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COMPARATIVE ANALYSIS OF THE NOISE LEVEL OF AN ELECTRIC VEHICLE ACCORDING TO THE ROAD SURFACE

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Abstract: *The paper reviews one of the methods for measuring external noise from vehicles. An electric vehicle Nissan Leaf 40 kWh was used to perform the tests, and noise measurements were made at different speed and on two types of road surface (smooth and coarse-grained). The obtained data show the difference in the noise level in dBA and the results are shown in graphical and tabular form.*

Keywords: *Vehicle noise, Noise emission, External noise, Road surfaces.*

INTRODUCTION

Vehicle noise is one of the main sources of noise pollution in cities and villages and is one of the main reasons for the deterioration of the health of the population. The increased noise level has a negative effect on the behavior of the driver and passengers. Noise affects central and peripheral nervous system, cardiovascular system, respiratory system, digestive system and endocrine system. (H. Harizanov).

The tread pattern of the tires and the movement of the cars on different road surfaces is one of the main sources of noise in electric vehicles. According to (Bergea Tr 2017) the causes of noise are:

- flickering of the tire's pages due to periodically occurring deformations when rolling;
- periodic displacement and suction of air in the profile channels upon movement (air-pumping);
- the greatest share of the sound energy of the rolling radius is the impact on the profile teeth (blocks) when they enter into contact with the road.

The purpose of this study is to make a comparative analysis of the noise level when driving the same electric vehicle on different road surfaces.

EXPOSITION

The study was performed with an electric vehicle Nissan Leaf 40 KWh shown in fig. 1 with technical characteristics described in table 1. (Technical data of Nissan Leaf 40 KWh)

The setting of the study is in accordance (BDS 12.948-96). Measurement of the external sound shall be carried out in a free sound field in designated areas. The location of the microphones is in accordance with the requirements (Staneva, G., K. Dimitrova, R. Ivanov, G. Kadikyanov 2019).

The sound pressure level was measure twice in one direction. If the difference exceeds 2 - 3 dB, the measurements are repeated. For each octave, the sound pressure level is defined as the arithmetic mean of the measurements.

Fig.1. Examined vehicle – Nissan Leaf 40 KWH

Table 1. Technical characteristics of NISSAN LEAF 40 KWH

Basic technical characteristics	NISSAN LEAF 40 KWH
Acceleration 0-100 km / h	7.9 s
Max. speed	144 km/h
Max. real mileage	230 km
Max. power	110 kW (150 к.с)
Max. torque	320 Nm
Suspension	Front
Capacity of the battery	38 kWh
Tires	215/50 R17

a) б)

Fig. 2. General view of the damaged coarse-grained surface:
a - coarse-grained surface; b - experimental section

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а) б)

Fig. 3. General view of fine-grained surface:
a - flat fine-grained surface; b - experimental section

Experimental studies were performed with a VI-410 [QusetTechnologies]. It is a digital, four-channel device for measurement and analyses of vibrations with channels 1, 2 and 3 using channel 4.

The measuring device VI-410, along with the computing power of its integrated digital signal processor, can perform 1/1 or 1/3 octave and FFT analysis in real time [QusetTechnologies]. The device is equipped with sound calibrator having the possibility to emit waves with sound level 94 or 114 dB at frequency 250 or 1000 Hz (fig. 4) (QusetTechnologies). Before starting to work with the device VI-410 and after finishing the work, it has to be calibrated.

The measurement results transferred to a computer using a USB cable and QuestSuite Professional II software. Through this software it can also be used to save profiles of user-made settings. At the end of each measurement, the data is stored in the memory of the measuring device VI-410. The results can transfer to tables and graphics.

a) b)

Fig.4. Measuring device VI-410 Quest Technologies
a - general view; b - sound calibrator QC-10.

Investigation and results

Fig. 5 and fig. 6 show the variation of the sound pressure level in octave bands, as well as in aggregate value (1st left column) in damaged coarse-grained and flat fine-grained surface at a speed of 50 km / h.

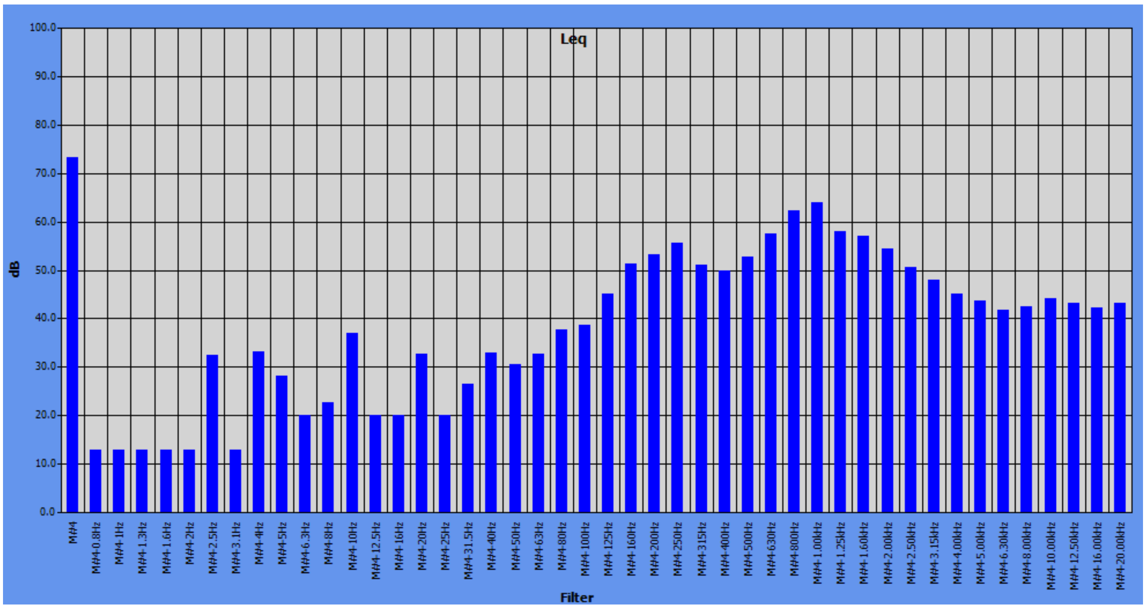

Fig. 5. The change of the level of the external sound in octave bands with a speed of 50 km/h when driving electric vehicle on coarse-grained surface

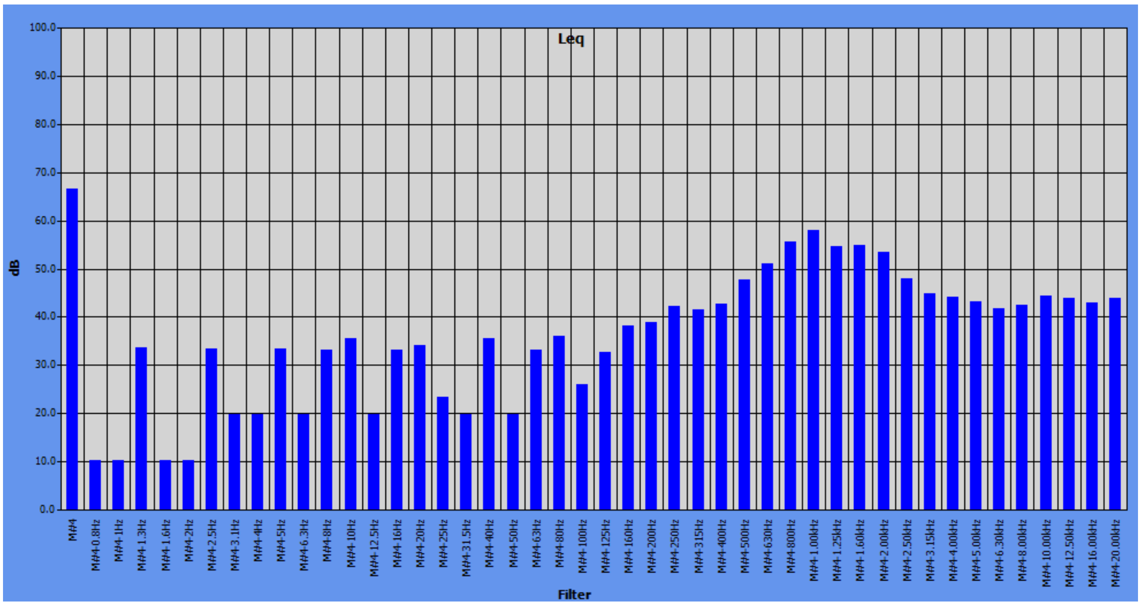

Fig. 6. The change of the level of the external sound in octave bands with a speed of 50 km/h when driving electric vehicle on flat fine-grained surface

In the measurement on coarse-grained surface, the first left column shows a total value and is measured 73.29 dB. The measured noise is high frequency, at 1 kHz it is 63.89 dB.

On flat fine-grained surface, the first left column shows the generalized value and is measured: 66.66 dB, the measured noise is high frequency, at 1 kHz it is 57.92 dB.

The results of the conducted measurements are indicated in table 2 and in fig. 7. The analysis of the given data shows that at: distance 7,5 m from the vehicle and speed 20 km/h on coarse-grained surface the sound level is higher than in comparison with the flat fine-grained one by 4.85 dB; at 50 km/h on coarse-grained surface the sound level is higher than in flat fine-grained surface by 6.63 dB and at 90 km/h the difference is 9.38 dB.

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Table 2 Noise level for different road surfaces

km/h / road surface	20 km/h	50 km/h	90 km/h
Coarse- grained	66,02 dB	73,29 dB	81,69 dB
Flat fine-grained	61.17 dB	66.66 dB	72,31dB
Difference	4,85 dB	6,63 dB	9,38 dB

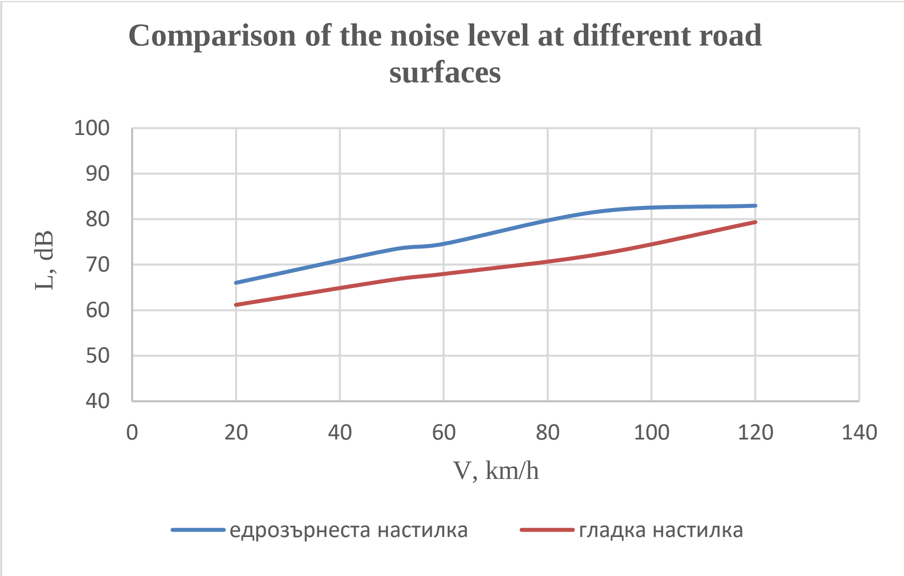

Fig. 7. Comparison noise level at different road surfaces

According to (Milford I., Gspan K. Aasebø, S. and Strömmer K, 2013) the sources of noise from the vehicle are mainly related to transmission's performance and the emission of noise when rolling tires, one of the most effective strategies to reduce the noise level is:

- integration of electric vehicle and hybrid vehicle in public and private transport;
- use of low noise tires;
- traffic on low-noise road surfaces;

To reduce road traffic noise and in particular the tyre/road component, the use of low-noise road surfaces is a well-established technology. Such surfaces can be a thin layer with optimized texture, single or two-layer porous surfaces or dense asphalt road surfaces with maximum chipping size in a range of 4–8 mm. Such surfaces will normally reduce the tyre/road noise in the range of 1–5 dB. Another type of surface is the poroelastic surface (PERS), which can give substantial reduction of noise levels from 8 up to 12 dB. (Bendtsen H. and Stahlfest Hock Skov R., 2015)

The Netherlands has also proposed a labelling system for roads in the same manner as for tyres (A. de Bondt, F. Bijleveld, B. Bobbink, R. Hermsen, M 2017). In addition to noise, a label for rolling resistance, wet skid resistance and life span are parts of the proposed system Except for a few countries, like the Netherlands, low-noise surfaces are still not in widespread use. (U. Sandberg, L. Goubert, K. Biligiri and B. Kalman 2010)

CONCLUSION

This study shows that the noise when driving a vehicle depends on many factors, such as the pattern of the tire tread, elements of the body, but most significantly depends on the type and condition of the road surface and speed.

For the conditions of this experiment, with increasing speed in the range of 20-90 km/h, the noise level increases, respectively, in coarse-grained road surface by about 15 dB, and in flat fine-grained - by about 11 dB.

The difference between the two types of road surface varies from 4.85 dB at 20 km/h to 9.38 dB at 90 km/h, in favor of flat fine-grained.

When analyzing the results at both types of road a higher noise level is reported in the high frequency bands. That proposed that the main noise source is the interaction of tires with the road surface, and not the electric drive motor.

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