Digital Twin Spark Ignition System (DTS-I)

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ABSTRACT:Spark Ignition Engine is widely used for powering motorbikes. During high speed and heavy loading conditions single spark plug is used to ignite the air-fuel mixture but it is not effective. In fact, the fuel burning process is not always instantaneous.An alternative solution is to make fuel combustion as quick as possible. This issue is solved by implementing the innovative twin spark ignition system.By using two spark plugs that alternatively spark at a certain interval of time and the diameter of the fuel's flame & instant burning increased.This system is called DTS-I (Digital Twin Spark Ignition System). Because of the DTS-i system strong performance and fuel efficiency could be mixed. The improved modes of engine efficiency have also led to lower fuel consumption.The performance of the small displacement engines is enhanced simply by increasing the number of fuel igniting factor i.e. Spark plug. Thus a good design and control of the system parameters becomes most important for optimum engine performance.DTS-I provides many advantages over traditional ignition system with mechanical spark.The DTS-I engine has been studied and tested by researchers on various parameters such as basic fuel consumption, thermal performance, exhaust gas emission, and engine power.A new well-improved ignition system is born called Triple Spark Technology requiring the use of three rather than one or two spark plugs.

KEYWORDS:Carburetor, Digital Twin Spark Ignition,Engine Fuel Feeding System,Fuel Injection,Swirl Induction,Tumble Flow Induction.

INTRODUCTION

An ignition system is a system by which a fuel-air mixture is ignited.Ignition systems are well known in the field of internal combustion engines, such as those used in petrol (gasoline) engines used to drive most motor vehicles, but are also used in many other applications, such as oil and gas-fired boilers, rocket engines and so on andall petrol engines is used as an electric spark for ignition[1].

DIGITAL TWIN SPARK IGNITION (DTS-I)

Combustion of fuel happens at the end of compression stroke and power stroke or stroke of expansion is started.The entire scenario of an engine performance may be changed by improving the power stroke.Bajaj Auto Ltd. has competed research and development on the power stroke and invented a new technology called the DTSI (Digital Twin Spark Ignition).This uses two- spark plug in this system combusted fuel inside the engine cylinder. Using two-spark plug increases the fuel's burning efficiency, and generates more power with less fuel[2]. It works from the two spark plugs produced on the principle of twin spark.Compared to single spark fired engines, the combustion of the air-fuel mixture occurs at an optimal level in twin spark engines and it generates more power.The spark produced is more due to the use of twin spark plug which burns the fuel more efficiently and more quickly.This results in more fuel, less power and less exhaust gas emissions.The DTS-I engine generates 26% more power than traditional single-spark engines of the same size.They are digitally controlled by an Electronic Control Unit (ECU) consisting of a microprocessor chip with pre-programmed Ignition Timing data for different engine rpm and engine load.It controls spark plugs firing according to requirement[3]. Figure 1 shows the digital twin spark ignition (DTS-I).

Fig.1: Digital Twin Spark Ignition (DTS-I)

WORKING OF DTS-I ENGINE

It's a technology which uses two spark plugs. This essentially has two spark plugs in 90 degrees at the opposite end of the engine cylinder head; rather than one spark plug which is typical in a traditional engine.Two spark plugs generate the spark according to input requirement during the power stroke[4]. The ECU sends the low and high frequency pulses to spark plug to work as per conditions, depending on engine load, RPM and at medium-high speed.Spark timing of spark plugs is digitally controlled. DTS-I engines burns air-fuel mixers efficiently at the right time. There are several benefits and disadvantages to it[5]. Figure 2 shows the layout of the system of DTS-I.

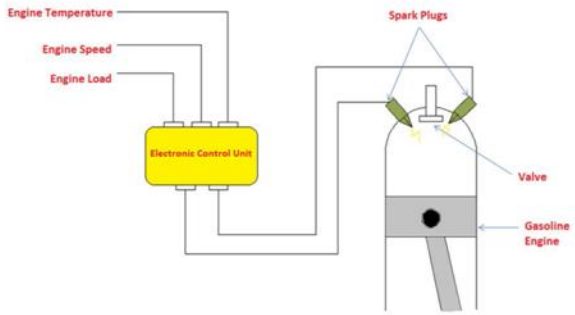

Fig.2: Layout of Digital Twin Spark Ignition System

1. *Advantages:*

- *Detonation can be reduced:* DTSI engine cannot detonate frequently because complete air-fuel combustion will not cause any disturbance between piston and wall.
- Less exhaust emissions.
- Better fuel efficiency.
- Less vibrations and smooth functional noise.
- Even at high rpm breathing performance of the engine is easy.
- No overheating problem.
- No un-burnt issue when combustion is complete.
- Rapid engine response even in cold and winter conditions.

2. *Disadvantages:*

- Expensive.
- Replacement of both spark plugs even one is damage due to connected in series.
- Design-complex.

ENGINE FUEL FEEDING SYSTEM

The main aim of the fuel feed system is to control the supply of fuel to the engine. In the case of a petrol engine, manufacturers use different methods to supply the fuel from the fuel tank to the motor cylinders.Petrol Engine Fuel Feed Systems include Gravity Feed System, Pump Feed System, Pressurized Feed System, Vacuum System, and Fuel Injection System.First four of these fuel feed systems work with a carburetor while an injector is used by the fuel injection system to supply the fuel to the engine cylinders[6].

1. *Carburetor:*

Carburetor operation is simple. The intake of air is via the air filter, and the intake of fuel comes from the fuel tank. The air and fuel mix together in a set ratio and then pass to the combustion chamber for power generation and burning.When the throttle is twisted, the air flow to the carburetor increases, resulting in swoosh of sucking force, thus increasing the fuel supply providing acceleration.It has many benefits such as quick to run, cheap to repair, easy service, can be opened individually without upsetting the engine.It has many limitations such as diaphragm inside is delicate and can tear which will end up having it replaced, tuning process needs a big screw driver and must be done physically, there is a certain amount of lag in fuel delivery process, old technology, air-fuel mixture ratio is not constant[7].

2. *Fuel Injection (FI):*

The Fuel Injection system operates in a more computerized manner and relies on many sensors. The fuel injection nozzle is directly installed in the combustion chamber. Air intake is measured by the position of the air sensor.There is a pressure pump that pressurizes the fuel that allows it to be atomized and the spray is in the form of a mist inside the combustion chamber that allows for complete and cleaner combustion[8].The fuel supply is controlled by the ECU which is the device that controls all of the bike's electronics. When the air supply increases the throttle is pulled and the air sensor detects the data then fed to the ECU so that the amount of fuel to be injected is also increased accordingly.The advantages of Fuel Injection are the optimum fuel delivery and the atomization of fuel allows complete combustion, increase in fuel efficiency and power output, increase the sensitivity of acceleration, change the air fuel mixture using various preloaded fuel maps for variable power outputs on the ECU.Fuel Injection's disadvantages are servicing the FI unit is cumbersome, if there is an ECU failure, the bike will take to work, it costs a lot and the service and maintenance is also expensive, producing new fuel maps requires loads of expertise, Procuring new fuel maps is a costly affair. The advantages and disadvantages of both fuel injections have the upper hand over carburetors because of the faster response and better power output, and also not to mention that they help to keep the levels of emissions in control[9].

MODERN TECHNOLOGY IN FUEL FEEDING SYSTEM OF MOTORCYCLES

1. *Swirl Induction:*

In swirl induction technology, the air-fuel mixture creates Swirl into the engine's combustion chamber, which should help improve fuel burning. The quality and concentration of the air-fuel mixture normally varies from one area to another within the combustion chamber under these conditions.The low turbulence combustion chamber spreads the flame like a balloon which is gradually expanding. That results in a slower combustion rate. It is also slowly raises the pressure that leads to less efficiency. Creating high turbulence inside the combustion chamber; under lean air-fuel mixing conditions, the combustion efficiency further improves. This technology is used primarily in Compression Ignition Engines where it is known as induction swirl.When the combustion occurs under heavy pressure the inflating flame surface breaks itself.This shapes projections such as fingertips raises the surface because of their geometry; conventional engines which use straight ports have limitations in creating high swirl values.When the combustion occurs under heavy pressure the inflating flame surface breaks itself.To create more turbulence or swirl, a port configuration is needed to stimulate that process.It is addressed through the design of offset ports which created the swirl's required degree.The ports offset positioning generates the air-fuel mixture in the combustion chamber with relatively high swirl and turbulence.This has been patented by Bajaj Auto Ltd under the name Digital Twin Spark Swirl Induction

(DTS-Si) for their twin spark ignition engines and is currently being used by them for some low-displacement engines as it only gives better results in them.Due to dual sparking there will be a smooth and clean combustion resulting in the engine acquiring a good efficiency with full combustion resulting in smooth operation of the engine and increased life span.Induction swirl is deliberate spinning of intake air, which encourages the mixing of fuel and air when the intake or cylinder is fueled by fuel.Swirl is generally created by piston and cylinder head shapes; as these shapes converge, the air is propelled to motion.Staggered intake valve closings promote swirl in four valve engines.Many engines have flaps that can be used to facilitate swirl in the intake manifold[10]. Figure 3 shows the combustion process in different twin spark ignition engine.

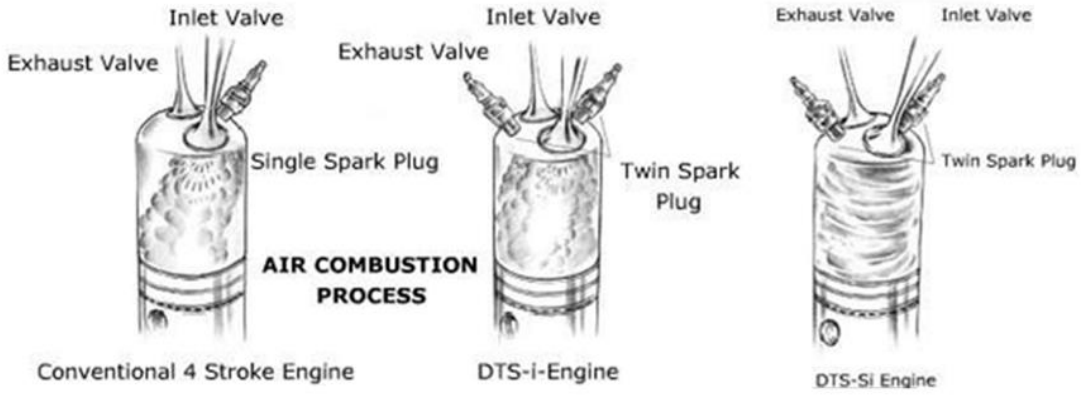

Fig.3: Combustion Procedure in Different Spark Ignition Engine

2. *Tumble Flow Induction:*

Tumble flow means the motion of a cartwheel.In this technology the mixture of air-fuel enters the cylinder of the engine with a somersault or tumbling action.Tumble Flow Induction Technology has the advantage that it delivers more efficient fuel burning.Thus, lower emissions the engine gives more power and better fuel economy.Technology focuses above all on the motorcycle's lower speed range.The traffic conditions and engine limitations a motorcycle may never reach the top speed mentioned on its dashboard.It operates at an average speed of 50-60 km / h most of the time.It clearly indicates that typically the bikes run at slower engine speeds, i.e. between 20-30 km / h, on average.The traffic conditions and engine limitations a motorcycle may never reach the top speed mentioned on its dashboard. Figure 4 shows the tumble flow induction in single spark ignition engine.

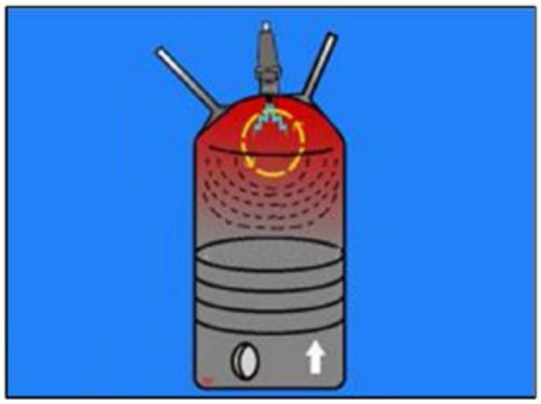

Fig.4: Tumble Flow Induction in Single Spark Ignition Engine

Lower engine rpm results in incomplete combustion process. It increases engine emissions. Induction process at low velocity becomes very slow. Consequently, the engine does not get enough air to completely burn the gasoline.The tumble flow also means that the airflow in the direction of the cylinder axis is circulating. It has

little effect on accelerating the process of combustion. So, when it completes near the end of the compression stroke, the tumble flow effectively improves engine combustion at light charge[11].

CONCLUSION

It is interesting to note that most researchers have under different conditions studied the performance of twin spark ignition system. Few tried to compare it to the single spark ignition system and to different fuel varieties.All of this research showed better results for reducing emissions, improving fuel economy and maximizing power out.There are many problems with this system, such as harmful NOX emissions, high speed overheating and loading condition due to faster and continuous air-fuel mixture burning, maintenance problems etc.Though the problem of overheating is addressed by introducing liquid cooling arrangement, it adds to the motorcycle's cost and its maintenance.It has good power out when used with fuel injection, but to use it in a larger displacement engine; it needs liquid cooling arrangement to deal with overheating, which adds to the motorcycle's weight and cost increase.Research also showed good results when used with 2-stroke engines, and it can be developed to be used again through emission control.Twin spark ignition system can be designed to be used for greater fuel economy and higher power output in multi-cylinder engines.It can also be designed to be used for optimum response with the Gasoline Direct Injection (GDI).But it will make the engines more complex; increase the costs of fabrication and maintenance. There are therefore many issues that can be addressed and at the same time there are many opportunities for parallel improvement that can help in the development of the Digital Twin Spark Ignition system.

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