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Design and Fabrication of Variable Compression Ratio Engine

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Abstract

Variable compression ratio is a technology to adjust the compression ratio of an internal combustion engine while the engine is in operation/manually. In scope to lower compression ratio at turbo charging to prevent knocking, switch between efficient or powerful engine, use alternative fuels with varying octane or Cetane numbers and improved NO_X particulate formation. The study comprises of sourced Single-cylinder Petrol engine from Suzuki Access 125 cc. The mechanism used is simple Sliding slotted cavity mechanism, for changing crankshaft's position. A sophisticated lever-link mechanism is used to control the magnitude of crankshaft's position controlled by power screw manually or actuator. Further results are verified in motion simulation software and brake dynamometer. Due to the change in mechanism, basic casing of engine to be improved and altered. In this method, a crankshaft bearing is carried in an eccentrically mounted carrier that can rotate to raise or lower the top dead center of the piston in cylinder. The compression ratio is adjustable by varying the rotation of the eccentric carrier.

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Keywords: Compression ratio, efficiency, Solidworks 2015

1. Introduction

Variation in compression ratio is done to increase fuel efficiency during varying loads. Larger loads demand lower ratios to provide more efficiency or vice versa. VCR engines change the volume above the piston at top dead center. This is done dynamically in response to the load and driving demands. Due to engine downsizing and supercharging, internal combustion engine already achieved impressive results. But internal combustion still has disadvantage that it can only switch between efficient or powerful engine, not both. It requires lower compression ratio at turbo charging. In addition, it cannot run on alternative fuels with varying octane or Cetane numbers. The requirement of fossil fuels conservation is very necessary in our life. A large proportion of global fossil fuels (diesel and petrol) go wasted by in-efficient engine causing un-burnt hydrocarbon due to knocking which further causes pollution in forms of NO_X, SO_X, CO etc. VCR technology signifies a new chapter in the story of the internal combustion engine. Engines are no longer limited by a fixed compression ratio. VCR Turbo engine can transform itself and seamlessly raises or lowers the height the, pistons reach. As a result, the displacement of the engine changes and the compression ratio can vary anywhere between 8:1 (for high performance) and 14:1 (for high efficiency). This study show how we can fulfill requirement of downsized turbocharged engine by introduction of new mechanism at crankcase.

2. Designing

To check whether the technical resources are available with to actually generate the required model, be it on the software or be it the actual physical model. It was decided to prepare the 3-D CAD model on Solidworks version 2015 along with its analysis on Ansys version 2015. And the fabrication part to be dealt at workshops outside. Emphasizes on the cost effective and economic feasibility of the desired model where through various market surveys and market research, the approximate cost is estimated which would be involved in generating this model on physical grounds.

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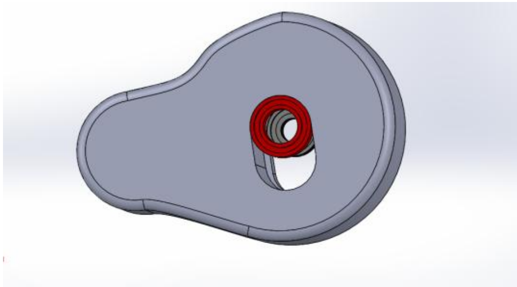

Fig 2.1 Casing with moving bearing

3. Prototyping

After creating the 3-D CAD model and on the basis of the analysis reports, the material was selected to be used to build the prototype which to a certain extent highlights the features of the actual working model of the V.C.R Engine and not the model as the whole. In this stage, the material is selected which would be ideal enough to build a cost effective prototype perfect enough to display the workability and essential features of the final model and most importantly its esthetic properties and surface characteristics. The material for the casing and the mounting u-slots is chosen for making the prototype. All other materials required to build the prototype are collected and using which the actual prototype is made. Equipment and Materials used would be- An Input Drive (be it a motor of lower rpm considering the fragility of the prototype) to give motion to the cam shaft, a u-slotted casing geometry to enable and enhance the compression ratio process and an output receiver, to study the effectiveness of the mechanism made. The prototype to be tested in this stage based upon the actual conditions or by simulation. During the testing phase, the outcomes to be evaluated compared to the expected ones generated during the calculations in the designing phase. Various sets of inputs to be provided based upon which various output readings are generated and a report is prepared.

4. Manufacturing the actual model

As per the report data received from the prototyping stage, Market analysis during the planning phase and the aesthetic simulation and analysis on software, the final material is chosen which fits the demands of design and results required for the engine to perform with full efficiency complying with the varying compression ratio mechanism.

4.1 Manufacturing the u-slots using a vertical mill

End Mill Dimensions to be used:

Cutter Diameter = 10mm
Cutter Compensation = 5 mm inside->(w.r.t center of cut)

Path Dimensions:
Length of cut= 20mm
Radius of curvature for U slot = R25.5mm (Fig. 1)
Radius of curvature for U slot = R3.05mm (Fig. 2)

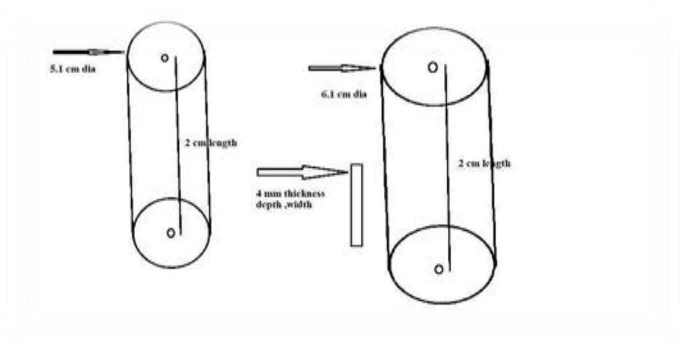

Fig. 4.1 Fig. 4.2

5. Calculations

5.1 Swept volume

Actual swept volume = V_c

= Cylinder Area x Stroke Length

= A_c x length

$$= \left(\frac{\pi}{4} \times d_c^2 \times L\right)$$

$$= \left(\frac{\pi}{4} \times 5.4^2 \times 5.4\right)$$

= 123.67 cm^3

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Experimented swept volume (Increased by 2 cm)

$= V_c$

= Cylinder Area x Stroke Length

$= A_c$ x length

$= (\frac{\pi}{4} \times d_c^2 \times L)$

$= (\frac{\pi}{4} \times 5.4^2 \times 7.4)$

$= 169.47\ cm^3$

5.2 Clearance volume

Actual clearance volume $= V_{cv}$

$= 14.53\ cm^3$

Experimented (Increased stroke length by 2 cm) clearance volume $= V_{cv}$

$= 14.53 + (\frac{\pi}{4} \times 5.4^2 \times 2)$

$= \quad 60.33\ cm^3$

5.3 Compression ratio

$$r = \frac{\text{Cylinder Volume at BDC}}{\text{Cylinder Volume at TDC}}$$

$$r = \frac{\text{Cylinder Volume} + \text{Cylinder Clearance Volume}}{\text{Cylinder Clearance Volume}}$$

Actual compression ratio = r

$$r = \frac{Vs+Vc}{Vc} = 1 + \frac{Vs}{Vc} = 1 + \frac{123.67}{14.53}$$

r = 9.6

Experimented compression ratio $= r_e$

$$r_e = 1 + \frac{123.67+45.53}{14.53+45.53}$$

$r_e = 3.83$

6. Results

After completing the calculation work, following are the results generated. It has been observed that the swept volume is increased by 37 % which provided a major advantage. It is also concluded that the clearance volume increased by 315% and in addition to that the compression ratio decreased by 60 %.

7. Conclusions

The Present VCR engine model can decrease the compression ratio from 9.6 to 3.83, which can be useful at the high turbo charging of engine resulting in higher volumetric efficiency, reduced knocking, NO_x generation and heavy load on cylinder block. Further modification on VCR engine can produce higher power boost to engine, and can be act as both powerful and economical engine. The mechanism has been successfully fabricated which is able to change the crankshaft axial position, and simultaneously changing the layout of the sprockets in timing chain of overhead cam (OHC). Therefore, it is concluded that this mechanism is suitable and useful to mechanical engineering.

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