Petrol and Diesel Engines Sound Measuring and Analyzing in Real Road Conditions

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***Abstract*— The problem of transport noise has two sides: external noise affecting the inhabitants of the settlement and noise in the vehicle where the driver's workplace and the seats of the passengers are. The object of research is the level of the generated internal noise emitted by the movement of a car on the territory of the city of Sofia. The values of the basic equivalent level of noise emitted during the movement of two laboratory cars of the same class with gasoline and diesel engines were determined. A comparison was made of the noise generated during aggressive and normal driving by the driver of the cars.**

Keywords— vehicle emissions, PID, particulate matter

I. INTRODUCTION

Noise is one of the typical harmful hazardous emissions to which we are constantly exposed. Regular and prolonged exposure to increased noise can lead to various adverse health consequences, such as hearing impairment, hypertension, ischemic heart disease, irritability and sleep disturbance, etc. [1-5]. The maximum safe level of noise to which people are exposed is 70 dB for 24 hours (World Health Organization, 2000). Noise levels of 85 dB or higher can cause permanent damage to hearing sensitivity and even cause hearing loss (Noise Induced Hearing Loss (NIHL), 2015). Noise-induced hearing loss is one of the most common occupational diseases. In the US, over 10 million people have suffered irreversible hearing damage from noise and 30 to 50 million people are exposed to hazardous noise daily (National Institute on Deafness and Other Communication Disorders, 1999).

The problem of noise from transport has two sides: the so-called external noise affecting residents of the settlement and noise in the vehicle where the driver's workplace and passenger seats are located [6-8].

The object of research are the levels of generated internal noise emitted by two passenger cars of the same class, equipped with a diesel and a gasoline engine.

II. SYSTEM DESIGN DESCRIPTION

The rapid economic development of mankind on a global scale significantly increases the transportation of passengers and goods by road transport. This, in turn, leads to a significant increase in the noise levels to which professionals, vehicle drivers and their passengers, as well as the general public, are exposed.

The aim of the work is to determine the levels of noise generated in the vehicle of passenger cars in real road conditions. Methodologies are developed and the necessary technical equipment is described for measuring the levels of the generated internal noise in the car, to which the driver of the car and the passengers in them are impaired in real road conditions in an urban environment [9-16]. Two laboratory cars of the Technical University - Sofia were used for the measurements, and the technical characteristics of the used cars are presented in table one. Cars additionally equipped with a system for tracking the movement of and visualizing its position on the map. Two cars with the following characteristics were used for the measurements (Tabl. I):

- Skoda Fabia – a passenger car powered by a diesel engine, shown in Fig. 1a.
- Skoda Fabia - a passenger car powered by a gasoline engine, shown in Fig. 1b.

(a) (b)

Figure 1. Tested vehicles Skoda Fabia on the territory of the TU-Sofia campus

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TABLE 1 Technical data of the experimental vehicles

Model:	Skoda Fabia II 1.4 TDI	Skoda Fabia II 1.2 12 V
Body style:		
Production period:	2007 January…2010 March	2007 January…2010 March
Engine:	1422 cm^3 Diesel	1198 cm^3 Petrol
Power:	69HP on 4000 min^{-1}	69HP on 5400 min^{-1}
Torque:	155 Nm on 1600 - 2800 min^{-1}	112 Nm on 3000 min^{-1}
Gearbox:	Manual gearbox (5 gears)	Manual gearbox (5 gears)
Drive type:	Front wheel drive (FWD)	Front wheel drive (FWD)
Maximum speed:	163	163
Acceleration 0-100 km/h:	14.8 seconds	14.9 seconds
Fuel consumption (l/100km):	4.8 (combined) 6.0 (urban) 4.2 (highway)	5.9 (combined) 7.7 (urban) 4.9 (highway)
Fuel tank capacity:	45 litres	45 litres
Car dimensions:	3.99m (length) 1.64m (width) 1.49m (height)	3.99m (length) 1.64m (width) 1.49m (height)
Gross weight:	1125 kg	1050 kg

To measure the noise levels in the cars of the two experimental cars, a USB Noise Meter (Pro Edition) [17] is used. It is intended for measuring a noise level sound pressure level (SPL) and AFC with high accuracy in the entire audible range up to 20,000 Hz. The source of the measured signal can be provided by industrial equipment. Usage of this microphone inset allows receiving a wide dynamic range of measured signal of 70 dB and a high threshold level of 150 dB, which makes this device suitable for this purpose. The measured signal is digitized inside the device and sent to a PC via USB port already in digitalised form. The noise meter operates with the software “Measuring Center” for Windows (a multifunctional measuring center for sound spectral analysis). This software has been created especially for work with Spl-Lab equipment; therefore it will not require additional calibration for taking accurate measurements.

We used the functions: Measuring the amplitude-frequency characteristic (AFC) of the signal - displaying the spectrum; Displaying the signal waveform; Measuring the sound pressure level with adjustable algorithm (SPL, dB); Measuring the amplitude and frequency of the peak values of the spectrum (Fig.2).

Figure 2. Measuring Center for USB Noise Meter (Pro Edition)

During the research, in parallel with the equipment for determining the noise levels in the car, diagnostic equipment is used to monitor the main indicators of the DHG and the car, TEXA model IDC5 (Fig.3).

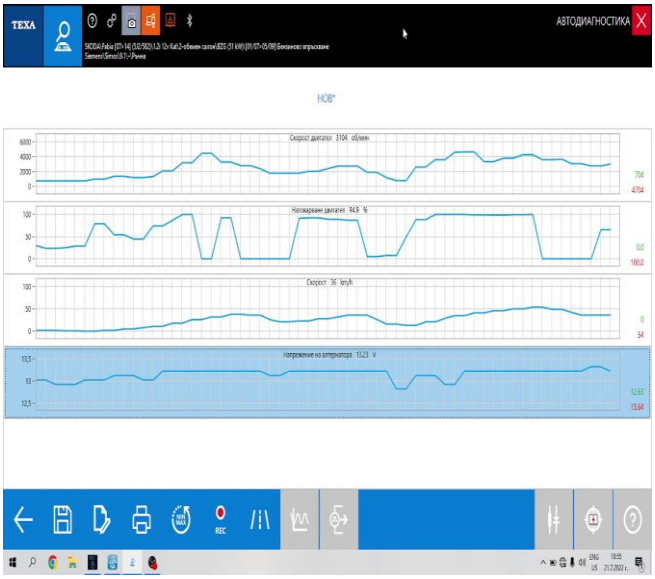

Figure 3. Screen of the diagnostic equipment TEXA model IDC5

To perform the measurements, four trials were conducted, respectively two trials with each car. In the first attempt, the car was driven with a used laboratory car of the Laboratory "Organization and management of automobile transport" at the Technical University - Sofia, and table one presents the technical characteristics of the used car - Skoda Fabia - a diesel-powered car. The car is additionally equipped with a system for tracking the movement of and visualizing its position on the map.

III. RESULTS

At the beginning, we defined two characteristic types of driving - normal and aggressive [9,11,12]. We determined the speeds and route. We then conducted experiments on the established routes and driving style. We repeated the route several times with both cars (Fig.4 and Fig.5).

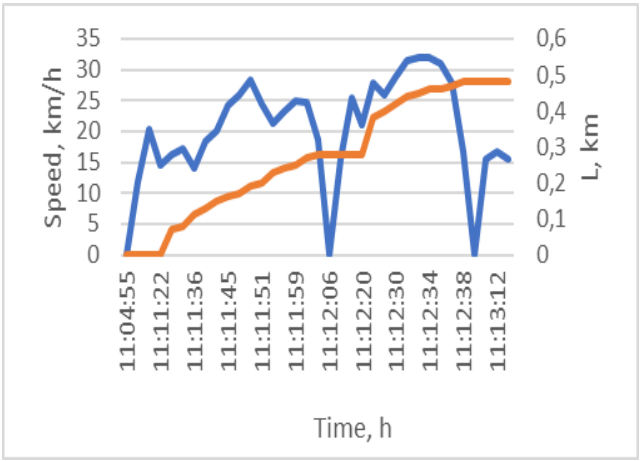

Figure 4. Normal driving

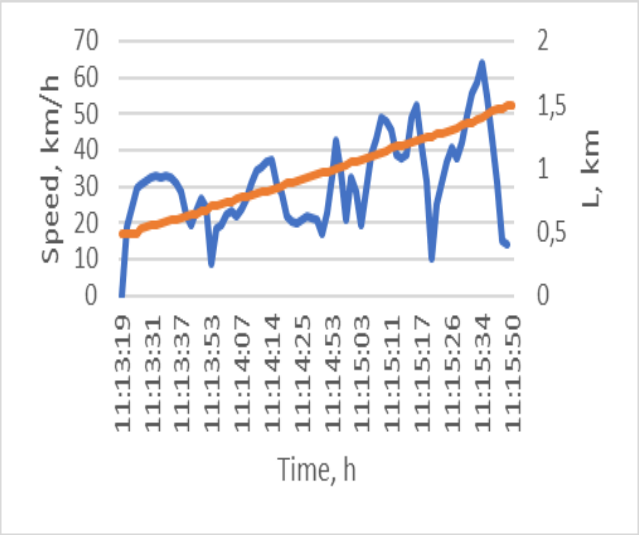

Figure 5. Aggressive driving

During the repeated crossing of the routes, we recorded the data on the sound pressure, speed and load of the car. We analyzed this data.

In the conducted experiments, several variables were mainly monitored, which are engine revolutions per minute, vehicle speed, measured noise in the passenger compartment and frequency of the measured noise. Based on these variables, the results will be analyzed and processed. Fig. 6 shows the ratio of speeds when conducting the experiment with the two cars, and Fig. 7 shows the ratios of the sound pressure levels in the passenger compartment when conducting the experiment with the two cars.

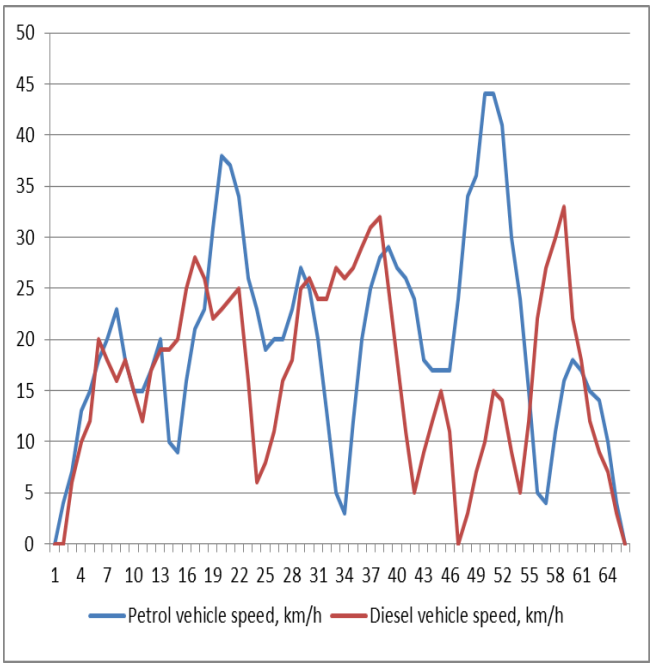

Figure 6. Ratio of speeds when conducting the experiment with the two vehicles

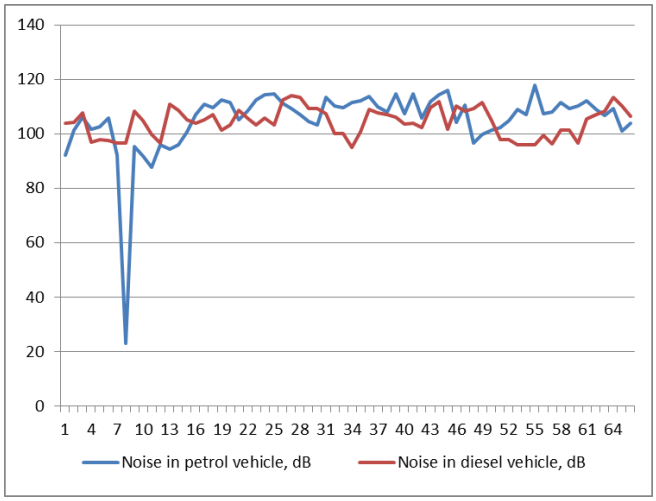

Figure 7. Ratio of sound pressure levels in the passenger compartment when conducting the experiment with the two vehicles

When calculating the correlation coefficients between the obtained data on the noise levels in the passenger compartment of the two cars, we obtained a total correlation coefficient of 0.155, which is an indicator that there is a significant correlation between the two types of data. This means that they are clearly distinguishable from each other and provides a prerequisite for their easy recognition.

After processing the results of the cabin noise frequencies of the cars, we have reduced the results to 11 different frequency values for the two cars. These values are presented graphically in Fig. 8. It can be seen from them that the frequencies of the two cars are relatively similar, due to the fact that we use the same compartments. It is also noticed that the frequencies of the diesel car are more linearly distributed compared to those of the petrol car. This can be said to be due to the fact that the engine runs at a lower rpm on the diesel compared to the higher rpm on the petrol car.

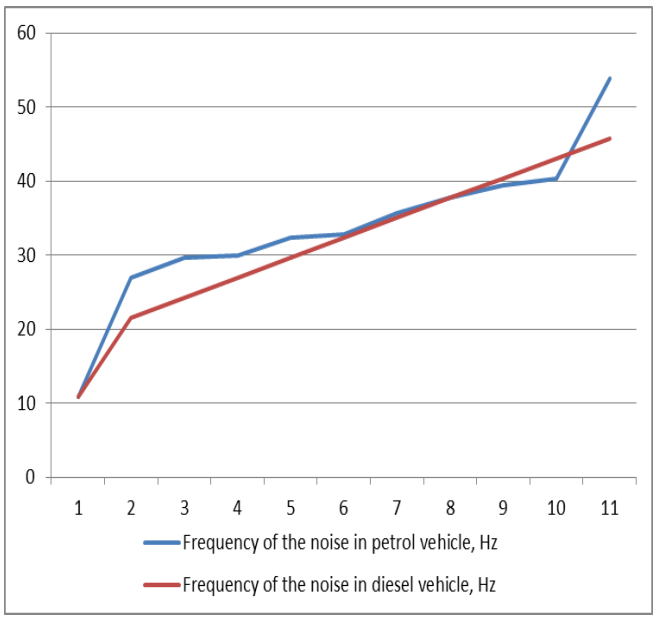

Figure 8. The frequency of the noises of the two vehicles tested

The above is confirmed by comparing the graphs from Fig. 8 and Fig. 9, which presents the data for revolutions per minute of the two engines during the experiment.

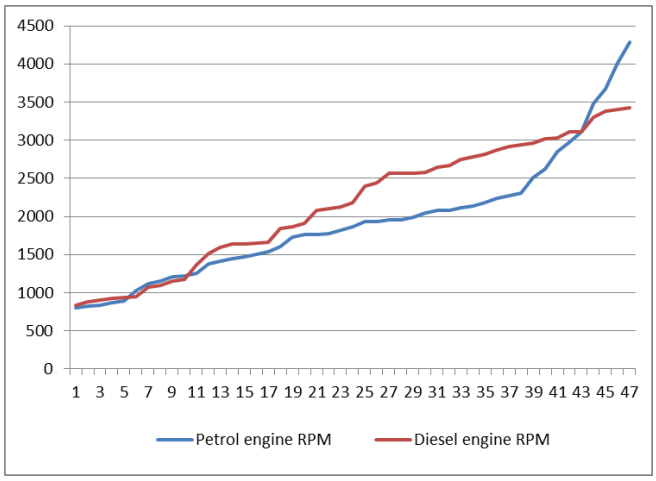

Figure 9. RPM data of the vehicle engines during the experiment.

The presented data and the comparative analysis are a prerequisite for future studies in this direction, as the relationship between the speed, the RPM of the engines and the sound pressure data in the passenger compartment of the vehicles is visible.

IV. Conclusion

The described investigation allows to measure the levels of the sound emitted inside the vehicles in real time situations.

By monitoring the noise in the vehicle, it is possible to determine whether the driver's driving style is relaxed or more aggressive. Moreover, through such monitoring, it is possible to derive analysis in another direction, for example, monitoring the road surface and how it affects the suspension of the car.

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