IJFEAT
INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

VARIABLE VALVE TIMING SYSTEM –A TECHNOLOGICAL REVIEW

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Abstract
To fulfil the customers requirement engineers have a great challenge to design the more efficient and low fuel consumption engine. In normal engine at low rpm engine have specific valve time to open and close the valve. But it observed that at high rpm of engine number of valve lifting increases simultaneously valve opening time decreases and effect of this, the low supply of air and fuel from inlet valve and less exhaust is emitted outside due to this the efficiency of engine is decreases. To overcome this problem engineer change valve timing at high rpm and it get sufficient time for suction the air and fuel and exhaust the burn gases. This technology is known as VVT technology that is Variable Valve Timing technology.
This paper is summaries the various technologies to change valve timing and controlling system of VVT technology.
Keywords: *Variable valve timing, Spark ignition engine, Engine Performance, Valve lift.*
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1. Introduction

Valves are use to control the flow of intake and exhaust gases in and out of the combustion chamber. Valve lift and time duration has play an important role in engine performance. Valve lift is sufficient when engine rotate at moderate rpm. And when rpm of engine is high then the valve lift time is decreases and the total amount of exhaust gas is not release from piston head and some of burn gas is traps in piston head. And its effect is it emits the NOX in large amount. And it also affects the engine performance at high speed. Although the valve timing is fixed in normal engine. we can understand that from following graph,

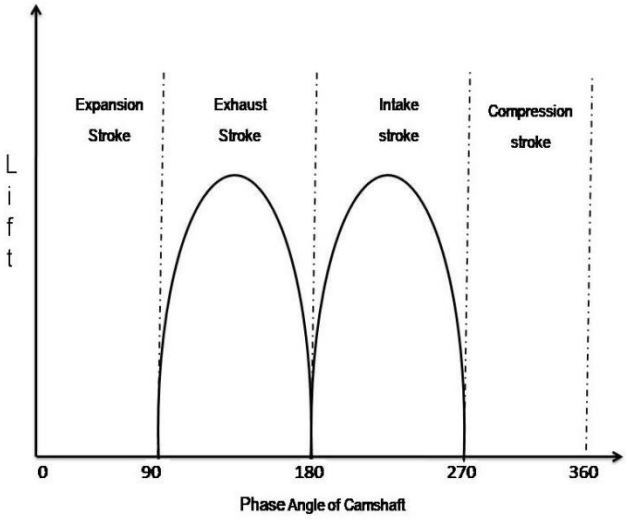

Fig-1.1: Normal Valve timing

To overcome this problem we have to vary time of valve lift at suitable time. This can be understood from following graph,

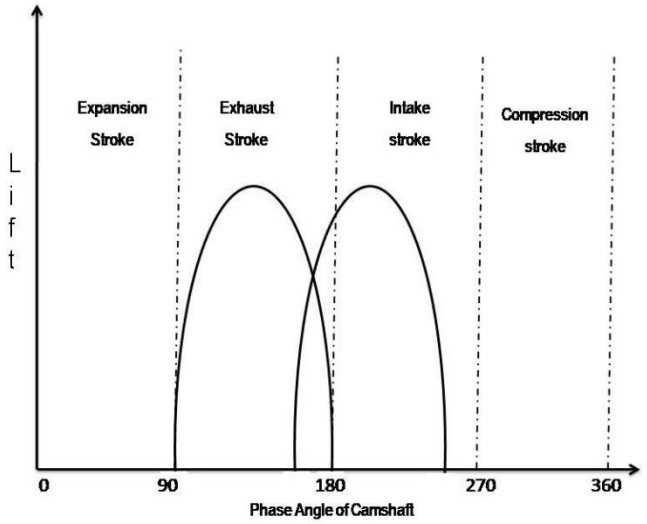

Fig-1.2: High Speed Valve Timing

Firstly in experiment 200 hp claret V-8 from the 1910s used a sliding camshaft to change valve timing. Some radial engine of the early 1920s incorporates variable valve timing in connecting with high compression ratio. In automobile to improve the engine and vehicle performance there is little need of variable valve duration. In 1958 Porsche made application for a German Patent, also applied for and published as British Patent GB861369 in 1959. The Porsche patent used an oscillating cam to increase the valve duration and lift. The desmodromic cam driven via a push/pull rod from an eccentric shaft or swashplate. It is unknown if any working prototype was ever made. Fiat was the first auto manufacturer to patent a functional automotive variable valve timing system which included variable lift. In 1960s by Giovanni Torrazza, system used hydraulic pressure to vary the fulcrum of the cam followers. The hydraulic pressure changed according to

engine speed and intake pressure. The typical opening variation was 37%.

The variable valve timing system in production cars firstly manufacture by the Alfo Romeo. The fuel injected models of the 1980 Alfa Romeo Spider 2000 had a mechanical VVT system. The system was engineered by Ing Giampaolo Garcea in the 1970s. In 1987 Nissan debuted their electronic variable valve timing technology called NVCS in their DOHC VG20DET and VG30DE engines. In 1989, Honda released the VTEC system. While the earlier Nissan NVCS alters the phasing of the camshaft, VTEC switches to a separate cam profile at high engine rpm to improve peak power. Honda produced the first VTEC engine was the B16A which was installed in the Integra, CRX, and Civic hatchback. In recently in 2017 Suzuki's GSX-R1000 is the first all-out superbike to be seen with variable valve timing. The purely mechanical system that eliminates both the need to be plumbed in to the engine oil system and need for electronic solenoid actuators.

2. LITERATURE REVIEW

2.1 Need of VVT

In engine there is need of cam phasing, cam changing, cam switching to vary phase and time respectively to increase the less NOX's emission, increase fuel efficiency, and less pumping action in cylinder. By changing variable valve timing it can be achieved. And effect of these increase in torque and output of engine.

2.2 Working principle

In engine VVT is the process of altering the timing of a valve lift event and is often use to improve performance fuel economy or emission. In two stroke engine use a power Valve system to gate similar results to VVT.

2.3 Typical effect of timing adjustments

Late intake valve closing is the first variation of continuous variable valve timing involves holding the intake valve open slightly longer than a traditional engine. Late intake valve closing has been shown to reduce pumping losses by 40% during partial load conditions, and to decrease nitric oxide (NOx) emissions by 24%. Peak engine torque showed only a 1% decline, and hydrocarbon emissions were unchanged.

Early intake valve closing is another way to decrease the pumping losses associated with low engine speed, high vacuum conditions is by closing the intake valve earlier than normal. This involves closing the intakes valve midway through the intake stroke. Air and fuel demands are so low at low-load conditions and the work required to fill the cylinder is relatively high, so Early intake valve closing greatly reduces pumping losses. Studies have shown early intake valve closing reduces pumping losses by 40%, and increases fuel economy by 7%. It also reduced nitric oxide emissions by 24% at partial load conditions

Early intake valve opening a process called valve overlap is used to aid in controlling the cylinder temperature. By opening the intake valve early, some of the inert/combusted exhaust gas will back flow out of the cylinder, via the intake valve, where it cools momentarily in the intake manifold. This inert gas then fills the cylinder in the subsequent intake stroke, which aids in controlling the temperature of the cylinder and nitric oxide emissions.

Early or late exhaust valve closing can also reduce emissions. Traditionally, the exhaust valve opens, and exhaust gas is pushed out of the cylinder and into the exhaust manifold by the piston as it travels upward. By managing the timing of the exhaust valve engineers can control how much exhaust gas is left in the cylinder. By holding the exhaust valve open slightly longer, the cylinder is emptied more and ready to be filled with a maximum air and fuel charge on the intake stroke.

2.4 TYPES OF VVT

2.4.1 Cam phasing

From the camshaft position sensor, crankshaft sensor, oil temperature sensor, mass air flow sensor, and the engine coolant temperature sensor, ECU receives signal and apply the information to adjust its output signal to an oil control valve. This valve acts as a hydraulic actuator and rotating a rotor (which is connected to the camshaft) inside a housing, which is connected to the crankshaft via a timing chain. Once the ECU has been changed the cam phase angle, the ECU continues to receive inputs from all of the sensors and continually adjusts the oil feed to the rotor. Like electronic throttle control, this is a closed loop system, which means that the difference between the current camshaft phase angle and the optimal camshaft angle is the "error signal" that is sent to the ECU.

2.4.2 Cam changing

Two sets of cams having different shapes to approve different timing and lift. One set operates during normal speed, below 4,500 R.P.M., the other set substitutes at higher speeds. Such layout does not allow continuous change of timing, therefore the engine performs modestly below 4,500 R.P.M. but above that it will suddenly transform into a wild animal.

2.4.3 Cam switching

This method uses two cam profiles; with an actuator to swap between the Cam switching can also provide variable valve lift and variable duration; however the adjustment is discrete rather than continuous.

2.4.4 Oscillating cam

These systems use an oscillating or rocking motion in a part cam lobe, which acts on a follower. Valve open and closes by this follower. A few oscillating cam systems use a conventional cam lobe, while others use an eccentric cam lobe and a connecting rod. The principle is similar to steam engines, where the amount of steam entering the cylinder was regulated by the steam "cut-off" point.

2.4.5 Eccentric cam drive

This system operates through an eccentric disc mechanism which slows and speeds up the angular speed of the cam lobe during its rotation. Arranging the lobe to slow during its open period is equal to lengthening its duration.

2.4.6 Three-dimensional cam lobe

This system consists of a cam lobe that varies with respect to its length (similar to a cone shape). One end of the cam

lobe has a small span and reduced lift profile and the other end has a longer duration and greater lift profile. In between, the lobe gives a smooth transition between both two profiles. By shifting area of the cam lobe which is in contact with the follower, the lift and span can be simultaneously altered. This can achieve by moving the camshaft axially and sliding it across the engine so a stationary follower is exposed to a varying lobe profile to produce different amounts of lift and span

2.4.7 Two shaft combined cam lobe profile

It consists of two closely spaced parallel camshafts, with a pivoting follower that separates both camshafts and is acted on by two lobes alternately. Each camshaft to be adjusted by phasing mechanism which allows it angular position. One lobe controls the opening of a valve and the other controls the closing of the same valve, because of opening and closing variable duration is archived.

2.4.8 Coaxial two shaft combined cam lobe profile

The principle is that the one follower spans the pair of closely spaced lobes. Up to the angular limit of the nose radius the follower 'sees' the combined surface of the two lobes as a continuous, smooth surface. When the lobes are exactly aligned the duration is at and when at the extreme extent of their misalignment the duration is at maximum crankshaft degrees.

2.4.9 Helical camshaft

Also known as "Combined two shaft coaxial combined profile with helical movement", this system is not known to be used in any production engines. It has a same principle to the previous type, and can use the same base duration lobe profile. However instead of rotation in a single plane, the adjustment is both axial and rotational giving a helical aspect to its movement.

2.4.10 Camless engines

The camless or free valve piston engine has poppet valves operated by means of pneumatic actuators, electromagnetic or hydraulic, instead of cams. Actuators can be used to open and close valves, or to open valves closed by springs.

2.4.11 Variable lift system

The main advantage of system is reduce the pumping losses due to convectional throttle however these are still under development.

Table No.1: Various Automobile companies using various types of VVT

SL.	Acronym	Full Form	Company	Year
1	**VVT**	Variable Valve Timing	**Fiat**	1960
2	**VVT**	Variable Valve Timing	**Volkswagen**	1980
3	**N-VCT**	Nissan-Variable Cam Timing	**Nissan**	1987
4	**i-VTEC**	Intelligent - Variable Valve Timing and Lift Electronic Control	**Honda, Acura**	1989
5	**MIVEC**	Mitsubishi Innovative Valve timing Electronic Control	**Mitsubishi**	1992
6	**VANOS**	Variable Nockenwellensteuerung	**BMW**	1992
7	**VarioCam**	---	**Porshe**	1992
8	**Camtronic**	---	**Mercedes Benz**	1994
9	**DCVCP**	Dual Continuous Variable Cam Phasing	**GM**	1996
10	**VVTi**	Variable Valve Timing (intelligent)	**Toyota**	1998
11	**VCT**	Variable Cam Timing	**Ford**	1998
12	**S-VT**	Sequential Valve Timing	**Mazda**	1998
13	**VVT**	Variable Valve Timing	**Suzuki**	2000
14	**CVVT**	Continuous Variable Valve Timing	**Renault**	2003
15	**CVVT**	Continuous Variable Valve Timing	**Volvo**	2003
16	**Valvelift**	---	**Audi**	2006
17	**VTVT**	Variable Timing and Valve Train	**Hyundai**	2008

According to p. Blair Shelton he give a review paper on VVT in may 2008 university of arkansas. VVT is play an important role in engine to improve power output and low emission of exhaust gas by using various type of VVT devices. Such as electro hydraulic system, cam less valve timing system and many more.

According to pankaj vig in 18OCTOMBER2016 in his paper he says that all technology like vtvt,VVT,VVT-i,ti-vtc except i-vtec vary only valve timing in accordance with the engine rpm. That is advancing opening of intake valve or providing valve over laps between intake and exhause optimum performance. The i-vtec goes a stape further and it can actually change the valve lift greater flexibility.

Afshari D and Afrabandpey present paper in Journal on Applied of Mechanical Engineering on Effect of Variable Valve Timing to Reduce Specific Fuel Consumption in HD Diesel Engine according to them This paper indicates that average generated torque in VVT mode increased 2% respect to primary ‘OM457’ engine while average of SFC parameter decreased 2.3% and average of nox pollutant decreased 1.6% from 800 to 2000 rpm.

According to, Sabaa H Khudhur, Adel M Saleh, Miqdam T Chaichan in his paper The Effect of Variable Valve Timing on SIE Performance and Emissions at International Journal of Scientific & Engineering Research, Volume6, Issue 8,

August-2015 173 ISSN 2229-5518 IJSER 2015. The recent experimental investigation paper deals with the effect of the overlap period variation by changing the valve timings. The reduction in overlap period at compression ratio shows the better compromises between the overall performances which mean higher Volumetric Efficiency.

In IJERA ISSN: 2248-9622G Suresh Patil publish paper on An Investigation of Variable Valve Timing application for controlling the HCCI Combustion Various studies have shown that the engine which uses variable valve timing allows the reduction of pumping loss, control of internal residual gas recirculation and emissions, along with improvement of performance over a wide range of revolutions per minute.

According to Ajinkya Deshmukh in A REVIEW ON ADVANCED ENGINES TECHNOLOGY in ICRTESM ISBN: 978-81-932073-3-7 he concludes that Downsizing and turbo charging, volt systems makes engine lightweight and powerful. This all new technologies make advanced engine with better fuel economy, reduces our time, cost and dependence on conventional fuels.

According to, Chen Jia-dui in his paper Dynamic Simulation and Experiments of a Novel Variable Valve Timing System at IJMUE, Vol.9, No.7 (2014),pp.383-394,Simulation and experimental results show that the system vary valve timing adjustment by regulating electromagnetic valve closing time according to the engine speed, and the system satisfies the principle of best engine valve timing proposed.

3. CONCLUSION

In this paper a review has been taken that VVT technology plays an important role to increase the engine performance and low NOXs emission. And increase in power output and torque of vehicle .Also it is found that the main problem in this system is only the cam changing or phase changing with respect to rpm of the engine, but if this both system combines together and the continuously variable valve timing system is develops due to this we can change both time and phase with respect to engine rpm. VVT system still not fully developed. Automobile manufacturers are very active towards improving CVVT technology.

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