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Design of camless rotating cylinder engine

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ABSTRACT : Present research work pertains to development a rotating cylinder valve mechanism and eliminating the poppet valve mechanism for a four stroke engine. The present mechanism overcomes the various drawbacks of poppet valves viz., reduced efficiency- part of the energy generated in IC engine is taken to operate poppet valve mechanism thus reducing the efficiency, more number of parts to operate poppet valve and extra manufacturing, maintenance and handling due to additional parts thus incurring additional cost. The valve mechanism consists of rotating cylinder fitted with a bevel gear at the bottom and has floating seals for the valves. Overall the camless rotating cylinder (CRC) engine offers quite simple and rugged construction; it consists of a piston, connecting rod and crankshaft assembly (including flywheel and crown gear) and a rotating cylinder assembly. Thing which distinguishes the CRC engine from the conventional engine is the use of less number of parts, and all the other differences come as a result of the above stated. Decreased number of parts in the CRC engine creates some major discrepancies and facilitates various benefits over the poppet valve engine as light weight, better Fuel efficiency, easy and economic to manufacture and maintain, less number of moving parts, no special machinery needed for manufacturing, energy conserving, better power output, multiple fuel capability, less noisy, compact in size, dual Power Output, multi Utility Designs, less Vibration, portable engine size possibility & emissions.

Keywords : Rotating Cylinder, Valves, Camless, Crown Gear, Poppet Valve.

I. INTRODUCTION

Development of camless Engines started as early as in 1899, when designs of variable valve timing surfaced. The main idea in this project was to use rotating cylinder to function as inlet & outlet valves. Fig.1. Cylinder rotates around piston at half crankshaft speed. Ports in the rotating cylinder passes fixed radial inlet and exhaust ports to provide the valve function. The rotating cylinder is effectively combined with the rotary valve in a single component. The rotating cylinder valve concept is simple with compact package and reduced component count compared to a 2-valve 4 stroke.

II. ROTATION MECHANISM

As stated earlier the cylinder (rotating) rotates at about half the speed with respect to the crank using a simple bevel gear Fig. 2 assembly affixed directly with both the rotating cylinder and the crank (Fig. 2). What this translates is that by rotating the crank at (a/2)o in clockwise or anticlockwise direction the cylinder rotates (a/2)o in anticlockwise or clockwise direction respectively Fig. 3.

It also has the advantage of efficient 4 Stroke combustion system as it has exhaust emission legislation compliance with conventional 4 stroke motorcycle after—treatment technology. It incorporates improved assembly and maintenance as the cylinder height similar to a 4-stroke engine. It has low component count delivering simple assembly. Additionally it doesn't need cam chain or valve lash clearance to adjust. Also it doesn't suffer from valve bounce at over-speed operation.

III. CONCEPT AND PRINCIPLE

The camless rotating cylinder engine is based on the Otto cycle. The Otto Cycle consists of adiabatic compression, heat addition at constant volume, adiabatic expansion and rejection of heat at constant volume.

Suction Stroke: Piston starts moving from top dead centre resulting opening of inlet valve. The fresh charge of air-fuel mixture enters in cylinder. Piston moves further to bottom dead centre (Fig. 4).

Compression Stroke: Inlet and exhaust valves are in close position and piston starts moving upward from bottom dead centre to top dead centre there by compression of charge took place (Fig. 5).

Expansion Stroke: The ignition is started by spark plug just before the end of compression stroke. Both inlet and exhaust valves are still closed. A rapid explosion takes place which is followed by expansion of hot gases pushing the piston to its bottom dead centre. In this stroke the useful work is obtained from the engine that is why, it is also called as working stroke (Fig. 6).

Exhaust Stroke: Piston starts moving upward from bottom dead centre resulting the burnt gases are pushed out through the exhaust valve till it reaches to top dead centre. Up to this point inlet valve remain closed. When the burnt gases totally exhausted to atmosphere, piston starts moving down, inlet valve opens, fresh charge is sucked and the cycle is again repeated as earlier (Fig. 7).

Construction : The camless rotating cylinder engine has the following main units:Engine block, End bearings, Crankshaft Sleeve/Rotating Cylinder, Connecting rod, Piston, Head.The engine consists of a block in which two end bearings are located on opposite side for supporting the crankshaft. The crankshaft is fitted with dead weights so as to balance the revolving motion. The crankshaft is also fitted with small bevel gear (pinion) (Fig. 8). Sleeve/Rotating cylinder is fitted with bevel gear (Fig. 9) having twice the no. of tooth with respect to the pinion providing 1:2 rotation ratios between the sleeve and the crank. One small end bearing is also fitted on upper side of the connecting rod (Fig. 10) which is fitted with gudgeon pin. Big end of the connecting rod is connected with the crankshaft. The connecting rod is connected with the piston (Fig. 11) which reciprocates inside the sleeve as the crankshaft rotates. So we have obtained two types of motion, one is the reciprocating motion of the piston & the other is the rotating motion of the sleeve. Two cavities are formed on the sleeve, one on the top head and the other on its radial face, similarly one cavity is formed on radial face of the head and one upon the top of the head (Fig. 12). Now according to the valve timing diagram the axial cavity of the head and the sleeve matches with each other giving an inlet flow for the fuel. The upper cavity formed one upon the sleeve and the other upon top of the head matches with each other giving an exhaust stroke as seen in final assembly (Fig. 13).

Working: The working of CRC engine can be explained based on the valve timing diagram as the engine works on the 4 stroke Otto cycle thereby following the P-V diagram also. The valve timing diagram is as shown below (Fig. 14) in petrol engine various strokes are performed to obtain the results from engine. By denoting the corresponding position of the piston attached to the crankshaft at which these strokes occurs, we can draw the exact moment in the sequence of events at which the valves are open and close. The graphical diagrams are known as valve timing diagram in power engineering. The valve timing are modified to set better charging and exhausting performance as there is always a difference between theory and practical.The diagram is drawn for two complete revolutions of the crankshaft means for one complete cycle.In suction stroke Piston starts moving from top dead centre resulting opening of inlet valve. The fresh charge of air-fuel mixture enters in cylinder (Fig. 15). Piston moves further to bottom dead centre. During compression stroke inlet and exhaust valves are in close position and piston starts moving upward from bottom dead centre to top dead centre there by compression of charge took place (Fig. 16). While in the expansion stroke the ignition is started by spark plug just before the end of compression stroke. Both inlet and exhaust valves are still closed. A rapid explosion takes place which is followed by expansion of hot gases pushing the piston to its bottom dead centre. In this stroke the useful work is obtained from the engine that is why, it is also called as working stroke (Fig. 17). In the exhaust stroke piston starts moving upward from bottom dead centre resulting the burnt gases are pushed out through the exhaust valve till it reaches to top dead centre. Up to this point inlet valve remain closed. When the burnt gases totally exhausted to atmosphere, piston starts moving down, inlet valve opens, fresh charge is sucked and the cycle is again repeated as earlier (Fig. 18). Theoretically above cycle is well perfect but in actual practice, it is slightly modified by the opening of inlet valve and delayed closing of exhaust valve. The details are as below.The inlet valve is opened 10 to 30 degree in advance to the top dead centre of the piston to facilitate the inrush of fresh charge and out rush of burnt gases.The piston moves down during suction stroke which is continued up to 30 to 40 degree or even 60 degree after the bottom dead centre. The inlet valve is then closed and compression stroke starts. To give some extra time to fuel to burn, the spark is produced at 30 to 40 degree before the top dead centre of piston. The pressure rises up and attains a maximum value when the piston is about 10 degree past to top dead centre. The exhaust valve is open about 30 to 60 degrees before piston reaches to bottom dead centre. The burnt exhaust gases pushed out of cylinder as the piston starts moving upward. This exhaust stroke continuous till the exhaust valve closed when the piston is about 8 to 10 degree or even 25 degree past the top dead centre. The angle between the position of the crank at the inlet valve opening and that exhaust valve closing is known as valve overlap. All this angular positions of crank can be plotted by a circular line corresponding to one vertical line; where top dead center can be taken at top of the line and bottom dead center at bottom of the vertical line.

Working of CRC engine based on the valve timing diagram: Initially the piston is at TDC (Fig. 19) and starts moving toward BDC with both the valves closed thus creating the required vacuum for suction (Fig. 20). Suction valves at the radial face start matching (Fig. 21). After the movement of crank through 10^{o} and continues until the piston reaches BDC. Then the piston starts moving upwards and compresses the air fuel mixture, both the valves are closed for this stroke (Fig. 22). The spark plug ignites the air- fuel mixture at the end of this stroke. The burning of fuel in the presence of air generates enormous amount of pressure and pushes the piston from TDC to BDC. This is the only working stroke in the complete cycle. The piston then starts moving from TDC to BDC, and exhaust valves at the top face of the rotating cylinder starts matching with the cavity on the head (Fig. 23). & thus exhaust stroke starts and it ends when the piston comes at TDC. The cycle repeats itself in the above stated manner.

IV. BENEFITS

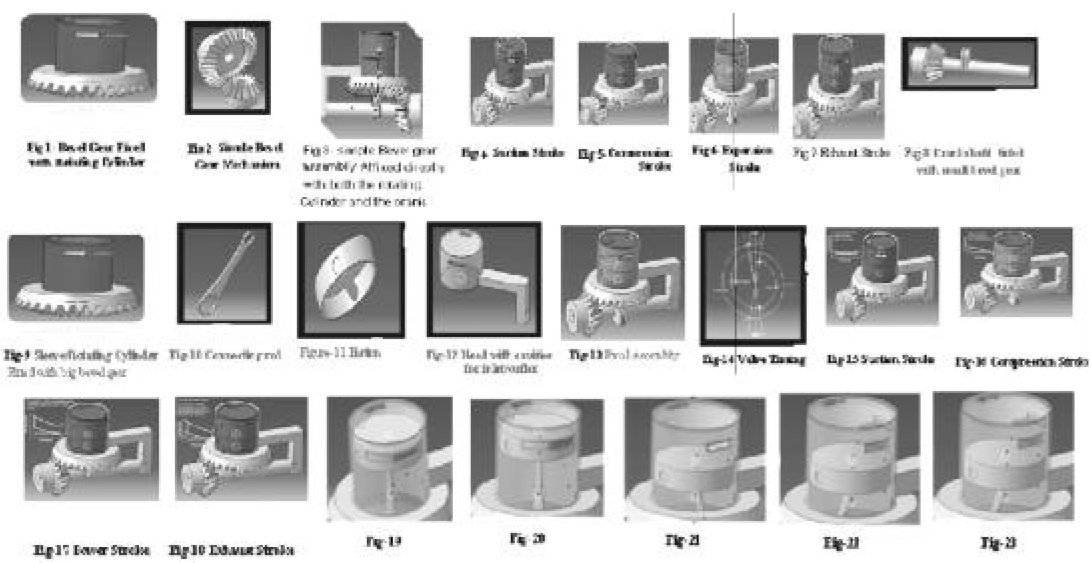
1. **Light Weight.** Since a considerable No. of parts are absent in CRC engine as compared to the poppet valve engine therefore it is very light in weight
2. **Fuel Efficient.** Increased volumetric efficiency and less load on the engine makes the CRC engine exploit the fuel very efficiently.
3. **Economic to manufacture and maintain.** CRC engine is very is very economic to manufacture as e don't have to manufacture the camshaft and poppet vale assembly, further as it' assembly is simple and minimal it require less maintenance.
4. **Less No. of moving parts.** The rotating cylinder itself performs numerous functions so many other mechanism are omitted
5. **No special machinery needed for manufacturing.** The CRC engine can be manufactured by using the general machineries so is easily acceptable by the companies.
6. **Multiple fuel capability.** The same engine design can be used for different types of fuels such as gasoline, diesel, LPG etc.
7. **Less Noisy.** It does not create much noise as compared to the moving parts of the poppet valve mechanism.
8. **Increased Portability:** Absence of many parts makes the engine very portable and small engine sizes are possible, e.g. 10cc.
9. **Duel power output.** Power can be taken out from the engine either from crankshaft or the cylinder for high speed and low speed applications respectively.
10. **Multi Utility design.** Since very small engine sizes are possible so it can be used for many applications such as toys, robots, and handheld chainsaws and medicine sprayers for agricultural purposes.
11. **Less Vibration.** The engine runs in a very balanced manner and do not suffers from dangerous vibrations.
12. **No Valve Bounce at high speed operation.**

The use of rotating cylinder valve causes reduced friction and fuel consumption. The Rotating cylinder provides continuous piston lubrication. It also eliminates valve train with net advantage considering seal losses & efficiency benefits particularly at part load. The use of rotating cylinder also causes improved volumetric efficiency with the use of unrestricted port with large effective valve area, thus very portable engine sizes are possible and the rotating cylinder creates much more turbulence than the poppet valve.

V. FURTHER RESEARCH DIRECTIONS

Further works are to be done in the following direction:

1. Decreasing friction between sleeve & head by using floating seals
2. Increasing turbulence by changing piston design
3. Decreasing the problem of overheating at full load by direct cylinder oil cooling
4. Decreasing oil consumption by revised cylinder/ crankcase oil distribution
5. Decreasing seal wear by using powder coating technology for seal material
6. Use of self lubricating metals for rotating cylinder/ sleeve to further reduce the frictional losses.



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