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NVH APPLICATION RESEARCH USING ACCELEROMETERS ON A CHASSIS DYNAMOMETER

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Abstract

Accelerometric tests, similarly to laser tests (with regard to human health) are something of novelty. All standards related to this issue refer to sound intensity (measured using specialised microphones). The work presents results of accelerometric tests conducted during driving cycles on an inertial load chassis dynamometer Maha LPS3000.

The object of the research was Mazda 3 1.6 (petrol), built in 2010, mileage 70 thousand km. The tests were related to vibration measurements on a chassis dynamometer using various, forced tractive effort (300, 500 and 700 N). No additional signal processing was used (except for operations necessary to create a spectrum) so as to present the whole vibration spectrum with special emphasis on the resonance frequency of human organs.

The article presents vibration amplitude measured at the level of the headrest for three forced tractive efforts: 300, 500 and 700 N. The measurements were made at the speed of 60 km/h in the fourth gear (which corresponds to about 2000 rpm). The obtained results, indicate that the maximum value of harmonics fall in the range 85-95 Hz. Hence, they are resonance frequencies of eyeballs.

In addition to this, one can state that the values of these harmonics are higher for higher values of forced tractive efforts. This would mean that seats should be additionally stabilised (dampened) to limit the influence of dangerous vibration on a human organism.

Keywords: *NVH, LDV, chassis dynamometer*

1. Introduction

Accelerometric tests, similarly to laser tests (with regard to human health) are something of novelty. All standards related to this issue refer to sound intensity (measured using specialised microphones). The work presents results of accelerometric tests conducted during driving cycles on an inertial load chassis dynamometer Maha LPS3000.

The harmfulness of vibroacoustic vibration and generated noise depend on numerous, usually physical, properties of the medium. These properties, or more exactly, mostly measurable parameters encompass spectral value of noise level, its length and character (continuous, interrupted, impulse). They have a direct influence on human health and can result in resonance [1].

2. Subject and scope of research

The object of the research was Mazda 3 1.6 (petrol), built in 2010, mileage 70 thousand km (Fig. 1). The tests were related to vibration measurements on a chassis dynamometer using

various, forced tractive effort (300, 500 and 700 N). No additional signal processing was used (except for operations necessary to create a spectrum) so as to present the whole vibration spectrum with special emphasis on the resonance frequency of human organs (Table 1).

Tab. 1. Sample frequencies of human organs [1, 3, 5]

Human Organ	Frequency of resonance [Hz]
Head	4 – 5
Jaw	6 – 8
Eyes	60 – 90
Chest organs	5 – 9
Upper limbs	3
Stomach organs	4.5 – 10
Bladder	10 – 18
Pelvis	5 - 9
Muscles	13 – 20
Liver	3 - 4

Fig. 1. Object of NVH tests mounted on the chassis dynamometer LPS3000

An original diagnostic system, based on PCB single axis accelerometers and National Instruments data acquisition cards, 9215 type, with a USB connection, was used for the measurements. The most important parameters of the system are as follows [4]:

1. Measurement range ±10 V.
2. 4-multiplex channels.
3. Max. sampling rate 100 kS/s/ch.
4. Resolution 16 bit.
5. Surge protection 60 V DC (earth ground).
6. BNC connection type.

An accelerometer was located between the passenger seat and its headrest, a dielectric waveguide (Fig. 2) on which a sensor was stuck was used.

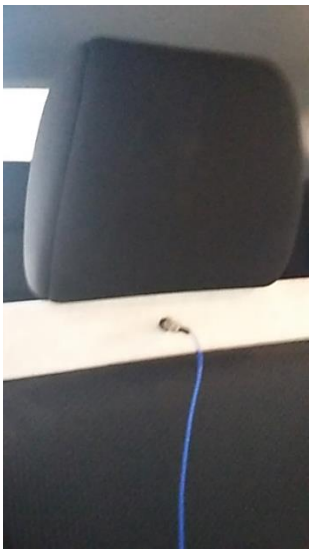

Fig. 2. Accelerometer located on a waveguide (passenger seat)

3. Research results

The figures below (3-5) present vibration amplitude measured at the level of the headrest for three forced tractive efforts: 300, 500 and 700 N. The measurements were made at the speed of 60 km/h in the fourth gear (which corresponds to about 2000 rpm).

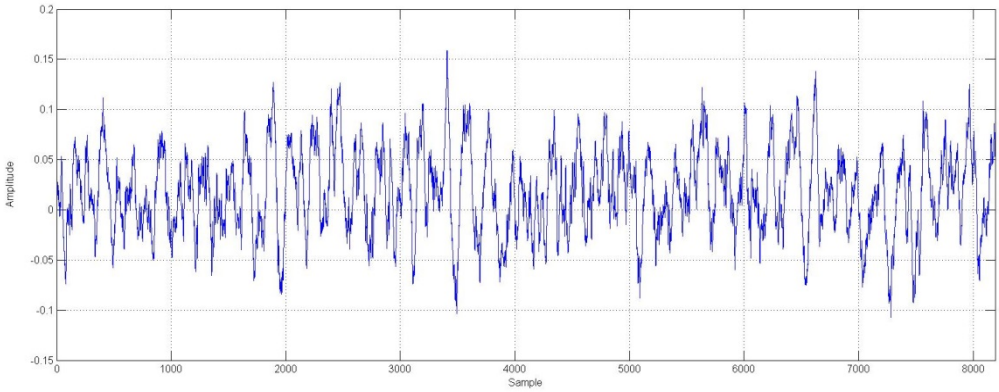

Fig. 3. Vibration measured on the headrest, tractive effort 300 N (4th gear, 60 km/h)

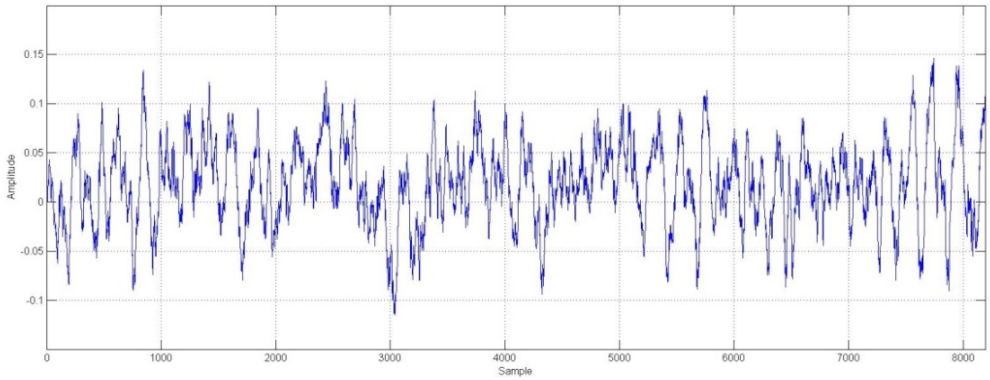

Fig. 4. Vibration measured on the headrest, tractive effort 500 N (4th gear, 60 km/h)

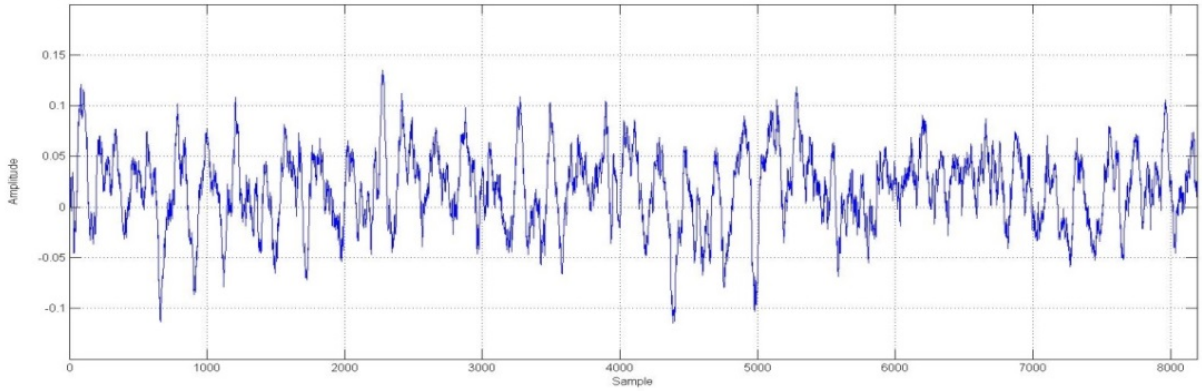

Fig. 5. Vibration measured on the headrest, tractive effort 700 N (4th gear, 60 km/h)

Due to the fact that the maximum resonance frequency of human organs does not exceed 90 HZ [16], a frequency analysis of vibration registered in this range is presented below. Fig. 6 and 7 show the harmonics up to 150 Hz, forced tractive effort 300 and 500 N. The vehicle was driving at 60 km/h (4th gear).

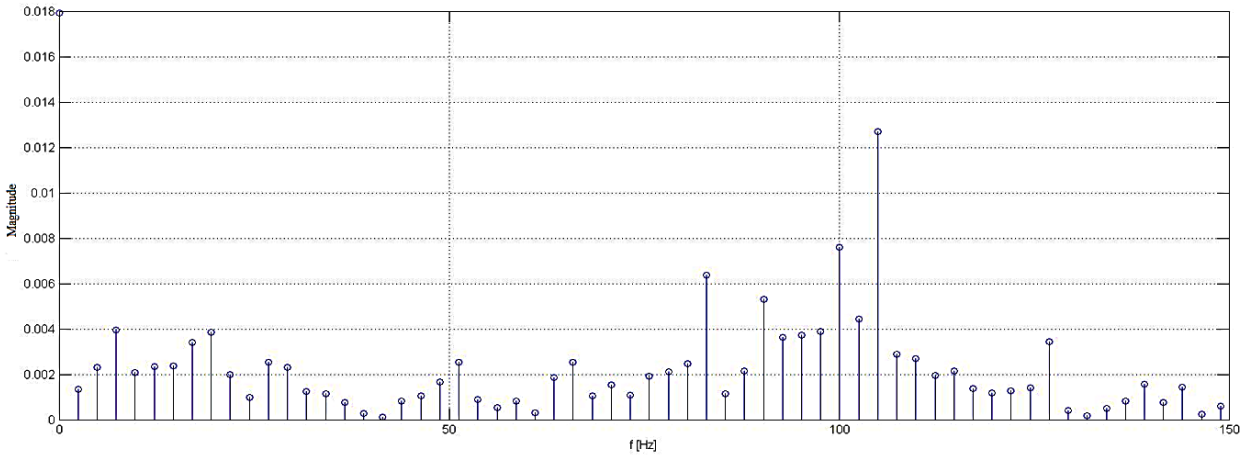

Fig. 6. Vibration spectrum measured on the headrest, tractive effort 300 N (4th gear, 60 km/h)

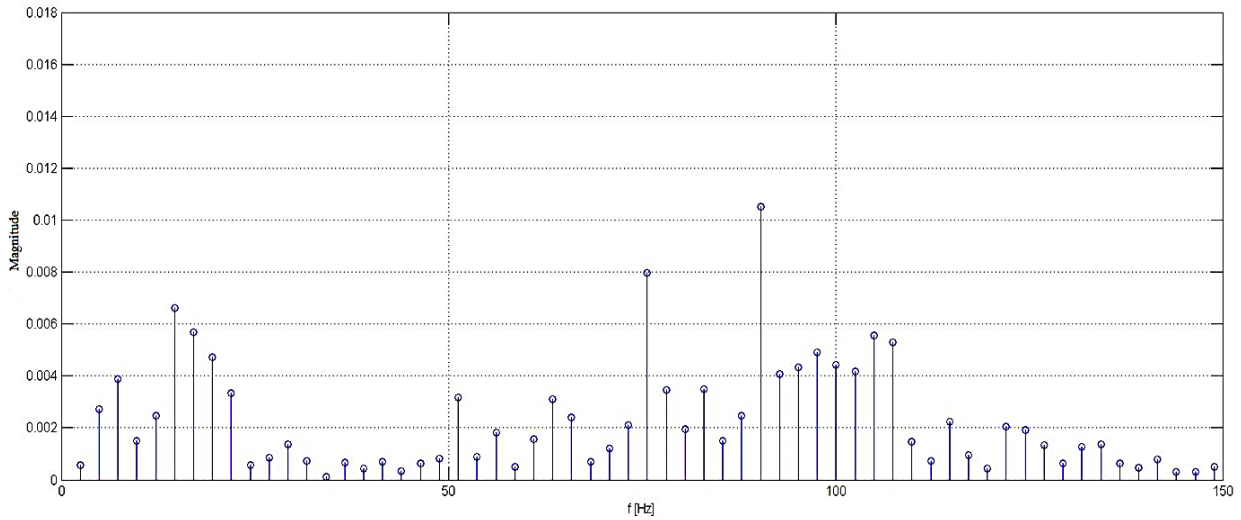

Fig. 7. Vibration spectrum measured on the headrest, tractive effort 500 N (4th gear, 60 km/h)

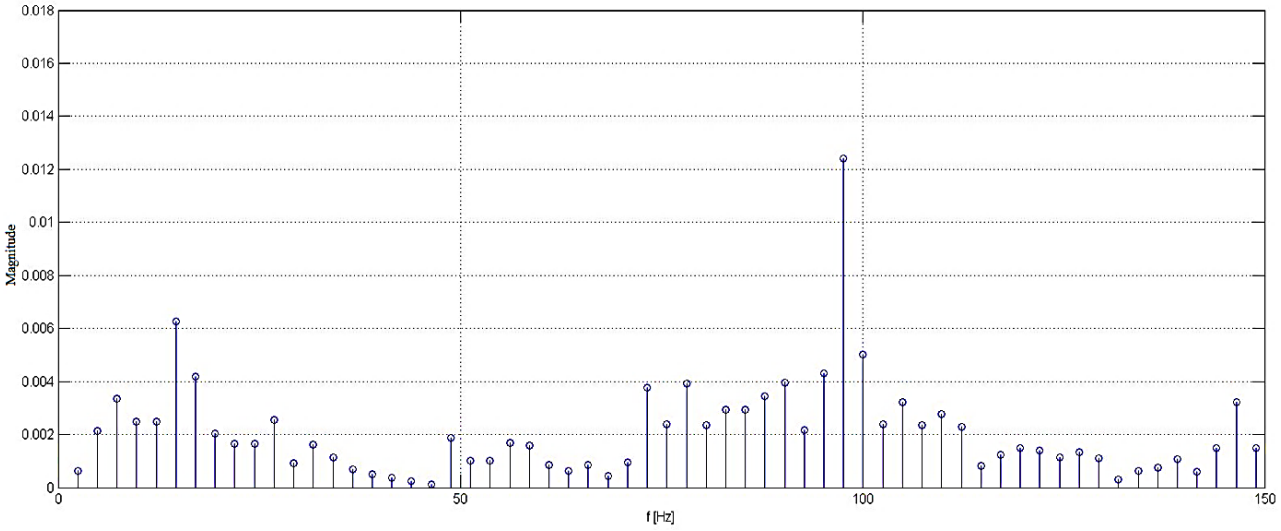

Fig. 8. Vibration spectrum measured on the headrest, tractive effort 700 N (4th gear, 60 km/h)

The above figures allow observing that with no regard to the forced tractive effort, in the vibration spectrum there are harmonics, which are potentially dangerous because they are close to the resonance frequencies of human organs. It becomes particularly clear at the largest used force of 700 N.

The sum of all measured frequency values registered in the range of 0-100 Hz and the maximum values occurring in this range were calculated. The measurement results are presented in Table 2. The obtained results, shown in the table, indicate that the maximum value of harmonics fall in the range 85 – 95 Hz. Hence, they are resonance frequencies of eyeballs. In addition to this, one can state that the values of these harmonics are higher for higher values of forced tractive efforts. This would mean that seats should be additionally stabilised (dampened) to limit the influence of dangerous vibration on a human organism.

Tab. 2. Sum of harmonic values and maximum values occurring in the range of 0 – 100 Hz, for 3 forced tractive efforts (300, 500, 700 N) in a vehicle mounted on the chassis dynamometer

Tractive effort value [N]	Sum of harmonic values in the range	Max. value in the range
300	0.108	0.0076 (at 95 Hz)
500	0.123	0.0181 (at 85 Hz)
700	0.114	0.0184 (at 95 Hz)

4. Conclusions

- We can to observe that with no regard to the forced tractive effort, in the vibration spectrum there are harmonics, which are potentially dangerous because they are close to the resonance frequencies of human organs.
- The obtained results, indicate that the maximum value of harmonics fall in the range 85-95 Hz. Hence, they are resonance frequencies of eyeballs.
- We can state that the values of these harmonics are higher for higher values of forced tractive efforts. This would mean that seats should be additionally stabilised (dampened) to limit the influence of dangerous vibration on a human organism.

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