Study and analysis of six stroke internal combustion engine

Mohsin Raza
Department Of Mechanical Engineering
JSS Academy Of Technical Education, Noida, India

***Abstract*— This paper deals with the analysis of six stroke internal combustion engine, its architecture, working and advantages of this type of engine. The six stroke engine delivers more power and increased thermal efficiency than the modern, widely used four stroke engines. The two additional strokes are the fifth stroke i.e., water injection stroke and the sixth stroke i.e., exhaust stroke. In a six stroke engine power is delivered twice in one cycle of six strokes. By capturing the exhausted heat from the four stroke cycle and using it to get additional power and exhaust stroke thereby providing 2 power strokes 8 more than in a four stroke engine. Reduced fuel consumption and high thermal efficiency are advantageous in six stroke engine. The automobile industry would be revolutionized by the development of a better design of six stroke engine with more power and less environmental hazards.**

***Index Terms*— Six Stroke Engines, combustion, heat, efficiency.**

I. INTRODUCTION

A six-stroke internal combustion engine is designed to deliver more power with increased thermal efficiency and reduced fuel consumption. [1] This engine has six strokes per cycle and have similar components as that of four stroke engine but acquire two more valves. Six stroke engines are used in heavy load-carrying vehicles where focus is on load carrying capacity than fuel economy. The two additional strokes in these engines increase the work extracted per unit input of energy which causes an energy efficiency of up to 30% higher than that of four stroke engine. [2] The top and bottom portion of six stroke engine is similar to the two and four stroke respectively. The crower stroke engine, invented by Bruce Crower from USA; the Bajulaz engine [3] by the Bajulaz S A company of Switzerland; and the Velozeta six stroke engine [4] built by the college of Engineering at Trivandrum in India are the new designs.

II. CONSTRUCTION OF SIX STROKE ENGINE

A. INTAKE VALVE: This valve controls the passage of fluid or air into the chamber.
B. HEATING CHAMBER VALVE: It controls the passage of air in the heating chamber
C. COMBUSTION CHAMBER VALVE: This valve regulates the amount of air and fuel mixture entering the chamber.
D. EXHAUST VALVE: This valve is used to control the removal of gases.
E. CYLINDER: This is the central part of the engine in which the piston moves.
F. COMBUSTION CHAMBER: In this section of the engine, combustion takes place.
G. AIR HEATING CHAMBER: In this chamber, air is heated to a high temperature sufficient for entering the combustion chamber.
H. FUEL INJECTOR: It injects the mixture of fuel and air in an appropriate proportion.
I. SPARK IGNITION SYSTEM: This system is used to ignite the compressed air and fuel mixture by sparking.

III. WORKING OF SIX-STROKE ENGINE

The six-stroke engine has one process for each stroke, thus the complete cycle consists of six processes. The processes are as follows: -

A. SUCTION STROKE

Here, the piston moves from top dead center (TDC) to bottom dead center (BDC) and mixture of air and fuel moves into the cylinder through inlet valves from the carburetor.

B. COMPRESSION STROKE

The inlet and exhaust valves are closed and the air and fuel mixture is compressed in the second stroke when the piston moves from bottom dead center (BDC) to top dead center (TDC).

C. IGNITION STROKE

During this stroke, power is obtained when the compressed air and fuel mixture is burned using a spark plug. The inlet and exhaust valves remain closed. The piston moves from top dead center (TDC) to bottom dead center (BDC).

D. RECOMPRESSION STROKE

As the piston moves from bottom dead center (BDC) to top dead center (TDC), , the exhaust valves are opened and the gases are removed from the cylinder in the fourth stroke.

E. WATER INJECTION STROKE

Here, the water inlet valves [6] are opened and water enters into the cylinder as the piston moves from top dead center (TDC) to bottom dead center (BDC). Meanwhile, the exhaust valves are kept closed.

F. EXHAUST STROKE

In this last stroke, the injected water into the cylinder in the fifth stroke is removed through water exhaust valves. [7-9] Besides this, the piston moves from bottom dead center (BDC) to top dead center (TDC).

These processes are repeated again and again and the engine works with high power and torque.

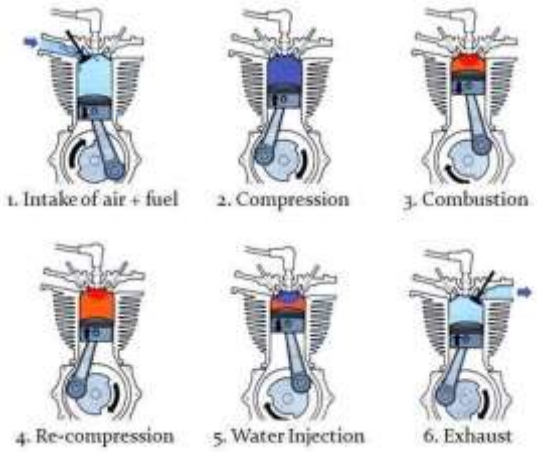

FIGURE 1. SIX STROKES OF THE ENGINE

IV. BASIC MODIFICATIONS

A. CAM FOLLOWER MODIFICATION:

The flat pattern on bottom of shape of the regular follower is suitable with the normal camshaft [10-11] for four stroke engines. The shape of the follower is changed from flat to roller or spherical shape while reducing the duration of valve opening 9000 to 6000.

B. CAMSHAFT MODIFICATION:

The piston moves three times up and down in six stroke engine. Hence, the valve opens two times in one revolution of a complete cycle. The exhaust cam occupies 2 lobes to open the exhaust valve at the fourth stroke and to push out the steam at the sixth stroke.

C. CRANKSHAFT TO CAMSHAFT SPEED RATIO MODIFICATION:

The angular speed of the crankshaft is twice that of the camshaft, such that the camshaft rotates once for every two revolutions of the crankshaft. [12-13] The camshaft pulley of the four stroke engine has a 42 tooth and the crankshaft pulley of four stroke engine has 21 tooth .

For six stroke engine, the crankshaft rotates 1080 degrees to complete one cycle while in four stroke engine, it rotates 720 degrees.

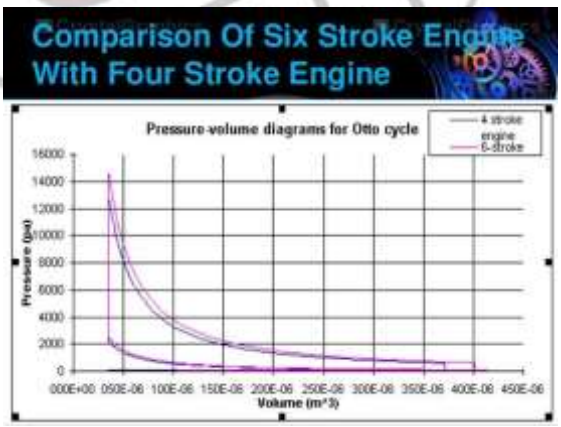

FIGURE 2. PRESSURE VOLUME GRAPH FOR BOTH ENGINES

V. ADVANTAGES OF SIX STROKE ENGINE

1. No external cooling required
2. Reduction in fuel consumption
3. Reduction in pollution
4. Two work cycles in six strokes [14-16]
5. Increased stroke volume
6. Adaptability to various fuels

7. Better thermal efficiency

VI. DISADVANTAGES OF SIX STROKE ENGINE

1. High initial cost due to change in gear structure
2. High manufacturing cost
3. Increased engine size due to additional strokes

VII. CONCLUSION

Today we are facing a huge energy crisis. The only way to tackle this problem is by inventing and designing new technologies with better efficiencies and implement them. The most important aim of the automotive industry is to have an engine with better performance, reduced polluting emission and improved thermal efficiency, this aim can be successfully fulfilled with the help of six stroke engine. Almost 40%-50% reduction in fuel consumption and 60%-70% reduction in polluting emissions can be achieved by implementing six stroke engines.

VIII. REFERENCES

[1] Andrew DeJong, Marc Eberlein, John Mantel Tim, Opperwall Jim, VanLeeuwen in Calvin College ENGR 340 on May 12, 2010.
[2] George Marchetti and Gilles Saint-Hilaire, "A Six-Stroke, High-Efficiency Quasiturbine Concept Engine With Distinct, Thermally-Insulated Compression and Expansion Components" in September 2005.
[3] Bajulaz, "Method for the transformation of thermal energy into mechanical energy by means of a combustion engine as well as this new engine" in 1985.
[4] Kapil N. Kariya, Mayur M. Raje, "Velozeta six stroke engine", IISN:2319-507X.
[5] A. Kéromnès, B. Delaporte , G. Schmitz , L. Le Moyne, "Development and validation of a 5 stroke engine for range extenders Application", in DRIVE – ID Motion Laboratory, University of Burgundy, 49 rue Mlle Bourgeois, 58027 Nevers, France-2014.
[6] James C. Conklin, James P. Szybist, "A highly efficient six-stroke internal combustion engine cycle with water injection for in-cylinder exhaust heat recovery", in Oak Ridge National Laboratory, 2360 Cherahala Blvd, Knoxville, TN 37932, USA-2010.
[7] R. Saidur, M. Rezaei, W.K.Muzammil , M.H.Hassan, S.Paria M.Hasanuzzaman, "Technologies to recover exhaust heat from internal combustion engines" in Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia-2012.
[8] George Marchetti and Gilles Saint-Hilaire, "A Six- Stroke, High- Efficiency Quasiturbine Concept Engine with Distinct, Thermally-Insulated Compression and Expansion Components", in September-2005.
[9] Mojtaba TAHAN, Saeed JAVAN, Mojtaba BIGLARI, "A comprehensive study on waste heat recovery from internal combustion engine using organic Rankine cycle".
[10] Bajulaz, "Internal Combustion Engine" in 1989.
[11] Professor V. K. Manglik, "Development of high-efficiency engine by combining I.C. Engine and E.C. Engine", e-IISN:2278-1684, p-IISN:2348-7593
[12] V. Ganesan, "Internal Combustion Engine", in 2013.
[13]Gerhard B. Schmitz, "Six-stroke internal combustion engine", US 4917054, on 17th April 1990.
[14] "Six-stroke engine." No. 2409339, on 6 Dec. 2000
[15] Lyons, Pete (2006-02-27). "Inside Bruce Crower's Six-Stroke Engine" on 28th July 2012.
[16] "A brilliant six-stroke from techies" on 14 February 2007.