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Analysing the implementation of six stroke engine in a hybrid car

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Abstract: The aim of the presented paper is to understand the latest trends in Internal Combustion Engine while maintaining its prime focus on six stroke engine. The underlying idea to write this paper is to try and implement a 6 stroke engine coupled to an electric motor in hybrid car. This would then be numerically analyzed with existing hybrid cars. The important aspect is to actually combine the beneficial actions of both hybrid technology and 6 stroke engines and to study its after effects. The parameters during the comparison are efficiencies, fuel consumption, etc. The paper progresses with the governing principles in ideal case and then slowly implementing the idea in practical sense. Also the predicted fuel economy is been discussed below.

Keywords: Six Stroke Cycle, Air Induction System, Water Injection System, Hybrid Cars

1. Introduction

Amidst the ever progressing automobile engineering comes a new trend of engines popularly known as the 6 stroke engines. The six stroke engines are mostly recommended for their extra power output and thus most preferred in heavy vehicles where the prime focus is on load carrying capacity rather than fuel economy. It consists of six strokes which are due to the radical hybridization of 2 strokes and 4strokes, i.e. the piston in each move goes up and down six times for the injection of fuel. The six stroke engine consists of 2 chambers having internal combustion and external combustion wherein, the unused or waste heat from the 4 stroke Otto cycle is then used to carry out further strokes. These 2 additional strokes increase the work extracted per unit input of energy, which then lead to 40% increase in fuel efficiency than the four stroke Otto cycle.

According to the literature survey done, the Niykado six stroke engine was the very 1stsix stroke engine model carried out, which then seemed to fail. Followed by Bazulaz, Crowers and Griffins' model of six stroke engines. Malcolm Beare was the most successful inventor of six stroke engines.

The six strokes of the six stroke cycles are as follows:
Intake stroke
Compression stroke
Ignition stroke
Recompression stroke
Steam expansion stroke and
Exhaust stroke

The first 4 strokes are similar to those in 4stroke Otto cycle engine. The first stroke i.e. in the intake stroke air fuel mixture by the carburetor is supplied in the intake valve wherein the exhaust valve is closed and the piston is said to move from TDC (Top Dead Center) to BDC (Bottom Dead Center). The second stroke of compression is wherein the intake as well as the exhaust valves is closed, consists of compression of the air fuel mixture and the piston moves from BDC to TDC. In the third stroke, ignition takes place as a spark plug is used to ignite the compressed mixture and here begins the 2ndrevolution wherein the piston again moves from TDC to BDC. In the fourth stroke, these burnt gases are led out from the cylinder through exhaust valve and reed valve which then completes the 2ndrevolution and the fourth stroke as the piston moves from BDC to TDC. [4]

The differentiating points are the remaining two strokes i.e. the 5th and the 6th stroke. The fifth stroke initiates the power stroke, wherein instead of air- fuel mixture only air is sucked into the cylinder from the air filter through the secondary air induction line and the piston moves from TDC to BDC. In the sixth stroke then the air from the cylinder is led to the atmosphere by the exhaust valve.

So in general to summarize the above statements we say

that the power strokes are the 3rd and the 5th stroke. The exhaust strokes are the 4th and the 6th stroke.

2. Literature Survey

2.1. Six Stroke Engine

This section explains the beneficial aspects ina six stroke engine which does not exist in a 4 stroke engine. The major differences between 4 are 6 stroke engines are the extra 2 strokes of which the 5th stroke is the power stroke. It is of 2 types listed below:

2.1.1. Air Induction System

The six strokes engines as discussed earlier are basically used for high power output and high fuel efficiency. In the air induction system, the air from air filter is then passed to the mass flow sensor. The mass airflow sensor in the system indicates the airflow whereas there is also an intake temperature sensor which helps in determining the temperature. As there is high power and fuel efficiency, it will be regardless in saying that there will be high compression ratio in the system. [7]

This leads to detonation effect or pre-ignition in the system. This effect produces noise which is nowadays eliminated by using a silencer. The air induction system thus consists of high temperature intake air, as there are the turbochargers and superchargers in the engine which provide heat to the intake air. This heat can further be eliminated by the intercoolers which help in cooling the temperature of the hot compressed air and thus decrease its pressure. This increases the performance by rejecting heat into the atmosphere. As it provides higher power and is useful in high load capacity engine, this system can be seen in aircrafts.

2.1.2. Water Injection

Water as it is known for its reliable properties has a specific heat value of about 4.18 J/g ^{o}C The vaporization of water or any liquid is taken into account by its property called as 'the latent heat of vaporization' which determines the change in state of water from liquid to gaseous state. As seen in the 6 stroke engine, there is an extra power stroke apart from the one existing power stroke in the four stroke engine. After the intake, compression, ignition and exhaust strokes there is water injection in the system. It is done in order to prevent detonation in the system. As the air is then feed back into the 5th stroke it leads to a very high pressure in the system which gives rise to higher pressures.[1]

These pressures and temperatures lead to an explosive burning of air which proves to be harmful for the engine. The water injection system is initialized after the temperature exceeds 40^{o}C. It gives higher compression ratios and thus provides antiknock properties to the system which help in protecting the system from detonation as well as provide an efficient power stroke. Boeing B-52 initially made use of water injection for takeoffs as these systems are required for higher load carrying capacity automobiles. The water injection method is presumed to be better than air induction method since water has a higher heat absorption capacity than air also when air absorbs the heat and expands in the 5th stroke it generates high pressures in the engine head leading to high stress on cylinder.

The six-stroke engine has the following advantages:[3]

- Thermal efficiency reaching 50%. (30% for the actual internal combustion engines)
- Fuel consumption reduced by more than 40%.
- Reduction of chemical, noise and the rmalpollution.
- Two expansions (work) through six strokes.
- Direct injection and optimal fuel combustion at every engine speed

Factors affecting fuel efficiency:

- The heat that is evacuated during the cooling of a conventional engine's cylinder head is recovered in the six-stroke engine by the air-heating chamber surrounding the combustion chamber.
- After intake, air is compressed in the heating chamber and heated through 720 degrees of crankshaft angle, 360 degrees of which in closed chamber (external combustion).
- The transfer of heat from the very thin walls of the combustion chamber to the air heating chambers lowers the temperature and pressure of the gases onexpansion and exhaust (internal combustion).[3]
- Better combustion and expansion of gases that take place over 540 degrees of crankshaft rotation, 360° of which is in closed combustion chamber, and 180° forexpansion.
- The glowing combustion chamber allows the optimal burning of any fuel and calcination of the residues.
- Distribution of the work: two expansions (power strokes) over six strokes, or a third more than the in a four-stroke engine.
- Better filling of the cylinder on the intake due to the lower temperature of the cylinder walls and the piston head.
- Elimination of the exhaust gases crossing with fresh air on intake. In the six stroke-engines, intake takes place on the first stroke and exhaust on the fourth stroke.
- Large reduction in cooling power. The water pump and fan outputs are reduced. Possibility to suppress the water cooler.[3]
- Less inertia due to the lightness of the moving parts.
- Lower oil temperature. With combustion taking place in a closed chamber, the high temperatures less stress the oil and the risk of dilution is reduced, even in cold starts. Since the six-stroke engine has a third less intake and exhaust than a four stroke engine, there is depression on the piston during intake and the back.[5]
- Pressure during exhaust is reduced by a third. The gain in efficiency balances out the losses due to the passage of air through the combustion chamber and heating chamber valves, during compression of fresh and superheated air.

2.2. Hybrid Technology

The gasoline-electric hybrid car is just what it sounds like -- a cross between a gasoline-powered car and an electric car. A gas-powered car has a fuel tank, which supplies gasoline to the engine. The engine then turns atransmission, which turns the wheels. [2]

The hybrid is a compromise. It attempts to significantly increase the mileage and reduce the emissions of a gas-powered car while overcoming the shortcomings of an electric car.

To be useful to you or me, a car must meet certain minimum requirements. The car should be able to:

- Drive at least 300 miles (482 km) before re-fueling
- Be refueled quickly and easily
- Keep up with the other traffic on the road

A gasoline car meets these requirements but produces a relatively large amount of pollution and generally gets poor gas mileage. An electric car, however, produces almost no pollution, but it can only go 50 to 100 miles (80 to 161 km) between charges. And the problem has been that the electric car is very slow and inconvenient to recharge.

A gasoline-electric car combines these two setups into one system that leverages both gas power and electric power.

Gasoline-electric hybrid cars contain the following parts:[2]

- Gasoline engine- The hybrid car has a gasoline engine much like the one you will find on most cars. However, the engine on a hybrid is smaller and uses advanced technologies to reduce emissions and increase efficiency.
- Fuel tank–The fuel tank in a hybrid is the energy storage device for the gasoline engine. Gasoline has a much higher energy density than batteries do. For example, it takes about 1,000 pounds of batteries to store as much energy as 1 gallon (7 pounds) of gasoline.
- Electric motor- The electric motoron a hybrid car is very sophisticated. Advanced electronics allow it to act as a motor as well as a generator. For example, when it needs to, it can draw energy from the batteries to accelerate the car. But acting as a generator, it can slow the car down and return energy to the batteries.
- Generator– The generator is similar to an electric motor, but it acts only to produce electrical power. It is used mostly on series hybrids.
- Batteries–The batteries in a hybrid car are the energy storage device for the electric motor. Unlike the gasoline in the fuel tank, which can only power the gasoline engine, the electric motor on a hybrid car can put energy into the batteries as well as draw energy from them.
- Transmission–The transmission on a hybrid car performs the same basic function as the transmission on a conventional car. Some hybrids, like the Honda Insight, have conventional transmissions. Others, like the Toyota Prius, have radically different ones.

3. Aim and Objective

The prime aim to analyze a six stroke engine along with a hybrid car is taken into consideration on the basis of its fuel efficiency and power saving. The working of 4stroke engine is very well known and the remaining 2 strokes i.e. the 5^{th} and 6^{th} stroke, as discussed earlier, will be carried out as an engine is started; it predominantly helps in utilization of fuel. As seen in today's scenario, it has been evident that the fuel consumption is maximized due to the ever increasing urbanization. The hybrid cars corroborate a regenerative braking system which helps in maintaining the fuel efficiency by charging the regenerative batteries after the engine is stopped. Thus, the combination of six strokes and a hybrid car would lead into an extraordinary car engine mechanism, which will not only increase the existing fuel efficiency in total of the system with regards to its individual fuel efficiencies but would also renew the entire system in terms of its mileage, power output and most importantly its demand.

4. Numerical Calculation

The prime idea is to merge the six stroke engine along with hybrid technology.

The mileage of a normal car is 11.76 kmpl i.e. it covers 100 km in 8.55 liters of gasoline on average.

The hybrid car covers 100 km in 3.92 liters i.e. has a mileage of 25.52 kmpl.

But an existing hybrid car has a 4 stroke engine installed with the electric motor. If a 6 stroke engine is coupled instead of 4 stroke engine then practically it is observed that the fuel requirement is decreased by 25% though the manufacturers claim it to be 40%.

So eventually the combo car covers 100km in 2.94 liters i.e. at an average of 34 kmpl.

5. Advantages and Disadvantages

Advantages:

1. Even lower fuel consumption than an existing hybrid car.
2. Greater mileage
3. Low pollution due to combined effect of hybrid technology and 6 stroke engine
4. The load carrying capacity of hybrid car is increased due to extra power stroke.
5. Less load on engine as the load is proportionately divided among engine and batteries.

Disadvantages:

1. High initial cost due to changes in gear structure connecting the electric motor and gasoline engine.[6]
2. High manufacturing cost of six stroke engine
3. Engine size increases due to many numbers of cylinders and additional components.

4. Brake power and indicated power per cycle is low.
5. The upper limit of speed is restricted.[6]

6. Conclusion

The increased efficiency is a result of recovering heat primarily from the engine combustion gases. The recovered heat is converted to mechanical energy at the crankshaft by expanding steam in the engine combustion chamber. This form of waste heat is recovered & is accomplished by using a 6-stroke engine cycle. The paper concludes that the adoption of combined effect of a hybrid car and six stroke engine would help in the betterment of world economy as it helps in reduction of pollution and it would also support the advancement of automobile industry as it focuses on fuel efficiency which has become a prime objective in today's scenario.

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