# THE EFFECT OF DIESEL ADDITIVE ON EMISSIONS AND ENGINE PERFORMANCE

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***Abstract***
*The article is focused on the impact assessment of the additives used in diesel fuel to improve the power and emission parameters of the vehicle and its consumption. The usage of additives in engine fuels have an increasing tendency. The manufacturers claim that additives have positive impact on engine operating parameters, cleaning the fuel supply system and decreasing fuel consumption by improving the engine combustion process. In the diesel fuel is often used as 2-ethylhexyl nitrate (C8H17NO3*) *based fuel additives summer version. Measurements were performed under laboratory conditions with the help of the MAHA MSR 500 test bench where we performed driving cycles selected by authors with pre-selected external conditions and time intervals (constant engine speed and constant load). Focus have been given on tracking of the vehicle's external speed characteristic and measurement of selected parameters: CO,* $NO_x$*, fuel consumption and smoke. The resultant values of the driving cycles measured before and after application of additives to the fuel was compared. The result of the experiment was find, that when was used the fuel additive, performance and torque, fuel consumption and emisssions were improved.*

**Key words:** *fuel additive VIF; smoke; diesel engine; engine speed characteristic.*

## INTRODUCTION
The increase of road transport (especially the individual transport) is a worldwide problem in the major part of cities. The fast growth of the world population and industrial development is linked with an increasing consumption of fossil fuels (*Rievaj et al., 2018*; *Jindra et al., 2016).* The increasing traffic intensity brings many negative impacts. The most significant negative impacts of transport include the noise, vibration and production of harmful exhaust emissions as CO, $CO_2$, NOx, HC and particulate matters. The exhaust gases emitted from the engine often get into the human respiratory tract and may cause headaches, irritation of the mucous membranes in eyes and throat and cause cancer (*Küüt et al. 2015*). The European Union annually orders automakers to reduce the production of harmful pollutants into the air. Therefore automakers are trying to reduce the amount of pollutants generated by combustion. Methods of reducing emissions are provided by various technologies such as particulate filters. Emissions can also be reduced by reducing of the engine volume, reducing fuel consumption or using charged engines. Developments in the field of technology bring with their positive impact and increase of life quality also undesirable side effects. One of the severe adverse effects of the scientific and technical progress is environmental pollution (*Lenďák, et al., 2014; Jablonický, et al., 2012; Králik, et al., 2015; Jablonický, et al., 2019*). Fuel consumption can be affected by driving, but also with the right choice of fuel or additive to fuels. Since diesel fuel has a biofuel content, which also has negative characteristics such as clogging injectors, it also causes rapid oxidation in the fuel system, the formation of deposits in the fuel tank and in the winter months reduces the fuel filtration point. The main goal of the additive is to improve the basic properties such as increasing the cetane number, improving the lubricity properties, avoiding oxidation, which ultimately has a positive effect on the life of the engine as well as on the lifetime of the fuel system (*Jablonický et al., 2012*).
Several additive manufactures such as: Castrol TDA, STP, Liqui Moly, Sheron, Ekolube, Valvoline, VIF and Tectane claim that their products improve technical state of fuel injection system by cleaning and improve cold engine starts, increase octane number. Some manufacturers guarantee decreases of fuel consumption in range of 2-7 % and improvement in emissions. For testing, we chose an additive from company Lang Chemie whose name is VIF because it is one of the most commonly used in Central Europe.
The aim of study was to assess the impact of the additives used in diesel fuel on the vehicle's power, emission parameters and consumption.

## MATERIALS AND METHODS

The aim of the contribution was to evaluate the effect of selected Super diesel from VIF manufacturer on the power and emission parameters along with the fuel consumption for the diesel. The tested vehicles is Volkswagen Passat (Fig.1) category M1 with the 2.0 TDI diesel engine with CR injection pump. The vehicle's main parameters are displayed in Table 1.


**Fig. 1** Tested vehicles Volkswagen Passat 2.0 TDI (164k km)

**Tab. 1** Main parameter of tested vehicle

| **Vehicle** | Volkswagen Passat |
|---|---|
| Year of manufacture | 2011 |
| Engine type | TDI, CR |
| Cylinders capacity | 1,968.0 $cm^3$ |
| Emission regulations | EURO 4 |
| Post-treatment emission systems | NKAT, EGR |
| Highest engine power/speed | 103 kW / 4,150 $min^{-1}$ |
| Operating weight | 1,601 kg |
| Number of driven axles | 1 / front |
| Number of driven kilometres | 164,500 |

***Characteristics of working mediums***

During measurements were used fuel from brand Slovnaft. It was a basic range of fuels without the additive with the trade name Tempo plus diesel. In the tank contained approximately 25 liters what was half the capacity of the tank. Pumped diesel fuel met the requirements of standard EN 590 and also satisfies the conditions of the World Association of Automobile Manufacturers. During the testing was used winter diesel fuel, which has a lower temperature of filterability compared to summer diesel fuel.
As tested additive was chosen known and in practice often used Super diesel additive made by VIF in a plastic bottle with 125 ml. It is a product constructed on the basis of 2-ethylhexyl nitrate, the manufacturer indicates improvement in the cetane number by 5 units, better combustion, reduced engine noise and lower fuel consumption by 5%. The additive serves to disposable one for 40 to 60 liters of fuel. In the tests, the entire volume of the additive was used, ensuring a dosing ratio of up to 1: 200 or, 0.125 l: 25 l.

***Characteristics of the instruments***
***Fuel flowmeter***

Due to inaccurate measuring of fuel consumption by a vehicle on-board computer, it was necessary to use a different, more accurate system. We used an AIC-5004 Fuel Flowmaster external fuel meter from AIC SYSTEMS AG, which joined the car's fuel system in its engine compartment
***Performance roller dynamometer:***
To measure the performance of the vehicle was used performance dynamometer by the German manufacturer MAHA with the designation MSR 500 with the possibility of measuring 4-wheel drive.

**Fig. 2** Performance roller dynamometer MAHA MSR 500

***Exhaust gas analyser***

To detect quantity of emissions in the exhaust gas was used analyser from brand MAHA and model MGT 5 / MDO2 - LON. It is a dual instrument to record the production of both petrol and diesel emissions.

**Fig. 3** Exhaust gas analyser - MGT 5 / MDO2 – LON by brand MAHA

***The course of measurement***

The measurement process itself consisted of several important steps: fixing the car on the roller, connection of the flowmeter, exhaust gas analyser, oil temperature probe and pairing the vehicle via OBD diagnostics with a computer to record all values from the control unit and the devices to the computer. After completion of the initial steps, the engine had to be warmed to the operating temperature to ensure the most accurate and trusted results.
It was necessary to calculate and analyse measured parameters using the basic following relationships:

Calculation of performance *P*

$$P = M_k . \omega = M_k . 2 . \pi . n \quad [\text{kW}] \quad (1)$$

Calculation of torque $M_k$

$$M_k = \frac{P}{2.\pi.n} \quad [\text{Nm}] \quad (2)$$

The quantity of fuel $V^{''}$ consumed for the selected period of time

$$V^{'} = V_2 - V_1 \quad [\text{dm}^3 . (30\text{s}^{-1})] \quad (3)$$

Hourly fuel consumption *V*

$$V = \frac{V^{'} . \rho_{fuel}}{t} . 3600 \quad [\text{kg.hod}^{-1}] \quad (4)$$

## RESULTS AND DISCUSSION

Based on the external engine speed characteristics obtained from the MAHA performance dynamometer, it was possible to assess and compare the performance parameters of the vehicles. As can be seen in Table 2, after comparing the results, it was concluded that the diesel power increased by 0.8 kW and torque by 3.3 Nm, that was in range of dynamometer measurement inaccuracy (2%). Therefore, we do not consider measured values as significant in terms of performance improvement.

**Tab. 2** Comparison of average performance parameters before and after adding additive to diesel

| Vehicle | Parameter | Before using the additive | After using the additive |
|---|---|---|---|
| Volkswagen Passat | Corrected performance [$P_{norm}$] | 108.6 kW<br>4405 $min^{-1}$ | 109.4 kW<br>4385 $min^{-1}$ |
| | Torque [$M_{norm}$] | 316.6 $N.m^{-1}$<br>2345 $min^{-1}$ | 319.9 $N.m^{-1}$<br>2395 $min^{-1}$ |

Another examined parameter was the influence of fuel additive on engine emissions. This was performed as a sequence of 5 consecutive measurements before and 5 measurements after addition within the specified time range. Similarly, to the measurement of emissions we measured the fuel consumption by using a flow meter that was connected to the fuel system of the car. The values of these measurements were averaged and statistically analysed. The results are shown in Tables 3.

**Tab. 3.** The results of measuring emissions and fuel consumption on the VW Passat

| Volkswagen Passat | Time of measurement | Value | Different | Standard deviation | Variation coefficient |
|---|---|---|---|---|---|
| Carbon monoxide CO (% of vol.) | before addition | 0.10 | - 0.07 | 0.015 | 0.103 |
| | after addition | 0.03 | | 0.013 | 0.205 |
| Oxid nitride $NO_x$ (ppmo) | before addition | 102 | - 4.0 | 0.65 | 0.164 |
| | after addition | 98 | | 0.84 | 0.143 |
| K-value ($m^{-1}$) | before addition | 0.131 | - 0.04 | 0.028 | 0.183 |
| | after addition | 0.091 | | 0.019 | 0.054 |
| Fuel consumption ($kg.hod^{-1}$) | before addition | 5.84 | + 0.08 | 0.08 | 0.067 |
| | after addition | 5.92 | | 0.07 | 0.058 |

The results of the experimental measurements show partially the positive effect of the selected additive on the fuel consumption and the emissions of the tested passenger car.
Measurement in Volkswagen Passat showed that CO emission decreased by 70 %, $NO_x$ emission decreased by 4 %. However, fuel consumption increased by 1 % therefore claimed statements by VIF producer to decrease fuel consumption in range of 5 % for diesel engine has not been confirmed by our measurements.
*Janoško et al., 2018* presented in other works, that improvement alternatively worsening of emissions and performance parameters also depended on the mileage performance. Measurement in Renault Clio with gasoline engine volume 1,149.0 $cm^3$, 43 kW, 73k km mileage showed that CO emission decreased by 39.76 %, HC decreased by 60.27 %. However, fuel consumption increased by 7.36 %. Measured parameters in Škoda Octavia 1,9 TDI, diesel engine with the higher mileage (approx. 388k km) showed that smoke (K-value) decreased by 29.20 % and fuel consumption decreased too by 3.39 % while VIF producer claims decrease by 5%.
Other such complex works by other authors have not yet been monitored / published. There are only partial additive evaluations for some parameters listed in the introduction chapter. The assumptions for improvement of CO, NOx and smoke emissions have been confirmed (*Küüt et al. 2015; Lenďák, et al., 2014; Jablonický, et al., 2012, 2019*).

## CONCLUSIONS

The aim of the paper was to evaluate the impact of the additives on the vehicle's power and emission parameters along with fuel consumption. This complex approach of additives testing brings more precise answers on energetical and emission changes in petrol and diesel engines.

Experimental measurements were performed in a test laboratory on preselected vehicle. For testing purpose, vehicle Volkswagen Passat with engine volume of 1,968 $cm^3$, 103 kW, 164k km mileage were chosen. The measurements partiality confirmed the additive manufacturer's claims about emissions improvement and performance parameter. In the case of a diesel engine, the difference was minor in range of dynamometer inaccuracy. We assume that the diesel additive does not have a significant effect on the engine's performance parameter, but it has a positive cleaning impact on the combustion chamber and emissions.

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