EXPERIMENTAL STUDY ON THE EFFECT OF AIR-FUEL RATIO ON PERFORMANCE OF SPARK IGNITION ENGINE FUELED WITH H_2O_2-GASOLINE BLEND

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DECLARATION

I declare that this project report entitled “Experimental study on the effect of air-fuel ratio on performance of spark ignition engine fueled with H_2O_2-gasoline blend” is the result of my own work except as cited in the references

Signature	:	....
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Date	:	....

APPROVAL

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

Signature : ....

Name of Supervisor : DR. ADNAN BIN ROSELI

Date : ....

DEDICATION

I would like to dedicate this thesis to my beloved mother, Mahmudah, and father, Ahmad Zahidi for endless support, to my brothers and sister for a constant encouragement to accomplish this work. Last but not least, people who have always been there to support, congratulate, and show me always the best path to follow.

ABSTRACT

This project was carried out to study the effect of air fuel ratio on the performance of an engine fueled with an additive of hydrogen peroxide blend with gasoline fuel. This project starts by finding the chemical properties of gasoline alone and hydrogen peroxide-gasoline blend in order to identify the different properties of additive fuel compared to gasoline alone. Experiments on the performance of the spark ignition engine ware carried out by using generator engine Precision GX420. Firstly, the spark ignition engine performance was tested starting with the gasoline alone and then followed by the addition of 5% and 10% of hydrogen peroxide blended with the gasoline. Pressure sensor and crank sensor had been installed on the engine set up in order to determine the in-cylinder pressure, volume and crank angle. Pressure sensor and crank sensor were connected to Data Acquisition System (DAS) which will display the result through DEWESOFTX2 software. The result was calculated using raw data that has been obtained from DEWESOFTX2 software and several parameters of engine performance such as indicated network, air fuel ratio and indicated specific fuel consumption. At the end of this project, it can be concluded that the use of hydrogen peroxide for gasoline engine must not exceed 10% in order to avoid lag during the combustion process.

ABSTRAK

Projek ini dijalankan untuk mengkaji kesan nisbah udara minyak terhadap prestasi enjin dengan diisi minyak campuran hydrogen peroksida bersama minyak petrol. Projek ini bermula dengan mengenal pasti sifat kimia minyak petrol dan minyak campuran hidrogen peroksida-petrol bagi mengenal pasti perbezaan sifat minyak campuran dibandingkan dengan minyak petrol. Eksperimen bagi mengenal pasti prestasi enjin menggunakan enjin penjana 'Precision GX420' untuk mengendali ujian. Pertamanya, eksperimen untuk ujian prestasi enjin nyalaan percikan dimulakan dengan penggunaan minyak petrol dan diukuti seterusnya dengan 5% dan 10% minyak campuran hydrogen peroksida dengan petrol. Sensor tekanan dan sensor engkol dipasang pada enjin bagi mengenal pasti tekanan, isipadu dan sudut engkol di dalam silinder. Sensor ini akan disambungkan kepada DAS yang akan memaparkan hasil melalui perisian DEWESOFTX2. Hasil akan dikira dengan dapatan data kasar daripada perisian tersebut dan juga dapat mengenal pasti beberapa parameter prestasi enjin sebagai contoh kerja bersih, nisbah udara minyak dan penggunaan bahan api tentu. Di akhir projek ini, menunjukkan penggunaan hidrogen peroksida bagi enjin petrol tidak boleh melebihi 10% campuran bagi mengelakkan lebih banyak kelewatan ketika proses pembakaran.

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CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBEREVATIONS

ICE	Internal Combustion Engine
SI	Spark Ignition
CI	Compressed Ignition
BSFC	Brake Specific Fuel Consumption
H_2O_2	Hydrogen Peroxide
AFR	Air Fuel Ratio
BP	Brake Power
BMEP	Brake Mean Effective Pressure
SFC	Specific Fuel Consumption
TSFC	Thrust Specific Fuel Consumption
OH	Hydroxide
CO	Carbon Monoxide
BTDC	Before Top Dead Center
ATDC	After Top Dead Center
TDC	Top Dead Center
EGT	Exhaust Gas Temperature
NOx	Nitrogen Oxide
MFB	Mass Fraction Burn
CNG	Compressed Natural Gas
DAS	Data Acquisition System
ASTM	American Society Testing Material
RON	Research Octane Number
HV	Heating Value
CA	Crank Angle
SFC	Specific Fuel Consumption
ISFC	Indicated Specific Fuel Consumption
GA	Gasoline Alone

RPM	Revolution per Minute
HRR	Heat Release Rate
PHRR	Peak Heat Release Rate
ITE	Indicated Thermal Efficiency
IP	Indicated Power

LIST OF SYMBOL

$\dot{m}_f$	=	mass fuel of flow rate (kg/s)
$\dot{m}_a$	=	mass air of flow rate (kg/s)
P_f	=	indicated power (W)
P_b	=	brake power (W)
n_f	=	thermal efficiency
P_{ig}	=	mechanical efficiency
N	=	number of revelation per minute (rev/min)
T	=	torque (Nm)
V_d	=	volume of cylinder (m^3)
$\dot{m}_{ath}$	=	air mass flow rate pass throttle plate (kg/s)
P_0	=	front of throttle pressure (Pa)
T_0	=	front of throttle temperature (K)
A_{th}	=	area of throttle (m^2)
C_d	=	discharge coefficient (0-1)
R	=	gas constant (0.287 kJ/kg K)
γ	=	specific heat ratio

CHAPTER 1

INTRODUCTION

1.1 Background

Every single day from a few years ago, we can see the rising of the atmospheric carbon dioxide and atmospheric pollutant that leads to major problems to the society nowadays (Ć & Oros, 2012). These problems come from the vehicle in the world on the exhaust gasses. Most of the researchers studied about the diesel engine having higher thermal efficiency. The problem with this diesel engine is that they have higher emissions and exhaust temperature (Nagaprasad K. S., 2012). These emissions can be reduced with the increasing of engine compression ratio. Increasing compression ratio can provide better the thermal efficiency (Lattimore, Herreros, Xu, & Shuai, 2016)

Internal Combustion Engine (ICE) can be divided into two groups according to fuel type, power, type of ignition and so on. First group is separated into Spark Ignition (SI) engine and Compression Ignition (CI) engine. The difference between these two types of ignition was the classification of SI engine as two strokes and four strokes. CI will be divided into direct injection and indirect injection engine (Cholakov, n.d.). Most vehicles ware using the Spark Ignition (SI) engine. Everyone knows the SI engine is conducted by each injection that begins when the air went in the intake port valve to the cylinder (Richard et al., 2011). The most important factor that needs to be considered in the internal combustion engine was the thermal efficiency and catalytic efficiency because having higher thermal efficiency will lead to a low fuel consumption, whereas high catalytic efficiency will produce a low exhaust emission from the vehicle (Jansri & Sooraksa, 2012). The fuel used in internal combustion engine will give high impact to the engine efficiency and brake power. If the engine is having higher efficiency, it will provide more power to the vehicle. Each fuel has their own characteristic to perform well in the internal combustion engine (Curtis, Owen, Hess, & Egan, 2008).

The main fuel used in our daily life are diesel and gasoline. There are many ways to increase the efficiency of the vehicle. One of them is by mixing the additive to the normal fuel. The ethanol-gasoline blend fuels will increase the brake power causing a higher spark timings and improve the Brake Specific Fuel Consumption (BSFC). Having higher thermal efficiency will lead to a faster combustion compared to gasoline alone (Lattimore et al., 2016). Other than that, with 1-buthanol-gasoline blend also can give high thermal efficiency to the engine. Fuel economy will then decrease by the 1-butanol-gasoline blend and hence can reduce the particle number of concentration (Lattimore et al., 2016).

The other method that leads to the enhancement system of fuel in an engine is by using hydrogen peroxide, H_2O_2. It will blend together to overcome this problem (Nagaprasad K. S., 2012). Hydrogen peroxide can raise the efficiency and can reduce the emission or soot. This additive will change to steam and can give a high vapor pressure in ICE to increase the brake power or torque. It also provide a cooling effect that can reduce the temperature in the engine system (Dixon, 1977). Besides that, hydrogen peroxide is one of the metastable compounds which can be classified as a harmless catalyst compared to the others (Roth, Eckhardt, Franz, & Patschull, 1998).

Hydrogen peroxide effects a desirable benefit as it was considered a successful burning of the product fuel that can reduce the contamination and increase the power of the engine. It also can be useful as an oxidizer for the fuel vapor when it enters the engine combustion chamber (Cox, 1981). Hydrogen peroxide is the weak acid between a strong oxidizing properties and can be an effective bleaching agent. This additive has a density of

1.130 g/cm^3 higher than diesel. When this additive blend with the fuel, the density does not increase when H_2O_2 exceed more than 15% (Khan, Ahmed, Mutalib, & Bustum, 2013).

The researcher used aqueous trapping method to determine the validity of H_2O_2 in the air using aqueous traps technique. This validity of H_2O_2 in the air explained exclusively during photochemical gas phase reaction mechanism. H_2O_2 has a lower pressure and infinite solubility in water, and it is very difficult to extract from the air with water traps. Ozone decomposition rate will be affected by a concentration of H_2O_2 (Irvine & Attribution, 1982).

1.2 Problem Statement

The additive hydrogen peroxide is a weak acid in a solution of water. It can also become a strong oxidizer agent, by mean that the H_2O_2 will provide more atom of oxygen to the solution. Hydrogen peroxide can reduce the emission of an engine and increase the efficiency. Other than that, H_2O_2 can increase the brake power. Besides, it can also reduce the temperature in the engine system. H_2O_2 acts as prevailing part in the hot ignition from low temperature to a middle of the temperature dynamic conduct. It was formed at the fire termination and occur in the exhaust gas that can change the kinetic behaviour in turbulent responding frameworks.

This research will targeted optimum percentage of the hydrogen peroxides that can be blend together with gasoline. From this different percentage of hydrogen peroxide blend with gasoline, the mass of air and fuel will change to get the air-fuel ratio (AFR). Other than that, the optimum ratio can be determined through the test of which can result the best performance for the engine. In this research, used of hydrogen peroxide as an additive is to increase the operating performance for SI engine and decrease the emission.

1.3 Objective

The objectives of this project are as follows:

1. To study the effect of air-fuel ratio on performance of spark ignition engine with H_2O_2-gasoline blend.
2. To investigate the optimum air-fuel ratio on performance of spark ignition engine with H_2O_2-gasoline blend.
3. To compare the air-fuel ratio on the performance of spark ignition engine based on gasoline alone.

1.4 Scope of Project

The scopes of this project focuses on the air-fuel ratio on spark-ignition (SI) engine based hydrogen peroxide-gasoline blend. In this project, gasoline alone (0%) will be used as the reference. Hence, an amount of 5% and 10%(by volume) of hydrogen peroxide (H_2O_2) were being used in the gasoline (C_7H_{12}) blended. This project focuses on finding the operating performance such as indicated power (IP), indicated specific fuel consumption (ISFC), indicated thermal efficiency (ITE) and heat release rate (HRR) with 0W, 500W, 1000W, 1500W and 2000W of the load. Throughout this research, the different percentage of hydrogen peroxide are expected to change the AFR value which will be found to be closer to the stoichiometric value.

CHAPTER 2

LITERATURE REVIEW

2.1 Theoretical Background

2.1.1 Indicated Specific Fuel Consumption (SFC)

ISFC is the weight of the fuel burned per unit time. Turbojets and fan are also known as the Thrust Specific Fuel Consumption (TSFC). The SI unit for this ISFC is kg/kWh. The SFC for the piston can be calculated using the equation (2.1). MF is the flow rate of fuel and and p is the power that is applied to the propeller. It can be expressed as ISFC = rate of mass fuel / power output. SFC is defined as a measurement of the efficiency of fuel to improve the fuel consumption. In addition, the fuel consumption can be measured as a mass flow rate, m_f and ISFC is the fuel flow rate per unit power output. Equation (2.2), (2.3) and (2.4) allows the measurement of the efficiency of an engine by using fuel to produce work (Heywood, 1988). As a result, we can summarize that the lowest ISFC will results the highest brake power or power output. There are different types of ISFC in Internal Combustion Engine (ICE) which are the Indicated Specific Fuel Consumption (ISFC) and Brake Specific Fuel Consumption (BSFC).

$$sfc = \frac{\dot{m}_f}{P} \tag{2.1}$$

$$sfc\left(\frac{mg}{J}\right) = \frac{\dot{m}_f\left(\frac{g}{s}\right)}{P(kW)} \tag{2.2}$$

$$sfc\left(\frac{g}{kW.h}\right) = \frac{\dot{m}_f\left(\frac{g}{h}\right)}{P(kW)} = 608.3\ (\frac{lbm}{hp}.h) \tag{2.3}$$

or

$$sfc\left(\frac{lbm}{hp.h}\right) = \frac{\dot{m}_f\left(\frac{lbm}{h}\right)}{P(hp)} = 1.644 \times 10^3\ sfc\ (\frac{g}{kW.h}) \tag{2.4}$$

2.1.2 Brake Specific Fuel Consumption (BSFC)

BSFC is the rate of fuel consumption that were divided into power output. The power output is also known as the brake power. BFSC is typically used to comparing the efficiency of internal combustion engine with a shaft output. BSFC will also decrease with the engine size due to the reduction of the heat losses from the gas to the cylinder wall. This BSFC is almost similar to SFC but BSFC has the mass of flow rate per unit brake power. On top of that, BSFC is a correlation proportion which can trace the efficiency of the fuel, how much fuel is used and lastly how much power was produced. From equation (2.5), the brake specific fuel consumption utilization was separated by the brake power. Usually, the outcomes are presented in kilograms per kilowatt hour. Normally dynamometer was used to calculate the BSFC transfer from the engine. Diesel motors regularly perform superior to any gas motors in terms of BSFC. The optimum value BSFC for Spark Ignition (SI) engine is about 75µg/J = 270 g/kW..h = 0.47 lbm/hp. h. The best value or the optimum value for Compression Ignition (CI) engine is about 55µg/J = 200 g/kW..h = 0.32 lbm/hp (Heywood, 1988).

$$bsfc = \frac{\dot{m}_f}{BP} \tag{2.5}$$

2.1.3 Thermal Efficiency

The efficiency of engine is converting the heat energy contained in the liquid fuel into mechanical energy. On top of that, thermal efficiency is the ratio of power produced in the burning fuel to produce power. It can be expressed as :

$$nf = \frac{W_C}{m_f}\frac{1}{Q_{HV}} = \left(\frac{Pn_R/N}{(\dot{m}_f\, n_R\,/N)Q_{HV}}\right) = \frac{P}{\dot{m}_f\ Q_{HV}} \qquad (2.6)$$

From equation (2.6), we know that m_f is the mass of flow rate and P, is the power. We can substitute the 1/SFC = power output / rate of mass fuel.

$$n_f = \frac{1}{sfc\ Q_{HV}} \qquad (2.7)$$

Furthermore, from equation (2.7), it is used to calculate thermal efficiency which is known as the fuel conversion efficiency. It is the ratio of the work produced per cycle to the amount of fuel energy supplied per cycle. Quantity of the fuel supplied to the engine and the heating value of fuel are given. The fuel energy supplied can be released only through combustion. Heat transfer, Q_{HV} can be determined through a standardized. This combustion process produces the thermal energy and absorbed by a calorimeter when cool down to their original temperature (Heywood, 1988). The heating values for hydrocarbon fuels used in engine is commonly between 42 to 44 MJ/kg (18000 to 19000 Btu/lbm). The SFC for this hydrocarbon can be inversely proportional to fuel conversion efficiency or thermal efficiency for normal hydrocarbon fuel. Actual process in combustion process is incomplete because the energy