

**AN ASSESSMENT OF CYLINDER DEACTIVATION
SYSTEM APPLIED TO CLOSABLE INTAKE
PORTS IN A SMALL SI ENGINE**

MUHAMMAD ARIF BIN DAUD

B041010155

BMCA

Email: meja_jepon91@yahoo.com

Draft Final Report

Projek Sarjana Muda II

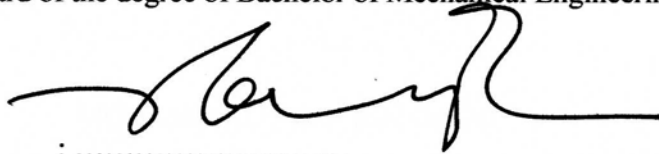
Supervisor: DR. AHMAD KAMAL BIN MAT YAMIN

**Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka**

JUNE 2015

SUPERVISOR DECLARATION

“I hereby declare that I have read this thesis and my opinion this thesis is sufficient in terms of scope quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive)”



Signature :

Supervisor : DR. AHMAD KAMAL BIN MAT YAMIN

Date : 27/5/2015

**AN ASSESSMENT OF CYLINDER DEACTIVATION
SYSTEM APPLIED TO CLOSABLE INTAKE
PORTS IN A SMALL SI ENGINE**

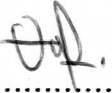
MUHAMMAD ARIF BIN DAUD

**This thesis submitted in partial fulfilment of the requirements for the degree of
Bachelor of
Mechanical Engineering (Automotive)**

**FACULTY OF MECHANICAL ENGINEERING
UNIVERSITI TEKNIKAL MALAYSIA MELAKA
2015**

DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries and quotations which have been duly acknowledge."

Signature : 

Author : MUHAMMAD ARIF BIN DAUD

Date : JUNE 2015

ABSTRACT

This project is conducted with the main objective of carrying out engine tests to get the engine performance with and without Cylinder Deactivation System (CDS) that addresses well on two criteria of the automotive industry, which are low fuel consumption and carbon dioxide emission during idle condition. The focus of the subject of the project is set on gasoline engine, the more generally used engines for cars in Malaysia. For the purpose of analysis and comparison of the modified engine model, the PERODUA Myvi 1.3 is made as the benchmark, with the engine being a 1.3L K3-VE four-stroke four-cylinder gasoline engine. In order to get low fuel consumption, the author with the advised of the supervisor, has decided to use the cylinder deactivation system. As to improve the vehicle engine efficiency especially low carbon dioxide emission, the intake port is closed is seen to be the best solution to prevent the oxygen to enter the intake port. The period given for the project is for two full semesters. Experiment like carbon dioxide emission test and vibration test are conducted in order to compare between 4 activated cylinder and 2 deactivated and 1 deactivated cylinder cylinder. The best engine performance concept is the 2 deactivated cylinder with closed intake port which is to have better engine combustion and low carbon dioxide emission.

ACKNOWLEDGEMENT

The author would like to express his utmost gratitude to the project supervisor Dr Ahmad Kamal bin Mat Yamin and co-supervisor Engr. Prof. Madya Dr Noreffendy bin Tamaldin for their inspiring supervision and guidance to direct the author from the start till the very end of the project. They have provided supports and technical advises for the author to expand his knowledge on the field of study in theory, practical as well as in industrial standards. On any shortcomings in performance, Dr Ahmad Kamal bin Mat Yamin will always give beneficial suggestions on rooms of improvement. Both the supervisors have guided the author throughout the whole project with great enthusiasm and professionalism.

Not forgetting the lab technician Mr. Ridwan for the engine familiarization process where the author gets to learn closely about the working principles of the four-cylinder gasoline engine through disassembling and re-assembling of the real engine during lab time.

Deepest appreciation is directed to the Final Year Project course coordinators, Profesor Madya Dr Azma Putra for coordinating the programme effectively, and to make it simple for the author as well as other undergraduates to accomplish their assigned tasks. The briefing conducted by Profesor Madya Dr Azma Putra have helped to clear all doubts of the author and kept the author on schedule to finish the project.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DECLARATION	iii
	ABSTRACT	iv
	ACKNOWLEDGEMENT	v
CHAPTER 1	INTRODUCTION	
	1.0 Introduction	1
	1.1 Problem Statements	3
	1.2 Objectives	3
	1.3 Scope	3
CHAPTER 2	LITERATURE REVIEW	
	2.0 Introduction	4
	2.1 Cylinder Deactivation	4
CHAPTER 3	METHODOLOGY	
	3.0 Introduction	7
	3.1 Project Equipment	9
	3.2 Test Set Up	13
	3.3 Table data	15
CHAPTER 4	RESULT AND DISCUSSIONS	
	4.0 Introduction	16
	4.1 Data Gathering	17
	4.2 Vibration Graph	20
	4.3 Carbon Dioxide	23
	4.4 Hydrocarbon	26

CHAPTER 5	CONCLUSION AND RECOMMENDATION	
5.0	Conclusion	28
5.1	Recommendation	28
	REFERENCE	30
	APPENDICES	31

LIST OF FIGURES

Figure 2.1	(a) Deactivating the pushrod	6
	(b) Electromechanical valves	6
Figure 3.1	Flowchart of final year report	8
Figure 3.1.1	Emission analyzer	9
Figure 3.1.2	Accelerometer sensor	10
Figure 3.1.3	4-2-1 exhaust runner	11
Figure 3.1.4	Gasket	12
Figure 3.1.5	Deactivation cylinder switch	13
Figure 3.2.1	All activated cylinder	14
Figure 3.2.2	One deactivated cylinder	14
Figure 3.2.3	Two deactivated cylinder	15
Figure 4.2.1	Vibration test on the benchmark engine	20
Figure 4.2.2	Vibration comparison	21
Figure 4.3.1	Carbon dioxide emissions test	23
Figure 4.3.2	Non-closed intake port	24
Figure 4.3.3	Closed intake port	25
Figure 4.4.1	Hydrocarbon emissions test	26

LIST OF TABLES

Table 3.2.3	Carbon dioxide emission	15
Table 4.1.1	Carbon dioxide emission (case 1)	17
Table 4.1.2	Carbon dioxide emission (case 2)	18
Table 4.1.3	Carbon dioxide emission (case 3)	18
Table 4.1.4	Summarized data	19

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

The project is chosen by the supervisor based on his involvement in the PERODUA Eco-Challenge, a car modification competition for the university. Synchronizing with the competition, the project requires the author to address two main criteria of the automobile industry which are fuel consumption and carbon dioxide emission. The focus of the project is on the city car instead of sports car.

Energy efficient vehicle (EEV) is defined as vehicle that meet a set of define specification in terms of carbon dioxide emission level and fuel consumption. In order to reduce fuel consumption by the vehicle due to increasing of fuel price, all vehicle need to pass this specification. Cylinder deactivation system is a cost effective method compare to start stop function engine since it requires additional system like battery. Cylinder deactivation has come into center of the world in the 80's the point at which it is initially offered in the Cardillac's 1981 Seville with the primary aim to lessen fuel consumption. This idea revolves around the finding that the commonplace engine load during daily traffic is low which brings about imperfect fuel consumption and by applying cylinder deactivation, better matching of the real engine load with the idea engine load can be accomplished. Subsequently, the load of the still activated cylinder is increased with enhanced efficiency.

However the cylinder deactivation can be embraced in a few distinctive systems. In this project, instead of variable valve timing technology, another approach is adopted by completely close the intake port to prevent the oxygen entering the chamber. This method will affect important criteria regarding λ sensor that trace the oxygen content. The sensor will then send the information to ECU. If the port is not closed, excess oxygen detected by ECU hence more fuel is injected to the port.

This project deals particularly with the car engine itself hence the engine specification are crucial data. The engine chosen for benchmarking is the Myvi 1.3L (manual transmission). The specification of the engine is outlined in Table 1.1.

TABLE 1.1: Engine Specification for PERODUA Myvi

Engine Specification	Description
Engine Classification	Four-Stroke Gasoline (SI) Engine
Engine Type	K3-VE
Valve Mechanism	DOHC, 16v with DVVT
Total Displacement	1298 cc
Bore x Stroke	72.0 mm x 79.7 mm
No. of Cylinders	4
Compression Ratio	10.1 : 1
Maximum Output (DIN)	67/6000 kW/rpm
Maximum Torque (DIN)	117/4400 Nm/rpm
Fuel System	Electronic Fuel Injection (EFI)
Fuel Tank Capacity	40.0 L
Transmission	5MT (SX)

1.1 PROBLEM STATEMENT

Based on the demand of the project, two essential criteria have to be fulfilled, which are fuel carbon emission and vibration.

1.2 OBJECTIVE

The objective of this project:

1. To assess the carbon dioxide emission for closed intake port based on time travelled by the engine by cutting off two of selected cylinder.
2. To investigate the vibration level on the engine for the cylinder deactivation system.

1.3 SCOPE

The scope of study for cylinder deactivation will be the determination of the suitable cylinder deactivation technology to adopt for a part load during idle condition.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter explains in detail about the existing of a cylinder deactivation system that covers in this report. Basically, most of the existing cylinder deactivation system has a better efficiency compare with other method such as variable valve timing, skipped cycle system, turbocharged, and hybrid car. Due to the increasing of carbon emission on environment and less efficient of spark ignition engine, cylinder deactivation system can give the solution for this problem by reducing the carbon emission and give a better engine performance of the vehicle.

2.1 CYLINDER DEACTIVATION

The previous old days has seen continuously more emission discharge for much essential carbon monoxide, hydrocarbon and nitrogen oxide without the concern of the future. Because of this, many method has been invented in order to reduce the emission levels through decreasing of combustion but actually led to the increasing of the carbon emission levels at the environment. Many said that in the next 20 years, the biggest challenge is to reduce the harmful gas emitted by the combustion. Other than that, the fuel combustion can be minimized because fuel combustion is one of the biggest factor affected the environment.

The increasing of fuel gas has forced automobile manufactures to investigate new methods and technologies to reduce the fuel consumption in Spark Ignition (SI)

engines. Many technology is found in order to decrease the fuel consumption on the vehicle. They can be classified into 4 components those are first is vehicle efficiency improvement which reduces force output needed to attain the desired vehicle performance, second is a powertrain efficiency improvement which allows the engine to operate in its most efficient region over wider range of vehicle operation, third is engine efficiency improvement which improves the engine internal conversion of fuel to brake torque and forth is energy storages house in which vehicle kinetic energy is converted to a stored and reused to launch or efficiently operate the vehicle. (John Michelin and Chris Glugla, 2003)

In 1981 General Motors were the first to introduce cylinder deactivation with valve shut down in mass production. Whilst this technology was initially mainly reserved to large displacement engines, it has been utilized in the recent past for the entire engine segment. Amongst such uses are also hybrid engines where cylinder deactivation is also used during coast down to minimize cylinder pumping losses and hence to enlarge recuperation. (Flierl et al, 2012)

Cylinder deactivation system is a method to decrease the fuel consumption at part load condition for the spark ignition engine. The fuel consumption can be save at 5 to 10 percent compare with standard engine. The cylinder deactivation system is working only at part load condition means at slow speed. The system is actually skip the cycle of the engine. The combustion cycle is not occur because no ignition and fuel is injected at the deactivated cylinder.

On the previous study, the cylinder deactivation is acknowledged by deactivating (shutting) the valves and blocking injector or ignition (Otto-motor) signals. Current cylinder deactivation system use a mechanical valvetrain, where a hydraulic control component is used to keep the cam adherents from actuating the valve. Figure 4.1a demonstrates a mechanical/hydraulic deactivation mechanism used by General Motors. Future camless valvetrain frameworks, figure 4.1b, simplify cylinder deactivation by making sure that the valves is closed.

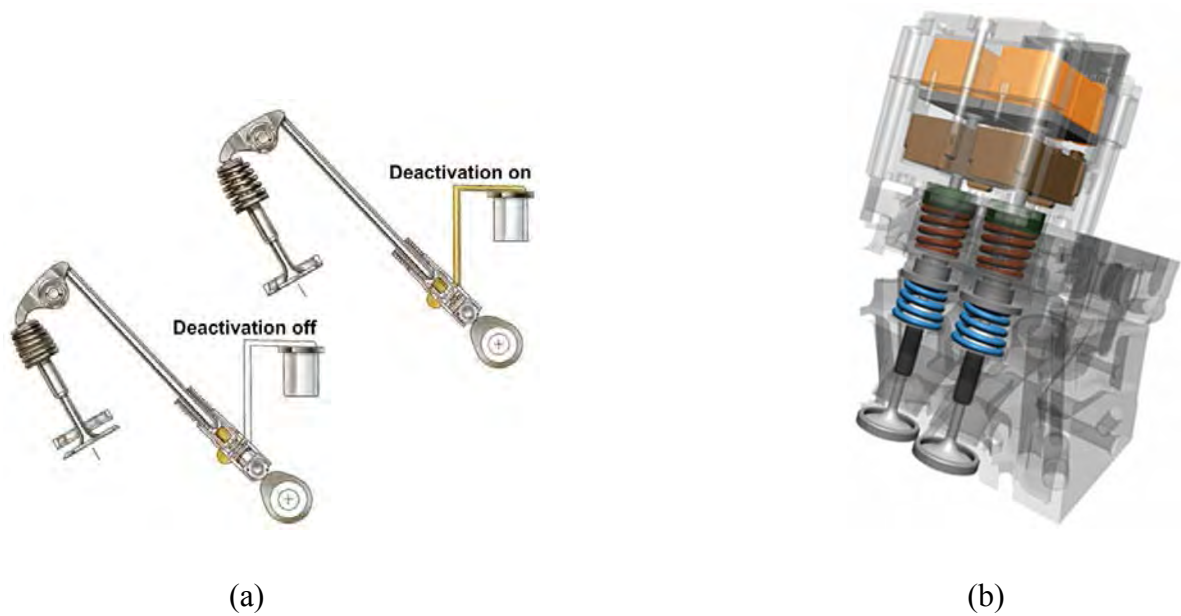


Figure 2.1: (a) Cylinder deactivation by deactivating the pushrod (source: GM) (b) Electromechanical valves system concept (source: Valeo)

The advantage of cylinder deactivation is that it increased the fuel efficiency by 10% to 20%. Moreover, it also decreased the emissions from deactivated cylinder. Furthermore, it has a better breathing capability of the engine, thereby reducing power consumed in suction stroke. (Gilbert Peters, 2007)

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter covers the detail explanation of the methodology used to complete this project. It defined the significant procedures used to achieve the main of this project by experimental methods. Figure 3.1 below shows the flow chart which represents the steps to finish this project. The car that used in this project is a PERODUA Myvi 1.3L, a common car in Malaysia. The engine of the car is modified into a cylinder deactivation concept. All the cylinder has its own on off switch in order to see the comparison between all activated cylinders and certain deactivated cylinder. The test is set up during idle condition that is on 2000 rpm. The fuel consumption of the car can be measure using weighing scales on five liter tank. The critical measurement which is carbon dioxide emission is measured using emission analyzer putted at the middle of the exhaust pipe. Under certain cases, the intake port is close by using gasket to prevent unused oxygen during combustion and pumping losses. At the end of this experiment, the fuel consumption and carbon dioxide emission of the modified engine should be lower than the benchmark engine.

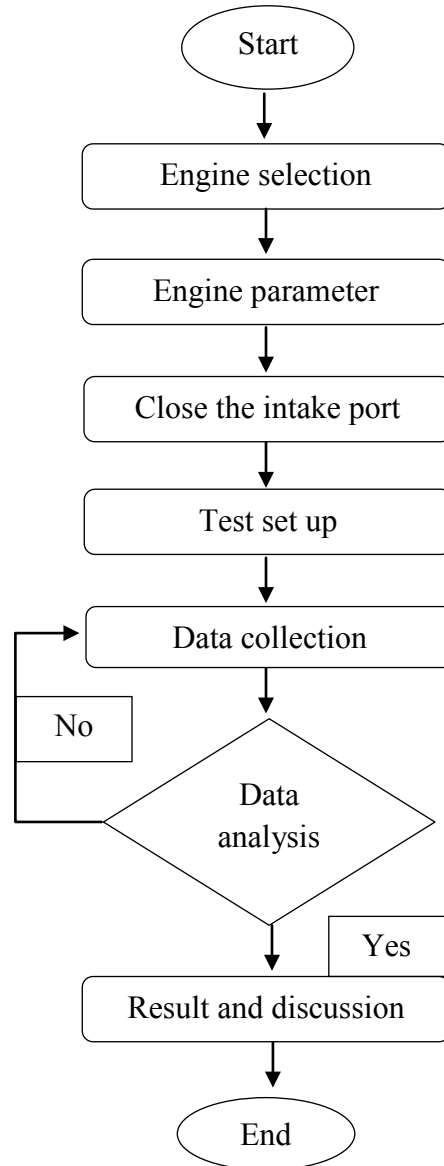


Figure 3.1: Flowchart of final year report

3.1 PROJECT EQUIPMENT

Detailed equipment and tasks are listed out for each process of the methodology.

3.1.1 PORTABLE EMISSION ANALYZER

The portable emission analyzer is a device to measure carbon dioxide, carbon monoxide, hydrocarbon, carbon dioxide, air-fuel-ratio and lambda. For this project, MEXA-584L has been chosen to measure the carbon dioxide emission in the exhaust pipe. The device has a lightweight and compact with a clear LCD and effortless operation, it can be used as a simple measurement instrument in any work situation. The portable emission analyzer is putted at the exhaust pipe during the experimentation. The data on the LCD cover is recorded every minute of the experimentation. The experiment is repeated by deactivating part of the cylinder. The data recorded will be analyzed.

Figure 3.1.1



3.1.2 ACCELEROMETER

An accelerometer is a device that measures the vibration, or acceleration of motion of a structure. The force caused by vibration or a change in motion (acceleration) causes the mass to “squeeze” the piezoelectric material which produces an electrical change that is proportional to the force exerted upon it. Since the charge is proportional to the force, and the mass is a constant, the charge is also proportional to the acceleration. The accelerometer is putted at the head of the engine during all the experiment. The vibration reading during deactivation system should be higher than during activation system.

Figure 3.1.2



3.1.3 4-2-1 EXHAUST RUNNER

A 4-2-1 exhaust runner is refer to the exhaust pipe layout. Four pipes come off the cylinder head (or additional header), which turns into two pipes, and the system finally ends with one pipe leading to the catalytic converter and muffler.

Figure 3.1.3



3.1.4 GASKET

A gasket is used to prevent air enter the combustion chamber at the selected deactivation cylinder.

Figure 3.1.4



3.1.5 DEACTIVATION CYLINDER SWITCH

The cylinder deactivation system consist of four switch. The switch is to cut off the fuel injection and at the same time cut off the spark ignition.

Figure 3.1.5



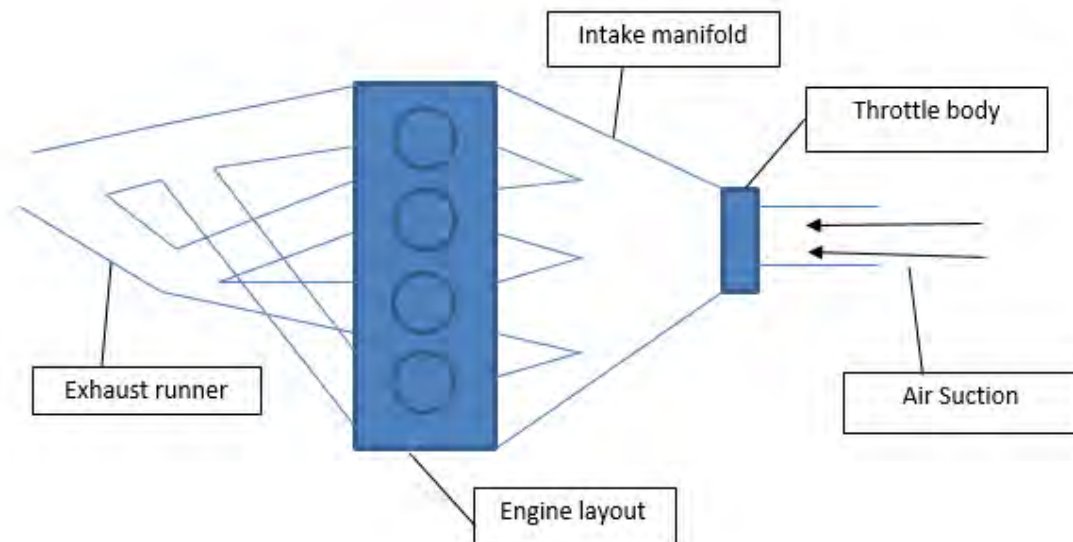
3.2 TEST SET UP

The test is set up by using three different cases in order to see the comparison of carbon dioxide emissions and vibration level.

3.2.1 CASE 1

The test is set up without any deactivation of the cylinder.

Figure 3.2.1: All the cylinders are activated



3.2.1 CASE 2

The test is set up by closing one intake port

Figure 3.2.2: One of the cylinder is deactivated with closed intake port