UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

CORRELATION OF RON95 AND RON97 GASOLINE PROPERTIES FROM VARIOUS BRANDS TOWARDS ENGINE PERFORMANCE AND EMISSION

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CORRELATION OF RON95 AND RON97 GASOLINE PROPERTIES FROM VARIOUS BRANDS TOWARDS ENGINE PERFORMANCE AND EMISSION

AIZUDDIN FAHMI BIN MOHD RIDUAN

A thesis submitted
in fulfilment of the requirements for the degree of Master of Science
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DECLARATION

I declare that this thesis entitled "Correlation of RON95 and RON97 Gasoline Properties from Various Brands towards Engine Performance and Emission" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Mechanical Engineering.

Signature : ……..

Supervisor Name : PROF. DR. NOREFFENDY BIN TAMALDIN

Date : ……..

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DEDICATION

To both of my lovely wonderful parents and also my late grandmother.

May her soul rest in peace.

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ABSTRACT

Effects of gasoline variations from different brands on vehicle performance have always been a debate among users and currently the facts remains inconclusive. Some claimed using a higher octane or particular fuel brand could affect overall engine behaviour, and when they do publically spread their own gathered findings, results collected were mostly done unscientifically. To overcome these problems, three objectives were planned for this research. Firstly, gasoline properties differences between Research Octane Number 95 (RON95) and RON97 from commonly available fuel brands in Malaysia were determined. Then, the examined gasoline properties were correlated towards engine performance and emissions through engine dynamometer testing. Lastly, influence magnitude of using different fuel brands and RONs towards overall engine behaviour were analysed. Research methodology was divided into Part A (Gasoline Properties Investigation) and Part B (Engine Testing Using Different Fuel Grades). In Part A, gasoline density, specific energy, and chemical formula group were determined utilizing a hydrometer, oxygen bomb calorimeter, and Fourier transform infrared spectrometer respectively. For Part B, an engine dynamometer and gas analyser were used to measure engine overall outcomes. Results gathered were torque, power, relative knock index, brake specific fuel consumption (BSFC), engine efficiency, carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen oxide (NOx). Gasoline density and specific energy results among each fuel samples demonstrated marginal differences, with biggest variation did not even exceeded 6%. Gasolines chemical content had presented all RON97 fuels possessed two additional chemical formula group which were polyetheramine and ethyl acetate. Every engine power and torque figures displayed minor variations of less than 4%. Nevertheless, relative knock index, BSFC, and engine efficiency did exhibited larger differences as certain cases depicted more than 10% deviation. Emission outputs were more substantially varied than all engine performance results, with CO and NOx shown variations of up to 20%. However, CO_2 outcomes differed between tested fuels by just less than 4%. Gasoline specific energy was proven having direct connection towards engine torque and power. Fuel energy density was illustrated having an overall effect on engine knock. BSFC were deduced to be possibly influenced by gasoline energy content, whilst at the same time had significant effect on engine efficiency. Ethyl acetate presence in RON97 fuels was established directly correlated towards gas emissions, where it help produced lower CO and higher CO_2 results than all RON95 gasolines. NOx emission was postulated to be linked with engine power since it could lead towards greater in-cylinder temperatures at higher outputs. Most engine outputs were better performed with RON97 fuels. However, with not even exceeding 2% engine performance improvements based on averaged results trend lines, employing a higher octane gasoline cannot be recommended since it is 15% pricier than RON95. Consumers can use collected finding as reference when comparing between fuels and no longer need to speculate because entire investigation was done in a controlled environment. Outcomes from this study could become a baseline for gasoline manufacturers in improving their product quality, of which would greatly benefit the consumer as well.

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ABSTRAK

Kesan menggunakan variasi petrol daripada jenama berbeza terhadap prestasi kenderaan selalu menjadi perbincangan dalam kalangan pengguna dan sehingga kini masih lagi tidak mencapai kesimpulan akhir. Ada yang menyatakan penggunaan oktana tinggi atau jenama tertentu boleh memberi kesan kepada keseluruhan prestasi enjin. Walaupun ada juga yang melakukan kaji selidik sendiri, hasil terkumpul selalunya tidak saintifik. Oleh itu, tiga objektif telah ditetapkan bagi mengatasi masalah ini. Pertamanya ialah mencari perbezaan sifat-sifat petrol antara nombor oktana penyelidikan 95 (RON95) dan RON97 daripada semua jenama yang biasa dijual di Malaysia. Sifat-sifat petrol dikaji kemudiannya dikaitkan dengan data prestasi enjin serta gas-gas terhasil yang dikumpul melalui ujian dinamometer enjin. Akhir sekali ialah menganalisis pengaruh setiap penggunaan petrol daripada jenama dan RON berbeza terhadap keseluruhan prestasi enjin. Kajian dibahagikan kepada Bahagian A (Mengkaji Sifat-Sifat Petrol), dan Bahagian B (Menguji Enjin Dengan Penggunaan Gred Petrol Berbeza). Dalam Bahagian A, ketumpatan, kandungan tenaga, dan komposisi kimia petrol ditentukan dengan hidrometer, bom oksigen kalorimeter, dan spektrometer inframerah Fourier. Untuk Bahagian B, dinamometer enjin dan penganalisis gas digunakan untuk mengukur hasil keseluruhan prestasi enjin. Data terkumpul dalam bahagian ini adalah tork, kuasa, indeks relatif ketukan, penggunaan petrol berkadar kuasa (BSFC), kecekapan enjin, karbon monoksida (CO), karbon dioksida (CO_2), dan nitrogen oksida (NOx). Ketumpatan dan kandungan tenaga setiap petrol menunjukkan variasi kecil di mana perbezaan antara sampel tidak melebihi 6%. Eksperimen terhadap komposisi petrol didapati semua RON97 sahaja mengandungi dua kandungan kimia tambahan iaitu polieter amina dan etil asetat. Setiap data tork dan kuasa janaan enjin menunjukkan variasi kurang daripada 4%. Hasil indeks relatif ketukan, BSFC, dan kecekapan enjin pula menunjukkan variasi lebih ketara di mana ada perbezaan mencapai lebih daripada 10%. Variasi data CO dan NOx merupakan paling tinggi sehingga ada melebihi 20%, sementara perbezaan gas CO_2 hanya kurang daripada 4%. Kandungan tenaga dibuktikan mempunyai korelasi kepada tork dan kuasa enjin. Ketumpatan tenaga didapati mempunyai kaitan dengan hasil ketukan enjin. Data BSFC pula ditunjukkan berkemungkinan dipengaruh oleh kandungan tenaga, dan pada masa yang sama memberikan kesan ketara terhadap kecekapan enjin. Etil asetat yang terdapat dalam RON97 menunjukkan korelasi langsung kepada gas-gas terhasil, di mana ia dapat mengurangkan CO dan mengoksidakan lebih tinggi CO_2 daripada semua RON95. Kuasa enjin diramal mempunyai hubungan dengan penghasilan NOx kerana suhu silinder selalunya dikaitkan oleh janaan kuasa enjin. Walaupun enjin berfungsi lebih baik apabila diuji dengan RON97, peningkatan prestasi kurang daripada 2% dianggap tidak wajar dengan harganya yang 15% lebih mahal berbanding RON95. Pengguna boleh menggunakan kajian ini sebagai rujukan bandingan antara petrol dan tidak lagi perlu membuat sebarang spekulasi kerana kajian ini telah dilakukan dalam keadaan persekitaran terkawal. Syarikat pengeluar minyak pula boleh merujuk hasil penyelidikan dan menjadikan data-data terkumpul sebagai penanda aras untuk meningkatkan kualiti pengeluaran mereka. Ini secara tidak langsung juga dapat memberikan impak positif kepada pengguna-pengguna.

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LIST OF ABBREVIATIONS

ABDC	-	After bottom dead centre
AIST	-	Advance Industrial Science and Technology
AKI	-	Anti-Knock Index
ATDC	-	After top dead centre
ATR-FTIR	-	Attenuate total reflectance – Fourier transform infrared
BBDC	-	Before bottom dead centre
BHP	-	BHPetrol
BP	-	British Petroleum
BSFC	-	Brake specific fuel consumption
BTDC	-	Before top dead centre
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
CR	-	Compression ratio
DAQ	-	Data acquisition
EPA	-	Environmental Protection Agency
FTIR	-	Fourier transform infrared
HC	-	Hydrocarbon
MON	-	Motor Octane Number
NA	-	Naturally aspirated
NEDC	-	New European Driving Cycle

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NIST	-	National Institute of Standards and Technology
NOx	-	Nitrogen oxide
NVH	-	Noise-vibrations-and harshness
O_2	-	Oxygen
Petronas	-	Petroliam Nasional Berhad
PON	-	Pump Octane Number
RON	-	Research Octane Number
RdON	-	Road Octane Number
RSC	-	Royal Society of Chemistry
SI	-	Spark ignition
ZnSe	-	Zinc Selenide

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LIST OF PUBLICATIONS

Riduan, A.F.M., Tamaldin, N., Yamin, A.K.M., and Sudrajat, A., 2019. Engine Performance Comparison between Various RON97 Gasoline Brands Available in Malaysian Market. *Journal of Advanced Manufacturing Technology*, 13 (2(2)), In Press.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In Malaysia, there are various oil and gas companies that produce and sell gasoline nationwide. Such examples which can be mentioned are BHPetrol (BHP), Caltex, Petron, Petroliam Nasional Berhad (Petronas), and Shell. All these companies have their own distinctive heritage and history in the country with some have more than centennial worth of experience when looked upon each individual organization profile.

Boustead Holdings, a main shareowner of BHP Petroleum Division, introduced BHP retail stations in 2005 through Boustead Petroleum Marketing Sdn. Bhd. after inheriting from British Petroleum (BP) which withdrew Malaysian fuel sector after its investments pursuing gasoline retail market was lacklustre. Caltex on the other hand, is a global energy company under Chevron Corporation that has been established in Malaysia since 1936. Petron meanwhile started business across Malaysia after its complete acquisition investment over ExxonMobil downstream businesses around first half of 2012. Petronas being the only fully Malaysian owned multinational integrated oil and gas corporation, debuted itself since 1974 and was ranked at number 125 among other highly billion dollar profitable companies in Fortune's coveted 2016 Global 500 list. Shell also boast a long history where the company dates back to more than 125 years with its first commercial activity initiated through a small kerosene venture. Described fuel brands official emblems are displayed in Figure 1.1.

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Figure 1.1: Logos of oil and gas companies in Malaysia

With different backgrounds and practices belonging to each establishment profile, there are some similarities between one and another when all are placed in the gasoline retail market sector. One major resemblance from all institutions business model is that their every filling stations irrespective of organizations sell at least two gasoline octane ratings, namely RON95 and RON97. There are a select few companies which offers more than just two fuel grades. For example, Shell has its V-Power Racing Euro 4M gasoline (octane rating higher than RON97) and Petron which develops and sell RON100 fuel conveniently referred to as Blaze 100 Euro 4M. Another similar connection among all these companies is equal fuel pricing for each gasoline octane rating regardless of what brand it is from. This was done using a managed float system which replaced Malaysian fuel subsidies entirely since it took effect on 1st December 2014.

Besides similarities of all corporations fuel retail market working management, there are also key distinct differences that needs to be stated between them. For instances are the gasoline formulation variation and manufacturing process from respective corresponding company. Each fuel producers has its own methods in ensuring their gasoline products achieve regulatory RON95 and RON97 standards by implementing additives of different

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blueprints. BHP uses German additives that are codename Infiniti Advance2x; Caltex fuels are instilled with Techron® technology; Petron implemented a gas saving booster which is identified as Blaze in all their gasoline productions; Petronas applies fuel economy formulation with Advance Energy Formula for both RON95 and RON97 under surname called PRIMAX; and Shell employed DYNAFLEX for its three sets of fuels.

1.2 Research purpose

Because of several gasoline brands availability to choose from in Malaysia, they were absolutely bound for comparisons by consumers. Although most road users use gasoline on a day-to-day basis, they are still uninformed when considering which brand is regarded best or even filling right fuel octane rating for their vehicles. There are even social media posts circulating online about discussing differences in fuel octane numbers and gasoline brands without using any legitimate scientific knowledge.

Since so much misconceptions passing amongst Malaysian people, it is then a duty of a researcher to formally or informally educate people on this matter through solid and definitive results from controlled lab experiments. Controlled lab experiments are important because it can remove external unwanted factors that can affect overall test outcomes. By focusing main components such as comparing different fuel brands and octane rating in a same engine configuration with proper controls over surrounding elements, a more clearly defined output can be conjured up for putting these claims and arguments to rest.

Another important key issue needed addressing is determining gasoline qualities itself which can affect overall engine performance and emissions. So far, the general public can only distinguish gasoline they use by brand, octane number, and price. With merely those information being available, misleading facts and false accusations when comparing between brands and fuel grades are becoming a common theme among Malaysians. Hence,

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