Design Alteration of Motor-Cycle Engine Cam for Pneumatic Operation

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Abstract – Power produced by pressurized gases/air has been used in many applications since decades. The power produced by that means is pollution free too. Hence substitution of petrol/diesel in engines with compressed air will be a step towards pollution free engine. The 4-stroke IC engine is to be converted into a 2-stroke pneumatic engine. Various design changes in camshaft design were carried out. The valve timing diagram was derived for the same. The cam profile of a double lobed cam as required in the valve timing diagram was designed in Pro-e software and was cut on a wire cut machine. The cam and camshaft were manufactured separately and then assembled.

Keywords – double lobed cam; pneumatic; valve timing diagram.

I. INTRODUCTION

Petroleum products are nowadays extensively used in every field of modern society. It is consumed at such a quick rate that in next few decades its petroleum products may get extinct. Man must thus shift from non-renewable resources like petroleum to renewable resources like solar energy, wind energy, tidal energy, etc. Thus renewable resources are the future of mankind. Moreover, the extensive use of petroleum products has resulted in hazardous pollutions which lead to effects like Global Warming [7].

Thus it is extensively important to shift to something pollution free and renewable in near future. The power produced by pressurized gases/air has been used in many applications since decades. The power produced by that means is pollution free too. Hence substitution of petrol/diesel in engines with compressed air will be a step towards pollution free engine [7]. Thus the use of pneumatics is one of the options available. And also almost all people are suffering from the high rate of petrol and diesel. The gas is also not convenient so far for vehicles in recent days.

Angelo Di Pietro had worked on the compressed air engine. A French inventor Guy Negre and A French company MDI has launched air car in the market [8]. But still one has not made a pneumatic bike engine. Here is the methodology for the conversion of 4-stroke single cylinder engine into 2-stroke pneumatic engine.

II. CONCEPT AND METHODOLOGY

A compressed air engine (CAE) is powered by using compressed air, which is stored in a tank. Instead of mixing fuel with air and burning it in the engine to drive pistons with hot expanding gases; compressed-air vehicles use the expansion of compressed air to drive their pistons [7]. One manufacturer claims to have designed an engine that is 90 percent efficient [8]. Compressed-air propulsion may also be incorporated in hybrid systems, e.g., battery electric propulsion and fuel tanks to recharge the batteries. This kind of system is called hybrid-pneumatic electric propulsion. Additionally, regenerative braking can also be used in conjunction with this system [7].

A. Working Cycles of Conventional 4-Stroke IC Engine

The working cycle of a 4-stroke IC engine consists of four stroke and two rotations of crankshaft.

1. Inlet stroke

Inlet valve remains open as shown in Fig. 1.

Exhaust valve remains closed.

Mixture of fuel and air is inlet in cylinder.

Piston moves from T.D.C. to B.D.C.

The piston has now made one stroke and crankshaft 180 degrees of rotation [4].

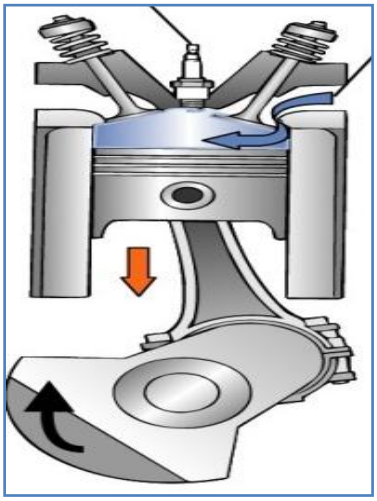

Fig. 1 : Inlet Stroke

2. Compression Stroke

Inlet and exhaust valves remain closed as shown in Fig. 2.

Piston moves from B.D.C. to T.D.C.

Fuel and air mixture is compressed up to its clearance volume [4].

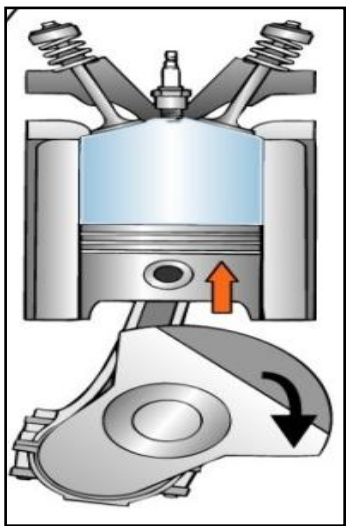

Fig. 2: Compression Stroke

3. Power Stroke

Inlet and outlet valve remain closed.

Mixture burn and High pressure and temperature gases push down the piston to create motive power.

Piston moves from T.D.C. to B.D.C as in Fig. 3 [4].

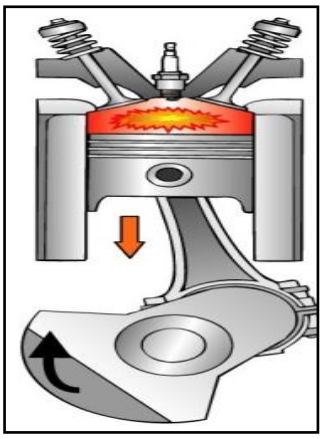

Fig. 3: Power Stroke

4. Exhaust Stroke

Inlet valve remains closed and exhaust valve is open.

The piston moves from B.D.C. to T.D.C.

During this motion, the piston pushes out the burnt gases from the cylinder as shown in Fig. 4 [4].

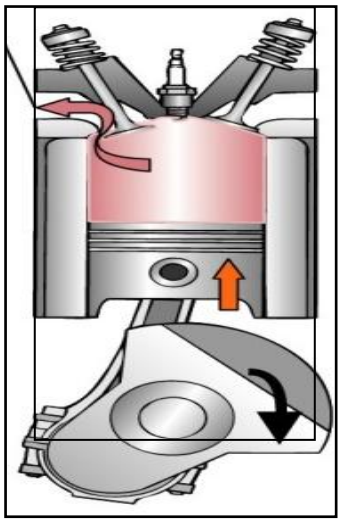

Fig. 4 : Exhaust Stroke

B. Cycle of 2-stroke Pneumatic Engine

1. Intake cum Power stroke

Compressed air from the storage tank enters the engine cylinder with opening of inlet valve and piston at the T.D.C. This exerts pressure on piston which drives piston downwards towards B.D.C. allowing compressed air to expand. This is the power stroke which is the main source for engine power and torque. This stroke is indicated in Fig. 5 [3].

2. Exhaust stroke

The inlet valve is closed and exhaust valve opens making way for the expanded air in the cylinder to evacuate the cylinder. The expanded air is at slightly higher pressure than atmospheric pressure for easy evacuating of cylinder. This is shown in Fig. 6 [3].

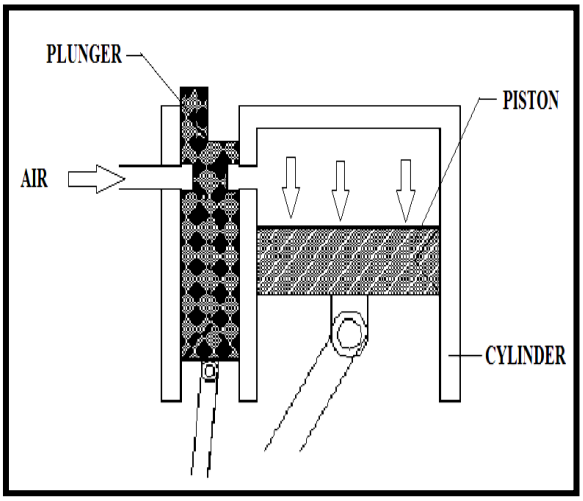

Fig. 5: Intake cum Power Stroke

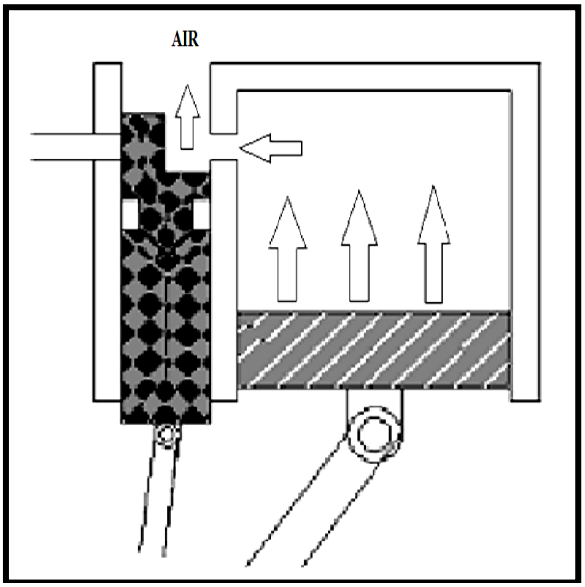

Fig. 6 : Exhaust Stroke

Two stroke fuel engine every stroke is power stroke but air compressed engine only one stroke is power stroke. To complete one cycle 360º revolution completed in crank shaft or one revolution completed. In this engine, zero percentage pollution will be produced.

III. VALVE TIMING DIAGRAM AND CAM DESIGN

A. For Conventional 4-stroke Engine

The Camshaft is the "heart" of the gasoline engine. The engine will not perform to its highest potential unless the cam is precision ground to provide performance at the speeds required [1]. The valve timing diagram for the conventional 4-stroke engine is shown in Fig. 7.

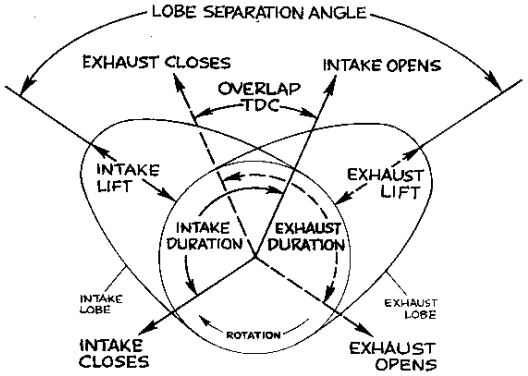

Fig. 7: Valve Timing Diagram for Gasoline engine

The angles (usually measured in crankshaft degrees) when the valves first leave and then return to their seats are used to prepare valve timing diagrams and termed as opening and closing angles. The opening and closing angles may also refer to a specified nominal lift, e.g. at 0.050 in cam lift [1]. A cam's timing may be stated as 25-65-65-25. These numbers are (1) intake opening before T.D.C., (2) intake closing after B.D.C, (3) exhaust opening before B.D.C. and (4) exhaust closing after T.D.C. For these numbers to have meaning, the lift at which the numbers are taken must be specified. The purpose of the cam lobe is to raise the lifter and open the valve [1]. Lob design for conventional engine is shown in Fig. 8.

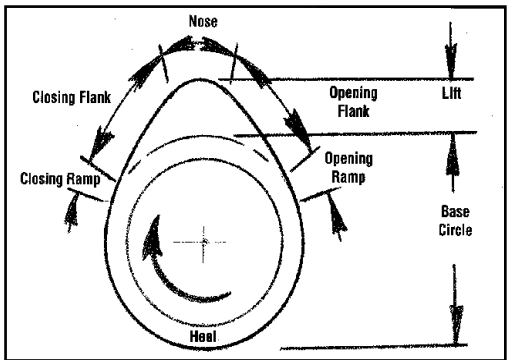

Fig. 8: Lobe Design

B. For 2-stroke Pneumatic Engine

From the comparison of the cycles of conventional IC engine and pneumatic engine, it is evident that the intervals for operation of the inlet and outlet valves are different. The valves must operate twice for retrofitted engine as compared to those of conventional engine.

Thus the cam for the retrofitted 2-stroke pneumatic engine must have double lift i. e. for 360^{o} of rotation; cam must actuate the valve twice. So considering the above, valve timing diagram was made as shown in Fig. 9

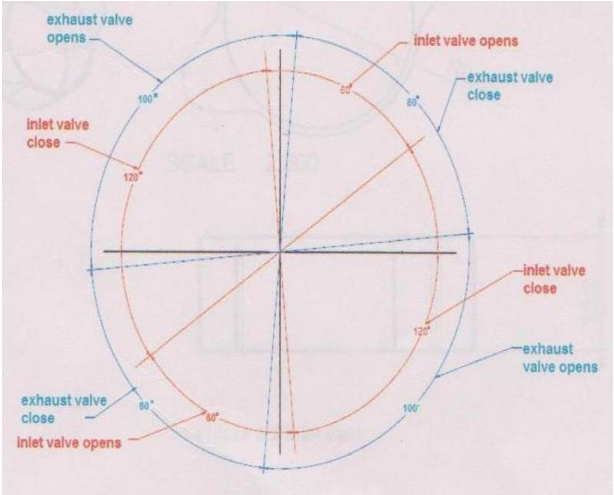

Fig. 9 : Valve Timing Diagram For Retrofitted 2-stroke Pneumatic Engine

Some part of the opening of the inlet and outlet valves must overlap in order to make sure that engine locking is avoided [1].

IV. Design and Implementation

The dimensions and design of the cams developed based of the discussions provided are given under.

1. Inlet Cam

1. Base Diameter : 20 mm
2. Lift : 5 mm
3. Open/Close : 355^{0} to 55^{0} (shm\ua)
   175^{0} to 235^{0} (shm\ua)
4. Thickness : 12 mm.

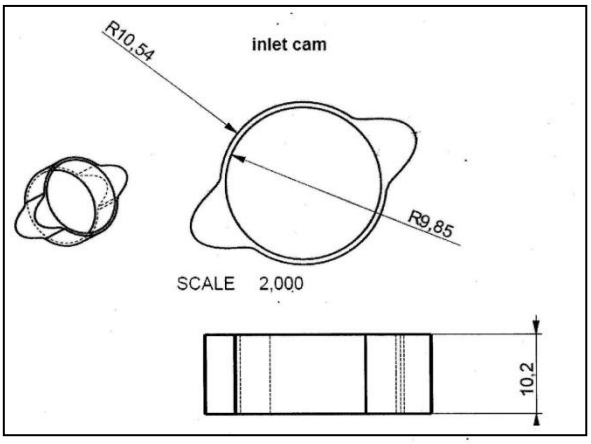

Fig.10: Inlet Cam

2. Exhaust Cam:

1. Base Diameter : 20 mm
2. Lift : 5 mm
3. Open/Close : 85^{0} to 185^{0} (shm\ua)
   265^{0} to 5^{0} (shm\ua)
4. Thickness : 12 mm.

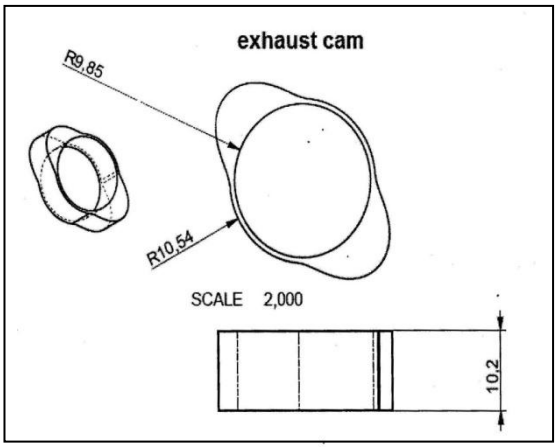

Fig. 11: Exhaust cam

The cam and camshaft were manufactured separately and cam was later mounted on camshaft. Cam is manufactured using wire cut machine. Design of cam was prepared in CAD software which was the required as input data for the computer controlled wire cutting machine.

As per the data provided outer profile of cam is cut on the wire cutting machine on a 12 mm thick steel plate. Centering and drilling on cam is done as per the required base radius. Camshaft is manufactured on precision lathe machine. Design specifications of camshaft were given to technician on lathe machine to get the camshaft of required design. Simple turning on steel rod was done to get required camshaft.

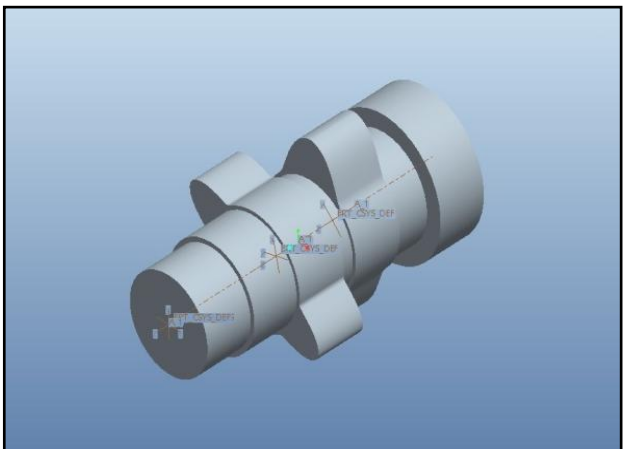

Fig. 12 : Cam and Camshaft Assembly

Cam is mounted on the camshaft at the required positions. Holes are drilled through cam and camshaft and tapping is done in the hole. Grub screw is fitted into the tapped hole for constraining all the motions of cam relative to cam and thus cam and camshaft becomes one piece. During assembly operation care should be taken so that both the cam are set relative to each other as per the design specifications. Any error here would lead to wrong valve timings.

V. CONCLUSION

The careful design of valve timings and cam profile allows conversion of conventional 4-stroke IC engine into 2-stroke pneumatic engine.

The cam needs to be manufactured with care and assembled with correct relative positions.

Single cylinder pneumatic engine can encourage for its use as an alternate for an IC engine in future. Exhaust of gases is at very low temperature than conventional IC engine which solves problem of engine heating up to a great extent. Engine can be made up of lighter weight as heating of engine is reduced. Zero carbon emission can be achieved if air is compressed from the renewable source of energy like wind, flowing water, dams or tidal energy. This can be a major step towards pollution free environment. This concept can also be used in stationary applications where space is available and power is produced by single cylinder IC engine.

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VII. REFERENCES

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