ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 07, Issue, 12, pp.17398-17402, December, 2017

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

DESIGN AND MANUFACTURE CAMSHAFT FOR OTTO CYCLE MODIFICATION TO REDUCING FUEL CONSUMPTION

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ARTICLE INFO

Article History:
Received 20th September, 2017
Received in revised form
10th October, 2017
Accepted 15th November, 2017
Published online 29th December, 2017

Key Words:
Crankshaft,
Camshaft,
Timing Gear Ratio
Angular Displacement

ABSTRACT

Goal of the research is creating a concept for otto cycle modification with changes valve mechanism system. Overall otto cycle modification concept is same four strokes engine standart. In diferent at last strokes (exhaust strokes), exhaust valve keep be opened (intake valve is not opened) then exhaust gas is entered again for be compressed and be burned again. At of the calculation and simulation result in this research activity with application otto cycle modification concept have to changes timing gear ratio (crankshaft : camshaft). Timing gear ratio be changed from 1 : 2 to be 1 : 4 and changes cam profile design with angular displacement is 45° each stroke. Then be resulted cam separation angle at intake cam ($L.in$) with first exhaust cam ($L.ex_1$) is 137.5°, first exhaust cam ($L.ex_1$) with second exhaust cam ($L.ex_2$) is 157.5° and second exhaust cam ($L.ex_2$) with intake cam ($L.in$) is 65°. It's calculation be resulted from the camshaft rotation angle. Process and trial with this concept, engine can be operated suitable.

Citation: Prihantoro, C. Rudy and Tri Noviyanto. 2017. "Design and manufacture camshaft for Otto cycle modification to reducing fuel consumption", *International Journal of Development Research*, 7, (12), 17398-17402.

INTRODUCTION

Valve mechanism system is one of more system which influence of characteristic and performance an engine. To changes or other word is modificaton a working cycle, it's means changes control system in the work cycle. Control system in an engine is valve mechanism system. To be changes a mechanism it's means to be changes control component design of that mechanism. Control component in a valve mechanism system is camshaft. Works principle at otto cycle modification which changes valve mechanism is such as: From works principle otto cycle modification concept above can be conclused that once suction stroke (intake valve) have to do eight piston moving or twice otto cycle standart, because at the second suction stroke, this concept is entering exhaust gas pass through exhaust valve to be compressed and be burned again. Pass through modification or redesign profil of the camshaft can change opens and closes timing valve, in other word can be controling valve working suitable as otto cycle modification concept.

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Other component which need attention is driver of the camshaft. Driver of the camshaft is timing gear mechanism, because rotation of the camshaft ought to be reduced (slow-moving) in order that can be finishing eight piston strokes in one of rotation camshaft. To be changes timing gear ratio is a solving of this explaination. Rotation of the crankshaft will be influencing rotation of the camshaft. High rotation speed of the camshaft will make the valve opens and closes quickly also. This matter will be influencing volumetric efficiency in this engine. So design of the camshaft profil ought to suitable with engine application. Purpose of this research is application the otto cycle modification concept in four strokes engine with low rotation (idle). Be wished this concept can be improved for increasing performance and efficiency in application this concept.

BASIC PARADIGM

Works process of internal combution engine occured in periodic time. Otto cycle engine is an engine which be finished four strokes works and results once power strokes in once cycle. Piston moves from Top Death Center (TDC) to Bottom Death Center (BDC) or from Bottom Death Center (BDC) to

Top Death Center (TDC) is once piston stroke and be rotating crankshaft 180°. Otto cycle standart using timing gear ratio:

Camshaft : Crankshaft
1 : 2

In other word, once rotation of camshaft is same twice rotation of crankshaft. Its can be conclused that: 1 x works stroke piston = 180° rotation of the Crankshaft 180° rotation of the crankshaft = 90° rotation of the camshaft and then be resulted comparation is:

$$\frac{1\ x\ works\ stroke\ crankshaft}{1\ x\ works\ stroke\ camshaft} = \frac{180°}{90°}$$

or

$$\frac{1\ x\ works\ cycle\ crankshaft}{1\ x\ works\ cycle\ camshaft} = \frac{720°}{360°}$$

Profil of the camshaft has each section. Section of the cam profil as shown in figure 1. Object which be used in this experiment has specification four strokes engine 115cc with Single Over Head Camshaft (SOHC). Section of the camshaft which be used as shown in figure 2.

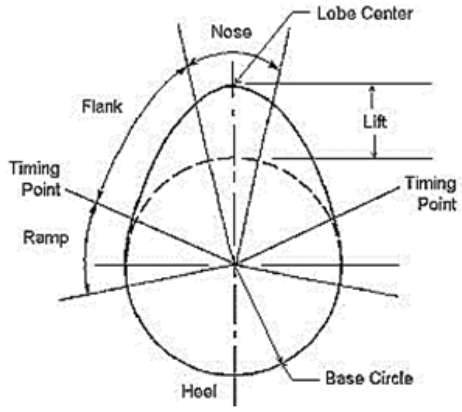

Figure 1. Section of the Cam Profile

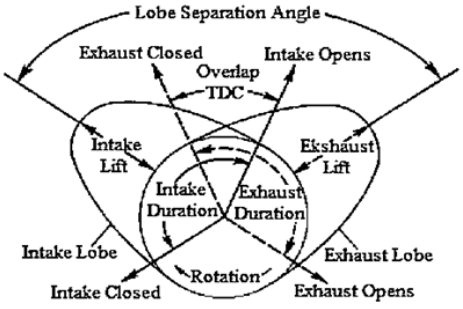

Figure 2. Section of the Camshaft

Rocker arm is a component in the camshaft mechanism which has function as follower of the cam profile. Rocker arm is a component which be transmising lift of the cam to valve. Follower type which be used in this experiment is roller follower and motion category which be used is uniform velocity motion (Figur 3). When will determine work valve timing (opens and closes valve) ought to concider efficiency volumetric. At the internal combution engine, valve is not be opened and be closed at death center point.

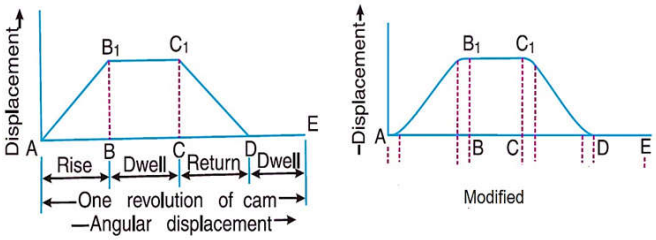

Figure 3. Uniform Velocity Motion

So with design of the profil cam, valve can be controled suitable with efficiency volumetric influences. Otto cycle modification concept is entering exhaust gas again for be compressed and be burned again. Exhaust gas contains elements which is not toxic such as *nitrogen* (N_2), *carbondioxide* (CO_2) and water (H_2O). But exhaust gas contains toxic elements also such as *carbon monoxide (CO), hidrocarbon (HC), oxide nitrogen (NOx), sulfur oxide (SOx), Pb* and solid particle. In actual condition internal combution engine never happens a perfect combution although its completely with advance control system.

METHODS OF RESEARCH

Object which be used in this experiment has specification four strokes engine 115cc with Single Over Head Camshaft (SOHC) and uses gasoline fuel. Modeling and simulation is performed by *Dassault Systems* (solidworks). Software Solidwork as software which be used to design camshaft modification.

Calculation and Design

After have been finding and concidering references, next steps of this research is calculation, such as:

Determine Works Angle of Camshaft Modification

Concept of the otto cycle modification is doing eight strokes piston with one rotation of camshaft. It is suction stroke I (intake valve), compression stroke I, power stroke I, exhaust stroke I (exhaust valve), suction stroke II (exhaust valve), compression stroke II, power stroke II, exhaust stroke II (exhaust valve) and back to first stroke again. Be gotten calculation :

$$Works\ angle\ cam\ in\ once\ cycle = 360°$$

$$Works\ angle\ cam\ in\ once\ stroke = \frac{360°}{number\ of\ strokes\ in\ once\ cycle}$$

$$= \frac{360°}{8}$$

$$= 45°$$

From calculation results above, section of the camshaft modification as shown in figure 4.

Determine Lobe Position

Position of the lobe at the section where valve will be concepted opens. Intake valve is opened at suction I section and exhaust valve is opened at exhaust I, suction II, exhaust II section. So position of the cam modification be shown at figure 5 (without efficiency volumetric influences).

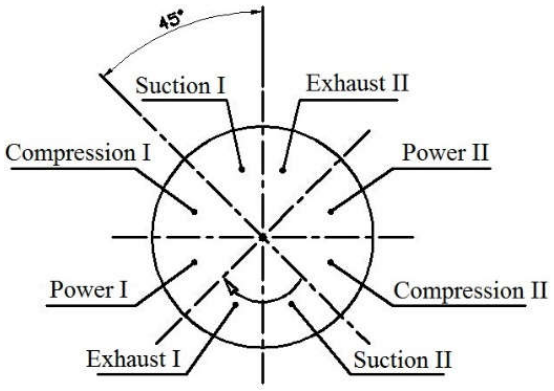

Figure 4. Works Section of the Camshaft Modification

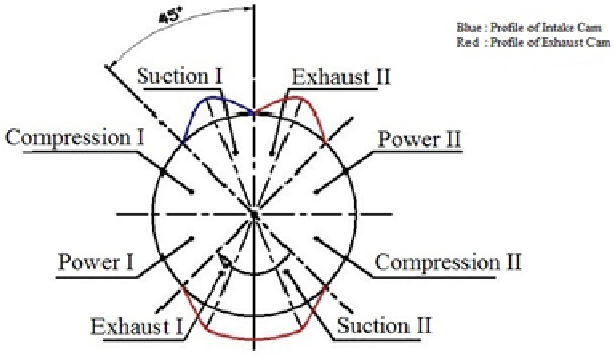

Figure 5. Determine lobes of the Camshaft

Determine Displacement Diagram and Profil of the Camshaft Modification

Function of the displacement diagram is ilustration if will determine start point, lift and end point (valve raised, dwell and valve lowered). At the displacement diagram be ilustrated how to works a follower. Type of displacement diagram which be used in this research is displacement diagram with roller follower and category of the follower motion is follower uniform velocity motion. This type be selected because suitable with experiment object.

Intake lobe

Displacement diagram with roller follower
Be known: Angular displacement = 45°
Valve raised = 20°
Dwell = 5°
Valve lowered = 20°
Stroke = 5 mm
One revolution of cam = 360°

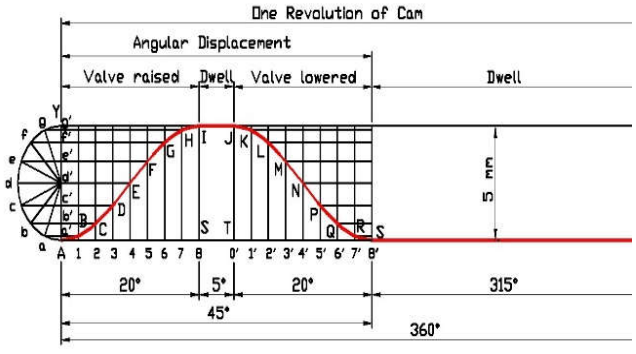

Figure 6. Displacement Diagram of Intake Lobe

ABCDEFGHIJKLMNPQRS: which be shown in figure 6 is displacement diagram of the intake cam profile and then draw profil of the cam.

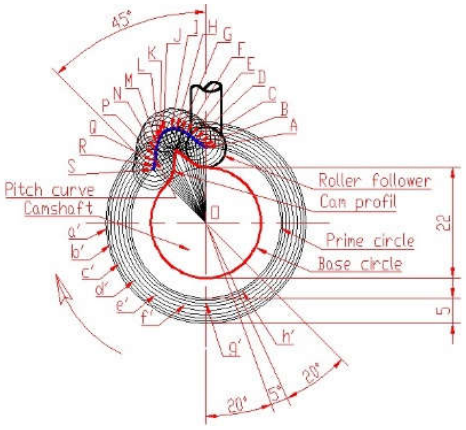

Figure 7. Form of the Intake Lobe (Non Efficiency Volumetric)

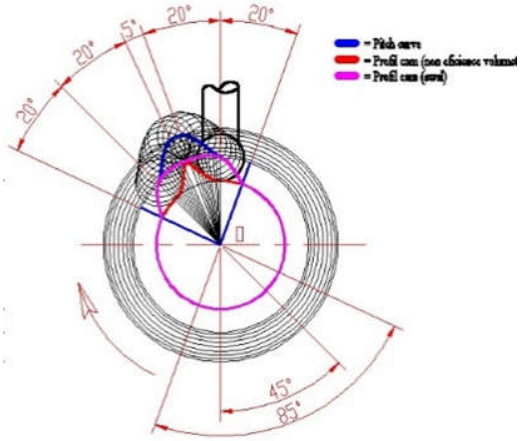

Figure 8. Beginning Profile of the Intake Lobe

Profil above is not considering efficiency volumetric influences, so grinding process at manufacture is not forming like figure 7. Enlargement of the profil be maked with purpose get the profil section for efficiency volumetric influences. Beginning profile as shown in figure 8. At object which be used experiment, position of the rocker arm is not same with Y axis (offset). Position of the rocker arm is assumpted 10° from the Y axis. Rocker arm of intake valve be placed 10° from counter rotation of the camshaft and rocker arm of the exhaust valve be placed 10° same direction with rotation camshaft. So position of the intake cam profile be moved 10° counter of the camshaft rotation (Figur 9).

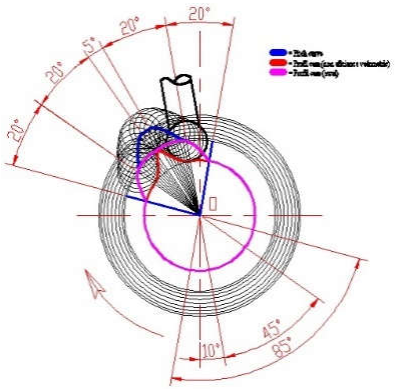

Figure 9. Profile of the Intake Lobe After be Moved

Exhaust Lobe

Exhaust lobe be divided two lobes or two cams. First lobe is $L.ex_1$ and second lobe is $L.ex_2$.
Displacement diagram with roller follower (Figur 10):
Be known: First lobe ($L.ex_1$)
Angular displacement = 90°
Valve raised = 20°
Dwell = 50°
Valve lowered = 20°
Stroke = 4 mm
One revolution of cam = 360°

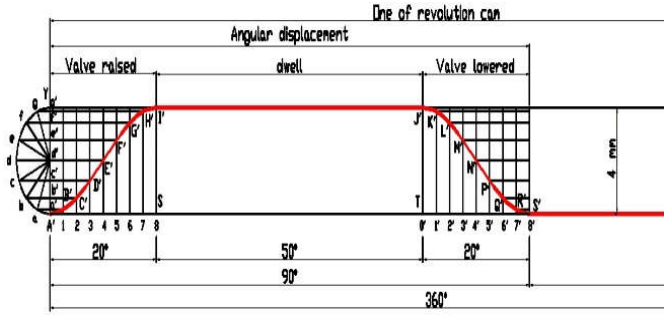

Figure 10. Displacement Diagram of $L.ex_1$

Be known: Second lobe ($L.ex_2$)
Angular displacement = 45°
Valve raised = 20°
Dwell = 5°
Valve lowered = 20°
Stroke = 5 mm
One revolution of cam = 360°
Shown in Figure 11.

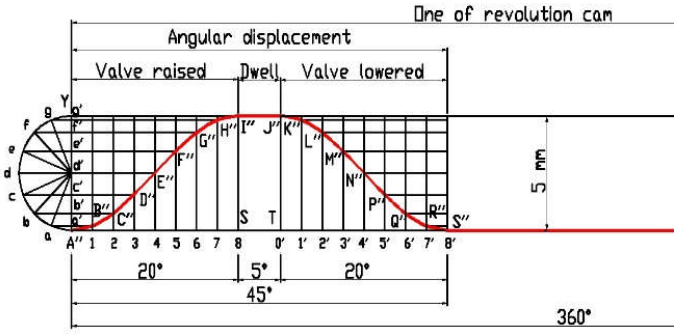

Figure 11. Displacement Diagram of $L.ex_2$

Neither intake rocker arm nor exhaust rocker arm same with Y axis, so be gotten calculation:

Intake Lobe ($L.in$)

$L.in$ moving angle = Distance angle from the Y axis
= 10°

First Exhaust Lobe ($L.ex_1$)

$L.ex_1$ moving angle = $L.in$ moving angle + Angle of the intake and exhaust rocker arm
= 10° + 20°
= 30°

Second Exhaust Lobe ($L.ex_2$)

$L.ex_2$ moving angle = $L.ex_1$ moving angle = 30°

So be gotten overall displacement diagram of the camshaft modification that is intake lobe ($L.in$), first exhaust lobe ($L.ex_1$) and second exhaust lobe ($L.ex_2$) which be shown in figure 12.

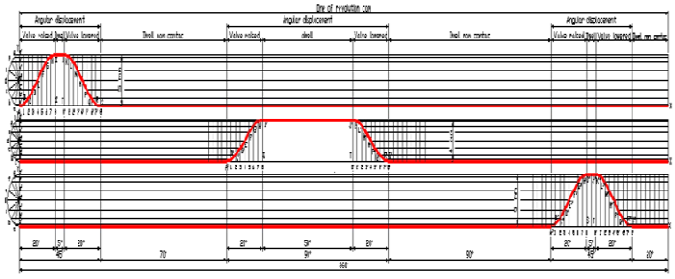

Figure 12. Displacement Diagram $L.in$ (left), $L.ex_1$ (center) and $L.ex_2$ (right)

In figure 12 be gotten lobe separation angle ($L.in$, $L.ex_1$ and $L.ex_2$) then we can determine first exhaust lobe ($L.ex_1$) with be oriaentated from lobe intake ($L.in$) position. Then be rotated 135° until section of first exhaust lobe ($L.ex_1$) touches the exhaust rocker arm. So have formed all profil of the camshaft modification which be shown in figure 13.

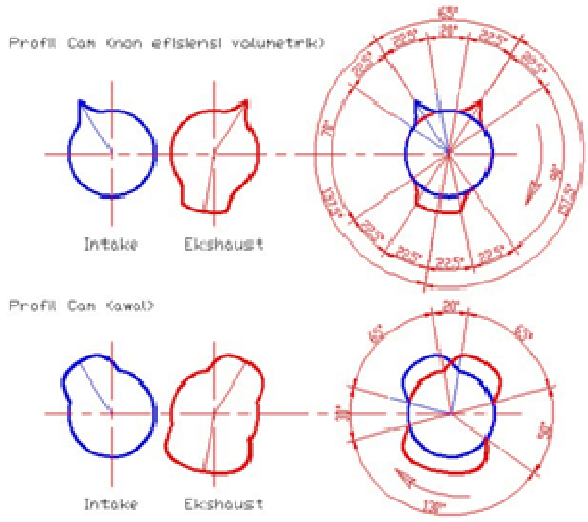

Figure 13. Profile of Camshaft Modification

Result of Camshaft Modification Design

From calculation and simulation above be gotten design of camshaft modification which be shown in figure 14 and figure 15.

Conclusion

After trial process, engine with modification otto cycle can be operated suitable with otto cycle modification concept. Operation of engine range 1500- 3400 rpm with fuel consumption of engine is 0,55 liter/hours at 3400 rpm. Finally research otto cycle modification means success. Hope this research can be developed to be increasing performance and efficiency about application this concept.

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