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Enhancing Efficiency of SI Engines using Water Induction with Assistive Hydrogen Compensation

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ABSTRACT

The peak efficiency of an internal combustion engine recorded till date is 33%. This is because of loss of energy in the form of waste heat. The efficiency of the system only increases when the heat is converted into volume or pressure, which helps to push the piston down. The waste heat can be recovered and used productively, but this does not increase the volumetric efficiency of the system in any way. In order to boost the efficiency of the engine and the vehicle as a whole, the heat energy must be converted into volume and pressure. This can be achieved by injecting pure, demineralised water into the combustion chamber.

The process of injecting water into the combustion chamber can't be achieved by using a fuel injection system because water is denser than both diesel and petrol, also water is incompressible. Therefore spray atomisation of water in the air intake manifold can be done for water injection. The result of doing so would result in a longer power stroke which causes significant increase in torque and also a noticeable increase in horsepower.

The main advantage is that, the process allows the engine to develop one of two desirable characteristics whenever needed, (a) increase in fuel economy, (b) increase in engine power output. Steam stripping of oil from the cylinder walls removes debris from within the combustion chamber and also allows for constant decarburising of the combustion chamber walls. Considerable decrease in the temperature of the engine results in reducing NOx emission and aids in complete combustion and reducing CO.

KEY WORDS: internal combustion engine, Water Induction, spray atomisation, Hydrogen Compensation.

1. INTRODUCTION

An SI is an internal combustion engine with spark-ignition, designed to run on gasoline and similar volatile fuels. It was invented in the year 1876 in Germany by German inventor Nicolas August Otto. In most of the gasoline engines, fuel and air are pre-mixed before compression, even though some modern petrol engines now uses cylinder-direct petrol injection. Formerly premixing was done in a carburettor, but now it is done by electronically controlled fuel injection, except in small engines where the cost or complication of electronics does not justify the added engine efficiency.

Depending on several factors, the efficiency of internal combustion engines lies and one of which is the compression ratio. Most of the gasoline engines have a geometric compression ratio (From the geometry of the mechanical parts the purely mathed compression ratio) of 10:1 (premium fuel) or 9:1 (regular fuel), with some engines even reaching a ratio of 12:1 or more than that, but greater the compression ratio the more efficient is the engine in principle, and for higher compression-ratio conventional engines in principle needs gasoline with higher octane value, even though the contrast between actual and geometric compression ratios complicates this simplistic analysis.

Air has approximately 21% of oxygen. If there is no availability of enough oxygen for proper combustion, there will be an incomplete fuel burning obviously resulting in the production of lower energy. An immoderate rich air fuel ratio gives increased pollutants from the engine. The fuel burns in three stages. First, formation of water vapour through burning hydrogen. Second, burning of carbon to form carbon monoxide. Finally, the carbon monoxide burns to carbon dioxide. This final stage produces most of the power in the engine. If the fuel mixture is rich then all of the oxygen is consumed before this stage and the engine's power is reduced.

There are a few oddities in introducing fuel upstream of the combustion chamber cooling down the incoming air through evaporative cooling. The additional fuel that is not burned in the combustion chamber cools down the intake air resulting in more power.

At idle state zero thermal efficiency occurs, since no usable work is obtained from the engine. Gasoline engines suffer efficiency losses during low speeds where, small throttle openings in the high turbulence and frictional (head) loss in closed throttle when the incoming air must force its way around it; diesel engines do not suffer this loss because the incoming air is not throttled. Efficiency in both types of engine during high speeds is reduced by pumping and mechanical frictional losses, and the minimum period within which combustion has to take place.

Mixtures with slightly less fuel, called lean burn are more efficient. The combustion is a mixture of several hydrocarbons, resulting in water vapour, carbon dioxide, and carbon monoxide rarely and fractionally burned hydrocarbons.

Working of the system: In order to boost the efficiency of the engine and the vehicle as a whole, the heat energy must be converted into volume and pressure. This can be achieved by injecting pure, demineralised water into the combustion chamber.

Here injecting the demineralised water into the combustion chamber can't be done using a fuel injection system because water is denser than both diesel and petrol, also water is incompressible. So spray atomisation of water is carried out in the air intake manifold which results in a longer power stroke with notable increase in torque and also in horsepower.

2. EXPERIMENTAL SETUP

The test bike used here is a Bajaj pulsar 150, the engine is a single cylinder upright, 10^0 inclined 150cc, air cooled, carburetted engine. The test was carried out with three levels of water induction.

- Pressure atomisation with mechanical pump.
- Steam induction with exhaust heat as steam source.
- Humidifier apparatus with hydrogen compensation.

Pressurisation Atomisation with Mechanical Pump: This system of water induction proved to be ineffective because of imprudent delivery of water. The system was also erratic and uncontrollable which caused the engine to stall frequently. The mechanical pump nozzle was also too large to atomise the water droplets to the required amount. This said there was also a bit of manifold wetting resulting in cold air intake, which reduced white smoke, significantly.

Steam Induction with Exhaust Heat as Steam Source: This method also proved to be in effective as it also caused the engine to stall. The steam added to the heat of the air causing knocking. The steam was also questionable because the air along with the steam can't be filtered.

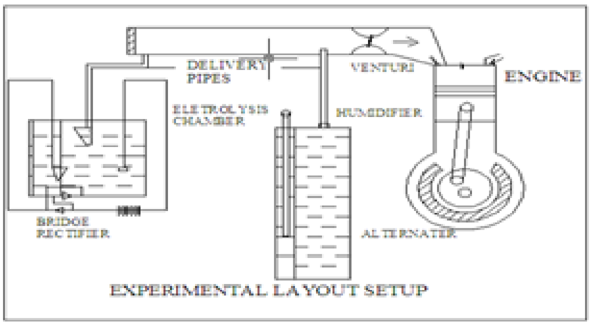

Fig.1. Experimental layout setup

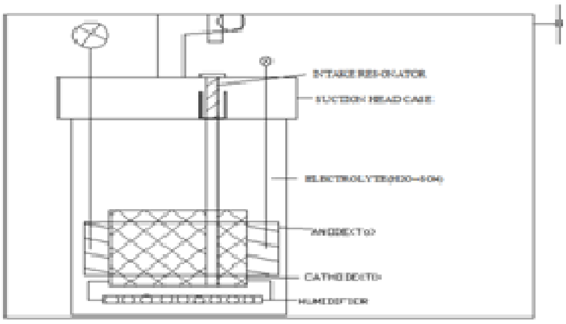

Fig.2. Humidifier Setup

Humidifier Apparatus with Hydrogen Compensation (Fig.1): Water has a very high heat of vaporization. As the ambient temperature water is inducted into the engine, heat is transferred from the hot cylinder head/ intake air into the water causing it to evaporate, thus cooling the intake charge.

A cooler intake charge is more dense (higher volumetric efficiency) and also will have a lower capacity to knock. However the water will displace some air, negating the denser intake charge from the lower temperature.

Knocking is normally a problem in forced induction engines rather than naturally aspirated so this can be a useful assistance in its prevention. On electronic ignition systems the ignition timing is generally retarded to avoid knock from occurring, but with water injection it can be advanced closer to Maximum Brake Torque (MBT) timing for additional power.

Fig.3. Actual Setup

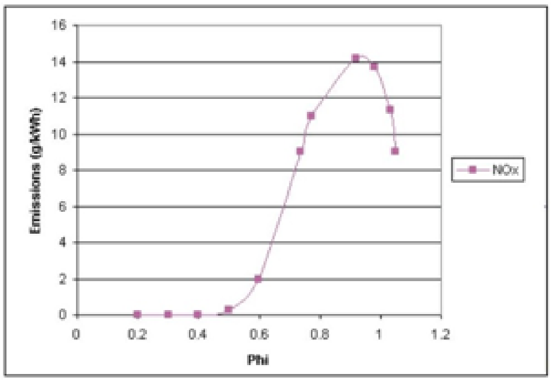

Fig.4. Emission for a hydrogen engine

The design (Fig.2) consists of two concentric titanium cages with a rubber spacer in-between. In addition to this, there is an aerator hose with a static charge inducer along with a spring resonator to impart charge to the moving air. By imparting stratified charge to the air the bonding of water to air is increased. The humidity of the air is increased to 23 % (approx.). This allows a volume of 0.0626cc of water per 150cc of engine volume per cycle. The actual setup installed in the engine is shown in the fig. 3.

3. RESULTS AND DISCUSSIONS

The results of this experiment are studied by tabulating the effects, before and after the installation of the system. Installation of the system resulted in the immediate increase in fuel economy.

- The vehicle which originally gave 45km/litre now gave 60km/lt to 65km/lt. This significant increase was due to the reduction of fuel being used.
- The vehicle also had better acceleration as the pressure inside the combustion chamber increased resulting in more torque being produced.
- The combustion was also stabilised because of the supplementary fuel, this was identified by the significant drop in combustion temperature and the absence of white smoke, which was predominant, prior to the installation of the system.
- The acceleration of the vehicle was not compromised, but in fact made better, without any stalling.
- The emissions were also reduced from a 4% to 1.2% which was due to the higher temperature of combustion promoted by hydrogen.
- There was an increase in noise levels because of the increase of combustion, this issue can be ignored because the vehicle remains within noise levels.

The carburettor clogging was reduced due to the back pressure being compromised with the supply of hydrogen.

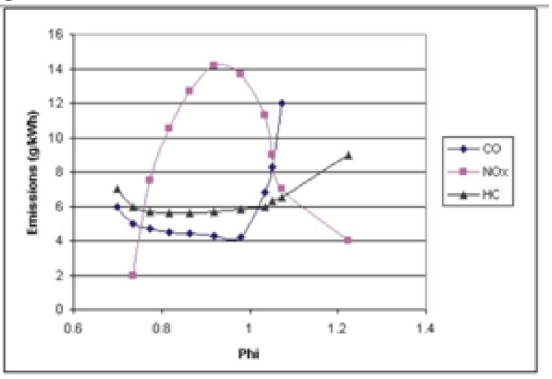

Fig.5. Emission characteristics of hydrogen

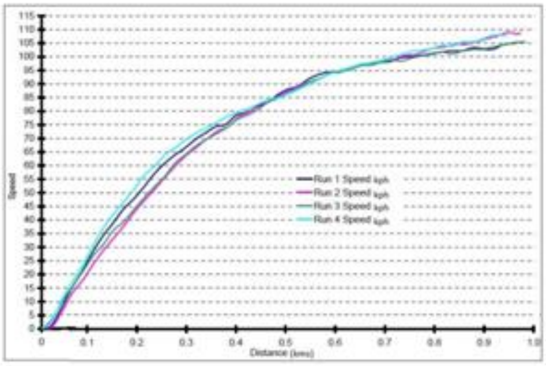

Fig.6. Speed vs distance graph

This chart (Fig. 4 and Fig. 5) indicates the emission characteristics of a hydrogen assisted gasoline engine, there is a definitive drop in the percentage of CO and NO_x levels. This was the result of water absorbing the heat energy and becoming steam. After the heat being absorbed, there will not be enough heat to raise the temperature sufficient to promote the formation of nitrogen oxides.

The insides of the valve faces and the walls of the combustion chamber were also de-carbonised and made more smoother, this results in less friction and a more lubricated and protected system.

The de-carbonising of the combustion chamber walls also results in the carbon deposits being carried with the exhaust gases the steam also prevents further formation of the carbon deposit. The carbon deposits have a tendency to be more affinitive towards steam, this makes them more in favour of the engine life, because there is no further deposition on the engine's combustion chamber walls.

Road testing of vehicle: The vehicle was tested on normal roads after installation of the integrated humidifier and electrolysis unit the vehicle had improved acceleration and a higher top speed both proof of increase in the torque produced and the top speed of the vehicle (Fig. 6)

Acceleration and top speed of vehicle without water induction kit tested on Chassis dynamometer .The chart below (Fig. 7) indicates the average acceleration of the bike when fully stock tested over the full range of the vehicle speed and gears. The test was calibrated to remove the loss of acceleration during shifting to provide an un-interrupted acceleration curve. The engine developed 13.5BHP.

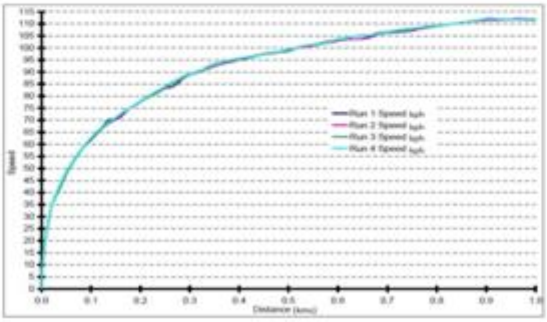

Fig .7. Acceleration and top speed of vehicle

Acceleration and top speed of vehicle with water induction kit tested on Chassis dynamometer. Engine power 14.1BHP.

The power developed by the vehicle before the addition of the water induction kit was 13.5 BHP, the engine developed 14.1 BHP after the activation of the water induction kit.

4. CONCLUSION

The system is effective and has shown considerable increase in power and acceleration. There was no noticeable corrosion, but heavier oil such as SAE10w60 or SAE 10w80 can be used. The engine was also de-carbonised in the process and does not have any soot deposits. This has made the engine smoother and more driveable in the process.

The overall performance of the vehicle has increased by a small amount with the addition of the water induction kit. Fuel consumption has also decreased which has resulted in reduced running cost of the vehicle. The system can be designed for larger engines to induct more water.

Smaller engines have relatively less benefits from the system due to their inability to induct sufficient water; they can be made more effective by addition of a turbocharger. Forced induction of air will make the water induction more effective due to higher travelling speed and greater suction. Although forced induction is not available for smaller engines as of now, it can still be used but its efficiency will have a limitation.

Modern MPFi engines and GDi engines have fuel metering systems and exhaust gas analysers, these engines have in built compensation mechanisms that meter the amount of fuel as per requirement. An individual injector can also be designed for injection of water. A dedicated injector would mean better atomisation of the water and a finer mist cloud production closer to the valve; this will directly increase the effectiveness of the system and also increase overall efficiency of the vehicle.

Reduction of the emissions is also a bonus point which makes the vehicle greener reducing the NOx emissions. Lower fuel consumption also means the lower carbon emissions both in the form of CO_2 as well as CO.

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