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INFLUENCE OF THE VIBRATION ON THE PASSENGERS IN THE MOTOR VEHICLE

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ABSTRACT
During motor vehicle steering various vibrations appear, which are transferred on drivers and passengers through series of elements that form certain chain of connections. Driving presents one subjective perception with large accent on the level of comfort that passengers experience during traveling in the motor vehicle. Motion of the vehicle, that is to say driving, presents one joint product of multiple elements. Contact vibrations, i.e. touch vibrations, that are transferred through the seat to passenger's body, hands and feet are the key factors that are most commonly associated with the driving. The paper gives an overview of basic vibration influence on a human being as a driver and drive quality from the viewpoint of comfort, taking into consideration vertical vibrations of the vehicle, as well as steering wheel and cabin of the vehicle.
Keywords: driving, vibration, comfort

1. INTRODUCTION

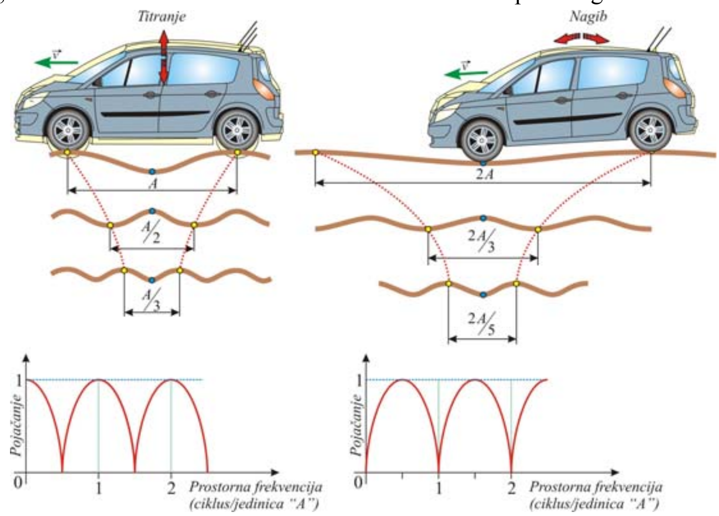
These vibrations can have a harmful influence on the psychomotor abilities of the driver, and thus endanger the safety of the passengers. Besides vibrations that occur during motor vehicle driving, there are also acoustic vibrations, i.e. noise, that influence driving perception. These are very difficult to isolate, since these noise types and levels often correlate with the vibrations of other surrounding vehicles. Besides vibrations (mechanical and acoustic), comfort level can also be influenced by the seat design and its adaptability to passengers, temperature, ventilation, interior area, arm holders, and other factors. Optimization of all these factors can improve the quality of driving. Mechanical and acoustic vibrations as key factors can be measured objectively, while other factors, such as seat comfort, are a matter of subjective assessment of each driver and passenger in the motor vehicle. Interactions between above mentioned factors are not well established. For example, research show that vibration tolerance in the vehicle can be drastically decreased if the space does not allow any body movement, i.e. no physical contact with hard points of the vehicle interior.

2. VERTICAL AND LONGITUDINAL VIBRATIONS

Mechanical vibration analysis very often applies simple quarter vehicle model mechanics, which presents a mistake because it does not describe a complete movement of the rigid bodies that can occur in the motor vehicle. Due to longitudinal wheelbase distance, the same is presented by the multiple entry system that reacts to vehicle slope change and their vertical vibrations. Depending on the conditions of the road and vehicle speed, one or other vibration can be absent. Slope change is very important because it is considered to be inconvenient, and a first source of longitudinal vibrations in places above vehicle's center of mass. Understanding slope change and vehicle vibration during motion is crucial, since their combination determines vertical and longitudinal vibration in any point of the vehicle. During the motion on the rough surface road, rear wheels have the same excitation profile as the front wheels, with little time delay „τ "equal to wheelbase (hereinafter „A"), divided with vehicle speed „$\vec{V}$ ". This time delay acts as an excitement amplitude filter of the vehicle vibration and slope, and is often referred to as „wheelbase filtering". In order to understand the influence of the wheelbase filtering, it is appropriate to note that vehicle has independent modules at vibration and slope change. If we observe a vehicle with two axles, as shown in Picture 1, moving along the rough surface road, we can see that excitation on front wheels, due to surface roughness, subsequently influences rear wheels with interval delay equal to wheelbase divided with the vehicle speed. As the roadway contains rough surface at all wavelengths, the reaction of the vehicle can be tested on individual wavelength.

As Picture 1 shows, vibration excitation appears at a wavelength equal to wheelbase, while slope excitation is shown at a wavelength two times bigger than wheelbase, or at any other short wavelength that has uneven integral multiple equal to double wheelbase.

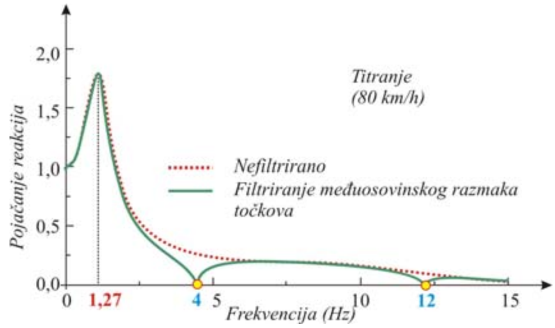
As a consequence, the vehicle will not react to certain wavelengths neither in vibration nor slope change on the roadway with filtration characteristics, as shown in Picture 1. The influence of this filtration is more emphasized in reinforced reaction for a simple vehicle that contains natural frequency of 1,25 Hz on front and rear axis when vibration and slope changes are turned off.



Picture 1: Wheelbase filtering mechanism

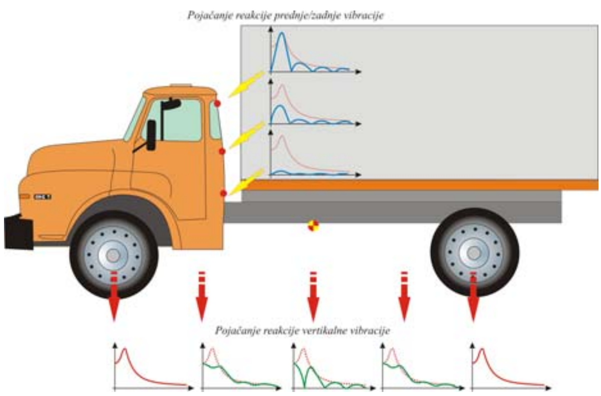
Picture 2 shows diagram of the reaction vertical enhancement on each axle, calculated from the quarter vehicle model. When excitement of the roadway combines with those of rear axle, and delay of front axle, the passenger reaction between the wheels will change due to wheelbase filtering.

If we consider average wheelbase of a sedan vehicle of $A = 2{,}7$ m at $80\ km/h$, zero reaction occurs at approximately $4, 12, 20$ Hz. Based on that, passenger vehicle is going through vertical vibrations during oscillation at high speed, while at low speed zero points are proportionally shifting to lower frequencies.



Picture 2: Influence of the wheelbase filtering on the vibration reaction

Zero frequencies for the same vehicle in slope have values of $8, 16, 24\ \text{Hz}$ etc. Therefore, low slope will exist during driving at normal speed on a highway. Only with lower speed the slope is properly excited by the roadway. Oscillation and slope vibrations with heavy duty vehicles (trucks) are somewhat different because of existence of high resonant frequencies and longer wheelbase. Due to more rigidity, vibration and slope natural frequencies are closer to the values of $2{,}3 \div 3\ \text{Hz}$. With wheelbase in range of $3{,}7 \div 4{,}6\ \text{m}$, opposite behavior occurs at high speed. In fact, vibration reaction will have zero point in resonant frequency, whereas slope reaction will be in full amplitude. Therefore, wheelbase filtering will influence the vibration reaction with large trucks, as shown in Picture 3.



Picture 3: Influence of the wheel base filtering on vertical and longitudinal reaction enhancement of heavy duty vehicle (truck)

3. CONCLUSION

The basic goal of every engineer is to eliminate all vibrations in the vehicle. Nevertheless, this can never be achieved in the vehicle, but it allows more thorough research. Practice proved that if we eliminate one vibration in the vehicle, another inconvenience will appear. A familiar fact of life is that rain (to a lesser or larger extent) is influencing a human mental state. It causes a slight slowing of the daily rhythm, even sleep, while a single drop from the water ''pipe'' can cause great mental burden, i.e. great inconvenience in the still condition. There are also stories that, when driving a motor vehicle is well conducted in a sense of vibration deflection, the clock noise became disturbing. On the other hand, vibration elimination is also unwelcomed, considering the fact that the source of vibrations coming from a roadway presents one of the key information to the driver that he is driving, while complete isolation would cause catastrophic consequences for safe driving. The same event occurs during intensive braking in the motor vehicle with ABS, therefore causing additional vibration on the driver's foot, which can be extremely dangerous in critical situations. Because of it inconveniency, the driver releases brake pedal thinking that something is happening to the vehicle, thus increasing the stopping distance which can cause traffic accident. This instance is more frequent with female drivers. In order to avoid these instances, it is necessary to research the problem and create conditions for its elimination.

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