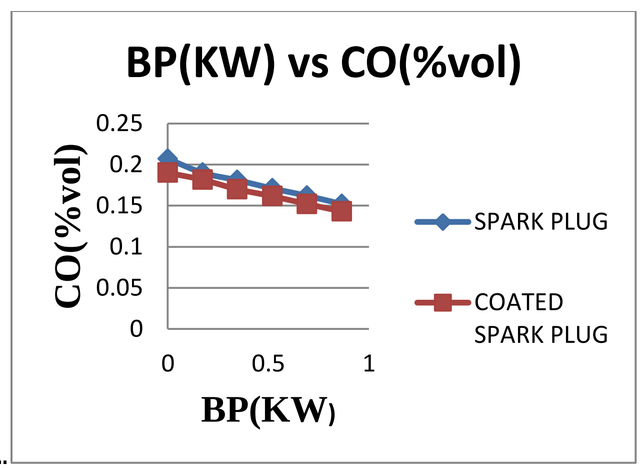

Chart -7: **Variation of CO with respect to BP**

Shows the observation of results in fig.(B.P. Vs CO) the CO Emissions of coated spark plug insulator tip is lesser than usual spark plug and there is an abundant availability of oxygen for complete combustion of carbon particles takes place leading to lesser CO emissions.

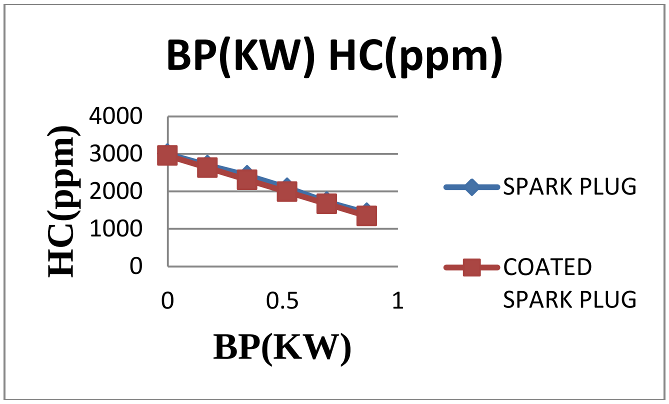

Chart -8: **Variation of HC with respect to BP**

From the observation of results in fig.(B.P. Vs HC) the HC Emissions of coated spark plug insulator tip is lesser than usual spark plug due to high boiling and condensing temperatures in SI engines there is no adherence of HC particles on the surface and prevents HC formation.

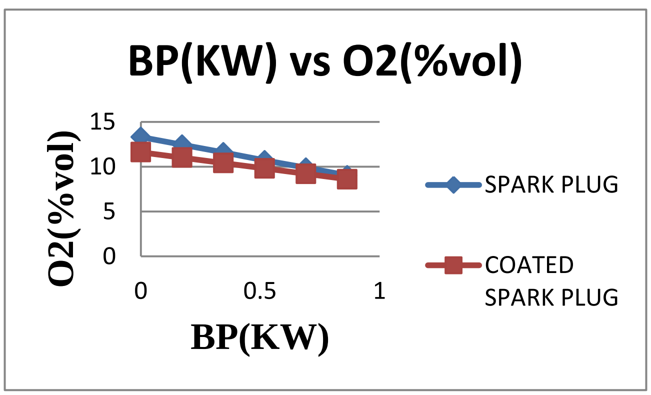

Chart 9: **Variation of HC with respect to BP**

Shows the variation of (O2) with brake power. The emission increases with increasing of usual spark plug reaches maximum value with using pure coated spark plug insulator tip. O2 are reported by several researchers to be increased with petrol fuel. The emission of O2 is determined by oxygen concentration, peak pressure, combustion temperature and time. The availability of oxygen in petrol can explain the increase in the HC, CO emissions.

4. CONCLUSION:

The Performance of an IC Engine of a 1500rpm, two stroke-single cylinder air cooled engine using the usual spark plug and coated spark plug insulator tip have been performed. The steady-state tests for each spark plug were conducted by varying the engine load. Afterwards, the Performance Curves were drawn using the experimental data. Finally, various Mechanical performance parameters of the engine were evaluated and compared with each other.

The conclusions we obtained from this experiment are:

1. The performance of the engine increases mainly due to the irreversible processes such as combustion. The energy losses due to the exhaust gas and heat flow from the control volume are reduced.
2. Coated spark plug insulator tip gives higher efficiency compared with other below percentage of usual spark plug. Emissions obtained from the performance has be gradually decreased which is clearly shown in above graphs.
3. Due to the higher resistance to the formation of hot spots the knocking tendency has been completely reduced during the performance.

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