Increasing Efficiency Of Engine By Combining Ic Engine And Ec Engine

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Abstract: Four stroke Diesel cycle and Otto cycle engines have very low thermal efficiency due to high amount of energy is lost in exhaust. It is estimated about 28%of fuel energy is lost in exhaust of engine and 22%of cooling lost .Remaining percent of energy of the fuel about 50 % of energy gets converted in to work. The development of new engine is proposed to use the energy of exhaust and also cooling of the engine in two more strokes of IC engine leading to a external engine. The internal combustion engines are generally a major source of air pollution. However the spark ignition engines are recognized by their carbon monoxide and unburned hydrocarbon emission. One of the methods used to reduce the emission of these pollutants is the use of external combustion engine. This paper describes the development of an external combustion engine which uses air in tanks at pressures of 30 - 50 MPa and at ambient temperature as combustion energy carrier, and hydrogen, alcohols or traditional motor fuel from organic minerals as chemical energy carrier. Research workings out are in the field finished to level of practical use. The mathematical and simulation model has been developed, tested, and verified to simulate a 4-stroke cycle of a spark ignition engine fuelled with gasoline.

IndexTerms- Combined, High efficiency, I. C. Engine, Steam engine, six stroke engine.

I. INTRODUCTION

The efficiency of internal combustion engines is very low due to loss of energy in exhaust, cooling of engine and also heat energy is low grade energy .The difficult challenges in engine technology are the urgent need of increase in engine thermal efficiency, thermal management strategies and the combustion process which are expected to play crucial roles in the development of high-efficiency engines for the 21st century .There are many concepts proposed for otto and diesel cycle. Some of them have been successfully used which include multipoint fuel injection and also ignition, turbochargers, etc. Some of them even tried to modify the basic four processes in the I. C. Engine.
These efforts have improved the efficiency but not significantly. There is no solution available today which can replace such a highly inefficient engine which is consuming fuel in enormous quantity and producing little work. Fuel consumption as on today in about 4-5 liters per 100 kilo meter for small car and to improve the efficiency of I C engine is an ongoing area of active research.

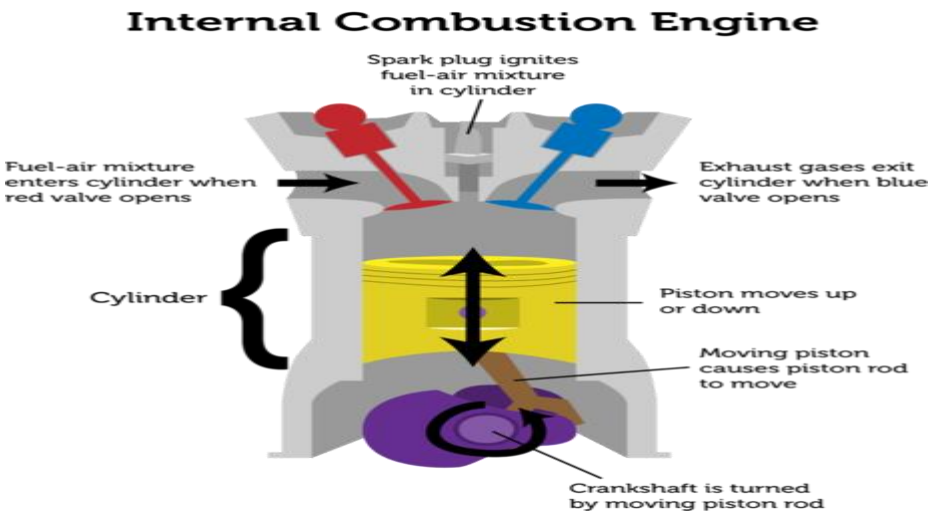
A six stroke diesel engine was proposed in SAE technical paper in 1999 . It has four strokes as per diesel engine using diesel as fuel and at the end of exhaust Methanol was injected which provided the second expansion stroke. The Injection timings and also the injection flow rates of diesel fuel and also the methanol were varied independently. The flow rate of diesel fuel and methanol were varied from 10% to 70%. It was found that NOx reduced considerably and almost zero emission of soot was achieved even if a small amount of methanol (less than 10% of the total fuel) was supplied in the second combustion process. The engine performance and heat release rate of the four stroke diesel engine and the dual fuel six-stroke engine were analyzed to understand the effect of duel fuel injection. It was concluded that the duel fuel IC engine has better performance and also considerably improvements in emission characteristics.

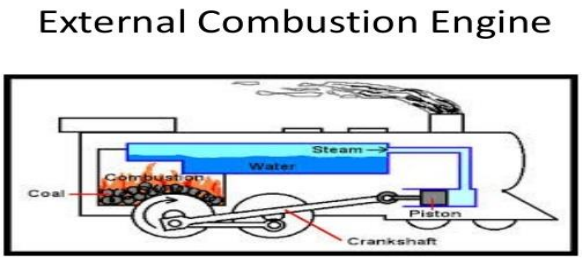
In an another approach, designer has modified a single-cylinder four stroke engine to work as six stroke engine where wasted heat energy created by fuel is used to convert water into steam after completion of the four strokes . After completion of the four strokes of I C Engine water is injected in superheated parts of I.C. Engine. Water coverts into steam and expansion of the order of 1600 times takes place which forces the piston to generate power. This also eliminates the requirement of cooling of the engine and therefore no energy lost in cooling.

In one of the other concept, the first four strokes are the same as a four stroke internal combustion engine . They have added two more strokes to complete a cycle. After the exhaust stroke (fourth stroke), fresh air is injected into the cylinder from the air filter. The air is heated from cylinder wall expands and carry out work and the air is removed during the sixth stroke. The heat energy left in the previous stroke is used to generate work by expanding air. It is claimed that the engine shows 40% reduction in fuel consumption and dramatic reduction in pollution. They have removed overlapping of valve and these additional two strokes provides better scavenging and modified engine shows 65% reduction in CO pollution .

The Piston charge engine (PCE) is a six stroke engine. It combines the advantages of two stroke and four stroke engines and the valve system is eliminated by incorporating pre compression cylinder. It delivers the fuel-/air mixture to a working cylinder . The working cylinder drives the crankshaft as per usual design of the petrol engine. Thus two strokes are added. This eliminates valve operations and therefore, valve and tappet noise is no longer present. The PCE concept can be used in Otto and also Diesel cycle engines. But it has several methodologies and processes for creating fuel/air mixtures . These processes have several alternatives to generate most optimum air fuel ratios for a petrol engine. In the proposed concept the engine exhaust is not completely thrown out. After exhaust valve opens and pressure reduces to near atmospheric pressure, it is closed. Now the usual compression stroke starts which compresses the exhaust to high pressure by keeping exhaust valve in closed position. Parallelly distilled water is circulated around the engine to cool it. The water is heated and injected at the end of second compression which quickly converts into steam. The conversion of water into steam causes 1600 times expansion which provides thrust on the piston to work as a expansion stroke. After carrying out the work by the steam it is exhausted in next stroke. Thus four stroke

engine works on Otto cycle and also on ranking cycle. Similar process can also be adopted for diesel cycle engine. By combining these two engines, two power strokes are generated in six stroke engine. The second power stroke does not need any external energy to perform work in the new engine.





2.0 Concept of combined engine

Paper is giving a concept of combining petrol engine and steam engine to give a new engine. It can also be used for combining Diesel and Steam engine also. First three strokes in new engine are same as in normal 4-stroke petrol engine where as fourth stroke is modified and two more strokes are added to complete a cycle. Such a new engine will improve the power generated, efficiency and also reduce pollution to environment.

2.1. First three strokes:

Suction stroke consists of piston moving from TDC (top dead center) towards BDC (Bottom dead center) where suction valve opens and fuel plus air sucked in to the cylinder. This charge is compressed which is assumed as adiabatic process while both valves remain closed. The compression ratio in such engine can be varied from 6-10. At the end of the compression stroke when piston approached TDC spark ignition takes place. It causes rapid rise in pressure and temperature which is assumed at constant volume. The generated high pressure and temperature produces a working/ expansion stroke which moves piston from TDC to BDC and produces power in the engine. Just before BDC exhaust valve opens for short duration to reduce pressure and also removes some of the exhaust gasses to start the fourth stroke of the modified Engine.

2.2. Second compression stroke (Fourth Stroke):

The fourth stroke is again a compression stroke where the remaining exhaust gases are compressed which is similar to second stroke of the petrol engine. The remaining combustion products from the third expansion stroke are recompressed to produce high temperature and pressure. The compression process assumed as adiabatic which is similar to second stroke in petrol engine.

2.3. Second power stroke (Fifth stroke):

Just before the end of the compression stroke distilled water which is already heated is sprayed in the combustion chamber with the help of injector. The spray is similar to diesel fuel spray at the end of second stroke of diesel cycle. Due to fine spray of water and high temperature, it immediately gets converted into steam whose volume increases by 1600 times to the volume of water. It causes high pressure similar to external combustion engine on the piston. The thermal energy of steam is now converted into work and piston moves from TDC toward BDC. Thus power is produced second time in such a combined engine without supplying any fuel from outside. Thus the extra power produced by engine increases its overall power and also efficiency of the engine increases significantly.

2.4. Exhaust stroke (Sixth stroke):

The exhaust valve begins to open at the time of the power stroke is about to complete. The exhaust consists of remaining gases from fuel burnt in first three strokes and steam and is at higher than the atmospheric pressure. These products come out through the exhaust manifold at high speed. Much of the noise associated with automobile engine is due to high exhaust velocity. The remainder of product is removed from the cylinder when the piston moves from BDC to TDC. During this stroke pressure inside the cylinder is slightly more than the atmospheric pressure. Some of the exhaust products are however left in the clearance space. The exhaust valve closes shortly after TDC.

The inlet valve opens slightly before the end of exhaust stroke and cylinder is ready to receive the fresh charge for new cycle. Therefore a cycle of combined engine has six strokes and at the same time crank moves three revolutions. Thus for six stroke cycle engine there are two power strokes for every three revolutions of crank shaft and in one cycle of operation.

3.0.changes needed:

Most of the petrol engine will remain as it is to work as a combined engine. However following major modifications are needed to convert an Otto cycle engine to work as combined engine.

3.1. Gear ratio between Crank shaft and Cam shaft:

In conventional four stroke engine, the gear ratio between crankshaft and camshaft is two and each cycle gets completed in one revolution of the Cam shaft while crank moves for two revolutions. The gear ratio in new engine needs to be modified to three so that one revolution of cam shaft is completed while crank shaft moves for 3 revolutions.

3.2. Modification in Cam:

The cam for opening the suction valve is not modified but it rotates at one third the speed of the crank shaft. The cam for opening and closing of exhaust valve needs significant modifications. It will need two lobes instead of one as in petrol engine. First lobe shall be at an angle near to 180 degree and sharp so that valve opens for shorter duration. The second lobe shall be at an angle of 300 degree and will be similar to the existing valve. It will open the exhaust valve for similar duration as in existing petrol engine. Thus the angle between the lobes of the cams in four stroke petrol engine and in combined engine will have significant modifications.

3.3. Addition of injector & pump:

Cylinder head of the engine needs to be modified to accommodate a water injector which is similar to the injector in diesel engine. It will inject measured amount of distilled water at the end of the fourth stoke of the combined engine. Injector will also have a pump to help in spray of water through injector. In modern engine it will be controlled by an Electronic controlled Unit (ECU) to provide measured amount of water at optimum pressure in to the engine.

3.4. Compatibility:

Injected distilled water and also produced steam needs to have good compatibility with lubricating oil. They should not react with lubricating oil and also have no effect while mixing with it. They should also not have drain -off effect on the lubricating oil. Modified lubricating oil or new type of the oil will be needed for new engine.

3.5 Addition of temperature sensor:

A temperature sensor in the exhaust of the engine is required to measure its temperature. This data will be fed to ECU. It will work with the electronic control unit (ECU) to control the amount of fuel and water supply to the combined engine.

3.6 .Distilled water storage tank:

A separate storage tank to store distilled water shall be needed. It will have similar capacity as of fuel tank. Of course distilled water after producing work can be separated and reused. However efforts needed to separate it will be more than the cost of distilled water.

4.0 Thermodynamic analysis:

An attempt is made to evaluate theoretically the performance of a petrol engine which is working in a bike. A 100 CC engine develops maximum of 5 kW power at 5000 rpm. Engine is assumed to have bore to stroke ratio as one with compression ratio of 9. The exhaust temperature of such engine varies from 200 to 400^0 C.

4.1. Cycle parameters:

It can be estimated that such a combined engine will have clearance volume of 12.5 CC and cylinder volume of 112.5 CC. The pressure after exhaust valve opens will be more than 1 bar i.e. atmospheric pressure. However for estimating extra power developed by such an engine on a safer side, the lower parameters are consider. The minimum exhaust temperature after first power stroke is taken 200^0C and pressure 1 bar. The estimated pressure after adiabatic compression of exhaust gases will be 21.7 bars.

4.2. Power produced:

Considering the distilled water addition is similar to petrol injection in six stroke engine. It means water admitted in every stroke will be 0.02 CC. It will be injected at the end of second compression stroke. The peak pressure produce shall be 110 bar [8]. The estimated adiabatic work of compression and expansion shall be 0.025 kJ and 0.15 kJ during 4^{th} and 5^{th} strokes of the engine.

Therefore , the additional work produced in these two strokes will be 0.125 kJ. Therefore, theoretical additional peak power produced for an ideal combined engine will be 3.4 kW. However such an additional power is ideal power and expected increase in power will be about 2 kW since power will be used in driving an additional pump, injector, friction of two strokes and cycle assumed also is ideal cycle with adiabatic processes [9].

5.0. Performance analysis:

By combining the Otto or Diesel cycle with Rankine cycle the efficiency of combined cycle increases significantly. Several attempts are made to increase the thermal efficiency of an I C engine. However, by combining these two engines there is much more increase in thermal efficiency than any other method suggested. The increase in efficiency is mainly due to use of the recovery of waste heat in cooling and also exhaust of the engine.

Otto cycle is also assumed as an ideal cycle. In real case increase in power will not be that much as shown in the thermodynamic analysis.
It practically eliminates the requirements of cooling of the engine. Thus the requirement of heat exchanger for cooling is eliminated. However such simplification is offset by the modification needed in the gear ratio, cam, extra injector etc. It means complication in engine configuration is not significant.
Since two power strokes are carried out in six strokes which is more than the single power stroke in 4 stroke engine the torque angle diagram is more smoother than the four stroke petrol engine. .
Engine shall work at lower temperature than the four stroke engine. It will improve the volumetric efficiency of the combined engine. Power production and also efficiency of the engine can be further increased by circulating water for injection around the exhaust gases.
Exhaust gases are re-circulated in the cycle which makes lower temperature and also significant improvements in the exhaust product. Beside reduction in pollution, it will considerably reduce the formation of NOx in the exhaust of the diesel engine. Interaction of exhaust gases are considerably reduced with fresh charge which also improves the engine performance.
In the present configuration of the engine, the distilled water should have compatibility with the lubrication oil. More over engine must work above the dew point temperature of the water otherwise combustion process of fuel will be affected. A distilled water storage tank similar to fuel tank also is needed for the engine.

CONCLUSION

The new concept in the engine will not require significant modifications in the existing petrol engine. The most important modification is the gear ratio between crank shaft and cam shaft of the engine. All the suggested modification are well within the technological understanding and applications.
Though the ideal thermodynamics cycle provide significantly more power developed by combined engine, yet expected increase in power shall be about 40 %.
Major achievement of the concept is to use the waste energy of exhaust and also cooling of the engine. Thus the second power stroke is developed without external use of energy. It improves the thermal efficiency of the engine, develops extra power, smoother turning moment diagram and considerable improvement in the exhaust of the petrol engine.
The use of the waste heat of internal combustion engine, the world energy demand on the depleting fossil fuel reserves would be reduced. Thus the combined engine would give more mileage and it would relief growing demand of the fuel.

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