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EXPOSURE TO VIBRATIONS GENERATED BY THE MOTOR VEHICLE

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Abstract

The article provides a discussion on the studies and analysis of exposure to vibrations generated by the motor vehicle. For the driving safety and comfort it is very important what kind and values of vibration are to car body. As the vibration source the motor-engine was chosen. The experiments were conducted on the car vehicle which was placed on the special test racks. It allows eliminate the road roughens impact on the suspension and in result to car body. The changes of the vibration signals from the motor-engine, floor panel and seat were observed and measured in 3 axes. These vibrations are producing a level of discomfort for driver..

Keywords: *engine vibration, exposure to vibration, vibration propagation*

1. Introduction

The vibrations are inseparable phenomena during operating and driving by all means of transport. Vehicles in motion are forced to vibration mainly by the road [20]. There are many of different vibration sources in vehicles as well. Some of them are main source of vibration during operating but without any movement. The motor engine should be considered as one of the most important vibration generator when the car doesn't drive. For the driving safety and comfort it is very important what kind and values of vibration are transfer to car body and driver. To improve the vibration isolation transferred to car body the identification of all sources of vibration and vibration material propagation should be taken into consideration. Thirty ears ago vehicles constructions were very heavy but than some policy started to demand to make the fuel consumption reduce. This started the evolution in material used in vehicles construction. Currently the car industry faces a crucial weight problem resulting from increasing customer demands in terms of safety and performance. Car bodies contribute 25% to the total weight of a car. Light weight metals are solution to decrease the body in weight. An increasing use of metals such as aluminium and magnesium in the automotive industry shows that there is still large scope for improvements [4,16,18]. It is very important to test new materials in many aspects. One of the more important is to guarantee the founded vibration damping level in terms of safety and comfort.

This paper take into account exposure to vibrations generated by the motor vehicle as the detrimental effect on the safety and comfort in mean of transport. The human response to vibration is depending on the values, frequencies and directions. The driver and passengers exposure to whole-body vibration of the vehicle can affect from short-term body discomfort and inefficient performance to longterm physiological damage.

2. Human perception of vibration in vehicles

Motor engine should be considered as the vibration generator as well. This kind of machine generate a disturbing force of one sort or another, but the frequency of the disturbing force should not be at, or near, a natural frequency of the structure otherwise resonance will occur, with the resulting high amplitudes of vibration and dynamic stresses, and noise and fatigue problems. Rotating machinery such as motors can generate disturbing forces at several different frequencies such as the rotating speed and blade passing frequency. Reciprocating machinery such as compressors and engines can rarely be perfectly balanced, and an exciting force is produced at the rotating speed and at harmonics. There are two basic types of structural vibration: steady-state vibration caused by continually running machines such as engines, air-conditioning plants and generators either within the structure or situated in a neighbouring structure, and transient vibration caused by a short-duration disturbance such as a lorry or train passing over an expansion joint in a road or over a bridge.

Ride comfort is extremely difficult to determine because of the variations in individual sensitivity to vibration. There are some research result published on effects of whole-body vibration and the ride comfort limits [6,9,10]. Some studies on heavy vehicles ride comfort mainly focus on road vehicles running on the ground [8,11]. There are some papers describing how vibration interferes with people's working efficiency, safety and health [1,14,15]. Therefore many researchers have concentrated their efforts on reducing the amount of vibration from vehicles. There are many reports describing the measurement of the transmissibility of the human body under vibration [7,12,13,17]. Some interesting researches were conducted for the low frequency discomfort for human analysed [19]. Ride vibrations are transmitted to the driver buttocks and back by the seat. The floor panel, pedal and steering wheel transmit additional vibrations to the feet and hands of the driver. These vibrations are producing a level of discomfort for driver.

Human perception of vibration is very good. It is a real challenge in structural design to ensure that the perception threshold level is not exceeded. Polish PN-91/N-01354 standard specifies methods for assessing exposure to vibrations of the overall impact on the human body. The parameter value can be used vibration dominant effective weighted vibration acceleration determined from the formula:

$$A_{w\max} = \max\{1.4 \cdot RMS(a_x), 1.4 \cdot RMS(a_y), RMS(a_z)\}, \quad (1)$$

where:
A_{wmax} - vibration dominant effective weighted vibration acceleration,
a_x – acceleration of vibration in X axis,
a_y – acceleration of vibration in Y axis,
a_z – acceleration of vibration in Z axis.

3. Research

Under the studies in question, active experiments were undertaken featuring measurements of vibration accelerations in a three directions in three selected points to analyse propagation of vibration generated by engine to driver feet and back.. It were recorded the vibration in three orthogonal axes (X,Y,Z). The purpose of the research was analysis of the car body vibration generated from motor engine. The experiments were conducted on the car vehicle which was placed on the special test racks. It allows eliminate the road roughens impact on the suspension and in result to car body. The paper presents some results of measurements vibration of motor engine, floor of the car under the driver foots and driver seat. It enables to analyse the way of vibration transfer from the source to driver. Ride vibrations are transmitted to the driver buttocks and back by the seat. The floor panel transmit additional vibrations to the feet of the driver. These vibrations are producing a level of discomfort for driver.

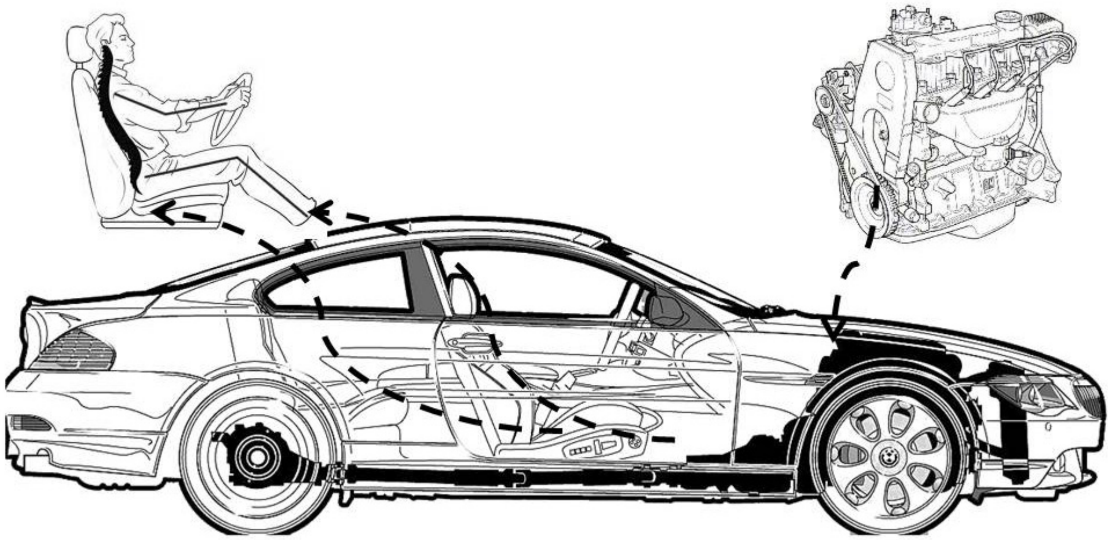

Fig. 1. Measurement of vibration of combustion engine in 3 directions

The established scope of research enables to observe changes of the vibration for chosen points on the vibration propagation way from engine. The three orthogonal axes were analysed separately. The comparison of the acceleration of vibration signals allows determine which directions of the vibration propagation is parent. The proposed methodology allows estimate influence of vibration generated by engine on human perception of vibration. The charts in this section illustrate time realization and spectrums of the vibration signals recorded during the experiments. The figures are grouped by the measurement points and contain vibrations in 3 axes.

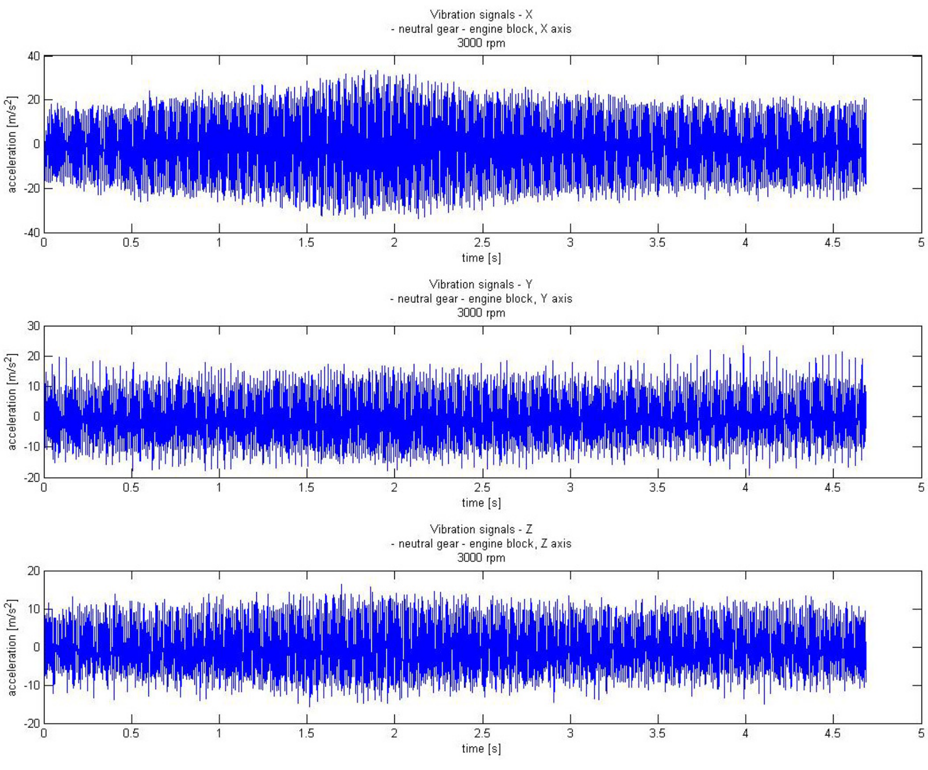

Fig. 2. Engine block vibration signal recorded in 3 axes

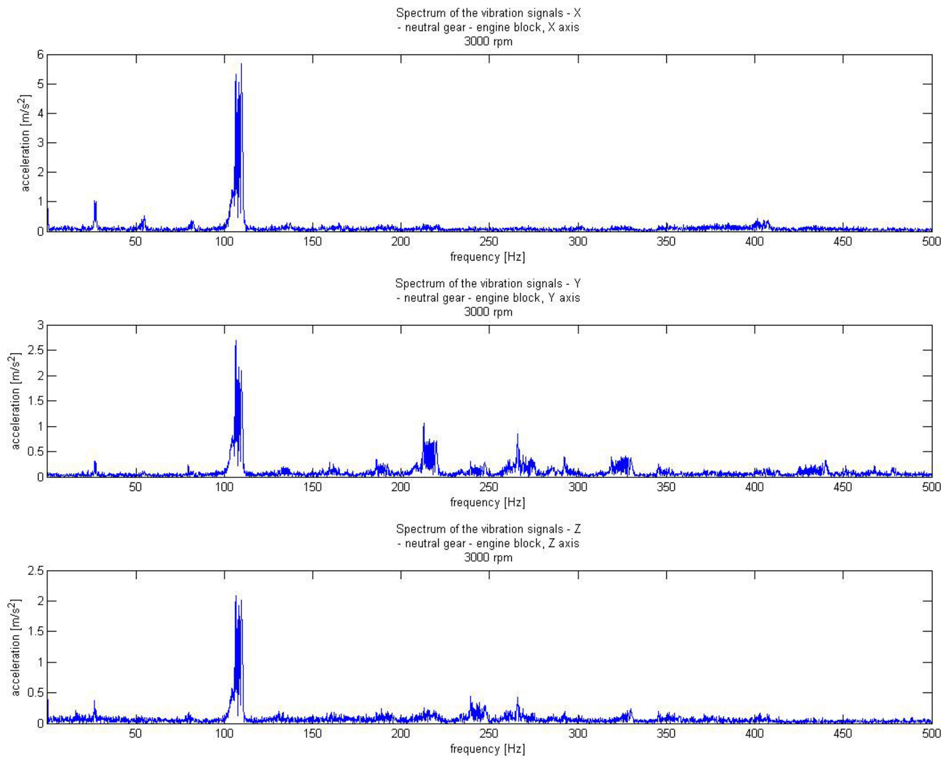

Fig. 3. Spectrums of the engine block vibration signal recorded in 3 axes

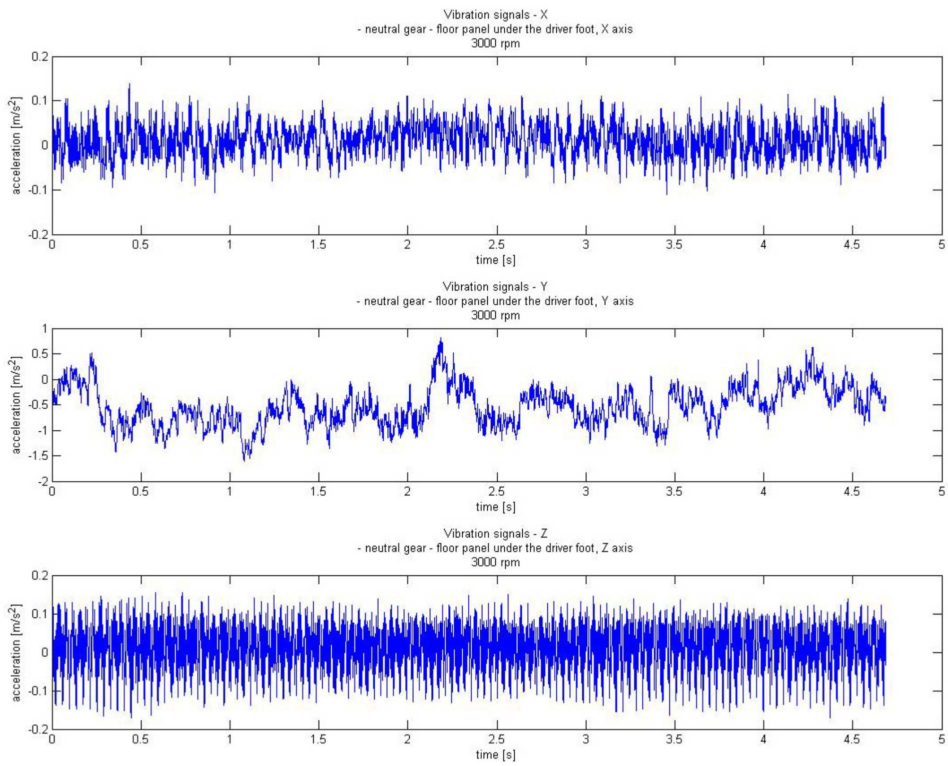

Fig. 4. Floor panel vibration signal recorded in 3 axes

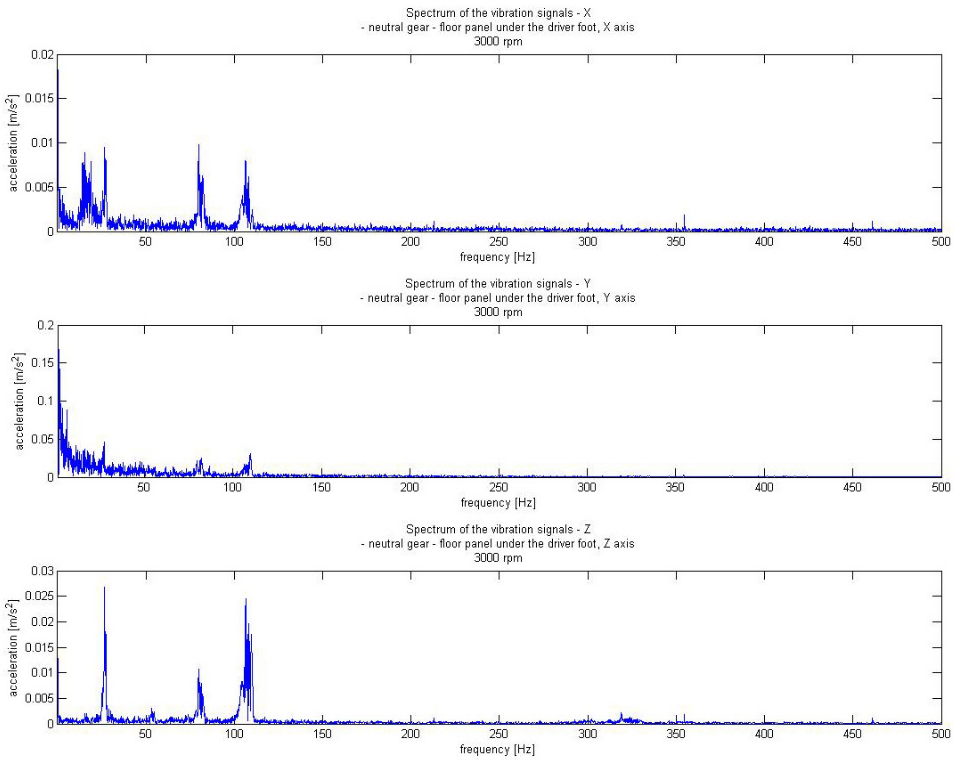

Fig. 5. Spectrums of the floor panel vibration signal recorded in 3 axes

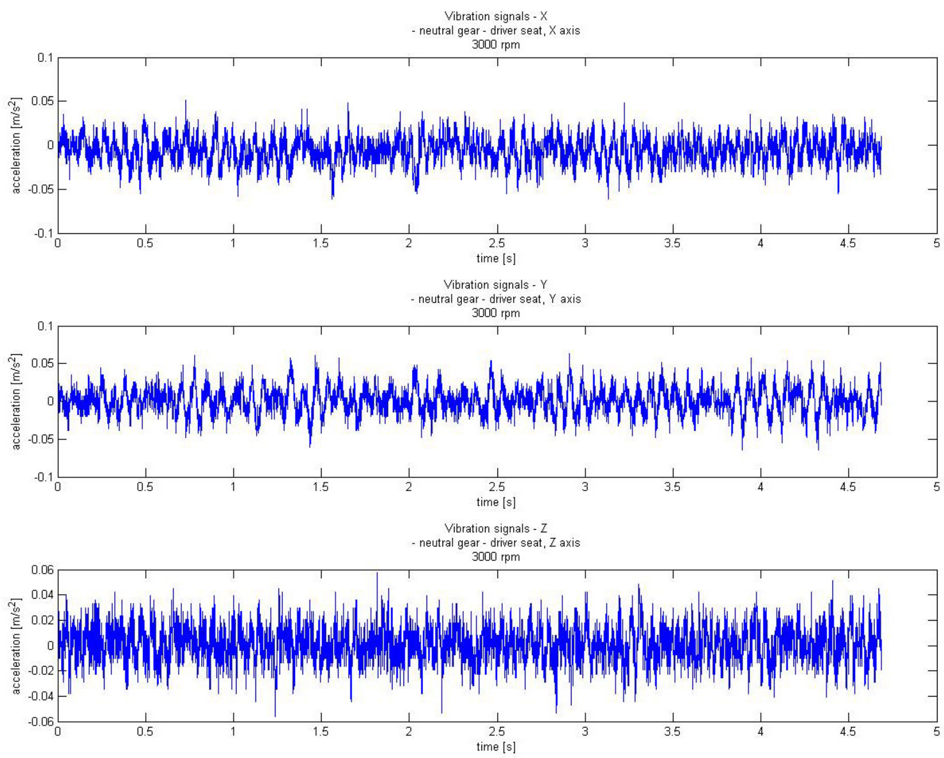

Fig. 6. Driver seat vibration signal recorded in 3 axes

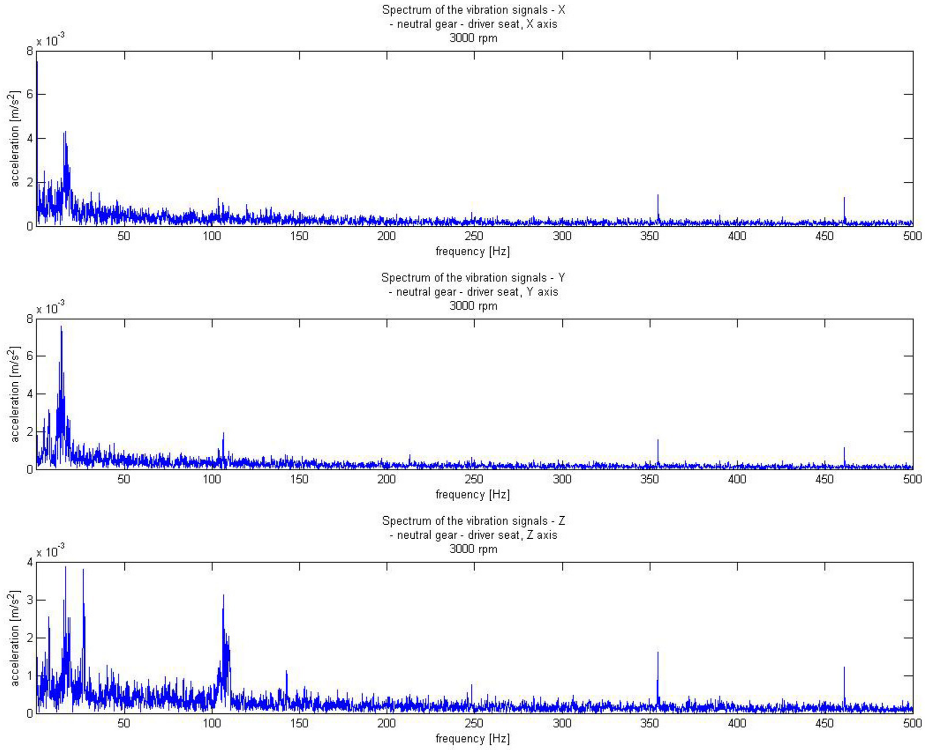

Fig. 7. Spectrums of the driver seat vibration signal recorded in 3 axes

To compare the energy of the vibration signal in orthogonal axes and energy loss during propagation of vibration the root mean square (RMS) was calculated. The results of RMS calculation have been depicted in Fig. 8.

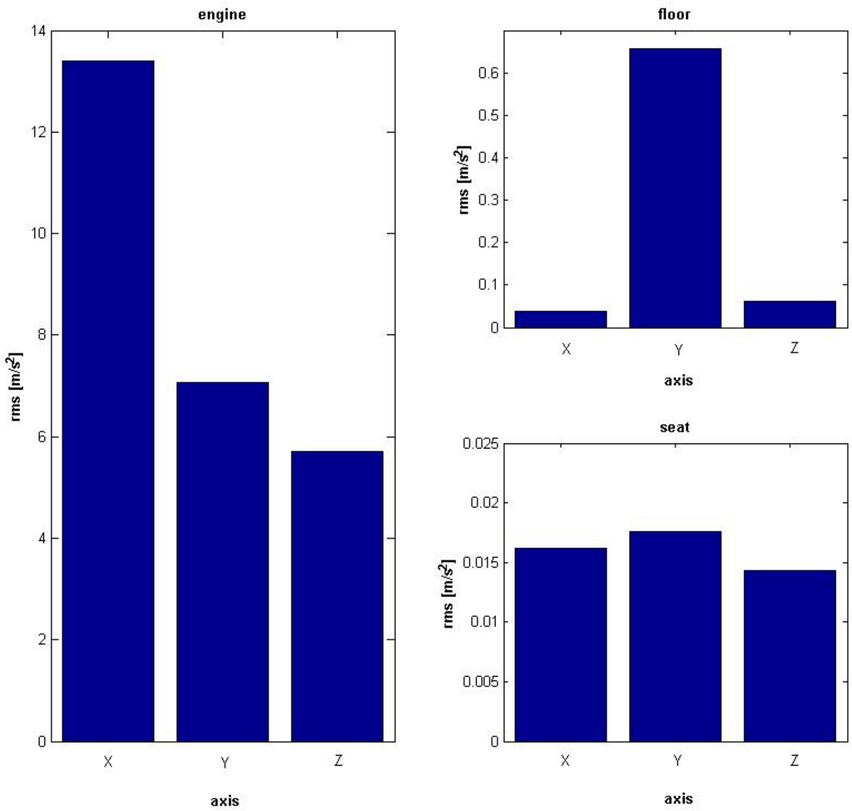

Fig. 8. The RMS values of the vibration in measured points and in 3 axes

This simple signal processing allows calculation of the vibration dominant effective weighted vibration acceleration. This estimator is used for assessing exposure to vibrations of the overall impact on the human body. The results have been depicted in Fig. 9.

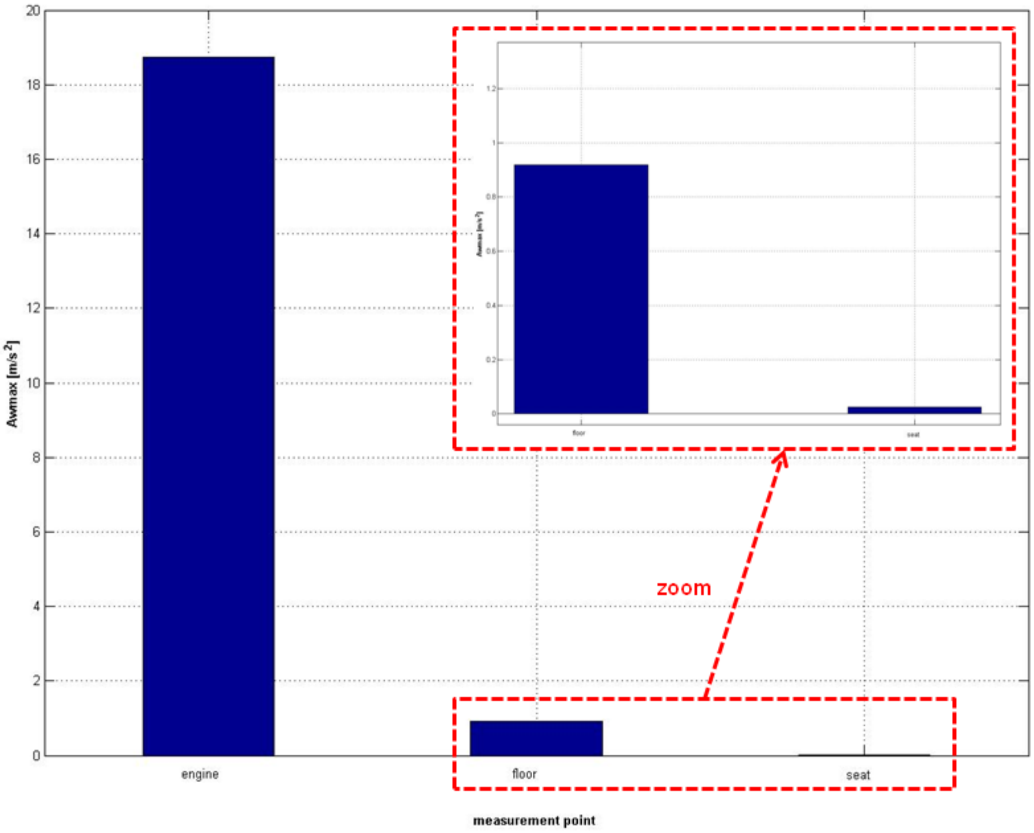

Fig. 9. A_{wmax} vibration dominant effective weighted vibration acceleration for the engine vibration propagation

4. Conclusion

The results of the conducted research allow detail analysing exposure to vibrations generated by the motor vehicle. As it has been presented in Fig. 2 and 3 the vibration of engine block are quasi stationary. The largest acceleration values can be observed for the longitudinal vibration (X axis). It can be effected by the engine mounting elements, which characteristics are mostly designed for vertical displacement preventing. Signals registered on floor panel and the seat have different dynamics structures. It can be observed domination of lower frequencies in the signal. Based on the results of the vibration dominant effective weighted vibration acceleration it can be assumed the vibration generated by the engine are strongly absorbed during the structural propagation and the human exposure to vibrations has small values.

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