ROTARY VALVE HEAD DESIGN FOR INTERNAL COMBUSTION ENGINES

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Abstract - This paper presents a study on the rotary valve engine head design and its numerous advantages. The concept relates to the replacement of conventional cam driven valves in internal combustion engines (hereafter called IC engines) with a simpler mechanism that allows the same valve timings. Current IC engines make use of cam based contact-no contact methods of actuation of valves and multiple compromises are made to ensure engine functioning and life.

Keywords - Replacement of poppet valves in internal combustion engines with rotary valves

I. INTRODUCTION

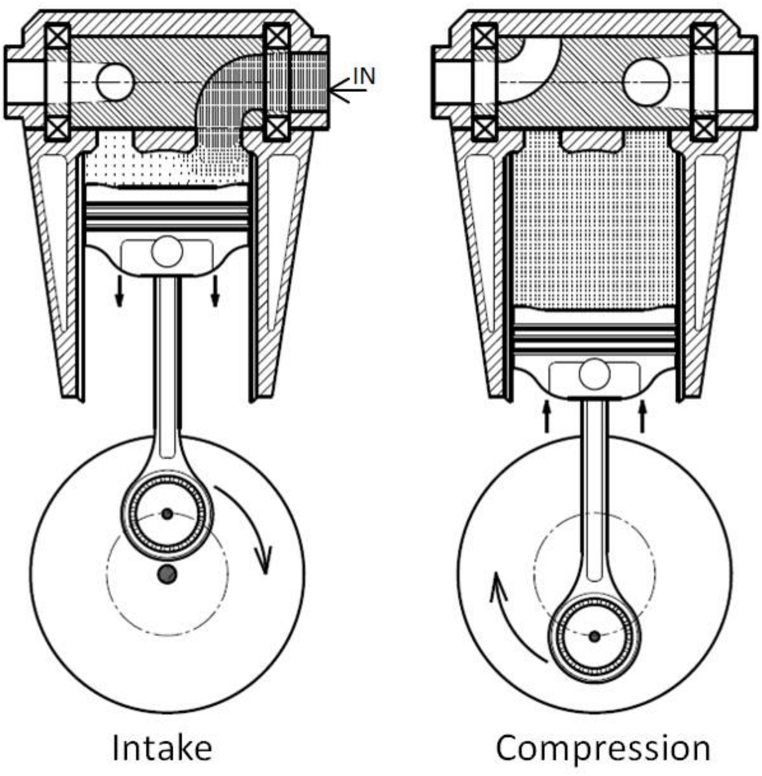
The concept relates to the replacement of conventional cam driven valves in IC engines with a simpler mechanism that allows the same valve timings.

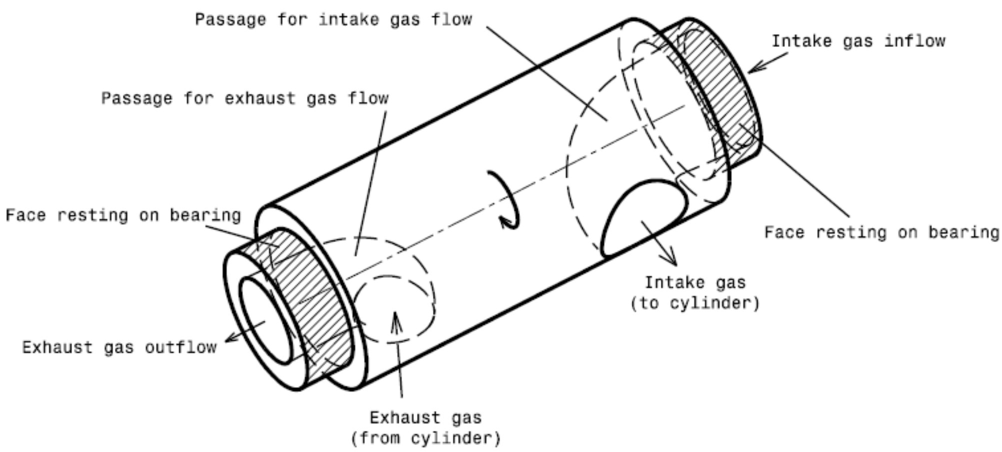
Current IC engines make use of cam based contact-no contact methods of actuation of valves. To achieve this configuration, multiple compromises are made to ensure engine functioning and life.

The rpms safely attainable by the traditional engine depend on the ability of the valves to move quickly in time with the engine rpm. The gas flow is also restricted by the geometry of the valve head, leading to pumping losses as they are forced to move at high speed over the face of the valve head.

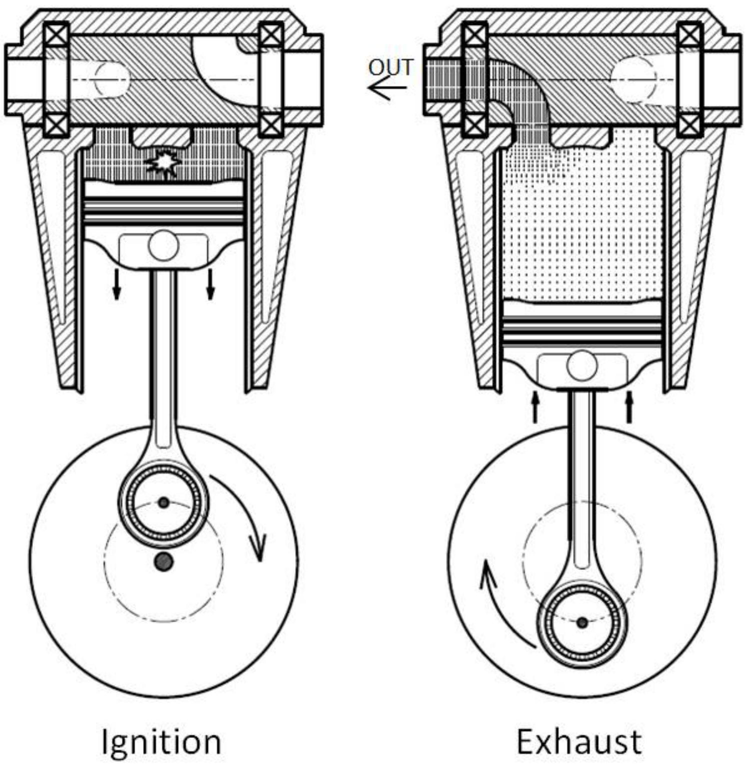
With the proposed valve actuation design, the conventional intake and exhaust port may retain their place but the engine head makes use of a rotating shaft with 2 passages. The rotation of the shaft is at ½ the speed of the engine rpm (as is the case with conventional camshafts). The passages in the rotating valve shaft are aligned with respect to each other in a manner to allow for axial gas flow. The other end of each passage exits radially and in an orientation that maintains the required intake and exhaust gas flow with the 4 strokes of the IC engine.

This rotary valve shaft is shown in the adjacent diagram. The orientation of the passages accommodates the requirement of valve overlap.The diagrams below show the intake, compression, combustion and exhaust stroke at the start of each stroke.





For simplicity, valve actuation is shown at BDC and TDC conditions and no overlap is depicted. It can be understood that conventional valve timings with the required valve overlap can be easily adopted.



Numerous concepts of the rotary valve design have been studied in the industry but with limited success in implementation. The major reliability related problems were:

1. Gas and lubricant sealing difficulties
2. Thermal distortion related stresses

These problems and the resistance to a change in the accepted poppet valve systems resulted in the rotary valve remaining confined to the domains of research. However it is hoped that the numerous advantages listed in the adjacent section encapsulates the need for further research in this concept.

II. ADVANTAGES OF ROTARY VALVE SYSTEMS

1. Volumetric efficiency

- The breathing capacity of rotary valve engines is greater (by an estimated 45%) than a traditional engine because gases are not forced over a valve head.
- Volumetric efficiency is maintained over a larger range of rpms unlike in case of poppet valve engines. Thus higher rpms (tested up to 25,000 RPM) also have similar volumetric efficiencies.

2. Lower frictional losses, noise and maintenance

- Gas flow is relatively unrestricted in rotary valve systems, lowering pumping losses.
- The problem of tappet noise is eliminated and the engine runs quieter and with lower vibrations. Regular tappet clearance adjustment would not be required.
- Fewer moving parts, lower friction and lower inertial loading imply higher engine life. This can be further increased by improving sealing designs to reduce peripheral wear.

3. Better fuel mixing

- The rotary valve engine has higher tumble flow, estimated to be about two times that of a poppet valve engine. The rotating action of the valve also leads to higher levels of turbulence.
- By making use of a tapped inner profile of the valve or an integrated turbulator, the fuel mixing can be further improved.

4. High resistance to knock

- The aforementioned increased turbulence allows for better fuel-air mixing which results in an increased flame speed. The faster flame front consumes the unburnt charge quicker and reduces the chances of auto-ignition and knocking.
- Traditional poppet valve engines are also limited in their ability to disperse heat away from the combustion chamber. They remain hot, creating hotspots which can be a significant contributor to knocking. This is further increased if there are carbon deposits.
- In a rotary valve however, the surface exposed to the combustion chamber is continuously rotating away from the cylinder (and back again). Better heat dissipation and lower overall temperature of the valve help reduce knocking tendencies.

5. Higher compression ratios and multiple fuel capabilities

- Ignition timing can be advanced significantly in a rotary valve engine compared to traditional engines. Higher resistance to knocking also allows for greater compression ratios. It has been claimed in a study that experimental rotary engines running up to 17:1 compression ratios had no incidences of knocking in the operating range.
- The rotary valve engine is more flexible with regard to the fuel in use: methanol, gasoline, kerosene and diesel have been tested without significant modifications. The experimentally claimed output from kerosene fuel was logged at 100hp per litre of engine displacement.

6. Higher RPMs attainable

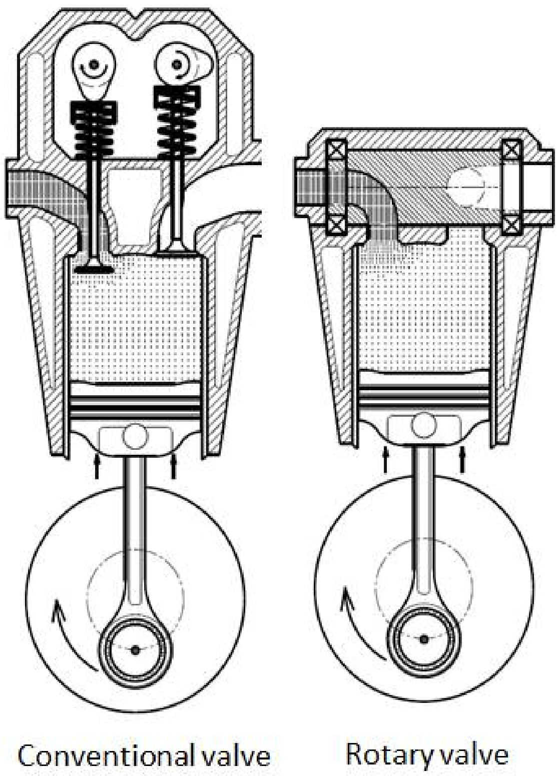
- The problems of valve spring related inertia constraints and dynamic loading limits are eliminated.
- There is no danger of piston-valve clash or clearance issues at higher rpms allowing significantly higher redline rpms.

7. Cheaper

- There are fewer moving parts in a rotary valve engine and the design can be manufactured using conventional fabrication techniques. The estimated manufacturing related cost of the rotary valve engine head unit is 40% lower than that of traditional engine heads.

8. Compact and lightweight design

- The weight saving in the engine head is considerable; a reduction of 4 kilograms per cylinder in conventional engines was reported in a study. An experimental rotary valve 3 Litre Formula 1 engine head was 16 kilograms lighter than its poppet valve equivalent.
- Since the weight reduction is in the upper region, the centre of gravity is lowered.
- The specific power output is significantly higher. It has been claimed to have performance similar to a 2 stroke engine while consuming fuel at the rate of a 4 stroke engine.



The adjacent diagram visibly shows the size reduction in a rotary valve engine.

9. Easier to optimize

- The peak volumetric efficiency is a function of the inner diameter of the valve. There are fewer parameters to be varied to achieve a target output and thus engine development times may be reduced.

CONCLUSION

Considering the numerous advantages of the rotary valve further research must be conducted to optimize the design with an objective of mass production. Worth noting is that significant cost reduction can also be achieved and conventional manufacturing methods can be employed to fabricate the rotary valve cylinder head unit.

REFERENCES

[1] Keith Lawes, RCV Engines Limited. The Rotating Cylinder Valve 4-Stroke Engine, A Practical Alternative. 2002-32-1828(SAE) 20024321(JSAE).

[2] KT Lawes and Dr B R Mason. RCV Engines Limited. November 2011. RCV Engine: Technical Analysis and Real World Benefits. IMehe Conference Internal Combustion Engines: Improving Performance, Fuel Economy and Emissions.

[3] Tony Wallis, Bishop Innovation. 2007. The Bishop Rotary Valve. AutoTechnology special 2007.

[4] Darrick Vaseleniuck and David Veseleniuck, VAZTEC LLC patent. April 2013. Head Assembly and Valve-Less Internal Combustion Engine. United States Patent US2013/0087117 A1.

[5] Coates International: The Coates Spherical Rotary Valve (CSRV) System. www.coatesengine.com/csrv-system.html

[6] RCV Engines Limited: Technology. www.rcvengines.com/technology.html

[7] Engine Developments Australia: About. www.enginedevelopmentsaustralia.com/about

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