Design And Analysis Of Six Stroke Internal Combustion Engine

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Abstract— The modern four stroke internal combustion engine has been widely applied due to excellent power to weight ratio and reliability. However, the major downside of the even most efficient modern 4 stroke engine is the production of significant amounts of excess heat energy, dissipated though the cylinder walls of the engine and expelled as waste energy during the exhaust stroke of the cycle. The development of a more efficient six stroke internal combustion engine for increasing the efficiency of four stroke engine for that the final two strokes designed to used of exhaust and convert it into power stroke and finally six stroke working as exhaust stroke and also batter scavenging. Some of basic modifications are done in four stroke engine and made a six stroke engine we can increase the brake thermal efficiency of the engine. Also the dramatic reduction in pollution and batter scavenging is occurs.

Key Words: 2-Cylinder Four Stroke Diesel Engine, Camshaft-design, Flywheel Design

I. INTRODUCTION

As the time passes, it is believed that the petroleum products and crude oil will be not enough and will be costly. Various researches are going on for the improvement of fuel economy of engines. However as the demand and availability for petrol and diesel is somewhat unbalanced and there is a need to balance since that is mainly happened due to enormous increase in number of vehicles. If the same situation continues then the scenario will be more disastrous and petrol and diesel will be more costly and limited. With increased use and the depletion of fossil fuels, today more emphasis is given on the alternate fuels.

A. Objective

- Reduction in fuel consumption
- Dramatic reduction in pollution
- Better scavenging and more extraction of work per cycle

The term six stroke engine describes two different approaches in the internal combustion engine, developed since the 1990s, to improve its efficiency and reduce emissions.

In the first approach, the engine captures the waste heat from the four stroke Otto cycle or Diesel cycle and uses it to get an additional power and exhaust stroke of the piston in the same cylinder. Designs either use steam or air as the working fluid for the additional power stroke. As well as extracting power, the additional stroke cools the engine and removes the need for a cooling system making the engine lighter and giving 40% increased efficiency over the normal Otto or Diesel Cycle. The pistons in this six stroke engine go up and down six times for each injection of fuel. These six stroke engines have 2 power strokes: one by fuel, one by steam or air. The currently notable six stroke engine designs in this class are the Crower's six stroke engine, invented by Bruce Crower of the U.S.A; the Bajulaz engine by the Bajulaz S A Company, of Switzerland; and the Velozeta's Six-stroke engine built by the College of Engineering, at Trivandrum in India.

The second approach to the six stroke engine uses a second opposed piston in each cylinder which moves at half the cyclical rate of the main piston, thus giving six piston movements per cycle. Functionally, the second piston replaces the valve mechanism of a conventional engine and also it increases the compression ratio. The currently notable six stroke engine designs in this class include two designs developed independently: the Beare Head engine, invented by Australian farmer Malcolm Beare, and the German Charge pump, invented by Helmut Kottmann.

II. LITERATURE SURVEY

A. Georage Marchetti and Gilles Saint-Hilaire: In his concept of six stroke engine, high octane fuels are preferred because higher engine efficiencies can be attained with these fuels. Higher efficiencies mean less fuel consumption and lower atmospheric emissions per unit of work produced by the engine.

The six-stroke quasi turbine concept engine is an engine, which by design, operates most efficiently with high-octane fuels like methanol. By separating the engine functions, the concept quasi turbine engine permits the efficient utilization of methanol by:

- Maximizing volumetric charge efficiency through the latent heat of vaporization of the methanol, which, in turn, reduces the temperature of the fuel/air charge during intake
- Minimizing the loss of compression heat by thermally insulating the compressor
- Minimizing the negative work associated with compression by reducing the final Compression temperature of the compressed fuel/air charge. [1]

B. Mr.Krishna Kanth.M. And Mr.Srinivas.D: A cycle of six strokes out of which two are useful power strokes. Due to its thermodynamic cycle and a modified cylinder head with two supplementary chambers: combustion and an air heating chamber, both independent from the cylinder. Several advantages result from this, one very important being the increase in thermal efficiency. It consists of two cycles of operations namely external combustion cycle and internal combustion cycle, each cycle having four events. In addition to the two valves in the four strokes engine two more valves are incorporated which are operated by a piston arrangement.

The Six Stroke is thermodynamically more efficient because the change in volume of the power stroke is greater than the intake stroke and the compression stroke.

The main advantages of six stroke engine includes reduction in fuel consumption by 40%, two power strokes in the six stroke cycle, dramatic reduction in pollution, adaptability to multi fuel operation.[2]

C. James C. Conklin And James P. Szybist: A concept adding two strokes to the Otto or Diesel engine cycle to increase fuel efficiency is presented h. It can be thought of as a four- stroke Otto or Diesel cycle followed by a two-stroke heat recovery steam cycle. A partial exhaust event coupled with water injection adds an additional power stroke. Waste heat from two sources is effectively converted into usable work: engine coolant and exhaust gas. An ideal thermodynamics model of the exhaust gas compression, water injection and expansion was used to investigate this modification. By changing the exhaust valve closing timing during the exhaust stroke, the optimum amount of exhaust can be recompressed, maximizing the net mean effective pressure of the steam expansion stroke (MEPsteam). The valve closing timing for maximum MEPsteam is limited by either 1 bar or the dew point temperature of the expansion gas/moisture mixture when the exhaust valve opens. The range of MEPsteam calculated for the geometry of a conventional gasoline engine and is from 0.75 to 2.5 bars.

The additional two strokes require substantial modifications to the exhaust valve operation as well as a manner to inject water directly into the combustion chamber because this injection water is heated by the engine coolant, this six-stroke concept presented here recovers energy from both the engine coolant and combustion exhaust gas. Thus, this concept recovers energy from two waste heat sources of current engine designs and converts heat normally discarded to useable power and work. This concept has the potential of a substantial increase in fuel efficiency over existing conventional internal combustion engines while potentially not decreasing the power density significantly.[3]

D. M.M.Gasim, L.G.Chui And A.Bin Anwar:
In six stroke engine, there are additional two strokes, namely another power and exhaust strokes. The engine works through harnessing wasted heat energy created by the fuel combustion. After the combustion stage water is injected into the superheated cylinder. The water explodes into steam and force the piston down. It in turn helps to cool the engine. That resulted in normal levels of power but using much less fuel. It also has the advantage of not requiring an external cooling system. In order to achieve these benefits, major modifications of conventional internal combustion engine must be done. The modifications are the gear ratio between the crankshaft and the camshaft and modification of the camshaft.[4]

E. Amit Bhatia, Ashish Mendiratta, Mayank Vaish: The proposed six stroke internal combustion engine consists of two concentric spherical chambers. The inner one being the combustion chamber, where combustion of charge takes places, is installed with a spark plug and is separated from the main cylinder through a connecting pipe in between which is equipped a valve on the head of the main cylinder. The space between the two concentric spheres i.e. the steam chamber, where the conversion of water into steam takes place, is regulated by two valves, first one controlling the inlet of water and the other one separating the steam chamber from the main cylinder.

After modified of above mention they conclude due to batter combustion there is a reduction in the level of emissions produced by this engine. The power distribution is also more even than its four stroke counterpart. Also, the fuel consumption of six stroke engine is found to be 33% lesser than that of a four stroke engine.[5]

F. Chinmayee Karmalkar, Vivek Raut: The aim of this research is to understand the latest trends in Internal Combustion Engine while maintaining its prime focus on six stroke engine. The idea to try and implement a 6 stroke engine coupled to an electric motor in hybrid car. The important aspect is to actually combine the beneficial actions of both hybrid technology and 6 stroke engine and to study its after effect.[6]

G. POOLA R.B. Et Al. carried out an experiment in the year 1993 with 20% by volume of orange oil and eucalyptus oil were separately blended with gasoline brake thermal efficiency, exhaust emissions and combustion parameters were obtained. The experiment was conducted on small capacity (145.45 cc displacement volume, 4.3 KW at 5200 r.p.m), loop scavenged, air cooled, single cylinder, two stroke -ignition engines with a compression ratio of 7.4. It was found out that the performance fuel blends was better than gasoline fuel. Experiment was performed on two compression ratios viz. 7.4 &9 and improvement of 20.5% in brake thermal efficiency was obtained at 2 KW, 3000 r.p.m, over the normal gasoline engine. Along with this hydrocarbon and carbon monoxide emission were reduced. While comparing the two fuel blends eucalyptus oil blend provides the best results for brake thermal efficiency with low exhaust emissions.[7]

H. Kiran P: in his work he has to used the approach of water is injected into the fifth stroke and used the waste of heat in the exhaust. For that he had to make some modification in crankshaft to camshaft gear ratio and cam lobes angle and after experiment he had to conclude that by the utilization the performance of internal combustion engine considerably increased and also the fuel efficiency would be increased by the development of six stroke engine with same amount of fuel the internal combustion engine would give more mileage and demand on the depleting of fossil fuel recovers would be reduced.[8]

III. CONCEPT OF SIX STROKE ENGINE

The 6 stroke ICE is advancement over the existing 4 stroke ICE which employs the same principle as that of the 4 stroke ICE. The 5^{th} stroke or the second power stroke uses the heat evolved in the exhaust stroke (directly or indirectly) as heat required for the sudden expansion of the secondary fuel (air or water) which pushes the piston downward for the 2^{nd} power stroke thereby rotating the crankshaft for another half cycle. As heat evolved in the 4^{th} stroke is not wasted, the requirement for a cooling system is eliminated.

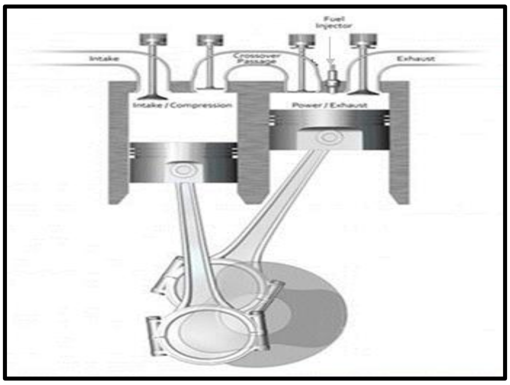

Fig. 1: Concept of Six Stroke Engine

Here fuel is injected once in every 3 complete cycles of the crankshaft which is any time better than a 4 stroke ICE where fuel is injected once in 2 complete cycles of the crankshaft. It should be noted that efficiency of the 6 stroke ICE is more than the existing 4 stroke ICE. Major type of secondary fuels used in the 5th stroke is air and water. Many types of 6-ICE have now been designed on these 2 fuels of which few important types will be discussed.

IV. Basic Parts Modification

A. *Crankshaft To Camshaft Speed Ratio*

The original angular speed of the camshaft is one-half that of the crankshaft, such that the camshaft rotates once for every two revolutions (or four strokes) of the crankshaft. The crankshaft pulley of the unmodified (4-stroke engine) engine has a 21 tooth and camshaft pulley of the engine has a 42 tooth. In conventional four stroke engine ,the crankshaft must rotate720° while the camshaft rotates 360° to complete one cycle. For six-stroke engine, the crank shaft must rotate 1080°to rotate the cam shaft 360° and to complete one cycle. Hence their corresponding speed ratio is 3:1. In modified engine a camshaft pulley has a 42 tooth which is same as that was in unmodified (4-stroke engine) engine and crankshaft pulley has a 14 tooth which is 1/3 of the camshaft pulley because the rotation ratio of crankshaft to camshaft is 3:1 in six stroke engine. So it is necessary to keep camshaft pulley three time bigger than crank shaft pulley.

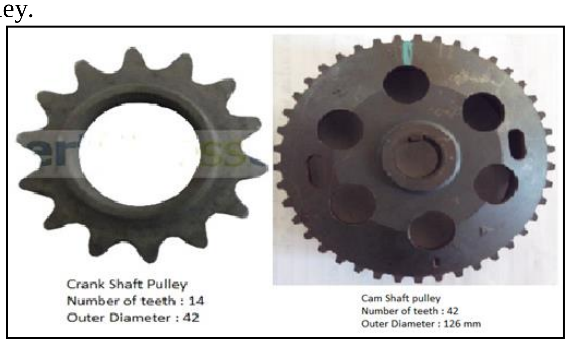

Fig. 2: Timing Pulley for Six Stroke Engine

B. *Modification In Inlet And Exhaust Manifold*

In given 4 stroke engine there is common inlet manifold through which required quantity of fresh charge from atmospheric air is sucked due to movement of piston and vaccum creation and mixed with the fuel for proper combustion.

Fig. 3: Inlet and Exhaust Manifold of Four Stroke Engine

As shown in figure 4 the common inlet manifold of four-stroke engine parted by welding a plate between the common inlet manifold. In six-stroke engine fuel is supplied in only 1st cylinder and not in second cylinder but exhaust of first cylinder is transferred to second cylinder. For carrying out the exhaust gases of second cylinder, inlet manifold of second cylinder is used for this purpose.

The plate welded between the inlet manifold is of aluminium. Because manifold is made of aluminium. The main benefit of this manifold is exhaust gases come out at high temperature so it will preheat the inlet air so increase the combustion rate.

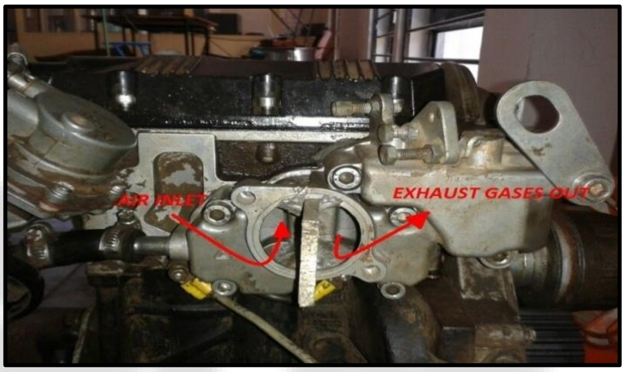

Fig. 4: Modified Inlet and Exhaust Manifold of Six Stroke Engine

C. *Camshaft Modification*

In six stroke engine piston moves three times up and down so for that valve open two times in a one revolution of a complete cycle. So that implace of four stroke engine in six stroke engine two lobes are provided as shown in fig.5

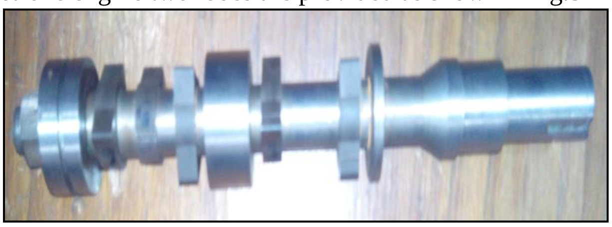

Fig. 5: Modified Camshaft

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