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THOMSON REUTERS
[NC-Rase 18] ISSN 2348 – 8034
DOI: 10.5281/zenodo.1494006 Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

REVIEW PAPER ON VARIABLE VALVE TIMING

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ABSTRACT

VARIABLE VALVE TIMING is one of the most important aspects of consideration in the design of an automobile engine. In general variable valve timing is the regulation or timing of opening or closing of the valves. It may be also defined as it is the way an engine 'breathes'. In an I.C.engine, generally the inlet valves open a few degrees (of crank angle) prior to TDC, and then close after BDC. Similarly, exhaust valves can be opened a few degrees before BDC and closed a few degrees after TDC. The most of the engines around the world utilized ordinary or static VT, where the parameters of valve opening, lift, and closing (VO, VL and VC) were fixed. This was satisfactory at normal engine speeds, but faced problems at high and low speeds. For example, at high engine speeds, the engine requires greater amounts of air. This, though beneficial at high speeds, would be a threat at low speeds as it may lead to exhaust of unburnt fuel, which results in fuel wastage, increased emissions and lower performance. The timing of the valves is not fixed, but varies, as per the demands of the situations. Therefore, extra demands of the engine can be met, which in turn, results in improved engine performance.

I. INTRODUCTION

Variable valve timing is generic term for automobile piston engine technology. Variable valve timing allows lift of duration or timing of the intake or exhaust vavle are to be change while the engine in operation. Variable valve timing (vvt) is the process of altering the timing of a valve lift and is often used to improve performance, fuel economy or emissions. It is largely being used in combination with variable valve lift systems. There are many different ways in which VVT can be achieved, ranging from mechanical devices to electro-hydraulic and camless systems. valves within an internal combustion engine are used to control the flow of the intake and exhaust gases in and out of the combustion chamber. The timing, duration and lift of these valve events has a great impact on engine performance. Without variable valve timing or variable valve lift, the valve timing is the same for all engine speeds and conditions, therefore adjustments are necessary. Variable valve timing is the regulation of the points in the combustion cycle, at which the valves are set to open and close. Since the valves require a finite period of time in which to open or close without abruptness, a slight lead-time is always necessary for proper operation.a fuel consumption benefit of about 3 to 12% can be achieved. The valves in these engines have a mechanically actuated valve motion fixed with respect to the crankshaft position for almost all operating conditions. These valve motions such as (valve lift profile, valve event, and open duration) are determined during the engine design stage by fixing the cam profile and its position. This procedure gave adequate operation at medium speeds and loads but was not optimized for high or low and idle speeds. The variable valve timing (vvt) is a remarkable technology to attain improvement of fuel economy, output power, and reducing emissions by development of intake and exhaust valves. Various mechanisms have been introduced in the market from the second half of the 1980s and adopted for many automobiles. The addition of variable valve timing (vvt) technology make it possible to control the valve lift, duration, and valve timing. Various types of vvt have been proposed and de-signed to inlet timing enhance the overall engine performance and to get full benefits from this technology inlet valve timing. The intake valve should open, theoretically at tdc, most engines utilise an intake valve opening, which is timed to occur a few degrees preceding to the arrival of the piston at tdc on the exhaust stroke. This is because by the time the valve becomes fully open, the piston would have travelled considerably down the bore, and since the valve would have to be fully closed before bdc, the actual time the valve would be fully open would be minimal. Additionally, the inertia of the incoming mixture plays a vital role. Keeping the inlet valve open after bdc forces more mixture to pack into the cylinder, in spite of that the piston is moving upwards. In exhaust valve timing, the exhaust valve is set to open before bdc, towards the end of the power stroke and close after tdc, at the beginning of the intake stroke. The reason the exhaust valve is opened before bdc is to avoid the exhaust gases from forming a high-pressure cushion, which would block the movement of the piston and rob the engine of power. This also ensures that the valve is fully open at the beginning of the exhaust stroke. It ensures that the exhaust gases rushing out of the cylinder creates suction, in order to draw in fresh mixture, and the fresh mixture entering the cylinder pushes out the burnt fuel mixture. Therefore, valve timing of any engine depends on: the intended usage of the engine.

The amount of valve overlap lag and lead, i.e. the degrees that the crankshaft turns between valve opening and tdc or bdc method & material.

Basic mechanism:-

The vvt, a sensor is used to detect the engine's speed. An electronic system then uses this information to adjust the valve opening and closing timings accordingly. This avoids the problems associated with static valve timing, and also allows for maximum torque at all engine speeds.

Types of vvt mechanisms:-

Cam-phasing vvt:-

Cam-phasing vvt is at present, the simplest, cheapest and most commonly used mechanism. However, its performance gain is also the least. Generally, shifting the phase angle of camshafts varies the valve timing. For example, at high speeds, to enable earlier intake the inlet camshaft will be rotated in advance by 30°. This movement is controlled by an engine management system considering the need and actuated by hydraulic valve gears.

Cam switching:-

This method uses two cam profiles, with an actuator to swap between the lift vs angle diagram (Toyota vvt-i)

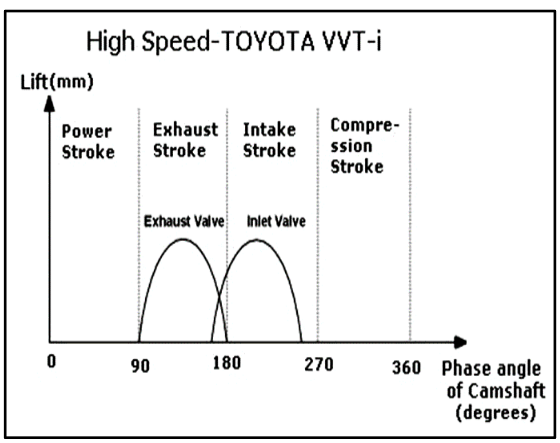

Fig1: lift vs phase angle diagram (toyota vvt-i)

Cam Phasing:-

Many production vvt systems are of cam phasing type, using a device known as a variator. This allows endless adjustment of the cam timing (although many early systems only used discrete adjustment), however the duration and lift cannot be adjusted.

ISSN 2348 – 8034
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Oscillating cam:-

These designs use an oscillating or rocking motion in a part cam lobe,[clarification needed] which acts on a follower. This follower then opens and closes the valve. Some of the oscillating cam systems use a conventional cam lobe, while the others use an eccentric cam lobe and a connecting rod. The principle is identical to steam engines, where the amount of steam entering the cylinder was regulated by the steam "cut-off" point.

Working

In contrast to the fixed valve timing of conventional engines, the variable valve timing system is a computer controlled mechanism that continously varies the opening and closing timing for the intake valves in accordance with the vehicle's operating conditions.

The Variable Valve timing system is designed to control the intake camshaft within a range of 50°(of Crankshaft Angle) to provide valve timing i.e. best suited for the engine condition .This improvises the torque for all the speed ranges as well as fuel economy and minimising exhaust emissions.

This system controls the intake camshaft valve timing so as to obtain balance between the engine output, fuel consumption & emission control performance. The actual intake side valve timing is feed backed by means of the camshaft position sensor for having constant control to the target valve timing.

The Variable Valve Timing system comprises of the engine control module, oil control valve and Variable Valve Timing controller. The engine control module forwards a target duty-cycle control signal to the oil control valve. This control signal then regulates the oil pressure supplied to the Variable Valve Timing controller. Camshaft timing control is performed according to engine operating conditions such as the intake air volume, throttle valve position and engine coolant temperature. The engine control module based on the signals transmitted by several sensors, controls the oil control valve. The Variable Valve Timing controller regulates the intake camshaft angle using oil pressure over the oil control valve. As a result, the relative positions of the camshaft and crankshaft are enhanced, the engine torque and fuel economy improve, and the exhaust emissions decrease under overall driving conditions. The engine control module finds the actual intake valve timing using signals from the camshaft and crankshaft position sensors, and performs feedback control. The target intake valve timing is verified in this way by the engine control module.

ISSN 2348 – 8034
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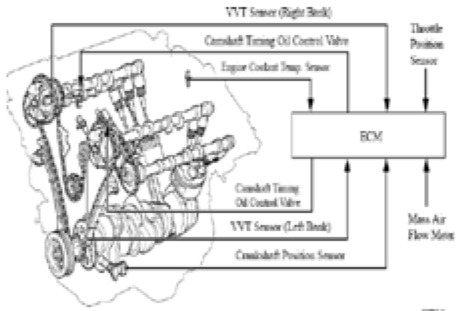

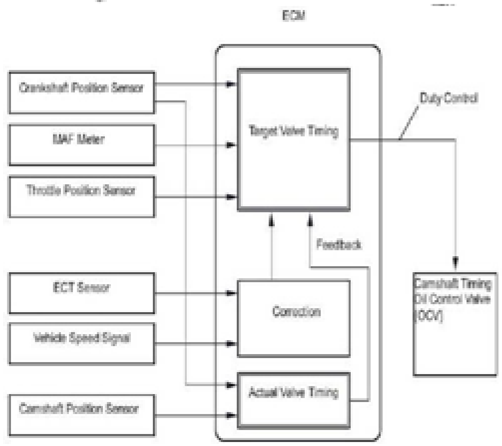

The engine control module enhances the valve timing using the Variable Valve timing system to control the intake camshaft. The Variable Valve Timing system comprises of the engine control module, the oil control valve and the Variable Valve Timing controller. The engine control module sends a target duty-cycle control signal to the oil control valve. This control signal regulates the oil pressure supplied to the Variable Valve Timing controller. The Variable Valve Timing controller is able to advance or retard the intake camshaft. After the engine control module sends the target duty- cycle signal to the oil control valve, the engine control module monitors the oil control valve current to establish an actual duty-cycle. The engine control module determines the existence of a fault and sets the DTC when the actual duty-cycle ratio varies from the target duty-cycle ratio.

II. HISTORY

- A patent was issued in 1899 that addressed the controlling of valves independently in engines (Gould et al., 1991). The author realized that to control each valve seperately would result in a wider power band. In late 1920, Automotive Industries published an article about a variable volume, variable valve timing engine. During the time, a barrel of oil had increased from $10 in 1915 to $27 in 1920 and fuel efficiency was the main issue. To vary the compression ratio of the cylinder the could raise or lower the crankshaft. This was attained by the flow of oil to a hydraulic piston which was controlled by a pump driven by the crankshaft. Importance to this paper is the ability of the cams on the camshaft to slide and change the closing points of the valves. The only time the intake valves were timed independently was through the compression stroke, therefore changing the compression pressure (Automotive Industries, 1920). The pressure could be regulated from ninety lb to fifty eight lb from startup speed to 2000rpm, respectively. The reason for the valve timing variations according to Charles Salisbury, the inventor, was to increase the volumetric efficiency at lower engine speeds (11% to be specific). In actual tests of the engine fitted in a car, increase of 21% and 36% were seen in fuel economy at 8 and 22 miles per hour, respectively (Automotive Industries, 1920).
- In 1933, a test rig was developed for aircraft engines that could vary the valve lift, opening and phase while the engine was being operated (Aircraft Engineering). The main objective was to enhance the output of the engine. This was one of the first engines which utilised dual cams for controlling the intake and the exhaust valves and

was also had an overhead setup therefore being one of the first dual overhead cam engines (DOHC). It was suited to be changed while running but all the controls were manually adjusted by hand. For the valve lift, a small cam A lifts a lever B, which then lifts up a slider that in turn lifts a rocker C and changes the valve lift amount. The slider was controlled by a handle that can be manually operated .This was a step in the direction of current VVT configurations, based on the fact that it could be used while the engine was running, but required a manual input that would eventually be replaced by an electronic control.

- In the 1960s, pollution began to be a major issue and the main reasoning for research into VVT was to reduce hydrocarbon and carbon monoxide emissions. In a paper by Hagen et al. (1962), he showed that emissions were highest with lower engine speeds but that at high engine speeds, the increase in airflow can also attribute to an increase in pollutants. He also discussed that the high amount of pollutants are produced at idle and deceleration and conducted experiment with the valve overlap. By decreasing overlap, it was reasoned that the fuel-air mixture would be of a higher quality and therefore the hydrocarbon concentration would be smaller. This assumption was only correct for a certain range of air-fuel ratios, but for the air-fuel operating range of the carburetor (10-12) the reduction in overlap actually increased the concentration of hydrocarbons (Hagen et al., 1962). Past a ratio of 15, the decreased overlap helps with the hydrocarbon problem, but was shown to make little difference in carbon monoxide concentrations. This was further shown in Freeman et al. (1972). The engine used in Hagen's paper had mechanical valve lifters that not only adjusted valve overlap, but also controlled each valves' amount of time open. This could have had an effect on the results and, therefore, these results should be taken suspiciously. Freeman's paper focused more on the elimination of nitrous oxides, something that the Hagen paper never mentioned. Using an apparatus that could vary the camshaft timing based on oil flow in the solenoid, the timing was retarded or advanced at conditions other than idle or wide open throttled. The controls were not fully automatic but the design was one that would eventually reach a level of automation.
- Schiele et al. (1974) published a paper describing the design of a camshaft that would change the timing of the intake valves relative to the exhaust valves. This design used a camshaft with movable pieces. The intake cams could slide on the axis of rotation and would rotate so as to change the timing. The exhaust valves would be unaffected due to the interior design of the cams (Schiele et al., 1974). In the engine setup, using a 350 CID V8, the new cam was fit into the space left empty by the stock one (Schiele et al., 1974). Each camshaft have had five independent cams fit onto a driveshaft and was hydraulically operated. In the reliability test, the timing of the intake cam was continously changed between 0 and 40 degree. The results of these schemes were documented. At high rpms, as can be expected, the timing indeed hurt the power and torque outputs. At lower rpms, the advances slightly improved torque and did not affect power.As far as emissions are involved, these tests showed that NOx quantities were greatly reduced but HC and CO were mostly unaffected. The high air fuel ratio (13:1) attained during advanced intake timing attributed to a slight increase in the HC and CO emissions and was a main factor in decreasing NOx concentrations.

III. ADVANTAGE

1. Better rpm strength – the main advantage of having a variable valve timing technology is the increase it will provide in your engine's revolutions per minute.
2. Better fuel economy – engine efficiency has a lot to do with the timing of the exhaust valve and intake valve.
3. This increased engine lifespan – if you continue to maintain an efficient and high performing engine, then you can expect to get a great number of years out of it.
4. Lower carbon emissions – any time your engine provides a better fuel economy, you will see reduced carbon emissions too.

IV. CONCLUSION

Variable valve timing has grown as technical availability has increased. The need for more even efficient clean powerful engine has pushed the bar higher within production automotive engine. Within a only few year, many of the problems have been saved within this new exciting field.

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If exhaust valve closed early not all gasses are going to escape and some of the gas will remains as it is when the intake stroke happens and this is also called egr if the exhaust valve is closed late all of the gases will escape and you will get a clean cylinder to be filled with air fuel mixture and will get good power if opened early some of the firepower escape through it and will charge the turbocharger when it turbo lag.

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