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Research Article

Replacement of Cam shaft by Rack and Pinion Mechanism for Variable Valve Timing

Tejaswini Kumbharde*, **Shubham Bhadane, Koustubh Deshmukh and Samata Mujumdar**

Mechanical Engineering Department, MITCOE, Pune, India

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Abstract

The valve timing is a closely studied process and affects the performance of an IC Engine greatly with respect to the emission, volumetric efficiency and brake power produced. If the valve positions with timing are varied, it results in higher efficiencies and overall performance of the engine is improved. Because of this, various modifications are attempted in valve timing and many variable valve timing systems have been proposed. Nowadays, most modern engines are equipped with variable valve timing. By various case studies, it has been found that there is no single system which simultaneously can control valve lift and timing in an IC Engine. Thus, researchers thought and designed a single system which is capable of both the valve lift and timing independently. A rack and pinion mechanism controlled by a programmed servo motor mounted vertically is most practical in achieving this within the size and space. A single cylinder diesel engine was simulated with a software 'Lotus Engine Simulation' to derive the optimum valve angles and lifts for a range of the engine operating speed and the system was accordingly programmed and designed. The system was designed in Autodesk Fusion 360 software and analyzed in ANSYS.

Keywords: *The valve timing, Performance of an IC Engine etc.*

1. Introduction

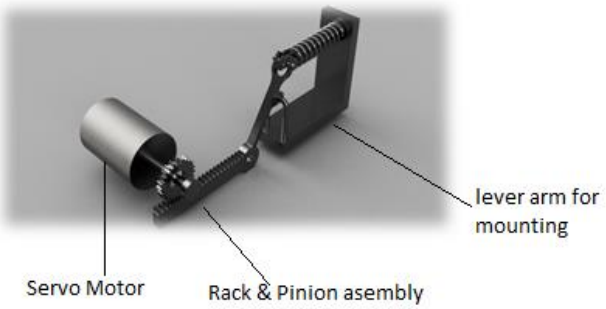
In an IC Engine, valve timing is the process of opening and closing of inlet and exhaust valves. It is denoted in terms of the crank angle at which the process occurs with respect to the BDC and TDC positions. The opening and closing of valves is very important process and effects on engine performance very greatly. Valve timing, lift and duration setting are quite different in case of low speed and high speed engines. Any optimal setting accordingly would cause lesser amount of Air and fuel at high speeds resulting in loss of power output. Similarly, any setting for high speeds would result in difficult idling and very rough engine performance at low speeds. Thus most cars use a setting which is in the mid-Engine speed range thus compromising on the low and high speed ends vehicle performance. Thus there is a need for a Variable type of valve timing setting which would not compromise on the Engine performance over the spectrum. Variable Valve timing (VVT) is the event of altering the valve timing and lift and is thus used to improve performance, fuel economy and emissions. This can be achieved in many ways from mechanical devices to electro-hydro camless systems. Due to increasingly strict emissions regulations, many automotive manufacturers are using VVT systems and treatments quality. But its use is still limited to high-end automobiles due to its cost.

*Corresponding author: **Tejaswini Kumbharde**

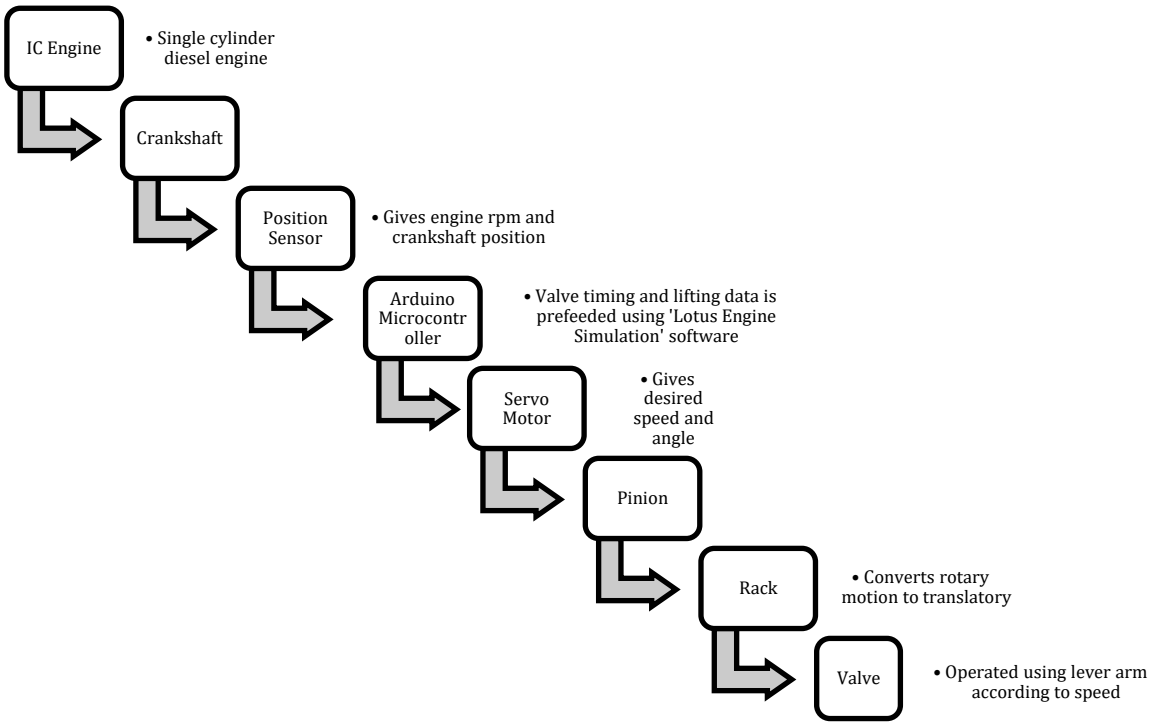
2. Model

As shown in the Fusion 360 model below. It consists of a Servo motor connected to a Rack and Pinion arrangement which is in turn connected to the lever arm of the Valve Arrangement

The crankshaft position sensor gives input data of the current engine rpm and the crankshaft position (degrees) as input to the Arduino microcontroller of the servo motor.



Thus depending on the Engine speed the micro controller chooses the correct valve actuation timing and lift and with crank position input(degrees) from the crankshaft position sensor, rotates the servo motor at the required time for the desired amount of angle. As the rack is connected to the lever arm it thus causes a differential actuation of the valve depending upon the amount moved by the Rack.



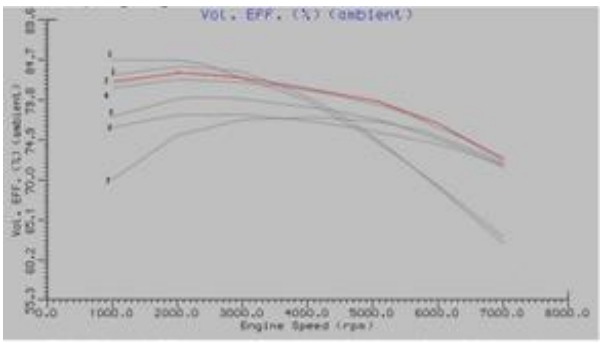
3. Methodology

1) First, A Model of the system was made for better understanding and conceptualization using FUSION 360 Software.
2) A single cylinder diesel engine is selected for the experiment due to its single cylinder nature and simple cylinder head making the mounting of the system simple and feasible. All the dimensions and parameters needed for designing of the system like the current Valve timing diagram, valve throat dimensions, cylinder dimensions etc. were measured or obtained from the Engine manual and thus here we show the method we adopted for fabrication.
3) Lotus Engine Simulation for the abovementioned Engine was performed and all the required performance characteristics of the Engine found out.
4) Using the parametric option of the Lotus software, a variable valve timing experiment was carried out in which, keeping all the other parameters constant, the valve opening and closing times and the Valve Lift were varied for a range of Engine rpms and the corresponding change in the Volumetric efficiency noted. Then the valve opening, closing and Lift Values which provided the maximum volumetric efficiency for each rpm were selected and the corresponding graphs were plotted.

Servo Motor Rotation Angle calculations

Sr. No	Speed	Lift(mm)	Servo rotation(degrees)
1	1000	7	16
2	2000	8	18
3	3000	9	20
4	4000	10	23
5	5000	11	25
6	6000	12	27
7	7000	13	30

Graph No.	Speed	IVO(TDC)(°)	IVC(BDC)(°)	Lift(mm)	η_{vol}
1	1000	0	0	6	84.5%
2	2000	0	0	7	84.5%
3	3000	10	15	8	83.5%
4	4000	20	25	9	82%
5	5000	20	35	10	79%
6	6000	25	45	11	77.5%
7	7000	25	45	12	73.5%



Conclusion

- It was evident from the research by A.H. Khakee and M. Pishgooie in their paper Determination of optimal valve timing for internal combustion engines using parameter estimation method [1]

that the variation of engine performance is less affected by the exhaust valve timing than the inlet valve timing. Thus the fulcrum of design synthesis and simulation and the eventual mounting on the engine is based on varying the inlet valve timing event for the sake of simplicity and convenience. But the system can be advanced further to vary both the Inlet and Exhaust Valve Timings by accommodating specific gear train for the exhaust valve variation.

- Thus the system can be used to alter the Timing, Duration as well as the Lift of a valve event, all the three independently of each other, something which has never been achieved till date.
- As shown in the design, a rack of around 50mm length and a pinion of diameter 40mm can be easily used to serve the purpose. Including the servo motor the overall space required for mounting the system is around 100mm×50mm×70 mm which can be easily accommodated in the cylinder head itself or nearby and is quite expendable for the improvement in Efficiency achieved. Also by using special purpose brushless motors and precision helical gears the system can be made even more compact.

References

H. Kakaee and M. Pishgooie, Iran University of Science and technology, Determination of optimal valve timing for internal combustion engines using parameter estimation method, International Journal of Automotive Engineering.

Osama H.M. Ghazal, Mohammad S.H. Dado, Gear Drive Mechanism for Continuous valve timing of IC Engines. Scientific Research Journal, Paper No-245- 250

Chun Tai, Tsu-Chin Tsao, Control of an Electromechanical Actuator for Camless Engines SAE paper-780413

Osama H. M. Ghazal, Yousef S. H. Najjar, Kutaeba J. M. Al-Khishali, University of Jordan, 'Modeling the Effect of Variable Timing of the Exhaust Valves on SI Engine Emissions for Greener Vehicles', Scientific Research Journal, Paper No- 2013, 5, 181- 189. http://dx.doi.org/10.4236/epe.2013.53018

Chihaya Sugimoto, Hisao Sakai, Atsushi Umemoto, Yasuo Shimizu and Hidetaka Ozawa, Honda R&D international Ltd. 'Study on Variable Valve Timing System Using electromagnetic mechanism', SAE paper- 2004-01-1869

G.SureshPatil, Dr. B. Anjaneya Prasad, An Investigation of Variable Valve Timing application for controlling the HCCI Combustion. International Journal of Engineering Research & Applications(IJERA) ISSN:2248-9622

C. Gray, A Review of Variable Engine Valve Timing, SAE Technical Paper No. 880386, 1988.

T. Dresner and P. Barkan, A Review and Classification of Variable Valve Timing Mechanisms, SAE Paper, No. 890667, 1989

Manipal Institue of Technology, Dhruv chawda, International journal of engineering research and applicationvol.4, research issue 11(version 1) Nov.2014