Effect of TRIPMEXX Additives on Engine Performance of a 1.6L Multi-Cylinder Gasoline Engine

Hazim Sharudin¹, Nik Rosli Abdullah*²*, A R Asiah³, Helmisyah Ahmad Jalaludin³, and Matthew EE⁴

¹Faculty of Mechanical Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Kampus Permatang Pauh, 13500, Pulau Pinang.
²Faculty of Mechanical Engineering, Universiti Teknologi MARA.40450 Shah Alam, Selangor, Malaysia.
³Faculty of Mechanical Engineering, Universiti Teknologi MARA, 23200 Bukit Besi, Terengganu, Malaysia.
⁴Unit No.312, Block E, Phileo Damansara 1, No.9 Jalan 16/11, Off Jalan Damansara, 46350 Petaling Jaya, Selangor Malaysia.

* nikrosli@salam.uitm.edu.my

Abstract. This study discusses the findings of the project data obtained from the experimental work. It was based on the analysis of experimental output responses obtained which were Brake Specific Fuel Consumption (BSFC), power and engine torque. A 1.6L multi-cylinder gasoline engine was used to investigate the effect of TRIPMEXX on the fuel economy. The experiment was performed at variations of engine speed (1500, 2000, 2500 and 3000 rpm) with a constant engine load of 40 Nm. From the results obtained, it showed that brake specific fuel consumption (BSFC), power and engine torque for TRIPMEXX were better than gasoline fuel without TRIPMEXX fuel additive. Combustion efficiency of gasoline engine has improved with the use of TRIPMEXX fuel additives. Overall, Fuel Economy, Power and Engine Torque for 1 ml + 10L RON95 fuel sample showed the best results for all measured parameters at all engine test conditions.

1. Introduction

The fear from the exhaustion of petroleum oil and uncertainty in the oil prices for the transportation sector has raised concerns around the world. Approximately 25% of the total world energy consumption was dominated by the transportation of people and goods as per reported by the Energy Information Administration (EIA) [1]. In the current economic crisis, the requirement to develop high technologies in automotive industries especially to improve the combustion process is a key for future engine development. However, combustion efficiency is also possible to improve through reformulation of existing fuel. This prompt researchers to develop a fuel additive which can meet present requirements of energy supply and improve the combustion process in the transportation sector [2]. Alcohols such as methanol, ethanol and butanol have been actively used by the researchers as a fuel additive in the gasoline fuels for spark ignition engines [3-5].

S.B. Singh et al. [3] integrated butanol-gasoline blends with 5,10,20 50 and 75% volume percentage in a four cylinder spark ignition engine. The butanol-gasoline blend consumes slightly higher consumption of fuel compared with gasoline due to its lower calorific value than gasoline. In
In addition, combustion duration of butanol-gasoline blends become longer than gasoline due to an increase in turbulence and flame velocity [3]. L. Siwale et al. [5] prepares dual alcohol-gasoline blends with various proportions of methanol and n-butanol to be compared with single alcohol-gasoline blends (methanol) on engine performance, exhaust emission and combustion characteristics. The dual alcohol-gasoline blend displayed better brake thermal efficiency (BTE) and reduce exhaust gas temperature (EGT) compared with the single alcohol-gasoline blend. This is due to improved volumetric efficiency and also reduced the compression work [5]. Demonstration performed by Andersen et al. [6] shows that reduction of vapor pressure and evaporative emission on the fuel delivery system can be achieved by mixing lower alcohol (ethanol) with higher alcohol (butanol).

In terms of fuel additives fueled in the gasoline, a proper fuel formulation leads to a complete mixing process that results in complete combustion. One of the best methods to improve the combustion behaviour is by blending base fuel with additives. Fuel additives can contribute towards fuel economy either directly or indirectly. Some additives with extra lubricity properties are also possible to extend engine lifetime than usual. Fuel additives on the market come from different bases such as metal-based additives, octane booster, oxygenated additives, cetane number improvers, antioxidants and lubricity improvers. All of them are used to meet specifications and quality before entering the market. The selection of fuel additives is important because some additives resulted in higher octane number that leads to engine damage due to knocking and overpower beyond engine specification.

This study involves advanced fuel additive called TRIPMEXX. Initially developed to enhance better fuel efficiency to boost engine power and later with additional developments resulted in fuel saving. TRIPMEXX now offers a complete fuel efficiency solution, providing improvement in power and fuel savings. There are several benefits offered by this additive such as enhanced power & torque, fuel economy, clean engine by reducing carbon & other deposits. Moreover, TRIPMEXX also able to reduce engine parts friction and prolong engine life-time, it is safe on the engine as it is non-flammable and non corrosive. TRIPMEXX fuel additive is an oil-based compound with an effective combination of essential chemicals and has undergone a unique and special process to make it safe for engine as it is non-flammable and non-corrosive. Though many advantages have been made by using TRIPMEXX, there are still limited information to acknowledge the effect of TRIPMEXX on fuel-saving, power and torque improvement at different engine speeds and torques of a gasoline engine. Therefore, the aim of this study is to investigate the fuel economy, power and engine torque on 1.6L multi-cylinder gasoline engine fueled with gasoline and TRIPMEXX fuel additive.

2. Materials and Methods

2.1 Engine setup
Experimental work was carried out by using a 1.6L four stroke multi-cylinder gasoline engine attached with the dynamometer having a maximum power of 150 kW as illustrated in Figure 1. The detail of the engine specification is shown in Table 1. The engine was controlled and monitored by DaTAQ Pro V2 software where the input and output parameters were set and obtained automatically throughout the experiments.
Figure 1. Schematic diagram of the engine setup.

Table 1. Engine specification.

| Engine Parameter       | Value                                      |
|------------------------|--------------------------------------------|
| Engine Model           | 4 Cylinder, DOHC 16V                       |
| Injection Type         | Fuel system multi-point injection (MPI)    |
| Number of Cylinders    | 4                                          |
| Configuration          | In-line                                    |
| Bore (mm)              | 76                                         |
| Displacement (mm)      | 1597                                       |
| Stroke (mm)            | 88                                         |

2.2 Engine test procedure

Engine testing was performed at a constant engine load of 40Nm with variations of engine speed from 1500 to 3000 rpm. During each test, the engine was warmed up with base fuel for 15 minutes to stabilize the engine temperature. The base fuel used in this study was Gasoline RON95 from Petronas Petrol Station. Then, every 10L of RON95 was blended with 1ml of TRIPMEXX additive as a tested fuel for this study. Two important parameters namely engine speeds and loads were controlled during the testing. Pro V2 software was used to communicate with engine and dynamometer. The engine performance was assessed based on the brake specific fuel consumption (BSFC), power and torque. The results presented in this study are the average of the measurements taken from three separate tests, with outlying points either removed or retested.

3. Results and Discussion

3.1 Brake Specific Fuel Consumption (BSFC)

Brake specific fuel consumption (BSFC) indicates how efficient the fuel consumption of the engine to perform work and the fuel is measured in terms of mass flow rate per unit of time for each engine speed. BSFC is one of the important parameters to evaluate engine performance and the quality of fuel combustion efficiency. The unit of BSFC is g/kWhr. The trends of BSFC on two types of different fuel at all engine test conditions are presented below.
Figure 2 shows the variation of BSFC of all test fuels (RON95 and 1ml + RON95) at different engine speed and constant engine load of 40Nm. The results showed a decreasing trend for both the base fuel and the TRIPMEXX additive blended fuels as the engine speed increased. Figure 2 shows that as the engine speed increases from 1500 rpm to 2500 rpm, the value of BSFC decreases. In average, base fuel (RON 95) has the highest value of BSFC as compared to 1ml + RON95. The average fuel saving when the engine operated with TRIPMEXX fuel additives was approximately 10.20% for the speed of 1500 - 3000 rpm. The average saving for the speed of 2000-3000 rpm was about 12.56%. However, this value increased up to 15.8 % when the engine operated at 2500-3000 rpm. Based on these data, the addition of 1ml TRIPMEXX into RON 95 has reduced the fuel consumption by (10.2% + 12.56% + 15.8%) at three different engine speed regions. The overall average fuel saving for all these regions was approximately 12.85% as tabulated in Table 2.

Table 2. Summary of fuel saving

| Engine Speed (rpm) | 1500  | 2000  | 2500  | 3000  |
|--------------------|------|------|------|------|
| RON95 (g/kWhr)    | 307.03 | 294.10 | 286.03 | 292.88 |
| 1ml + RON95 (g/kWhr) | 297.50 | 276.67 | 231.67 | 255.61 |
| Fuel Saving (%)   | 3.1   | 5.9   | 19.01 | 12.73 |

The reduction of BSFC occurs due to the ability of additive to promote complete mixing process resulted in homogenous combustion process [7]. At lower speed values, the presence of additives can act as anti-oxidant to accelerate the reaction and assist in producing complete combustions. It also showed that blends gave a better anti-knock performance during low speed acceleration than hydrocarbon fuels of the same octane range [7]. At higher speed of 3000 rpm, BSFC increased for both fuels due to the heat loss to the combustion chamber walls which was proportional greater while combustion efficiency was poorer. The volumetric efficiency was also reduced at higher engine speed that resulted in poor combustion process. Higher BSFC result also affect higher friction power at a rapid rate of engine speed. However, engine operating with TRIPMEXX fuel additive has lower BSFC as compared to RON95 without TRIPMEXX even at higher speed region.
3.2 Power Curve
The main performance envelope (power curve) for the engine is depicted in Figure 3. Power is the measure of how much work can be done in a specified time. The power of an internal combustion engine increases as engine speed increases. This is because power is dependent on torque and engine speed. However, the power of engine drops after reaching a certain engine speed. The maximum power for both fuels is almost identical. However, 1ml + RON95 showed a slightly higher power (approximately 3.0% higher) at the same engine speed especially at higher speed region. It indicates that 1ml + RON95 burns less fuel in order to produce the same power at the same engine speed. This result also showed that the power produced by TRIPMEXX fuel additive is within engine capacity that protect the engine from damage due to higher pressure and severe knocking during combustion process [8].

![Power Curve](image_url)

**Figure 3.** Power curve for engine speed of 1500-6000 rpm

3.3 Torque Curve

![Torque Curve](image_url)

**Figure 4:** Torque curve for engine speed of 1500-6000 rpm
Torque and engine speed are the measured quantities of engine output. The amount of torque the engine can exert usually varies with engine speed. Figure 4 shows the variation of torque of all test fuels (RON95 and 1ml + RON95) at different engine speed. The results show a decreasing trend for both the base fuel and the additive blended fuel as the engine speed increases. This is because max torque occurs at the maximum volumetric efficiency (breathing ability of the engine) of the engine [9]. The volumetric efficiency of engine was higher at lower speed as compared to higher speed. The results showed that engine operated with 1ml TRIPMEXX fuel additive + RON95 produced higher torque (approximately is 3.0%) as compared to RON95 without fuel additive. Higher torque provides good acceleration and improves the power of an engine while driving. Torque is higher at lower engine speed region as compared to higher engine speed region. This is due to volumetric efficiency. This peak pressure is usually at the lower middle of the engine rpm range and hence resulted in peak torque in this range.

4. Conclusions
The results found that base fuel blended with TRIPMEXX fuel additive improved the BSFC, power and engine torque. The study proved that 1 ml TRIPMEXX fuel additive + RON 95 resulted in higher engine performance and good acceleration. The comparison between two types of fuel at constant engine load and various speed of the engine is listed below:

1. Base fuel blended with 1ml of TRIPMEXX fuel additive resulted in lower brake specific fuel consumption (BSFC) by approximately 3.1%, 5.9%, 19.01% and 12.73% at 1500 rpm, 2000 rpm, 2500 rpm and 3000 rpm respectively. Average fuel saving for engine operating with TRIPMEXX at engine speed of 1500 – 3000 rpm is approximately 10.2%.
2. Average fuel saving on engine when operating with 1ml TRIPMEXX fuel additive is approximately 12.56% at a higher speed of 2000– 3000 rpm. This speed region can be estimated as 80-110 km/hr on the road speed for a normal car.
3. Average fuel saving on higher engine speed (2500 - 3000 rpm) region that is possible to estimate as a highway driving cycle is approximately 15.8%.
4. Therefore, overall fuel saving for city driving and highway driving mode is approximately 12.85%.
5. The Power curve of 1ml TRIPMEXX fuel additive + RON95 resulted in increasing power by approximately 3% and torque by approximately 3% as compared to base fuel without TRIPMEXX fuel additive.

In conclusion, the base fuel blended with TRIPMEXX fuel additive showed better fuel economy, power and torque at all engine test conditions. During the test on power and torque, there is no evidence of knocking and jerking due to the fact that TRIPMEXX fuel additive does not alter the original fuel formulation (RON95), therefore we strongly believe that there is no damage done to the engine. This is due to the properties of TRIPMEXX fuel additive that improve fuel properties that resulted in complete and smooth combustion process.

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