Experimental Study on Revetec Engine Cam Performance

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Experimental Study on Revetec Engine Cam Performance

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Abstract. In Revetec engine (three-lobed) cam replaces the crankshaft to convert the reciprocating motion of the engine piston, to a rotating motion in the drive line. Since the cam controls the piston movement, the cam profile has a great effect on engine performance. In this paper an experimental study was done to a (three- lobed) cam with Cycloidal motion profile but with different ratios between the base circle radius of the cam and the radius of the roller follower. DEWESoft was used to find the displacement and the vibration of the piston, and compare the actual results from the test with the theoretical results from the cam profile equation. The results showed that there is a periods of miss contact between the follower and the cam when the ratio between the base circle radius of the cam and the radius of the roller follower is less than a certain value, and also increasing of vibration . The suggested ratio between the cam and follower radius is to be more than 2:1.

1. Introduction

Efficiency of conventional IC engines is less than 50% percent due to heat and friction losses. About two- third of the input energy is lost in exhaust gases and water cooling [1], and the mechanical losses due to friction are about 8% [1].

Due to economic crisis and shortness of oil resources, efforts are done to increase IC engines efficiency by reducing the heat and friction losses.

All conventional IC engines used crankshafts to convert the piston reciprocating motion to a rotating motion in the drive line, but crankshafts are responsible of side thrust force, vibrations and also they are not efficient in transferring the power to the drive line.

Crank-less and free piston engines were a good example to overcome the crank shaft problems, but these new kinds of engines are facing a control and starting problems [2].

In 1996, an Australian engineer called Bradley Howell Smith, managed to produce a new mechanism to convert the reciprocating motion of the internal combustion engines pistons, to rotating motion in the drive line, by using a three-lobed counter rotating cams and called the new engine arrangement as Revetec engine [3].

In Revetec engine, shown in Figure 1, there are two opposite pistons controlled by two (three-lobed) cams. On both sides of each piston, there are two bearing which act as the follower for the cams. As each cam has three arms (three-lobed), meaning, in every two cycles of engine there are three power stokes compared to one power stroke in the conventional engines, and every stroke in Revetec engine completed in just 60 degrees instead of 180 degrees in conventional engines.

The cam profile contributes great effect in the engine performance, because the cam profile controls the piston motion, meaning that by changing the cam profile the piston motion will change too.

There is a wide variety of cam motion schemes, but the main motions for cams followers, are: simple harmonic, constant acceleration and Cycloidal motion [4]. Cycloidal motion is the best profile for high speed engines because it maintain the maximum cylinder pressure when compared with the other motion schemes [5].

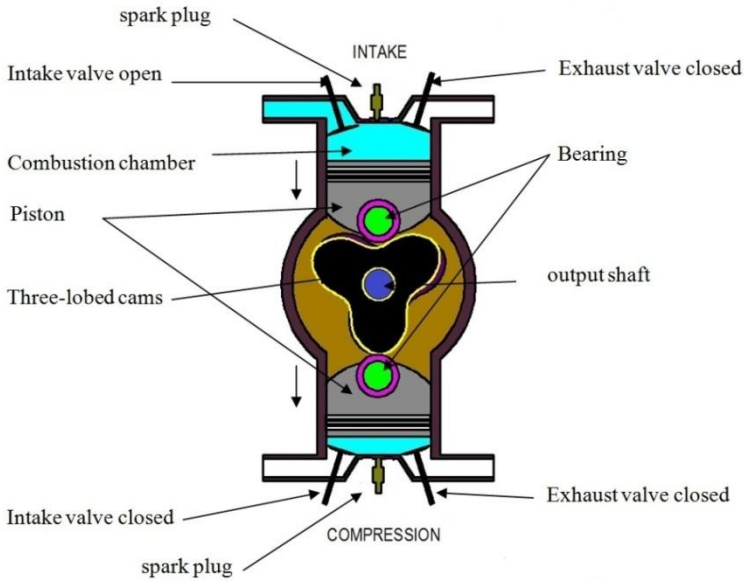

Figure 1: Revetec engine with two cylinders during intake-compression stroke

In this paper an experimental study done to calculate the displacement, speed and acceleration of the piston when connected to three lobed cam having a Cycloidal motion profile.

2. Cam design and manufacturing

By using CNC milling machine cams with different radii of the cam base circle were manufactured. Figure 2 shows one of these cams. The x and y coordinates of the milling cutter are given as:

$$C_x = -\left[R_f + R_b + \Delta R\right]\sin\phi + \left[R_c - R_F\right]\sin(\phi - \alpha) \quad (1)$$

$$C_y = \left[R_f + R_b + \Delta R\right]\cos\phi - \left[R_c - R_F\right]\cos(\phi - \alpha) \quad (2)$$

Where:

R_f = Radius of the roller follower

R_b = Radius of the base circle

ϕ = angle into rise or fall interval that defines the instantaneous follower properties.

R_c = Mill cutter radius

ΔR = Instantaneous follower displacement, which can be calculated from the equation:

$$\Delta R = H\left[\frac{\phi}{\beta} - \frac{1}{2\pi}\sin\left(\frac{2\pi\phi}{\beta}\right)\right] \quad (3)$$

H = Maximum follower displacement

β = Rotation angle of cam during the rise or fall interval.

α = the angle between the follower centerline and the cam contact point, which calculated from:

$$\alpha = \tan^{-1}\left[\frac{v\left(R_f + R_b + \Delta R\right)}{\omega\left(R_f + R_b + \Delta R\right)^2}\right] \quad (4)$$

ω = Rotational speed of the cam

v = instantaneous velocity of the cam follower at the cam angle ϕ, which obtained from the equation:

$$v = \frac{H\omega}{\beta}\left[1 - \cos\left(\frac{2\pi\phi}{\beta}\right)\right] \quad (5)$$

one of the cams designed depending on these equations and by using AutoCAD is shown in Figure 2. Then using CNC machine one of the manufactured cams is shown in Figure 3.

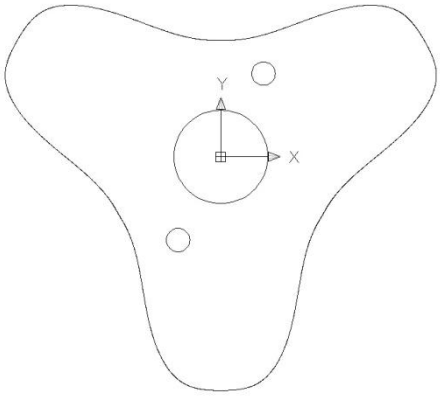

Figure 2: Three-lobed cam drawing

Figure 3: Three-lobed cam

2. Test rig layout

Figure 4 shows the test rig layout which consist of the hardware components. In the hardware there are: shaft (1) which drives the three lobed cam (2) using the electric motor (3). Three sensors exerted in different positions, sensor (4) measures the follower (5) displacement. The spring (6) maintain the contact between the follower and the cam.

The data from the sensor is transferred to DEWESoft which is data acquisition software. By using the software the data is recorded and illustrated in Figures 5 and 6.

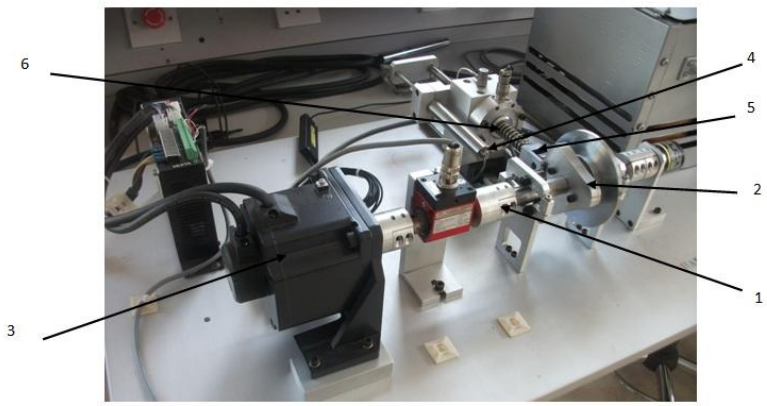

Figure 4: Test rig layout

3. Results

Figure 5 illustrates the displacement and vibration of cam follower against the time. The graph shows unobtainable displacement at the beginning of fall intervals. This unobtainable displacement is due to large diameter of the roller follower or the- respectively- small base circle of the cam.

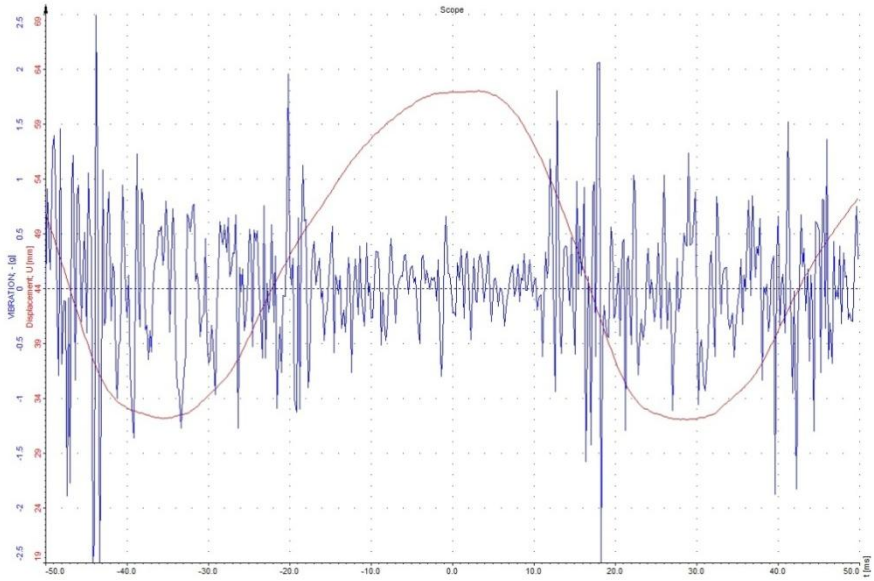

Figure 5: Displacement of the cam with small base circle comparing to the roller follower.

After increasing the diameter of the base circle the miss contact between the cam and the follower is disappeared, and also the vibration decreased, as shown in figure 6.

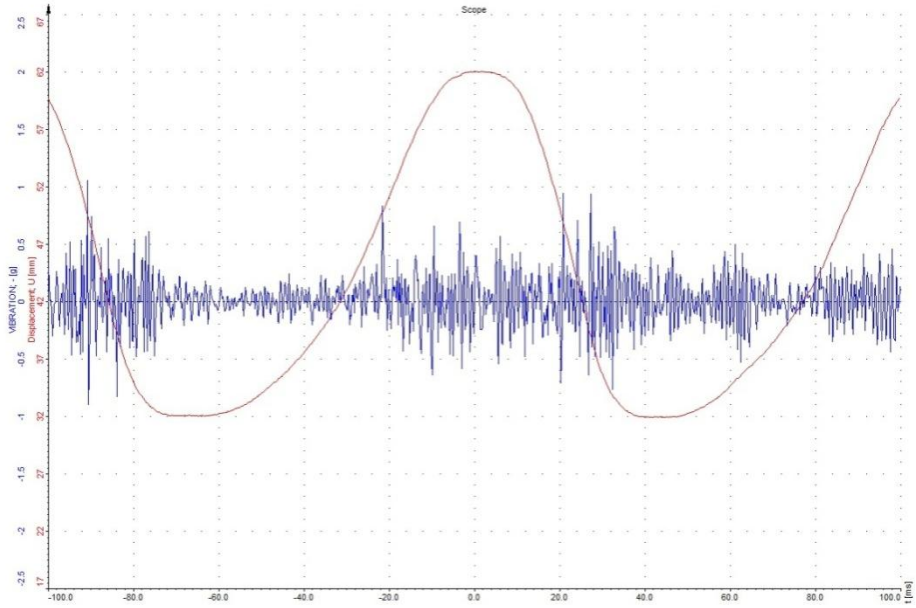

Figure 6: Displacement of the cam with large base circle comparing to the roller follower.

4. Conclusion

Three-lobed cam used in Revetec engine to convert the piston reciprocating motion to a rotating motion in the drive line. The cam profile used here was designed to give the piston a Cycloidal motion, which is proven to be the best motion to maintain the maximum cylinder pressure during combustion.

Different cam base circle radius used and tests were carried out measure the displacement using DEWESoft. The results from the test shows that the best ratio-to avoid miss contact between the cam and follower and to decrease the vibration- is more than 2:1.

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