DESIGN AND TIMING ANALYSIS OF VARIABLE VALVE TIMING (VVT) FOR INTERNAL COMBUSTION ENGINE

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"I hereby to declare that the work is my own except for summaries and quotations which have been duly acknowledged "

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Date : ………………………………

Dedicate to my family, my friends and all compatriots.

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Alhamdulillah, thanks to God because with His blessing, I can finish this project with successful. I would like to express my gratitude and appreciate to my PSM supervisor, Mr. Herdy Rusnandi because he gives many valuable suggestion and advice throughout the project. He also help in obtaining the reference and read through the manuscript of this report.

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ABSTRACT

This project is focusing about design and analysis variable valve timing (VVT) mechanism for spark ignition engine. This VVT mechanism will be applied to Proton Wira 1.6 L with 4G92 SOCH engine as a car model to develop which does not have VVT system yet. VVT is a system which that allows for more varying time at which valve open, duration and valve overlap period. Design of this VVT system is based on three parameters which are the configuration, dimension and complexity of the engine. The timing analysis wil be done to get the suitable mechanism for this system.

ABSTRAK

Projek ini memfokuskan tentang rekabentuk dan analisis mekanisma VVT untuk enjin S.I. Mekanisma VVT ini akan di masukkan pada Proton Wira 1.6 L yang menggunakan enjin 4G92 SOHC sebagai model kerata yang ingin dibangunkan. Sistem VVT ini membenarkan masa untuk bukaan dan tutupan injap masukan berubah-ubah mengikut kesesuaian kelajuan enjin. Rekabentuk system VVT ini adalah dengan mengambil kira konfigurasi, dimensi dan kerumitan sesuatu enjin. Analisis masa akan dilakukan untuk menentukan masa dan tempoh yang sesuai dengan mekanisma VVT.

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CHAPTER 1

INTRODUCTION

Nowadays, technology in automotive was blooming. Many automotive manufacturer produce may invention to conquer the market. These inventions are including producing the engine. Many consumer want cars with low capacity engine but have high performance and low fuel consumptions. As example, VVT (Variable Valve Timing) can give the small engine the high performance.

Variable valve timing is a system that allows for more efficient engine operation by varying the time at which valves opens, duration of opening, and valve overlap period. Some manufacturer called this mechanism in various name such as VVT-i, i-Vtec, Mivec, VTC, CVVT and others. Common camshaft was designed with the tolerance between low RPM for better fuel economy and high RPM for better performance.

When we increase the rpm, this configuration for the camshaft does not work well. If the engine is running at 4,000 rpm, the valves are opening and closing 2,000 times every minute. When the intake valve opens right at the top of the intake stroke, it turns out that the piston has a lot of trouble getting the air moving into the cylinder in the short time. Therefore, at higher rpm ranges we want the intake valve to open prior to the intake stroke, so that by the time the piston starts moving downward in the intake stroke, the valve is open and air moves freely into the cylinder during the entire intake stroke.

For maximum engine performance at low engine speeds, the valves need to open longer and close differently than they do at higher engine speeds.

So, VVT engine have an ability to vary the valve timing and opening duration in both low and high speed operation. New technology such as i-Vtec mechanism allow camshaft to operate at best performance on any speed.

Example car use VVT engine

- BMW - Valvetronic
- Honda - i-VTEC
- Mitsubishi - MIVEC
- Proton - Campro CPS
- Toyota - VVT-i
- Daihatsu - DVVT

1.1 Project Overview

This project is about to design the new variable valve timing (VVT) system which wants to applied for internal combustion engine. The design must be suitable for spark ignition(S.I) engine.

To design this VVT, the mechanisms must be design first. To design this mechanism, all of aspect must be known to ensure mechanisms can be applied to the system.

Beside that to design this system, all the calculation for the mechanism must be calculate to get the theoretical result and the graphs.

1.2 Problem statement

In Malaysia, Proton Wira is the most seller car. It maybe this car is cheap and comfortable. But according to fuel consumption and power, it left out compare to other similar car because this car is using more fuel and its power is lower.

The factor of this problem is this car used regular engine with old technology. Now, almost of new car used the new technology such as turbocharged, VVT, hybrid and others. This technology will give the car's engine more energy in performance and used low fuel consumption.

Now, Proton Wira must use the new engine to walk together with other cars. The engine must more powerful with low consumption like VVT system. VVT can be applied at Proton Wira engine because that engine is based on Mitsubishi engine (4G92). Now Mitsubishi have Mivec which is one of VVT type system.

With VVT in Proton Wira, Proton Berhad which is the manufacturer of this car can be advance and able to compete with other car manufacturer in worldwide market.

1.3 Objective of Project

The main objective of this study is:

- To design and timing analysis VVT mechanism for Spark Ignition Engine (SI engine).

1.4 Scope of Project

The scopes of this project generally involve the following:

- Analyze the valve timing
- Conceptual design for 4 stroke engine passenger car with SI engine.
- Drawing VVT mechanism with CAD software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of VVT

Variable valve timing (VVT) is a generic term for an automobile piston engine technology. VVT allows the lift or duration or timing of the intake or exhaust valves to be changed while the engine is in operation. Two-stroke engines use a power valve system to get similar results to VVT.

Piston engines normally use poppet valves for intake and exhaust. These are driven by cams on a camshaft. The cams open the valves for a certain amount of time during each intake and exhaust cycle. The timing of the valve opening and closing is also important. The camshaft is driven by the crankshaft through timing belts, gears or chains. The profile, position and shape of the cam lobes on the shaft, is optimized for a certain engine rpm, and this tradeoff normally limits low-end torque or high-end power. VVT allows the cam profile to change, which results in greater efficiency and power.

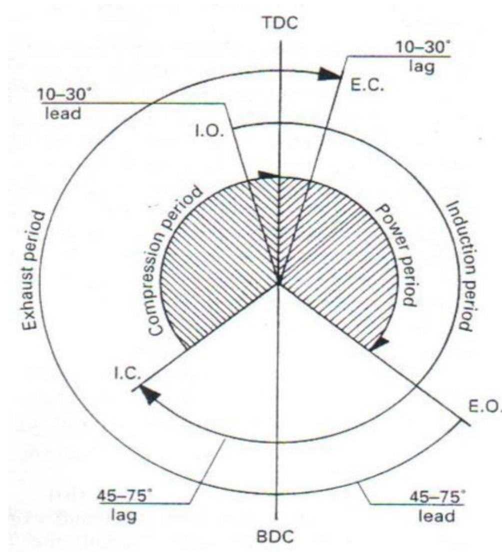

Figure 2.1: VVT diagram (Source: Ed. M, (2000))

At high engine speeds, an engine requires large amounts of air. However, the intake valves may close before all the air has been given a chance to flow in, reducing performance. On the other hand, if the cam keeps the valves open for longer periods of time, as with a racing cam, problems start to occur at the lower engine speeds. This will cause unburned fuel to exit the engine since the valves are still open. This leads to lower engine performance and increased emissions. Pressure to meet environmental goals and fuel efficiency standards is forcing car manufacturers to turn to VVT as a solution. Most simple VVT systems advance or retard the timing of the intake or exhaust valves. Others like Honda's VTEC switch between two sets of cam lobes at a certain engine RPM.

Table 2.1: basic function principle of variable valve timing concept

	Function principle	Function	Main effects
1		Variable intake and/or outlet cam spread	Emissions, full load, fuel economy, running smoothness
2		Switchable intake/outlet valve lift, cylinder deactiv.	Fuel economy (full load)
3		Variable valve lift (variable duration)	Fuel economy (full load)
4		Variable intake closing (lost motion)	Fuel economy full load
5		Variable intake closing, variable intake opening	Fuel economy full load

2.2 The conventional valve timing

The valve timing for the conventional engine is fixed and not variable. It's that means the valve timing is same when the engine run in low RPM and high RPM. For the 4G92 SOCH engine, the valve timing open 14^0 before top dead center (BTDC) and close at 58^0 after bottom dead center (ABDC). For the exhaust valve, it open at 52^0 before bottom dead center (BBDC) and close at 16^0 after top dead center (ATDC).

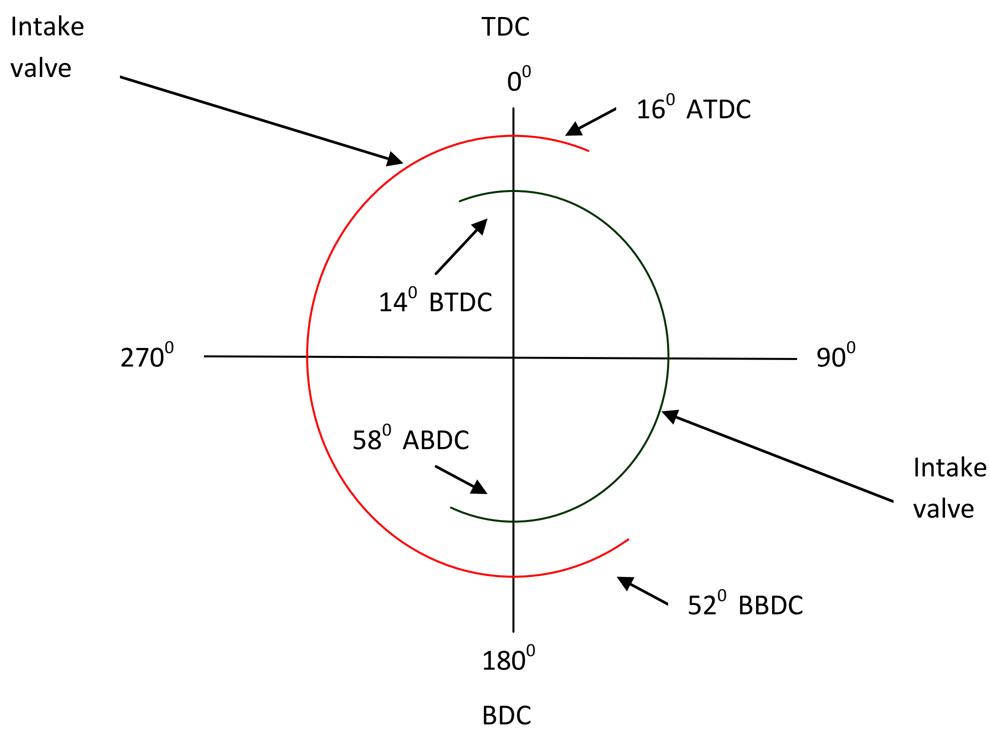

Figure 2.2: Valve timing diagram

2.3 Categories of VVT

Variable valve timing (VVT) has three main categories. They are variable phase control (VPC), combined valve lift and phase control (VLPC), and variable event timing (VET) systems.

2.3.1 Variable phase control (VPC)

Variable phase control, VPC implies varying the overlap so that low speed torque and, with it, specific fuel consumption is improved over most of the speed range. Since the duration of opening remains constant, wide-open throttle power is unaffected.

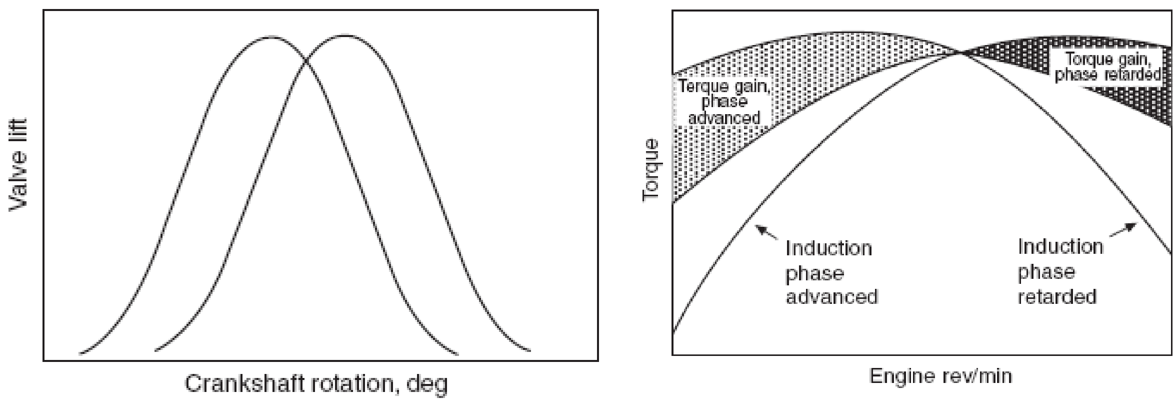

Figure 2.3: The inlet opening point for VPC. (Source: Garrett, T. K. (2001))

The inlet opening point can be retarded to reduce the overlap which, during idling, ensures stability and low emissions with VPC. For good low-speed torque and low fuel consumption, the inlet opening should be advanced, to increase the overlap.

2.3.2 Combined valve lift and phase control (VLPC)

VLPC offer further performance enhancement, but is more costly than VPC. It has axially stepped cams, the variation being effected by shifting the followers from step to step, but such a mechanism is complex. Tapered cams, such as the Fiat Tittolo system combining variable lift and event timing, are an alternative but this means virtually point contact, between cam and follower and, if the duration of opening is kept constant, the cam is extremely difficult to manufacture. Moreover, the axial loading introduced is about 10% of the force between the cam and follower, so a powerful controller is needed.

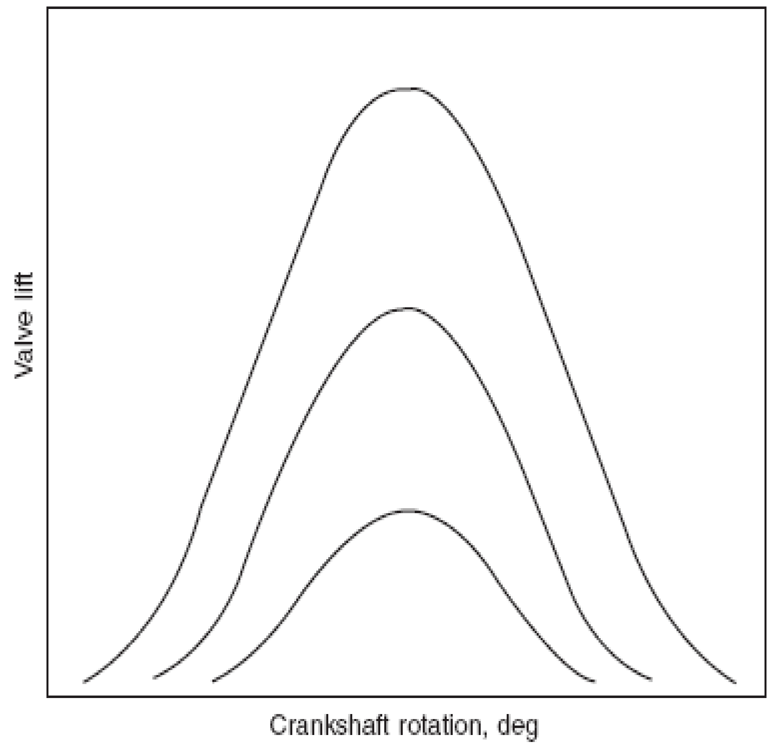

Figure 2.4: Stepped cams provide variable lift and timing (VLTC) with rocker actuated valves. (Source: Garrett, T. K. (2001))

From the figure above, at the lower lifts, friction is reduced, charge swirl enhanced and fuel consumption improved. The curves represent three steps, though up to ten are practicable

2.3.3 Variable event timing (VET)

Varying the valve event timing (VET) is the changing of the duration of lift while keeping the timing and magnitude of maximum lift constant. In other words, only the opening and closing points are varied. This improves part load emissions and economy, leaving the wide-open throttle condition unchanged, and has the advantage that the ramps on the cam remain effective both as the valve begins to lift and when it re-seats.

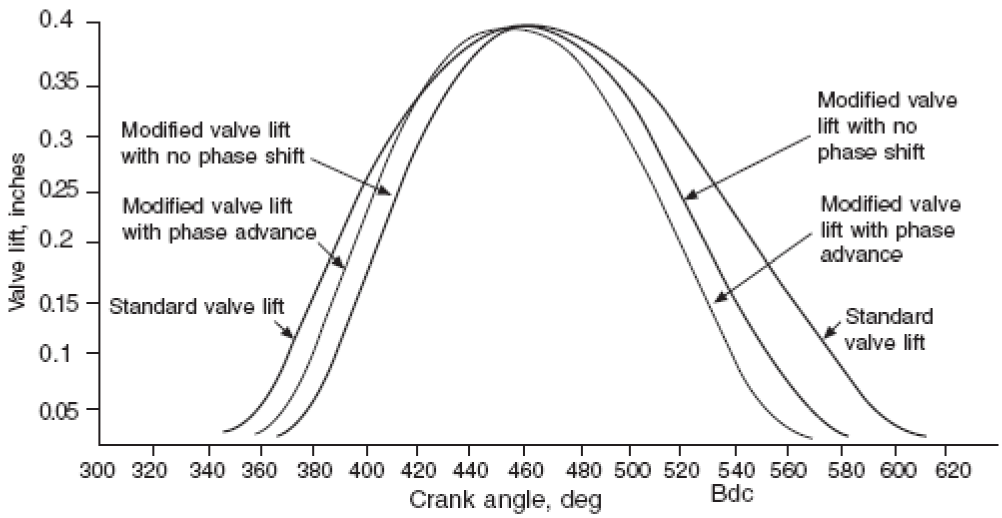

Figure 2.5: Curves of variable event (VET) timing without phase change. (Source: Garrett, T. K. (2001)).

Valve lift remains constant and the variation is effected continuously. Part-load emissions and economy are improved, and the wide-open throttle condition is unimpaired

2.4 Principles of current VVT

After the first patent application for a rotary displacement of a SI engine camshaft was submitted in 1918 by Haltenberger, hundreds of patents for camshaft adjustment systems have been issued, but only three construction principles have made their way to series production. These systems use either mechanical or hydraulic functional principles.

2.4.1 Axial movement of a piston with helical gear teeth

The system is obtained from the functional principle of a spur/helical gear sleeve. When the engine was in idle mode, a return spring keeps the system safely in the first valve timing position. When engine oil pressure acts on the piston against the load exerted by the spring, the helical cut gear spline teeth will translate the axial displacement of the piston into a rotational movement. This causes rotation of the camshaft relative to the drive sprocket and thus relative to the crankshaft.

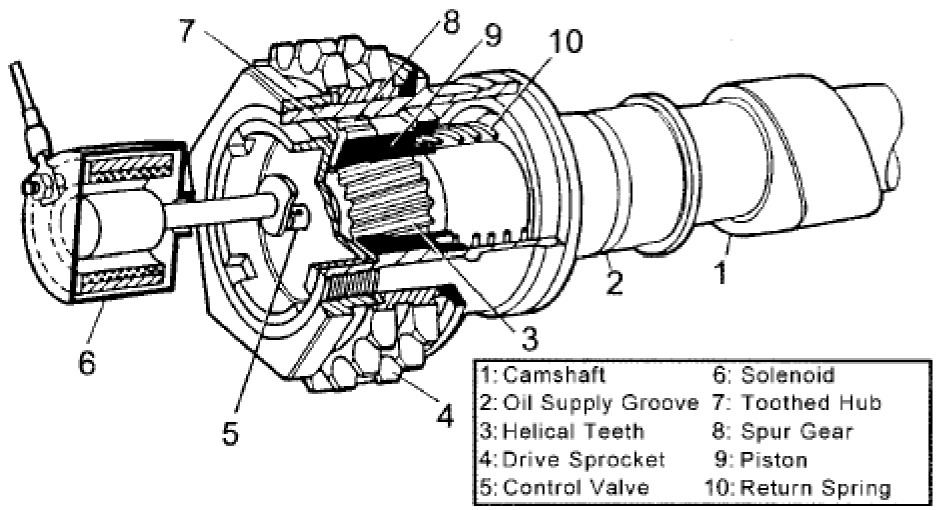

Figure 2.6**:** Helical spline system (Source: Jost, K. (2002))

2.4.2 Camshaft chain adjustment

These systems employ a small chain between the intakes and exhaust camshaft. The chain tensioner will moving upwards or downwards by oil pressurized piston will vary the phase angle between the shafts. In this arrangement, the exhaust camshaft is directly driven by the crankshaft and the intake camshaft can be repositioned by the adjuster. This system is quite compact and costeffective, but permits only one camshaft to be adjusted.