CHARACTERIZATION OF DIESEL ENGINE WITH PALM OIL AT DIFFERENT COMPRESSION RATIO

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To my family, especially my parents, wife and children

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Praise to the Almighty...

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ABSTRACT

The performance, emission and combustion characteristics of a single cylinder four stroke direct injection air cooling various compression ratio multi fuel engine when fueled with palm oil methyl ester and its 2%, 5%, 7% and 10% blends with diesel (on a volume basis) are investigated and compared with standard diesel. The experiments were conducted at a fixed engine speed of 3000 rpm at different loading conditions and at compression ratios of 16:1, 18:1, and 20:1and 22:1. The impact of compression ratio on fuel consumption, brake thermal efficiency and air fuel ratio was investigated and presented. The optimum compression ratio which gives the best performance was identified. Comparisons between compression ratio with diesel and the biodiesel blends on the brake specific fuel consumption (BSFC), brake thermal efficiency (th) , carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxide (NOx) and exhaust smoke were carried out in this study for every value of CR. In the engine experiment, it was found that the palm oil methyl ester functions better with VCR than fixed CR in terms of performance (SFC and th) where the SFC decreases by 5.4%, η_{th} increases by 3.7% at CR 22 with B2, the Smoke quality and CO showed a decrease by 22% and 29% at CR 22 with B2 while the NOx decreases by 30% at CR 16 than CR20 and diesel.

ABSTRAK

Ciri-ciri prestasi, pelepasan dan pembakaran satu silinder 4 lejang suntikan udara langsung menyejukkan bahan api dengan nisbah mampatan boleh ubah pelbagai enjin apabila didorong dengan metil ester minyak sawit dan 2%, 5%, 7% dan 10% campuran dengan diesel (pada volumeasas) disiasat dan berbanding dengan diesel standard. Kajian ini telah dijalankan pada kelajuan enjin 3000 rpm tetap pada keadaan pembebanan yang berbeza dan pada nisbah mampatan 16:01, 18:01, dan 20:01 dan 22:01. Kesan nisbah mampatan pada penggunaan bahan bakar, kecekapan haba brek dan nisbah bahan api udara telah disiasat dan dibentangkan. Nisbah mampatan yang optimum yang memberikan prestasi yang terbaik telah dikenalpasti. Perbandingan antara nisbah mampatan dengan diesel dan biodiesel menggabungkan brek penggunaan bahan api tertentu (BSFC), Kecekapan terma brek (th), karbon monoksida (CO), karbon dioksida (CO2), nitrogen oksida (NOx) dan asap ekzos telah dijalankan dalam kajian ini untuk setiap nilai CR. Dalam eksperimen enjin, ia telah mendapati bahawa minyak kelapa sawit ester fungsi metil lebih baik dengan VCR daripada CR tetap dari segi prestasi (SFC dan η_{th}) di mana SFC menurun sebanyak 5.4%, peningkatan th oleh 3.7% pada CR 22 dengan B2, kualiti asap dan CO menunjukkan penurunan sebanyak 22% dan 29% di CR 22 dengan B2 manakala NOx berkurangan sebanyak 30% pada CR 16 daripada CR20 dan diesel.

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D	–	100% diesel
PM	–	palm oil methyl ester
B2	–	2% biodiesel 98% diesel
B5	–	5% biodiesel 95% diesel
B7	–	7% biodiesel 93% diesel
B10	–	10% biodiesel 90% diesel
BSFC	–	brake specific fuel consumption
η_{th}	–	brake thermal efficiency
CO	–	carbon monoxide
CO_2	–	carbon dioxide
CR	–	compression ratio
NO_x	–	nitrogen oxides
O2	–	oxygen
VCR	–	variety compression ratio
AF	–	air fuel ratio
BP	–	brake power
SFC	–	specific fuel consumption
	–	

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Presently, there has been a global increase in the investigation on the application of alternative fuel sources for daily use, such as biodiesel and alcohol. This universal search for alternative fuel source is not unconnected to the fact that petroleum products are becoming very scarce and expensive, and also the price of petroleum products is always on the high side. In this part of the world, there is an awareness on global concern due to air pollution caused by the extensive use of conventional fuel in an internal-combustion engine.

Further confirmation of the increase stringent rules and regulations guiding emissions and more worry about resultant effects of air pollution towards fauna and flora have encouraged an intense investigation into alternative fuel for transportation application in the past 30 years. Bio diesel is an oxygenated, sulfur-free, biodegradable, non-toxic and environmentally friendly alternative diesel fuel. Bio diesel is defined as the alkyl monoesters of fatty acids from renewable resources, such as palm oil, animal fats and waste from restaurant greases.

One of the attractive characteristics of bio diesel is that its use does not require any significant modifications to the diesel engine, so the engine does not have to be dedicated to bio diesel. Also as alcohol fuels, in general bio diesel has lower energy content and different physical properties than diesel fuel; because of its varying characteristics bio diesel will effect some changes in the engine performance and emissions including lower power and higher oxides of nitrogen.

Bio diesel can be blended in any proportion with petroleum-based diesel fuel and the result of the changes is often proportional to the fraction of bio diesel being used. In the past decade, several studies have been carried out to understand the features of bio diesel and its performance in engines (Chang and Van Gerpen,1997; Schumacher and Van Gerpen, 1996; Schmidt and Van Gerpen,1996; Zhang and Van Gerpenin,1996, Graboski and McCormick,1998).The majority of the investigations carried out is based on the methyl ester of soybean oil.

Soybean oil was selected because in America it is the only oil that is available in sufficient quantity to supply a national market. Bio diesel was found to possess same physical properties as diesel oil, and in addition it is a renewable energy and safe for the environment. Empirical evidence of using a blend of 30% of volume bio diesel towards diesel oil indicates similar engine performance as compared to using 100% of diesel fuel, and by using this composition no adjustment of the vehicle is required.

For the past two decades, vegetable oil has been used as a substitute for diesel fuel in an internal-combustion engine (Srivastava and Prasad, 2000; Almieda et al., 2002; Altin et al., 2001; Karaosmanoglu et al., 2000), such as mahua oil, sun flower oil, seed oil, waste cooking oil and palm oil. Previous studies that authors conducted and the experiments to study the performance and emission characteristics of the diesel engine when fueled with biodiesel fuel or a blend of vegetable oil with diesel and its derivatives as fuel; they opined that biodiesel can be utilized as a substitute to fossil fuel in an internal-combustion engine with or without engine, modification which depends on alternative-fuel type, for instance, when used palm oil is adopted as fuel, this type of fuel is utilized without engine modification, however, the researcher found that biodiesel fuel is economical and competitive when compared to standard diesel or fossils fuel.

In addition, biodiesel has lower sulphur and aromatics contents, better lubricity, improved biodegradability and toxicity and reduced net carbon dioxide (CO2) emission relative to fossil diesel (Ng et al., 2009). Bio diesel can be used easily because it can be mixed at any proportion with diesel oil, hence enabling us to apply it immediately for diesel engines that are available without much modification, easy biodegradability, 10 times less poisonous compared to the ordinary diesel oil, has a better cetane number than the ordinary diesel fuel, the waste products (ashes) of bio diesel are not black, do not contain sulfur and other aromatic contents.

Chairil A et al (year) reported that combustion emission produced is safe for the environment and does not add to the accumulated carbon dioxide gas in the atmosphere, thus lessens the global heating effect or what is most commonly referred to as zero CO_2 emission. Bio diesel is the result of making the best use of the non fossil resources, substitution of bio diesel (1- 3%) in diesel oil will save the foreign exchange substantially for the nation. Considering exhaust emissions, Graboski MS et al (year) reported that the use of bio diesel results in lower emissions of unburnt hydrocarbons, carbon monoxide, smoke and particulate matter with some increase in emissions of NO x. A number of researchers have investigated vegetable oil-based fuels (Srivastava and Prasad, 2000; Almieda et al., 2002; Altin et al., 2001; Karaosmanoglu et al., 2000; Isigigur et al., 1994).

McCormick et al (year) had concluded that vegetable oil can be safely burnt for a short period of time in a diesel engine. However, using raw vegetable oil in a diesel engine for an extended period of time may result in severe engine deposits, piston ring sticking, injectors choking, and thickening of the lubricating oil. Authors have reported that, Malaysia has a very bright future for producing this potential fuel because of its wide accessibility to palm oil. Being the largest producer and exporter of crude palm oil, it avails the country an opportunity of taking the largest chunk of the global palm oil market. Among 140 countries in the universe palm oil sales nets about RM30.4 billion in GDP in 2004. Currently, the country is making stringent efforts to be among nations that use palm oil based fuel as an alternative to conventional diesel energy. This is not unconnected to the status of the nation as a global leader for both edible oil and palm oil.

Malaysia accounts for fifty one percent of universal palm oil production and sixty two percent universal export, including eight percent and twenty two percent of oil and fats export market. Malaysia produced approximately 12.4 million tons of palm oil in 2003, source from The Malaysian Palm Oil Promotion Council (MPOPC). According to (Masjuki et al., 1998), export earnings from palm oil exceeded that of oil and gas, thus making this commodity the biggest single export revenue earner for the country. Unlike oil and gas, which has a heavy foreign content, palm oil production is virtually 100% local. In 1997, palm oil industry earned nearly RM13 billion in exports and 16 to 18 billion in the year 1998. Palm Oil Research Institute of Malaysia (PORIM) has taken an initiative since 1985 to look at the possibilities of converting oil palm products into fuel.

One of the first products was the use of methyl ester as diesel substitute. Bio diesel has a great opportunity in the future and can be the core strength in palm oil industries in facing a global competition for a new decade. In 2004 total usage of bio diesel globally exceeded 2.5 million tones with assured prospect of 25% annual increment over time. This situation shows a positive sign to Malaysia as a largest exporter of palm oil. In view of the foregoing, the researcher is motivated to investigate a more environmentally friendly fuel source. The specification of this fuel should be cleaner, available anywhere and cheaper when compared to fossil fuel.

1.2 Problem Identification

In the current contemporary world, there have been a continuous rise in the price of petroleum products and also a decrease in the quantity of the products as well as an attendant increase in air pollution as a result of emissions from internal combustion engines making use of petroleum products. This assertion has made the researcher to think about an alternative energy source which can be used as a substitute to fossil fuel and this would be equally probable and become an essential fuel in the future.

This fuel must be environmentally friendly and suitable with the engine requirement such as vegetable fuel source. Although past empirical findings have exposed some attendant constraint to this potential fuel source and subsequently are trying harder to investigate how to solve these problems. Some of them were successful in most trials, but more research is needed in order for it to become an essential fuel in order for it to be used in the internal-combustion engine.

The present study analyzes the characteristics of an diesel engine and shows the suitable compression ratio (CR), when utilizing palm oil blends with pure diesel at various CR, and with this a comparative study can be carried out.

1.3 Objective

The objective of this project is to study the characteristic features of a diesel engine performance and the exhaust gases' emission with a various compression ratio from 16:1 to 22:1 by utilizing alternative fuel (Palm oil metal ester) blends with diesel fuel at a different percentage to run on a single-cylinder engine four stroke air cooled. The concept of various compression ratio promises improved engine performance, efficiency and reduction emissions as (Shaik et al. (2007). The fuel utilized in this study consists of 2% palm oil and 98% diesel, 5% palm oil and 95% diesel, 7% palm oil and 93% diesel, 10% palm oil and 90% diesel.

1.4 Scope of project

The specification of the project is given as follows:

I Test the property of pure diesel and the blend of B2 (2% palm oil methyl ester and 98% diesel), B5, B7 and B10 used in this study.

II Study the engine performance of one cylinder diesel engine such as brake thermal efficiency (η_{th}), brake specific fuel consumption (BSFC) and air fuel ratio (AF) by using specified blends with compression ratio (16:1,18:1,20:1(original) and 22:1)

III Examine emission exhaust such as CO, CO2, O2 NOx and smoke for all types of fuel and compression ratios mentioned above.

IV Compare the results taken from the engine fueled blends and pure diesel for specified compression ratio with compression ratio 20:1(reference) in order to identify the suitable compression ratio which gives the optimum performance.

1.5 Brief Research Methodology

This research will be based on researched literature of previous authors who had investigated on engine characteristics measurement with utilized palm oil as a fuel mix with diesel at different percentages and changed the compression ratio. This change will be carried out by changing the combustion chamber volume by regulating the thickness of the gasket. Data will be secured after testing which include the exhausts emissions and engine performance and will thus be compared with the engine that operates on pure diesel engine and compression ratio 20:1.

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