



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**STUDY ON EFFECT OF INTAKE AIR FILTER SYSTEM ON
ENGINE PERFORMANCE ON NATURALLY ASPIRATED
ENGINE**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Automotive Technology) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Study on effect of intake air filter system on engine performance on naturally aspirated engine” is the results of my own research except as cited in references.



APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Automotive Technology) (Hons.). The member of the supervisory is as follow:



ABSTRAK

Penapis udara enjin pembakaran dalaman adalah salah satu bahagian utama untuk meningkatkan prestasi enjin dan meningkatkan pembakaran. Walau bagaimanapun, keadaan penapis udara akan menjejaskan prestasi dan pelepasan emisi ekzos. Tujuan kajian ini adalah untuk mengkaji jenis kesan penapis udara pada kenderaan prestasi dan kesan ke atas pelepasan ekzos. Prestasi kereta dipengaruhi oleh udara yang penting untuk membuat pembakaran yang sempurna. enjin perlu campuran yang sempurna daripada bahan api dan udara untuk enjin silinder untuk pembakaran. Penapis udara enjin pembakaran dalaman adalah salah satu bahagian utama untuk meningkatkan prestasi enjin dan meningkatkan pembakaran. Walau bagaimanapun, keadaan penapis udara akan menjejaskan prestasi dan pelepasan emisi ekzos. Tujuan kajian ini adalah untuk mengkaji kesan jenis penapis udara pada enjin dari segi prestasi dan pelepasan ekzos dengan menggunakan casis dinamometer dengan perisian pro dyno-max dan penganalisis gas ekzos. penapis udara penapis udara telah menggunakan tiga jenis penapis, ia tersumbat dengan penuh dengan debu dan kotoran, penapis OEM udara baru dan juga prestasi penapis udara. Hasilnya, penapis udara tersumbat merakam hidrokarbon yang tinggi (HC), karbon monoksida tinggi dan rendah untuk oksigen. pelepasan HC yang lebih tinggi, membawa kepada sistem pernafasan manusia memberi kesan seperti asma, lapisan ozon yang lebih rendah kesan atmosphere.CO daripada pembakaran tidak lengkap bahan api. CO mengurangkan keupayaan darah untuk membawa oksigen dan boleh menyebabkan sakit kepala, masalah pernafasan dan pada kepekatan yang tinggi, juga kematian. Penapis prestasi udara menawarkan aliran udara yang lebih baik dan penapisan udara yang lebih baik untuk memasuki enjin dan membakar bahan api dengan sempurna.

ABSTRACT

The air filter internal combustion engine is the one of main part to enhance engine performance and improve combustion. However, the condition of air filter will affect performance and the exhaust emission release. The aim of this research is to study the effect types of air filter on performance vehicle and the effect on exhaust emission. The car performance is influenced by air which is important to make a perfect combustion. an engine need a perfect mixture of fuel and air to cylinder engine for combustion. The air filter internal combustion engine is the one of main part to enhance engine performance and improve combustion. However, the condition of air filter will affecting performance and the exhaust emission release. The aim of this research is to study the effect of type air filters on the engine in terms of performance and exhaust emission by using chassis dynamometer with dyno-max pro software and an exhaust gas analyzer. The air filter was using three type filter, it is clogged air filter with is full of dust and dirt, new OEM air filter and also performance air filter. As a result, clogged air filter record the high hydrocarbon (HC), High carbon monoxide and low for oxygen. The higher HC release, lead to human respiratory system affect like asthma, lower ozone layer of atmosphere.CO effect from incomplete combustion of fuel. CO reduces the ability of blood to carry oxygen and can cause headaches, respiratory problems and, at high concentrations, even death. The performance air filter offer better air flow and better air filtration to enter the engine and burn the fuel perfectly.

DEDICATION

I dedicate this final year project report to my father and mother, Mr. Jusoh Bin Salleh & Madam Rogayah Binti Wook for stay strong to care on my life journey and also to my lovely family.



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TABLE OF CONTENT

DECLARATION	iv
APPROVAL.....	v
ABSTRAK	vi
ABSTRACT.....	vii
DEDICATION	viii
ACKNOWLEDGMENTS	ix
LIST OF ABBREVIATIONS, SYMBOL AND NOMENCLATURE	xvii
CHAPTER 1	1
1.0 Introduction	1
1.1 Problem Statement	2
1.2 Objective	3
1.3 Project Scope	3
CHAPTER 2	4
2.0 Naturally Aspirated Engine	4
2.1 Major System in Internal Combustion	5
2.2 Intake system	5
2.3 Air Filter	6
2.3.1 Drop in Air Filter	8
2.3.2 Open Pod Air Filter	8
2.4 Standard Air Filter Vs Performance Air Filter	9
2.5 With Air Filter Vs Without Air Filter	10

2.6	Air Filter Construction Material.....	12
2.7	Performance Parameter	15
2.7.1	Horsepower and Torque.....	16
2.7.2	Exhaust Emission.....	16
2.7.3	Fuel Economy	18
2.8	Dynamometer	18
2.8.1	Engine Dynamometer.....	19
2.8.2	Chassis Dynamometer.....	20
2.8.3	Dynamometer Features and Function	20
CHAPTER 3		23
3.0	Introduction	23
3.1	Flow Chart.....	24
3.2	Material Selection.....	25
3.2.1	Filtration Media.....	25
3.2.2	Drop in Air Filter	26
3.2.3	Proton Perdana V6 Specification	27
3.3	Area of Testing.....	29
3.4	Approach Toward Experiment Testing	29
3.4.1	Engine Test Run and Data Collection.....	29
3.5	Experimental Testing	30
3.6	Exhaust Analyzer	31
3.6.1	Chassis Dynamometer.....	33

3.6.2	Dyno-Max Pro Software	34
CHAPTER 4		36
4.0	Introduction	36
4.1	Experiment Result	36
4.2	Clogged Air Filter	39
4.2.1	Horsepower	39
4.2.2	Torque	41
4.2.3	Torque & Horsepower vs Speed	43
4.3	New OEM Air Filter.....	44
4.3.1	Horsepower	44
4.3.2	Torque	46
4.3.3	Horsepower & Torque against Speed Engine	48
4.4	Performance Air Filter.....	49
4.4.1	Horsepower	49
4.4.2	Torque	51
4.4.3	Torque & Horsepower vs Engine Speed.....	53
4.5	Exhaust Analyzer	54
4.5.1	Hydrocarbon (HC)	55
4.5.2	Carbon Dioxide (CO ₂).....	57
4.5.3	Nitrogen Oxide (NO _x)	58
4.5.4	Carbon Monoxide (CO)	60
4.5.5	Air Fuel Ratio.....	62

CHAPTER 5	63
5.0 Introduction	63
5.1 Conclusion.....	63
5.1.1 Performance	64
5.1.2 Exhaust Emissions	65
REFERENCES.....	67
APPENDICE.....	68



LIST OF FIGURES

CHAPTER 2

Figure 2-1 - Basic four stroke internal combustion.....	4
Figure 2-2 - Air Flow Intake System	7
Figure 2-3 - Drop-In Air Filter.....	8
Figure 2-4 - Open Pod Air Filter.....	9
Figure 2-5 - (Nik Rosli Abdullah, 2014).....	11
Figure 2-6 - (Nik Rosli Abdullah, 2014).....	12
Figure 2-7 - A paper filter (Clayton,pp 87).....	13
Figure 2-8 - Cotton gauze filter (Clayton, pp 90)	14
Figure 2-9 - Foam Filter (Clayton, pp 87).....	14
Figure 2-10 - Operation of an oil bath filter (Heisler, pp 409)	15
Figure 2-11 - General illustration of the dynamometer	19
Figure 2-12 - Engine dynamometer	19
Figure 2-13 - Chassis dynamometer	20

CHAPTER 3

Figure 3-1 - Air Filter X.....	27
Figure 3-2 - Gas Exhaust Analyzer.....	32
Figure 3-3 - Example of data taken from Gas Exhaust Analyzer	32
Figure 3-4 - Chassis dynamometer	34
Figure 3-5 - DynoMax Pro software on laptop	35

CHAPTER 4

Figure 4-1 - Performance Air Filter	37
Figure 4-2 - New OEM Air Filter and Clogged Air Filter.....	37
Figure 4-3 - Chassis Dynamometer Machine	37
Figure 4-4 - Exhaust gas analyzer.....	38
Figure 4-5 - Graph of horsepower vs engine speed	40
Figure 4-6 - Graph of torque vs engine speed for clogged air filter	42
Figure 4-7 - Graph of torque and horsepower vs engine speed on clogged air filter.....	43
Figure 4-8 - Graph of horsepower vs engine speed on new OEM air filter.....	45
Figure 4-9 - Graph of torque vs engine speed on new OEM air filter	47

Figure 4-10 - Graph of torque and horsepower vs engine speed on new OEM air filter	48
Figure 4-11 - Graph of horsepower vs engine speed on new OEM air filter.....	50
Figure 4-12 - Graph of torque vs engine speed on performance air filter.....	52
Figure 4-13 - Graph of torque and horsepower vs engine speed on performance air filter	53
Figure 4-14 - Graph effect of types air filter on hydrocarbon.....	55
Figure 4-15 - Graph effect of types air filter on carbon dioxide.....	57
Figure 4-16 - Graph effect of types air filter on nitrogen oxides	58
Figure 4-17 - Graph of effect types air filter on carbon monoxide.....	60
Figure 4-18 - Graph of effect types air filter on air fuel ratio	62
CHAPTER 5	

Figure 5-1 - result on effect horsepower and speed in comparison	64
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LIST OF TABLE

CHAPTER 2

Table 2-1 - Gas and Effect	17
Table 2-2 - Dynamometer features	21
Table 2-3 - Dynamometer Type Advantages and Disadvantages	22

CHAPTER 3

Table 3-1 - Proton Perdana V6 specification	28
Table 3-2 - Example of test run data table	30

CHAPTER 4

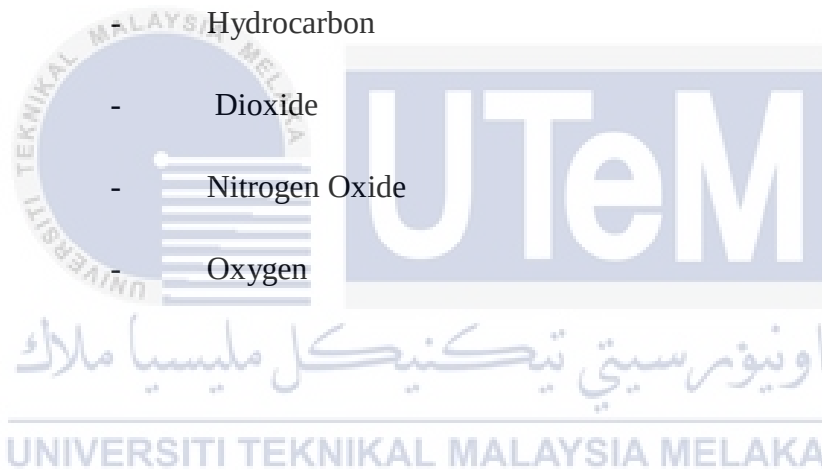
Table 4-1 - Data for clogged air filter on horsepower	39
Table 4-2 - Data for clogged air filter on torque	41
Table 4-3 - Data new OEM air filter on horsepower	44
Table 4-4 - Data for new OEM air filter on torque	46
Table 4-5 - Data for performance air filter on horsepower	49
Table 4-6 - Data for performance air filter on torque	51
Table 4-7 - Gas emissions data on exhaust analyzer	54

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LIST OF ABBREVIATIONS, SYMBOL AND NOMENCLATURE

AFR	-	Air/fuel Ratio
HP	-	Horsepower
OEM	-	Original Equipment
PPM	-	Part Per Million
RPM	-	Revolution Per Minute
HC	-	Hydrocarbon
CO ₂	-	Dioxide
NO ₂	-	Nitrogen Oxide
O ₂	-	Oxygen



CHAPTER 1

INTRODUCTION

1.0 Introduction

The air filter intake system is an appliance that is constituted of fibrous matter which removes solid particle and microorganisms from the air that prevent any matter from enter the engine cylinder. Air intake systems are the first point in the process that makes the engine produces the power that moves the vehicle. One of the main parts an intake system in a vehicle's is air filters which affect a vehicle performance, horsepower, fuel economy and exhaust emission. In order to improve combustion efficiency to enhance engine performance, introducing more the air into the air fuel mixture is an effective way(Nik Rosli Abdullah, 2014). However, the bad condition of air filter like clogged air filter will make the engine performance less which reduce the fuel economy and acceleration(Kevin Norman, 2009). Then the capacity to filter function of air into the engine is reduced when air filter become clogged. A clean air filter will increase engine life, better acceleration, lower emission and improved engine performance. Not only does an air filter clean the air entering on engine but also prevent debris from entering on the engine, and causing damage.

There are many types of air filter that used in automotive that from various material. Two types of common air filter use, which is a drop in and open pod. Drop in air filter give advantage on less noise and more fuel efficient. However, there are cons, it still hinder the movement of wind power normal or increased slightly for the drop in performance air filter. Besides, the second air filter is Open-pod type which gives benefit of more power, puffs of wind better and RPM easier ride. Disadvantages of this type is produces noise, possibility of inhaling hot air directly from the engine if without heat shield and cold air intake, easy dirty because open, less fuel efficient cause itchy feet fun kid press the pedal to the high RPM. For the type of air filter there are different category are used for each type. Air filter category is stock air filter and performance aftermarket air filter. Generally, naturally aspirated engine car usually

using a stock original air filter (OEM) from a manufacture that not most efficient in allowing air circulation and cannot used for a long time. Different with a performance air filter, which are high performance and also more efficient in allowing maximum of air circulate in an engine which is that turbo engine used. The stock filter will offer good enough airflow and overall performance when it's new and clean, but will become worse very quickly when it clogs up. Differs with performance air filter that is reusable through washing it and improve engine horsepower and also enhance fuel consumption.

1.1 Problem Statement

Generally, the NA engine uses the stock standard air filter that some research show the standard air filter cannot stay for a long time, also cannot be reused where waste money and less performance. While, performance air filter can offer better airflow and better filtration of the air that entering the engine. The performance aftermarket air filter of filtration can increase air intake pressure by high speed on the engine where increase performance engine, increase air flow due to increasing acceleration and increase fuel economy. This is because of the type of material used in developing a good air filter.

In order to researches the effect on NA engine, the change of stock original air filter to performance air filter are needed to know how air filter type will affect the torque, horsepower and exhaust emission. This is the easiest way to improve airflow to the engine is by replacing the stock air filter with a performance air filter. The low performance and durability of engine air cleaner are effect if using any low performing serviceable aftermarket air filter. Then, the better design of air filter is required to maximize filtration performance, improve flow management, and improve engine durability. Other than that, with change air filter to proven that performance air filter will save consumer money and the comparison of these air filters.

1.2 Objective

- To study the effect of type air filters on the engine in terms of performance and exhaust emission by using chassis dynamometer and an exhaust gas analyser.
- To compare the result between using clogged air filter, new OEM air filter and performance air filters.

1.3 Project Scope

This project will focus on study of engine performance on car model Perdana v6 by using clogged air filter, new OEM air filter and performance air filter. The chassis dynamometer test will be done to get the result on torque and horsepower. The exhaust emission analyzers are able to measure the exhaust emission result. This research project will compare the differences between the clogged air filter, new OEM air filter and performance air filter.

CHAPTER 2

LITERATURE REVIEW

2.0 Naturally Aspirated Engine

A naturally aspirated engine is an internal combustion engine where the air intake depends merely on atmospheric pressure and which does not depend on forced induction through a turbocharger or a supercharger. Heat engine can divide into two types it is external combustion engine and an internal combustion engine. In external combustion, a heat engine in which ignition occurs outside the chamber in which heat is converted to mechanical energy. There are two categories of external combustion, which is steam system and turbine. Secondly, internal combustion (IC) consists of two types, petrol engine and diesel engine. Internal combustion engine is a heat engine that change chemical energy that keep in a fuel into mechanical energy, usually made on a rotating output shaft.

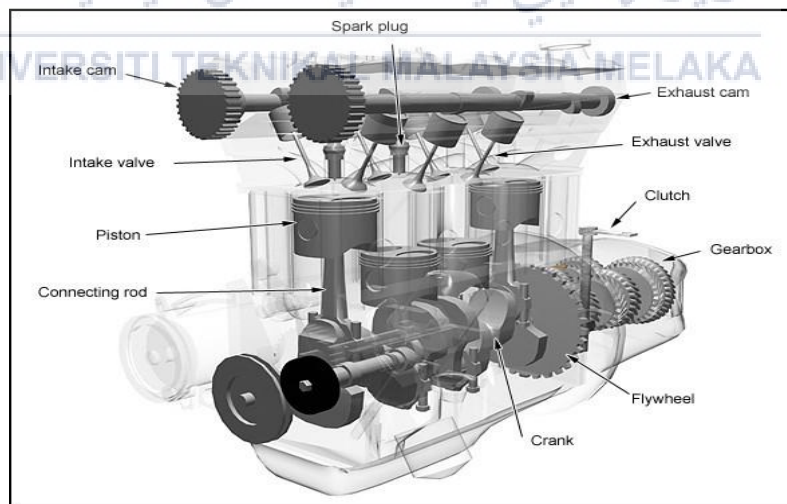


Figure 2-1 - Basic four stroke internal combustion

2.1 Major System in Internal Combustion

Every car had several systems for internal combustion in order to carry out specific activity and perform each duty for running engine perfectly. There are list the major system that include in internal combustion engine:

- i. Intake system
- ii. Exhaust system
- iii. Lubricating system
- iv. Electrical system
- v. Cooling system
- vi. Fuel system
- vii. Hydraulic system
- viii. Drive Train system

2.2 Intake system

An intake system is a set of part that essentially let an internal combustion engine to breathe in, in the same way that the exhaust system allows it breathe out. The intake system designed to increase engine performance, whether for power and torque which is air admission system are created to replace the OEM air-box of the car.

The old intake systems were simply duct that allowed air to pass unimpeded into the carburettor, for a modern naturally aspirated, air consumption framework has three fundamental parts air filter. It shapes an imperative part of a vehicle's admission framework through which the engine relaxes. Intake system has three main parts such as air filter, mass air flow sensor and throttle body.

The air filter is one of the main part because what are coming inside the engine are the factor engine can run smoothly or not also affect the performance of the engine. An engine needs a perfect mixture fuel and air to engine the cylinder for combustion. Every air need to enter intake air filter for dirt and any particle dust to be filtration. This catches foreign particles in the air are important to maintaining the performance engine and preventing dirt from entering the system and possibly damaging the engine (B.Payan Kumar Goud, 2014).

Mass Air Flow Sensor second main part of intake system that function to relay a signal to the engine control unit (ECU) and detects the amount of air drawn into the engine. Then, the proper amount of fuel to deliver to the engine was calculated by the signal.

Thirdly is throttle body. Throttle is a valve that directly controls the amount of air entering the engine. Simply it means throttle body is to control the intake air flow in an internal combustion engine to avoid engine from various problems. It also indirectly controlling the charge (fuel + air) burned on each cycle due to the fuel-injector or carburettor sustain a relatively constant fuel/air ratio.

2.3 Air Filter

A filter is a permeable membrane that gas or liquid is move through in order to split out the matter. Filters are important in automotive because they remove contaminants that get into mechanical and lubrication systems. Air is a type of pollution surround with all kinds of contaminant particles such as smog, fumes and others where these particle are usually not visible with the eye, but they are harmful to the engine and can lead to some damage of components (Albert K.Sunnu, 2013) . Without proper filtration, these contaminants would cause significant damage to mechanical components. It means air filter is a device to the appliance of fibrous material which removes particulates and prevents abrasive particulate matter from entering the engine cylinders.

There are two categories of air filter for a car which is air filter intake system and the cabin air filter. Cabin air filter is for a vehicle passenger compartment that

placed outside the air intake. In an automotive intake system, the air filter always sits ahead of the throttle body and mass air flow sensor and for old vehicle its location at above carburetor or throttle body. The air filter in an air intake system permanently removes unknown particles such as dust and sludge from the intake air, thereby maintaining the performance of the engine and protecting it from damage. A spotless air channel results in enhanced gas mileage, better speeding up, expanded engine life, lower discharges and general enhanced motor execution. Not just does an air channel clean the air entering the engine, however, it additionally keeps flotsam and jetsam from entering the engine and bringing about harm. As an air channel gets to be filthy, the limit for it to channel the air going into the engine is diminished (De Amaral, 2013). Once the air filter become clogged it will affect engine to work properly like emission control systems of the car; reducing air flow and causing a too rich air-fuel mixture which can foul the spark plugs also drivability problem. Two types of air filter that are available in a market which are open pod air filter and drop in air filter.

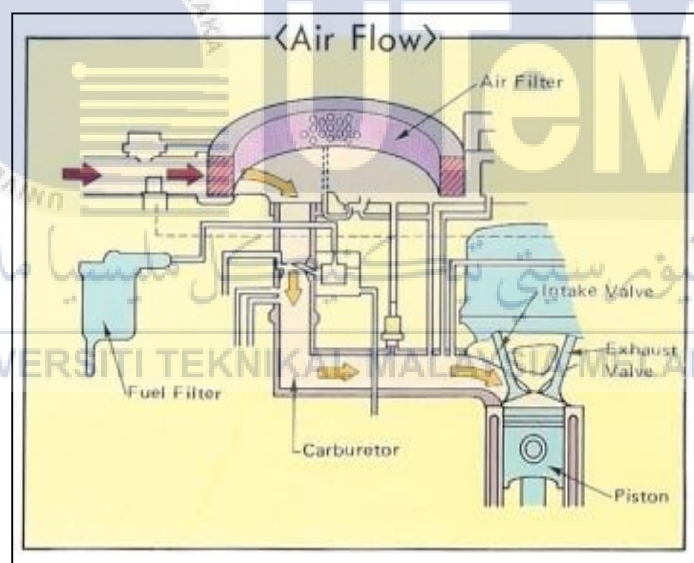


Figure 2-2 - Air Flow Intake System

2.3.1 Drop in Air Filter

Drop in air filter is easily to in term of replacement. This type is simple and can swap OEM air filter without modification necessary. Even the filtration not as good but for air intake is generally better than standard OEM air filter. The advantages of this air filter are less noisy, unusual appearance and more fuel efficient. However, disadvantage is it hinders the movement of wind, normal power or increased slightly for the drop in performance air filter.

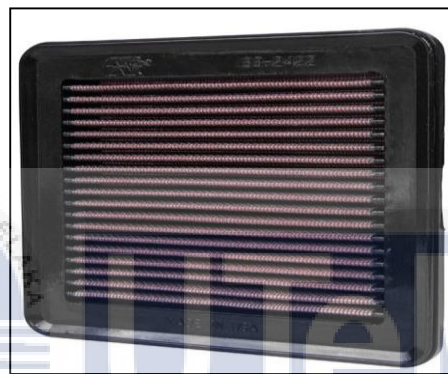


Figure 2-3 - Drop-In Air Filter

2.3.2 Open Pod Air Filter

Open pod is larger in size and it need to remove of the whole standard air intake unit when changing the air filter. The open pod can give the best performance when it comes to air intake but lack filtration capabilities. Open pod pros are better inhalation of the wind, more power and easily increase speed. The disadvantages are it produces noise, the possibility to inhale hot air directly from the engine without heat shield and Cold air intake. Then, open pod air filter is easy to become dirty because of the open type, and cause less fuel efficient if pedal is always pressing at a high RPM.



Figure 2-4 - Open Pod Air Filter

2.4 Standard Air Filter Vs Performance Air Filter

Some studies were done on the effect of the different types of air filter and condition of performance and emission of four stroke engine. (Sulay N.Patel, 2013) The researcher was running for four tests. The first one is Wide Open Throttle test, which the purpose is to check the changing in air filter pressure drop. The second test is, Initial Testing that uses the different air filters and it will explore largest clean until clogged air filter. The third test is Highway Fuel Economy Test (HFET). This test run at least three rounds with new air filter and clogged air filter to check whether fuel economy increases or not. Then, the result shows the standard OEM filter are in higher pressure drop than aftermarket performance filter. The relationship are show the higher pressure drop, more energy need to take to move air through air filter and make powerless. The main part of an intake air system is an air filter, which function to reduce the pollutant in the air intake to maximise reduction, but at the same point to increase the flow restriction of air intake (Nik Rosli Abdullah, 2014). There are many types of air filter that use in a drop in and open pod type that can be created from various filter media. Air filters is one of the most usual part of the engine that the public think it is economical, provide induction noise and can offer an immediate power gain. Without public realize, using of low performing serviceable aftermarket air filter affect the performance and durability of engine air cleaner (Bugli, 2005). The first category of air filter is a standard stock air filter. Standard stock air filter is an

original air filter that is already available in the car engine that is coming from the manufacturer and is mostly made up from the paper material.

From the research studies, there are some pros and cons identified for using standard air filter and performance air filter. Performance air filter is an aftermarket air filter that can offer better air flow and better filtration of the air that enter the engine. It is also improving economical because the engine can get enough air to burn the fuel perfectly. The aftermarket air filter of filtration can also increase performance, increase air flow due to increase in acceleration and increase fuel economy. It can also boost the engine horsepower and save money since it is reusable and washable. However, performance air filter, maybe, sometime will let too much dirt through it, thus, it will require regular cleaning. Most of the naturally aspirated engine use the standard air filter. However, the standard air filter cannot stay for a long time because once it become clogged of dirt it cannot be used anymore. Thus, the standard type is not reusable and washable. It will be waste money to use a standard type because it will need to be changed at a suitable millage and performance also at normal. However, standard advantage is cheap to manufacture and simple in servicing and also easy to replace. Although it cannot beat the performance type, the standard air filter still can provide a good air flow and consistent horsepower with little pressure drop across the filter.

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2.5 With Air Filter Vs Without Air Filter

To enhance engine performance, more air should be let into the air mixture so that it can increase combustion efficiency. In order to let more air into a fuel mixture, increase the air flow rate is to reduce the air flow restraint through air filter element. Running an engine without an air filter can damage various components when the contamination is freely moving into the intake and the engine. It disturbs the internal combustion engine that depends on air for use as an oxidizer in the process of burning fuel.

Analysis on engine performance, fuel consumption and exhaust emission by using an air filter and without an air filter prove that the different air intake pressure effect these engine behaviour (Nik Rosli Abdullah, 2014).An experiment by using

5kW eddy current type electric dynamometer are running for fuel consumption checking. Analysis on engine performance, Fuel consumption influenced by the air fuel ratio where leaner combustion will consume less fuel and richer combustion will consume more fuel (Sayin, 2010). Without an air filter the removal air volume is bigger than the variable with the air filter.

The main factor affecting the air intake in a naturally aspirated engine is the engine speed. Air intake pressure will happen with greater engine speed. On analysis at figure 5, the percentage of carbon dioxide volume is increase without an air filter and decreasing with an air filter. This is because of lower quality of combustion due to a richer air fuel mixture caused by less induced air in the carburettor. From the graph in figure 6, it can be concluding that NO_x composition without air filter fluctuated from condition 1 to 3, but variable with an air filter, the NO_x formation decreased from condition 1 to 3. The most obvious different is in condition 3. The improved combustion process causes higher in-cylinder temperature and pressure on the varying without an air filter, which then contribute to the increasing NO_x composition (Abdullah et al., 2009). The increase in combustion pressure and temperature in the condition without an air filter increases the formation of NO_x (Nik Rosli Abdullah, 2014).

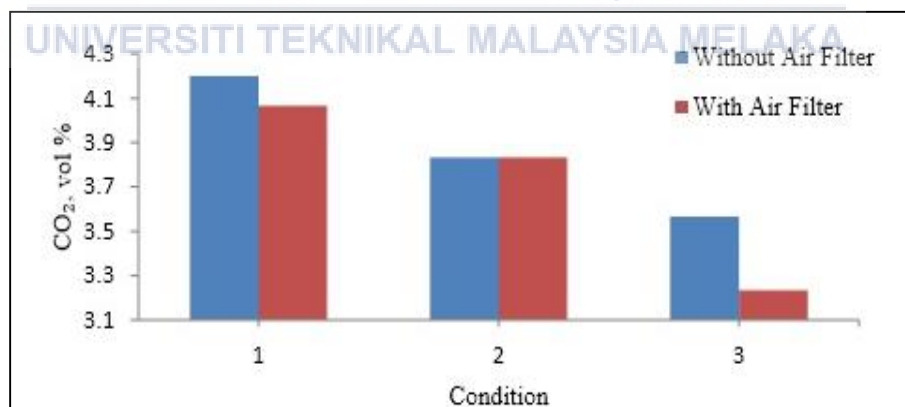


Figure 2-5 - (Nik Rosli Abdullah, 2014)

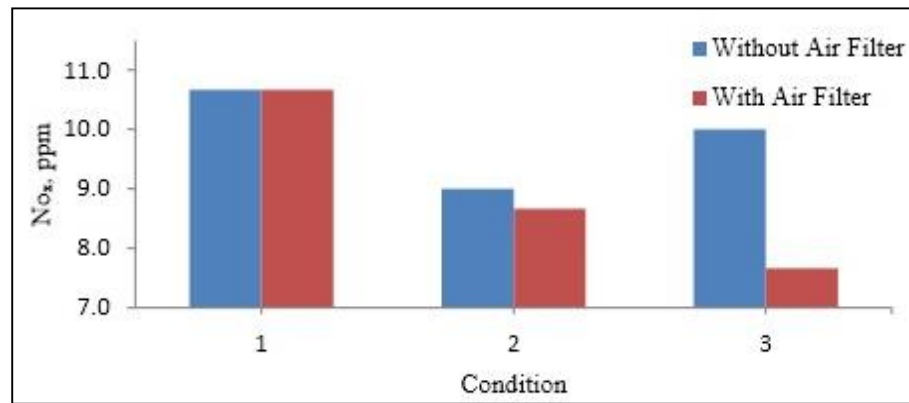


Figure 2-6 - (Nik Rosli Abdullah, 2014)

2.6 Air Filter Construction Material

Air filters function in trapping some of the small particles in environment while allowing air to flow relatively unrestricted. When air first enters the intake system, it has to pass through the air filter. By passing through the filtration media, any particle matters larger than the pores in the filter gets stuck, while the air itself is capable to pass through. This causes a certain level of restriction on the flow of air, but it is typically negligible when the filter is relatively clean. The material construction element is important in producing a better filtration on intake system.

Three main filter characteristics should be examined. Firstly, is the flow that filter must have the ability to flow a sufficient quantity of air or liquid for normal application operation. The second consideration is the usable capacity of the filter. The filter must have adequate contaminant-holding capacity to stay around in service for an acceptable period of time. As soon as the air filter becomes dirty, the capacity for it to filter the air going into the engine is reduced (B.Payan Kumar Goud, 2014). Finally, is the ability to adequately remove contaminants of a size critical for the application. This refers to air filter efficiency. Efficiency is a major factor when selecting engine air filter although dust holding capacity is the primary feature (Schwartz, 2008). There are 4 basic air filter media construction. It is paper, foam, cotton and oil bath.

a) Paper

Generally, many fuel injection vehicles use the paper material that is pleated paper filter to increase the surface contained within a given volume space. However, it had metal or plastic component to provide rigidity. Pleated paper is considered as a wear item and once it becomes clogged, it cannot be used anymore. However, some type of pleated paper is creating due to improvement that specialise to reuse and become more efficient, easy to service also cost effective.

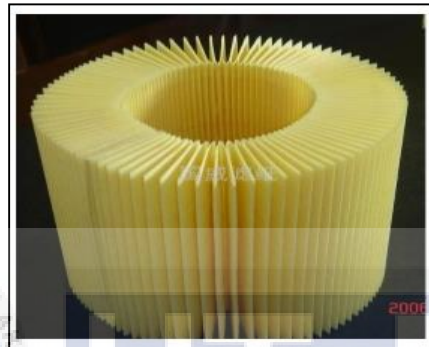


Figure 2-7 - A paper filter (Clayton,pp 87)

b) Cotton

The cotton type element is long lasting and for high performance market. This material construction is treated with oil to help particulate trap without creating excessive construction on air flow. So no clogged will happen. Cotton air filter is washable and re-oiled before using it again. Cotton air filter is made of oil-wetted cotton gauze and is better known for high-performance automotive applications such as racing cars.



Figure 2-8 - Cotton gauze filter (Clayton, pp 90)

c) Foam

The foam material is more or less the same with cotton which used oil to trap the particle. This foam uses polyurethane soaked in oil foam. Polyurethane is open cell material that lightweight, low odour, and high resistance to mildew for filtration. The polyurethane foam is high tensile and elongation. This type had high level of air flow to trap the particle before it becomes obstructed. For motorsport, it has ability to pack a lot of dirt. The good thing in high dust condition is that it can be cleaned and reused. The multilayer foam filtration technology eliminates engine air filter maintenance in term of cost while it is also improving engine durability and decrease evaporative emission (Sulay N.Patel D. P., 2013).



Figure 2-9 - Foam Filter (Clayton, pp 87)

d) Oil Bath

Oil bath consists of a pool of oil, fibre, foam and mesh. It's very high level dust encountered where this material type can be strained and separate dirt in all size without eliminating the efficiency

or air flow. However, liquid oil must relatively bigger to avoid excessive restriction at high air flow rate and they tend to increase exhaust emission of unburned hydrocarbon

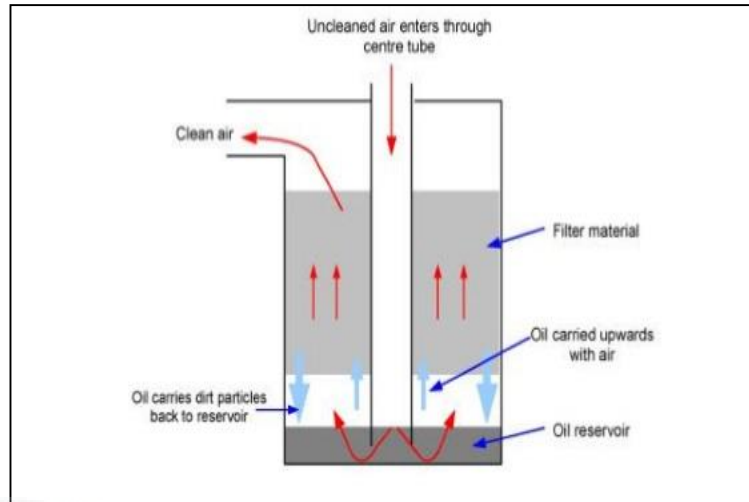


Figure 2-10 - Operation of an oil bath filter (Heisler, pp 409)

e) Stainless Steel

Stainless steel material allows more air to pass through and can give maximum engine efficiency. Used on turbo engine to make sure no particle can enter the engine through the turbo.

2.7 Performance Parameter

The intake air filter condition affects engine performance. The better filtration and pressure into the engine can increase performance, increase air flow due to increasing acceleration and increase fuel economy. Clogged air filter increases the pressure drop which reduces fuel economy and acceleration, but fuel economy, not significantly affected in electronic injection, but in case of carburetted engine clogged air filter affects more (Sulay N.Patel D. P., 2013). The engine without an intake air filter will increase the formation of NO_x where it increases combustion pressure and

temperature (Nik Rosli Abdullah, 2014). There are various performance parameters that can be measured using dynamometer machine.

2.7.1 Horsepower and Torque

An engine operates by taking in air (oxygen), mixing it with fuel and burning the resulting mixture to produce power. The better outline, air filter will give the base limitation, permitting high airflow into an engine. The expanding air flow will build engine performance measured by horsepower and throttle reaction (torque). The power of an engine is called horsepower that characterized as work over time. Torque is the propensity of a power to pivot an article around a hub as a power is push or draw, a torque can be considered as a turn to an object measuring the torque output of the engine. In a vehicle, torque is measured at various engine speeds, or revolutions per minute (RPM). Torque is how strong the engine is and horsepower is a measure of how fast it can use that power. In some research (GoaCbiewski, 2013), the engine without air filter being mounted reached the maximum torque of 140.1 Nm at lower rotational speed ($n=1900 \text{ min}^{-1}$) when compared to that with air filter being mounted 131.0 Nm ($n=2200 \text{ min}^{-1}$). Without air filter, expanded standard measurement uncertainty for engine torque did not exceed 1%. The torque value is thus larger by 6.9% for engine.

2.7.2 Exhaust Emission

Exhaust emission is a smoke that is a nuisance to the public environment which produced from incomplete combustion such as oxides of nitrogen and unburned hydrocarbon. To enhance engine performance, let more air into air fuel mixture can improve combustion efficiency for a complete combustion with reduce air flow restriction through a better air filter element (Nik Rosli Abdullah, 2014). Good reaction between oxygen and fuel during combustion process make CO₂ emission increase (Sayin et al). By using

analyzer exhaust emission composition, it able to produce the percentage of emission composition and ppm for gases. Without an air filter in filtration, the more incomplete combustion will happen in the engine. The enhanced burning procedure, that causes higher in cylinder temperature and pressure on the variable without an air filter, which at that point leads to higher NO_x composition (Abdullah et al., 2009). A combustion process in automotive can be concluded into two types of pollutants which are perfect and unperfected combustion.

Exhaust emission is a pollutant that comes out of the tailpipe exhaust when the engine running. Both gasoline and diesel are mixture of compound which is carbon atoms and hydrogen. By refer on table 1, there are 5 gases that normally produced from engine combustion.

Table 2-1 - Gas and Effect

GAS	EFFECT
Hydrocarbon (HC)	1. Unburn fuel 2. React with NO_x in sunlight to produce photochemical oxidants (including ozone) cause breathing problem and asthma.
Carbon monoxide (CO)	1. Incomplete combustion of fuel 2. CO reduces the ability of blood to carry oxygen and can cause headaches, respiratory problem and death.
Carbon dioxide (CO ₂)	1. Non-toxic gas, but contributes towards acidification of the ocean. 2. One of important greenhouse gases 3. Reduces CO₂ emission to combat global warming
Oxygen (O ₂)	1. No adverse effect
Oxides of Nitrogen (NO _x)	1. React with HC to produce low level ozone. 2. Reduced lung function

2.7.3 Fuel Economy

Engine performance was affected by an air filter condition where the clogged air filter increase pressure drop that reduces fuel economy on Highway fuel economy test (Sulay N.Patel D. P., 2013). However, the fuel economy is not affected on electronic injection, but effect on carburetted engine clogged air filter. Then, the high air intake improves fuel economy by letting a leaner air fuel mixture. The fuel consumption directly influences by the air fuel ratio (Nik Rosli Abdullah, 2014).

2.8 Dynamometer

Dynamometer is simply known as a measurement of change in performance. It measures mechanical force, speed (RPM), and torque (Nm or lb-ft), in which used in calculating power (HP or kW) of device such as transmission, engine, electric motor and generator. Using four stroke gasoline engine attached to a dynamometer for the variation of engine speed and load (Nik Rosli Abdullah, 2014). Two types of dynamometer are engine dynamometer and chassis dynamometer. Dynamometer testing means the engine is running under its own power up to control amount of resistance. The reason of using dynamometer for measurement is to address engine performance and durability before the installation, behavior to controlled break-in of a newly rebuilt engine and identify a problem without risking a breakdown on the road. Thirdly, to test a vehicle without the need for a Commercial Driver License and reduce warranty or return for service after a reconstruct or repair.

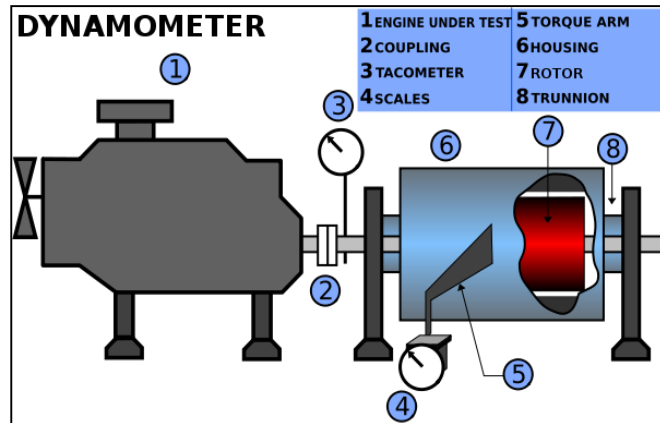


Figure 2-11 - General illustration of the dynamometer

2.8.1 Engine Dynamometer

Engine dynamometer is measures torque directly attach to the engine and give accurate picture of how much power the engine makes. An engine dynamometer is a device used to test an engine that has been expelled from a vehicle, generator, or whatever other piece of hardware powered by an internal burning engine. The objective is to confirm performance before the engine is introduced back in the hardware. Engine dynamometer can help troubleshoot by deciding when an engine is overheating, or by recognizing irregular performance and sensor issues. The engine dynamometer can be divided into four categories which are eddy current, AC engine, water brake and DC type.



Figure 2-12 - Engine dynamometer

2.8.2 Chassis Dynamometer

Chassis dynamometer measures engine output at a wheel that measure torque and power deliver by power train direct from drive wheel. Chassis dynamometer can be divided into three categories which are water brake chassis, eddy current chassis and AC chassis.



Figure 2-13 - Chassis dynamometer

2.8.3 Dynamometer Features and Function

There are some differences between engine dynamometer and chassis dynamometer that can be clearly seen. Firstly, for the measurement, engine dynamometer measures torque directly and give an accurate picture on how much power the engine makes. Its accurate result gets directly from the engine which does not count the power loss in a drivetrain. Instead, chassis dynamometer measure engine output to measuring power at drive wheel that has standard factor for engine power losses through drivetrain. It has high loss mechanical energy (tire or gearbox). Next, the engine dynamometer has a control board to show reading of torque, RPM, temperature, pressure, exhaust temperature, air fuel ratio via sensor connector to engine. It is also easy to access the engine for turning, repeatability and well controlling testing. For chassis dynamometer, it has a capability to monitor air fuel ratio and efficient drivetrain.

Table 2 state the features of a dynamometer, while table 3 list the advantages and disadvantages of the four types of dynamometer.

Table 2-2 - Dynamometer features

Features	Eddy Current	Alternating Current	Direct Current	Water Brake
Motoring Ability	No	Yes	Yes	No
Inertia	Varies	Low	High	Low
Control Stability	Good	Excellent	Very Good	Low
Speed Capability	High	High	Moderate	High
Power Line Regeneration	No	Yes	Yes	No
Control Response	Moderate	Fastest	Fast	Slow
Cooling Requirements	High	Low	Low	High
Electrical Requirements	Low	High	High	None
Technology	Old	New	Old	Old
Power Range	High	Moderate	Moderate	High

Table 2-3 - Dynamometer Type Advantages and Disadvantages

Dynamometer Type	Advantages	Disadvantages
Eddy current	Precise control Low maintenance Widely accepted in the automotive industry	High inertia Moderate cost
Ac	Motors and absorbs Very low inertia Very fast response Line regenerative	High cost Requires high amperage electrical service
DC	Motors and Absorbs Fast Response Blower Cooled (No coolant required) Line Regenerative	High Cost (Dynamometer and Power Amplifier) High Inertia Requires high amperage electrical service
Water Brake	Low Cost Low Inertia	Difficult to Control High Maintenance

CHAPTER 3

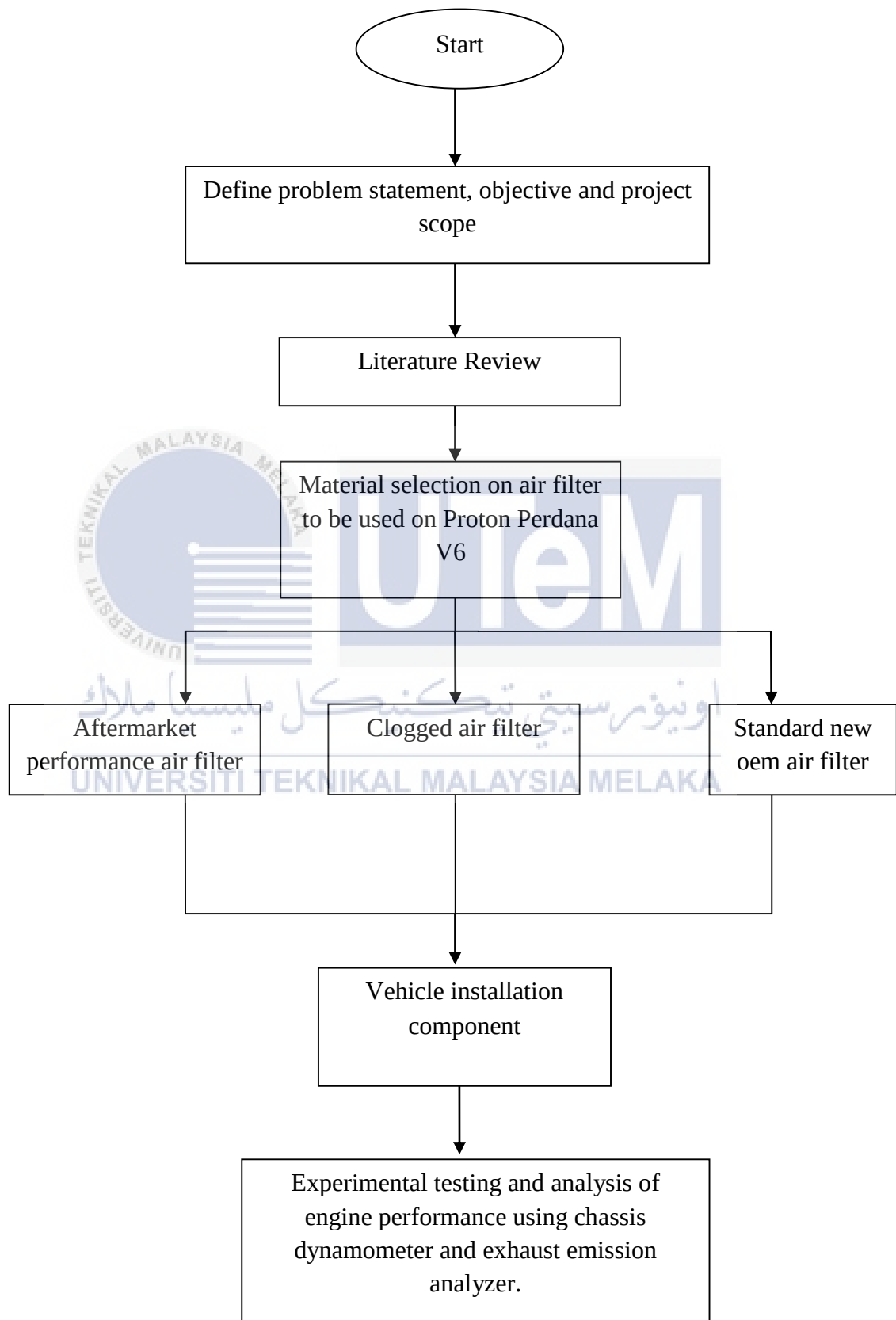
METHODOLOGY

3.0 Introduction

This section will explain on how this project will be conducted in order to achieve the objective. The aim of this project is to get the result on effect air filter on the engine V6 in term of performance and exhaust emission by using chassis dynamometer and an exhaust gas analyzer. This section will cover up the equipment detail, material selection choosing and others related.



3.1 Flow Chart



3.2 Material Selection

The experiment will be running using three type of air filter which is a standard new oem air filter, clogged air filter, and performance air filter that will be installed in engine car. In order to study the effect of different air filters on the engine performance, some criteria are listed down in choosing the better air filter for the testing.

3.2.1 Filtration Media

The filtration media chosen are important to filter dirt since dust is harmful to the engine because it decreases carburetor and efficiency. The harmful dirt is able to damage the various parts of the engine like exhaust valve and cylinders. Second filtration choosing factor is mileage, where it is improved by changing the air filter from a time needed. Replaced the clean air filter will contribute the car to get the mileage the car wants. Moreover, by changing the air filter, the material construction media will affect the millage of a car. Air filter paper must be replaced in approximately 15000 miles. Pleated-paper filter is sized appropriately for the airflow volumes encountered in a particular application, such filters present only trivial restriction to flow until the filter has become significantly clogged with dirt. Then the stainless steel with nonwoven fabric are efficient in letting air into engine. It allow maximum of air to circulate in engine and designed to increase horsepower. After refer to all type of filtration media, the paper air filter for new OEM air filter was choosing and stainless steel material for performance air filter.

3.2.2 Drop in Air Filter

Some survey on air filter is done to check the type of performance air filter that is still available on nowadays market for Proton Perdana v6. The survey is carried out to know the advantages on each performance air filter available and filtration media that manufacturer used. Drop-in air filter is easily for replacement and no modifications are necessary. The air intake is better than the standard OEM air filters but filtration is not as good. That is the reason why the performance air filter is use in order to know the performance and emission on the engine, and also to complete the objective which is to compare standard and performance air filter effect. Finally, the drop in type air filter is chosen because of the stainless steel with nonwoven fabric material that will be long lasting and for high performance market. These criteria on material construction are treated with oil to help particulate trap without creating excessive construction on air flow. So no clogged will happen. From some study on the manufacture, the air filter x is the most suitable because it creates to increase the horsepower and torque engine.

1) Air Filter X

- Increase horsepower (5%- 20%) , improved throttle response
- Greater torque throughout engine RPM
- Extends engine life span
- Save cost where washable air filter, light weight and strong
- Material from stainless steel, durable rubber & nonwoven Fabric
- Higher air intake and more dust absorbing than original paper air filter.



Figure 3-1 - Air Filter X

3.2.3 Proton Perdana V6 Specification

Proton Perdana V6 is the engine selected for the experiment on the engine performance. Proton Perdana V6 is a 4 doors sedan/saloon car equipped with a 1999 cc 150 ps petrol engine. This 2 liter engine generates 150 ps at 6750 rpm and its max torque value is 179 nm at 4000 rpm. The car's weight is kg. It is a front wheel drive car and the petrol engine of the Perdana V6 emits g CO₂ per km.

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Table 3 -1 - Proton Perdana V6 specification

Bodywork Specification	
Body type	4/5 seater sedan/ saloon
Number of doors	4
Engine of Proton Perdana V6	
Engine type	Naturally aspirated petrol
Engine manufacture	Mitsubhishi
Engine code	6A12
Cylinders	V6
Engine volume	2 liter / 1999cc / 121.986 cu in
Engine properties	double overhead camshaft (DOHC) 4 valves per cylinder 24 valves in total
Max engine power / maximum output [hp/kW/rpm]	150ps / 148bhp / 110kW @ 6750 rpm
Specific output	74 bhp/liter 1.21 bhp/cu in
Max torque	179 Nm (132 ft·lb) (18.3 kgm) at 4000 rpm
Specific torque	89.54 Nm/liter 1.08 ft·lb/cu 3
Bmep (brake mean effective pressure)	1125.3kPa / 163.2psi
Engine coolant	Water
Unitary volume	333.17 cc
Aspiration	Normal
Performance	
Accelaration 0-100km/h	13.00 s
Maximum speed	205 km/h (127mph)

3.3 Area of Testing

The area for the test engine running will be at the engine laboratory located at Universiti Teknikal Malaysia Melaka. This place is chosen because of the safety and it is that far from the public, no cost is needed on using the machine, and this laboratory has all the facilities that are needed for the test.

3.4 Approach Toward Experiment Testing

Before the test running on the machine, the basic knowledge of technical procedure is needed for changing air filter with another air filter. The equipments needed for this project include a high performance laptop with a suitable requirement for DynoMax Pro software air filter selection type, gas exhaust analyzer and chassis dynamometer.

3.4.1 Engine Test Run and Data Collection

- In this process, the engine model needs to be checked out for faulty on the external and internal parts. Then, the engine will be servicing by changing a different air filter for this project.
- The tools or machine that have been selected is, chassis dynamometer, dynomite100 software, exhaust gas analyzer. After the car has been serviced, the engine will undergo the test run process. Pre data collection will be done to determine the engine power and torque outputs after being tested for at least 3 times of running tests. The data sample will be written in a table below. This table will be used as a check sheet for each test run session for recording the data of the engine torque, horsepower and the exhaust emission.

3.5 Experimental Testing

The test that will be carried out is the gas emission test using exhaust gas analyzer (model 5002), chassis dynamometer for the performance test, and software.

Table 3 - 2 - Example of test run data table

ENGINE SPEED (RPM)	TORQUE OUTPUT (N/M)	POWER OUTPUT (Hp)	EXHAUST EMISSION
1000			
1500			
2000			
2500			
3000			
3500			
4000			
4500			
5000			
5500			
6000			

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3.6 Exhaust Analyzer

Exhaust Emission analyzers is a device that calculate the quantity of air pollutants that caused from the engine or industry release into the air. This machine has to warm up about 5 to 10 minutes before running. Three major air pollutants that the gasoline-fuel vehicle generates are hydrocarbons (HC), carbon monoxide (CO), and Nitrous oxide (NOX). This exhaust emission analyzer is a portable EMS with large integral LCD panel where that device can detect multiple gasses including Oxygen (0-25%), Carbon Monoxide (0-10%), Carbon Dioxide (0-20%) and Nitrogen Oxide (0-5000 ppm). Lambda and Air Fuel Ratio also can be calculated and link to the computer. This device has a fast response time which < 9 seconds and up to 90% accuracy.





Figure 3-2 - Gas Exhaust Analyzer



Figure 3-3 - Example of data taken from Gas Exhaust Analyzer

3.6.1 Chassis Dynamometer

A chassis dynamometer or called as rolling road measures power delivered to the surface of the "drive roller" by the drive wheels. The vehicle is often parked on the roller or rollers, which the car then turns, and the output measured thereby. Chassis dynamometers can be fixed or portable, and can do much more than display RPM, horsepower, and torque. With modern electronics and quick reacting, low inertia dyno systems, it is now possible to tune to best power and the smoothest runs in real time. Other types of chassis dynamometers are available that eliminate the potential for wheel slippage on old style drive rollers, attaching directly to the vehicle hubs for direct torque measurement from the axle. Because of frictional and mechanical losses in the various drivetrain components, the measured rear wheel brake horsepower is generally 15-20 percent less than the brake horsepower measured at the crankshaft or flywheel on an engine dynamometer

Once the vehicle is at metal rollers on the ground or on a movable stand onto which cars can be driven for testing their engines, brakes on the rollers are disengaged. Now when the vehicle engine starts turning its wheels, the rollers turn too but the vehicle remains stationary. The rollers are actually very heavy metal drums connected up to sophisticated electronic measuring instruments that figure out how much torque, horsepower, or speed the engine is capable of producing by measuring how fast the drums take to accelerate. A device like this is called a chassis dynamometer. It's a type of absorption dynamometer that uses the drums' heavy inertia to soak up the car engine's power.



Figure 3-4 - Chassis dynamometer

3.6.2 Dyno-Max Pro Software

DYNO-MAX “Pro” Software creates a full vehicle dashboard on PC or laptop. Features include: real-time trace graph display, adjustable-limit alarm warnings, pushbutton controls, user configurable analog and digital gauge ranges, color graphing, test-report database, instant playback, full inertia compensation, Smart Record trigger points, adjustable data dampening, multiple data import/export options, semi-automatic zeroing, voice alarms on all gauges, wireless remote Pocket DYNO-MAX control interface, drag strip and others. DYNOMite data-acquisition computer displays and records true unlimited Hp, torque, RPM, elapsed time at up to 1,000 readings per second (per channel). It will even automatically apply SAE correction factors for air temperature, barometric pressure, and relative humidity. More than acceleration Hp can be measured with DYNOMite absorption units, because they utilize an actual strain-gauge-equipped torque transducer. Measuring power under a controlled RPM load is vital for the proper mapping of engine management systems and guess-free emissions work. Avoid dyno that simply spin the vehicle’s tires up against their roll’s inertia (flywheel resistance) without having any ability to simultaneously control and measure absorption load. Rather than measuring the torque, they derive it from the acceleration.



Figure 3-5 - DynoMax Pro software on laptop



CHAPTER 4

RESULT AND DISCUSSION

4.0 Introduction

This section will shows all data from the DYNO-MAX “Pro” Software for chassis dynamometer and exhaust analyzer. The data come out after use the three different air filter which is clogged air filter, new OEM air filter and performance air filter. The aim of this project is to get the result on effect air filter on the Proton Perdana V6 in term of performance and exhaust emission. The data will be represent in the table and graph.

4.1 Experiment Result

In this project, there are two experiments that had been conducted, which is using chassis dynamometer and exhaust analyzer. For chassis dynamometer the data are come out from linked on Dyno-,Max Pro software on the computer, meanwhile, data for exhaust analyzer were shown on the panel screen equipment. The engine were running at idle 2500 rpm for data start taken and the result for horsepower and torque we taken at the higher speed also same goes to exhaust analyzer data.



Figure 4-1 - Performance Air Filter



Figure 4-2 - New OEM Air Filter and Clogged Air Filter



Figure 4-3 - Chassis Dynamometer Machine

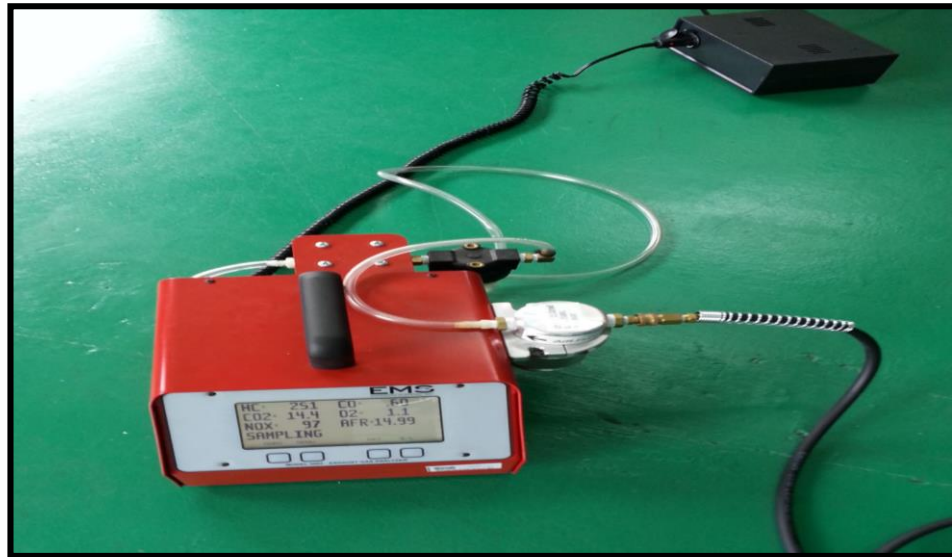


Figure 4-4 - Exhaust gas analyzer



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4.2 Clogged Air Filter

4.2.1 Horsepower

Table 4-1 - Data for clogged air filter on horsepower

Speed (RPM)	Horsepower (hp)
2398	8.69
2592	11.65
2906	15.69
3482	17.00
3709	25.42
4882	27.54
5406	28.01
5576	30.46
6007	33.95
6963	34.47
7088	35.25
7196	38.24
7229	41.63
7248	45.55
7272	47.68
7299	45.15
7326	36.95

From the table 4-1, by using clogged air filter, the result shows at idle speed (2398 RPM) the horsepower is 8.69 HP. The pedal was accelerating until the maximum speed. The data was record that the higher horsepower for clogged air filter is 47.68 HP.

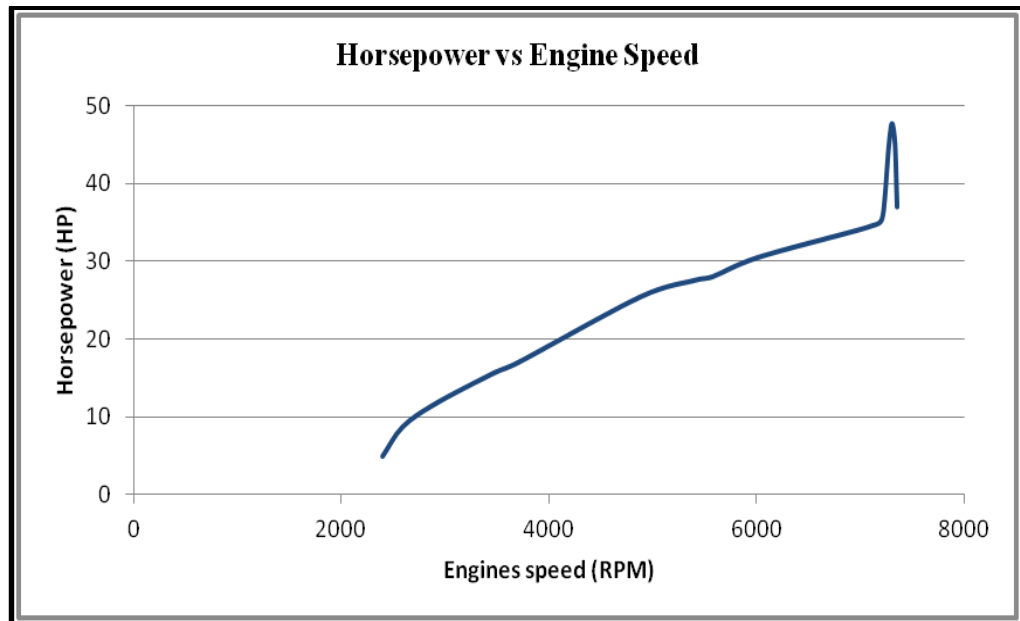


Figure 4-5 - Graph of horsepower vs engine speed

From the figure 4-5 above, the graph shows the changing of horsepower over the engine speed. Axis of x shows the speed (RPM) with interval 2000 RPM and y-axis are set for horsepower (HP) with 10 HP intervals. The horsepower is a measurement on how fast it can used power. The graph visually shows it slightly increases and at the some peak point of speed the horsepower value are drop. Its means although the speed increase the power of the engine only limited at that horsepower. Speed was recorded at starting speed of 2398 RPM at 8.680 HP. The engine was start pick up at that point and the data recorded by make sure the speed on dyno-max pro software reading and the meter on car are same. The horsepower was increase until maximum horsepower 47.68 HP at 7272 RPM. Then, the graph recorded that horsepower line was drop to 45.15 HP at increasing speed 7299 RPM. As the rpm increases and due to dirty condition of air filter, it get harder to get optimal amount of air and fuel into cylinder and burn it at optimal rate. The faster the engine revs, the less time there to suck in, compress, burn and blow out. It is mean mixture start burn process at unsuitable timing as the flame stop before exhaust valve open. The data it show the higher speed increase the horsepower after reach the limit power, horsepower will decreased. The drop horsepower also because of condition of

air filter. It state that the clogged air filter can running on Proton Perdana V6 until power of maximum speed at 47.68 HP at top speed 7272 RPM.

4.2.2 Torque

Table 4-2 - Data for clogged air filter on torque

Speed (RPM)	Torque (Nm)
2398	23.9
2592	28.6
2906	32.1
3482	32.6
3709	37.1
4882	36.3
5406	35.8
5576	34.1
6007	34.7
6963	34.6
7088	34.9
7196	37.7
7229	40.9
7248	44.6
7272	46.5
7299	35.8
7326	34.1

From the table 4-2, by using clogged air filter, the result shows at idle speed (2398 RPM) the torque is 23.9 Nm. The pedal was accelerating until the maximum speed. The data was recorded that the higher torque is 46.5 Nm at 7272 RPM.

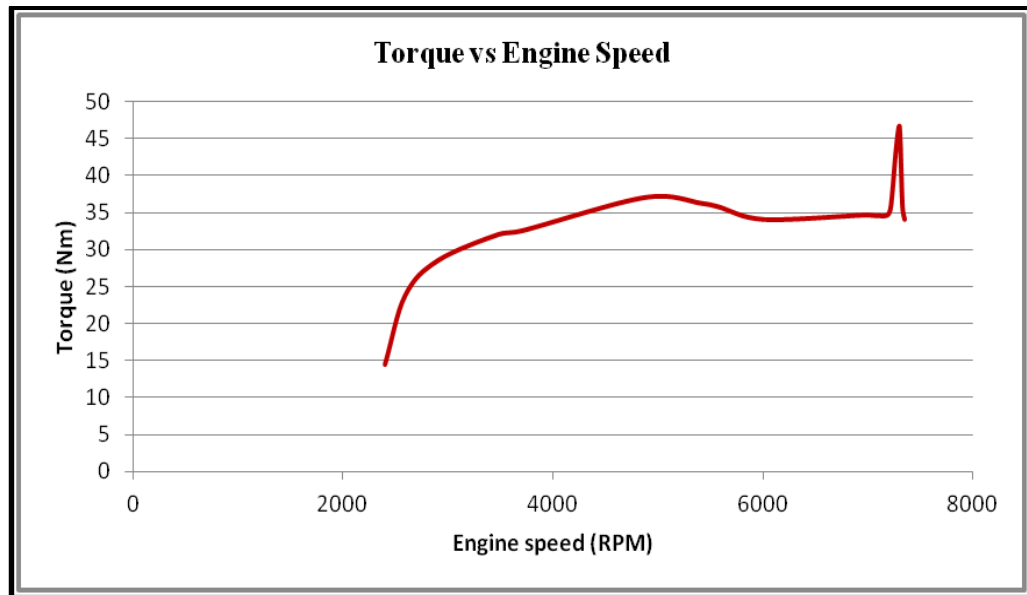


Figure 4-6 - Graph of torque vs engine speed for clogged air filter

For figure 4-6 above, it shows x-axis represent as engine speed (RPM) and y-axis represent as torque (Nm) for clogged air filter. At idle speed 2398 RPM, the torque was recorded at 23.9Nm. The graph visually shows, the increase and decrease line in graph because of condition of clogged air filter that dirty and due to paper air filter material. The capacity of filter function of air into engine become reduced when air filter become clogged. Torque is how strong the engine is. The torque remain increase until at 3709 RPM it become decrease and increase again at maximum torque 46.5 Nm at 7272 RPM. Then suddenly continues drop to 35.8 RPM at others increasing speed recorded. Torque starts to decrease because the engine cannot breathe as well. Due to the speed, the cylinder does not fill with air as well. The torque of the engine is a reacts to efficient combustion which means the maximum torque is achieved when the fuel combustion occurs most efficiently. This efficiency reaches a peak at certain values and after this the torque value starts to drop. Torque also start to decrease although RPM increased because of air not able to enter and out into engine in accordance with the required efficiency.

4.2.3 Torque & Horsepower vs Speed

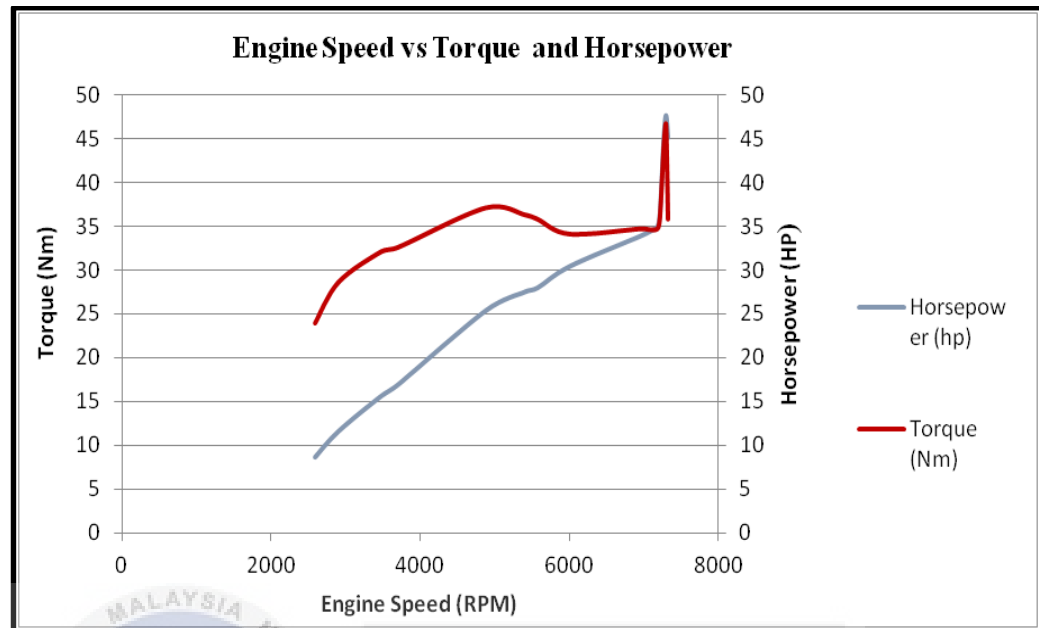


Figure 4-7 - Graph of torque and horsepower vs engine speed on clogged air filter

Figure 4-7 shows the graph of torque and horsepower against speed in double scatter graph for clogged air filter. The graph shows the different between horsepower line and torque line. The torque was totally higher than horsepower produce at the middle running. A clogged air filter may rob power of engine. From these graph, the clogged air filter produces higher torque and low on horsepower at middle running. The clogged types shows the power are less at the middle running but the torque still can give higher rotating force on crankshaft to move the car. The peak point of horsepower still more than the torque, it means the dirty air filter still had power to make the car moving faster and the torque still able to support the car to moving.

4.3 New OEM Air Filter

4.3.1 Horsepower

Table 4-3 - Data new OEM air filter on horsepower

Speed (RPM)	Horsepower (hp)
2827	21.70
3019	24.04
3593	27.34
4012	28.87
4720	34.91
5003	37.98
6139	50.53
6265	51.90
6475	53.85
6684	55.76
6894	59.35
7069	61.68
7201	62.98
7244	63.30
7287	61.93
7326	57.53

Table 4-3 above shows the reading of horsepower and torque of Proton Perdana V6 on new OEM air filter. The data shows horsepower was increase from 21.70 HP to 63.3 HP. For the idle speed (2827 RPM), the horsepower is 21.70 HP. Engine was speed up until reach maximum rpm and the result show the peak horsepower for new air filter is 63.30 HP at 7244 RPM. Meanwhile, the reading was recorded that horsepower was continue decrease to 61.93 HP at the speed 7287 RPM after reach the peak of Perdana V6 horsepower.

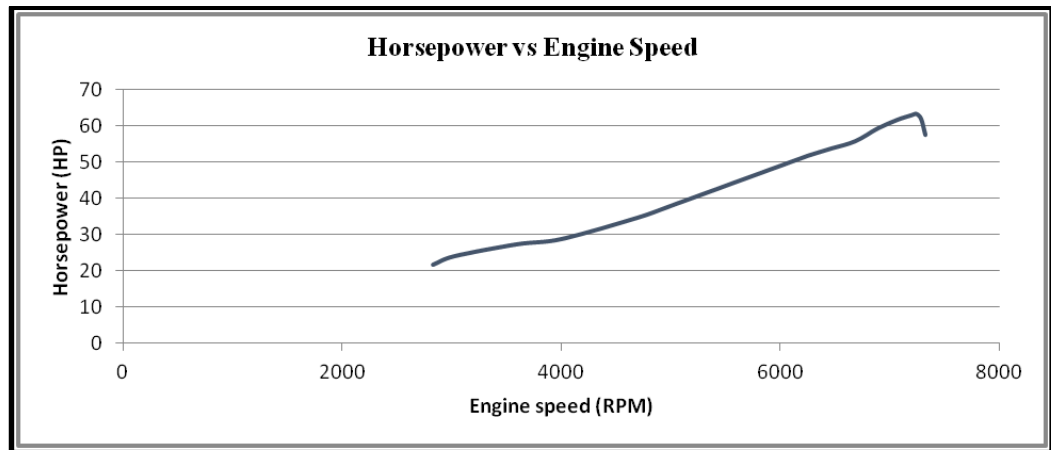


Figure 4-8 - Graph of horsepower vs engine speed on new OEM air filter

From the Figure 4-8 above, the graph shows the changing of horsepower over the engine speed on new OEM air filter. Axis of x shows the speed (RPM) with interval 2000 RPM and y-axis are set for horsepower (HP) with 10 HP intervals. The horsepower is a measurement on how fast it can used power. Engine has a peak horsepower, an rpm value at which the power available from the engine is at its maximum. The graph visually shows it slightly increased and at the some peak point of speed the horsepower value are drop. The engine speed was recorded at starting speed of 2827 RPM at 21.70 HP. Engine produces 63.30 HP at 7244 RPM which means the engine can do the amount of work per unit time (power) at 7244 RPM. The horsepower increase by increasing RPM because of the power that produced by an engine is limited by the amount of air used in combustion. The faster an engine spins, the more air per unit time moves through the engine, the more energy is released for that unit of time. Then, the graph recorded that horsepower line was drop to 61.93 HP at increasing speed 7287 RPM. This new OEM air filter with clean surface increase horsepower to 63.30 HP compare to the clogged air filter that only produce 47.68 HP due to dirty condition.

4.3.2 Torque

Table 4-4 - Data for new OEM air filter on torque

Speed (RPM)	Torque (Nm)
2827	54.6
3019	55.7
3593	53.2
4012	52.5
4720	53.7
5003	54.1
6139	58.6
6265	59.0
6475	59.2
6684	59.4
6894	61.3
7069	62.1
7201	62.3
7244	62.1
7287	60.5
7326	55.9

Table 4-4 above shows the reading of horsepower of Proton Perdana V6 on new OEM air filter. The data shows horsepower was increase from 54.6 P to 62.1 HP. For the idle speed (2827 RPM), the torque is 54.6 Nm. Engine was speed up until reach maximum rpm and the result show the peak torque for new air filter is 62.1 Nm at 7244 RPM. Meanwhile, the reading was recorded that torque was continue decrease to 60.5 Nm at the speed 7287 RPM after reach the peak of perdana V6 torque.

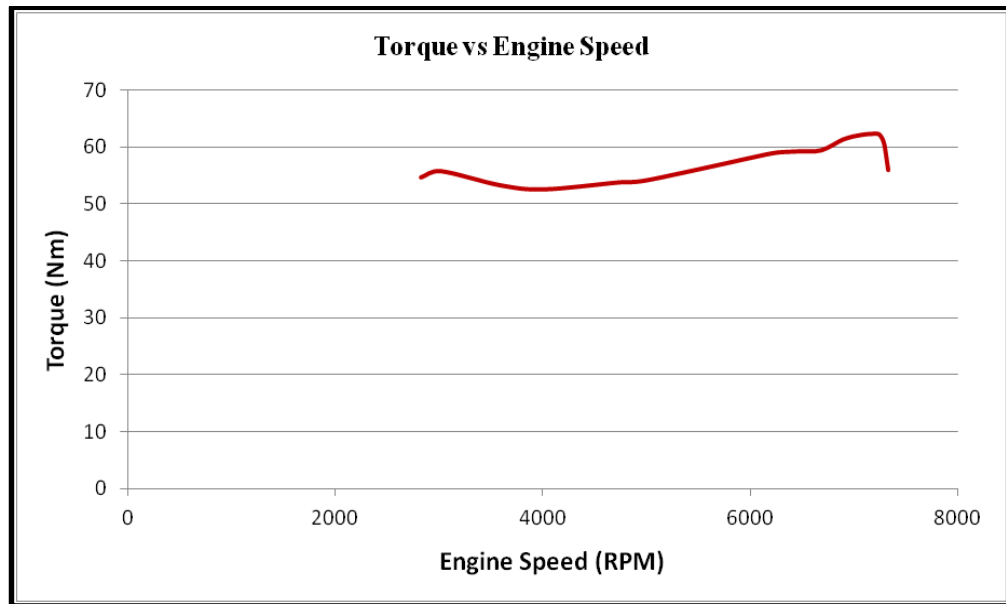


Figure 4-9 - Graph of torque vs engine speed on new OEM air filter

For figure 4-9 above, it shows x-axis represent as engine speed (RPM) and y-axis represent as torque (Nm) for new OEM air filter. For the speed 2827 RPM, the torque was recorded at 54.6 Nm. The graph shows that for new OEM air filter with clean condition, the torque was increases compared to clogged air filter. At the peak of engine speed, the torque is 62.1Nm at 7244 RPM. Since the speed engine increase the torque was decrease. When the torque peaks at a certain RPM and starts to drop off, the decrease is small and is not enough to offset the increasing RPM. Eventually the decrease in torque becomes large enough that it outweighs the increase in RPM and we see the power start to drop.

4.3.3 Horsepower & Torque against Speed Engine

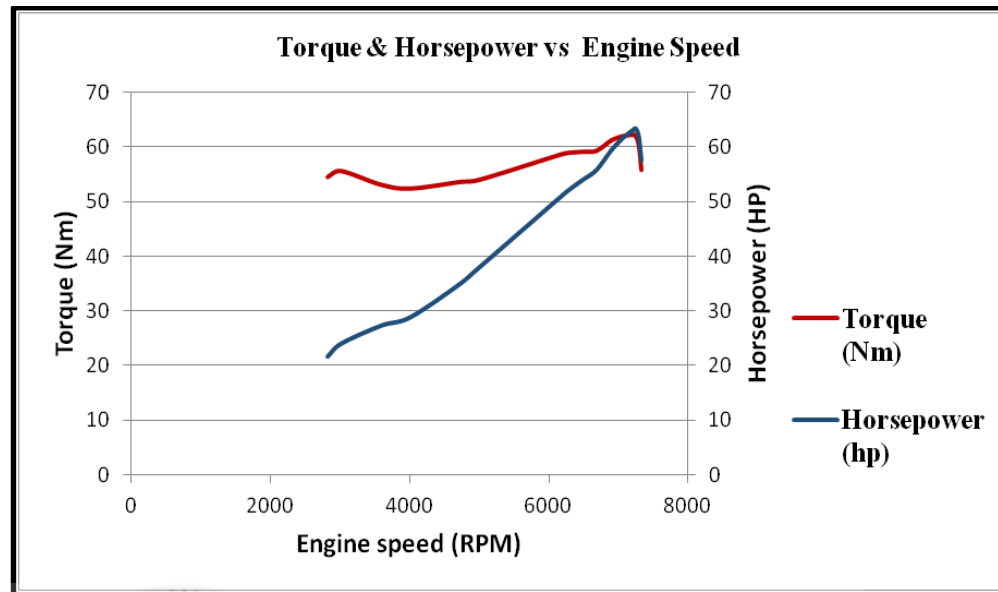


Figure 4-10 - Graph of torque and horsepower vs engine speed on new OEM air filter

Figure 4-10 shows the graph of torque and horsepower against speed in double scatter graph for new OEM air filter. The graph also shows that new OEM is higher for horsepower compared the clogged air filter. The new OEM air filter types give maximum horsepower. It can contribute more force (torque) acting over a given distance from rotation axis within given amount of time. A peak point of these two graph line state that increasing the rpm on a spark ignition engine will increase the HP some until it reaches a peak and then begins to decrease. That's because the peak torque occurs at a significantly lower rpm than peak horsepower. The reason the peak torque starts to fall off is because of increased pressure losses in the air filter and intake manifold as the corrected airflow continues to increase with rpm. torque also falls off at an increasing rate and it change in torque per change in engine speed will drop to a point where horsepower stops increasing and starts to fall.

4.4 Performance Air Filter

4.4.1 Horsepower

Table 4-5 - Data for performance air filter on horsepower

Speed (RPM)	Horsepower (HP)
2843	20.95
2980	22.87
3263	25.87
3590	27.37
3990	29.50
4171	30.16
4602	32.02
4800	36.35
5122	38.96
5548	43.64
6003	52.26
6272	55.16
6497	57.75
6727	61.93
6960	64.31
7145	65.97
7190	63.82
7231	57.25

For the table 4-5 above, it shows the reading of performance air filter for horsepower. The engine was running above 2500 RPM same with other type of air filter and the data was recorded on Dyno-max pro software. At the idle speed 2843 RPM, the horsepower is 20.95 HP. For the highest speed at 7145 RPM, the horsepower is 65.97 HP. , it shows the highest horsepower peak for performance air filter is 65.97 HP.

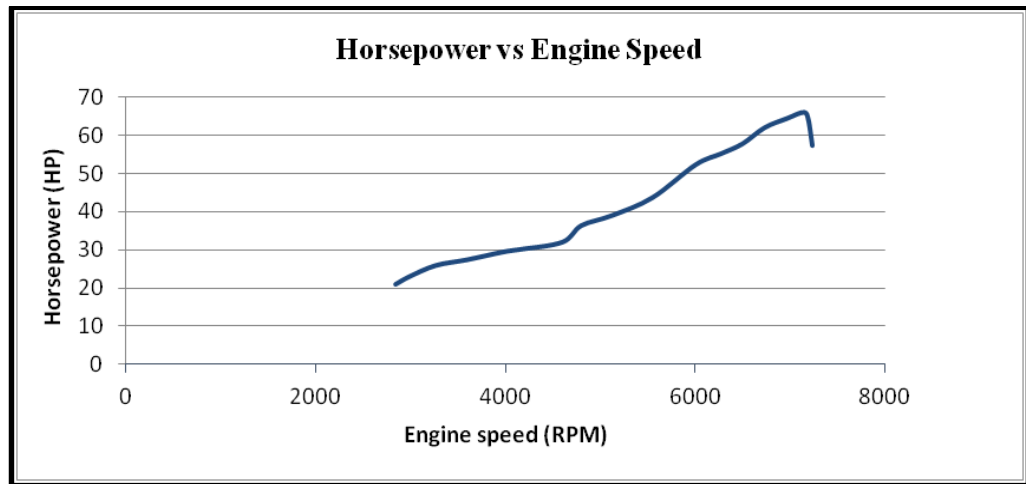


Figure 4-11 - Graph of horsepower vs engine speed on new OEM air filter

From the Figure 4-11 above, the graph shows the changing of horsepower over the engine speed on new OEM air filter on performance air filter type. X-axis shows the speed (RPM) with interval 2000 RPM and y-axis are set for horsepower (HP) with 10 HP intervals. The horsepower is a measurement on how fast it can used power. The graph visually shows it slightly increased and at the some peak point of speed the horsepower value is drop. The engine speed was recorded at idle speed of 2843 RPM at 20.95 HP. Engine produces maximum horsepower at 65.97 HP on 7145 RPM which means the engine can do the amount of work per unit time (power) at 7145 RPM. The horsepower increase by increasing speed because of the power that produced by an engine is limited by the amount of air used in combustion. The faster an engine spins, the more air per unit time moves through the engine, the more energy is released for that unit of time. Then, the graph recorded that horsepower line was drop to 63.82 HP at increasing speed 7190 RPM. The stainless steel material on performance air filter caused the engine horsepower increase. This material is ensuring a huge sacked air volume from outside quickly and effectively and higher air intake. Introduce more air into air fuel mixture can improve performance.

4.4.2 Torque

Table 4-6 - Data for performance air filter on torque

Speed (RPM)	Torque (Nm)
2843	52.5
2980	54.6
3263	56.6
3590	55.3
3990	52.0
4171	51.5
4602	51.1
4800	53.9
5122	54.1
5548	58.4
6003	62.3
6272	62.6
6497	63.3
6727	65.6
6960	65.8
7145	65.7
7190	63.2
7231	56.4

For the table 4-6 above, it shows the reading of performance air filter for torque. The engine was running above 2500 RPM same with other type of air filter and the data was recorded on Dyno-max pro software. At the idle speed 2843 RPM, the torque is 52.5 Nm. For the highest speed at 7231 RPM and torque value is 56.4 Nm . From the data above, it shows the highest torque peak for performance air filter is 65.7 Nm.

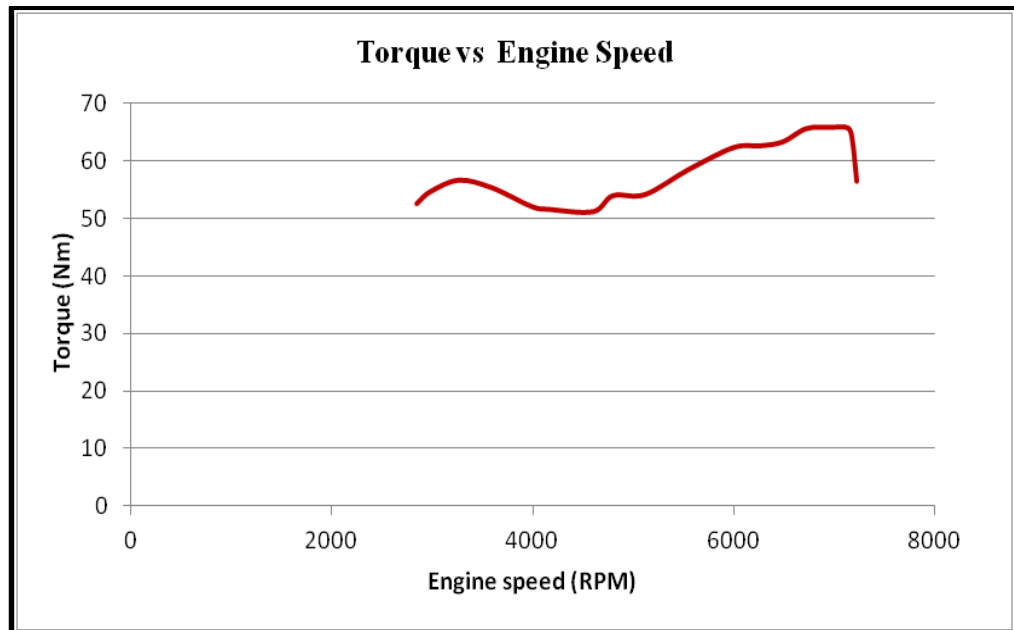


Figure 4-12 - Graph of torque vs engine speed on performance air filter

For figure 4-12 above, it shows x-axis represent as engine speed (RPM) and y-axis represent as torque (Nm) for performance air filter. At idle speed 2843 RPM, the torque was recorded at 52.5 Nm and at maximum speed of 7145 RPM the torque is 65.7 Nm. After that, the torque was decreased when speed continue increased. The decreased of air intake with higher speed, the time of each stroke decreases since the piston moves faster up and down. Intake which means less air get into cylinder, less fuel can burn and less torque. Other than that, the drop torque reading at speed 7190 RPM for 63.2 Nm explained that torque starts to decrease because the engine cannot breathe as well. Due to the speed, the cylinder does not fill with air as well. The torque of the engine is a reacts to efficient combustion which means the maximum torque is achieved when the fuel combustion occurs most efficiently. This efficiency reaches a peak at certain values and after this the torque value starts to drop. Torque also start to decrease although speed increased because of air not able to enter and out into engine in accordance with the required efficiency. Torque is how strong the engine is.

4.4.3 Torque & Horsepower vs Engine Speed

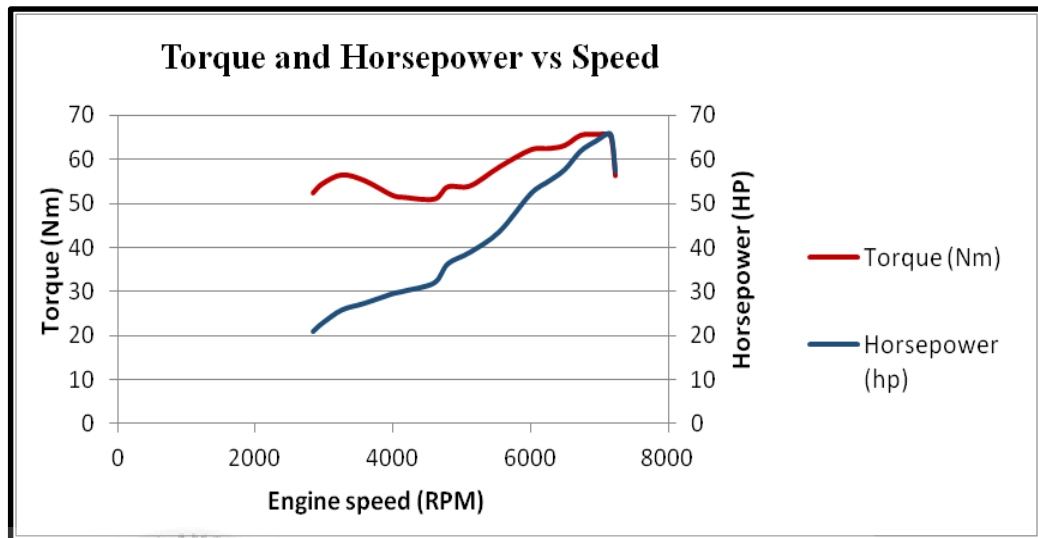


Figure 4-13 - Graph of torque and horsepower vs engine speed on performance air filter

From the figure 4-13 above, the graph shows the combination of two variables, it is horsepower and torque for performance air filter type. For the performance air filter, the result of horsepower show positive increasing compared to another types air filter on (Figure 4.3 and Figure 4.6). The condition of performance air filter plus with the material was help to horsepower increasing. Power is indicative of how fast a car ultimately is and how far the force of the engine can push it, so it stands to reason that more horsepower typically means a higher top speed. The performances also produce a higher torque due to higher horsepower.

4.5 Exhaust Analyzer

The exhaust gas emitted into atmosphere is combination of burned and unburned fuel. Exhaust gas released as a result of fuel combustion. There are pollutants that come out of a car's tailpipe exhaust when engine is running. The result shows the effect on three types air filter on hydrocarbon, carbon dioxide, carbon monoxide, oxygen, nitrogen oxides and air fuel ratio.

Table 4-7 - Gas emissions data on exhaust analyzer

Types of air filter	Hydrocarbon, HC (ppm)	Carbon Dioxide, CO ₂ (%)	Nitrogen Oxide, No _x (ppm)	Carbon monoxide, CO (%)	Oxygen, O ₂ (%)	Air Fuel Ratio
Clogged Air Filter	131	13.70	237	2.60	0.3	13.81
New OEM Air Filter	91	14.70	202	0.25	0.6	14.70
Performance Air Filter	48	15.10	626	0.07	0.6	14.99

For the table 4-7 above, it shows the reading of various gases for different types of air filter. It consists of clogged air filter, new OEM air filter and performance air filter. For hydrocarbon, clogged air filter produce higher hydrocarbon at 131 ppm, less new OEM air filter and performance air filter it is 91 ppm and 48 ppm. The clogged types let the oxygen into combustion in poorly at 0.3% different with new OEM air filter and performance air filter which is oxygen release is 0.6%. As for carbon dioxide, it is 13.70% on clogged air filter, 14.70% on new OEM air filter and increase 15.10% for performance air filter respectively. The clogged air filter was produce nitrogen oxide of 237 ppm, less for new OEM air filter which is 202 ppm and increased after change to performance air filter types of 626 ppm. Furthermore, carbon monoxide for performance are less than other types, it is 0.07%. Then, carbon monoxide for new OEM air filter is 0.25% and performance air filter is 0.07%, meanwhile clogged air filter is 2.60%. Lastly, the air fuel ratio data shows that the ideal ration was on new

OEM air filter which is 14.70, then clogged air filter is 13.81 and performance air filter is 14.99.

4.5.1 Hydrocarbon (HC)

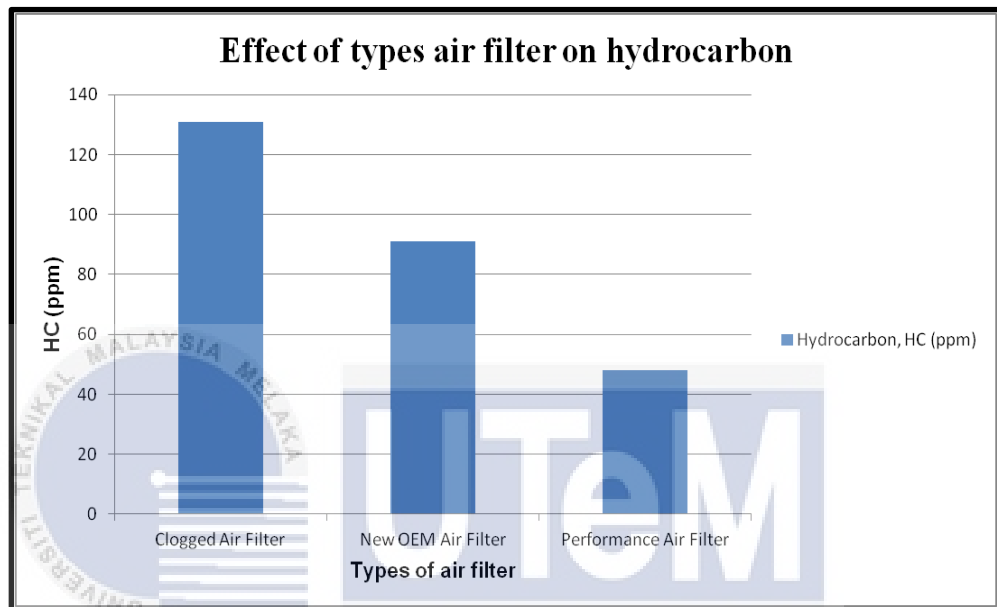
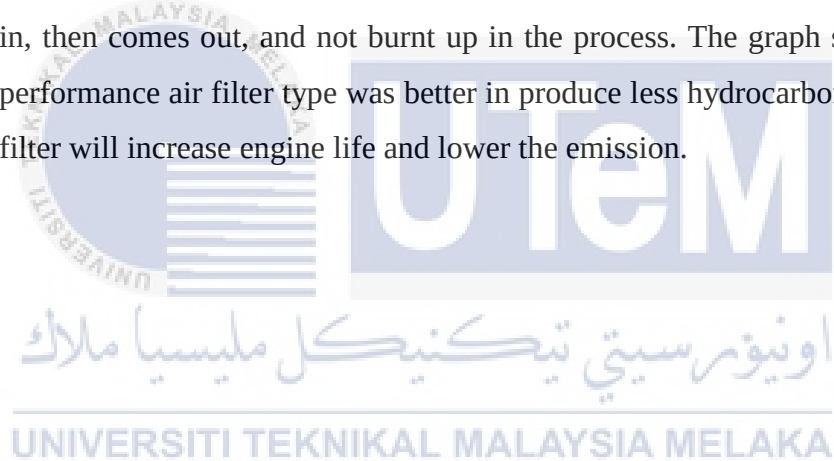


Figure 4-14 - Graph effect of types air filter on hydrocarbon

During combustion process there are compound that considered dangerous are formed. These pollutants are hydrocarbons (HC). Hydrocarbons are consists only of carbon (C) and hydrogen (H). Hydrocarbons happen when combustion does not take place at all and it emitted from combustion chamber in large amount which mean that fuel which was not burned during combustion process. Hydrocarbons are quite simply and raw unburned fuel. An effect of hydrocarbons to environmental is lead to human respiratory system affects such as asthma or breathing problem. then, When exposed to sunlight, nitrogen oxide (NO_x) and hydrocarbons are reacts to form ozone. The lower ozone layer of atmosphere is hazardous substance which irritates the mucous membranes and cause headache.

From the figure 4-14, the bar graph shows the effect of types air filter on hydrocarbon. Hydrocarbon are measured by exhaust analyzer in part per million (ppm). From these three type, the clogged air filter resulting in produce the higher hydrocarbon at 131 ppm, more less for new OEM air filter at 91 ppm and much more less on performance air filter 48 ppm. Due to clogged type air filter condition, the unburned Petrol, represents the amount of unburned fuel due to incomplete combustion exiting through the exhaust are more higher than other type air filter that had more available space of particular vehicles outside-air intakes. This is because there too much fuel for available oxygen for combustion and lead to unburn fuel. An insufficient air supply from a dirty air filter results in unburn fuel exiting the engine in the form of soot residue. This soot accumulates on the spark plug that in turn cannot send the necessary charge to the engine. Hydrocarbons emitted after fuel is burned in an engine which goes in, then comes out, and not burnt up in the process. The graph shows that the performance air filter type was better in produce less hydrocarbons. A clean air filter will increase engine life and lower the emission.



4.5.2 Carbon Dioxide (CO₂)

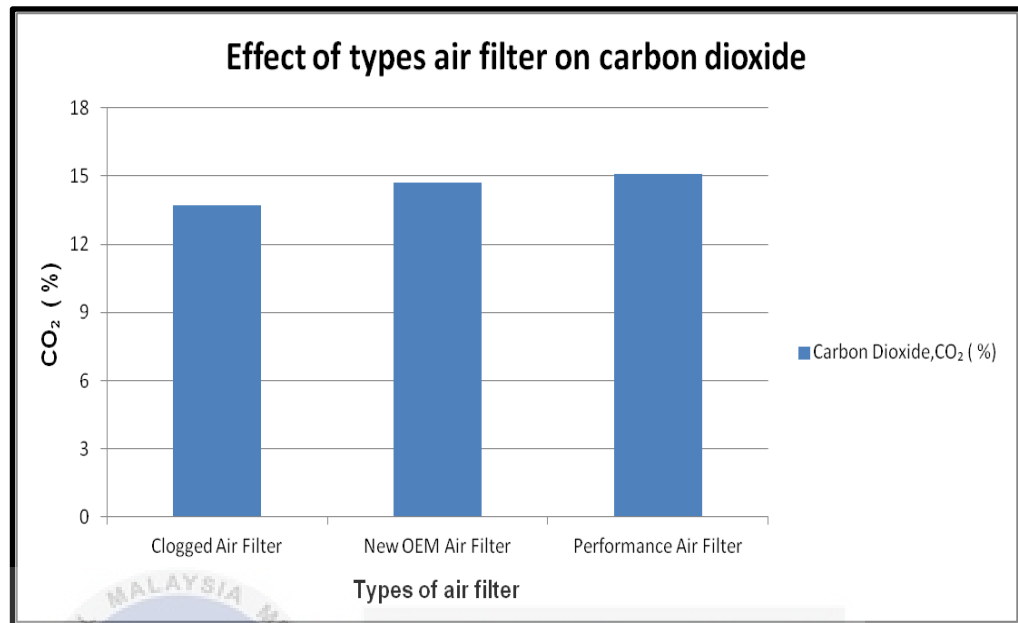


Figure 4-15 - Graph effect of types air filter on carbon dioxide

Carbon dioxide is an indicator of complete combustion where the higher on readings means the high efficiency. Carbon dioxide produced when carbon from the fuel is fully oxidized during combustion process. Carbon dioxide is a complete combustion and by product of efficient. Carbon dioxide is a combination of carbon monoxide and oxygen. Completely burned petrol, represents how well the air/fuel mixture is burned in the engine (efficiency). This gas gives a direct indication of combustion efficiency generally 1-2% higher at 2500 RPM than at idle. Carbon dioxide is a non-toxic gas but contributes towards acidification of oceans and one of the most important greenhouse gases. Greenhouse gases are a group of compounds that are able to trap heat (long wave radiation) in the atmosphere, keeping the earth surface. Increases the amount of greenhouse gases in the atmosphere enhances the greenhouse effect which is creating global warming and consequently climate change. Greenhouse gases allow sunlight (short wave radiation) to pass through the atmosphere freely, where it is then partially absorbed by the surface of the earth. The world is pursuing policies to reduce CO₂ emissions to combat the global warming.

For the graph 4-15 it shows the effect of types air filter on carbon dioxide (CO_2). Carbon dioxide measured by an exhaust analyzer in percent (%). The graph proves that performance air filter resulting as higher carbon dioxide released which is 15.1%. In theoretical result, the near perfect combustion for carbon dioxide levels is almost 15.5%. Carbon dioxide levels are affected by air fuel ratio and spark timing. High carbon dioxide (CO_2) readings indicate a nearly ideal air-fuel ratio and efficient combustion. Other than that, the clogged air filter produced 13.7% of carbon dioxide. Low carbon dioxide readings indicate a fuel mixture either too rich or too lean, and exhaust system leaks. CO_2 will decrease in any of the above cases because of an air/fuel imbalance or misfire. The new OEM air filter recorded reading at 14.70% of carbon dioxide.

4.5.3 Nitrogen Oxide (NO_x)

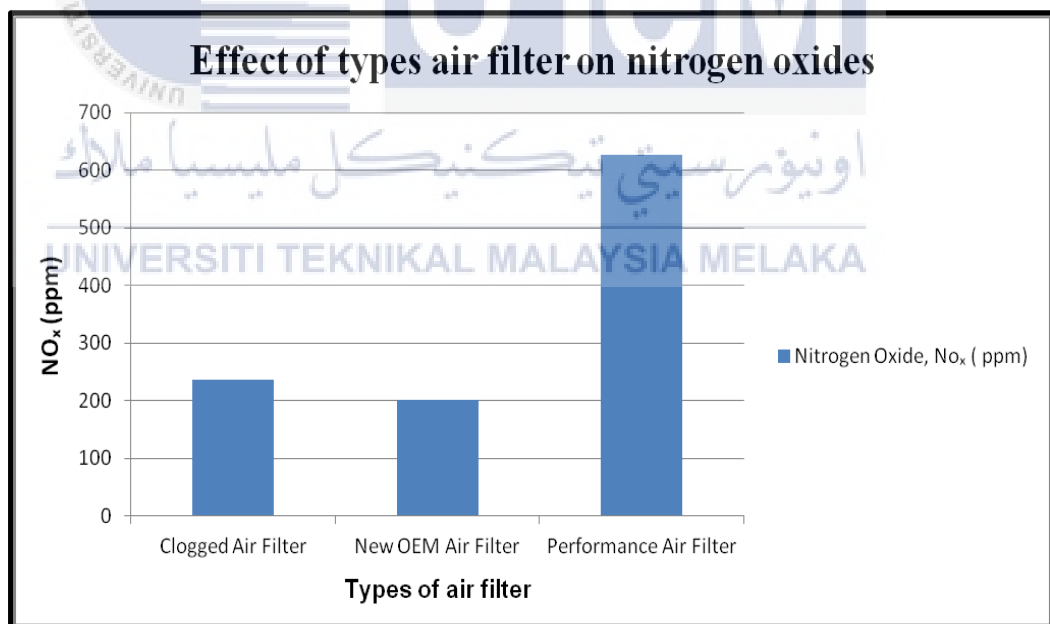


Figure 4-16 - Graph effect of types air filter on nitrogen oxides

Nitrogen Oxides is produced in any combustion process. NO_x is formed in large quantities when combustion temperature exceed about 2500°F . Oxygen and nitrogen from the air react at engine temperature. This makes nitrogen

monoxide which, when it is released into the atmosphere reacts with more oxygen in the air to form nitrogen oxide. There is a varying amount of nitrogen oxides in car exhaust which then released into atmosphere and damages it. NOx emissions are oxidised in the atmosphere and contribute to acid rain. Nitrogen monoxide and nitrogen dioxide are jointly referred to as **NOx**. They react with hydrocarbons to produce low level ozone which can cause inflammation of the airways, reduced lung function and trigger asthma, and also contribute to the formation of particulate matter.

From the graph 4-16 above it shows the graph of effect types air filter on nitrogen oxides for Proton Perdana V6 when it running until above 7000RPM. Nitrogen oxides measured by an exhaust analyzer in part per million (ppm). New OEM air filter recorded the lowest of NOx emission released at 202 ppm, for clogged air filter it is 237 ppm the more increases for performance air filter at 626 ppm. Anything which causes combustion temperature to rise will also cause NOx emission to rise. Misfire can also cause NOx to rise because of the increase in oxygen. The stainless steel material filters for performance type are advantage on higher air intake and more dust absorbing. With the more oxygen and more speed where cause the higher temperature on engine the NOx released are increased. Other than that, the higher of Nox also cause by combustion advance on spark timing. At the higher temperature, the fuel inject the directly burned before reach top dead center compression. While the engine is hot, the exhaust temperature is in low. It caused the performance air filter produce higher NOx compare with others.

4.5.4 Carbon Monoxide (CO)

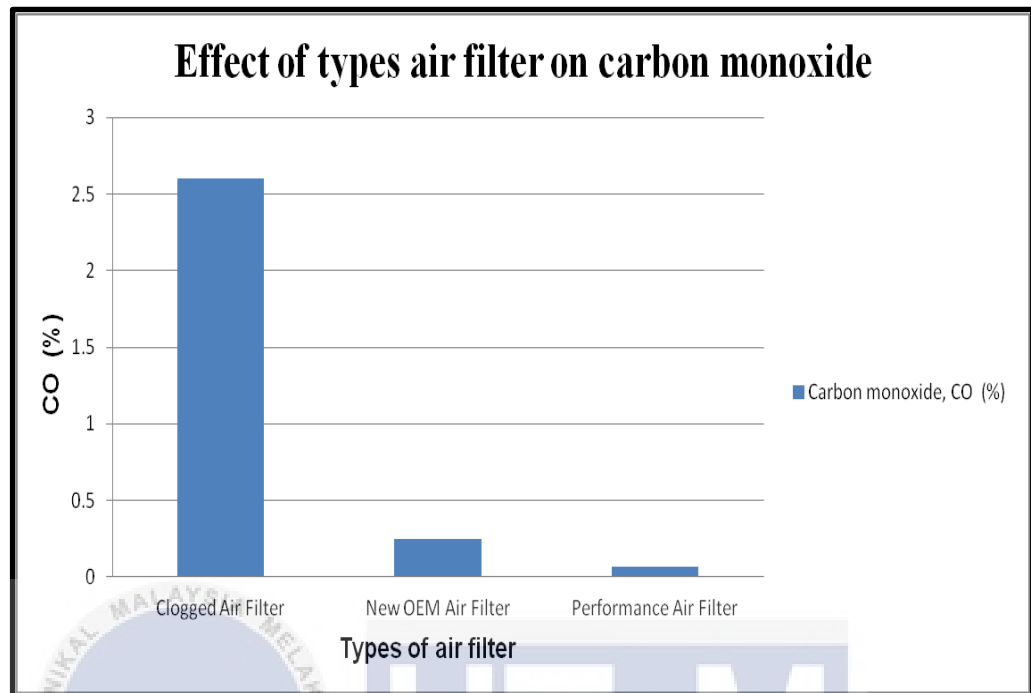


Figure 4-17 - Graph of effect types air filter on carbon monoxide

Carbon monoxide (CO) is an incomplete combustion of vehicle fuels where it is fuel rich equivalence ratio that not enough oxygen to convert all carbon to carbon dioxide (CO₂). CO₂ and CO formed in the engine cylinders because fuel and air mixture uncomplete combustion in engine cylinders. Higher results indicate rich condition and are indicator of incomplete combustion. Carbon monoxide is a colourless, odourless and tasteless gas. The compound, consisting of carbon and oxygen, is formed during incomplete combustion of carbon-containing substances and is very poisonous to the respiratory system.

Figure 4-17 above recorded the data on carbon dioxide using three types air filter which is clogged air filter, new OEM air filter and performance air filter that engine running until above 7000 rpm. Carbon monoxide is measured by an exhaust analyzer in percent (%). The graph reading that the clogged air filter recorded the higher carbon monoxide at 2.60%. New OEM air filter is 0.25% and performance air filter at 0.07%. this result shows that at clogged air filter type had insufficient oxygen compare to new OEM air filter and performance air filter. Apart from condition air filter factors, the material

type also is the factor that affects the emission reading. The clogged are made from material paper, same as new OEM air filter. However, plus with condition clogged air filter that more dust stuck it makes it worse where limited air to enter the combustion produced the low formation of CO₂ and increase formation for CO. High CO also means too much fuel is delivered to the engine for amount of air entering the intake manifold. The performance air filters are made from stainless steel material with nonwoven fabric. With nonwoven fabric the air filter greatly increase air intake volume and more dust absorbed. Stainless steel is higher for air intake and more better from paper air filter. Without any clogged condition on performance type, this material type allow more air to pass through and give maximum engine efficiency with oxygen are still available to present during combustion process to convert carbon monoxide to carbon dioxide (CO₂).



4.5.5 Air Fuel Ratio

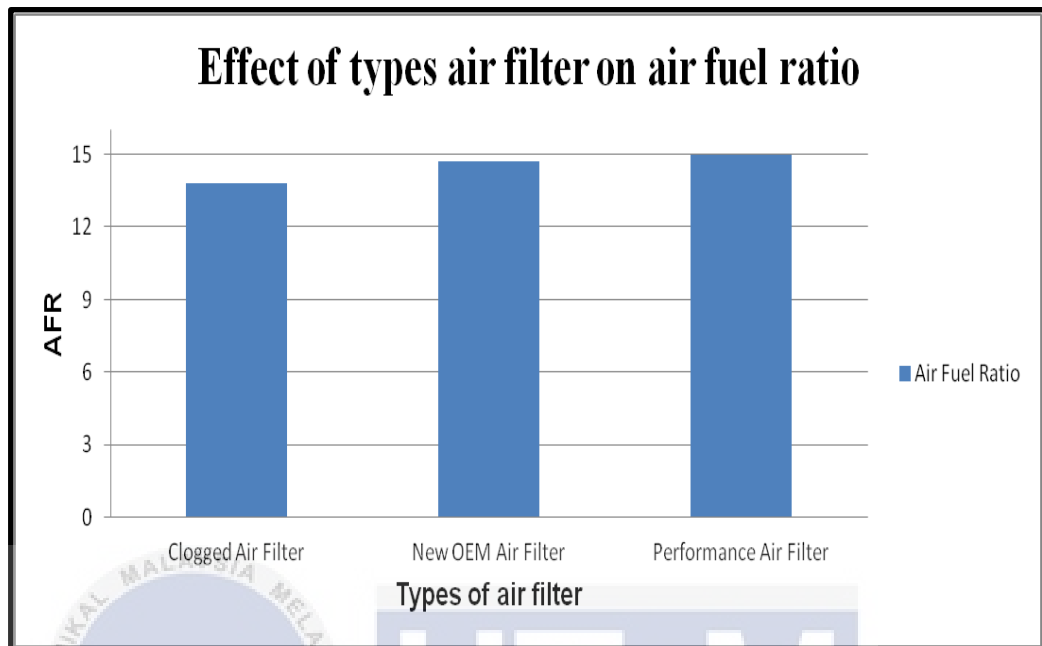


Figure 4-18 - Graph of effect types air filter on air fuel ratio

Figure 4-18 above shows the graph of air fuel ratio (AFR) on three type air filters that resulted from exhaust analyzer. Air fuel ratio is the ratio of the air to the fuel by weight. Air/Fuel Ratio or Lambda value based on the HC, CO, CO₂ and O₂ concentrations. This Proton Perdana V6 normal is air fuel ratio 14.7:1. Clogged air filter recorded air fuel ratio of 13.81. Second, the new OEM air filter recorded 14.70 of air fuel ratio and performance air filter air fuel ratio is 14.99. There are three type of mixture involve in air fuel ratio, it is a rich mixture, lean mixture and stoichiometric ratio. The rich mixture ratio is 13:1 refer to too much fuel for available oxygen. Second, the lean mixture air fuel ratio is 15:1 is referring for too much oxygen. At lean temperature the temperature engine was high because fuel burn more slowly. The ideal air/fuel ratio (AFR) or stoichiometric AFR is 14.7:1 which is a good mixture to producing the most complete combustion of fuel. The clogged air filters are heading to rich mixture which is too much fuel for available oxygen. Meanwhile the new OEM air filter almost to ideal mixture and performance air filter are heading to lean point which is too much oxygen.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Introduction

This section will discussed about the conclusion of this project study and recommendation for improvement needed in this experimental study.

5.1 Conclusion

This experiment study is to determined effect of type's air filters on the engine in terms of performance and exhaust emission. The experiment was done on Proton Perdana V6 using chassis dynamometer with dyno-max pro software and exhaust gas analyzer. Three type air filter are used is clogged air filter, new OEM air filter and performance air filter.

5.1.1 Performance

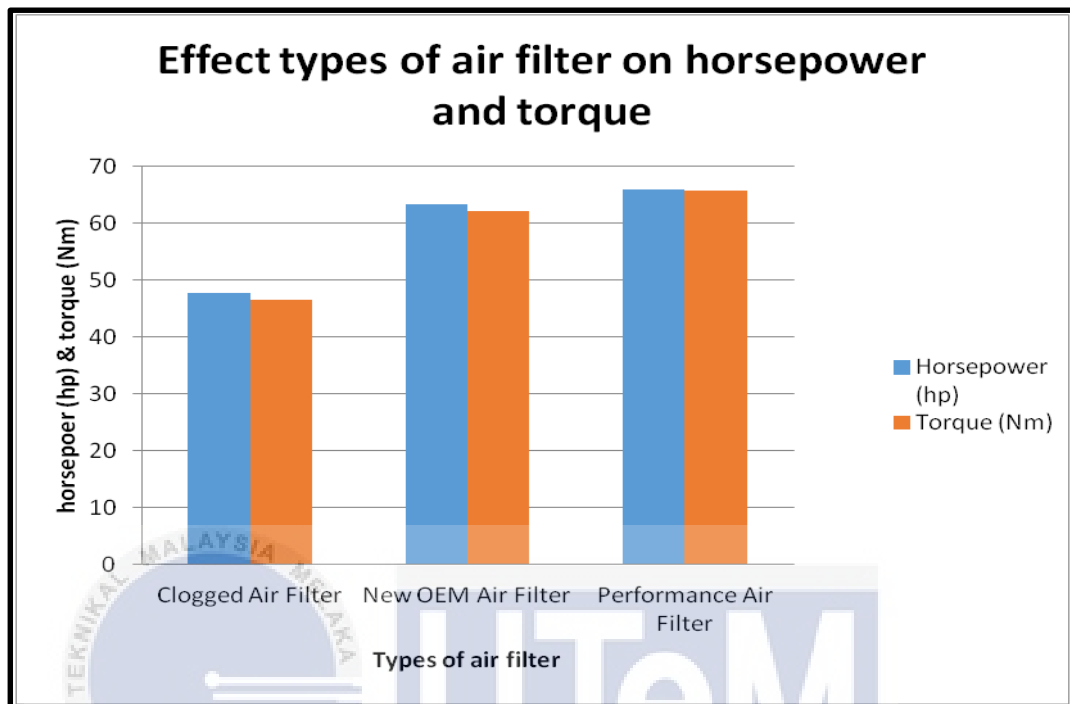


Figure 5-1 - result on effect horsepower and speed in comparison

The engine performance parameter used in this experiment study using chassis dynamometer is torque (Nm) and horsepower (HP). Power is to show how fast the vehicle finally (top speed) and simply means the power of engine produces. The more horsepower, it usually means speed higher. Then, force that to move the car is called as torque. The more horsepower produced, the more torque potential there is from the engine.

Figure 4-19 above shows the effect types of air filter on horsepower and torque by using three variables which is clogged air filter, new OEM air filter and performance air filter. The objective of this experimental study is to compare the result between using clogged air filter, new OEM air filter and performance air filters and studies the effect on performance. The graph clearly shows that clogged air filter produce less torque and less horsepower. A dirty filter on engine will not get the power it wants so it will try to add gas to make up for the insufficient air. This gives a worse effect to horsepower because the

fuel to air mixture will not be correct. The pleated paper material made for clogged air filter make the capacity to filter air are reduced because of dust, dirty and clog. Moreover, after change clogged air filter to a new OEM which is also use material paper air filter, the horsepower and torque were increase because that new and clean air filter give advantage in let more air into combustion and low restriction. The three air filter prove that a clean air filter improve the performance of horsepower and torque also lower emission. As the result plotted on bar graph, visually data can be interpreted that the performance air filter are give more for torque and horsepower on Proton Perdana V6. The faster an engine run, more power it will produce at full throttle. The performance air filter type use material from stainless steel allow more air to pass through, can maximum the engine efficiency, and increase horsepower. From the experimental study and analysis, the result can be conclude that the performance air filter are chosen for the better horsepower and torque due to higher horsepower and torque. The performance air filter can offer better air flow and better air filtration to enter the engine and burn the fuel perfectly. The result shows that the oxygen produce more at performance air filter because of material stainless steel and nonwoven fabric that ensuring a huge sucked air volume from outside quickly. At once, by referring performance air filter graph it improves the horsepower of engine due to perfect combustion and almost an ideal air fuel ratio.

5.1.2 Exhaust Emissions

Based on data and analysis result on chapter 4 on exhaust emission, conclusions are:

1. The exhaust analyzer is used in check the gases produce from the vehicle. It determined the Hydrocarbon (HC), carbon dioxide (CO₂), nitrogen oxide (NO_x), carbon monoxide (CO), Oxygen (O₂) and air fuel ratio (AFR).

2. Clogged air filter record the high in hydrocarbon (HC), high Carbon monoxide (CO) and low for oxygen. The higher HC release, lead to human respiratory system affect like asthma, lower ozone layer of atmosphere.CO effect from incomplete combustion of fuel. CO reduces the ability of blood to carry oxygen and can cause headaches, respiratory problems and, at high concentrations, even death.
3. The air fuel ratio result shows that clogged air filter are nearly heading to rich mixture because of too much fuel on available oxygen. Then performance air filter resulted at 14.99 closely with near to the lean mixture where too much oxygen. Then the new OEM air filter record 14.7 near to the stoichiometric ratio that are ideal mixture to produce most complete combustion.
4. The effect type of air filter on carbon dioxide is increase for performance air filters. Non-toxic gas but contributes towards acidification of oceans and one of the most important greenhouse gases. Governments around the world are pursuing policies to reduce CO₂ emissions to combat global warming.

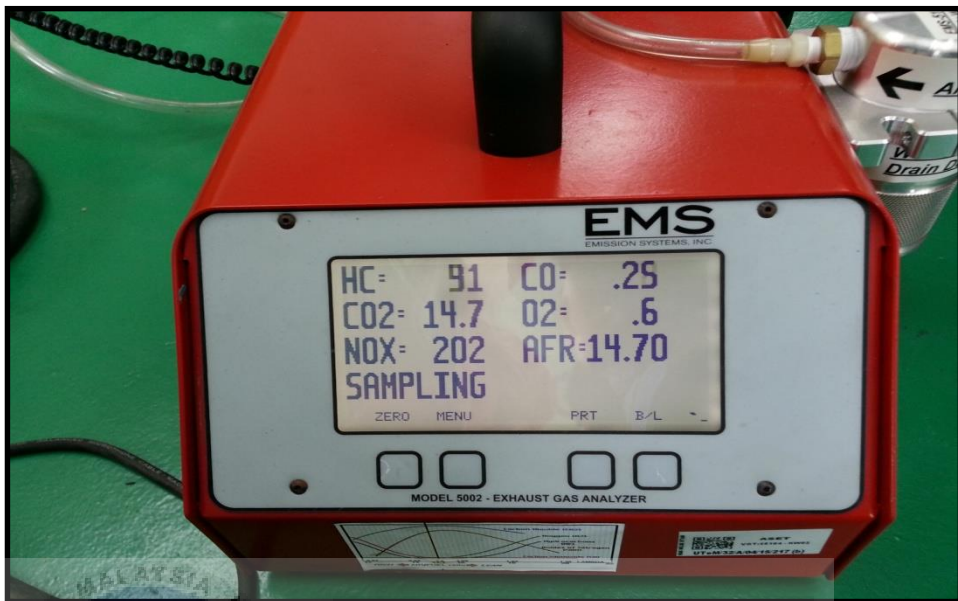
5.2 Recommendation

It is recommended for the future study of this experiment, using engine dynamometer were better on performance. So, an engine dynamometer is use to give most accurate picture of how much the power engine makes. An engine dynamometer is suitable for accurate result because measure directly from engine and do not count the power losses in drivetrain like chassis dynamometer. Then for data collected direct from chassis dynamometer and exhaust analyzer need to be improved. Both equipment needs to add a display to connect them and added a printer for easily data printed to the paper.

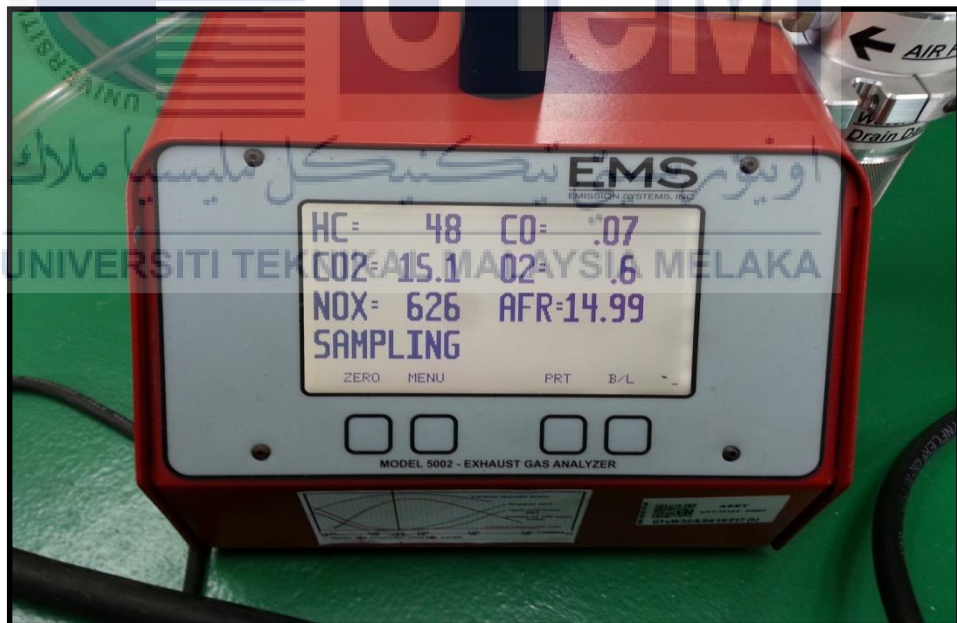
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APPENDICE



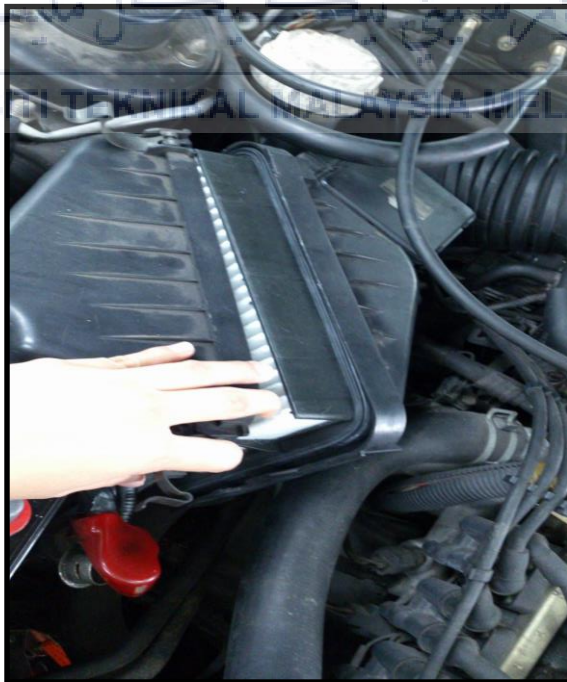
Result for clogged air filter on exhaust gas analyzer



Result for new OEM air filter on exhaust gas analyzer

Sec (Seconds)	RPM (RPM)	Hp (Hp)	Torque (N-m)	BSFC (lb/Hp-hr)	A/F (A/F)	FuelMass (lb/hr)	ACFM (CFM)	Avg-EGT (Degree F)
9.825	6003	52.56	62.3	0	0	0	0	725.0
9.925	6048	52.64	62.0	0	0	0	0	724.9
10.025	6093	52.91	61.8	0	0	0	0	724.9
10.125	6138	53.36	61.9	0	0	0	0	725.0
10.225	6182	53.90	62.1	0	0	0	0	725.0
10.325	6227	54.50	62.3	0	0	0	0	725.0
10.425	6272	55.16	62.6	0	0	0	0	725.0
10.525	6317	55.77	62.9	0	0	0	0	725.0
10.625	6362	56.27	63.0	0	0	0	0	725.0
10.725	6407	56.69	63.0	0	0	0	0	725.0
10.826	6452	57.16	63.1	0	0	0	0	725.0
10.926	6497	57.75	63.3	0	0	0	0	724.9
11.026	6542	58.52	63.7	0	0	0	0	725.0
11.126	6588	59.46	64.3	0	0	0	0	725.0
11.226	6634	60.41	64.8	0	0	0	0	725.0
11.326	6680	61.25	65.3	0	0	0	0	725.0
11.426	6727	61.93	65.6	0	0	0	0	725.0
11.526	6774	62.46	65.7	0	0	0	0	725.0
11.626	6819	62.92	65.7	0	0	0	0	725.0
11.726	6867	63.38	65.7	0	0	0	0	725.0
11.827	6914	63.84	65.7	0	0	0	0	725.0
11.927	6960	64.31	65.8	0	0	0	0	724.9
12.027	7006	64.78	65.8	0	0	0	0	725.0
12.127	7052	65.30	65.9	0	0	0	0	725.0
12.227	7099	65.88	66.1	0	0	0	0	725.0
12.327	7145	65.97	65.7	0	0	0	0	725.0
12.427	7190	63.82	63.2	0	0	0	0	725.0
12.527	7231	57.23	56.4	0	0	0	0	725.0
12.627	7261	45.01	44.1	0	0	0	0	725.0
12.727	7277	28.27	27.7	0	0	0	0	725.0
12.828	7274	10.48	10.3	0	0	0	0	725.0
12.928	7255	-4.585	-4.5	0	0	0	0	725.0

Result for Chassis dynamometer



Air filter position



Laptop with Dynomax Pro software

اونيورسيتي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA