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RESEARCH INTO NOISE EMISSIONS BY A CAR COMBUSTION ENGINE EXHAUST SYSTEM

ABSTRACT

This article presents the results of research into noise emission produced by a car combustion engine exhaust system. Passenger cars were the object of the research. The sound levels in chosen points outside the car were measured. For the purpose of this experiment cars with damage exhaust system were chosen. Measurements were carried out for damaged cars and after the repair. The research was preliminary therefore the evaluation of the influence of damage on noise emissions was qualitative.

Keywords:
noise, car exhaust system, sound spectrum.

INTRODUCTION

The proper car engine operation depends on a number of systems and subsystems. One of these systems is the exhaust system. Its proper functioning has a direct influence on car engine efficiency and car surroundings. The exhaust system can be affected by many noxious agents. Very high temperature of gases and destructive components combustion of gases constitute two of the most important factors which intensify the exhaust system wear. Other factors that fasten this degradation process are water, snow and brine. The location of this system in the car may increase the probability of the mechanical damage. A precise technical condition assessment of the exhaust system requires an organoleptic test, which can be difficult. The preliminary assessment can be made on the basis of the noise emissions. During daily service in the case of special cars, (e.g. military cars) it is the most important to keep cars at full readiness and efficiency.

SOURCES OF NOISE

In the surrounding there are many sources of acoustic vibrations. Every machine, equipment or means of transport have many sources of the acoustic vibrations. Sources of acoustic vibration can by divided into: vibrations of material (mechanical, technological and electrical) and aerodynamic and hydrodynamic sources [4].

Noise of car is an undesirable effect for both: the surrounding and the people inside. There are two main methods of fighting the noise emissions: with law regulations and with engineering methods of active and passive reduction of noise [2, 7]. Noise level emitted by a car especially depends on power transmission system (engine and exhaust system) loudness [9]. There are other systems where many elements are connected with bearings (gearbox). All of them are the sources of noise which intensifies with their damage. The main sources of noise in a car are : the tire noise, the primary inlet and exhaust noise, the noise radiated through the walls of the inlet and exhaust systems, the noise engine vibration, the gear box and transmission noise, the cooling fan noise [1]. A sound level map of engine car operation in a wind tunnel is shown in figure 1.

Fig. 1. Sound level map of engine car operation in a wind tunnel

The function of the car exhaust system: carrying combustion gases to place in car where they can be released to atmosphere, reducing the noise accompanying the combustion gases release and reducing toxic compounds to defined level.

The main elements of the exhaust system include the exhaust manifold, exhaust silencer and exhaust pipe. Nowadays the car exhaust system has got a catalyst with a lambda sensor or a diesel particulate filter.

RESEARCHES

To measure the sound level at work stand with a transport sound level meter with A and C frequency weighting are used. In this research sound level meter SON-50 and a set of octave band filter OF-50 were used.

The range of this research included analyses of the car acoustic characteristics with a damaged exhaust system. The research was made for a standing car with a working engine. Cars with SI and CI engines with different power were tested. Sound levels were measured in some points outside the cars along the exhaust system. The measure points location is presented in figure 2. The sound level meter was fixed on a tripod and set in 10 cm distance from the car contour.

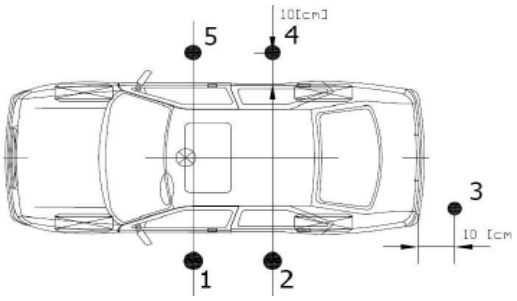

Fig. 2. The location of measure points (1–5 numbers are the measure points)

Before measuring at each point the sound level meter was calibrated. The test were made for a standing car with an engine working on idle run speed at about 800 rpm. All measurements were made for an engine heating up to 70 ºC. The ambient noise was about 55 dB and the difference between turning on and turning off engine was higher than 10 dB.

The sound level measurements were divided into two phases. In first phase the values of: L_{Aeq}, L_{CPK}, L_{AS}, $L_{AS\,max}$, $L_{AS\,min.}$ in each measure point were measured. In the second phase the values of: L_{feq}, L_{fs}, L_{fpk} in each measure point were measured with a sound level meter with an octave band filter in separate frequency bands.

This test was made for a car with damaged exhaust system. Next, the car was checked in service and repaired. After the repair, the car sound levels were measured again in the same conditions and in the measure points. Figure 3 presents the location of the sound level meter in measure points.

a)  b) 

Fig. 3. Location of soun level meter in measure points:
a) measure point 1 (symmetrical to point 5 on the other side); b) measure point 3

ANALYSIS OF RESULTS

Recorded measure results were average. The ambient noise was measured every time and the difference between turning on and turning off engine was higher than 10 dB so the results may not be correct. The results of test for Skoda Fabia car with 1,4 MPI CI engine (183 000 kilometers run) are presented in figures 4, 5, 6. The exhaust system in this car was unsealed and the middle exhaust silencer was damaged. After the repair exhaust system was sealed and the middle exhaust silencer was replaced with a new one. For a detailed analysis was octave band spectrum determined. The results of this analysis are presented in figure 6.

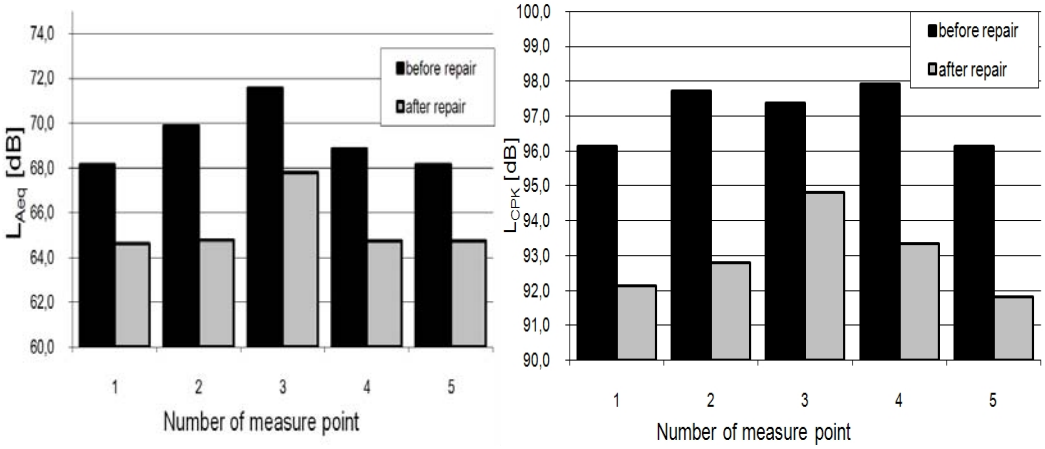

Fig. 4. L_{Aeq} sound level at measure points (A-weighting, equivalent level) and L_{CPK} sound level at measure points (C-weighting, peak value)

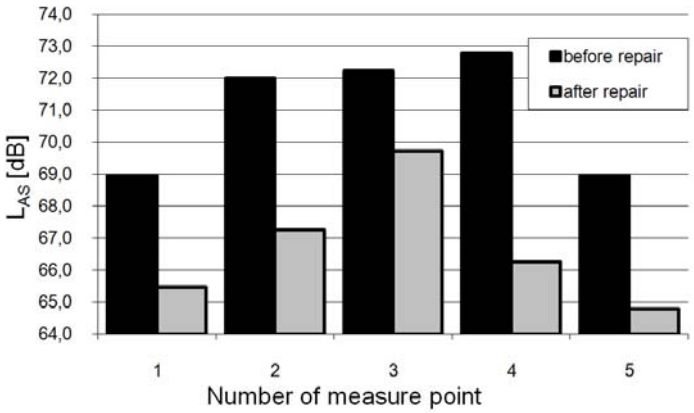

Fig. 5. L_{AS} sound level at measure points (A-weighting, rms value, time-constant SLOW)

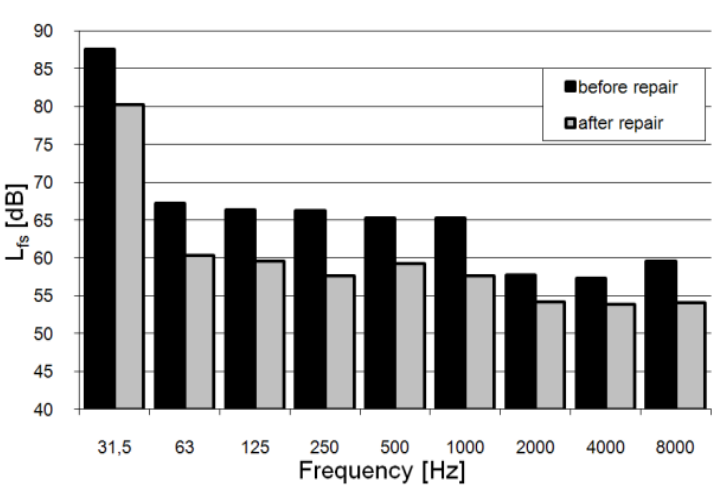

Fig. 6. Octave band spectrum at measure point no 3

CONCLUSIONS

The sound level measured during the research in conditions described by PN-94/N-01307 norm concerning stationary noise. The scope of the research included a group of cars with many different damages of the exhaust system. On the basis of the research results, it can be concluded that the damage of exhaust system increases the sound level of a standing car with the engine turned on. In each case, after the repair of the exhaust system sound level was lower than before the repair.

In this case the highest sound levels were recording at measure points 2, 3 and 4. The location of these points was close to the damaged place (the middle and last exhaust silencer). The noise emitted by a standing car with the engine turned on had lower frequency. The highest sound level in the octave spectrum were at 31,5 Hz middle frequency. The highest differences in the sound levels in the octave spectrum before and after the repair are for low frequency (below 500 Hz).

Due to the complexity of many noise sources and other problems with sound of sound level measurements of a standing car with the engine turned on, the results are compared only for the purpose of the quality assessment. The analysis of the research results indicate the possible frequency bands which can be used in preliminary test of the exhaust system technical conditions.

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BADANIA EMISJI HAŁASU UKŁADU WYLOTOWEGO SILNIKA SPALINOWEGO POJAZDU SAMOCHODOWEGO

STRESZCZENIE

W artykule przedstawiono wyniki wstępnych badań emisji hałasu układu wylotowego silnika spalinowego. Obiektem badań były pojazdy samochodowe. Mierzono poziomy dźwięku w określonych punktach na zewnątrz pojazdu. Do eksperymentów wybrano pojazdy z uszkodzonym układem wylotowym. Pomiary przeprowadzone były w pojazdach w stanie uszkodzonym oraz po wykonanej naprawie. Eksperymenty miały charakter badań wstępnych, dlatego ocena wpływu uszkodzeń na generowany hałas ma wymiar jakościowy.

Słowa kluczowe:

hałas, układ wydechowy silnika, widmo dźwięku.

Recenzent prof. dr hab. inż. Jerzy Merkisz