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Analysis And Review 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 cycleA Six Stroke Engine is that in which the power is obtained twice in a cycle of six strokes. This engine generates more power with higher fuel efficiency than the existing engines. As a result a new engine concept is formed, which is a six stroke engine.In a typical four stroke diesel engine, Piston moves up and down twice in the cylinder during one rotation of crank. The power stroke is obtained once during the two cycles that generates the torque to move vehicle. In Six stroke engine the power stroke is obtained two times out of six strokes. The automobile industry is now seeking for the best six-stroke design which adds one more power stroke which results more efficiency and better utilization of the fuel. In this paper the concept, features and the comparative discussion on six-stroke engine is done. Further it's advantages and disadvantages are discussed.*

Keywords: *stroke, internal combustion engine, diesel*

I. Introduction

The 6 stroke internal combustion engine is advancement over the existing 4 stroke internal combustion engine which employs the same principle as that of the 4 stroke internal combustion engine. The 5th 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 2nd power stroke thereby rotating the crankshaft for another half cycle. As heat evolved in the 4th stroke is not wasted, the requirement for a cooling system is eliminated. Here fuel is injected once in every 3 complete cycles of the crankshaft which is any time better than a 4 stroke internal combustion engine where fuel is injected once in 2 complete cycles of the crankshaft.

The six-stroke engine is a radical hybridization of two and four stroke engine that the top portion of two stroke engines and the bottom rather the middle section of a four stroke engine. In six-stroke cycle, two parallel functions occur in two chambers which result in eight event cycle: four events internal combustion cycle and four event external Combustion cycles. [2] The first cycle of four events is of external combustion.

- Pure air intake in the cylinder.
- Pure air compression in the heating chamber.
- Keeping pure air pressure in closed chamber where a maximum heat exchange occurs with the combustion chambers walls, without direct action on the crankshaft.
- 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.

- Re-compressions of pure heated air in the combustion chamber.
- Fuel injection and combustion in closed combustion chamber, without direct action on the crankshaft.
- Combustion gases expanding in the cylinder, work.
- Combustion gases exhaust.
- During these four events, the air comes in direct contact with the heating source

Principle Of Six-Stroke Engine

The six-stroke engine describes a number of approaches in IC engine to utilize the waste heat from the 4-stroke diesel cycle or Otto cycle and use it to generate more power. Generally the one compression and one power strokes are added to cycle which higher the thermal efficiency and reduces the fuel consumption. The piston in six-stroke engine moves up and down six times for each injection of fuel. The first four strokes are same as that of the 4-stroke engine after the exhaust the fuel-air mixture is again compressed and burned gases are removed during the sixth stroke. The glowing combustion chamber allows the optimal burning of any fuel and calcinate the residues. The first stroke of the six-stroke cycle, i.e. the admission of the air or of the air-fuel mixture, involves only low pressure admission cylinders. The third and fourth strokes of this same cycle, i.e. the

second compression and the first expansion of the combustion gases respectively, involve only high pressure combustion cylinders. The final discharge of the combustion gases under low pressure, which represents the sixth stroke of the cycle, involves only low pressure admission cylinders and low pressure discharge cylinders The engine shows 30-40 percent reduction in fuel consumption and also economical. The engine can also use variety of fuel. As the engine has two powers stroke that gives the efficient burning of the fuel and lower the pollution.

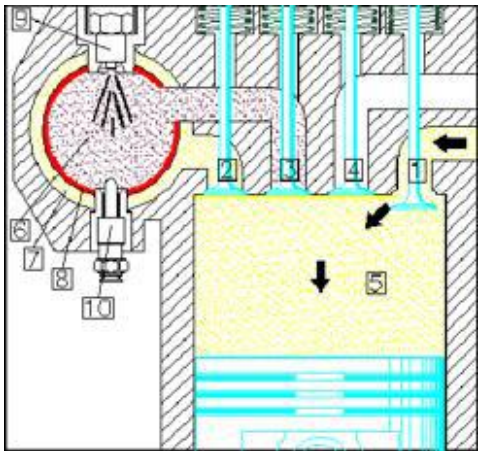
Analysis Of Six-Stroke Engine

The six-stroke engine consists of six stroke and these are shown in figure the each figure shows the movement of the air-fuel mixture, valves and piston. The name of the components are-

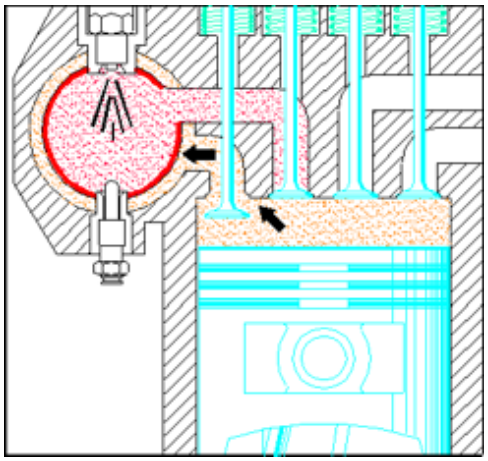
1. Intake valve
2. Heating chamber valve
3. Combustion chamber valve
4. Exhaust valve
5. Cylinder
6. Combustion chamber
7. Air heating chamber
8. Wall of combustion chamber
9. Fuel injector
10. Heater plug

The working of all strokes in this engine is as below:

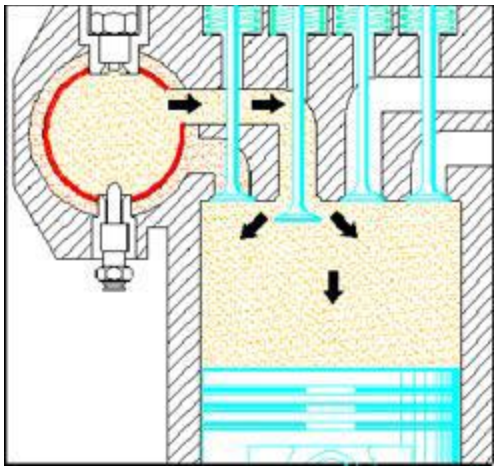
FIRST STROKE (suction stroke): During the first stroke, the inlet valve opens and air-fuel mixture from carburettor is sucked into the cylinder through the inlet manifold.



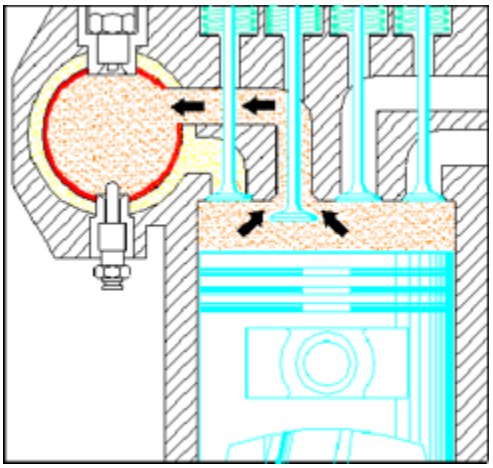
SECOND STROKE(Compression Stroke): During the second stroke, piston moves from Bottom Dead Centre to Top Dead Center, both the inlet valve and exhaust valves are closed and air-fuel mixture is compressed.



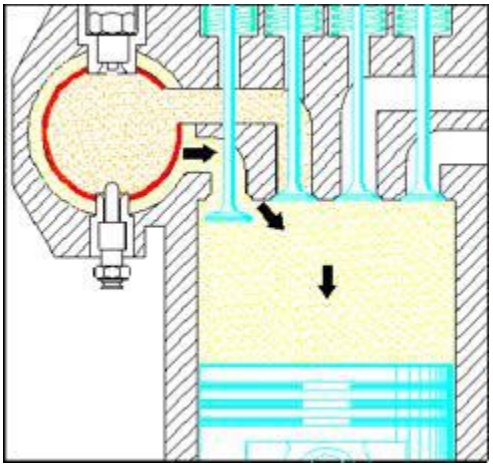
THIRD STROKE (Fuel Power Stroke): During the third stroke, power is obtained from the engine by igniting the air-fuelmixture using a spark plug. Both valves remain closed. Piston moves from Top Dead Center to Bottom Dead Center.



FOURTH STROKE (Re-Compression Stroke): During the third stroke, piston moves from Bottom Dead Center to Top Dead Center. Both the inlet and the exhaust valves are closed. By the time piston reaches Top Dead Center, water injector injects water which is then converted to steam.



FIFTH STROKE (Steam Power Stroke): During the fifth stroke, the steam initiates the second power stroke. Both valves remain closed. Piston moves from Top Dead Center to Bottom Dead Center.



SIXTH STROKE (Exhaust Stroke): During the sixth stroke, piston moves from Bottom Dead Center to Top Dead Center. The inlet valve remains closed. The exhaust valve opens and the exhaust gases are released.

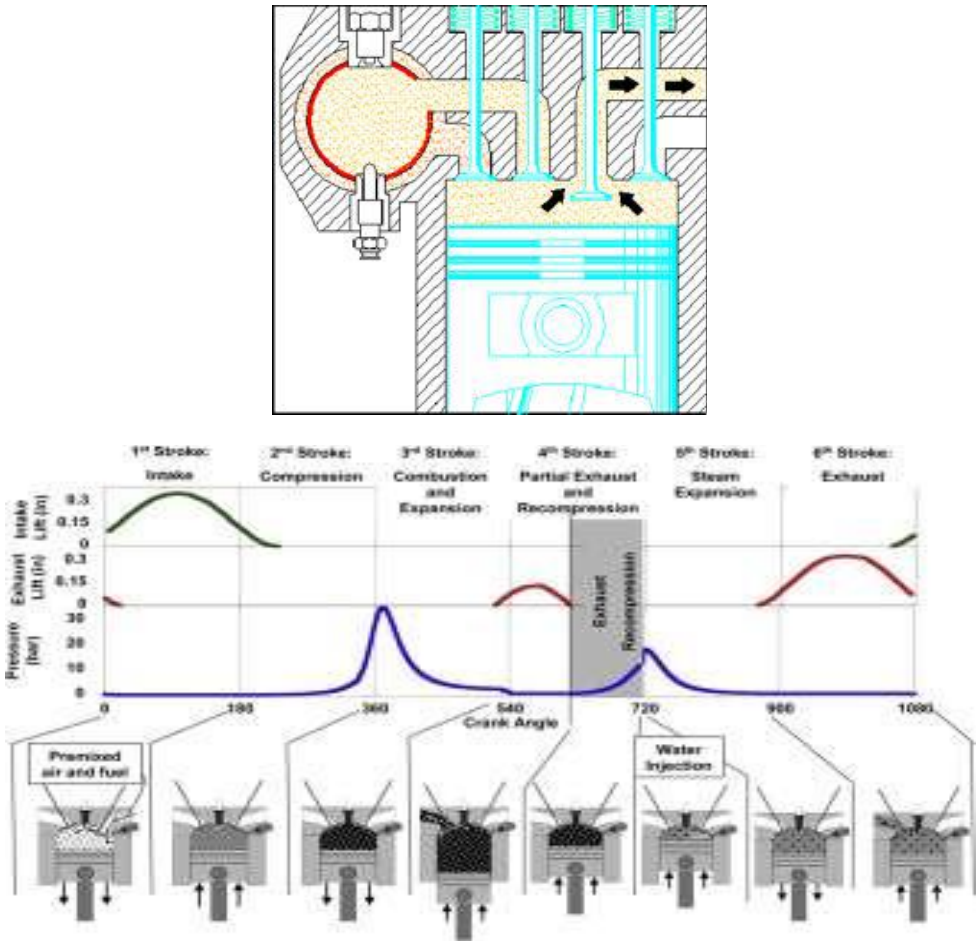


Figure: Workingofsixstrokeengine

II. Literature Review

[1] A. Kéromnès, B. Delaporte , G. Schmitz , L. Le Moyne,‖—Development and validation of a 5 stroke engine for rangeextenders Application‖, **DRIVE – ID Motion Laboratory,University of Burgundy, 49 rue Mlle Bourgeois, 58027**
Nevers, France-2014

Current trends in engine development are governed by moreand more stringent emission regulations and aim at lowering consumption and emissions in order to obtain ever cleaner engines. The efficiency of a reciprocating internal combustion engine is strongly linked to its expansion ratio since increasing the expansion ratio allows an increase of the fuel conversion efficiency. However, in traditional internal combustion engines, the compression ratio is limited due to mechanical stress and combustion issues. Power losses from the engine are mainly due to thermal losses. For most engines, either spark ignition engines or compressed ignition engines, around one third of the energy available in the fuel is lost inside the cylinder due to heat losses through

[2] Kiran P, **—**A Feasibility Study on Waste Heat Recovery in Six Stroke IC Engine‖ **International Journal on MechanicalEngineering and Robotics (IJMER), Volume-1, Issue-1,2013.**

Waste heat recovery from internal combustion engines (ICE) is one of the opportunities for economizing of energy consumption. In an ICE, a great amount of fuel energy is wasted in the form of heat due to thermal limitations. To recover the waste heat, various methods are being adopted. 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. The automotive industry may soon be revolutionized by a new six-stroke design which adds a second power stroke, resulting in much more efficiency with less amount of pollution.In a six stroke engine, when the combustion chamber temperature reaches approx. 400 °F (200°C), just before the fifth stroke fresh water is injected directly into the hot combustion chamber

through the engine's fuel injector pump, which is quickly turned into a superheated steam, which causes the water to expand to 1600 times its volume and forces the piston down for an additional power stroke. By the utilization of the waste heat, the performance of the internal combustion engine is considerably increased. With the utilization of the waste heat of internal combustion engine the world energy demand on the depleting fossil fuel reserves would be reduced. The fuel efficiency would be increased by the development of six stroke engine with the same amount of fuel the internal combustion engine would give more mileage and it would relief growing demand.

[3] Tejaskumar U Kothari, Mr.Devranjan Kumar, Mr.K.D.Tandel, ―Design and Analysis of Six Stroke InternalCombustion Engine‖ **Thermal Engineering department, SVMIT, Bharuch-392001, Gujarat, INDIA-2014.**

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 six stroke engine modification promises dramatic reduction in fuel consumption of an internal combustion engine. The fuel efficiency of the engine can be increased and also the valve timing can be effectively arranged to extract more work per cycle. The brake thermal efficiency of four stroke two cylinder diesel engine can increases by modified its some component and convert into six stroke engine.Better scavenging is possible because exhaust of first cylinder exhaust is become a inlet of second cylinder during the fifth stroke and its work as second power stroke the exhaust during the sixth stroke.

Basic Parts Modification

1. Crankshaftto 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 times bigger than crank shaft pulley

2. Modificationin Inlet And Exhaust Manifold:

In given four 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 vacuum creation and mixed with the fuel for proper combustion The common inlet manifold of four-stroke engine parted by welding a plate between the common inlet manifold. 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.

Figure: ModifiedInletandExhaustManifoldofSixStrokeEngine

Figure: InletandExhaustManifoldofFourStrokeEngine

3. 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 in place of four stroke engine in six stroke engine two lobes is provided.

Figure: Modifiedcamshaft

Advantages And Disadvantages

An operating efficiency is of approximately 50%, hence the large reduction in specific consumption. 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. Chemical, noise and thermal pollution are reduced. There occurs no problem in combustion due in flammability difference in six stroke engine. Better combustion and expansion of gases that take place over 540° of crankshaft rotation, 360° of which is in closed combustion chamber, and 180° for expansion. It has less inertia due to the lightness of the moving parts. [6] It has also some disadvantages as brake power & indicated power per cycle per cylinder is comparatively lesser. The Engine size increases due to number of cylinders & additional components. These engines are complex in design and hence higher manufacturing cost.

III. Conclusion

From the above data the concept and working of the six-stroke engine can be understood. Six stroke engines with all the desired qualities as better from four stroke engines will be hitting the market soon. Reducing fuel consumption and pollution without any effect on performance will reassessed the concept of automobile. 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 good impact on the environment and world economy.

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