PUBLICATION ARTICLE

COMPARISON ANALYSIS OF ENGINE PERFORMANCE USING I-VTEC SYSTEM AND ENGINE WITHOUT I-VTEC SYSTEM HONDA CR-V

Submitted as a Partial Fulfillment of the Requirements for Getting the Bachelor Degree of Engineering in Automotive Department

Arranged by :

Jonas Suhardi
NIM : D700070001

MECHANICAL ENGINEERING DEPARTMENT
INTERNATIONAL PROGRAM IN AUTOMOTIVE/MOTORCYCLE ENGINEERING
MUHAMMADIYAH UNIVERSITY OF SURAKARTA
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APPROVAL

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Written by:

Name : **Jonas Suhardi**

NIM : **D700070001**

Has been approved and legalized on:

Day : Thursday

Date : 18 December 2014

Supervisor I	Supervisor II
Ir. Sartono Putro, MT.	**Nur Aklis,ST.M.Eng.**

Admitted by:

Secretary of International Program

UNIVERSITAS MUHAMMADIYAH SURAKARTA INTERNATIONAL PROGRAM

Wijianto,ST.M.Eng.Sc.

COMPARISON ANALYSIS OF ENGINE PERFORMANCE USING I-VTEC SYSTEM AND ENGINE WITHOUT I-VTEC SYSTEM HONDA CR-V

Jonas Suhardi, Sartono Putro, Nur Aklis
Automotive Department of Muhammadiyah University of Surakarta
Jln. A. Yani Tromol Pos I Pabelan-Kartasura. Telp. (0271) 715448 Surakarta

ABSTRACT

Vehicle manufactures develop technology which can increase of performance and the engine can have a great power and torque. One of this technology is using Intelligence Variable Timing and Lift Electronic Control (i-VTEC) that can be used to solve problem above because it can control timing valve. i-VTEC can increase engine performance that can make the gasoline engine will increase power and torque. The aim of this research is to compare power and torque on active i-VTEC and non-active i-VTEC system on Honda CRV.

This test was done by installing Honda CR-V 2.4 with active i-VTEC and non-active i-VTEC on Dynamometer. The Dynamometer presented the data of power and torque based on engine rotation.

The result from Dynamometer test showed that maximum torque from engine use active i-VTEC is 211.7 Nm at 4900 Rpm and maximum torque from engine non-active i-VTEC is 202.8 Nm at 5350 Rpm. The engine torque using active i-VTEC is 3.67% higher than non-active i-VTEC engine. The maximum power from engine use active i-VTEC system is 181.5 Hp at 6910 Rpm and maximum power from engine non-active i-VTEC system is 167.7 Hp at 7020 Rpm. The engine power using active i-VTEC is 9.33% higher than non-active i-VTEC engine. I-VTEC organizes timing of valve which can make overlapping on the machine. Overlapping make number of air fuel mixture in combustion chamber will increase which can make performance will increases.

Keywords: *gasoline engine, i-VTEC, Dynamometer, power, torque.*

BACKGROUND

Internal combustion engine is a device converting the energy of a fuel-air mixture burning within a combustion chamber into mechanical energy. A mixture of fuel and air, or just air in a diesel engine, is forced by atmospheric (or greater) pressure into the cylinder through the intake port than the intake valve is closed. The volume of air/fuel mixture that is drawn into the cylinder compared to the volume of the cylinder is called the volumetric efficiency of the engine.

Basically the previous system on automobile combustion is complex. To generate maximum power at low RPM is required a different setting than if we want to generate maximum power at high RPM. The engine setting for low RPM will reduce the engine's power and torque while run in high RPM. Otherwise the engine setting for high

RPM will cause poor engine performance while run in low RPM.

i-VTEC (Intelligent-Variable Valve Timing and Lift Electronic Control) is a valve train system developed by Honda to improve the volumetric efficiency of a four-stroke internal combustion engine. The i-VTEC system uses two camshaft profiles and electronically selects between the profiles.

Based on this background, it is necessary to understand the effect of active i-VTEC and non-active i-VTEC to the gasoline engines performance of Honda CRV.

OBJECTIVE OF THE STUDY

The research objectives are compares the power and torque on active i-VTEC and non-active i-VTEC system on Honda CRV.

REVIEW OF LITERATURE

Sanjaya, Danil (2012), his research about the comparison analysis performance of Honda Jazz using active vtec and non-active vtec system engine. His research concluded data from analysis torque and power. The highest engine torque can be reached when the engine use active VTEC system. Maximum torque from engine use active VTEC is 99.8 FtLb at 4990 rpm and The highest engine power can be reached when the engine use active VTEC system is 111 Hp at 6020 rpm.

Siswanto,Y.D (2012), his research study about the effect of variety lobe separation angle camshaft to engine power. The research use LSA standard $104^{o,}$ LSA widened camshaft 107^{o} and LSA narrowed camshaft 101^{o} at different engine speed. Based on the data analysis, it concluded that the change of LSA narrowed camshaft (101^{o}) produces higher maximum power at 5500 rpm-9000 rpm than the change of LSA widened camshaft (107^{o}). LSA widened camshaft will produces higher maximum power at 4000 rpm – 5500 rpm than standard camshaft.

FUNDAMENTAL THEORY

1. Four Stroke Engine Work

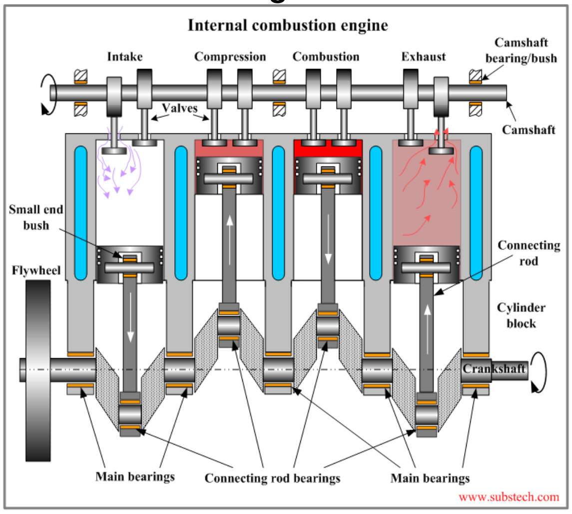

Figure 1 four stroke operating Cycle (Source : www. Substech.com)

a. **Intake Stroke**

Intake valve is open and exhaust valve is close. The piston descends from the top of the cylinder to the bottom of the cylinder, reducing the pressure inside the cylinder. A mixture of fuel and air, or just air in a diesel engine, is forced by atmospheric (or greater) pressure into the cylinder through the intake port. The volume of air/fuel mixture that is drawn into the cylinder, relative to the volume of the cylinder is called, the volumetric efficiency of the engine.

b. Compression Stroke

Both intake and exhaust valves closed. The piston returns to the top of the cylinder compressing the air, or fuel-air mixture into the combustion chamber of the cylinder head.

c. Expansion Stroke

While the piston is close to Top Dead Center, the compressed air–fuel mixture in a gasoline engine is ignited, usually by a spark plug, The resulting massive pressure from the combustion of the compressed fuel-air mixture forces the piston back down toward bottom dead center.

d. Exhaust Stroke

During the exhaust stroke, exhaust valve open. This action evacuates the burnt products of combustion from the cylinder by expelling the spent fuel air mixture out through the exhaust valve.

2. Engine Performance Parameter

a. Torque (T)

Torque is the twisting force or energy that an engine produces. Torque is multiplication between force and radius that can be formulated as below:

$$\boldsymbol{T = F \cdot \ell}$$

where:

F = force (N)

ℓ = lever length (m)

b. Power

Power is work done that produced by the engine in the experiment, which can be formulated as bellow (Willard W. Pulkrabek, 2001):

$$\dot{W} = \frac{\boldsymbol{2 \cdot \pi \cdot n \cdot T}}{\boldsymbol{60000}}$$

where:

$\dot{W}$ = Power (kW)

n = Engine rotation (rpm)

T = Torque (Nm)

3. Engine Performance Characteristic

Engine performance characteristic are convenient graphical presentation of an engine performance. Both torque and power are functions of engine speed.

At low speed, torque increases as engine speed increases. As engine speed increases further, torque reaches a maximum called Maximum brake torque (MBT) and then decreases as shown in Figure 2.6. Torque decreases because the engine is unable to ingest a full charge of air at higher speeds.

Indicated power increases with speed, while brake power increases to a maximum and then decreases at higher speeds. This is because friction losses increase with speed and become the dominant factor at very high speeds.

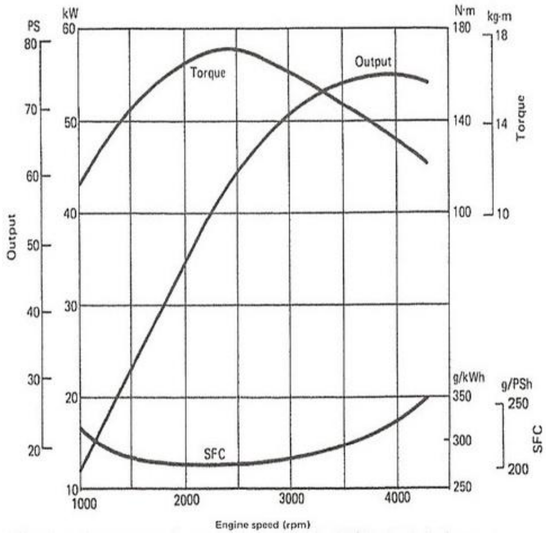

Figure 2 Engine Performance Curves

(Source: J.B Heywood. Internal combustion engine fundamentals)

Brake specific fuel consumption decrease as engine speed increases, reaches a minimum and then increase at high speeds. Fuel consumption increases at high speed because of greater friction loses. At low speed, the longer time per cycle allows more heat loss and fuel consumption goes up.

4. Volumetric Efficiency

The parameter used to measure the effectiveness of an engine induction proses is the volumetric efficiency. It is defined as the volume flow rate of air into the intake system divided by the rate at which volume is displaced by the piston.

$$\eta_v = \frac{m_a}{\rho_a V_d}$$

where:

m_a = mass of air into the engine
ρ_a = air density
V_d = displacement volume

5. Valve Timing

Valve timing is a system that developed for measuring valve operation in relation to crankshaft position (in degrees), particularly the points when the valves open, how long they remain open, and when they close.

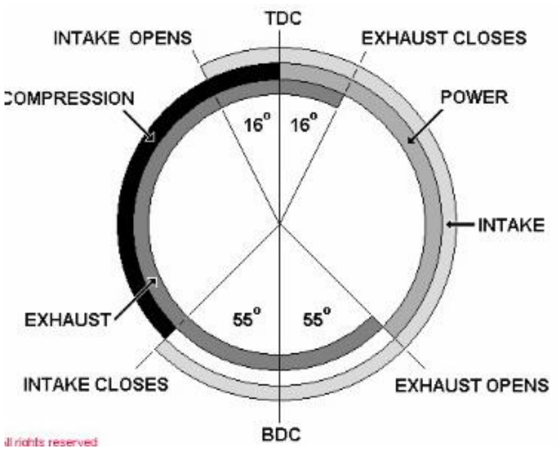

Figure 3 Valve Timing (Source: valves and valve machanism.pdf)

6. i-VTEC System Construction

The i-VTEC system is designed to control the intake camshaft to provide valve timing that is optimally suited to the engine condition

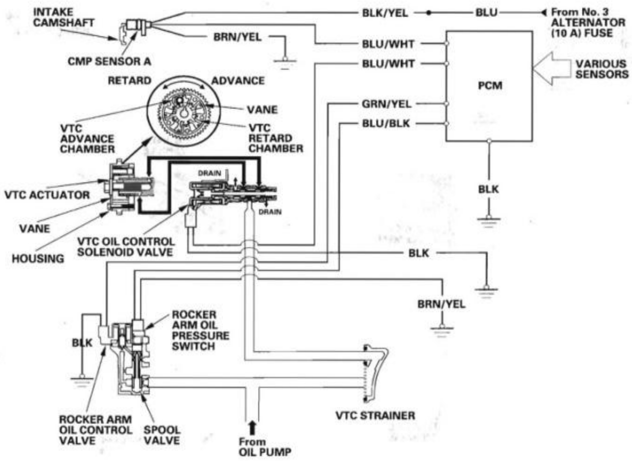

Figure 4 i-VTEC system diagram (Source: Honda CR-V Service Manual Book)

7. Mechanism of VTEC

The mechanism has 3 cams with different timing and lift profile. This mechanism operated is like this:

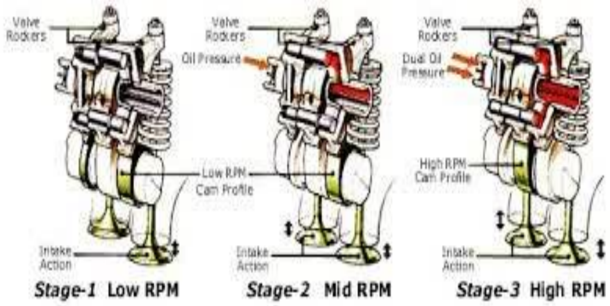

Figure 5. VTEC Mechanism (Source:www.howstuffwork.com/ engine-valve-technology)

Stage 1 (low speed) : the 3 pieces of rocker arms moves independently. Therefore the left rocker arm, which actuates the left inlet valve, is driven by the low-lift left cam. The right rocker arm, which actuates the right inlet valve, is driven by the medium-lift right cam

Stage 2 (medium speed) : hydraulic pressure (painted orange in the picture) connects the left and right rocker arms together, leaving the middle rocker arm and cam to run on their own. As a result, both inlet valves obtain slow timing but medium lift.

Stage 3 (high speed) : hydraulic pressure connects all 3 rocker arms together. Since the middle cam is the largest, both inlet valves are actually driven by that fast cam. Therefore, fast timing and high lift are obtained in both valves.

As seen from the power curve graph, each of the three stages has a distinct curve. The optimal portions for the three stages can be combined into one curve.

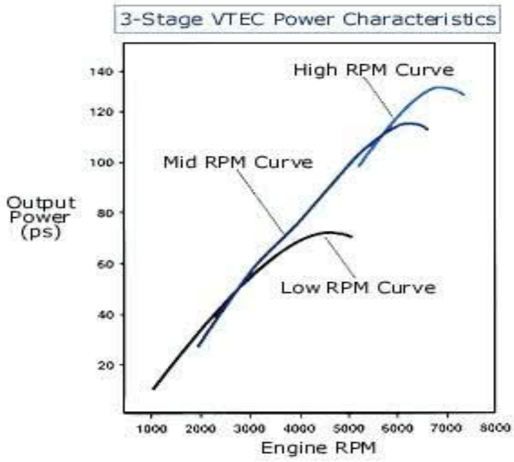

Figure 6. VTEC Power graphic (Source:www.howstuffwork.com/ engine-valve-technology)

8. Mechanism of VTC
Advance

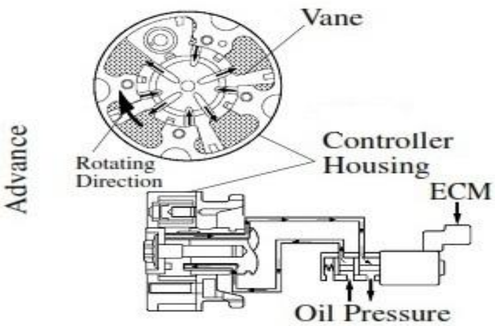

Figure 7. advance position (Source:www.howstuffwork.com/ engine-valve-technology)

The resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.

Retard

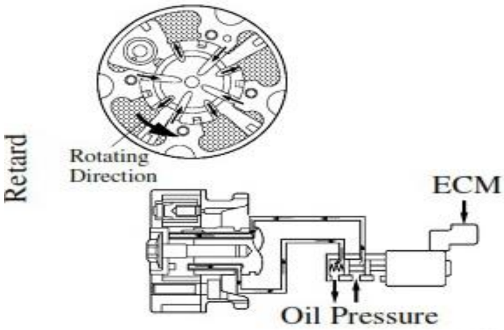

Figure 8. retard position (Source:www.howstuffwork.com/ engine-valve-technology)

The resultant oil pressure is applied to the timing retard side vane chamber to rotate the camshaft in the timing retard direction.

Hold

The ECM calculates the target timing angle according to the traveling state to perform control as described below.

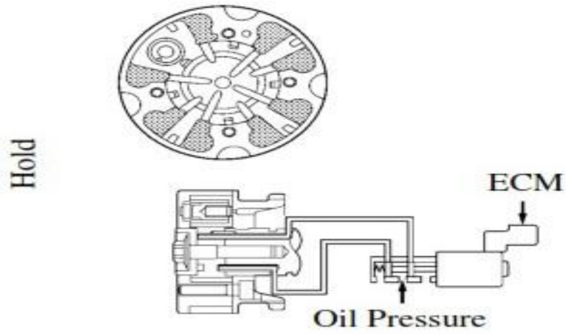

Figure 9. hold position (Source:www.howstuffwork.com/ engine-valve-technology)

9. Effectiveness of the i-VTEC System

The VTC system makes changes intake valve timing based on the operation conditions. Intake valve timing is optimized to allow the engine to produce maximum power. The VTEC system changes the cam profile to correspond to the engine speed. It maximizes torque at low engine speed and output at high engine speed.

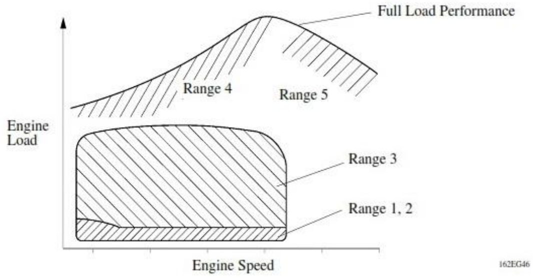

Figure 10.Conceptual graphic operation during various conditions (Source: FE Engine.pdf)

Table 1 Influence Loads toward Valve Timing (Source: FE Engine.pdf)

Operation State	Range	Valve Timing	Objective	Effect
During Idling	1	TDC, Latest timing, EX, IN, BDC (178EG18)	Minimizing overlap to reduce blow back to the intake side	Stabilized idling rpm Better fuel economy
At Light Load	2	To retard side, EX, IN (178EG19)	Decreasing overlap to eliminate blow back to the intake side	Ensured engine stability
At Medium load	3	To advance side, EX, IN (178EG20)	Increasing overlap to increase internal EGR for pumping loss elimination	Better fuel economy Improved emission control
In Low to Medium Speed Range with Heavy Load	4	TDC, EX, IN, BDC, To advance side (178EG21)	Advancing the intake valve close timing for volumetric efficiency improvement	Improved torque in low to medium speed range
In High Speed Range with Heavy Load	5	EX, IN, To retard side (178EG22)	Retarding the intake valve close timing for volumetric efficiency improvement	Improved output
At Low Temperatures	—	Latest timing, EX, IN (178EG23)	Minimizing overlap to prevent blow back to the intake side for reduction of fuel increase at low temperatures, and stabilizing the idling rpm for decreasing fast idle rotation	Stabilized fast idle rpm Better fuel economy
Upon Starting/ Stopping the Engine	—	Latest timing, EX, IN (178EG24)	Minimizing overlap to minimize blow back to the intake side	Improved startability

RESEARCH METODOLOGY

1. Research Flow Chart

The flow chart of engine test can be explained below:

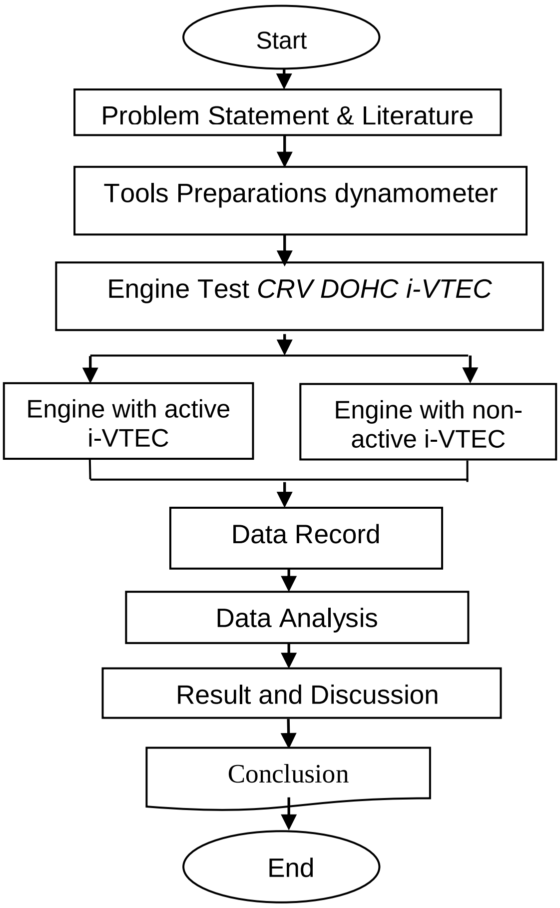

Figure 11 engine test Flowchart

2. Material

Material that used is spark ignition four stroke engine with the volume cylinder 2354 cc, four cylinder and vertical engine types.

Table 2 Specification of Honda CR-V i-VTEC

Engine specification	
Type	In-Line 4-Cylinder
Valve mechanism	16-Valve DOHC i-VTEC®
Displacement volume	2354 cc
Engine configuration	4
Valve configuration	16
Bore x Stroke (mm)	87 x 99
Compression Ratio	10:1
Maximum power (Ps/rpm)	187 @ 7000
Maximum torque (Nm/rpm)	222 @ 4400
Carburation system	PGM-FI

3. Tools

The dynamometer will be used is digital dynamometer. The output of engine performance parameter is shown by graphic on display. The parameter will be shown are rotation, power and torque.

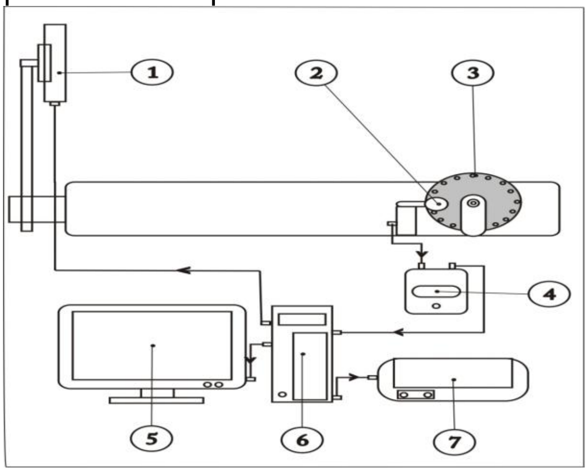

Figure 12. Scheme of Dynamometer

Legend: 1. Monitor
2. pick up coil sensor
3. pick up coil roller
4. *dyno* GUI (*graphic user interface*) console
5. Monitor 2
6. CPU
7. Printer

4. Engine Test

Tools preparation step is conducted to prepare the entire tools that are used in the test. First step, prepare the Honda CRV engine with i-VTEC. Test of performance Honda CRV engine with DOHC i-VTEC on dynotest. After that give trouble on ECU to make i-VTEC on the Honda CRV engine does not work so there is no signal and the hydraulic oil to solenoid cannot move and the pin on cam also does not working. Pull out VTC Solenoid valve cable to make trouble on ECU. Then, test of performance of CRV engine with non-active i-VTEC on dynotest.

5. Data Record

1. Power and torque can be obtained by running car on dynamometer. The procedure of data acquisition must be followed. For the first, shift the transmission on the D Lever. Running the car just like in normal condition then hold the engine then hold the engine speed to 1500 Rpm. Push and Hold the gas pedal until engine reach 7500 Rpm. Then release the gas pedal and wait until engine back to normal condition again.
2. The output data can be read on the monitor that connect to dynamometer.
3. Repeat the step above up to four times experiments to get the accurate data.

ANALYSIS

1. Engine Torque

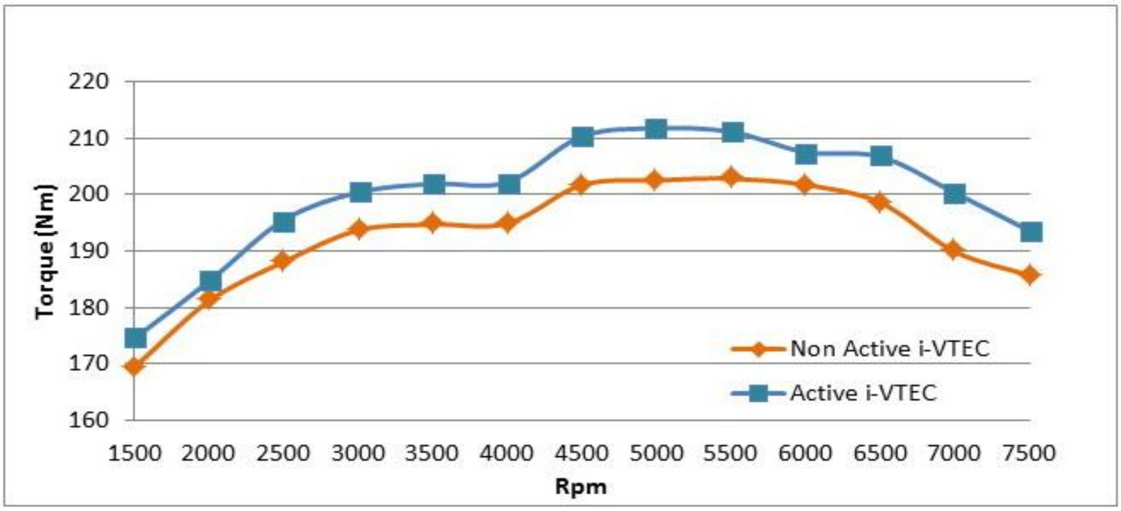

Figure 13. Graphic comparison of analysis Torque between active i-VTEC system and non-active i-VTEC system

The highest torque generated by active i-vtec system is 211.7 Nm at 4900 Rpm and the highest torque generated by non-active i-vtec is 202.8 Nm at 5350 Rpm. On low rotation and high rotation, torques has generated by active i-vtec system are higher than torques generated by non-active i-vtec system.

As the result, the mean average value of torque that resulted from engine using active i-VTEC is 200.03 Nm. On other hand, the mean average value of torque that resulted from engine non-active i-VTEC is 192.69 Nm. The engine torque using active i-VTEC is 3.67% higher than non-active i-VTEC engine. This occurs because the active i-VTEC is advancing the intake valves closing time and opened the intake valves for longer duration based on engine loads. The volumetric efficiency is improved by increasing amount of air that inhaled to combustion chamber which resulting to increasing torque.

The highest torque that can be achieved based on manual book is 220

Nm at 4400 Rpm. The tested engine give smaller torque value than the torque based on manual book because the engine used for testing is not new engine so engine performance is decreasing.

2. Engine Power

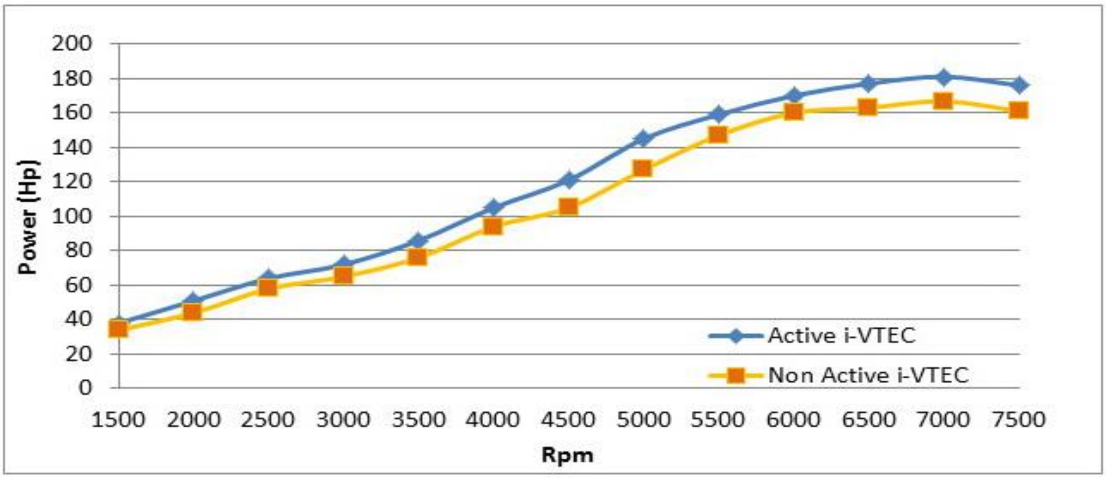

Figure 14. Graphic comparison of analysis Power between active i-VTEC system and non-active i-VTEC system

The highest power generated by active i-vtec system is 181.5 Hp at 6910 Rpm and the highest power generated by non-active i-vtec is 167.7 Hp at 7020 Rpm. From the graphic, it shows at low and high rotation, active i-vtec system will resulting higher power than non-active i-vtec system.

As the result, the mean average value of power that resulted from engine using active i-VTEC is 118.85 Hp. On other hand, the mean average value of power that resulted from engine non-active i-VTEC is 107.75 Hp. The engine power using active i-VTEC is 9.33% higher than non-active i-VTEC engine. This occurs because the active i-VTEC is advancing the intake valves closing time and opened the intake valves for longer duration based on engine loads. The volumetric efficiency is improved by increasing amount of air that inhaled to combustion chamber which resulting to increasing power. The highest power that can be achieved based on manual book is 190 PS or 187.4 Hp at 7000 Rpm. The tested engine give smaller power value than the torque based on manual book because the engine used for testing is not new engine so engine performance is decreasing.

CONCLUSION

a. The maximum torque from engine use active i-VTEC is 211.7 Nm at 4900 Rpm and maximum torque from engine non-active i-VTEC is 202.8 Nm at 5350 Rpm. The engine torque using active i-VTEC is 3.67% higher than non-active i-VTEC engine. Torque will increase if the engine using active i-VTEC system.
b. The maximum power from engine use active i-VTEC system is 181.5 Hp at 6910 Rpm and maximum power from engine non-active i-VTEC system is 167.7 Hp at 7020 Rpm. The engine power using active i-VTEC is 9.33% higher than non-active i-VTEC engine. Power will increase if the engine using active i-VTEC system.

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