DESIGN AND TEST OF A TILTING SEAT FOR IMPROVING CHILDREN'S COMFORT DURING TRAVELING

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Abstract: *Tourism is directly related to passenger transport. For the improvement of quality of transport, thus – tourist services and quality of human life, the road vehicles are constantly developing. The moving speeds are rising and therefore – the accelerations acting on the passengers rise too. As a result - the comfort level drops. During cornering with high speeds lateral accelerations, which are a powerful irritant, causing discomfort, nausea and motion sickness called kinetosis, are generated. Systems for passenger cars tilting, which reduce lateral acceleration, are being used for a long time in railway transport. In automobiles such systems are harder to engineer and that is why they are still in experimental phase. A cheaper option is just tilting the seats in the automobiles. As children are the most vulnerable group of such kind of interference, the authors propose a special construction of a tilting child seat. The seat is designed, built and tested in real road conditions. Results from road and proving ground tests, showing a significant reduction of the lateral acceleration when using a tilting child seat, are shown in the paper.*

Keywords: *Tilting seat, ride comfort, lateral acceleration, travelling*

1. INTRODUCTION

To improve the quality of travelling, vehicles are constantly developing. Vehicles from road, railway, water and air transport are built to be faster and faster. The increase of moving speed is directly related to the consumed energy and thus to harmful emission, emitted during the extraction of energy, necessary to move vehicles and transport people and freights. Therefore a lot of efforts are made to reduce the fuel consumption and the emitted harmful components from vehicles, using a proper set of routes [1], [2], [3], [4], optimal combination of engine and transmission characteristics [5], [6] use of new alternative fuels such as biofuels, hydrogen, oxyhydrogen etc. [7], [8], extraction of energy from renewable energy sources like sun, water, wind etc., which is then transformed into electric energy. Electric vehicle, which are able to easily use it, are evolving. Big attention is paid to the effective and economical use of energy by electric vehicles – for their propulsion [9] and for additional needs [10], [11] such as air conditioning, lights, wipers etc. The energy saving is related to both – pollution reduction and single charge range extension of electric vehicles, which is not only an important indicator but the only obstacle in front of their wide spread, and the shift of the conventional vehicles with internal combustion engines. Rising motion speed is connected not

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only to the increased energy consumption but also to increased accelerations, acting on passengers. Lateral accelerations, generated during cornering, have especially negative influence and cause unpleasant sensations and symptoms of motion sickness in adults with lower threshold of sensitivity and children. The most common and most apparent symptoms are: nausea, vomiting, pallor, cold sweating, headache, general weakness etc. [12].

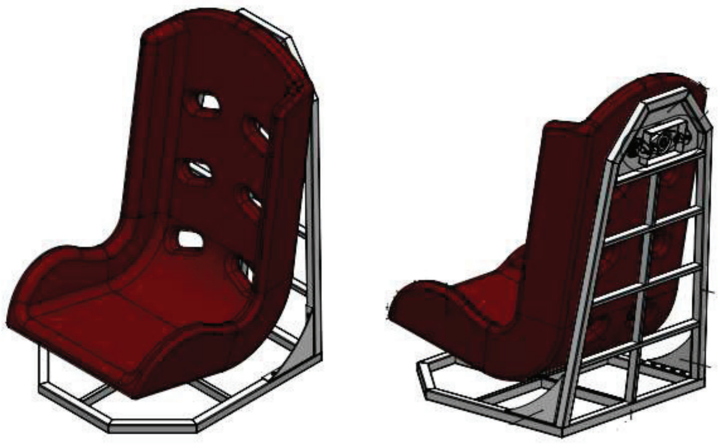
The term: “motion sickness” (or “travel sickness”) was introduced for the first time by J. A. Irwin (1881) [13]. The symptoms are mostly expressed during low frequency motion (under 1Hz) [14] and are most frequently observed in children at the age between 3 and 12 years. Motion sickness or kinetosis is due to conflicting signals from the eyes and the receptors of motion, which enter the brain. Child seats are mounted on the rear seat or on the front seat, facing the motion direction. Thereby the vestibular system gives signals for alteration of the body position but the motion sensors indicate that the body rests – this leads to confusion of the brain, which has to perceive and process the contradictory information. Several methods to decrease the accelerations, acting on passengers, can be used in order to reduce the inconsistencies from the different perceptions. The motion speed of vehicles varies a little during long journeys if we exclude the departure (begin to move) and the stop at the end points. Therefore no large and frequently changing accelerations are present. As roads, depending on their type, have more or less corners, the more frequent accelerations, acting on passengers, are the lateral ones, which, except for changing in magnitude, also change in direction – depending on the corners - left or right. Furthermore, the human body is less adapted to large lateral accelerations, because of its environmental specifics and the everyday activities it performs.

Systems for tilting passenger cars towards the center of rotation are used for a long time in high speed railway vehicles, in order to reduce the centrifugal force influence and to increase the passenger comfort. In automobiles, despite the constructor’s efforts, systems for lateral tilt of the vehicle body are not being used yet – only systems which lessen the tilt in direction, opposite to the center of rotation are present. In order to reduce these impacts and to enhance passenger comfort with children travelling, which are the most vulnerable group, the authors design a special construction of a child seat, which tilts in during cornering.

2. DESIGN OF THE TILTING CHILD SEAT

The idea about the tilting child seat was presented of the authors for the first time in work [15]. It represents child seat, which is mounted to a frame via a hinge joint in its upper end (Fig.1).

Figure 1: Tilting child seat design.

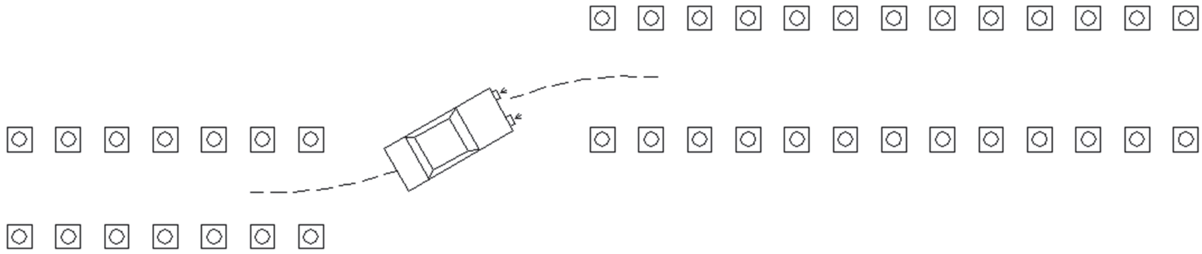


The so mounted child seat is installed on the rear seat of the automobile. The hinge joint is located over the mass center of the child, sitting in the seat. This way, while the automobile is cornering, the centrifugal force acts in the child's mass center and makes the seat with the sitting child tilt around the joint and towards the center of the corner. The lateral accelerations magnitude drops but the accelerations, normal (perpendicular) to the seating plane and to which the human body has lower sensitivity (higher threshold of sensitivity), rise.

3. METHODOLOGY

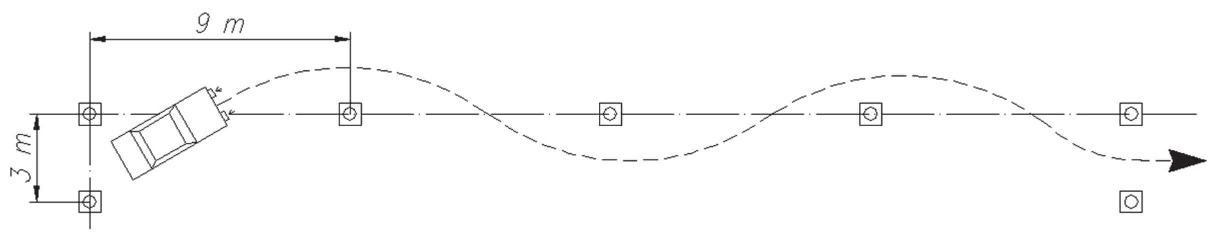
Proving ground and road tests are used in order to analyze the efficiency of the seat proposed over the reduction of the lateral accelerations. The road tests include "Line changing" test with the scheme of the track shown on Fig.2.

Figure 2: "Line changing" test.



The next track for proving ground tests is slalom with cones, placed over 9 meters. The scheme is shown on Fig. 3.

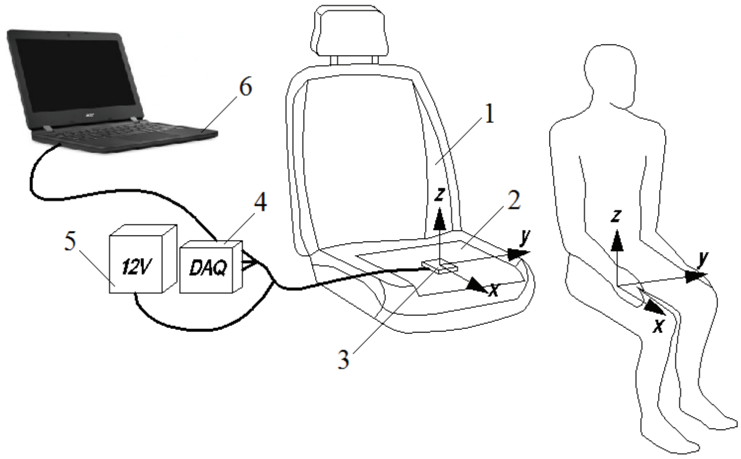
Figure 3: Slalom test.



The third way of testing is movement in a circle with a 5,5m radius.

The road tests are conducted on a mountain road, which has a lot of corners.

Figure 4: Equipment, used to measure the accelerations: 1 – seat, 2 – rigid frame, 3 – three axial accelerometers, 4 – Data acquisition device, 5 – Power supply, 6 – Mobile computer [19].



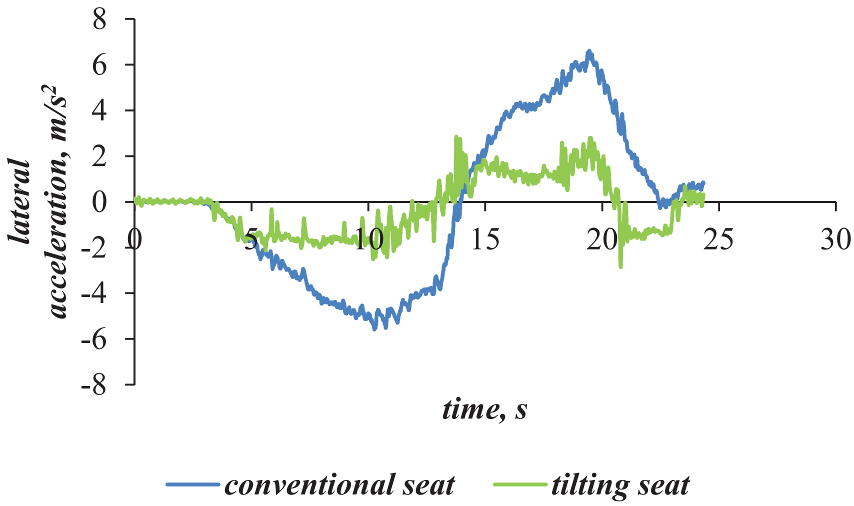
Micro-electromechanical sensors (MEMS) [16], [17], [18] are used in order to define the accelerations. Data Acquisition Device (DAQ) which transforms the MEMS signals for accelerations and sends them to a mobile computer where they are visualized and recorded is used to store the data (Fig.4).

The experiments are not conducted with real children, but with mannequins, especially designed with the proper mass and geometric parameters.

4. RESULTS

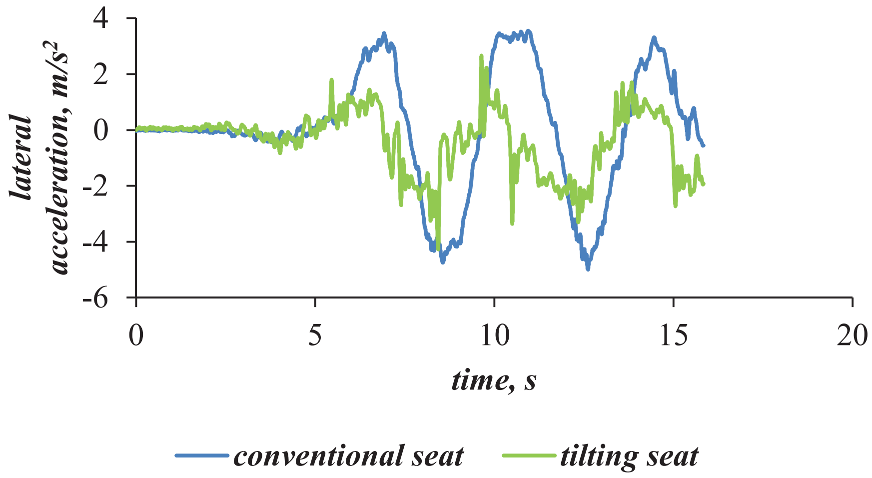
Results from the conducted lane change test are shown on Fig.5.

Figure 5: Lateral acceleration at elk test.



Results from the conducted slalom test with vehicle speed of 20 km/h are shown on Fig.6.

Figure 6: Lateral acceleration at slalom test.



Results from the test with movement in a circle and with vehicle speed of 20 km/h and 30 km/h are shown on Fig. 7 and Fig. 8 respectively.

Figure 7: Movement with 20 km/h in a circle with a radius of 5,5m.

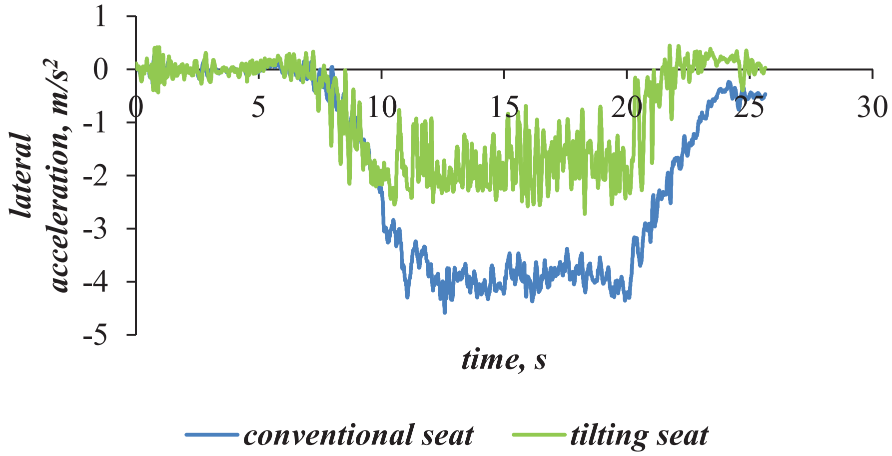


Figure 8: Movement with 30 km/h in a circle with a radius of 5,5m.

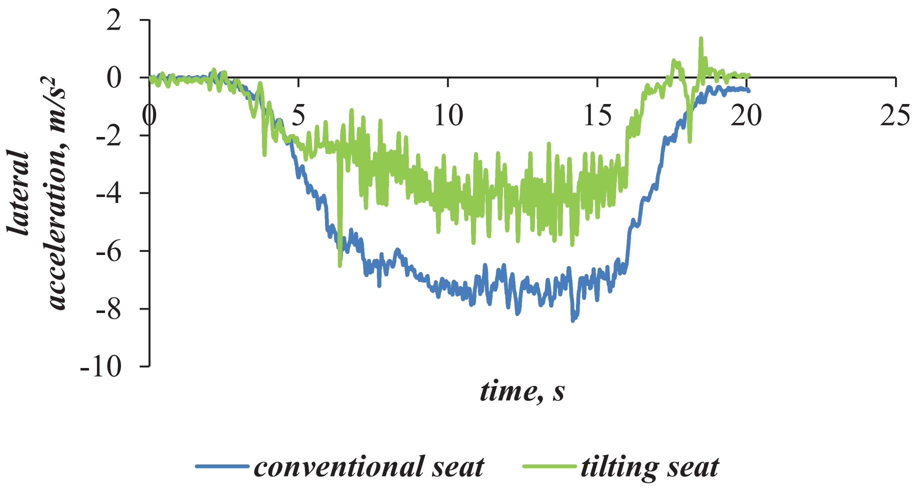
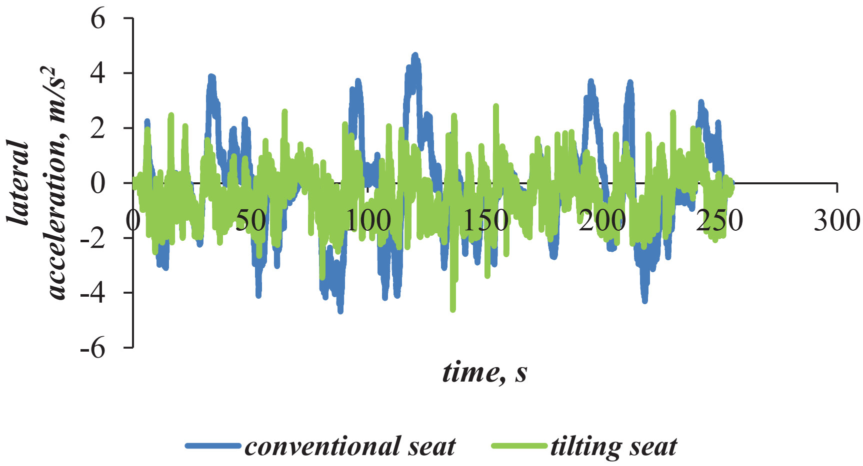
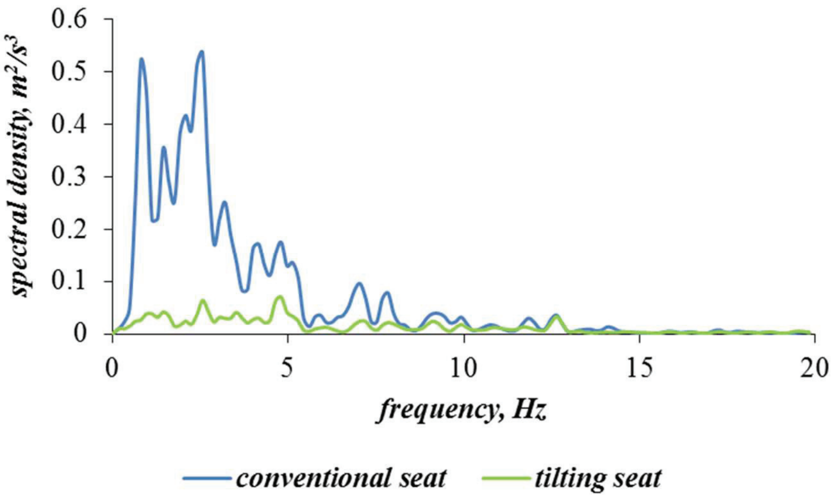


Figure 9: Lateral accelerations of road experiments.



The results for lateral accelerations on a mountain road with a lot of corners are shown on Fig. 9. The spectral densities of the accelerations, which give us information about its energy and intensity with different frequency, are shown on Fig.10.

Figure 10: Spectral density of accelerations in road experiments.



It can be seen on figures 5 to 9, that the lateral accelerations, acting on the child, travelling on a tilting seat, are much lower than the ones, acting on a child, travelling on a conventional seat. Fig. 10 also shows a significant reduction of the intensity of the lateral accelerations in the lower frequencies – the ones from 0 to 1 Hz, which are the ones, causing the unpleasant symptoms of the motion sickness.

5. CONCLUSION

It can be seen from the represented results that the proposed tilting child seat contributes to the reduction of the lateral acceleration, acting on children, during traveling. The reduction is significant – almost two times, compared to the accelerations, generated with conventional child seat. The spectral density of accelerations shows that the low frequency accelerations, which are the main reason (irritant) causing motion sickness symptoms, are the ones reduced most efficiently. These results show that the use of the tilting principle could be successfully used for the comfort improvement in automobile transport. After additional researches and development, the principle could be applied over passive or active seat tilting – separately or for the whole row of seats for buses, transporting children – school buses, tourist buses etc. Thus reduction of cases of nausea and vomiting for travelling children and an increase in the comfort could be achieved. In this way cases of vehicle stop because of nausea of children will be limited. The time for travelling will be reduced because the tilting seats will permit higher speeds in corners without the discomfort for the passengers. This will lead to the improvement of transport and tourist services.

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