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Effect of gasoline vaporizer tube (GVT) with magnetic field on spark-ignition engine: Investigation, discussion, and opinion

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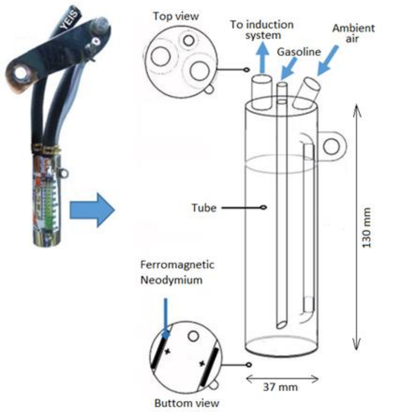

Highlights:
- The performance of a gasoline vaporizer tube (GVT) with a magnetic field on a single cylinder spark-ignition engine was studied.
- Changes in the arrangement of the hydrocarbon molecules in the fuel due to the influence of the magnetic field have been discussed.
- The results of this investigation provide new insights for potential users of GVT.
- Further testing with a standard driving cycle by considering the total fuel consumption is needed.

Abstract
Applying magnetic fields to improve the arrangement of hydrocarbon molecules in fuel lines have been continuously studied in recent decades. However, scientific reports regarding the application of a magnetic field integrated with a gasoline vaporizer tube (GVT) on engine performance have not been widely discussed. Therefore, this article presents an investigation of the application of GVT with magnetic field on a single cylinder gasoline engine with three different fuel qualities, including RON88, RON92, and RON98. Torque, power, emissions and fuel consumption have been tested for scientific opinion. The results of our present investigation seem to confirm the claims of GVT inventors, where GVT increases engine torque and power, reduces CO and HC content in exhaust gases, and reduces fuel consumption. However, without considering the supply of gasoline and air from the GVT to the engine is an unfair analysis. In fact, although the established theories reveal the benefits of applying a magnetic field to the fuel line, in this case, only a small part of the fuel is induced by the magnetic field, outside the main line from the tank to the injectors. Finally, the results of this investigation provide new insights for potential users of GVT, which is currently commercially available.

Keywords: Magnetic field; Hydrocarbon molecules; Gasoline vaporizer; Engine performance

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1. Introduction

Combustion performance in internal combustion engines (ICE) can be improved by correcting the mixture of fuel and air molecules, one of which is using a magnetic field intervention in the fuel lines. Studies on magnetic field effects for gasoline and diesel engines were intensively discussed [1]–[10]. A Gasoline Vaporizer Tube (GVT) equipped with a magnetic field was also introduced to the market as a power booster. The inventor claims that GVT can decompose gasoline ions by intervening with powerful ferromagnetic neodymium to increase engine power and reduce emissions. However, scientific data is not yet openly available as a reference for academia, industry, and related communities. Therefore, this article presents evaluations and opinions as scientific references through an experimental study on a single-cylinder gasoline engine.

The GVT is inspired by performance enhancer technologies such as induction system technology, the hydrocarbon crack system (HCS) technology, octane booster, and the treatment of fuel with magnetic fields. The induction system was introduced by Hata et al. [11] and has been widely used since 1980 for two-stroke engines [12]. It is a simple modification of the intake system, eliminating the "torque bend" problem, and has been shown to improve engine performance and reduce fuel consumption [13]. Recent inventions such as double chambers in the intake system and each have a filter, wherein the induction system can be adjusted [14] and research related to induction systems is still popular today [15]–[17].

Apart from the induction system, HCS is another technology used to optimize combustion processes and reduce emissions. In HCS, regular grade gasoline is broken down by a hydrocarbon converter consisting mainly of propane, propylene, butane, and pentane. HCS technology eliminates chemical elements that can be a source of harmful fumes that form in conventional engines [18]. Abdillah & Sugondo [19] investigated the fuel consumption of a car engine when using HCS and claimed there were savings of up to 50% at 700 rpm and 61% at 2500 rpm. Meanwhile, Suryono et al. [20] analyzed the fuel temperature in the HCS reactor and its effect on emissions in a Toyota 4AFE engine. They claimed a significant reduction in HC and CO emissions when the HCS was operated at 80 °C and 100 °C, respectively.

On the other hand, installing a magnetic field pack before the injector can increase combustion efficiency and reduce exhaust gas pollutants [21]. The magnetic field is usually generated from a permanent magnet or an electromagnet coil. Sahoo and Jains [22] used permanent magnets made of an alloy of neodymium, iron, and boron. They placed them in three different locations from the combustion chamber of a diesel engine. Placing a magnet near the combustion chamber reduces 4% of brake-specific fuel consumption. It increases 4% of brake thermal efficiency for clean diesel engines. Another study conducted by Govindasamy & Dhandapani [23] claims the strong magnetic field in the fuel line reduces carbon monoxide emissions by 13%. Meanwhile, Faris et al. [24] investigated CO and HC when the engine used four Gaussian permanent magnets and found that the properties of the fuel changed when exposed to a magnetic field, with CO and HC reductions of 30% and 40%, respectively. Abdel-Rehim and Attia [25] proved their curiosity regarding the strength of the magnetic field in the fuel system, and their research confirmed that there was a significant reduction in fuel consumption and major pollutants. Studies on magnetic field effects for gasoline and diesel engines are ongoing discussions to date, with research variables being developed [2]–[8], [26].

There are many devices related to the magnetic field to change the arrangement of the hydrocarbon molecules in the fuel line, both for spark ignition engines and compression ignition engines [3], [27]–[31]. From the available literature, a magnetic field device is installed in the main fuel system where all the fuel entering the engine passes through the magnetic field. In our present study, a magnetic field is implemented in the fuel booster device and only a small amount of vaporized gasoline is affected by the magnetic field. Until this article was written, scientific reports regarding applications of GVT with magnetic field treatment on engine performance were very limited. Therefore, this experiment was conducted to provide evidence on the application of GVT with magnetic field treatment on engine performance, fuel consumption, and exhaust emissions.

2. Methods

2.1. Gasoline vaporizer tube (GVT) and tested engine

This research was conducted on a Yamaha 155 cc engine, with the specifications presented in **Table 1**. Three tests were carried out: a performance, road, and exhaust emissions test. The GVT consists of three main parts: a 100 cc cylinder with a level indicator, a circulation tube for air and gasoline vapor, and two neodymium iron boron (NdFeB) permanent magnets which are placed at the bottom tube as shown in **Figure 1**. The top of the GVT is equipped with three channels, where the first channel is to capture ambient air, the second channel is to put gasoline from the fuel tank into the vaporizer

Table 1. Yamaha NMax specification [32]

Parameter		Specification
Engine type	:	Liquid cooled 4-stroke
Number of cylinders	:	Single cylinder
Diameter x Stroke	:	58.00 mm x 58.7 mm
Compression ratio	:	10.5: 1
Maximum power	:	11.1 kW/8000 rpm
Maximum torque	:	14.4 Nm/6000 rpm

tube, and the third channel is to supply a mixture of gasoline and air to the induction system. The GVT was mounted on a tested motorcycle as shown in Figure 2.

2.2. Setup experiment

As shown in Figure 1 and Figure 2, the GVT is an auxiliary device that is installed stand alone on the induction system and is not installed to cut the main fuel line. Four different fuel operations were tested. The first experiment was carried out without GVT. The other three experiments were equipped with GVT involving three Fuel types, including RON88, RON92, and RON98. The Fuel was carefully injected into the GVT tank at a certain volume. To ensure that the increase in engine performance is not affected by fuel quality, we used RON98 for testing without GVT.

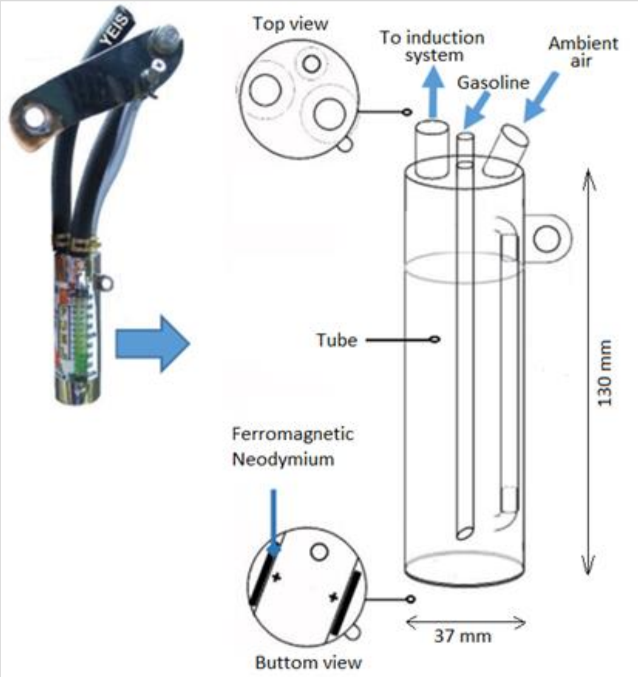


Figure 1. Gasoline Vaporizer Tube (GVT)

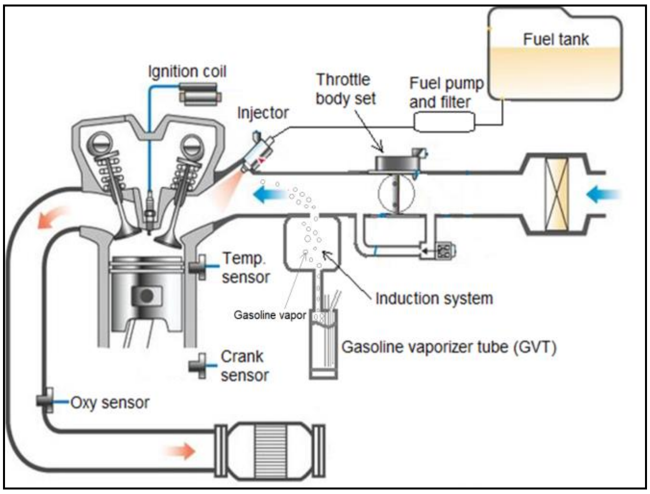


Figure 2. GVT installation on tested motorcycle

Engine performance testing was carried out on the chassis dynamometer which was integrated with the Dyno-Max, Land & Sea software to obtain engine speed, torque, and power. Engine torque and power were recorded from 4500 rpm to 9800 rpm, at 100 rpm intervals. A road test was conducted with drivers who weighed 55 kg to get data on fuel consumption. The motorcycle tank was filled with one liter of gasoline and driven at 40 - 60 km/h until the Fuel was empty. The distance was recorded to get the actual fuel consumption.

The exhaust emissions were measured by a Tecnotest Type Stargas 898 OIML CLASS 0. It measured the concentration of HC, CO, CO_2, and O_2 in the exhaust gas and the air-fuel ratio (λ). The tests were performed at idle speed. The room temperature during the tests was in the range of 25-31 °C. The test was executed four times for each variation to get accurate data. The data were validated, compared, and analyzed using paired t-test statically analysis with a 0.05 two-tail level of confidentiality.

3. Results and Discussion

3.1. Engine performance

Figure 3a and Figure 3b present engine torque and power using four fuel variations. The black, red, blue, and green lines represent engine performance without GVT, GVT+RON88, GVT+RON92, and GVT+RON98, respectively. Maximum torque and power without GVT reach 11 Nm at 5000 rpm and 9.246 HP at 8100 rpm, respectively. The GVT+RON98 has the highest power and torque. Maximum torque reaches 11.6 Nm at 5000 rpm, and maximum power reaches 9.942 HP at 8400 rpm. It increases torque and engine power by 5.5% and 7.5% compared to without GVT, respectively, both of which use RON98. In the GVT+RON88 application, it produces a maximum torque of 10.9 Nm at 5200 rpm and a maximum power of 9.483 HP at 8100 rpm. Maximum power with GVT+RON88 increased by 2.6% compared to engine power without GVT, although it was lower than GVT+RON92 and RON98. Engine power with GVT+RON88 was 4.8% lower than GVT+RON98 and 2.1% of GVT+RON92. On the other hand, engine torque with GVT+RON88 is 6.4% lower than GVT+RON98 and 5.8% more than GVT+RON92.

The increase in power on the use of GVT+RON98 against GVT+RON88, it is possible to be influenced by higher octane. Increasing the octane rating will generally improve combustion performance due to its resistance to knocking symptoms. However, it is also very dependent on the compression ratio and combustion chamber temperature. Research on the effect of octane number on engine performance has long been investigated in various combinations with related variables, and many researchers have proven that octane number has a positive effect on engine performance [33]–[36]. In certain cases, different results were found in the study of Saud et al. [37]. The results of this study seem to show the benefits of using GVT because the torque and power of the engine without GVT and RON98 is lower than that of GVT+RON88, the lowest quality fuel we used in this study.

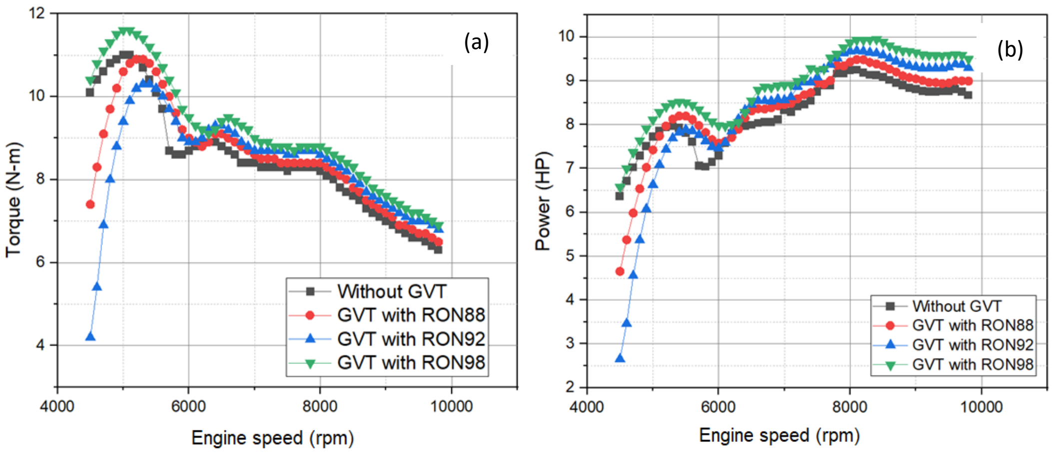
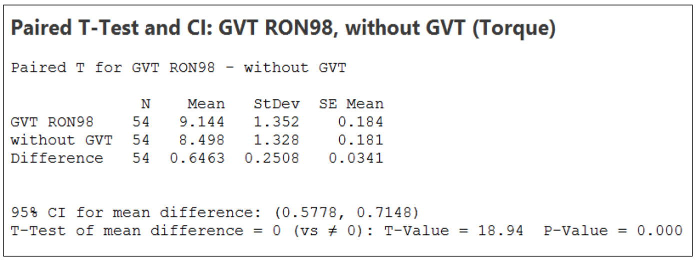


Figure 3. Effect of GVT on engine performance: (a) torque and (b) power

Furthermore, statistical tests were carried out to ensure that the engine performance test results showed significant differences before and after the GVT application. The two-tail paired t-test was used to validate and analyze each engine's torque and power. Before the paired t-test, the normality and outlier tests were conducted to prove that the data are normally distributed and that there is no significant outlier. **Figure 4** and **Figure 5** show the paired t-test results using Minitab for the engine without GVT and the engine equipped with GVT+RON98. The confidence level was 95% using 54 data. It shows a significantly higher engine power when using GVT+RON98 (8.991± 0.827 HP) compared to the engine without using GVT (8.262±0.732 HP) with a t-value = 20.53 and P-value ≤ 0.25. The results of this statistical test confirm a feasible difference in torque and power from a technical point of view.



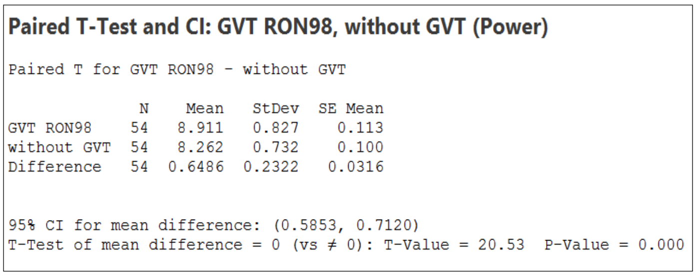
Paired T-Test and CI: GVT RON98, without GVT (Torque)

Paired T for GVT RON98 - without GVT

	N	Mean	StDev	SE Mean
GVT RON98	54	9.144	1.352	0.184
without GVT	54	8.498	1.328	0.181
Difference	54	0.6463	0.2508	0.0341

95% CI for mean difference: (0.5778, 0.7148)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = 18.94 P-Value = 0.000

Figure 4. The result of paired t-test for engine torque



Paired T-Test and CI: GVT RON98, without GVT (Power)

Paired T for GVT RON98 - without GVT

	N	Mean	StDev	SE Mean
GVT RON98	54	8.911	0.827	0.113
without GVT	54	8.262	0.732	0.100
Difference	54	0.6486	0.2322	0.0316

95% CI for mean difference: (0.5853, 0.7120)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = 20.53 P-Value = 0.000

Figure 5. The result of paired t-test for engine power

3.2. Fuel consumption

Figure 6 presents the results of the fuel consumption test in this study. The fuel consumption of tested vehicles with GVT and without GVT was evaluated in actual operation at the same speed, and distance travelled. As is known, there are at least two methods to measure fuel consumption, by standard procedures in the chassis dynamometer and by real tests on the road. Tests on the chassis dynamometer with standardized test procedures were reported by many researchers [37]–[39], and one of the real test methods on the road was carried out by Nguyen Duc [40] on the LPG application for a motorcycle. We chose the real operation method to represent the actual result, although the uncertainty of this method is greater. The results of our current study show that the use of GVT+RON98 can reduce fuel consumption by up to 4.9%. Compared to another experiment performed by Arias et al. [1] in a compression ignition engine applying magnetic fields in the pipes that transport the diesel the fuel consumption was reduced by approximately 4.89%, which is practically equal to the result of this research. The variations in some physical-chemical properties of the diesel fuel (such as surface tension and rheological behavior) will result in more efficient atomization and smaller droplets. Thus, achieving a more homogeneous air-fuel mixture produces more complete combustion and fuel savings.

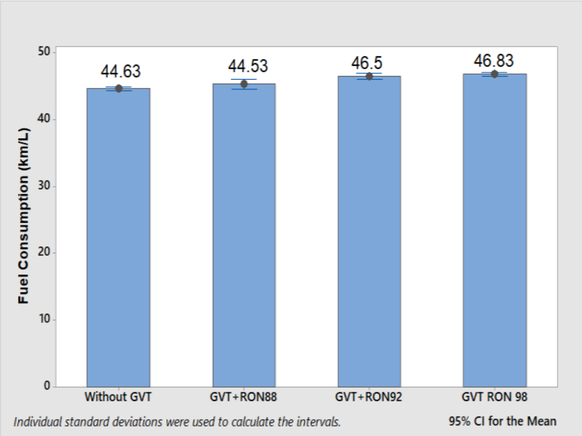


Figure 6. Fuel consumption based on real operation mode

3.3. Emissions

The exhaust emissions content represents a combustion process in the combustion chamber. Theoretically, complete combustion does not leave HC, CO, and O_2 to be converted into CO_2 and heat of combustion. However, because the combustion process occurs dynamically and in a swift time, HC and CO are still formed. Now, not only HC and CO must be reduced but also CO_2 simultaneously to reduce greenhouse gas effects. **Table 2** shows the content of CO, CO_2, HC, and O_2 in the exhaust gas for each condition of the tested engine. The gas measurements were performed at idle speed, approximately 1500-1600 rpm. It indicates that an engine with GVT filled with higher octane gasoline would improve exhaust gas emissions. As is known, complete combustion leaves a small amount of CO and HC. In this study, in addition to reducing CO and HC, CO_2 reduction was also found but increased O_2. In the current analysis, considering the GVT construction as presented in **Figure 1**, the vaporized fuel and ambient air are added through the channel in the GVT cap, where ambient air enters the GVT tube. Theoretically, the decrease in the HC and CO emissions when the GVT with the magnetic field is used shows that with this technology, complete combustion is achieved because the process is more efficient. The reduction in CO_2 emissions is due to the reduction in fuel consumption obtained with this technology, as demonstrated in the research developed by Arias et al. [1]. However, in reality, there is a reduction in fuel in the GVT which is converted into vapor (see **Figure 2**), which means there is additional fuel to the engine apart from the main fuel system, from the tank to the injectors. The final results as shown in **Table 2**, cannot be used as a reference by normal analysis because the oxygen sensor provides information based on the remaining oxygen content in the exhaust gas to control the injection volume through the ECU, whereas in this experiment, the amount of vaporized gasoline from the GVT is not controlled by ECU.

Table 2. Exhaust gas content

Test Condition	CO (%)	CO_2 (%)	HC (ppm)	O_2 (%)
Without GVT	0.426	3.06	58	15.83
GVT+RON88	0.209	2.98	68	16.02
GVT+RON92	0.171	0.76	15	17.96
GVT+RON98	0.211	0.59	30	18.24

3.4. Establish theories

Hydrocarbons are well known for their long-branched geometric chains of carbon atoms. This tends to fold over on itself and adjoining molecules; this is due to the intermolecular electromagnetic attraction that exists between them. When exposed to an external magnetic field, fuel molecules are usually excited, causing more reorientation to accommodate the applied external magnetic field. This phenomenon is explained by the fact that at the molecular level, a spinning electron absorbs a specific amount of electromagnetic energy and spin-flips into an aligned state [41].

The interaction of the magnetic field with the hydrocarbon molecules and oxygen molecules of the Fuel makes the magnetic treatment effective. Their physical attraction forms a pseudo-solid compound that can be associated and form a stable structure. Without magnetic field interference, the quality of mixing of Fuel and air molecules occurs along the intake manifold, resulting in incomplete combustion and finally forming carbon and carbon monoxide particles as combustion residues. By interfering with the magnetic field on the fuel line, the originally naturally occurring polarization of the hydrocarbon fuel is made possible by applying external force by the magnetic field. The application of the magnetic fields causes the loss of fixed valence electrons which are responsible for the bonding process of hydrocarbon fuels. These conditions help create a free association of the fuel particles. They become aligned in a magnetic dipole that does not need to form new hydrocarbon chains but arranges the bonds in such a way that they repel each other and make room for the entry of oxygen molecules [42].

Through the threat of a magnetic field, the hydrocarbon fuel molecules are subjected to a declustering process, making the very small particles more rapidly penetrated by oxygen, which leads to better combustion [43]. **Figure 7** shows the para and ortho-hydrocarbon states before and after magnetic treatment of the Fuel, where the hydrogen molecules have opposite spins; as a result, they stick together [42]. After passing through magnetic fields, the polarity changes, and they start to rotate in the same direction resulting in a repulsive force. When Fuel passes through a magnetic field formed by powerful permanent magnets, the hydrocarbon molecules shift orientation (para to ortho). At the same time, the intermolecular force is much reduced. This process aids in oil particles' dispersion and fine division [27]. It allows oxygen molecules to gain a place in the chain and therefore causes complete combustion [44]. As shown in **Table 2**, the magnetic field interference in the GVT significantly reduced CO, HC, and CO_2 emissions for all tested fuel qualities.

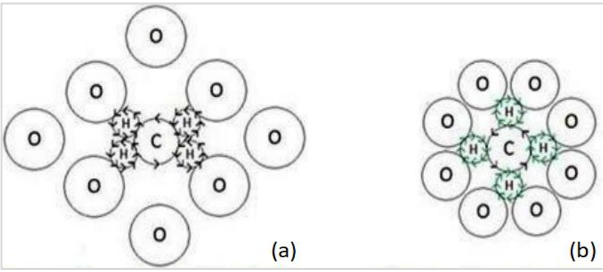


Figure 7. Oxygen molecules clings on to hydrocarbon molecules after magnetic treatment: (a) para-hydrogen and (b) ortho-hydrogen at time of combustion [42]

4. Conclusion

The data from this investigation seems to provide benefits regarding the application of GVT on engine performance, emissions, and fuel consumption, as claimed by the inventor. Torque and engine power tested using the same fuel quality increased by 5.5% and 7.5%, respectively. Paired t test method on all test samples showed a significant difference using GVT with 95% confidence level. In addition, the application of GVT with a magnetic field reduces the CO and HC content in exhaust emissions. The results of the fuel consumption test using the actual driving method also show significant fuel savings of up to 4.9%. Although the established theories explain the benefits of applying magnetic fields to the fuel line, they are not representative in this case. Keep in mind that the GVT is an auxiliary device, not all gasoline that is fed into the engine passes through the magnetic field on the fuel line. That means, there is additional gasoline supplied to the engine, apart from the injectors. Therefore, the claims of improved performance, reduced emissions and fuel consumption by the inventors are unfair if gasoline supplies from GVT are not included in the analysis. Differences in results are possible if the mass flow rates of gasoline vapor and ambient air from the GVT are considered. The results of this investigation provide new insights for potential users of GVT, which is currently commercially available. For more valid results, it is necessary to carry out further testing with a standard driving cycle on the dynamometer by considering the total fuel consumption.

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Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

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