The comfort of the passengers

R Hasa, T Liedl and J Bucha
Slovak University of Technology in Bratislava, Institute of Transport technology and engineering design, Námestie Slobody 17, Bratislava, Slovakia

E-mail: richard.hasa@stuba.sk

Abstract. A people spending in the vehicles a lot of time. In the Slovak republic is still a lot of roads with damage road surface with holes and cracks. The idea of these paper is about increase driving comfort using additional seat foams. These foams are tested on different road surfaces at the different speed.

1. The measuring vehicle
The vehicle was loan to the Institute of Transport Technology and Engineering Design by VW Slovakia a.s. The VW e-Up! (Figure 1) is a typical city vehicle. Power drive is not the combustion engine, but by the electrical engine. The maximum driving range is around 140 km. The top speed of the vehicle is 135 km / h. At the time of testing the vehicle was 3 years old and the odometer showed around 10 000 km. At the start of each test drive the tire pressure has been checked. Vehicle has been loaded by the mandatory equipment and measuring equipment.

Figure 1. VW e-Up!

2. The measuring equipment
The measuring equipment consisted of 7 accelerometers, 12 V power supply, voltage transducer to 3,3 V, measuring card, notebook and CAN to USB convertor. The 3 axes accelerometer was connected to the network by Ethernet cable. The accelerometer recorded the data only in the Z axis with sampling
frequency 100 Hz [1]. This sampling frequency made possible to create FFT analysis to 50 Hz. According to Figure 2 FFT analysis till 50 Hz is sufficient [2].

![Diagram of human body resonance frequencies]

**Figure 2.** The human body resonance frequencies

The electrical vehicles uses CAN BUS network, such as standard vehicles with combustion engines. Using convertor that is compatible with CAN 2.0 A/B of standard ISO 11 898 data flow thru OBD/OBD II/EOED connector that convert signal from CAN to USB port. In that case was used convertor VECTOR VN1610, that communicates with Matlab-Simulink. The CAN BUS has sampling frequency 1000 Hz, but for lowering of data was sampling frequency changed to 100 Hz.

3. **Sensor position**

Important condition to assembly sensors was to save removability. This condition was fulfilled using fired pistol glue. Increased resistance of sensors was using electrical tape and pulling tapes. First sensor was assembly to left arm of front axle, second was assembly to right arm of front axle, third was in the middle of rear axle, fourth was in the vehicle trunk, fifth was under the front hood on chassis, sixth was on the drivers leg and seventh was on the passenger leg.
Under the vehicle was problem with deployment of cables. In the case of rapid weather change it has to protect sensors of short circuit. After some tests drives was made decision to remove chassis housing. This decision made easier to connect all of the sensors together with computer and cables were easily fixed to the vehicle gear (Figure 4).

The another ends of cables were drag through the rear window. However VW e-Up! has side openable windows and in the winter month was very cold in the interior of vehicle. In that case was used tape to fill all holes among window and cables.

In the interior of the vehicle was everything original. On the rear seats were cables, measuring card and voltage transducer. During the test drives were rear seats downcast to protect measuring equipment from impact of vibrations, acceleration and deceleration. On the rear floor was 12 V power supply and in the middle of front seats was CAN to USB convertor. On the dashboard was notebook connected to measuring card and USB port.
4. Testing roads
All of the testing roads were in Bratislava. The testing roads were consist of the different road surface:

1. the road consist of concrete blocks – 40 km/h, 50 km/h, 60 km/h (Figure 6)
2. standard road surface (Figure 7)
3. car park consist of concrete undulate blocks – 30 km/h, 40 km/h, 50 km/h (Figure 8)
4. the road consist of granite cubes – 40 km/h, 50 km/h, 60 km/h (Figure 9)
Figure 7. The test road No 2

Figure 8. The test road No.3
5. Testing materials
The choosing of seat materials was done in cooperation of Poly, s.r.o company in Žilina, that is member of Eurofoam Group. After discussion was elected 8 types of materials (Figure 10), from 3 main foam groups: Normal, Visco a Cold foams. Each foam has 2 main characteristics, first two numbers in the name of foam are bulk density (kg/m$^3$) and the second group of two are compression resistance (kPa).

6. Conclusion
The results after the processing and the evaluating of the measured data on the all testing road surfaces and testing materials are shown in the graph in Figures 11 and 12. The best properties of tested foams has cold foam R4036. The processing of measured data was done by Matlab. From the measured data
were counted FFT analysis for each kind of foam and each test road at the different speed. From all of FFT analysis were counted abundance of each frequency. These abundance are evaluated and the frequency spectrum from 0 – 20 Hz with lowest abundance given best material for improve passenger comfort. When the values are negative the comfort decrease.

Figure 11. Results for test road No 4, blue – 40 km/h, orange – 50 km/h, grey – 60 km/h

Figure 12. Results for test road No.2

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References
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