Cam Mechanism for Car Seat Testing

P. Srb, P. Kulhavy, V. Fliegel and P. Lepsik

Abstract This paper deals with optimization of a device designed for long-term dynamic testing of car seats. This kind of tests is important for car seat innovation with respect to improving safety and comfort of passengers. This type of testing is based on linear periodic movement of a car seat cushion on which a weight representing a passenger is placed. Movement of seat is generated by a cam mechanism. Several cam profiles were proposed by a computational software, in order to achieve acceleration occurring during a real car driving. Based on this information concept of the whole device was proposed. Thereafter the static and dynamic FEM analysis were carried out. Finally an optimization of the cam mechanism and the whole device was accomplished in order to achieve the best compromise of conflicting requirements of large acceleration at low frequencies.

Keywords Cam · Mechanism · Car seat · Cushion

1 Introduction

Testing of automobile seats and their parts is very important for increasing safety and comfort of passengers, but also for development of new design solutions. Evaluating of car seat comfort is a very complex issue because of great individual personal differences, like body structure, road conditions etc. Other important perceptions include visibility from the car, reachability of controls, vibrations, noise, temperature, humidity etc.

Among all these factors there are vibrations, one of the most important factors affecting the overall assessment of comfort and related safety. The whole body vibration (WBV) [1] manifests itself when a support of human body forms vibrant surfaces. The passenger sitting on a car seat is a typical example of the WBV

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exposure. The vibrations are transmitted to the torso through the seat and the backrest, to hands through the steering wheel and to legs through the car floor [2].

Good automobile car seats should provide particular support to passengers under all driving conditions and reduce vibration transmission from the car to human the body. Although the tolerance of the same level of vibration is individual for each, it turns significant increase of sensitivity in the frequency range 2–10 Hz [3] which corresponds to the natural frequencies of the vital organs, higher frequencies have a negative impact on the nervous system. The exposure of a human body to such vibration is contrary to the sense of comfort of the passengers, and negatively affects the concentration which is closely connected with safety. For these reasons design a car seat so as to provide comfort and safety parameters in sufficient amount for its entire lifetime is very important. Therefore, it is necessary to carry out endurance tests. However, to make this kind of tests in real conditions and with the entire car is expensive and very time consuming.

A testing device that will simulate real traffic loads is appropriate to create for these tests. These devices can operate continuously for long time and thus simulate loading of a car or its parts in less time.

2 Testing Device

The prototype testing device [4] (Fig. 1) was designed and built in cooperation with an international company producing car seats.

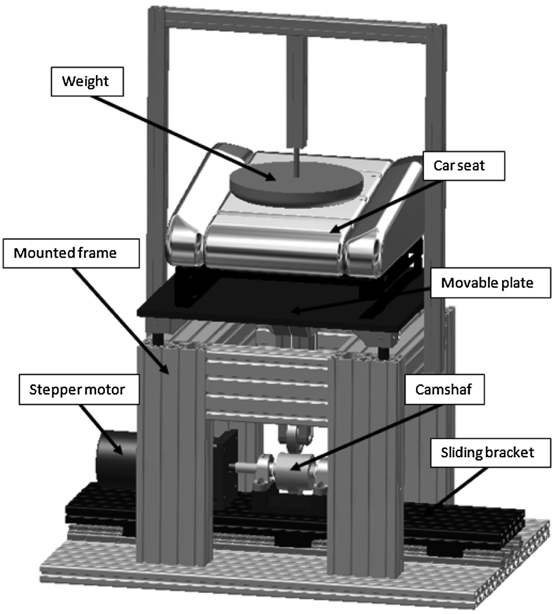


Fig. 1 First concept of testing device

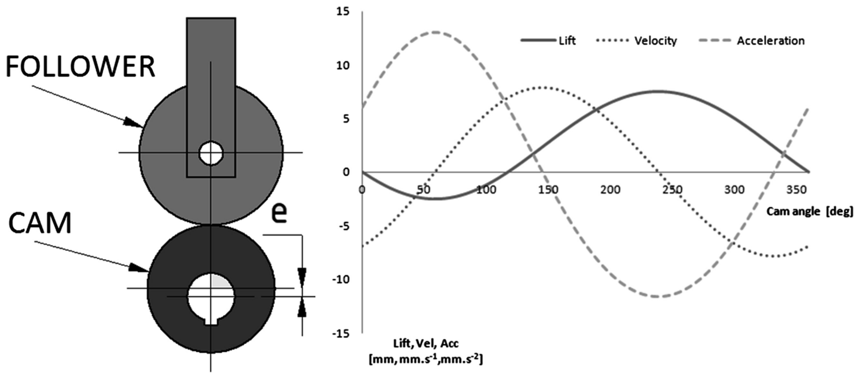


Fig. 2 Cam mechanism and lift, velocity and acceleration curves

A mounted frame made of aluminum profiles is the base part. On a base plate a sliding bracket is placed. On the sliding bracket an electric step motor is fastened which is connected to a camshaft module by a flexible coupling. The camshaft module contains three changeable eccentric cams. Into the frame a movable plate is inserted which is guided in four points. In the middle of the plate a support with a roller cam follower is placed which transfers rotation of the camshaft to reciprocating movement of the plate. On the plate a whole seat or a sample of polyurethane foam can be mounted. Additional weights representing the passenger load are placed on seat. During test it is possible to record position or acceleration of the seat frame and weights. An eccentric cam with diameter 80 mm and a rotating follower with diameter 90 mm were used in the first version. The eccentricities were 1, 2.5 and 5 mm, curves are shown in Fig. 2. To prevent bouncing of the follower from the cam the device was operated up to 120 rpm.

3 New Cam Designs

Later, the design requirements on the process of vibrations were defined more precisely: achieving pulses of acceleration 25 ms^{-2} with frequency of repetition 1–5 Hz. After considering several possibilities it was determined that for acceleration 25 ms^{-2} at the frequency 1 Hz a cam with diameter of hundreds mm is required and the whole device would be too heavy on a real engine power. For these reasons the requirements were revised and a compromise solution was proposed that there would be used three cams for three frequency bands. In this solution the initially required acceleration 25 ms^{-2} is achieved only at the frequency 15 Hz, but the requirements on the size of the device and engine power are acceptable [4].

The detailed design of the cam mechanism was made using a Design Accelerator which is integrated in the software Autodesk Inventor Professional 2015. The course of acceleration was chosen so that there will be two pulses of positive

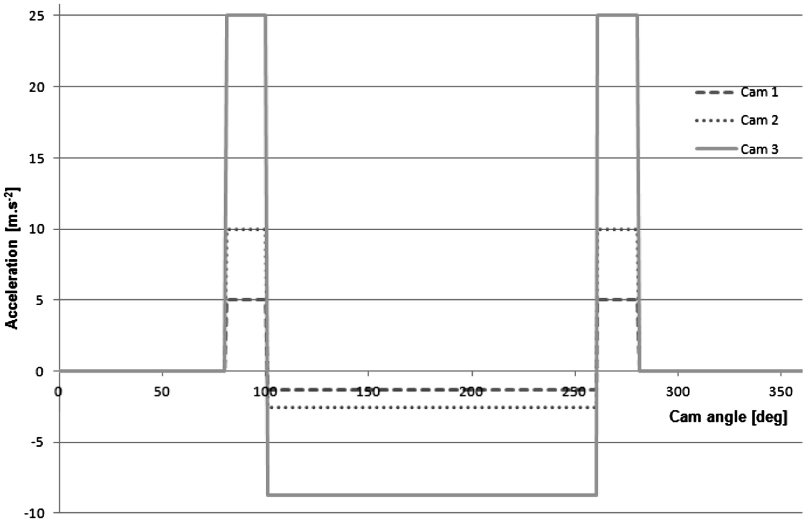


Fig. 3 Acceleration curves of new cams [4]

acceleration during one rotation of the cam, that are symmetrically distributed by 180° rotation of the cam as shown in Fig. 3.

From the viewpoint of force ratios on the whole structure the tangential force component on the follower is the most important. In Fig. 4 a force situation is shown where G is an action force from weight, N and T are component forces, angle φ is given by the shape of the cam and depends on the cam angle ψ.

The course of the tangential force T on the largest (the most unfavorable cam) is shown in the following graph Fig. 5.

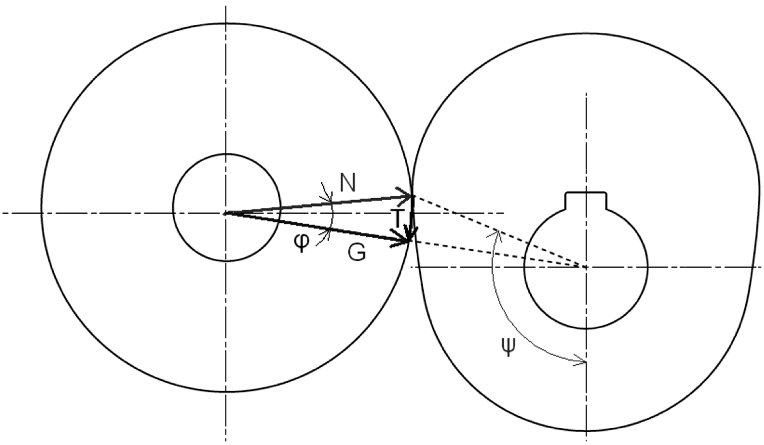


Fig. 4 Forces on cam mechanism

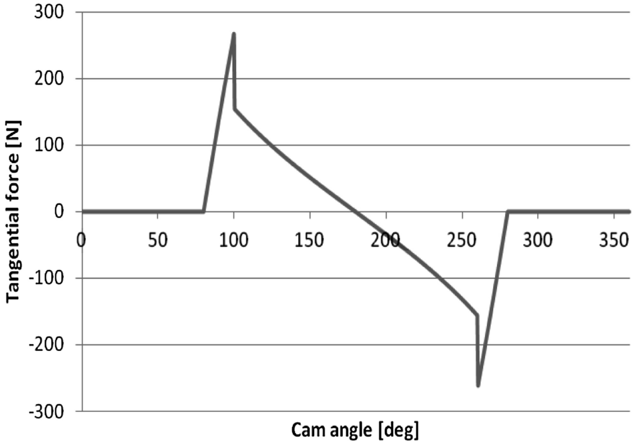
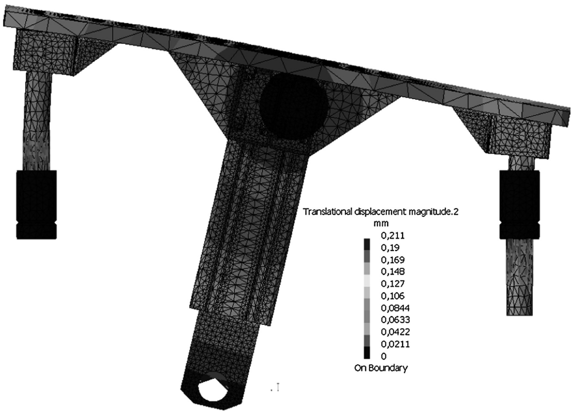


Fig. 5 Course of the tangential force

4 FEM Simulations

The simulations were performed in software CATIA V5. Guiding bearings were fixed and between bearings and guiding rods a frictionless contact was applied. The center of the top plate was constrained by a vertical movement. On the center of the follower a force was applied 300 N in the tangential direction and 1200 N in the vertical direction. The design was optimized after a first draft simulation where the values of deformation were unacceptable. The second simulation (Fig. 6) shows much better results, the maximal stress was 16 MPa and deformation was 0.2 mm on the holder of follower.

Fig. 6 Result of simulation



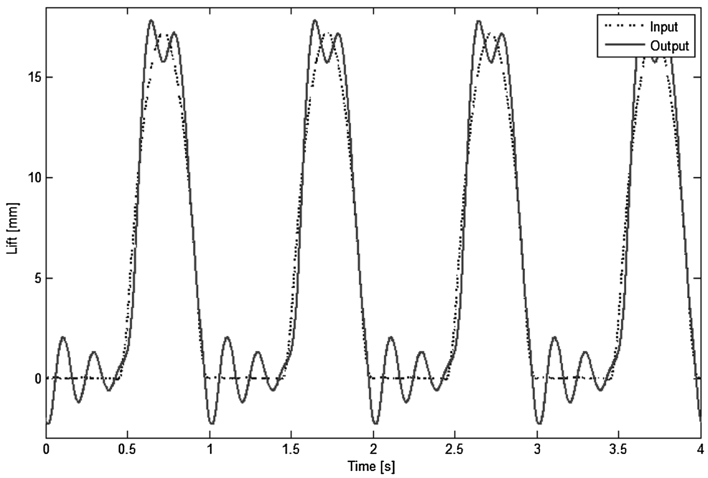


Fig. 7 Example of recorded data

5 Conclusions

The device for durability testing of automobile seats was optimized for increasing of stiffness of structure based on the FEM simulations. The new cam mechanism was designed by software Inventor. On Fig. 7 an example of measured values is shown where the dotted line represents the course of lifting of the car seat and the full line represents horizontal movement of the weights placed on the seat.

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