ISBN 978-93-86878-04-5
6th International Conference on Science, Engineering, Technology and Healthcare (SETH-2017)
Kuala Lumpur (Malaysia), Nov. 20-21, 2017

Effect of Aftermarket Fuel Saver on Engine Fuel Consumption on Real Road Test Condition

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***Abstract*:** *The unstable price of fuel and the introduction of new regulations have driven the introduction of more innovative aftermarket products into the market. In this regard, manufacturers have come out with claims that their products such as innovative fuel savers are able to help reduce fuel consumption in different types of vehicles regardless of their conditions. Thus, this paper focused on the analysis and comparison between several types of fuel saving devices currently sold in the market. Three common fuel saving devices, Magnetic Fuel Saver, Mini Turbo Fan and Voltage Stabilizer, which are priced from RM (Ringgit Malaysia) 60 to RM 250 were chosen to represent the most known fuel saving devices and were installed to Toyota Wish second generation engine (Manufacturing year 2013. Type: 2ZR-FAE 1.8L). A series of tests was conducted on selected roads in Malacca, Malaysia. Different readings were collected to compare between urban driving, extra urban driving and mixed urban and extra urban driving condition. Comparative experimental measurements with and without usage of the proposed products were also conducted and it was observed that all three devices produced different readings, with Magnetic Fuel Saver showing more effectiveness followed by Mini Turbo Fan and Voltage Stabilizer. However, the results do not confirm any significant positive effect of the products on engine fuel consumption.*

Keywords: *Magnetic Fuel Saver, Mini Turbo Fan, Voltage Stabilizer*

1. Introduction

There are various aftermarket fuel saving products with different technology, that are claimed to save fuel consumption [1]. Even in Malacca, one can find more than 10 different fuel saving products being sold. This number does not include extra additives mixed with fuel which are claimed to reduce fuel consumption and increase engine performance. Thus, this study aims to investigate and compare the effectiveness of these devices on increasing fuel efficiency. The objective of this exercise is to compare the performance of three different fuel savers in reducing an engine's fuel consumption. The study will also compare engine fuel consumption with and without the fuel saver. For this experiment, it is hoped that each fuel saver device could impact engine performance (less fuel consumption) and perhaps, illustrates that different fuel savers produce different results.

1.1. Voltage Stabilizer.

The vehicle supply voltage varies considerably and this depends on the state of charge of the battery, the engine speed and the loads, such as lamps and motors that are in operation. The Voltage Stabilizer is a device designed to reduce the variations in the voltage supply to other apparatus [2] . In this light, a car battery acts like a big voltage stabiliser whereas, the traditional lead-acid battery is not able to switch from charge to discharge rapidly enough. During operation, electricity generated from the alternator will be sent to the battery and electrical devices as required by the system; when low voltage of electricity is being used, such as when the audio and headlights are off, the electricity charged by alternator will be stored in the battery while during the high use of electricity, for example when the audio and headlights are turned on, there will be more electricity being used than being recharged. In this regard, the availability of battery affects fuel consumption [3].

The fluctuations of voltage can significantly affect the value of fuel quantity injected into the combustion system. These changes can be avoided by applying an additional electricity storage device so that the change of the battery voltage during engine start-up and immediately afterwards does not affect the accuracy and quality of injection control [4]. The Voltage Stabilizer device is normally attached directly to a car battery at both the positive and negative terminals, and depending on its design, some Voltage Stabilizer can be attached directly to a vehicle's cigarette output plug. Its main function is to regulate the flow of electricity running from the car battery to its electrical components, smoothing idle, and improving the output from the headlights and audio equipment. It can increase battery life, improve combustion efficiency, increase power/torque and decrease emission.

1.2. Magnetic Fuel Saver

Magnetic Fuel Saver is installed at the fuel path between the fuel tank and fuel injector. Normally, it is installed near to fuel injector. This invention improves the running of an internal combustion engine by increasing the amount of fuel passing through the fuel saver apparatus. This provides fuel with superior characteristics, particularly higher flame burning speed during combustion which totally fills the engine internal piston chamber with a highly turbulent mixture. This produces improved fuel characteristics in the fuel mixture during the mixture vaporization and provides a better fuel distribution in the engine internal piston chamber [5]. Consequently, past experimental studies had presented evidence on the benefits of magnetic treatment. Ali S. Faris [6] tested different magnetic intensity (2000 to 9000 Gauss) on the fuel pipe line and found that magnetic intensity affects gasoline consumption and that fuel consumption had reduced by 14%. Therefore, the presence of magnetic field can also improve thermal efficiency and consequently, increase combustion performance [7].

1.3. Mini Turbo Fan

Theoretically, a turbo fan spins the air into the engine which boosts the volumetric flow rate of the air and at the same time, helps the oxidation of hydrocarbon fuels by air [8, 9]. The general principle of combustion is that the performance of combustion depends on the available amount of oxygen. In this regard, the vortex created by the fan increase air flow into the combustion chamber which led to higher engine efficiency. Some turbo fans have electric motors which are controlled by the system while some turbo fans are activated by the flow of air during combustion; the more air flows into the engine, the faster the fan will rotate and more vortex will be produced.

1.4. NEDC (New European Driving Cycle) and Real Road Experiment

There are numerous methods that can be adopted for this experiment. One of these methods is NEDC (New European Driving Cycle) [10] which need to be performed either in a laboratory or on real road conditions; NEDC is a driving cycle which was designed to assess the emission levels of car engines and fuel economy in passenger cars , excluding light trucks and commercial vehicles. Some studies had conducted experiments on real road conditions; Jerzy Merkisz [11] conducted a series of real road tests in the city of Poznan. The distance for the test was 16 km for each reading and the experiment was conducted on mornings and on midday. In the meantime, Martin Weiss [12] used three types of routes (rural, urban and mixed rural and urban) in his experiment. The experiment was conducted around the city of Milan, Italy with the distance ranging between 35 km to 135 km and speed ranging from 25 km/h to 108 km/h.

2. Methodology

Several considerations had been made in the selection of fuel savers. First of all, there should be no major modification on the vehicle's engine, hence only *plug and play* devices should be used. Second, in term of functionality, each device should work differently. Based on these considerations, three different devices have been selected for this study, which are

1. Voltage Stabilizer (FPS Saver)

2. Magnetic Fuel Saver (Magsaver)
3. Mini Turbo Fan (Simota Twin Fan)

As mentioned, all three devices have their own working principles; the Mini Turbo Fan [8] works by boosting the volumetric flow rate of the air and consequently, improves fuel efficiency. Meanwhile, Voltage Stabilizer works to stabilise the current into the engine and Magnetic Fuel Saver [5, 13] improves fuel characteristics to ease the reaction of fuel with oxygen to create a better combustion and fuel efficiency.

2.1. Type of Vehicle

Some procedures were prepared before the test was done. In this light, the weight of the vehicle was kept constant at all tests by installing the similar driver and measurement equipment to the vehicle system for all tests. The mass of measurement equipment was neglected as its weight was less than 200 grams. The windows were kept closed during the test and all air conditioning systems and radio were switched off. The test was done during sunny days when there were no rain. Before the test was conducted, the temperature of the engine was measured using scanner tools which were connected to the engine by using an OBD cable. The experiment used the engine of an automatic transmission Toyota Wish manufactured in 2013 (Table II) and there is no modification done on the engine and other systems in the vehicle. The vehicle was kept clean and the tires are new and the engine was serviced before the experiment. Table I shows the controlled parameters: -

TABLE I : Other Parameters

Parameter	Value
Type of Fuel	RON95
Lubrication / Gearbox Oil	Toyota own brand
Tire Pressure	200psi or 14 bars.
Driver Weight	90kg
Temperature before start	90º to 95º Celsius

TABLE II : Vehicle Specification

Parameter	Value
Number of Cylinder / Engine Arrangement	4-cylinder / In-line
Valve Mechanism	16-valve DOHC, Chain Drive (Valvematic VVT-I)
Combustion Chamber / Fuel System	Pent roof Type / SFI
Displacement cm3 (cu. in.) / Compression Ratio	1798 (109.7) / 10.0:1
Bore x Stroke mm (in.)	80.5 x 88.3 (3.17 x 3.48)
Max Output*1 (SAE NET)	110 kW @ 6000 rpm / (150 HP @ 6000 rpm)
Max Torque*1 (SAE NET)	179 Nm @ 4400 rpm / (132 ftlbf @ 4400 rpm)
Fuel consumption	15.1 km/L
Valve Timing Intake Open / Close	1º - 56º BTDC / 65º - 10º ABDC
Valve Timing Exhaust Open / Close	51º - 11º BBDC / 3º - 43º ATDC

2.2. Location of Fuel Device

Each device was installed at different places based on the manufacturer recommendations on the packaging. The Mini Turbo Fan (Simota Twin Fan) was installed in the air intake path right before the throttle body. No modification was done since the size of Mini Turbo Fan fits the diameter of the intake hose. Meanwhile, the Magnetic Fuel Saver was attached on the fuel hose before the injector and the Voltage Stabilizer was plugged into cigarette input plug.

2.3. Test Location

The area in Melaka Tengah (Melaka) was selected for this experiment. The tests were carried out in the morning from 8:00 am to 11:00 am from Monday to Friday. The temperature recorded was between 30 to 31 º Celsius. The tests were carried out by repeating the runs several times (10 runs each) on the selected routes. Three types of tests were performed;

1. Urban driving cycle (UDC) which was conducted on Lebuh Ayer Keroh

2. Extra urban driving cycle (EUDC) which was conducted between the Ayer Keroh highway exit and the Simpang Ampat highway exit,
3. The Combination of UDC and EUDC

Two routes were selected for the tests. For the Urban Driving Cycle route, the test length was about 27.2 km and the vehicle stopped several times at traffic lights along the selected road. The test started near to INB Resort Sdn Bhd, along the Leboh Ayer Keroh until Jalan Tun Mutahir near to River Cruise Taman Rempah and back to INB Resort Sdn Bhd. The average speed was 50 km/h and the highest was 80km/h. For Extra Urban Driving Cycle, the distance of travel was 45.8 km. The highway near Melaka Tengah was selected for this test. The starting point was at the Ayer Keroh highway exit, along the PLUS highway to exit Simpang Ampat and going back again to Ayer Keroh highway exit. In this light, the average speed for the highway test was 90 km/h despite the maximum allowable speed for highways in Malaysia is 110km/h. For combination of UDC and EUDC, the test started at Jalan Tun Mutahir near to River Cruise, along the Leboh Ayer Keroh to PLUS highway starting from exit Ayer Keroh Highway until exit Simpang Ampat and going back to Jalan Tun Mutahir using the same route.

The test would be cancelled or repeated if there are any anomalies such as rain and accidents that occurred during the experiment. To obtain a better result, 10 experiments were conducted for each test and at the end, the average reading was analysed as the total result.

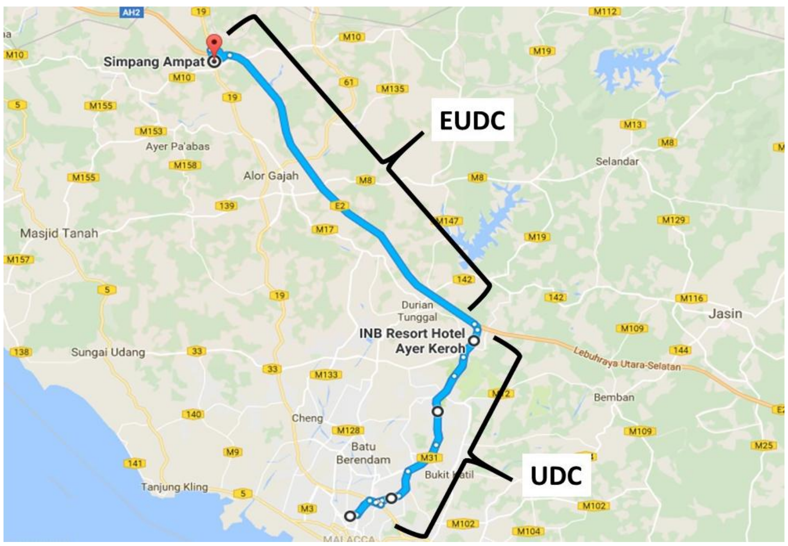

Fig. 1: Test Routes

2.4. Data Reading

The advent of new technology allows drivers to check theirs fuel consumption directly on the vehicle dashboard panel as a majority of recent passenger vehicle models are installed with fuel economy driver interface (FEDI). Thus, the Toyota Wish used in this experiment was installed with a fuel consumption information panel or an FEDI where the average fuel economy reading is directly displayed on the dashboard panel. The FEDI provides drivers with information of fuel usage and displays fuel economy information in a variety of forms. Undoubtedly, one of the functions for fuel economy driver interface (FEDI) is to provide an indicator for the driver on how to have better driving behaviour that can result in improved fuel consumption [14-16]. In this regard, numerous studies had measured the effect of driving behaviour on fuel consumption and found that drivers can save 5-10% of fuels and some drivers were able to reach up 20% fuel saving by making changes to their driving style [17]. A study showed that a group of driving instructors undergoing training had saved 13% of fuel throughout a 40 km journey [17]. On the other hand, for this experiment, the driving behaviour was follow the traffic condition and remained similar for all test.

Five different tests were conducted for each route. For the first test, the vehicle was run without any fuel saver device. For the second, third and fourth test, each vehicle was installed with Voltage Stabilizer, Mini Turbo Fan and Magnetic Fuel Saver, respectively. For the fifth test, all of the devices were used together in the vehicle.

Fig. 2: Data fuel consumption in km/L on dashboard panel

3. Result and Discussion

3.1. Urban Driving Cycle

Figure 3 presents the average fuel consumption for each test. According to Figure 8, Magnetic Fuel Saver showed more mileage than other devices. The standard fuel consumption without fuel saver was 15.9 Km/L and the use of Magnetic Fuel Saver improved fuel consumption by 9.6% or 1.54 more kilometre than the standard vehicle without any device installed while engine with Voltage Stabilizer recorded more fuel consumption. Consequently, installing this device on a vehicle's engine could increase fuel consumption by 1% and the fuel consumption will be decreased by around 4% if all devices are simultaneously used in one engine.

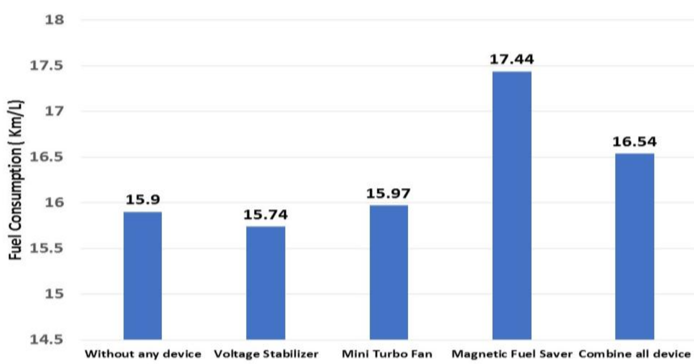

Fig. 3: Urban Driving Cycle

3.2. Extra Urban Driving Cycle

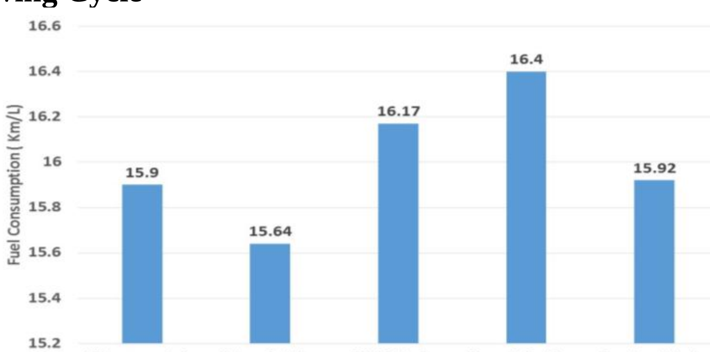

Fig. 4: Extra Urban Driving Cycle

The result on Figure 4 looks similar to what reported in the first sets of experiments of the Urban Driving Cycle as the Magnetic Fuel Saver showed better fuel consumption compared to other devices, and once again, Voltage Stabilizer did not seem to improve fuel consumption and in this experiment, it showed far worse result compared to Urban Driving Cycle. For all combined device, it shows very little improvement on fuel consumption.

3.3. Combination of Urban Driving Cycle and Extra Urban Driving Cycle

The study was also conducted for the combination of UDC and EUDC. During this cycle, the vehicle began its journey from a federal/city road and passed through federal/city road and highways without any stop. The experiment used several routes and showed that Magnetic Fuel Saver has less fuel consumption (5.6% fuel saving) compared to Mini Turbo Fan and Voltage Stabilizer. In this light, Voltage Stabilizer did not show any improvement on the fuel consumption (0.87% fuel increment), while Mini Turbo Fan recorded improvement of about 1.2%.

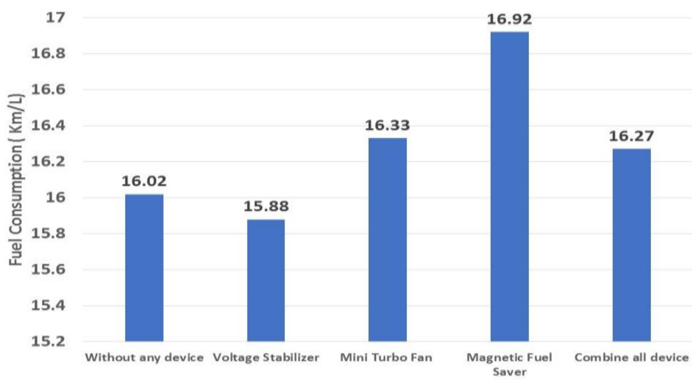

Fig. 5: Combination of Urban Driving Cycle and Extra Urban Driving Cycle

3.4. Comparison all Tests

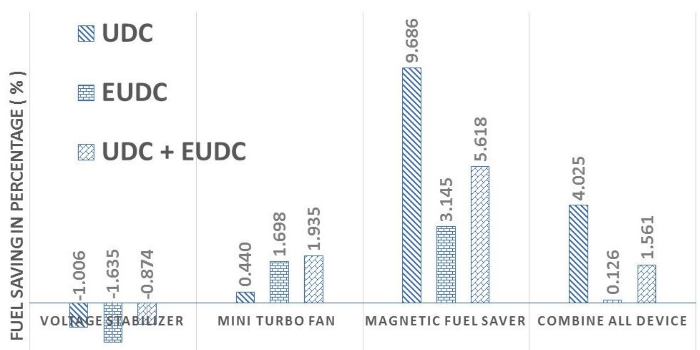

Fig. 6: Comparison fuel Consumption to Standard Engine

Based on the result of this experiment conducted using Toyota Wish on actual real road conditions, it can be concluded that not all devices are effective in reducing fuel consumption as claimed by their manufacturers. The most unreliable device is Voltage Stabilizer which caused the engine to consume more fuel despite the manufacturer's claim that it can save up to 15% of fuel. The experiment showed that the engine with Voltage Stabilizer consumed about 1% more fuel. Meanwhile, for Mini Turbo Fan, the result shows that the device has very low effectiveness at just 1.935% for combination tests in UDC and EUDC. This contradicts the manufacturer's claim that it can save up to 30% of fuel. Magnetic Fuel Saver is more reliable compared to other devices and even though it does live up to manufacturers' claim that it saves about 35% of fuel, the result showed that it consumed 9.68% less fuel consumption during UDC. Thus, it can be concluded that it is the best device among all three. Meanwhile, previous studies had shown different experimental results. Laboratory based experiments on magnetic fuel saver, such as one conducted by Shweta Jain [13] and Ali S Faris [6] reported the increase of vehicle's mileage to 10-40% and 14% respectively. However, a different result was reported for aftermarket products with similar working principles to reduce fuel consumption. Sherry W.J [18] used Hiclone which has the same function like Mini Turbo Fan and Super fuel Max/SUPERMAX which has similar to Magnetic Fuel Saver, the study found that there was no significant reduction in fuel consumption.

4. Conclusion

The study found that the use of devices did not result in high level of fuel efficiency as claimed by their manufacturers; however, the overall result indicated that the use of Fuel Saving Devices has both positive and negative effects on engine fuel consumption. In this light, in term of fuel consumption, the different types of Fuel Saving Devices installed in the engine reacted differently to different types of experiments. For example, the use of Mini Turbo Fan used during the EUDC and UDC combined experiment showed reduced fuel consumption of 1.935%, 1.698% during EUDC and 0.44% during the UDC. Similar results were also observed in Voltage Stabilizer and Magnetic Fuel Saver. It can be concluded that the best Fuel Saving Device for Toyota Wish with 2ZR-FAE 1.8 L engine is Magnetic Fuel Saver, particularly for the short distance driving test. However, it could produce different result if same products are going to be tested in different countries as the roads condition and temperature are different.

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