REVIEW SIX STROKE ENGINE

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***Abstract*—Now a day the most difficult challenges in engine technology is to increase its thermal efficiency, If the efficiency is higher, than there will less fuel consumption and lower atmospheric emissions per unit of work produced by the engine. In Six Stroke engine, the name indicates a cycle of six strokes in which two are useful power strokes. The engine which we get by adding two more stroke in existing four stroke engines generates more power with higher fuel efficiency. The exhausted heat generated form four stroke cycle is used in this engine to get an additional power and exhaust stroke of the piston in the same cylinder. In this engine, steam is produce from water with the help of heat generated from four-stroke cycle, which is later used as a working fluid for the additional power stroke. This steam will force the piston down. As well as extracting power, the additional stroke cools the engine by water which is used for steam generation and removes the need for a cooling system which is used in four stroke Otto cycle and makes the engine lighter and giving 40% increased efficiency over the normal Otto cycle. In six stroke engine. The pistons go up and down six times for each injection of fuel. These six stroke engines have two power strokes: one by fuel, one by steam**

Keywords—Six Stroke Engine, Ic Engine, Transport

1. INTRODUCTION

Engine work successfully only when it follows a cycle of operation in a sequential manner. In IC 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. The six-stroke engine is an internal combustion engine with an advance feature of more power generation. This engine consists of similar components Present in the four-stroke engine with addition of two more cylinders and have similar working concept to the actual internal reciprocating combustion engine as piston is in reciprocal movement which is converted into a rotating movement with the help of connecting rod and crankshaft. In four stroke engine, the cycle of operation take place in four stroke which are Suction or intake stroke, compression stroke, expansion or power stroke and exhaust stroke. In starting the inlet valve opens and the charge consisting of fuel air mixture is drawn into the cylinder and then piston moves from top dead Centre to bottom dead Centre Then the intake and exhaust valves closes instantaneously. During the compression stroke, the piston moves upward compressing the air-fuel mixture in the clearance volume. But before the piston reaches its highest position, the spark plug injected the air-fuel mixture and the mixture ignites, increasing the pressure and temperature of the cylinder. The high-pressure gases which are emitted from previous cylinder force the piston down, which in turn forces the crankshaft to rotate, producing a useful work output during the expansion or power stroke. At the end of this stroke which is Exhaust stroke, the piston is at bottom dead centre moves to top dead centre pushes the combustion product to top dead centre during this process the exhaust valve is open and inlet valve is closed. Thus, the piston completes four strokes which give two complete revolutions to the crankshaft. But in six stroke engines the exhausted gases are used which are left after combustion in next stroke for generating steam from water. Then water is injected in superheated cylinder. The hot gases which emit from fourth stroke is used to changes the phase of water to steam as the temperature of the hot gases is high so this steam will work as working fluids which will forces the piston down. This movement will give an additional two stroke for the same cycle. In four stroke coolant is required but in six stroke engines, there is no need of external cooling system because water which is used as working fluid will cools the system. So, in six stroke, fuel consumption is reduced and increases its power. It reduces the weight and complexity of the engines head by as much as 50%. Torque is increased by 35% and increases its efficiency. The first six stroke engines.which is Bajulaz Six Stroke Engine was invented in 1989 by the Bajulaz S A company, based in Geneva, Switzerland. The design of Bajulaz six stroke engines is similar to a regular combustion engine. There was a modification to the cylinder head, in which he used two supplementary fixed capacity chambers, a combustion chamber and an air preheating chamber above each cylinder is done. The combustion chamber present in engine receives a charge of heated air from the cylinder and then the injection of fuel begins, at the same time it burns which increases the thermal efficiency compared to a burn in the cylinder. The high pressure achieved from previous cylinder is then released into the cylinder to work as power or expansion stroke. Whereas a second chamber which blankets the combustion chamber has its air content which is heated to a high degree by heat passing through the cylinder wall? This heated and pressurized air is used to power an additional stroke of the piston. The advantages of this engine include reduction in fuel consumption by 40%, multi-fuel usage capability as we use water, and a dramatic reduction in pollution.

2. *Types of six-stroke engine:*

2.1 A single piston design In this design he uses 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.

2.1.1 Griffin six stroke engine

This type of engine is very much capable of burning heavier and cheaper grades of oil. The engine works on the principle of a heated exhaust jacketed external vaporizer, inside which the fuel is being sprayed. Sufficient temperature around 550 degree Fahrenheit is held for physically vaporizing the oil but not to breaking it down chemically. This type of fractional distillation supports the use of heavy oil fuels, asphalts, unusable tars separating out in the vaporizer.

2.1.2 Bajulaz six-stroke engine

The Bajulaz six-stroke engine is somewhat similar in design to combustion engine as change with two supplementary fixed capacity chambers with two supplementary fixed capacity chambers. the first is combustion chamber in which pre-heated air enters from the cylinder and fuel begins are isochoric (constant volume) burn which increases the thermal efficiency and high pressure is released to the cylinder to work as expansion stroke another air pre -heating chamber which blanket the combustion chamber to a high degree heating by passing through the cylinder wall. Then an additional stroke of piston is generated by this heated and pressurized air.

2.1.3 Velozeta six-stroke engine

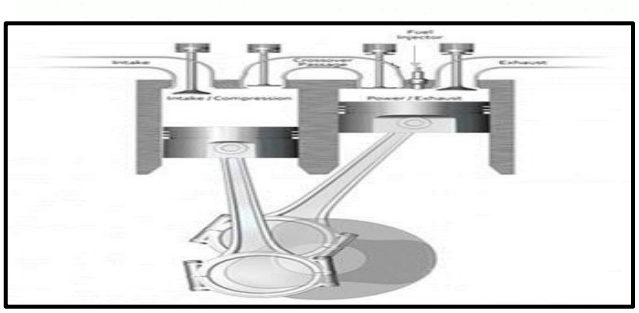
In this engine, fresh air is used and injected during the exhaust stroke, which expands the air by heat and forces the piston down for additional stroke. this engine has the ability to run on various fuel, ranging from gasoline and diesel fuel to LPG

2.1.4 Crower six-stroke engine

In this engine, he uses the waste heat and put it into the use of driven piston by injecting water into the cylinder after the exhaust stroke which instantly turns into steam and forces the piston down for an additional stroke. The engine provides with 40% less fuel consumption and some power output at lower rotational speed. The engine weight is balanced by addition of water tank and eliminating cooling arrangement which is not needed as waste heat is being is used up.

2.1.5 Opposed-piston designs

In These designs, there are two pistons per cylinder operating at different rates, in which combustion occurs between the pistons. it is a reciprocating internal combustion engine.



2-1: Beare head

This design was invented by Malcolm beare of Australia. He creates a hybrid engine. In this engine, he combines a four-stroke engine bottom end with an opposed piston design. So, by adding these four strokes plus opposed piston design he create a six-stroke engine.

2-2: M 4+2

The M4+2 engine is performed by joining two opposed piston in the same cylinder .it is a combination of two working modes of engine-Two Stroke and Four Stroke Engine .fuel is injected and ignition take place by two spark plug .the power generated is transferred by two crankshaft

2-3: Piston-charger engine

The Piston charger charges the main cylinder and simultaneously it regulates the inlet and outlet aperture due to which there is no loss of air and fuel in the exhaust. The design is similar to the Beare head but piston charger replaces the valve system. in the main cylinder combustion take place in every turn as in two stroke engine and lubrication as in four stroke. Fuel injection takes place in piston charger.

3. Principle of six stroke Engine

A six stroke is an engine in which we use exhausted gas from four Otto cycle and use it to generate more power. Generally, the one compression and one power strokes are added to cycles which have higher thermal efficiency and reduce the fuel consumption. This Design either use a steam or air as a working fluid for the additional power stroke as well as extracting power, the additional stroke

cools the engine and removes the cooling system making the engine lighter and giving 40% increased efficiency over the Otto cycle.

4. Analysis of six stroke Engine

The six-stroke engine consist of six stroke

Stroke-1: During the first stroke the inlet valves are opened simultaneously the exhaust valves are closed and air-fuel mixture from carburetor is sucked into the cylinder through the inlet manifold and at that time piston is at top dead center.

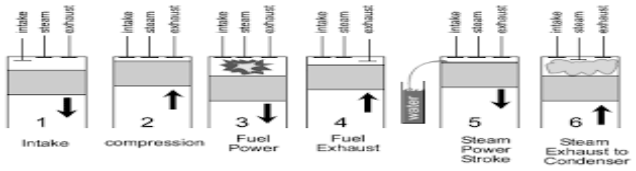
Stroke-2: During the second stroke, piston moves from bottom dead center to top dead center, both the inlet and exhaust valves are closed and the air fuel mixture is compressed.

Stroke-3: During the third stroke, power is obtained from the engine by igniting the compressed air-fuel mixture using a spark plug. Both valves remain closed. During this process piston moves from TDC to BDC.

Stroke-4: During the fourth stroke, the exhaust vale and reed valve open and remove the burned gases from the engine cylinder. Piston moves from BDC to TDC.

Stroke-5: During the fifth stroke the chamber valve open and 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 second power stroke.

Stroke-6: During the six stroke the combustion chamber valve opens. The piston moves upwards forcing the pure air into the combustion chamber.



MODIFICATION IN SIX STROKE ENGINE Modifications are only done to specific parts of conventional four stroke engine so that the new engine in which two more cylinder are added for additional power 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 720 degree while the camshaft rotates 360^{o} to complete one cycle. For six-stroke engine, the gear at the Crankshaft must rotate 108^{0} to rotate the camshaft 360^{o} and complete one cycle. Hence their corresponding gear ratio is 3:1. So it is necessary to keep

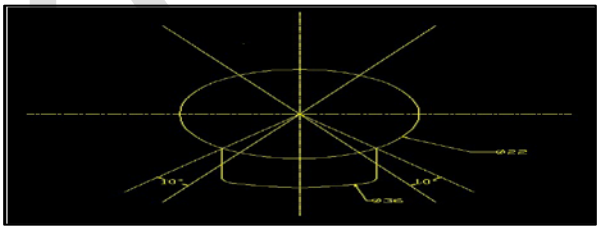
Camshaft pulley three times bigger than crank shaft pulley

2) Camshaft Modification In the six-stroke engine, the 360 degree of the cam has been divided into 60degree 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 as used in inlet valve and closed valve has the flat pattern, which is suitable with the normal camshaft for four stroke engine. By making roller follower it reduces the duration of valve opening from 9000 to only 6000. Therefore, the shape of the follower must be changed from flat to roller or spherical shape.

A. DESIGN OF CAM LOBES

Suppose The diameter of camshaft (D) is taken empirically



as

$$D' = 0.16 \times \text{cylinder bore} + 12.7 \text{ mm}$$

$$= 0.16 \times 75 + 12.7$$

$$= 35.1 \text{ say } 36 \text{ mm}$$

The base circle diameter is about 3 mm greater than the camshaft diameter.

$$\text{Base circle diameter} = 36 + 3$$

$$= 36 \text{ say } 40 \text{ mm}$$

The width of cam taken equal to the width of roller, i.e. 14 mm The width of cam ($W^{‟}$) is also taken empirically as

$$W^{‟} = 0.09 \times \text{cylinder bore} + 6 \text{ mm}$$

$$= 0.09 \times 75 + 6 = 18.6 \text{ mm}$$

CAM PROFILE FOR FIRST CYLINER INLET AND EXHAUST VALVE

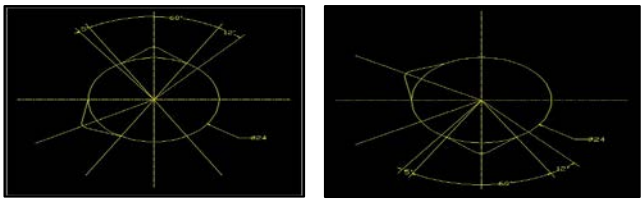


Figure 3: Cam Profile for First Cylinder Inlet Valve and Cam Profile for First Cylinder Exhaust Valve

2.3.2 CAM PROFILE FOR SECOND CYLINER INLET AND EXHAUST VALVE

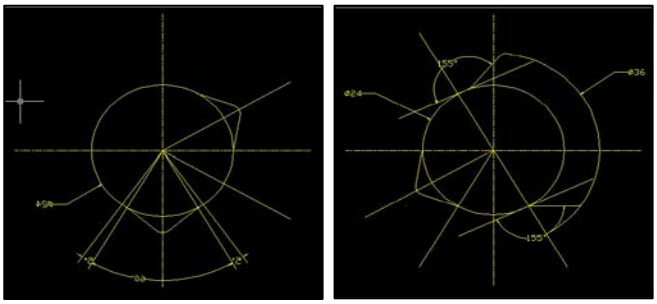


Figure 6: Cam Profile for Second Cylinder Inlet Valve and: Cam Profile for Second Cylinder Exhaust Valve

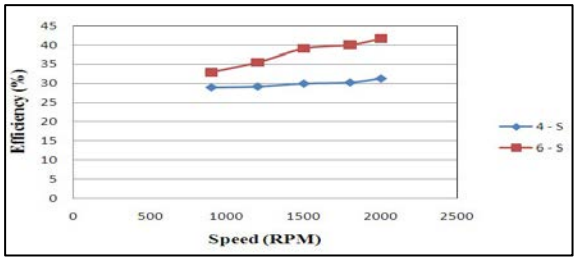
CAM PROFILE FOR FUEL INJECTOR

Figure 8 Cam Profile for Fuel Injector

5. COMPARISON BETWEEN FOUR STROKE AND SIX STROKE ENGINE

ADVANTAGE OF SIX STROKE ENGINE

Most importantly, the fuel consumption is reduced by more than 40%, because of the multi fuel system in six stroke engines. There is an operating efficiency of approximately 50%, therefore there is a reduction in specific consumption. Maximum reduction of noise. chemical and thermal pollution. Steam stroke cools the engine internally, hence use of much higher compression ratios. There is a better combustion and expansion of gases that takes place over 540 degrees of crankshaft rotation, in which 360 degree is in closed combustion chamber and 180 degree for expansion. Due to lightness of moving parts, it has less inertia. Better scavenging can be get in fifth stroke



Disadvantages of six stroke engine:

The Disadvantages of Six Stroke Engine are as follows:

1. Due to total change in Gear structure, high initial cost is needed.

2. Manufacturing cost of Six Stroke Engine will be high.

3. Increase in size of engine due to extra two Strokes (Fifth and sixth).

4. There is a difference between first two consecutive strokes (360 degrees) and next four strokes (720 degrees), as first power stroke is strong and second power stroke is very weak which create imbalance power and vibrations in vehicle.

5. Extra space will be required by the water tank in the vehicle.

6. Conclusion

The Six Stroke Engine alteration assures dramatic reduction in pollution and fuel consumption in an IC Engine. Having this type of engine will bring a tremendous impact by the automobile industry on the environment and world economy. There will be 40% reduction in fuel consumption and 60% to 80% in polluting emission, depending upon the fuel being used. It also increases the compression ratio. With all the desired modifications and qualities, the Six Stroke Engine better than the Four Stroke Engine will be hitting the market soon. As in this day, there is no replacement of the internal combustion engine and only current technology can help it to progress within reasonable time and financial limits.

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