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Six Stroke Engine

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ABSTRACT

Six Stroke engine, the name itself indicates a cycle of six strokes out of which two are useful power strokes. 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. However, it differentiates itself entirely, 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. In this, the cylinder and the combustion chamber are separated which gives more freedom for design analysis.

In addition to the two valves in the four-stroke 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 include a reduction in fuel consumption by 40%, two power strokes in the six-stroke cycle, a dramatic reduction in pollution, adaptability to multi-fuel operation. Six-stroke engine's adoption by the automobile industry would have a tremendous impact on the environment and world economy.

There are additional two strokes, namely another power, and exhaust strokes. The engine works by 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 forces 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. In this paper, the modification of the conventional four-stroke internal combustion engine is illustrated to convert it into six stroke engine.

Keyword: *Internal Combustion Engines, Six Stroke, Water Injection, Engine Modification, and Specification.*

1. INTRODUCTION

In internal combustion engines, operating on different cycles have one common feature, combustion occurring in the cylinder after each compression, resulting in a 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. However, it differentiates itself entirely, due to its thermodynamic cycle and a modified cylinder head with two supplementary chambers: 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 of the 180 degrees of crankshaft rotation that occurs during the expansion of the combustion gases (work).

The combustion chamber is totally enclosed within the air-heating chamber. By heat exchange through the glowing combustion chamber walls, the air pressure in the heating chamber increases and generate power for a supplementary work stroke. Several advantages result from this, one very important being the increase in thermal efficiency. In the contemporary internal combustion engine, the necessary cooling of the combustion chamber walls generates important calorific losses. 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. It is also possible to charge two working cylinders with one piston charger. The combination of compact design for the combustion chamber together with no loss of air and fuel is claimed to give the engine more torque, more power, and better fuel consumption.

(View of a Six Stroke Engine)

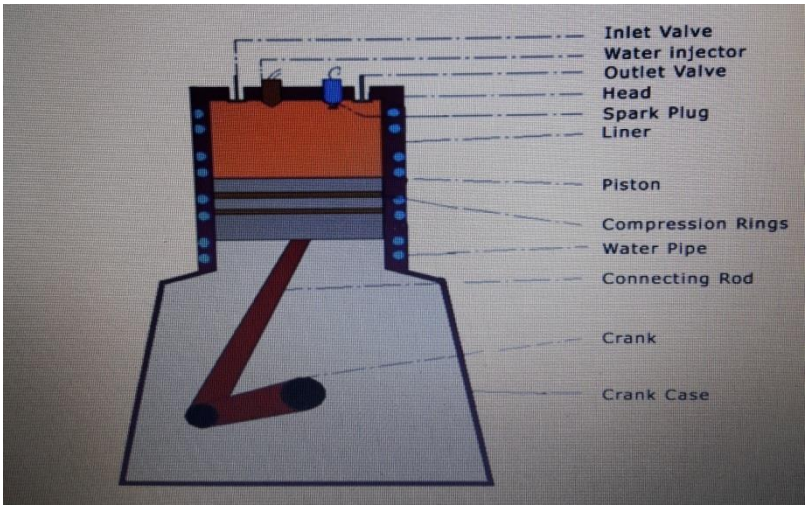

Fig. 1 Sectional View

2. ANALYSIS OF SIX STROKE ENGINE

Internal combustion engines efficiency is less than 40%. Most of the energy generated by burning the fuel in the combustion chamber is lost in water cooling and exhaust. Figure 1, below, shows a typical energy split in internal combustion engines.

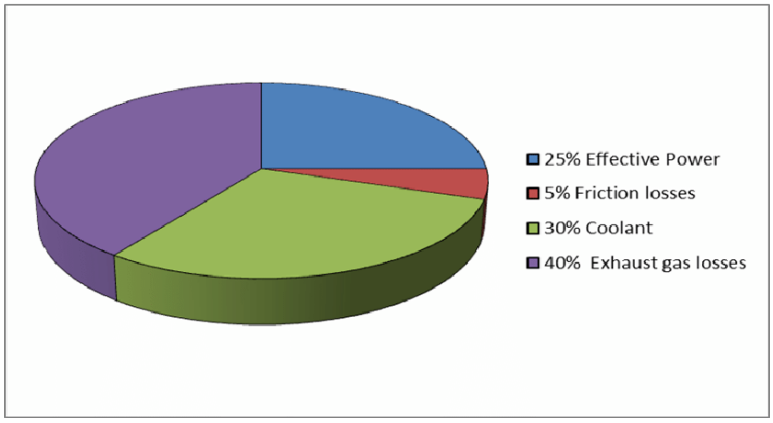

Fig. 2 Energy Split in Gasoline Internal Combustion Engines

2.1 Engine Cycle

In one cycle, there are six strokes are present are as follow:

- Suction stroke
- Compression stroke
- Power stroke-I(expansion stroke)
- Exhaust stroke-I(fuel exhaust stroke)
- Power stroke-II
- Exhaust stoke-II(steam exhaust stroke)

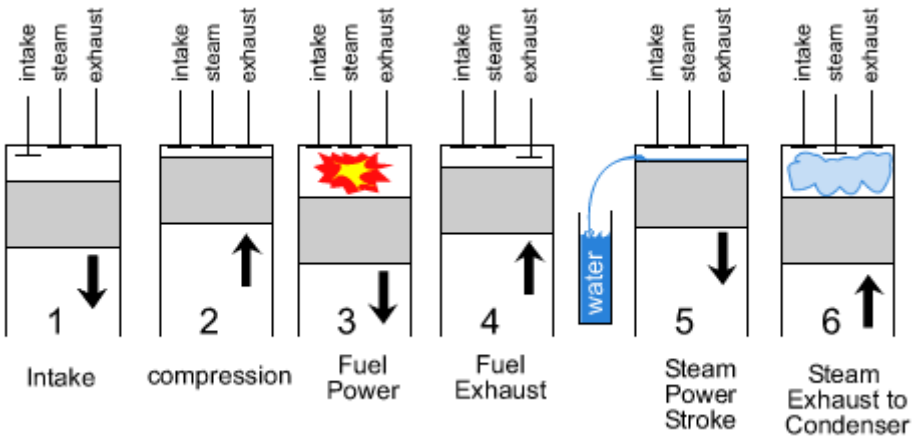

FIG. 3 Six Strokes Cycle

2.2 Valve Timing Diagram

- Inlet valve open 5° before TDC,
- Inlet valve closed 20° after BDC,
- Fuel Exhaust valve open 20° before BDC,
- Fuel Exhaust valve closed 5° before TDC,
- Water intake valve open 5° before TDC,
- Water intake valve closed 10° after TDC,
- Steam exhaust valve open 10° after TDC,
- Steam exhaust valve closed 10° after TDC.

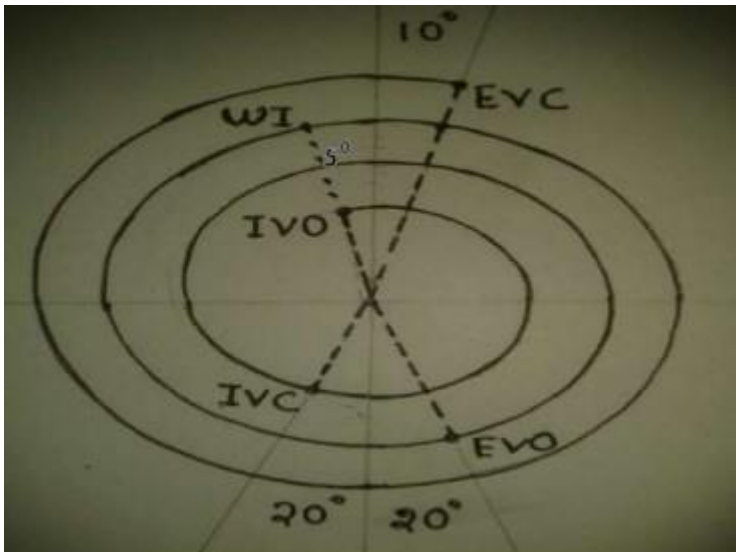

Fig. 4 Valve Timing Diagram

(IVO = inlet valve open, IVC = inlet valve closed, EVO = exhaust valve open, EVC = exhaust valve closed)

2.3 Engine Modification

To make a six-stroke engine from the conventional four-stroke engine, a few modifications must be done to specific parts of the conventional engine to be sure that the new engine with six-stroke will run successfully. A Mitsubishi single cylinder spark ignition engine was used to apply these modifications to it. These modifications are:

2.4 Crankshaft to Camshaft Ratio Modification

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

Figure 5 shows the previous gear at regular engine running in the four-stroke engine at ratio 2:1 and the new gears to work with six stroke engine. The new gear at the crankshaft has 18 teeth and the camshaft gear has 54 teeth. The type of gear is helical gear because it is suitable for high-speed, high power application and quite at high-speed rotation.

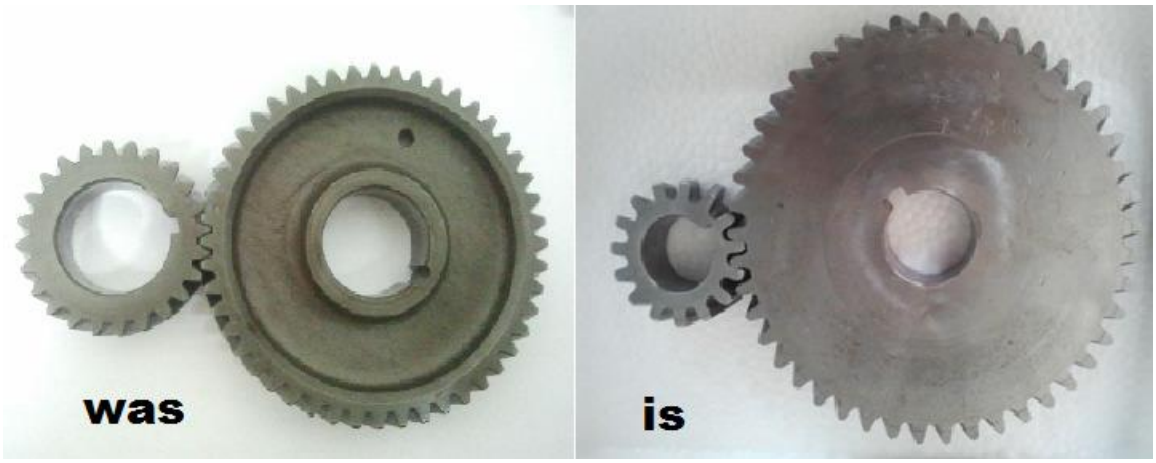

Fig. 5 Crankshaft to Camshaft Ratio Modification

2.5 Camshaft Modification

In the six-stroke engine, the 360 degrees of the cam has been divided into 60 degrees among the six-strokes. The exhaust cam has 2 lobes to open the exhaust valve at a fourth stroke (first exhaust stroke) and at the sixth stroke to push out the steam. Figure 6 shows the new cams and the new camshaft

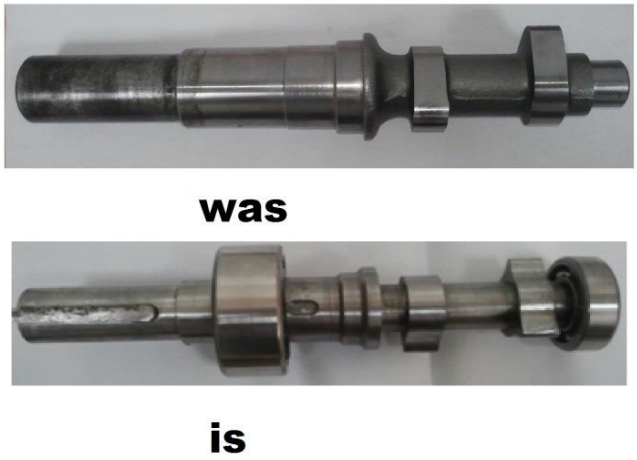

Fig. 6 Camshaft Modification

2.6 Cam Follower Modification

The bottom shape of regular follower has the flat pattern, which is suitable with the normal camshaft for a 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. In this case, a spherical shape is chosen.

2.7 Testing the Engine

After applying these modifications on the engine, a test was carried out to be sure that the engine can run smoothly with six stroke instead of four stroke cycles. The same starter coupled with the engine was used to start the engine. After two or three attempts the engine was running smoothly with six stroke cycles.

3. ADVANTAGES

- Reduction in fuel consumption by at least 40%.
- Two expansions (work/Power stroke) in six strokes.
- Dramatic reduction in pollution (up to 65%).
- Higher overall efficiency.
- Lower engine temperature & noise level.
- Due to more air intake, the cooling system is improved.
- Better scavenging and more extraction of work per cycle.
- Less inertia due to lightness of moving parts.

4. DISADVANTAGES

- Brake power & indicated power per cycle per cylinder is comparatively lesser.
- Engine size increases due to any numbers of cylinders & additional components.
- Higher manufacturing cost of six stroke engine.

5. APPLICATION

- Automobiles, heavy goods, construction-site and farm vehicles.
- Motor-pumps, generator sets, stationary engines, etc. Intended for agriculture and industry.
- Motorboats.

6. CONCLUSION

In this paper, the modification required to convert the four-stroke conventional engine to six stroke engine is illustrated. The modifications are the gear ratio between the crankshaft and the camshaft and modification of the camshaft.

The previous efforts done on six-stroke engines was applied by using solenoid valves and a DC- motor to start the engine, in this research it is proven that the engine can work with the six-stroke engine by using the same conventional mechanical valve systems and the conventional engine starter.

7. ACKNOWLEDGEMENT

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