Research and analysis of noise emitted by vehicles according to the type of surface roads and driving speed

Marek Rybakowski\textsuperscript{a} · Grzegorz Dudarski\textsuperscript{a} · Edward Kowal\textsuperscript{a}

\textsuperscript{a}University of Zielona Góra, Faculty of Mechanical Engineering, Institute of Safety Engineering and Work Sciences, prof. Z. Szafrana 4, 65-516 Zielona Góra, Poland

**ABSTRACT**

This study deals with examine and assess the noise emitted by the vehicles, depending on the type of road surface and driving speed. Studies have shown that the noise reduction can be achieved by the reduction of the speed of movement of vehicles. The changes to the noise level emitted by passenger car, a commercial vehicle and a truck were also measured. The results give an answer to the question of whether the type of road surface has a significant impact on the noise level of a moving car or it is rather caused by other factors related to the movement of the car at a certain speed. Noise measurements were carried out using a controlled pass-by method (CPB). The results of measurement show significant influence of the type of road surface and driving speed on the noise level.

**Keywords:** Survey • Noise • Motor vehicles • Road surface • Work and life safety

1. Introduction

Traffic noise is today one of the most common hazards of life and work of humans. It is a social problem for many people and their environment. It is a source of discomfort and stress at work [1], after work and during leisure time. Exposure to traffic noise in cities is so common that it is difficult to find a place and time in which we would be outside the emissions of that type of noise.

In the vast majority of vehicles, we can distinguish the following sources of noise: engine, powertrain, tires cooperating with the road surface, the aerodynamic phenomena while driving, the flow of liquids and gases in systems and installations of the vehicle, vibration of other components of the vehicle [2-4]. It is estimated that the most intense source of noise and vibration is not a motor but the cooperation of the wheels with the road surface and the airflow around the vehicle. There are many sources of noise in vehicles and their elimination is quite effective in the design phase of the vehicle. Unfortunately, neither the vehicle manufacturer nor its user has the influence on the type and quality of the road surface.

With the increase in traffic volume there is a problem with noise emission while cars ride on old road surfaces of stone paving. These types of surfaces, often in a very good condition can be found in both urban and rural areas. These are usually historic sections of the road surface that, due to its historical value are not exchanged for less noisy ones.

The aim of this study is to evaluate the noise emitted by motor vehicles, depending on the type of road surface and driving speed. The results give an answer if the type of road surface has a significant impact on the volume of a moving car or rather it is caused by other factors that are directly related to the movement of the car at a given speed.

One way to eliminate traffic noise is to reduce the speed of traffic. This method is mainly used in urban areas, where other methods of reducing the noise propagation are not feasible.

Two questions were the aims of the study. The question of what effects of noise reduction will be achieved by reducing the speed of movement of vehicles and by how much will the noise level change if it is emitted by the passenger car, van and truck depending on the type of road surface.

2. Material and methods

To evaluate the noise conditions, the application has three methods of measurement. The first is the CPX method (called Close Proximity Method), also known as the method
of attachment that takes into account only the noise of rolling tires [5]. Other sound sources of moving vehicle are ignored in this method. All other noise sources are taken into account in SPB method (called Statistical Pass-By Method), in Poland called statistical method of travel or the method of road traffic [6]. Both methods are standardized and widely used around the world. The third is a method of the controlled passage CPB (called Controlled Pass-By method) [7].

The studies used the CPB method, which is called controlled pass-by passage in Poland. It measures the level of sound coming from the tested vehicle that is travelling, fitted with tires of known characteristics. The noise measurement is carried out using a microphone placed on the side of the road at a distance of 7.5 m from the middle of the traffic lane where vehicles are driving. The microphone is mounted on a stand at a height of 1.2 m in relation to a level road surface.

Measurements were performed on selected sections of roads with surfaces:
1. asphalt: bitumen – (Fig. 1);
2. concrete – (Fig. 2);
3. paving stones – (Fig. 3).

For the study, the road sections were selected in such a way that there were no other objects in their environment, which could cause an additional source of noise or screen causing the reflection of the acoustic wave. Weather conditions: air temperature 9 – 10˚C, no wind, no rain, and dry road surface. The air humidity was not measured. In the first part of the examination procedure there was used a car: OPEL Vectra Combi. The study was conducted at two different speeds: 50 and 80 km h⁻¹ on each of the surfaces:
- travel at a constant speed (50 km h⁻¹ - riding on 4th gear, RPM 1600 r min⁻¹; 80 km h⁻¹ – riding in 5th gear, RPM 2000 r min⁻¹);
- drive at neutral gear the vehicle was speeded up earlier to provide the required speed on the measurement section). On the measurement section the car was moving at neutral gear with the uniformly retarded motion. It was set by repeated attempts that the speed of the vehicle could be required at the measuring point, when at the beginning of the measuring section it moves at 50 km h⁻¹ (at 53 km h⁻¹ exactly), while for the 80 km h⁻¹ (84 km h⁻¹ exactly).
Research on the influence driving speed on noise emission was carried out using three types of vehicles: the car OPEL Vectra Combi – a factory vehicle without any modification; van – type ‘BUS’ by RENAULT MASTER brand – a factory vehicle without any modification; heavy goods vehicle by SCANIA brand without trailers - vehicle factory without any modifications. All vehicles selected for the study were fitted with tyres fitted at the factory and in a good condition. The diagram of a research is shown in Figure 4. Portable sound and vibration analyzer SVAN 912 was used for noise measurements. During the measurements there was made the registration of the time charts of noise with A correction and step buffer 0.125 s. This feature allowed the graphical representation of changes in the level of noise while zooming in and out of the vehicle from the point of measurement. At the same time it was measured the frequency analysis of noise in one-third octave frequency bands with a linear correction.

3. Results and discussion

Analysing changes at the level of noise emitted by the vehicle during the passing of the measuring point, there was used the recording of the time course of individual research events. The results of analyzes are shown in Fig. 5 to 8.

The waveforms recorded during the measurement illustrate the variations in noise level at the measuring point. For further analysis there was taken into account the maximum noise level that occurred at the time when the vehicle was passing the measuring point.

The overall level of noise emitted by the vehicle on the tested road surfaces are shown in Table 1.

Noise emitted by the passenger vehicle during the passage was of a low frequency. Changes in the level of noise occurred in the entire frequency band and in particular in the range from 100 Hz to 1600 Hz.

The emission of noise when driving on roads with paving stone is by far the biggest and reaches an average of 82 dB (A) at a speed of 50 km h\(^{-1}\) and 90 dB (A) at a speed of 80 km h\(^{-1}\). When driving on an asphalt surface it was recorded the lowest level of noise – 75 dB (A) at a speed of 50 km h\(^{-1}\) and 82 dB (A) at a speed of 80 km h\(^{-1}\).

Changing speeds (from 50 km h\(^{-1}\) to 80 km h\(^{-1}\)) causes an increase in the noise level at the measuring point. When driving on an asphalt surface it increases by about 7 dB, while on the surface of the paving stones by about 9 dB. No significant difference was observed in the emission of noise when driving in 4th gear and neutral gear. Changing the engine speed does not have a significant impact on the level of noise.

In the next stage it was measured the influence of speeds of cars, vans and trucks on the noise level. The study was performed on the asphalt surface. The obtained measurement results are presented on Fig. 9 – 11.
Figure 5 Noise emitted by passenger vehicle at 50 km h\(^{-1}\) – riding on 4\(^{th}\) gear

Figure 6 Noise emitted by passenger vehicle at 50 km h\(^{-1}\) – riding on neutral gear
Figure 7 Noise emitted by passenger vehicle at 80 km h\(^{-1}\) – riding on 5\(^{th}\) gear

Figure 8 Noise emitted by passenger vehicle at 80 km h\(^{-1}\) – riding on neutral gear

Table 1 Noise emitted by the passenger vehicle under investigated conditions

<table>
<thead>
<tr>
<th>Type of the surface</th>
<th>Noise level (L_{\text{max}}) (dB(A))</th>
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<tbody>
<tr>
<td></td>
<td>50 km h(^{-1})</td>
</tr>
<tr>
<td>Asphalt</td>
<td>Gear</td>
</tr>
<tr>
<td></td>
<td>75.3</td>
</tr>
<tr>
<td>Concrete</td>
<td>Gear</td>
</tr>
<tr>
<td></td>
<td>75.4</td>
</tr>
<tr>
<td>Paving stone</td>
<td>Gear</td>
</tr>
<tr>
<td></td>
<td>81.8</td>
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Figure 9 Comparison of noise emitted by passenger vehicle at 3 different speeds (asphalt surface)

Figure 10 Comparison of noise emitted by the vehicle van at 3 different speeds (asphalt surface)

Figure 11 Comparison of noise emitted by heavy goods vehicle at 3 different speeds (asphalt surface)
The overall level of noise emitted by the tested types of vehicles while driving at different speeds is shown in Fig. 12.

Noise emissions when driving a car increases strongly with increasing speed. At a speed of 40 km h\(^{-1}\) is about 72 dB (A), while at 80 km h\(^{-1}\) almost 82 dB (A). The noise tests of road vehicles using the method of CPB indicate that limiting the speed of the passenger vehicle from 80 km h\(^{-1}\) to 40 km h\(^{-1}\) can reduce noise emissions by approximately 10 dB.

Definitely less impact of speed on noise reduction was observed for the type of delivery vehicles and trucks. A speed limit of vehicles in the same speed range reduces the noise level by about 5 dB, while for the truck by about 0.6 dB.

4. Conclusion

The problem of noise emission by moving vehicles on public roads with different types of surfaces in the literature was undertaken on several occasions. It is obvious that the noise levels of vehicles depend largely on the size and construction of vehicles (cars, trucks, special), traffic volume, speed of vehicle, type and characteristics of the road surface with which tires of different types and manufacturers cooperate [8-10].

An important result of the study is data that allow predicting changes in the level of noise emission by motor vehicles in the case of e.g. changing the surface of the paving stone to asphalt - bitumen surface. The applied research method and the results obtained allow assessing whether a change to a quieter road surface will bring the expected results of noise reduction, or whether restrictions should be imposed at the same time speed.

Reducing the speed can always reduce the level of noise emitted by road vehicles. An alternative method is to change the road surface. Such a treatment will increase the speed of movement of vehicles in areas with high traffic without increasing noise.

The results also allow to determine for what type of vehicles, the introduction of speed limits will bring the best results, while maintaining the required bandwidth for a specific (for appointed research) road surface.

References


