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Six Stroke Engine

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ABSTRACT

The quest for an engine which having the same or more power with higher fuel efficiency than the existing ones has started before many years. As a result of all these researches a new engine concept is formed, which is a six stroke engine. Lot of research works are conducting on this topic nowadays and already six types of six stroke engines were discovered yet. Of these the resent developed three six stroke engines, i.e., Beare head, Bruce crowers and Velozeta's are undergoing tremendous research works.

During every cycle in a typical four stroke engine, piston moves up and down twice in the chamber, resulting in four total strokes and one of which is the power stroke that provides the torque to move the vehicle. But in a six stroke engine there are six strokes and out of these there are two power strokes. Automobile industry will cause great change by introducing six stroke engines which have a second power stroke that will result in much more efficiency with fewer amounts of fuel and pollution

1. INTRODUCTION

The majority of the actual internal combustion engines, operating on different cycles have one common feature, combustion occurring in the cylinder after each compression, resulting in gas expansion that acts directly on the piston (work) and limited to 180 degrees of crankshaft angle.

According to its mechanical design, the six-stroke engine with external and internal combustion and double flow is similar to the actual internal reciprocating combustion engine. Six-stroke engine differentiates itself due to its thermodynamics cycle and a modified cylinder having one combustion chamber and one air heating chamber, both independent from cylinder. Combustion does not occur within the cylinder but in the supplementary combustion chamber, does not act immediately on the piston, and its duration is independent from the 180 degrees of crankshaft rotation that occurs during the expansion of the combustion gases (work).

The combustion chamber is kept inside the air-heating chamber. Air pressure in the heating chamber increases and generate power for a supplementary work stroke by virtue of heat exchange through glowing combustion chamber walls. Several advantages result from this, one very important being the increase in thermal efficiency. In the present time internal combustion engine, important calorific losses are generated due to the required cooling of the combustion chamber walls.

The six-stroke engine has the following advantages:

1) Thermal efficiency reaching 50%. (30% for the actual internal combustion engines)

2) Fuel consumption reduced by more than 40%.

3) Reduction of chemical, noise and thermal pollution.

4) Two expansions (work) through six strokes.

5) Direct injection and optimal fuel combustion at every engine speed.

In six-stroke cycle, two parallel functions occur in two chambers which result in eight event cycle: four event internal combustion cycle and four event external combustion cycles.

The first cycle of four events is of external combustion.

It includes Event 1: pure air intake in the cylinder.
Event 2: pure air compression in the heating chamber.
Event 3: keeping pure air pressure in closed chamber where a maximum heat exchange occurs with the combustion chambers walls, without direct action on the crankshaft.
Event 4: expansion of the super heated air in the cylinder, work.
During this four event's cycle, the pure air never comes in direct contact with the heating source.

The second cycle of four events is of internal combustion.

It includes Event 5: re-compressions of pure heated air in the combustion chamber.
Events 6: fuel injection and combustion in closed combustion chamber, without direct action on the crankshaft.
Events 7: combustion gases expanding in the cylinder, work.
Event 8: combustion gases exhaust.
During these four events, the air comes in direct contact with the heating source.

2. TYPES OF SIX STROKE ENGINE

A Single piston designs

These designs use a single piston per cylinder, like a conventional two- or four-stroke engine. A secondary, non-detonating fluid is injected into the chamber, and the leftover heat from combustion causes it to expand for a second power stroke followed by a second exhaust stroke.

A.1 Griffin six-stroke engine

Heated exhaust-jacketed external vapuriser, into which fuel was sprayed, was the main principle of working of griffin six stroke engines. The temperature was held around 550 °F, sufficient to vapourise the oil but not to break it down chemically. This fractional distillation supported the use of heavy oil fuels, the unusable tars and asphalts separating out in the vapouriser.

A.2 Bajulaz six-stroke engine

The Bajulaz six-stroke engine is similar to a regular combustion engine in design. There are, however, modifications to the cylinder head, with two supplementary fixed capacity chambers: a combustion chamber and an air preheating chamber above each cylinder. The combustion chamber receives a charge of heated air from the cylinder; the injection of fuel begins an isochoric (constant-volume) burn which increases the thermal efficiency compared to a burn in the cylinder.

A.3 Velozeta six-stroke engine

In a Velozeta engine, fresh air is injected into the cylinder during the exhaust stroke, which expands by heat and therefore forces the piston down for an additional stroke. The valve overlaps have been removed and the two additional strokes using air injection provide for better gas scavenging.

A.4 NIYKADO Six Stroke Engine

This is the only engine that is categorized as a fully working prototype. The first prototype was developed in 2004, which used only two valves. The second prototype, developed in 2007, was an improved design using four valves.

A.5 Crower six-stroke engine

In a six-stroke engine prototyped in the United States by Bruce Crower, water is injected into the cylinder after the exhaust stroke and is instantly turned to steam, which expands and forces the piston down for an additional power stroke. Thus, waste heat that requires an air or water cooling system to discharge in most engines is captured and put to use driving the piston

B Opposed piston designs

These designs use two pistons per cylinder operating at different rates, with detonation occurring between the pistons.

B.1 Beare Head

The term "Six Stroke" was coined by the inventor of the Beare Head, Malcolm Beare. The technology combines a four stroke engine bottom end with an opposed piston in the cylinder head working at half the cyclical rate of the bottom piston. Functionally, the second piston replaces the valve mechanism of a conventional engine.

B.2 M4+2

The M4+2 engines have much in common with the Beare Head engines, combining two opposed pistons in the same cylinder. One piston works at half the cyclical rate of the other, but while the main function of the second piston in a Beare Head engine is to replace the valve mechanism of a conventional four stroke engine, the M4+2 takes the principle one step further.

B.3 Piston charger engine

In this engine, similar in design to the Beare head, a "piston charger" replaces the valve system. Piston charger perform the work of charging the main cylinder and simultaneously it control the inlet and outlet opening which leads to no loss of air and fuel in the exhaust. In the main cylinder, combustion takes place every turn as in a two-stroke engine and lubrication as in a four-stroke engine. Fuel injection can take place in the piston charger, in the gas transfer channel or in the combustion chamber.

3. PRINCIPLE OF SIX STROKE ENGINE

A six stroke engine describes a number of different approaches in the internal combustion engine to capture the waste heat from the four stroke Otto cycle and use it to power an additional power and exhaust stroke of the piston. 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 Otto Cycle. The pistons in a six stroke engine go up and down six times for each injection of fuel .The six stroke engine has 2 power strokes, one fuel, one steam or air. The currently notable six stroke engine designs include Crower's six stroke engine, the Bajulaz engine and the Six-stroke engine The Beare Head engine is called a six stroke by its designer but stands apart from the others. It 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. It does not use any additional working fluid. After the exhaust stroke, instead of air/fuel mixture (as in case of petrol engines), fresh air is sucked into the cylinder from the air filter, and is removed during the sixth stroke. The valve overlaps have been removed and the additional two strokes have been provided for better scavenging, using air injection. The engine shows 40% reduction in fuel consumption and dramatic reduction in pollution. Its specific power is not less than that of a four-stroke petrol engine. The engine can run on a variety of fuels, ranging from petrol and diesel to LPG. An altered engine shows a 65% reduction in CO pollution when compared with the four stroke engine from which it was developed

4. MODIFICATION IN SIX STROKE ENGINE

Modifications are done to specific parts of conventional four stroke engine so that the new engine with six strokes works successfully. These modifications are:

1) Crankshaft to Camshaft Ratio Modification

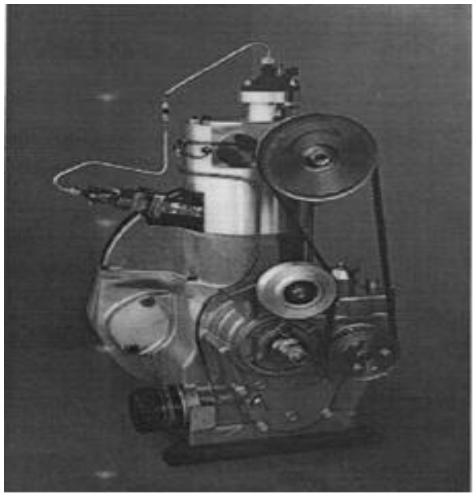
In conventional four stroke engine, the gear at crankshaft must rotate 720o while the camshaft rotates 360o to complete one cycle. For six-stroke engine, the gear at the Crankshaft must rotate 1080o to rotate the camshaft 360o and complete one cycle.
Hence their corresponding gear ratio is 3:1.

2) Camshaft Modification

In the six stroke engine the 360 degree of the cam has been divided into 60 degree among the six-strokes. The exhaust cam has 2 lobes to open the exhaust valve at fourth stroke (first exhaust stroke) and at the sixth stroke to push out the steam.

3) Cam follower modification

The bottom shape of regular follower has the flat pattern, which is suitable with the normal camshaft for four stroke engine. When reducing the duration of valve opening from 9000 to only 6000 the shape of the follower must be changed from flat to roller or spherical shape.



5. WORKING OF SIX STROKE ENGINE

Different working strokes of a six stroke engine are:

1st stroke (suction stroke)

The inlet valve is kept open. Due to cranking, Piston moves downward which results in the formation of a pressure difference due to which pure air enters the cylinder.

2nd stroke (compression stroke)

The inlet valve closes and the heating chamber valve opens. The piston moves upward due to cranking forcing air into heating chamber. The air at this stage is converted to high pressure.

3rd stroke (1st power stroke)

The combustion chamber valve opens and gases of combustion enter the cylinder.

4th stroke (exhaust stroke)

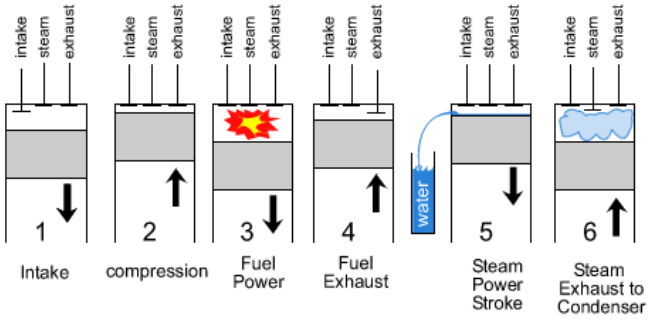
The exhaust valve opens. The piston moves upwards and the exhaust gases are removed via this valve.

5th stroke (2nd power stroke)

The chamber valve opens and the pure air now at high pressure and high temperature enters the cylinder which does work on the piston and hence it moves downward resulting in the 2nd power stroke.

6th stroke (2nd exhaust stroke)

Finally the combustion chamber valve opens. The piston moves upwards forcing the pure air into the combustion chamber.



6. FACTORS AFFECTING THERMAL EFFICIENCY AND FUEL CONSUMPTION

1) 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.

2) 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).

3) 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 on expansion and exhaust (internal combustion).

4) 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° for expansion.

5) The glowing combustion chamber allows the optimal burning of any fuel and calcinate the residues.

6) Distribution of the work: two expansions (power strokes) over six strokes, or a third more than the in a four-stroke engine.

7) Better filling of the cylinder on the intake due to the lower temperature of the cylinder walls and the piston head.

8) 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.

9) Large reduction in cooling power. The water pump and fan outputs are reduced. Possibility to suppress the water cooler.

10) Less inertia due to the lightness of the moving parts.

11) 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, the depression on the piston during intake and the back

12) 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. Friction loss, in six stroke engine, is balanced due to better distribution of pressure on parts and elimination of direct combustion.

7. ADVANTAGES OF SIX STROKE OVER FOUR STROKE ENGINES

Main advantages of the six-stroke engine

1) Reduction in fuel consumption by at least 40%:

An operating efficiency of approximately 50%, hence the large reduction in specific consumption. The Operating efficiency of current petrol engine is of the order of 30%. The specific power of the six-stroke engine will not be less than that of a four-stroke petrol engine, the increase in thermal efficiency compensating for the issue due to the two additional strokes.

2) Two expansions (work) in six strokes:

Since the work cycles occur on two strokes (3600 out of 10800) or 8% more than in a four-stroke engine (1800 out of 720), the torque is much more even. This lead to very smooth operation at low speed without any significant effects on consumption and the emission of pollutants, the combustion not being affected by the engine speed. These advantages are very important in improving the performance of car in town traffic.

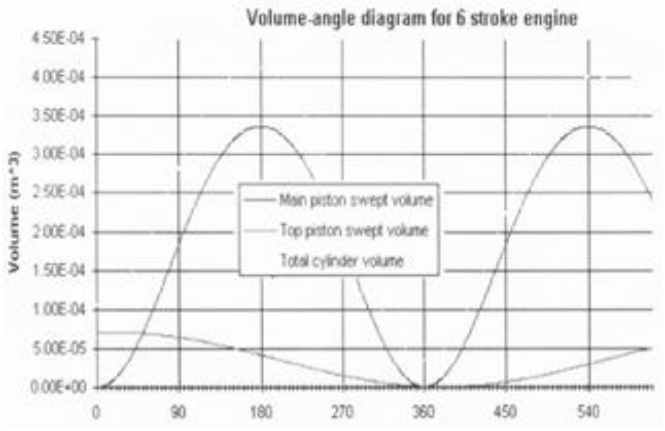
3) Dramatic reduction in pollution:

Chemical, noise and thermal pollution are reduced, on the one hand, in proportion to the reduction in specific consumption, and on the other, through the engine's own characteristics which will help to considerably lower HC, CO and NOx emissions. Furthermore, its ability to run with fuels of vegetable origin and weakly pollutant gases under optimum conditions, gives it qualities which will allow it to match up to the strictest standards.

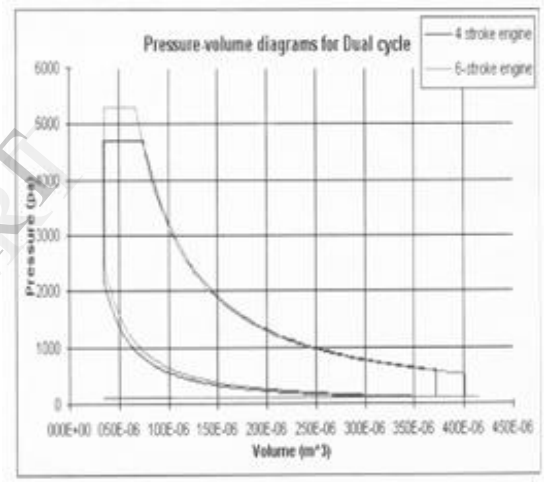
4) Multifuel:

Multifuel par excellence, it can use the most varied fuels, of any origin (fossil or vegetable), from diesel to L.P.G. or animal grease. There occurs no problem in combustion due inflammability difference in six stroke engine. It's light, standard petrol engine construction, and the low compression ration of the combustion chamber; do not exclude the use of diesel fuel. Methanol-petrol mixture is also recommended.

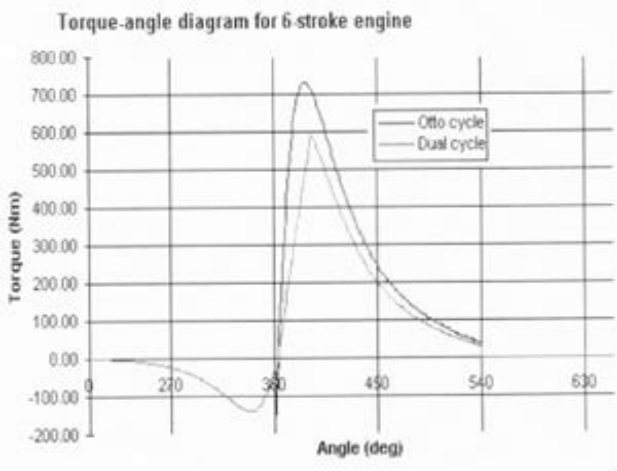
8. GRAPH FOR SIX STROKE ENGINE



Volume-angle diagram for six stroke engine.



Comparison of P-V diagram of 4-stroke and 6-stroke engine.



Torque-angle diagram for 6-stroke engine.

9. CONCLUSION

Billions of explosion engines are running worldwide at this time, and this era is not about to end. It is commercially obvious that the big market if for automobile, heavy goods, construction-site and farm vehicles. This is a priority for the six-stroke engine. Reducing fuel consumption and pollution without any effect on performance will reassessed the concept of automobile.

There is, at this day, no wonder solution for the replacement of the internal combustion engine. Only improvements of the current technology can help it progress within reasonable time and financial limits. The six-stroke engine fits perfectly into this view. Its adoption by the automobile industry would have a tremendous impact on the environment and world economy, assuming up to 40% reduction in fuel consumption and 60% to 90% in polluting emissions, depending on the type of fuel being used. Fuel consumption for mid-sized cars should be within 4 and 5 liters per 100km. and 3 to 4 liters for the small-sized cars

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