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Telescopic Spark Ignitor in Spark Ignition Engines Elimination of a Spark Plug

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Abstract: In the present scenario of the automotive industry, the technical experts are exploring on concepts to increase the efficiency and working accuracy of the internal combustion engines, now what we are going to see is about how we can effectively eliminate a spark plug in a spark ignition engine and use another component in the place of it which also is accurate in its spark timing preventing pre-ignition. This system is advantageous in many more ways which we explained in detail in the later part of the paper.

1. INTRODUCTION

When we speak of spark-ignition engines, what strikes our minds immediately are the spark plugs. Now let us see what spark plugs are? Spark plug is a device for delivering electric current from an ignition system to the combustion chamber of a spark-ignition engine to ignite the compressed fuel/air mixture by an electric spark, while containing combustion pressure within the engine. [1]Now knowing what spark plugs are, we must know where, why and how they are used and last but the least how they are made. Spark plugs are used only in SI-engines as we all know petrol needs to be ignited while just high pressure is enough to go on with diesel. The spark plug has two primary functions – i) to ignite the air/fuel mixture. Electrical energy is transmitted through the spark plug, jumping the gap in the plugs firing end if the voltage supplied to the plug is high enough. This electrical spark ignites the gasoline/air mixture in the combustion chamber. ii) To remove heat from the combustion chamber. Spark plugs cannot create heat, they can only remove heat. The temperature of the end of the plug's firing end must be kept low enough to prevent pre-ignition, but high enough to prevent fouling. The spark plug works as a heat exchanger by pulling unwanted thermal energy from the combustion chamber and transferring heat to the engines cooling system. The heat range of a spark plug is defined as its ability to dissipate heat from the tip.[2]

2. OPERATION OF A SPARK PLUG

The plug is connected to the high voltage generated by an ignition coil or magneto. As the electrons flow from the coil, a voltage difference develops between the center electrode and side electrode. No current can flow because the fuel and air in the gap is an insulator, but as the voltage rises further, it begins to change the structure of the gases between the electrodes. Once the voltage exceeds the dielectric strength of the gases, the gases become ionized. The ionized gas becomes a conductor and allows electrons to flow across the gap. Spark plugs usually require voltage in excess of 20, 000 volts to 'fire' properly. As the current of electrons surges across the gap, it raises the temperature of the spark channel to 60, 000 K. The intense heat in the spark channel causes the ionized gas to expand very quickly, like a small explosion. This is the "click" heard when observing a spark, similar to lightning and thunder. The heat and pressure force the gases to react with each other, and at the end of the spark event there should be a small ball of fire in the spark gap as the gases burn on their own. The size of this fireball or kernel depends on the exact composition of the mixture between the electrodes and the level of combustion chamber turbulence at the time of the spark. A small kernel will make the engine run as though the ignition timing was retarded and a large one as though the timing was advanced.[3]

3. CONSTRUCTION OF A SPARK-PLUG

A spark plug is made of a center electrode, an insulator, a metal casing or shell, and a side electrode (also called a ground electrode). The center electrode is a thick metal wire that lies lengthwise within the plug and conducts electricity from the ignition cable hooked to one end of the plug to the electrode gap at the other end. The insulator is a ceramic casing that surrounds much of the center electrode; both the upper and lower portions of the center electrode remain exposed. The metal casing or shell is a hexagon-shaped shell with threads, which allow the spark plug to be installed into a tapped socket in the engine cylinder head. The side electrode is a short, thick wire made of nickel alloy that is connected to the metal shell and extends toward the center electrode. The tips of the side and center electrodes are about 0.020 - 0.080 inch apart from each other depending on the type of engine), creating the gap for the spark to jump across. The several hundred types of spark plugs available cover a variety of

internal-combustion engine-driven transportation, work, and pleasure vehicles. Spark plugs are used in automobiles, trucks, buses, tractors, boats (inboard and outboard), aircraft, motorcycles, scooters, industrial and oil field engines, oil burners, power mowers and chain saws. Turbine igniters, a type of spark plug, help power the jet engines in most large commercial aircraft today while glow-plugs are used in diesel engine applications.

The heat range or rating of a spark plug refers to its thermal characteristics. It is the measure of how long it takes heat to be removed from the tip of the plug, the firing end, and transferred to the engine cylinder head. At the time of the spark, if the plug tip temperature is too cold, carbon, oil, and combustion products can cause the plug to "foul out" or fail. If the plug tip temperature is too hot, pre-ignition occurs, the center electrode burns, and the piston may be damaged. Heat range is changed by altering the length of the insulator nose, depending on the type of engine, the load on the engine, the type of fuel, and other factors. For a "hot" plug, an insulator with a long conical nose is used; for a "cold" plug, a short-nosed insulator is used. Spark plugs are under constant chemical, thermal, physical, and electrical attack by corrosive gases at 4, 500 degrees Fahrenheit, crushing pressures of 2, 000 pounds per square inch (PSI), and electrical discharges of up to 18, 000 volts. This unrelenting assault under the hood of a typical automobile occurs dozens of times per second and over a million times in a day's worth of driving.[4]

4. THE CONCEPT

Now let us see how we can eliminate a spark plug by introducing a telescopic pin that is mounted on the piston head. In this arrangement there is a telescopic pin which has three hollow tube like pins and a small pin with a sharp edge capable of producing a spark when near another pin that is charged by unlike charges. Now there is a ring that is a good conductor of electricity that is mounted on the inner wall of the combustion chamber and completely insulated from the combustion chamber and the ring is connected to positive terminal.

When this telescopic pin like mounted structure passes through the ring, the ring allows only the pin from inside to come out through it and reach a point nearer to the other electrode that is negatively charged and is mounted from the top of combustion chamber's inner side and is also insulated from the combustion chamber. each time the ring pushes the pin out there occurs a spark, this is okay in the case of a two stroke engine but in a four stroke engine we will have to0 control the distributor and see to that the switch contacts open or close only according to the calculated timings else we will have to go for a EC unit controlled system that perfectly functions which is also a better option rather than using a magneto or coil ignition system.

5. DIAGRAMS

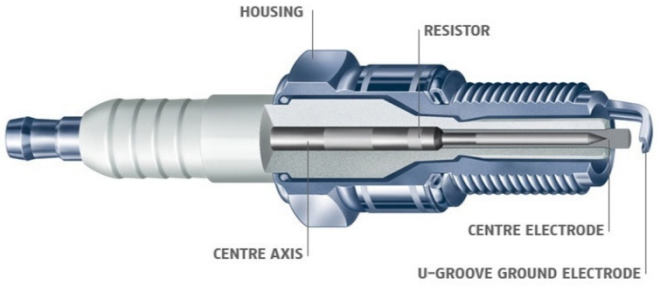

Fig1: a typical spark plug

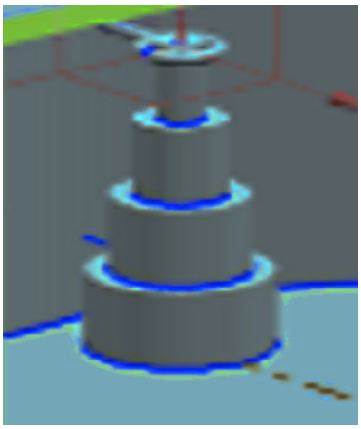

Fig 2: Telescopic pin and ring structure

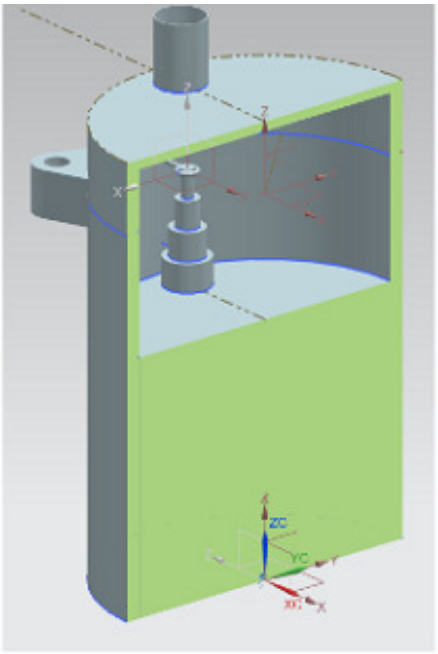

Fig 3: The engine setup cross-section view

6. TABLES

SL. NO	PART NAME	SIZE
1.	Inlet and exhaust port diameter	10.5 mm
2.	Ring diameter	4 mm
3.	Piston head diameter	64 mm
4.	Cylinder diameter	68 mm
5.	Height of telescopic housing	23 mm
6.	Diameter of telescopic housing	10 mm

7. DEFINITIONS

- **Combustion chamber:** A combustion chamber is the part of an engine in which fuel is burned. [5]
- **Combustion:** Combustion or burning is the sequence of exothermic chemical reactions between a fuel and an oxidant accompanied by the production of heat and conversion of chemical species. The release of heat can produce light in the form of either glowing or a flame. In a complete combustion reaction, a compound reacts with an oxidizing element, such as oxygen or fluorine, and the products are compounds of each element in the fuel with the oxidizing element. [6]
- **Compression ratio:** The compression ratio of an internal-combustion engine or external combustion engine is a value that represents the ratio of the volume of its combustion chamber from its largest capacity to its smallest capacity. It is a fundamental specification for many common combustion engines. In a piston engine, it is the ratio between the volume of the cylinder and combustion chamber when the piston is at the bottom of its stroke, and the volume of the combustion chamber when the piston is at the top of its stroke. [7]
- **Crankshaft:** The crankshaft, sometimes abbreviated to crank, is responsible for conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating linear piston motion into rotational motion, whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion.[8]
- **Cylinder**: A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels.[9]
- **Exhaust:** An exhaust system is usually piping used to guide reaction exhaust gases away from a controlled combustion inside an engine or stove. The entire system conveys burnt gases from the engine and includes one or more exhaust pipes.[10]
- **Gasoline:** Gasoline or petrol is a transparent, petroleum-derived liquid that is used primarily as a fuel in internal combustion engines. [11]
- **Ignition:** An ignition system is a system for igniting a fuel-air mixture. Ignition systems are well known in the field of internal combustion engines such as those used in petrol (gasoline) engines used to power the majority of motor vehicles, but they are also used in many other applications such as in oil-fired and gas-fired boilers, rocket engines, etc. [12]
- **Piston:** A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from the crankshaft to the piston for the purpose of compressing or ejecting the fluid in the cylinder. In some engines, the piston also acts as a valve by covering and uncovering ports in the cylinder wall. [13]
- **Stroke:** Reciprocating motion, used in reciprocating engines and other mechanisms, is back-and-forth motion. Each cycle of reciprocation consists of two opposite motions: there is a motion in one direction, and then a motion back in the opposite direction. Each of these is called a **stroke**. The term is also used to mean the length of the stroke.[14]
- **Thermal efficiency:** In thermodynamics, the thermal efficiency is a dimensionless performance measure of a device that uses thermal energy, such as an internal combustion engine, a steam turbine or a steam engine, a boiler, a furnace, or a refrigerator for example. In other words, efficiency indicates how well an energy conversion or transfer process is accomplished.[15]
- **Valve:** A valve is a device that regulates, directs or controls the flow of a fluid (gases, liquids, fluidized solids, or slurries) by opening, closing, or partially obstructing various passageways. Valves are technically valves fittings, but are usually discussed as a separate category. In an open valve, fluid flows in a direction from higher pressure to lower pressure.[16]

8. DEFECTS IN THE EXISTING SPARK PLUGS

Now as we all know a coin has two sides, there are advantages as well as disadvantages in this case as in every other case. Some of the disadvantages those considerably affect the efficiency of the spark plugs are jotted below:

a) The appearance of corona stains on the insulators of the spark plugs that occur due to leakage of charges or electrons along the body of the spark-plug.

b) At times there are unwanted or undesired contacts between the terminals or the electrodes of the spark plug creating conditions like pre-ignition, misfiring ., etc

c) There occurs a metal-oxide or carbon deposit as the combustion takes place in the combustion chamber of the internal combustion engine.

d) In certain situations the timing is not absolutely accurate as there are chances the contacts may open or close due to some errors.

9. ADVANTAGES OF THIS CONCEPT

a) There is minimal risk while taking into consideration the chance of appearance of a corona stain that takes place due to leakage of electrons or charges along the body of the insulator.

b) There is no possibility of unwanted or undesired contacts as the pin reaches near the other electrode only when the piston comes to the top dead center and that is accurately when we need the spark to be produced precisely.

c) As the pin is almost inside the telescopic tube there is less chance for the carbon particles or other gaseous or solid impurities to get deposited on the pin.

d) As we told earlier the timing of the producing the spark need not be worried about as it takes place only when it needs to take place accurately.

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