

ANALYSIS OF PERFORMANCE AND EMISSION ON 4-STROKE 4-CYLINDER SPARK INGNITION GASOLINE ENGINE AT DIFFERENT AIR INTAKE TEMPERATURE



BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (Automotive Technology) WITH HONOURS

2022



Faculty of Mechanical and Manufacturing Engineering Technology



NAVEEN A/L CHANDRAN

Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

2022

ANALYSIS OF PERFORMANCE AND EMISSION ON 4-STROKE 4-CYLINDER SPARK IGNITION GASOLINE ENGINE AT DIFFERENT AIR INTAKE TEMPERATURE

NAVEEN A/L CHANDRAN



Faculty of Mechanical and Manufacturing Engineering Technology

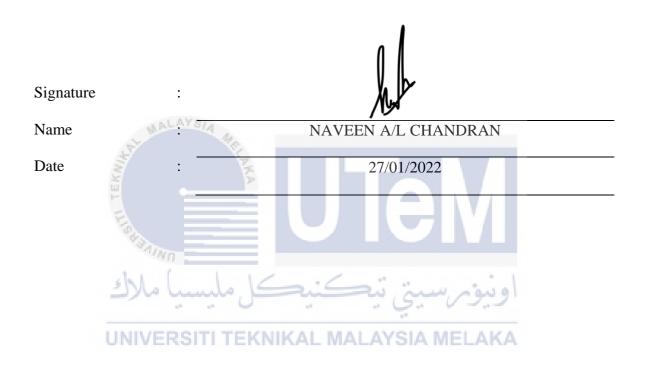
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I hereby declare that the work in the thesis is my own except for quotations and summaries

which have been duly knowledge.



APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive) with Honours.

Signature ALAYS MR. ADNAN BIN KATIJAN Supervisor Name 27/01/2022 Date UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEDICATION

This project report is dedicated to my beloved mother, Muththamil Selvi d/o Suppiah, my beloved father, Chandran s/o Perumal Marimuthu and my beloved family. Thank you for your love which support and prayer throughout the year my supervisor, Mr. Adnan Bin Katijan. Thank you for your monitory, advice and suggestions that drive me forward all my beloved seniors and friends. Thank you for all your helps and endless supports throughout the years.



ABSTRACT

The impact of changing in air intake temperature assumes a significant part to the spark ignition engine. Consequently, expanding or diminishing of surrounding temperature on the earth these days will impact the performance and the quality of air especially related to spark ignition engine. Thus, this study will be led to decide the warmed worth of air intake temperature that impact for better engine performance and emission. Spark ignition engine also called heat engine depends on such a great amount to the progressions in temperature. This proposal will present the trial result on the performance of spark ignition engine at various heated air intake temperatures on four-stroke four-cylinder spark ignition engine. It also researched the level of emission delivered to the climate because of expansion in air intake temperature. In this study, to measure the Torque value and calculate the Brake Power value the four-stroke four-cylinder spark ignition engine (Satria neo-1.6L G Manual) were tested using Chassis Dynamometer (DYNOMITE). While the exhaust emissions percentage values of CO2 and HC was recorded by using EMS gas anayzer. The data was taken under three different gears (gear 2,3 and 4) at varying speed (1500,2000,2500,3000 and 3500 rpm) and intake temperature range (55°C~60°C). Based on the data and result recorded increase in temperature do increase the engine performance in terms of brake power and torque but also increase the emission percentage as well.

تىكنىكا ملىسىا م UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSTRAK

Kesan perubahan suhu pengambilan udara memainkan peranan penting kepada prestasi enjin penyalaan percikan. Oleh itu peningkatan atau penurunan suhu sekeliling di dunia pada masa kini akan memberi kesan kepada prestasi dan kualiti udara terutamanya yang berkaitan dengan pencucuhan enjin. Oleh itu, kajian ini akan dijalankan untuk menentukan nilai panas suhu pengambilan udara yang mempengaruhi prestasi enjin yang lebih baik dan pelepasan. Enjin pencucuh api juga dikenali sebagai enjin haba sangat bergantung kepada perubahan suhu. Tesis ini akan membentangkan hasil eksperimen tentang prestasi enjin pencucuh api pada pelbagai suhu pengambilan udara yang dipanaskan pada enjin pencucuh empat silinder empat lejang. Ia juga menyiasat tahap pelepasan yang dikeluarkan ke alam sekitar akibat peningkatan suhu pengambilan udara. Dalam kajian ini, untuk mengukur nilai Tork dan mengira nilai Kuasa Brek, enjin pencucuh api empat lejang empat silinder (Satria neo-1.6LG Manual) telah diuji menggunakan Dinamometer Casis (DYNOMITE). Manakala nilai peratusan pelepasan ekzos CO2 dan HC direkodkan dengan menggunakan analyzer gas EMS. Data diambil di bawah tiga gear yang berbeza (gear 2,3 dan 4) pada kelajuan yang berbeza-beza (1500,2000,2500,3000 dan 3500 rpm) dan julat suhu pengambilan (55°C ~ 60°C). Berdasarkan data dan hasil yang direkodkan peningkatan suhu meningkatkan prestasi enjin dari segi kuasa brek dan tork tetapi juga meningkatkan peratusan pelepasan juga.

رسيتي تيكنيكل مليسيا ملاك

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ACKNOWLEDGEMENTS

First and foremost, I thank God for endowing me with health, patience, and knowledge to complete this project. I am very grateful as I can complete my undergraduate project report for the past 14 weeks.

I wish to express my sincere gratitude towards Mr. Adnan Bin Katijan, my supervisor for this project. I would like to thank him for supervising, educate and guiding me throughout the duration of this research. Without their continuous support, guidance, and provision this project would not be completed on time.

Furthermore, I would like to express my sincere thanks to the authority of University Technical Malaysia Melaka (UTEM) Campus FTKMP for providing good facilities to me to complete this project. I would also like to thank all the personnel who are involved during my research period especially to those who assisted and encouraged me. I am extremely thankful and indebted to them for sharing their expertise and knowledge. Besides, my deepest appreciation goes to my beloved parents, families and friends for their unceasing encouragement, support, and attention. I also place on record, my sense of gratitude to everyone, who directly or indirectly, have lent their hand in this venture.

TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATION	i
ABSTRACT	ii
ABSTRAK	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF SYMBOLS AND ABBREVIATIONS	X
LIST OF APPENDICES	xi
CHAPTER 1 INTRODUCTION	12
1.0 Background of Study	12
1.1 Problem Statement	13
1.2 Objective of Study	13
1.3 Scope of Research	13
1.4 Significant of Study	14
1.5 Summary	14
shield labor Sin a sin	1
CHAPTER 2 LITERATURE REVIEW	16
2.1 Internal Combustion Engine	16
2.2 Engine Emission	17
2.2.1 Complete Combustion	18
2.2.2 Incomplete Combustion	18
2.2.3 Emission in Internal Combustion Engine	19
2.2.4 Carbon Dioxide (CO2)	20
2.2.5 Hydrocarbon (HC)	20
2.2.6 Carbon Monoxide (CO)	21
2.2.7 Nitrogen Oxides (NOx)	21
2.3 Engine Performance Parameter	21
2.3.1 Engine Power	22
2.3.2 Brake Power and Torque	22
2.4 Air Intake System	23
2.4.1 Types of Air Intake Design	25
2.5 Intake Temperature and Performance	25
2.6 Intake Temperature and Emission	26

CHAPTER 3 METHODOLOGY	
3.1 Introduction	27
3.2 Methodology Flow Chart	27
3.3 Experiment Design	29
3.3.1 Experiment Layout	29
3.3.2 Tools and Equipment	30
3.4 Analysis	38
CHAPTER 4	41
4.1 Introduction	41
4.2 Brake Power	41
4.3 Engine Performance	41
4.3.1 Gear 2	42
4.3.2 Gear 3	43
4.3.3 Gear 4	44
4.3.4 Summary	45
4.4 Torque	46
4.4.1 Gear 2	47
4.4.2 Gear 3	48
4.4.3 Gear 4	49
4.4.4 Summary	50
4.5 Emission	51
4.6 Hydrocarbon (HC)	51
4.6.1 Gear 2	51 52
4.6.2 Gear 3 4.6.3 Gear 4 VERSITI TEKNIKAL MALAYSIA MELAKA	52 53
4.6.4 Summary	54
4.7 Carbon Dioxide (CO ₂)	55
4.7.1 Gear 2	56
4.7.2 Gear 3	56
4.7.3 Gear 4	57
4.7.4 Summary	58
CHAPTER 5 CONCLUSION AND RECOMMENDATION	61
5.1 Introduction	61
5.2 Conclusion	61 62
5.3 Recommendation	62
DEEDENCES	()
REFERENCES	62 65
APPENDICES	65

LIST OF TABLES

TABLE	TITLE	PAGE
Table 3.1	1.6L Satria Neo engine specification	32
Table 3.2	Specification of the heater	34
Table 3.3	Table Generated for The Dynometer Test Varying Speed and Gear	38



LIST OF FIGURES

Figure	TITLE	PAGE
Figure	2.1 Types of Internal Combustion Engine	17
Figure	2.2 Flow Chart of The Air Intake System	23
Figure	2.3 The Intake Manifold and Throttle Play Major Role in air intake system	24
Figure	3.1 Research Flow Chart	28
Figure	3.2 The Schematic Diagram for The Experimental Layout	29
Figure	3.3 Set Up of Chassis Dynamometer (Dynomite)	31
Figure	3.4 Satria Neo Air Filter 1.6L	33
Figure	3.5 Heater	33
Figure	3.6 Digital Temperature Controller	34
Figure	اويوم سيتي بيڪنيڪل مليسيا ملائد	35
Figure	3.8 12 V Car Battery TEKNIKAL MALAYSIA MELAKA	36
Figure	3.9 Switch 12V	36
Figure	3.10 The 90 cm Copper Wire	37
Figure	3.11 EMS Emission Analyzer.	38
Figure	4.1 The Graph Brake Power vs Speed Generated on Gear 4	41
Figure	4.2 The Bar Graph Speed *rpm) vs Power (kw) on gear 2	42
Figure	4.3 The Graph Speed (rpm) vs Power (kw) on gear 3	43
Figure	4.4 The Graph Speed (rpm) vs Power (kw) on gear 4	44
Figure	4.5 The Torque (NM) against Speed (rpm) on gear 4 for the performance test	46

Figure	4.6 The bar graph Speed (rpm) vs Torque (NM) on gear 2	47
Figure	4.7 The bar graph Speed (rpm) vs Torque (NM) on gear 3	48
Figure	4.8 The bar graph Speed (rpm) vs Torque (NM) on gear 4	49
Figure	4.9 The bar graph Speed (rpm) vs Hydrocarbon (HC) on gear 2	51
Figure	4.10 The bar graph Speed (rpm) vs Hydrocarbon (HC) on gear 3	52
Figure	4.11 The bar graph Speed (rpm) vs Hydrocarbon (HC) on gear 4	53
Figure	4.12 The bar graph Speed (rpm) vs Carbon Dioxide (CO_2) on gear 2	55
Figure	4.13 The bar graph Speed (rpm) vs Carbon Dioxide (CO_2) on gear 3	56
Figure	4.14 The bar graph Speed (rpm) vs Carbon Dioxide (CO ₂) on gear 4	57



LIST OF SYMBOLS AND ABBREVIATIONS

BP	- Brake Power
cc	- Cubic centimeter
cm	- Centimeter
CO	- Carbon monoxide
CO_2	- Carbon dioxide
h	- hour
HC	- Hydrocarbon
kg	- kilogram
kW	- kilowatt
MPa	- Megapascal
Nm	- Newton meter
NO _x	- Nitrogen oxides
HC	- Hydrocarbon
°С	Degree Celsius
rpm	- Revolution per minute
S	UNIVESecondi TEKNIKAL MALAYSIA MELAKA
SI	- Spark ignition

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
А	Gantt Chart PSM I & II	65
В	Dynometer Testing	67
С	Data Result of Power, Brake Power, Hydrocarbon and Carbon Dioxide at Different Speed and Gear	70



CHAPTER 1

INTRODUCTION

1.0 Background of Study

The air intake system is important to the engine's functioning, air collection and cycle transmission. As the air intake system is a motor gear, the engine must be understood first to determine how the air intake system works. Most of the motor converts thermal energy into mechanical energy and it is known as a heat motor. Heat motor classified in two types: one is an automotive and the other an external fusion reactor such as a steam motor. In the drying circuit with fuel and air mixed with concern for isothermal conditions, the electric motor relates to the ignition [1]. The air to be combined with the fuel is supplied via the air intake system. Air oxygen is one of the key components in the combustion process. A proper air intake system ensures the clean and continuous air flow to the engine, which delivers more power and improves vehicle efficiency.

The air intake system includes the air filter, the level raise and the mass transmission sensor. Engine performance is one of the most important problems nowadays for customers, designers and manufacturers of internal combustion engines. The designers are always interested in technology to improve vehicle performance without increasing the cost by altering cargo capacity or the mix of air- fuel [2]. The cheapest way is to change temperatures or heat. One big plans alteration is to change the humidity intake. The aim of this research is to study the effect on engine power (brake power and torque) and pollution of different heat air intake temperatures. This research is conducted using a 4- stroke ignition engine to collect scientific results from the test rig.

1.1 Problem Statement

The spark-ignition engine is the most prevalent motor type used in Malaysia and globally because petroleum fuel is utilized more than diesel fuel in most nations. The SI engine's intake temperature depends on the ambient temperature. Various temperatures result in varying engine performance and emissions. This research thus determines the optimal average temperature intake value, which affects fuel efficiency and pollution.

1.2 Objective Study

The objective of the study is to analyze the performance and emission of 4-stroke engine at various air intake temperature (55° C ~ 60° C) under different speed (1500,2000,2500,3000 and 3500 rpm) and different gears (Gear 2,3 and 4) by installing air heater. Below are the objectives that need to be achieved at the end of the study:

- i) To investigate the engine performance and emission characteristics of a 4-stroke spark ignition gasoline engine based on various air intake UNIVERSITI TEKNIKAL MALAYSIA MELAKA temperature.
- ii) Compare the emission level from vehicle by using heated air intake temperature ($55^{\circ}C \sim 60^{\circ}C$)

1.3 Scopes of Study

The research focuses on 4-cylinder spark ignition engine or petrol engine car, which are commonly used in Malaysia. The research has placed some restrictions to guarantee the results of the study are useful and practical. Here are the scopes of the research:

- i) The study conducted on 4 stroke 4 cylinder spark ignition engine with engine capacity of 1.6L
- ii) The experiment was conducted under three different gears (gear 2, 3 and 4) varying speed (1500, 2000, 2500, 3000 and 3500 rpm) and temperature range (55°C ~ 60°C)
- iii) The performance (brake power and torque) and emission level (Carbon dioxide and Hydrocarbon) of 4 - stroke spark ignition gasoline engine on different heated air intake temperature (55°C~60°C) were measured.

1.4 Significant of Study

The finding of the study will contribute to:

- i) Increase further understanding of engine performance and emission characteristics under different heated air intake temperatures.
- ii) To suggest the most appropriate air intake temperature condition to obtain the best result of performance and emission of the engine.

1.5 Summary

In this study, an attempt has been made to experimentally investigate the suitable air intake temperature for the engine performance and emission. The engine performance parameters are brake power and torque of the tested vehicle which is the SATRIA NEO 1.6L G manual with 3 different gears with varying speed (1500,2000,2500,3000 and 3500 rpm) and

temperatures. Moreover, the experiment also conducted to study whether the varying air intake temperature does it effects the emission level which are the Hydrocarbon and Carbon dioxide. The result will contribute to the future car designers to set the default temperature without depending on the ambient temperature.



CHAPTER 2

LITERATURE REVIEW

2.1 Internal Combustion Engine

At the end of the sixteenth century the first theory of internal combustion engine was developed; nevertheless, it was abandoned because the steam control engine began to show significant promise in the development of steam-powered engine. The actual main four-stroke cycle was presented to Nicklaus August Otto in 1876 and it ended up known as Otto Cycle [4]. Otto-cycle petrol engines were still the main movers for rider vehicles as for the first aircraft, while diesel engines were originally limited to high-speed sea and rail applications [5]. Internal combustion (ICE) engines produce mechanical energy from the fuel as the consequence of the combustion process happened inside the ICE. The gases expand and push the piston to a mechanical mechanism to spin its revolving shaft. The spinning shaft responded as an engine output, linked to the gear or transmission train to transfer the driving power of the vehicle. There are three kinds of internal combustion engine.

Rotating engine unit, internal combustion engine and gas turbine engine are provided. In rotating motors, a rotor spins in the motor to provide power. In the case of mutual motors, a piston interfaces with a cylinder. The reciprocal piston action is reborn into the movement of the wheels of the vehicle. Mutual motor area unit used in automobiles. They're the most often utilized engine kind. Figure 2.1 shows the categorization of the combustion engine. The ICE mechanism comprises of a piston movingin a very cylinder, forming a moving gas screen tight from the crankshaft and rod for motion. [1] Pistons are usually dome-shaped on the top and hollow on the rock bottom on a very ICE, and complete a cycle of reciprocation with four intakes, compression, power, and exhaustion. There are 2 kinds of 4-stroke engine; the spark-infection (SI) area unit engine is a combustion engine and a combustioninfection (CI) engine or is usually called the diesel engine. Since 4-stroke engines are the most wide-spread engines, the so-called IC engines are known.

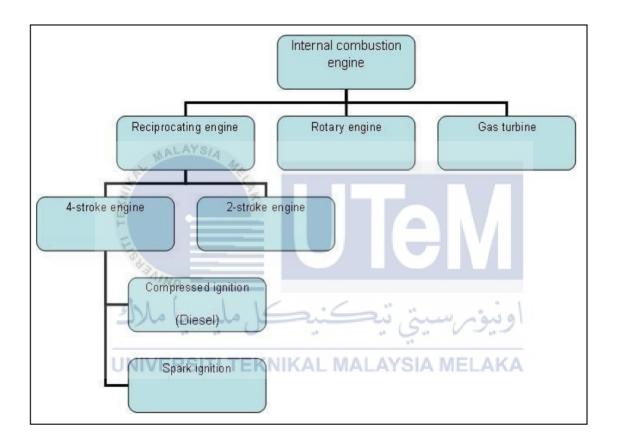


Figure 2.1: Types of Internal Combustion Engine [2]

2.2 Engine Emission

Engine emissions are mainly pollutants in exhaust fuel gases that are damaging to air quality, the engine exhaust, the carcass, and the fuel and carburetor are three major sources. Burned and unburned hydrocarbons, carbon monoxide and nitrogen oxides are discharged from the emissions. The crankcase is a supplementary source of hydrocarbons unbranded and, to a less degree, carbon monoxide. Hydrocarbons that constantly evaporate from gasoline are a small but not an inconsequential contributing element in pollution in the fuel tank and older cars.

2.2.1 Complete Combustion

Complete or simply renowned combustion is necessary to use all petrol correctly, without leftovers. Fuels or chemicals completely burned and only produce greenhouse emissions and water in full combustion. For each atom inside the molecule, there must be sufficient chemical element to search for a match or a combination within the surroundings. The organic molecule combines the chemical element O2 of the atmosphere with the water and greenhouse emission, CO2.

2.2.2 Incomplete Combustion

If another fuel is not fully burnt with oxygen to carbon dioxide and water, the whole combustion is termed. Unfinished combustion may cause fuel inefficiency and pollutants. Normally, in full combustion, less heat is produced than full combustion. Incomplete combustion is caused to incorrect mixing and flame shock, according to [1]. Inappropriate air and fuel mixing is incomplete if some fuel particles do not locate an oxygen molecule to ignite. This may lead to a release of exhaust. Flames quench when flames near to the wall and a tiny quantity of fuel mixture is unreacted, are additional causes of incomplete combustion.

4 CH4 + 7O2 → **2CO + 2 CO2 + 8H2O** (2.2)

2.2.3 Emission in Internal Combustion Engine

Internal combustion engine emissions are becoming one of the world's main concerns because of its detrimental effect on air quality, human health and global warming. Therefore, most governments make an integrated effort to regulate them. Unburned hydrocarbons (HC) and carbon dioxide (CO2) are emissions from combustion [6]. These are the gases emitted from the combustion of natural gas, petrol, biodiesel blends, diesel fuel, fuel oil or coal. It is released into the river via a tailpipe, flue gas stack, or propelling nozzle, according to the motor type. In a pattern termed an exhaust feather, it frequently spreads downwind.

Over the years, the engineering behind a vehicle emission system has evolved significantly, yet pollutants are still being emitted into the air which should be of concern to the public. By comprehending the hazardous emissions of car exhaust, individuals may take a more active part in decreasing car traffic pollution. There are three kinds of car emissions known as evaporative emissions

Emissions, refueling losses and emissions from exhaust. This research focuses primarily on exhaust emissions, but it is still essential to know other kinds of emissions to understand the functions, effects and consequences of this emission. [7], indicated that the emissions from the spark-ignition engines are three methods can be reduced modifications in engine design, circumstances of combustion, and catalytic treatment afterwards.

Each of the pollutants resulting from normal combustion has its own degree of toxicity and may produce hazardous contaminant situations in combination with other components, such as water droplets in the atmosphere. Each element has its unique characteristics, which may cause major issues if big groups of cars are travelling continuously on the same routes every day [6]. Nitrogen oxide (NOX), total organic compounds (TOC), carbon monoxide (CO) and particulates are the primary pollutants of internal combustion engine which include both visible (smock) and non-visible emissions. During the combustion process, the production of nitrogen oxides is directly connected to the high pressure, temperature and nitrogen concentration of the fuel. Incomplete combustion causes the additional pollutants, Hydrocarbon (HC) and Carbon dioxide (CO2).

2.2.4 Carbon Dioxide (CO2)

Carbon dioxide (CO2) is a combustible gas that is slightly less dense than air and is colorless, odorless and tasteless. Carbon dioxide is generated by partial gasoline oxidation which includes atoms of carbon and hydrogen. Carbon (C) from the fuel mixes with oxygen (O2) from the air to generate carbon dioxide during combustion (CO2) Carbon monoxide burns with blue flames and produces carbon dioxide in presence of oxygen, including ambient amounts. The oxidation rate of CO2 is restricted by the kinetics response and can only be speeded up to some degree by improvements in air and fuel combustion.

اونيوم سيتي تيكنيكل مليسيا ملاك

2.2.5 Hydrocarbon (HC) TEKNIKAL MALAYSIA MELAKA

A tiny part of the fuel oil that comprises of compounds passes unburned through the engine and during the heating process additional molecules are produced. Therefore, the hydrocarbons are mostly charred and partially burnt fuel. Lubricating oil also adds to hydrocarbon emissions. Air temperatures may vary in patterns and in various sizes from hydrogen (CH 4) to lengthy hydrocarbon chains with diverse contents such as H, C, N, S and O. The following are gaseous and non-gaseous hydrocarbons: Gaseoushydrocarbons are those which exist at a temperature of 190°C in the gas phase. Some molecules condense in liquid or solid forms at cooler altitudes.

2.2.6 Carbon monoxide (CO)

Carbon monoxide (CO) is generated by not completing a combustion process, either because of a lack of oxygen or owing to low concentrations. Colorless and odorless gas is carbon monoxide. The result of incomplete combustion in the IC engine is carbon monoxide. The carbon containing molecules is partially oxidized. Carbon dioxide (CO2) is often produced following burning in the combustion process. But if the combustion process does not have enough oxygen, carbon monoxide (CO) formations are incomplete. With the reduction of the air intake temperature, carbon monoxide and hydrocarbons were reduced. Combustion processes have impressive outcomes at a lower quatrain than higher intake temperatures because of the greater oxygen content.[6]

2.2.7 Nitrogen Oxides (NOx)

NOx gases are typically generated during ignition in the air by nitrogen and oxygen reactions, particularly at high heats such as in automobile engines. [8] Vehicle nitrogen oxides are mostly produced in combustion engines at temperatures over 1700°C. The higher the pressure of blower increases the emissions of NOX. The Zeldovich mechanism states that the production of NOx is exactly proportionate to the highest combust temperatures and pressures.[3]

2.3 Engine Performance Parameter

The performance of the engine is frequently determined by many parameters. The word potency is related. Today, the development of an internal combustion engine requires all criteria for moving motors in beauty and efficiency.

2.3.1 Engine Power

The output or strength unit of the engine is the greatest power that the grade engine produces. It is usually represented in kilowatts or in power units. The output of the ability relies on the engine size and style, but the pace at which the engine is operating and the load or force. Most power at relatively high speeds and heavy loads is obtained. Power is the quantity of work per time or the pace of labor.

2.3.2 Brake Power and Torque

Measure the motor's ability to use torque power generations. The torque of the engine is usually measured using a dynamometer. The motor is attached to a test bed and the shaft to the testing machine rotor is connected. Brake power refers to the volume of useable power supplied to the crankshaft by the engine [9]. Brake power also refers to the engine's measuring output. This power is assessed by a hydraulic system also known as the brake beside the engine drive shaft. The motor is linked to a brake or load cell which may be loaded to measure the torque of the motor.

> Brake power, BP = 2ΠΝΤ (2.3) N= rpm T = torque

2.4 Air Intake System

Any engine running on an internal fuel combustion must be operated by air. The air intake system is crucial to the operation of the motor, collects the air and directs it to the various cylinders, although not all of this. This is because gasoline can't burn without particularly oxygen in the air and the combustion that drives the engine. In contemporary cars the air must always be cleansed before the intake manifold and ignition chamber is entered. Moreover, contemporary engines depend on an exact air-to-fuel ratio. When the engine is hungry for air, the fuel mix is excessively rich, affecting the engine's performance. The air was fed to the engine via an inlet collector.[10]

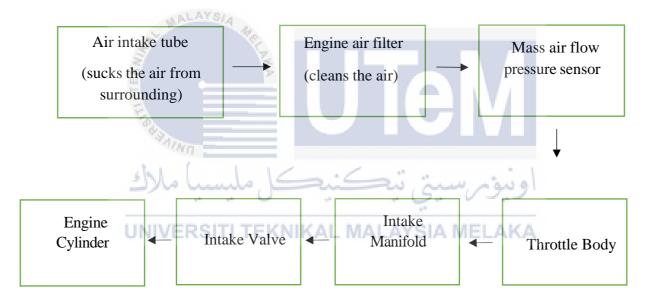


Figure 2.2: Flow chart of the air intake system [10]

Any motor running on internal combustion fuel want to operate air. This is because, although air is not particularly oxygen-free, fuels cannot burn and provide the combustion that drives the engine. In trendy vehicles, the air should really be clean until the manifold and fire chamber is introduced. In addition, trendy engines allow a certain air to fuel relation of size. Once the engine is starving of air, the fuel combination is said to operate too well, resulting in the engine's performance. The air fitted to the motor via multiple.



Figure 2.3: The intake manifold and throttle body play major role in air intake system [11]

The intake manifold is the pipe connecting the intake system to the electric motor inlet valve and is termed the intake manifold when the air fuel mixture passes through. [1], the rise in the mixture's intake temperature increases toward the conclusion of compression, thus raising the final portion of the load temperature to burn, reducing the delay time, and increasing the propensity of burning significantly. [1]. Therefore, the inlet temperature should be kept low, but not too low, so that fuel cannot start vaporizing before the pace at which an engine speeds up with a certain mixture or Electronic Fuel Injection (EFI) ratio is significantly influenced by the quantity of heat and air provided. Within these limitations, the larger the heat supply to the load and the higher its heat at the inlet port, the faster the engine would accelerate [11], a completely controlled diesel engine was built to examine the impact on the performance and emission of a diesel engine on inlet air load temperature. The intake temperatures varied, but the temperature of the coolant was regulated to isolate the impact of the cylinder walls.

2.4.1 Types of Air Intake Design

There are many kinds of air intake systems, and the intake type is based on the function and role of the vehicle. Most pro cars have an inlet of warm air. The most basic air flow systems are intended to improve energy efficiency while providing the driver with sufficient power. The air collected by a warm air consumption is warmer outside the car and, thus, more stimulated but less compact. Each cylinder is pushed to produce less gas and less fuel is required to burn oxygen. The ram-air intake depends on the car's forward motion to bring more air into it, leading to more oxygen in the engine and higher performance. In the engine compartment, the placement of the ram-air intake may influence its performance. The motor may cause air around it to heat and become less dense, with less oxygen per consumed quantity. The inhalation of chilly air. It takes the air away from the engine from a considerable distance, where the air is denser, colder and as oxygen rich as possible. The cold air supplies also provide colder air to your internal combustion engine. This makes your gasoline more efficient. This will enhance the combustion rate of carbon, leading to greater power in the car. Low air flow resistance and excellent air dispersion are some key design requirements for designing intake system.[12]

2.5 Intake temperature and Performance

Improving the burning efficiency of air into the fuel mixture may increase engine performance [13][14]. The easiest method to raise the air flow rate is to decrease the air flow limit through the air filter element. Modern internal combustion (IC) motors utilize an air intake system to filter the air into clean air and route clean air into the combustion rooms. Increased air intake temperature enhances the speed of destruction of molecules. This reduces HC and CO emissions. The increase in air intake causes that flame temperature to rise.[15]

2.6 Intake Temperature and Emission

alund a

With decreased air intake temperature, despite of engine speed, CO emissions decreased. The possible reason for this is that the higher oxygenation at lower temperatures resulted in gasification process mixing and oxidation. The air intake temperature also controls exhaust and combustion emissions. Emissions and flame quality are controlled by a complete process of mixing between fuel and air. The improved combustion results in increased motor power, better fuel economy, superior heat efficacy and less air pollution. At a larger methanol fraction (30 per cent or more) and higher intake air temperatures like 60-70 °C the effect of intake temperature and a methanol fraction on emissions is remarkably stronger. [16] The increase in air intake at constant air mass flow rates improves combustion efficiency and reduces HC, CO, and nanomaterials greenhouse gases without raising Exhaust emission.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CHAPTER 3

METHODOLOGY

3.1 Introduction

Planning is the first step that should be taken into consideration before any given job begins. Careful design work can be successful. A Tally Chart was developed to comprehend the summary of the entire execution and activities of the project. A flow chart explains the whole process of the entire tests and thus the technique discussed here is one which replicates the engineer and emission characteristics tests carried out to achieve the previously stated goal.

3.2 Methodology Flow Chart

The flow chart shown on Figure 3.1 is for the flow process to achieve the objective of the study. This will be the guideline for sequence from staring of material preparation until the result and analysis.

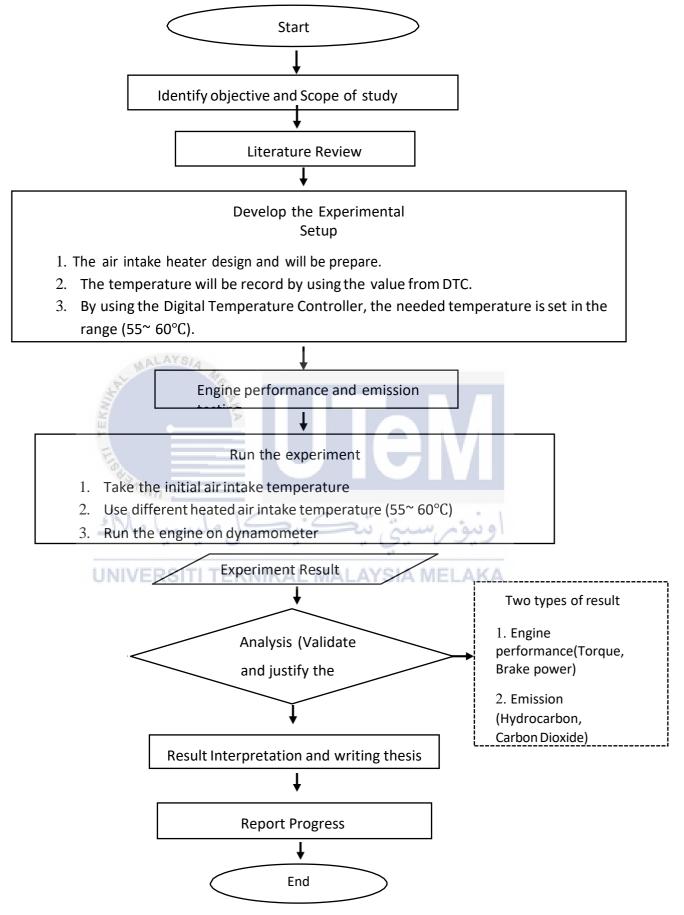


Figure 3.1: Research Flow Chart

3.3 Experiment Design

As illustrated in Figure 3.1, the experiment has been set up. The experimental equipment in this research is given below. The engine utilized for this experiment is 1.6L Satria Neo 4-stroke engine. The engine undergo test with the dynamometer chassis dynamometer (Dynomite). The manipulative variable in the test are RPM, the air intake and the gear (Gear 2,3 and 4). A heater and digital temperature controller with temperature probe sensor on the air intake system varying the air intake warmth depending on the desire situation for the intake temperature. The dyno test (Torque) and exhaust test (hydrocarbon and carbon dioxide) was employed in these manipulative variables).

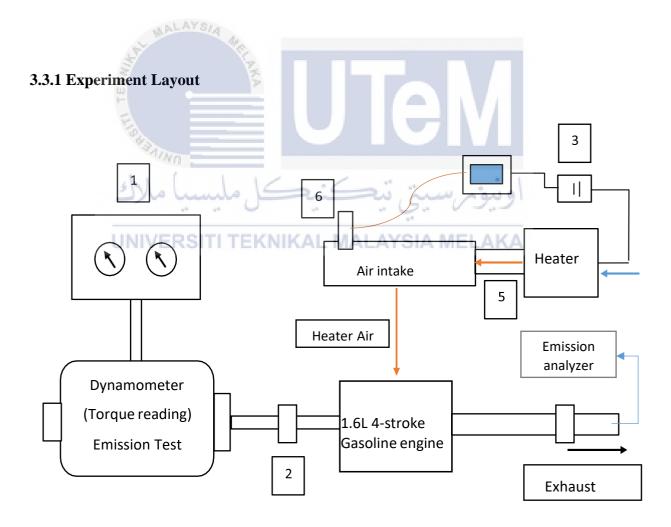


Figure 3.2: The schematic diagram for the experimental layout

- 1. Data acquisition system (control panel)
- 2. Flywheel
- 3. 12 V car battery
- 4. Digital Temperature controller
- 5. Air inlet
- 6. Temperature probe sensor
- 7. Emission analyzer

3.3.2 Tools and Equipment

a) Chassis Dynamometer (Dynomite)

Dynamometer is a practical instrument to measure the power and performance of an automobile, bicycle, truck or even of an agricultural equipment. By transmissions (gearbox, differential), the torque generated by a motor will be transformed to a traction force at wheels. Power is the torque multiplied by the rotary speed; therefore, it is sufficient to measure the tractive force so that the tire power can be calculated for a vehicle, truck and motorcycle. [18] The dynamometer needs know much more to show us the actual power losses of the engine, and the dyno must also know either the components from different (wheel speed ratio to engine speed) or the frequency of the engine directly. Chassis dynamometers are set up as indicate in Figure 3.3 which remove the possibility to slide the wheel from old-style drive rollers and connected directly to the car hubs to measure the torque from the axle. In the development test cell systems, the integration of the dynamometer control system and automate calibration tools for engine system calibration are frequently encounter. The load and engine speed of the dynamometer will be change to various engine operation points inside these systems, while chosen engine management

parameters differ and the information will be automatically record. Subsequent examination of this data may then be utilized to produce engine calibration computer data. Several instruments will be used for testing, such as the Chassis Dynamometer itself (Dynomite), harness belt, fan, laptop as a data processing device, ratchet strap harness, rpm to record motor speeds.



Operating Procedure of Chassis Dynamometer Dynomite

Some procedures must be taken to operate the dynamometer of the chassis (Dynomite). This is because it would be extremely hazardous without appropriate understanding of the equipment and because the machine itself is expensive. All equipment is first will be install and test. The parking lot on the Dynamometer after everything is check. The ratchet strap harness will be fixed to retain the car. The tachometer to measure engine speed (revolution every minute) while driving will be fix after the strap harness is fix and check. Next, the fan and PC simulation fan will activate. Finally, automotive data such as number and type of vehicle will be entered into the PC simulation and the dyno test will be perform once.

(b) 1.6L 4-stroke Satria Neo Engine

The vehicle will be use in this study is Satria Neo 1.6L manual transmission. The engine plays an important role in both the dyno test and emission test. Thus, it is a must to know and understand the details of the engine being use. Table 3.1 below shows the engine specification.

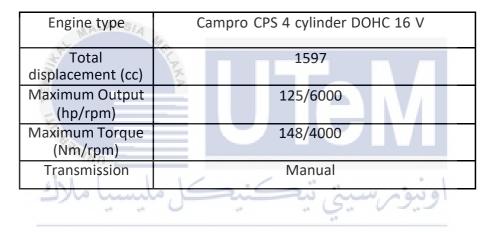


Table 3.1: 1.6L Satria Neo engine specification

(c) Air Intake ERSITI TEKNIKAL MALAYSIA MELAKA

The air filter box plays a huge part in this experiment. This is because the main part of the air intake system in a vehicle is the air filter box consist of the air filter, temperature sensor and throttle body. The air from the surrounding is suck through this filter box to the air filter and then to the engine cylinder for the combustion process. In this experiment the air filter will be modify with added thermocouple and connect with the heating system.



Figure 3.4: Satria Neo Air Filter 1.6L

(d) Heater

The heater is shown in Figure 3.5 that is used in this experiment. The main function of the heater is to supply hot air that is heated until the temperature reaches until 60°C~80°C. The purpose is to heat the air that enters the air intake. This heater consists of heater coil. The heater will be installed on the air filter box. The table 3.2 shows the specification of the heater fan was used in the experiment.

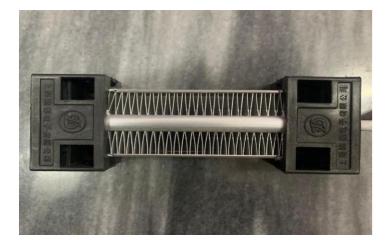


Figure 3.5: Heater

Power supply	12 V
Input power and main unit	150 W
Product size	110 x 40 x 26mm
Weight	150g

Table 3.2: Specification of the heater

(e) Digital Temperature Controller (DTC)

The temperature controller as illustrated in figure 3.6 is a temperature control device primarily without significant participation by the human. A climate control system controller will take a transistor, RTD sensor as input and compares the actual warmth here to intended control or set point. It will then give a control element with an output. The DTC is the power source for the mains (DC current 12 V 150 W) with the NTC10K probe.

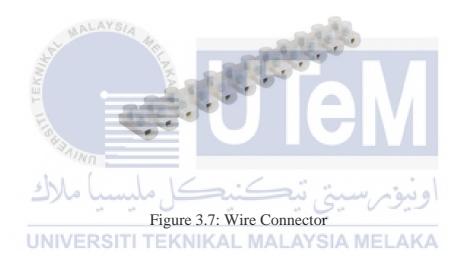
UNIVERSITI TEKNIKAL MALAYSIA MELAKA



Figure 3.6: Digital Temperature Controller

(f) Wire Connector

Electrical circuits are composed of a multitude of components, including wires and cables. Electrical connectors indicated in Figure 3.7 are used to join these to form a continuous path for electrical current to flow. Connectors have male-ends (plugs) and female-ends (jacks) which connect to each other forming either a permanent connection or, more often, a temporary connection that can be assembled and removed with special tools. For this study the wire connector used to connect the whole heater system electrical circuit.



(g) 12 V Battery

The battery is essentially a device that generates electron via electrochemical processes and includes positive (+) and negative (-) terminals. One or more electrochemical cells are formed into a battery that immediately transforms stored chemical energy into electricity. The 12V battery indicated in Figure 3.8 was utilized for the purposes of the electronic air warmer and the digital temperature sensor. The battery flow speed is controlled by resistance and external load, thus the rationale why 12V battery is chosen is based on the specifications of the equipment utilized.



Figure 3.8: 12 V Car Battery

(h) Switch (12V)

An electrical switch as illustrated in figure 3.9 serves the purpose of controlling the flow of electrical current within a circuit. It can be used to both inhibit the flow of the current or to initiate it. A switch performs the task of manually cutting or reconnecting power from an electrical supply by creating or closing an air insulation gap between two conduction points. For this study the switch used to connect in heater system circuit to prevent any damage to heater and wiring when the current flowing through electrical circuit supersedes its design limits.



Figure 3.9: Switch 12V

(i) Wire

The wire plays an important role as it is the one which connects all the electric components such as the starter relay, fuse, digital temperature controller and car fan heater and completes the entire circuit. The wire used is 90 cm copper wire as depict in figure 3.10 below.



(j) Emission Analyzer

Emission analyzer is shown in Figure 3.11 that is used to measure the amount of gas emission level produced by the vehicle. The EMS gas model 5002 exhaust emission analyzer is used to get the accurate data of exhaust gas emission. Combustion analysis is a part of a process intended to improve the quality of the emission gaseous that emits from the engine combustion, reduce undesirable exhaust emission, and improve the safety of fuel burning equipment. The transportable exhaust-gas testing system is ideal for all mobile testing applications. For this study the EMS gas analyzer is used to analyze the emission value of the 1.6L 4-stroke Satria neo engine.

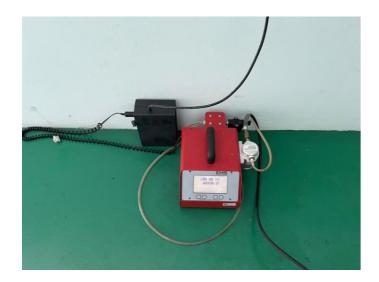


Figure 3.11: EMS emission analyzer.

3.4 Analysis

The experimental data were collected at different speed with apply heater and without heater. The experiment will be repeat at three different gears which is gear 2, 3 and 4.

. alun 5 å ing

Table 3.3: Table Generated for the Dynometer Test Varying Speed and Gear

Speed (rpm)	Brake power (kw) (with heater)	Brake power (kw) (without heater)
1500		
2000		
2500		
3000		
3500		

Speed (rpm)	Torque (NM) (with heater)	Torque (NM)(without heater)
1500		
2000		
2500		
3000		
3500		

Speed (rpm)	Hydrocarbon (HC) (%) with heater	Hydrocarbon (HC) (%)without heater
1500		
2000		
2500	AY SIA	
3000	110	
3500		
IN TEK		

Speed (rpm)	Carbon Dioxide (CO ₂) (%) with heater	Carbon Dioxide (CO_2)(%) without heater
1500		
2000 IVER	SITI TEKNIKAL MALAYS	SIA MELAKA
2500		
3000		
3500		

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter will discuss and analyse result of the experiment that have been conducted b obtain the data of performance and emission of the 4-stroke engine. The tests are to investigate and compare the data obtained before and after the installation of the heaterin terms of engine performance (brake power and torque) and emission (Hydrocarbon and Carbon dioxide). All the data obtained from the experiments are presented in bar and line graph form.

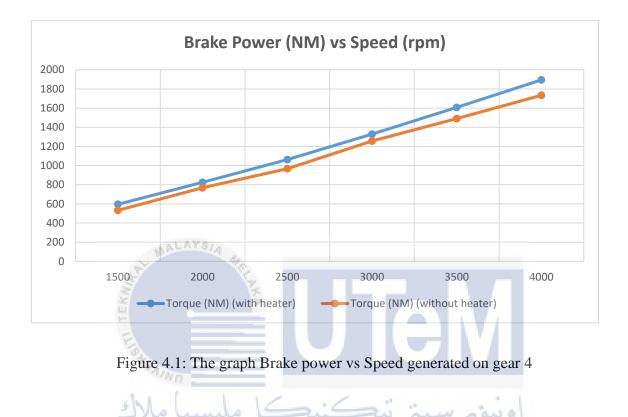
4.2 Brake Power

The brake power value was recorded at two condition which is with and without heater under **UNIVERSITIEE ANAL MALAYSIA MELAKA** varying speed and different gears. The first test that was conducted was the overall performance of the vehicle. Whereby the engine was let run on the dyno machine on gear 4 until it reaches 4000 rpm. The data were collected and recorded as shown in figure 4.1. The figure was increasing steadily. As the speed increases the brake power value also increases.

4.3 Engine Performance

The engine performance that are tested in this experiment was engine power and torque. The brake power and torque value were recorded in two condition which is before installing heater and after installing heater at different speed (1500,2000,2500,3000 and 3500 rpm)

and gear (2,3 and 4). The data were recorded and presented in the form of graph for better understanding.



4.3.1 UGear 2 RSITI TEKNIKAL MALAYSIA MELAKA

Based on Figure 4.2 below the bar graph indicates the power increases as the speed increases steadily on gear 2. The brake power of the vehicle is higher with the presence of heater compared to the brake power obtained without the presence of heater. The highest power value was obtained when the vehicle was running on 3500 rpm for both graphs was 2566.36 kw with heater and 2201.31 kw without heater. The lowest power value was 466.52 kw without heater and 741.73 kw with heater at 1500 rpm. This shows that brake power increases when heat is supplied to the engine.

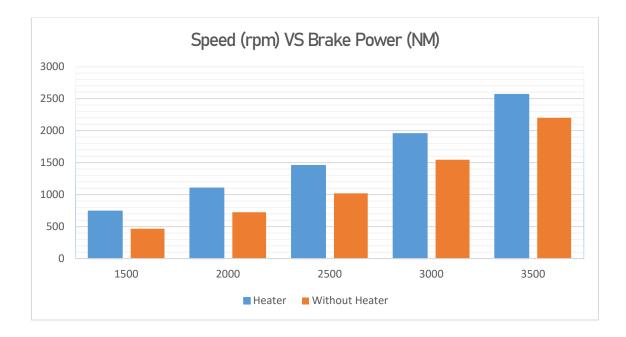


Figure 4.2: The bar graph Speed (rpm) vs Power (kw) on gear 2



Figure 4.3 suggests the bar diagram indicates the power will increase as the speed will increase progressively on gear 3. The power with heater value recorded greater than the power without heater in gear 3. The best possible brake power performed was 1915.42 kw (with heater) at some point of 3500 rpm, and the lowest was 755.86 kw (with heater)on 1500 rpm. For the power value without heater, the most power value obtained was 1836.26 kw and the least was 706.85 kw. The increase in brake electricity is influenced by using the heater.

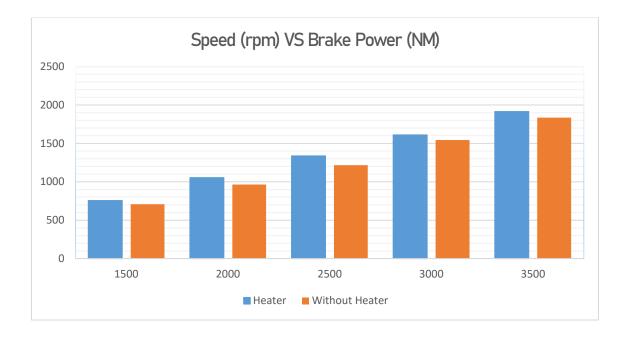
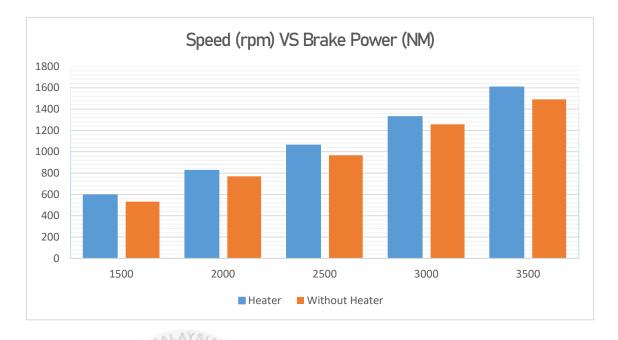
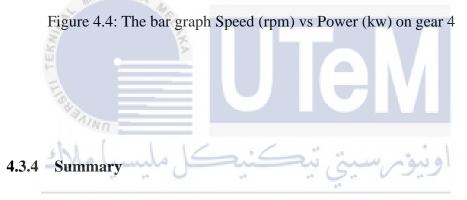


Figure 4.3: The bar graph Speed (rpm) vs Power (kw) on gear 3



From the figure 4.4, the highest power value recorded was 1490.99 kw without the presence of heater and the highest recorded with the presence of heater was 1607.55 kw. This shows that the brake power varies when load is applied which is gear 4. On gear 4 the load makes the engine heavier, and the heat supplied makes the power varies from previous gears. The lowest brake power recorded was in without heater condition that is 532.49 kw without heater and 595.64 kw with heater condition.





UNIVERSITI TEKNIKAL MALAYSIA MELAKA

From all the graph performance that have been observed, the engine performance in terms of power increases as the load increase and as the temperature increases. This is because the combustion efficiency increases in the engine. The preheat intake air temperature triggers the air-fuel mixture burn quickly as the temperature is far higher than the ambient temperature. As the load and the speed increases more air is being sucked into the engine makes the power to increase slightly. In article [19], the intake air is taken at the 3 different temperature, 20°C ,25°C and 30 °C and the Brake Specific fuel consumption (BSFC) when the engine is operating at 1500 rpm until 3000 rpm. Brake Specific Fuel Consumption is the rate of fuel consumption divided by power produced. At higher engine speed, a larger portion of gaseous fuel to be

involved in the oxidation process that leads to higher reaction activity resulted in lower BSFC. The results also show that the BSFC decreases as the air intake temperature decreases. The highest value of brake specific fuel consumption was observed at higher air intake temperature 30 °C, which was 4% lower than the lowest air intake temperature 20 °C. As we know the BSFC is inversely proportional to the BSFC the brake power increase with the increasing rpm. On our project we find out the nature of the brake power with the heater added and removed on the different rpm. The result of our project shows with the heater added the brake power also increases with the increasing rpm and similarly brake power has the similar graph plotted for the added heater. Thus, we can verify with the data from the article and the above summary of the current project. Also, with the article [20], the brake power increase with increase in rpm which also verifies the results we have obtained. Deviation of our project with the article: as the higher temperature intake air gives the higher BSFC value that means the higher temperature intake air would give less value of brake power. But in our case, we have found out adding heater the power is greater than the power without adding heater.

4.4 Torque

For the torque value the first test was the overall performance test. The engine was let run on the dyno machine on gear 4 until it reaches 4000 rpm. The data were collected and recorded as shown in graph 4.5 below the graph was increasing sharply as the speed increases the torque value also increases. The highest torque value recorded was 75.4 NM with heater and 69.0 NM without heater.

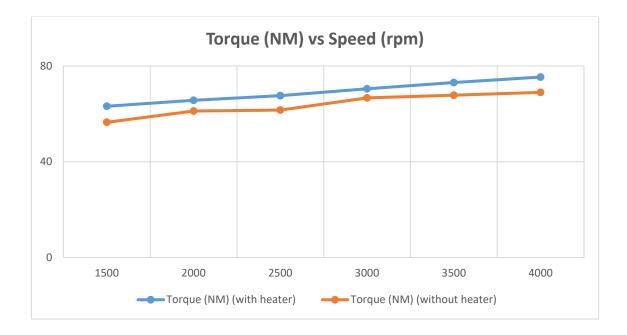


Figure 4.5: The Torque (NM) against Speed (rpm) on gear 4 for the performance test

4.4.1 Gear 2

Based on figure 4.6 below, the bar graph shows that the torque value obtained with the presence of heater increases gradually. Whereby the torque value fluctuated without the presence of heater. The maximum torque value reached was 115.7 NM at 3500 rpm and the least value was 78.7 NM with the presence of heater at 1500 rpm for the highest torque value recorded without the presence of heater was 100.1 NM at 3500 rpm and the lowest was 49.5 NM at 1500 rpm. This shows that torque value increases with the presence of heater compared to the condition without the presence of heater.

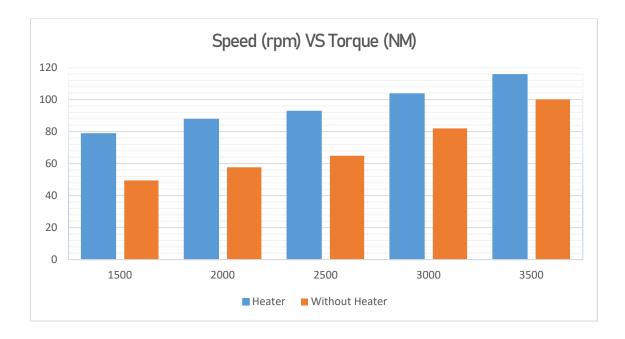
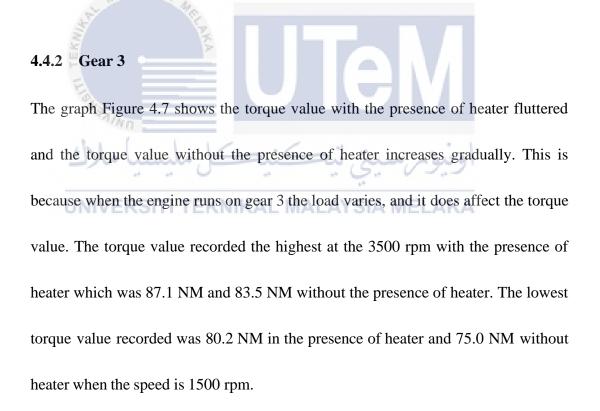


Figure 4.6: The bar graph Speed (rpm) vs Torque (NM) on gear 2



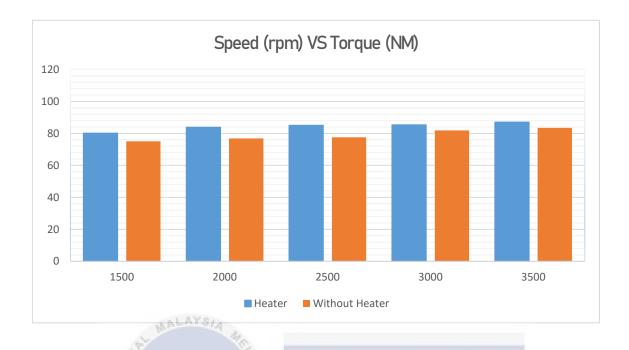


Figure 4.7: The bar graph Speed (rpm) vs Torque (NM) on gear 3

4.4.3 Gear 4

Based on Figure 4.8, the graph shows the torque value undergoes fluctuation on both conditions. The highest torque value was 73.1 NM with heater and 67.8 NM without heater recorded is when the speed was 3500 rpm. From the data obtained, it can be clearly seen that gear 4 load makes the torque to fluctuate consistency's 3500 rpm is the bench maker where the torque value reaches its peak and drops again. The lowest torque value 56.5 NM without heater and 63.2 NM with heater obtained was at the initial speed which is 1500 rpm.

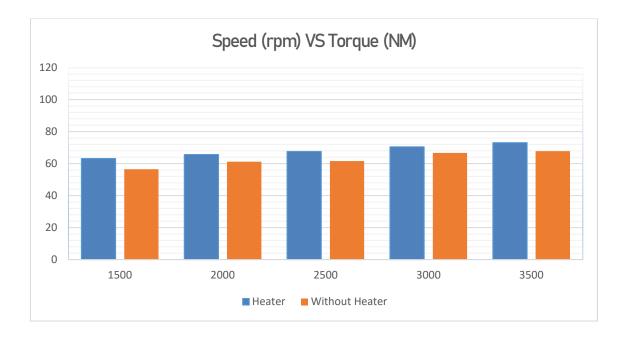


Figure 4.8: The bar graph Speed (rpm) vs Torque (NM) on gear 4

4.4.4 Summary

As an overall observation from all the graph the torque value increases as the speed and load increases. This is due to those the high intake air temperatures increased the in-cylinder gas temperature at the end of the compression stroke and accelerated the entire combustion process thus increases the engine power. The engine power was calculated through the torque recorded and this proves that the engine power should increase simultaneously as the torque increases. The load also has influenced the torque value aswell as the engine operates more efficiently as the preheated air intake has increase the engine efficiency. In the journal [21], it has found out the engine performance for the different engine speeds and with the variation of intake design. As seemed the graph plotted for every of the design are increasing with respect to the increasing rpm. For some of the intakes the torque reaches the maximum value at some point and again starts to decrease from the point with respect to increasing torque. Also, in the journal [22], in this experiment the four-cylinder, air cooled, direct injection diesel engine operated over a range of inlet air temperatures. For the experiment constant speed 2100 rpm and variable Torque (2,4,6,8 and 10) Nm and variable intake air temperature (normal ,20 C,30 C and 40 C) and make comparison with the normal state. As the obtained results the air at room temperature, the values of the torque plotted increases and reach the maximum value of torque but after increasing the temperature above room temperature the torque values increase steadily over the increasing engine speed. This verifies our results obtained in the project that is the torque value increases as the speed and the load increases.

4.5 Emission

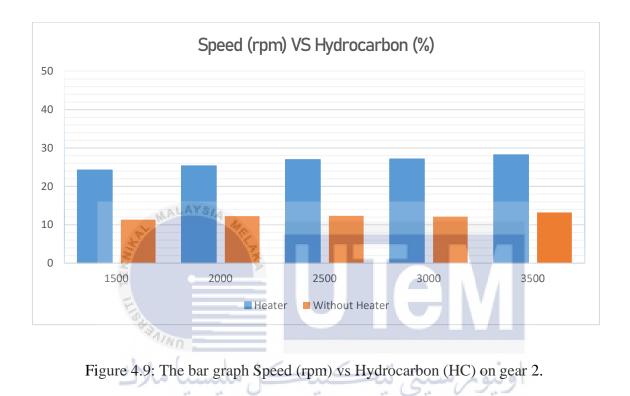
The emission test was conducted on the same dyno machine. The hydrocarbon and carbon dioxide value were recorded in two condition which is before installing heater and after installing heater at different speed (1500,2000,2500,3000 and 3500 rpm) and gear (2,3 and 4).

4.6 Hydrocarbon (HC)

4.6.1 Gear 2

Based on Figure 4.9, the bar graph shows the hydrocarbon value increases with the presence of heater compared to the hydrocarbon value without the presence of heater. This is because the heated air leads to complete combustion, and this increase the hydrocarbon level as the engine piston works at its usual speed but at heated air intake temperature increasing it combustion efficiency. The highest hydrocarbon value with

heater recorded was 28.21 % at 3500 rpm and the lowest was 24.28 % at 1500 rpm. While for the hydrocarbon level without heater the highest value was 13.2% and the lowest was 11.32%.



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

4.6.2 Gear 3

The bar graph in Figure 4.10 shows, the hydrocarbon value undulated in both conditions but with the presence of heater the hydrocarbon value increases compared to the condition without heater. This is because the heated air leads to complete combustion, and this increase the hydrocarbon level as the engine piston works at its usual speed butat heated air intake temperature increasing it combustion efficiency. The increasing speed with higher gear influences the hydrocarbon value. The highest hydrocarbon value with heater recorded was 23.43% at 3500 rpm and the lowest was

14.86 % at 1500 rpm. While for the hydrocarbon level without heater the highest value was 21.21 % and the lowest was 8.72 %.

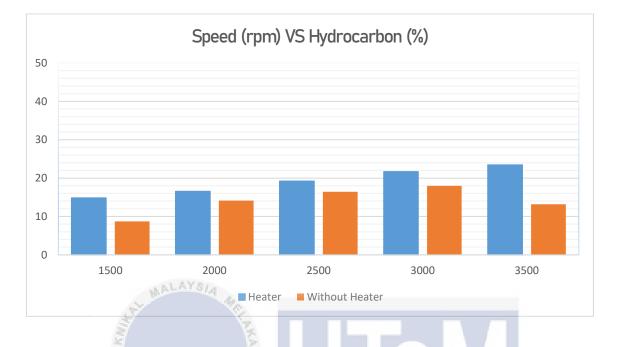


Figure 4.10: The bar graph Speed (rpm) vs Hydrocarbon (HC) on gear 3

4.6.3 Gear 4

As per the bar graph Figure 4.11 shows, the hydrocarbon value undergoes fluctuation in each conditions however with the presence of heater the hydrocarbon value increasing contrast to the condition without heater. This is due to the fact the heated air leads to entire combustion, and this amplify the hydrocarbon level as the engine piston works at its common speed however at heated air consumption temperature growing it combustion efficiency. The best possible hydrocarbon value with heater recorded was 22.34 % at 3500 rpm and the lowest was 12.66 % at 1500 rpm. While for the hydrocarbon level without heater the highest value was 11.93 % at 3000 rpm and the lowest was 8.6 % at 1500 rpm.

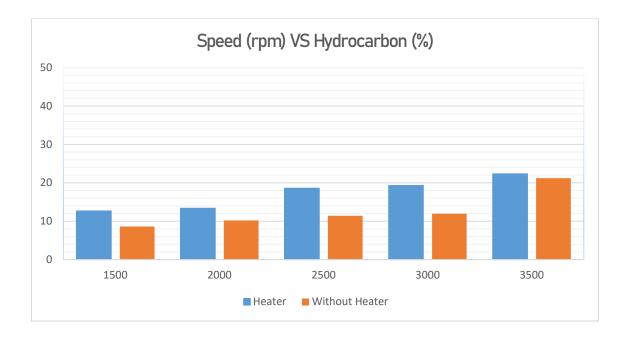


Figure 4.11: The bar graph Speed (rpm) vs Hydrocarbon (HC) on gear 4



Overall observation from all the graphs, shows that the as the load and speed increases the hydrocarbon percentage value increases steadily. This is because incomplete combustion was advanced with the increase of intake air temperature. Emissions are generally produced due to incomplete combustion of a carbon containing fuel. The increased preheated air availability in the combustion chamber can promotes incomplete combustion of both CO and HC emissions. The incomplete combustions make the hydrocarbon from fuel not completely burned thus increases its percentage value. In the journal [23], It has been observed that HC emissions increase with increasing braking force and exhaust gas recirculation. When the braking force is 4kW, if 10% of the hot exhaust gas is fed back directly to the intake manifold, the HC emission will increase slightly (about 3.5%). However, under the same braking performance conditions, if the exhaust gas is cooled in a heat exchanger before it is recirculated, the increase in HC emissions will be significantly higher than without EGR (approximately 14%). As the exhaust gas recirculation rate increased from 10% to 20%, HC emissions increased in both hot and cold exhaust gas recirculation (EGR). The increase in HC concentration with the increase in EGR rate is due to the reduced availability of oxygen in the intake charge due to the recirculated exhaust gas in the cylinder. In summary, HC emissions increased when the exhaust gas was recirculated to the intake manifold compared to an engine operating without EGR. HC emissions were further increased by cooling the exhaust gas at $820 \degree C$.

4.7 Carbon Dioxide

4.7.1 Gear 2

From the graph below, the graph 4.12 suggests that the value of carbon dioxide is increasing progressively with the presence of heater. Meanwhile, without the presence of heater the carbon dioxide value fluctuates. Higher engine speed and heated air intake temperature cause higher combustion rate that subsequently will produce more carbon dioxide. The highest carbon dioxide with heater recorded was 22.07 % at 3500 rpm and the lowest was 13.54 % at 1500 rpm. While for the carbon dioxide level without heater the highest value recorded was 14.58 % at 3500 rpm and the lowest was 9.76 % at 1500 rpm.

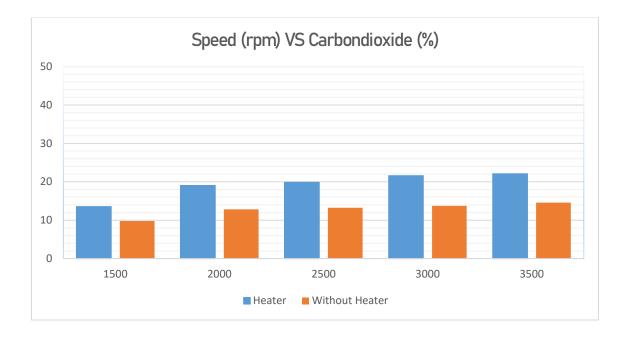


Figure 4.12: The bar graph Speed (rpm) vs Carbon Dioxide (CO₂) on gear 2



As for Figure 4.13, the graph indicates that the carbon dioxide value undulated in both with and without heater condition. The increasing engine speed and heated air intake temperature cause higher combustion rate that eventually will produce greater carbon dioxide. The carbon dioxide with heater value reaches the highest value 18.64 % at 2500 rpm and lowest value 17.26 % at 2000 rpm. For the value without the heater, the highest value obtained was 13.4 % at 2000 rpm and the lowest value was 12.87 % at 2500 rpm. The increasing gear (load) influences the percentage value of the carbon dioxide.

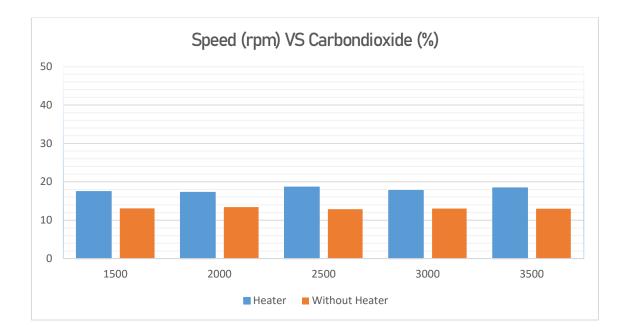


Figure 4.13: The bar graph Speed (rpm) vs Carbon Dioxide (CO₂) on gear 3



Based on Figure 4.14, the graph suggests the presence of heater increases the level of carbon dioxide. The bar graph with heater increases progressively and reaches its peak value which is 30.13 % at 3500 rpm. The carbon dioxide degree recorded lowest value was 23.85 % with heater at 1500 rpm and 12.83 % without heater at 2500 rpm. The highest gear and top speed produce more carbon dioxide in contrast to other lower gears. This virtually shows that growing speed will increase the combustion and produce greater carbon dioxide.

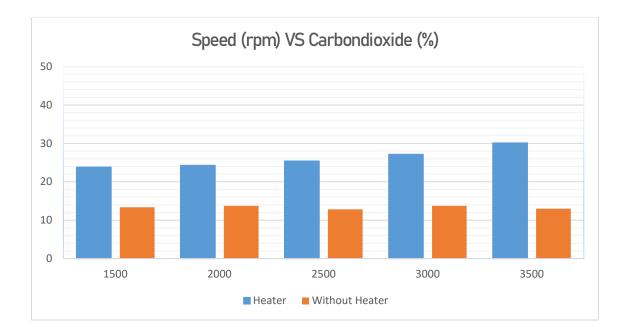


Figure 4.14: The bar graph Speed (rpm) vs Carbon Dioxide (CO) on gear 4

4.7.4 Summary

Based on all the graph observed, the percentage level of the carbon dioxide increases as the load and speed increases. Carbon dioxide emissions are generally produced due to incomplete combustion of a carbon containing fuel. Lower excess concentration results in rich air fuel mixtures at different locations inside the combustion chamber. This heterogeneous mixture does not combust completely and results in highercarbon dioxide emissions. In addition, the longer ignition delay due to the oxygen deficiency caused by increased air intake temperature will lead to poor oxidation process. Thus, increases the carbon dioxide emission level. In the journal [24], they discuss and analyze the results of experiments performed to obtain emission data from 4-stroke engines. The purpose of the test is to investigate and compare the data obtained before and after the installation of the cooler in terms of carbon dioxide emissions. They show that the percentage of carbon dioxide is arranged according to different gear values, different engine speeds, and the presence or absence of radiators. Their experiments were carried out by designing a cooling system that cools the air below ambient temperature. The data for this experiment was collected in terms of emission levels by running the test on a bench test machine. Emissions testing records the percentage of carbon dioxide in different gears (2nd, 3rd, 4th), speeds (1000, 1500, 2000, 2500, 3000) rpm and different conditions: no radiator and with radiator. The results obtained show that lowering the intake air temperature can reduce the proportion of carbon dioxide in the exhaust gas that can contaminate nature.

In the journal [23] it shows that CO_2 emissions increase as the braking force increases. However, it has been shown that operating with exhaust gas recirculation reduces CO_2 emissions. When the braking force is 4 kW, recirculating 10% of the exhaust gas to the intake manifold at a temperature of 820 °C reduces CO_2 emissions (about 5.5%). However, under the same braking performance conditions, cooling the exhaust gas with a heat exchanger before recirculation results in a significant (about 16%) reduction in CO_2 emissions compared to not using EGR. Increasing the gas recirculation rate to 20% reduced the CO_2 emission concentration to 8.9%, but for the same cold EGR ratio, the CO_2 emissions were about 8 vol%. CO_2 emissions decreased as the proportion of EGR increased, probably due to lower oxygen concentrations in the gas fuel and air mixture. Cold EGR lowers the cylinder temperature, further reducing the rate of fuel oxidation in the combustion chamber and reducing CO_2 emissions. In summary, CO_2 concentration emissions were reduced when the exhaust gas was recirculated to the intake manifold compared to an engine operating without EGR. However, when the exhaust gas was cooled before the recirculation, the CO_2 concentration was further reduced compared to the direct recirculation of this hot gas.



CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

In this chapter will discuss the result, data, conclusions, and recommendation based on the experiment that had been done conducted. The conclusion made based on the earlier scopes of the experiment on Chapter 1, and to make some improvement and safety for further study, some recommendation was made for the experiment.

5.2 Conclusion

This experiment was conducted by designing a heater system that heats the air higher than the ambient temperature. The data for this experiment, was collected in terms of engine performance and emission level by conducting test on dynometer test machine.For the engine performance, brake power and torque value tabulated while for the emission test, hydrocarbon percentage value and carbon dioxide percentage value were recorded under different gears (gear 2,3 and 4), speed (1500,2000,2500,3000 and 3500) and different conditions which was without heater and with heater. The data collected from the experiment shows that there are significant differences in engine performance and exhaust emissions depending on the temperature of the intake air. The highest temperature recorded was 57.3 °C which was according to the set range (55 °C \sim 60 °C) on the gear 4 and on its top speed which was 3500 rpm. In this condition is where the brake power(1607.55kw), torque (73.1 NM), hydrocarbon (22.34 %) and carbon dioxide (30.13 %) recorded the highest. Compared to the data recorded before, on gear 4 without heater the engine

temperature was 42.8 °C. At this condition the brake power (1490.99 kw), torque (67.8 NM), hydrocarbon(11.74%) and carbon dioxide (13.72%). The differences are significant which showed that the air intake temperature has a significant role to increase the combustion efficiency, that leads to better engine performance but poor exhaust emission. This clearly shows that increasing air intake temperature could increase the engine performance. At the same time, it also increases the percentage level of hydrocarbon and carbon dioxide at the exhaust emission that can pollute the nature. Thus, increasing air intake temperature has its advantage and disadvantage.

5.3 Recommendation

For further improvement to the experiment, several suggestions and recommendations are given.

- Increase the temperature much higher than 60 °C, this experiment has limit and maybe increasing the temperature would get data that is more favourable.
- It is made sure that there are no leaks before starting the experiment as a leak could cause invalid data during the experiment.
- Reduce the temperature than the ambient temperature by reducing the temperature data for the engine performance and emission can be compared.
- The way conducting the test using the simulation type system. More to program-based method rather than the manual method using the heater

4.0 **REFRENCE**

- Yesserie, "The impact of ambient temperature on combustion engine effectiveness," Nhk技研
 , 2015.
- [2] V. Davis, M. Shafee, and P. Baskar, "Four-stroke si engine study with warmed air intake," *Int. J.Chem. Sci.*, 2015.
- [3] N. R. Abdullah, N. S. Shahruddin, R. Mamat, A. M. I. Mamat, and A. Zulkifli, "Air intake pressures on engine performance, fuel efficiency and small petrol engine exhaust pollutants," *J. Mech. Eng. Sci.*, 2014, doi: 10.15282/jmes.6.2014.21.0091.
- [4] C. J. Brace, G. Hawley, S. Akehurst, M. Piddock, and I. Pegg, "Improvements to the cooling system - Evaluation of emissions and fuel consumption," *Proc. Inst. Mech. Eng. Part D J. Automob. Eng.*, 2008, doi: 10.1243/09544070JAUT0685.
- [5] V. Smil, Creating the Twentieth Century: Technical Innovations of 1867-1914 and Their Lasting Impact. 2005.
- [6] N. R. Abdullah, H. Ismail, Z. Michael, A. A. Rahim, and H. Sharudin, "Effects of air intake temperature on the fuel consumption and exhaust emissions of natural aspirated gasoline engine," *J. Teknol.*, 2015, doi: 10.11113/jt.v76.5639.
- S. H. Oh and E. J. Bissett, "Chemical reaction architecture automotive uses and future researchrequirements," 2006, doi: 10.1016/s0167-2991(06)81533-8.
- [8] H. Omidvarborna, A. Kumar, and D. S. Kim, "NOx emissions from lowerature combustion of biodiesel made of various feedstocks and blends," *Fuel Process. Technol.*, 2015, doi: 10.1016/j.fuproc.2015.08.031.

- [9] T. J. Wallington, E. W. Kaiser, and J. T. Farrell, "Automotive fuels and internal combustion engines: A chemical perspective," *Chem. Soc. Rev.*, 2006, doi: 10.1039/b410469m.
- [10] C. Cinar, A. Uyumaz, H. Solmaz, F. Sahin, S. Polat, and E. Yilmaz, "Effects of intake air temperature on HCCI engine combustion, performance and emission parameters were fuelled using combinations of 20% n-heptane and 80% occupants are relatives.," *Fuel Process. Technol.*,2015, doi: 10.1016/j.fuproc.2014.10.026.
- [11] A. J. Torregrosa, P. Olmeda, J. Martín, and B. Degraeuwe, "Experiments on the influence of inlet charge and coolant temperature on performance and emissions of a DI Diesel engine," *Exp. Therm. Fluid Sci.*, 2006, doi: 10.1016/j.expthermflusci.2006.01.002.
- [12] M. A. Ceviz, "Intake plenum volume and its influence on the engine performance, cyclic variability and emissions," *Energy Convers. Manag.*, 2007, doi: 10.1016/j.enconman.2006.08.006.
- [13] M. M. Rahman, M. Kamil, and R. A. Bakar, "Engine performance for hydrogen-powered engine for 4-cylinder direct injection," Simul. Model. Pract. Theory, 2011, doi: 10.1016/j.simpat.2010.10.006.
- [14] S. Nallusamy, S. Sendilvelan, K. Bhaskar, and N. M. Prabu, "Performance analysis, emission and combustion characteristics of new pine oil ethanol," *Rasayan J. Chem.*, 2017, doi: 10.7324/RJC.2017.1031787.
- [15] A. Calam and ve Y. Içingür, "Effect of inlet temperature on combustion and HCCI engine power,"

Isi Bilim. Ve Tek. Dergisi/ J. Therm. Sci. Technol., 2019.

[16] W. Pan, C. Yao, G. Han, H. Wei, and Q. Wang, "The impact of intake air temperature on performance and exhaust emissions of a diesel methanol dual fuel engine," *Fuel*, 2015, doi: 10.1016/j.fuel.2015.08.073.

- [17] S. Jo, H. Jun Kim, and S. Park, "High air-intake effects on cetane number with constant charge efficiency," *Fuel*, 2020, doi: 10.1016/j.fuel.2020.117733.
- [18] C. Birtok-Băneasă, S. A. Raţiu, and T. Hepuţ, "Thermal conductivity calculation for new materialused in petrol engine load resistances," 2017, doi: 10.1063/1.4992307.
- [19] C Birtok Baneasa, S. R. (2011). Influence of intake air temperature on internal combustion engine operation. *International Conference* on Applied Sciences (ICAS2016), 8.
- [20] M. A. Kalam*, S. N. (2011). Power boosting of a modified natural gas engine. International Journal of the Physical Sciences , 10.
- [21] Muhammad Hariz Khairuddin, M. F. (2017). Simulation analysis of spark ignition engine intake manifold for better performance. Jurnal Teknologi, 8.
- [22] Waheb, D. J. (2015). Study on Effect of Heating Inlet Air Temperature on Emissions and Performanceof Diesel Engine. *Journal of applied Science Research*, 5
- [23] Aritra Ganguly, B. N. (2018). Performance and Emission Characteristics of a Four Stroke Spark Ignition Engine with Recirculation of Hot and Cold Exhaust Gases. International Journal of Engineering & Technology.
- [24] Prem Kumar, N. R. (2021). Effect of Changing in Air Intake Temperature on Engine Performance Using Thermocouple. *Journal of Advanced Industrial Technology and Application.*

APPENDIX A

GANTT CHART PSM I

									Ser	nest	er 2	020/	202	1				
Project Activity											Wee	k						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17 18	19 20
Confirmation of supervisor and title																		
Preparation and pre research																		
Submission the proposal of project Researching																	Final	
about the study		WP	LAY	SIA				Mid								St	Sem	Sem
Identify suitable method and study the concept and working principle of the thesis	AN TERUIRA				~~	NKA I		Term Break	J							Study Week	Final Semester Examination	Semester Break
Project report writing (Draft: Chapter 1-3)	5	Lo	(J.		ما	کر			_	23:	ë		· /	بو:	او			
Submission of draft project report to supervisor	JNI	VE	RS	ITI	TE	KN	IIK.	AL	MA	LA	YSI	AN	ΛEI	_AI	κA			
Editing and correction of any errors																		
Submission of thesis																		
Presentation preparation																		
Presentation for PSM1																		

APPENDIX A

GANTT CHART PSM II

		Semester 2021/2022																		
Project Activity											W	eek								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
First meeting with supervisor																				
Preparing tools and equipment's										Mid										
Discussion on testing date at FTK										Mid Semester Break										
Submission letter of using dyno and emission analyzer to FTK Laboratory	The second se	AAL	AYS	14	Ser Pro-					Break						Study Week		Final Comoctor Evamination		<i>د</i>
manager Dyno Testing being held at FTK Results update on the report	6.63	INT									G					Week		Evamination	Semester Break	
Project report writing (Draft: Chapter 1-5)	М) م	~~~	لي	۵ ر	4		÷		2	i J.	:32:	20	in the second se	وي	1				
Submission of draft project report to supervisor	NIV	EF	lSI		ΓE	KN	IK/	A.L.	M.	AL/	AYS	AI	ME	EL/	AK.	A				
Editing and correction of draft report																				
Submission of report																				
Ready for presentation																				
Presentation for PSM2																				

APPENDIX B

DYNOMETER TESTING (ENGINE PERFORMANCE AND EMISSION)



Calibrating the dyno rpm and the vehicle rpm to be same before starting the dyno run



The digital temperature controller measuring air intake temperature



The heater system set up on the air filter



Measured and obtain the emission value manually from the EMS gas analyser



The performance graph obtained from the dynometer testing

APPENDIX C

DATA RESULT OF POWER, BRAKE POWER, HYDROCARBON AND CARBON DIOXIDE AT DIFFERENT SPEED AND GEAR

Speed (rpm)	Torque (NM)(with heater)	Torque (NM)(without heater)
1500	63.2	56.5
2000	65.7	61.2
2500 MALAYS	67.6	61.6
3000	70.5	66.7
3500	73.1	67.8
4000	75.4	69.0

The performance data on gear 4 (Torque)

ونو

	ALC: 101 101 101 101	
I ININGLOCITI TEVNIKAI BAALAVUA BA		
UNIVERSITI TEKNIKAL MALAYSIA ME	and the second	

Speed (rpm)	Brake power (kw)(with heater)	Brake power (kw)(without heater)
1500	595.64	532.49
2000	825.56	769.06
2500	1061.85	967.61
3000	1328.89	1257.26
3500	1607.55	1490.99
4000	1895.01	1734.15

The performance data on gear 4 (Brake power)

		Rpm	1500	2000	2500	3000	3500
	Gear 2	Heater	78.7	87.7	92.7	103.6	115.7
		Without heater	49.5	57.7	64.9	82.0	100.1
Torque (Nm)	Gear 3	Heater	80.2	83.9	85.1	85.4	87.1
		Without heater	75.0	76.8	77.5	81.9	83.5
	Gear 4	Heater	63.2	65.7	67.6	70.5	73.1
		Without heater	56.5	61.2	61.6	66.7	67.8

The performance data on different gear and speed (Torque)

	San MAL	ALL PAR				1	
	TE	Rpm	1500	2000	2500	3000	3500
	Gear 2	Heater	741.73	1102.07	1456.1 <mark>2</mark>	1952.81	2566.36
	Ainn	Without heater	466.52	725.07	1019.44	1545.66	2201.31
Power	Gear 3	Heater	755.86	1054.31	1336.74	1609.75	1915.42
(Kw)		Without heater	706.85	965.09	1217.36	154 <mark>3.77</mark>	1836.26
	Gear 4	Heater	595.64	825.56	1061.85	1328.89	1607.55
		Without heater	532.49	769.06	967.61	1257.26	1490.99

The performance data on different gear and speed (Brake power)

		Rpm	1500	2000	2500	3000	3500
	Gear 2	Heater	24.28	25.35	26.99	27.12	28.21
		Without heater	11.32	12.27	12.32	12.14	13.2
Hydrocarbon (%)	Gear 3	Heater	14.86	16.56	19.22	21.71	23.43
		Without heater	8.72	14.13	16.42	17.98	21.21
	Gear 4	Heater	12.66	13.37	18.57	19.29	22.34
		Without heater	8.6	10.2	11.4	11.93	11.74

Emission percentage value on different gear and speed (Hydrocarbon)

	stat MALA	and we a					
	EKA	Rpm	1500	2000	2500	3000	3500
	E Gear 2	Heater	13.54	19.04	19.87	21.57	22.07
	SA ALVO	Without heater	9.76	12.82	13.22	13.74	14.58
Carbon dioxide	Gear 3	Heater	17.45	17.26	18.64	17.73	18.42
(%)	يا ملاك	Without heater	13.07	13.4	12.87	13.04	13
	Gear 4	SITI TERNIKA	23.85	24.31	1E ^{25.42}	2 7.16	30.13
		Without heater	13.37	13.76	12.83	13.74	13.72

Emission percentage value on different gear and speed (Carbon dioxide)

VITA

The author was born on June 12th, 1997, in Kuala Kubu Bharu, Selangor Darul Ehsan, Malaysia. He went to Sekolah Menengah Seri Garing Rawang, Malaysia for his secondary school. He pursued his Diploma education at Polytechnic Premier Sultan Salahuddin Abdul Aziz Shah, Malaysia. He then enrolled to study in Bachelor of Mechanical Engineering Technology (Automotive) with Honours in Universiti Teknikal Malaysia Melaka for four years.





UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: ANALYSIS OF PERFORMANCE AND EMISSION ON 4-STROKE 4-CYLINDER SPARK IGNITION GASOLINE ENGINE AT DIFFERENT AIR INTAKE TEMPERATURE

SESI PENGAJIAN: 2020/21 Semester 1

Saya NAVEEN A/L CHANDRAN

mengaku membenarkan tesis ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

- 1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
- 2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
- 3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
- 4. **Sila tandakan (✓)

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

TERHAD

SULIT

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

Alamat Tetap:

No 11A, Jalan Teratai 15B/2 Taman Bukit Teratai, Sungai Choh, Rawang, Selangor.

Tarikh: 18 January 2022

Cop Rasmi:

Jabatan Teknologi Kejuruteraan Mekanika: Fakulti Teknologi Kejuruteraan Universiti Teknikal Malaysia Melaka

Tarikh: 27 Jan 2022

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

ANALYSIS OF PERFORMANCE AND EMISSION ON 4-STROKE 4-CYLINDER SPARK INGNITION GASOLINE ENGINE AT DIFFERENT AIR INTAKE TEMPERATURE

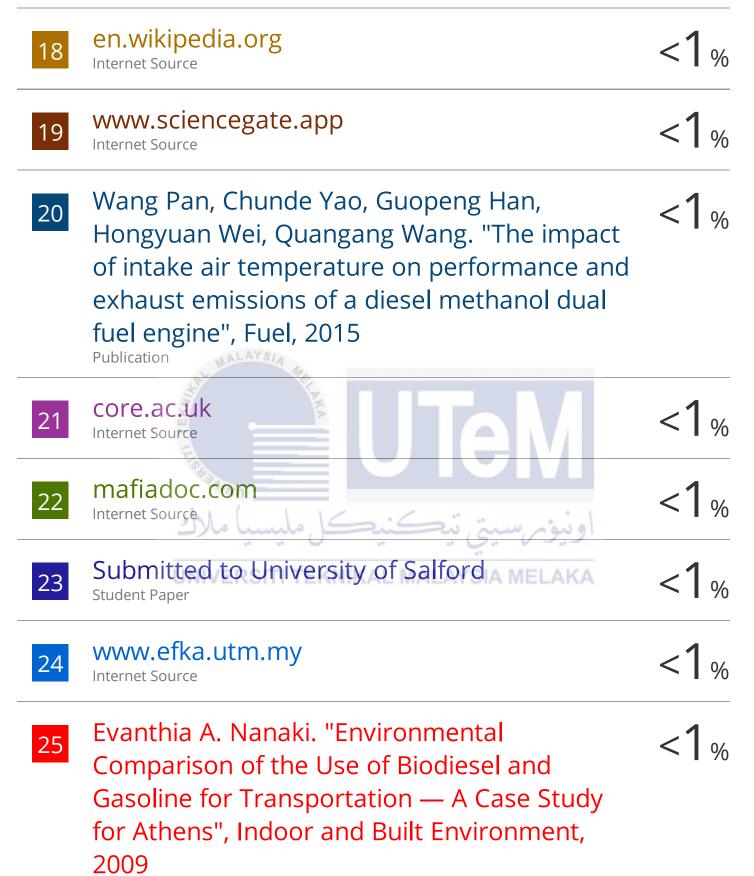
ORIGINALITY REPORT

24% SIMILARITY INDE	20% INTERNET SOURCES	4% PUBLICATIONS	8% STUDENT PAPERS
PRIMARY SOURCES			
1 pene Internet	rbit.uthm.edu.my		8%
2 Subn Mala _{Student}		y Tun Hussein	Onn 2%
3 eprin	ts.uthm.edu.my		2%
4 WWW Internet	.coursehero.com	KAL MALAYSIA N	
5 Scien	cepubco.com		1 %
6 WWW Internet	.c3controls.com		1 %
7 Subn	nitted to Universiti Paper	Teknologi MA	ARA 1 %
8 eprin	ts.utem.edu.my		1 %

9	www.dfliq.net Internet Source	1 %
10	Submitted to Universiti Teknikal Malaysia Melaka Student Paper	<1%
11	umpir.ump.edu.my Internet Source	<1%
12	Submitted to Loughborough College Student Paper	<1%
13	studentsrepo.um.edu.my	<1 %
14	data.mcc.gov	<1%
15	Submitted to University of Greenwich	<1%
16	Cinar, Can, Ahmet Uyumaz, Hamit Solmaz, Fatih Sahin, Seyfi Polat, and Emre Yilmaz. "Effects of intake air temperature on combustion, performance and emission characteristics of a HCCI engine fueled with the blends of 20% n-heptane and 80% isooctane fuels", Fuel Processing Technology, 2015. Publication	<1 %

17 Submitted to Institute of Graduate Studies, UiTM





Publication

Submitted to University of Huddersfield

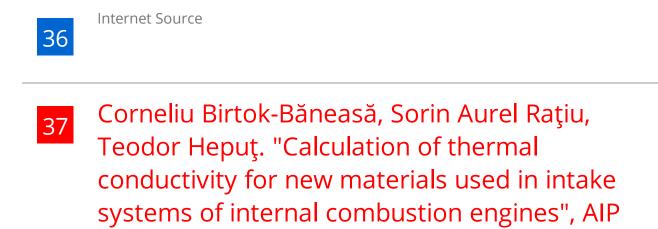
Student Paper

26	Student Paper	<1%
27	napier-surface.worktribe.com	<1%
28	tec-stop.co.uk Internet Source	<1%
29	www.groundai.com	<1%
30	ejuow.uowasit.edu.iq	<1%
31	portal.arid.my Internet Source	<1%
32	Submitted to Clemson University	<1%
33	Submitted to University of Portsmouth AKA Student Paper	<1%
34	C Birtok-Băneasă, S Rațiu, V Puţan, A Josan. "Study of materials used for the thermal protection of the intake system for internal combustion engines", IOP Conference Series: Materials Science and Engineering, 2018	<1%

Publication



aip.scitation.org

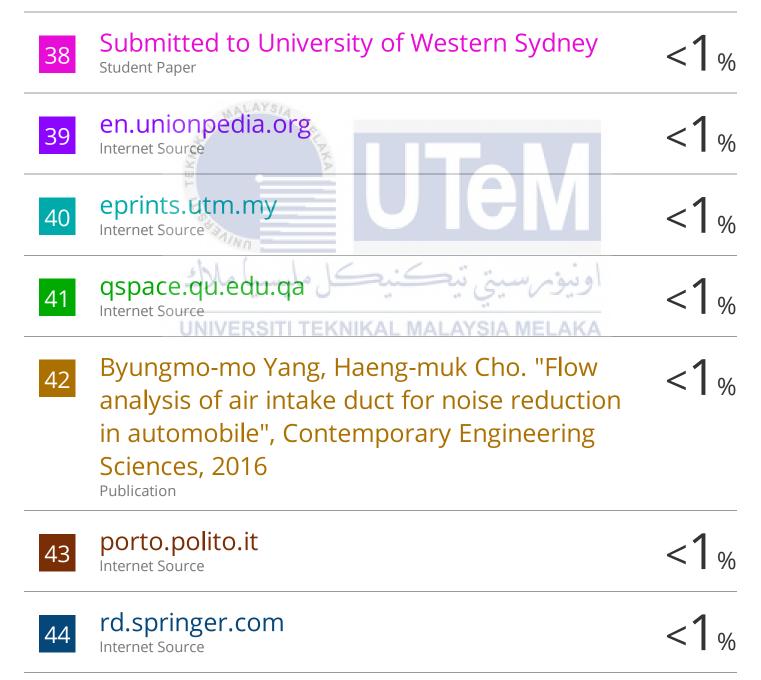


<1%

<1 %

Publication

Publishing, 2017



45	Aritra Ganguly, Baidya Nath Murmu, Somnath Chakrabarti. "Performance and Emission Characteristics of a Four Stroke Spark Ignition Engine with Recirculation of Hot and Cold Exhaust Gases", International Journal of Engineering & Technology, 2018 Publication	<1%
46	Hongyan Zhu, Jianan Wei, Hu Wang, Mingfa Yao. "Combined effects of fuel reactivity and intake thermodynamic conditions on heat release and emissions of compression ignition combustion", Fuel, 2020 Publication	<1%
47	S. Dey, N.S. Mehta. "Automobile pollution control using catalysis", Resources, Environment and Sustainability, 2020 Publication	<1%
	UNIVERSITI TEKNIKAL MALAYSIA MELAKA	

Exclude quotes On Exclude bibliography On

Exclude matches

Off

M

ADNAN BIN KATIJAN Jurutera Pengajar Jabatan Teknologi Kejuruteraan Mekanika: Fakulti Teknologi Kejuruteraan Universiti Teknikal Malaysia Melaka