DTSI

Revolution of Twin Spark in I.C. Engine

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DIGITAL TWIN SPARK IGNITION (DTSI)

A New Revolution of Twin Spark in I.C. Engine

Abstract

It is very interesting to know about complete combustion in automobile engineering, because in actual practice, perfect combustion is not at all possible due to various losses in the combustion chamber as well as design of the internal combustion engine. Moreover the process of burning of the fuel is also not instantaneous. However an alternate solution to it is by making the combustion of fuel as fast as possible. This can be done by using two spark plugs which spark alternatively at a certain time interval so as increase the diameter of the flame & burn the fuel instantaneously. This system is called ***DTSI*** (***Digital Spark Ignition system***). In this system, due to twin sparks, combustion will be complete.

This paper represents the working of digital twin spark ignition system, how twin sparks are produced at 20,000 Volts, their timings, efficiency, advantages & disadvantages, diameter of the flame, how complete combustion is possible & how to decrease smoke & exhausts from the exhaust pipe of the bike using ***Twin Spark System***.

Introduction

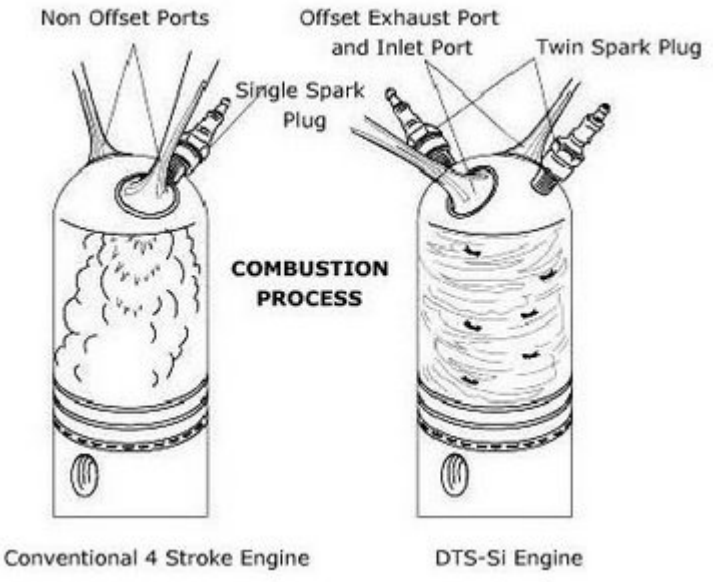
A conventional 4 Stroke engine has a Single Spark Plug located at one end of the combustion chamber and hence the combustion is inefficient leading to sub optimal mileage and sub optimal performance & can even have problems with oil flow. Hence forth there was a requirement to change engines' design, fuelling, ignition, production and quality to achieve the following objectives. Uniform power delivery in all operating conditions:-

- A high degree of drivability
- First rate standards of reliability
- Long service life.

With a view to overcome the above limitations a new patent was introduced that is known as DTS-I technology & its use is increasing day by days.

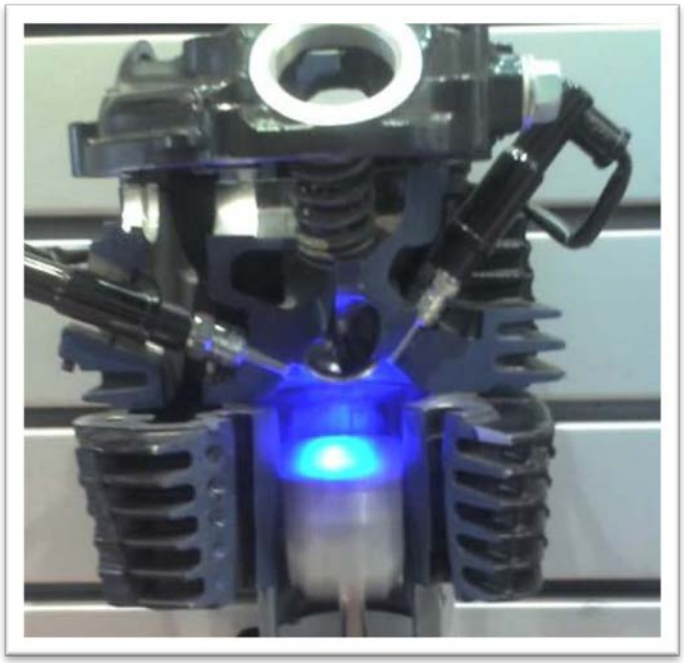
DIGITAL TWIN SPARK

ignition engine has two Spark plugs located at opposite ends of the combustion chamber and hence fast and efficient combustion is obtained. The benefits of this efficient combustion process can be felt in terms of better fuel efficiency and lower emissions. The ignition system on the Twin spark is a digital system with static spark advance and no moving parts subject to wear. It is mapped by the integrated



digital electronic control box which also handles fuel injection and valve timing. It features two plugs per cylinder.

This innovative solution, also entailing a special configuration of the hemispherical combustion chambers and piston heads, ensures a fast, wide flame front when the air-fuel mixture is ignited, and therefore less ignition advance, enabling, moreover, relatively lean mixtures to be used. This technology provides a combination of the light weight and twice the power offered by two-stroke engines with a significant power boost, i.e. a considerable "**power-to-weight ratio**" compared to quite a few four-stroke engines. The actual picture of Bajaj Pulsar Bike is -



Moreover, such a system can adjust idling speed & even cuts off fuel feed when the accelerator pedal is released, and meters the enrichment of the air-fuel mixture for cold starting and accelerating purposes; if necessary, it also prevents the upper rev limit from being exceeded. At low revs, the over boost is mostly used when overtaking, and this is why it cuts out automatically. At higher speeds the over boost will enhance full power delivery and will stay on as long as the driver exercises maximum pressure on the accelerator.

Main characteristics

- Digital electronic ignition with two plugs per cylinder and two ignition distributors;
- Twin overhead cams with camshaft timing variation;
- Injection fuel feed with integrated electronic twin spark ignition;
- A high specific power;
- Compact design and Superior balance;

This power unit, equipping the naturally aspirated 2-litre used on the Alfa 164, is a direct dilative of the engine fitted on the 2.0 Twin Spark version of the Alfa 75, a recent addition to the Alfa car range. It includes a number of exclusive engineering solutions resulting in superior power output and exceptional peak torque for this cylinder capacity. Its main characteristics are:

- Digital electronic ignition with two plugs per cylinder and two ignition distributors
- Twin overhead cams with camshaft timing variation
- Injection fuel feed with integrated electronic twin spark ignition

Cylinder capacity amounts to 1,962 cc thanks to an 84 mm bore and 88.5 mm stroke with the Compression ratio 10: 1.
Maximum power output at 5,800 rpm is a remarkable 148 BHP DIN, while maximum torque, of 19 mkg DIN, is reached at 4,000 rpm. The shape of the torque curve has been perfected to make available fully 16 mkg when revving speed reaches 2,000 rpm and 18 mkg as early as 3,000 rpm, thus making the engine's performance much more responsive.

Engine construction

The engine used on the Alfa 164 T. Spark is a four-in-line cylinder unit whose weight has been considerably reduced with all aluminium-alloy engine block, cylinder head, oil sump and tappet covers.

Eight counterweights ensure optimal balancing of the high strength nitride steel crankshaft.

The pressed-in cast iron cylinder liners feature wet mounting for more effective heat dissipation.

Constructional Detail

The construction of DTS-i engine is same as that of the conventional 4-Stroke engine. It consists of following parts:

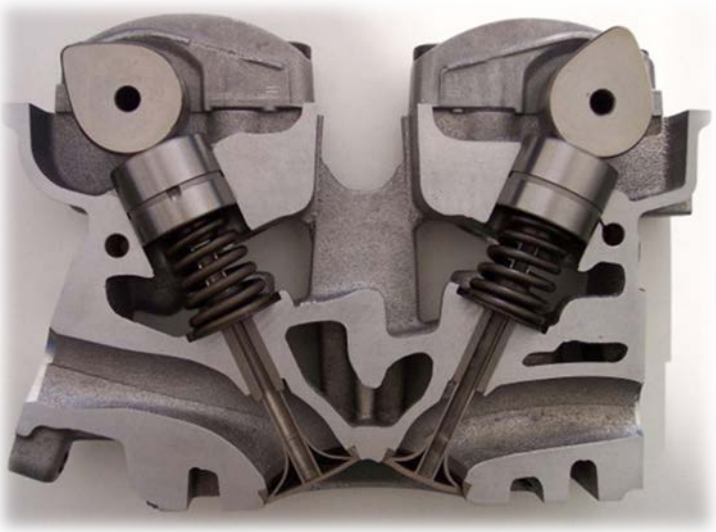
- Piston
- Cylinder
- Crankshaft
- Connecting rod
- Fly wheel
- Carburettor
- 2-sparkplug
- 2-ports
- 2-valves

Here the only change made is that the 2 sparkplug placed at the two opposite end of the combustion chamber At 90 degree to each other.

Valve drive

The twin overhead cams, driven by a double chain, act directly on the valves set in a tight Vee configuration (46°).

The timing of the valve train is not fixed as in most present day engines, but can be adjusted by a patented device conceived and produced by Alfa Romeo, the timing variation.



This is an electro-hydraulic actuator keyed onto the gear that drives the camshaft acting on the intake valves. This actuator enables the camshaft to be shifted into two different angular positions and to modify the intake valve opening durations. Its operation is controlled by the electronic control box of the integrated ignition and fuel injection system.

Valve timing actuator logic is predetermined so that overlap - i.e. that fraction of the engine's operating cycle when both the exhaust and the intake valves are open simultaneously – is shorter at low revs and with lighter loads,

and longer at higher engine speeds when extra power is required.

- At high and medium-high engine speeds or whenever additional power has to be provided (normal timing) cylinder filling is optimal, maximizing power output and torque
- At low and medium-low revs and lighter loads (delayed timing), fluctuation-free operation is ensured combined with a reduction in specific consumption.
- At all engine speeds, noxious emissions are minimized.

Fuel feed

The Alfa 164 T. Spark power plant is equipped with the ML 4.1 Bosch Motronic multi-point injection system, controlled by the same microprocessor which governs the twin spark ignition and variable valve timing Systems.

The excellent volumetric efficiency of the Twin Spark engine is also enhanced by the special straight section individual intake man folding that cuts down losses and fully exploits intake resonance for better mid-range torque.

Having all thermodynamic cycle components under the wings of a single electronic control unit means that the power plant used on the Alfa 1 64 T. Spark can guarantee-in addition to outstanding torque and power figures-regular, smooth running at all speeds regardless of load. Moreover, this engine features particularly attractive specific fuel economy compared with rival naturally aspirated units in the same displacement class (with savings of up to 20- 25%).

Working

The working of DTS-i engine is very similar to 4-stroke engine but here the only modification done is we are using two spark plug at two ends of the combustion chamber. Which require less time to reach the farthest position of the combustion chamber and optimize the combustion chamber characteristics.
There are some advance technology used in DTS-i engine which makes it more powerful than the conventional single sparkplug 4-stroke engine like

1. Tricks III technology
2. CDI technology

TRICS III.

Throttle Responsive Ignition Control System 3rd generation. It is a means of controlling the Ignition by operating the Throttle. Depending on the needs of the Rider whether it be cruising, acceleration or max speed, the ignition requirements constantly change. Based on a particular amount of Throttle opening, the Magnetic field generated by the Magnet opens or closes the Reed switch. The Reed switch is connected to the Digital CDI, which signals the CDI to change/switch, the desired Ignition Advance Timing Maps. This helps in achieving a good balance between driveability and Optimum

Ignition Spark advance, resulting in an almost perfect Ignition Spark advance for every Throttle opening and Engine rpm.

Ignition with a Digital C.D.I.

A Digital CDI with an 8 bit microprocessor chip handles the spark delivery. The programmed chip's memory contains an optimum Ignition timing for any given engine rpm, thereby obtaining the best performance characteristics from the combustion chamber. Working together with the TRICSIII system, it delivers Optimum Ignition Timing for varying load conditions.

Ignition

The ignition system on the Twin spark is a digital system with static spark advance and no moving parts subject to wear. It is mapped by the integrated digital electronic control box which also handles fuel injection and valve timing. It features two plugs per cylinder.

This innovative solution, also entailing a special configuration of the hemispherical combustion chambers and piston heads, ensures a fast, wide flame front when the air-fuel mixture is ignited, and therefore less ignition advance, enabling, moreover, relatively lean mixtures to be used. As a result, the adoption of twin spark ignition yields:

- A remarkable improvement in thermodynamic efficiency and hence a considerable increase in the amount of power available;
- more effective combustion at low load and at idling speed;
- A sizeable reduction in specific fuel consumption;
- A reduced exhaust emission;
- Less chance of ignition system failure...

(Failure of either circuit will not stop the engine, which can still work with single spark ignition).

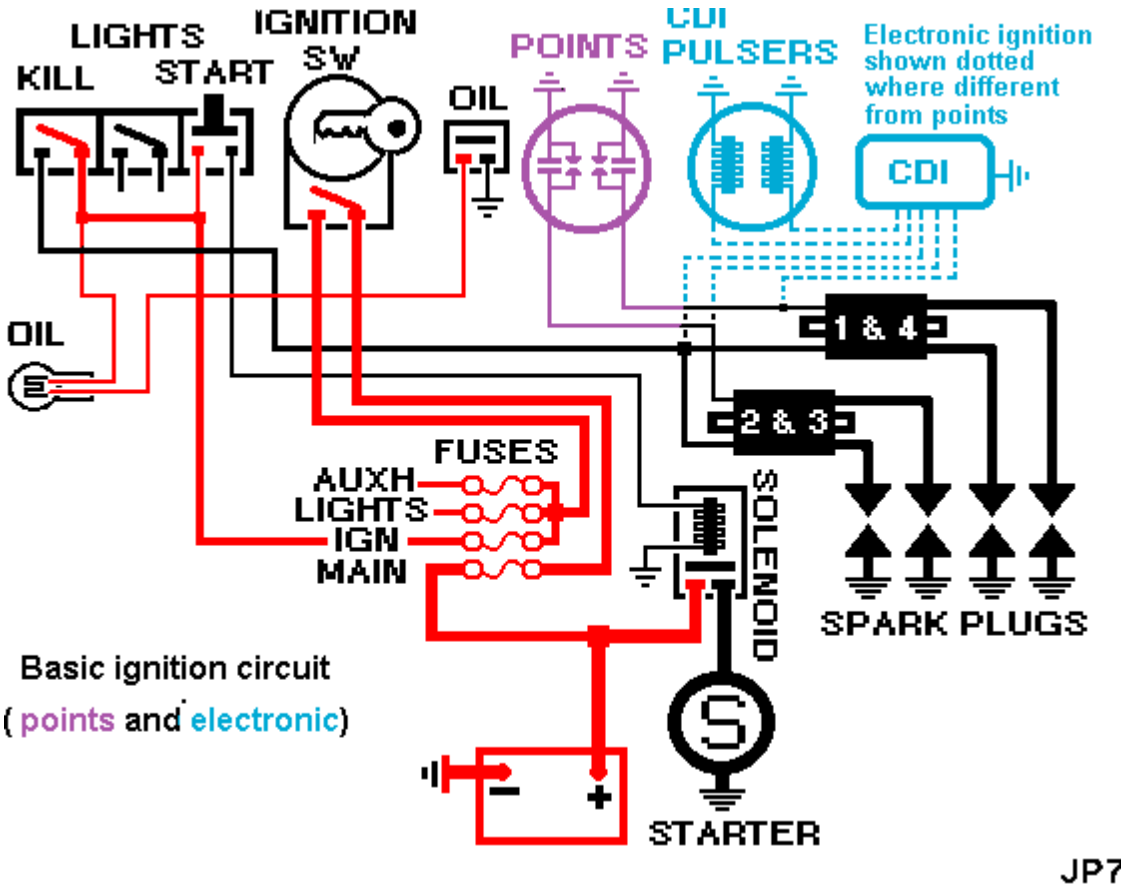


Fig: Starting of Pulsar DTSI Bike

Mathematical Model

Governing equations of the cycle model:

- *The energy equation in crank angle basis is written as*:

$$\Delta U = Q - W = m\frac{du}{d\theta} + u\frac{dm}{d\theta} = \frac{dQ}{d\theta} - p\frac{dV}{d\theta}$$

- To determine instantaneous cylinder volume, pressure, and burned and unburned gas temperatures, the following governing equations have been used

$$V(\theta) = V_c\left\{1 + \frac{r-1}{2}\left[1 - cos\theta + \frac{1}{r_{cr}}\left[1 - \left(1 - r_{cr}^2 sin^2\theta\right)^{.5}\right]\right]\right\}$$

- *Equations to determine the burnt mass fraction*

$$\frac{dm_e}{d\theta} = \rho_u A_f U_e$$

$$\frac{dm_b}{d\theta} = \rho_u A_f S_L + m_e - {m_b}/{\tau_b}$$

$$\tau_b = {l_T}/{S_L}$$

Where,

$\boldsymbol{A_f}$ = *area of flame front*

$\boldsymbol{\tau_b}$ = *the characteristics burning time*

$\boldsymbol{l_T}$ = *length scale of characteristic flame*

$\boldsymbol{S_L}$ = *laminar flame speed*

$\mathbf{V_c}$ = *volume of combustion chamber*

$\boldsymbol{U_e}$ = *internal energy*

$\boldsymbol{\theta}$ = *crank angle*

Advantages of using Twin Spark

- Less vibrations and noise
- Long life of the engine parts such as piston rings and valve stem.
- Decrease in the specific fuel consumption
- No over heating
- Increase the Thermal Efficiency of the Engine & even bear high loads on it.
- Better starting of engine even in winter season & cold climatic conditions or at very low temperatures because of increased Compression ratio.
- Because of twin Sparks the diameter of the flame increases rapidly that would result in instantaneous burning of fuels. Thus force exerted on the piston would increase leading to better work output.

Disadvantages of using Twin Spark

- There is high NO_x emission
- If one spark plug get damaged then we have to replace both
- The cost is relatively more
- You spend double the amount on spark plugs when it is time to replace them.
- The engine tends to overheat and loose power at higher speeds as compared to a single plug engine.
- In case the Engine is kept unused for a long time soiling of spark plugs occur. Twin Spark system helps to reduce this problem.

Conclusion

Hence it can be concluded that the application of these technologies in the present day automobiles will give the present generation what they want i.e. power bikes with fuel efficiency. Since these technologies also minimize the fuel consumption and harmful emission levels, they can also be considered as one of the solutions for increasing fuel costs and increasing effect of global warming.

From this paper I have concluded that perfect Combustion in Internal Combustion engine is not possible. So for the instantaneous burning of fuels in I.C. engine twin spark system can be used which producing twin sparks at regular interval can help to complete the combustion.

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