Vibration Device for Long-Term Testing of Car Seats

P. Srb and V. Fliegel

Abstract Testing of automobiles is important for increasing safety and passengers' comfort. The device is designed to simulate the load of a seat during a car ride under different conditions. The device can work continuously for several days unattended. Long-term testing is useful to obtain knowledge about wear-out particularly of the comfort layer and other parts of the seat. Electric step motor and cam mechanism were used to create the vibrations.

Keywords Automobile seats · Vibrations · Long-term testing · Cam mechanism

1 Introduction

The design for the vibration testing device was commenced due to the need for long-term testing of car seats in proseat company. There were following initial requirements.

On the seat there should be placed an indentor and relevantly substantial weight oscillated by required frequency. For example, an electric motor with eccentric flywheel is used for the oscillating; it is also used as a part of the weight. The device must allow the seat to clamp with a backrest; the backrest shall not touch the indentor or other device components during the test.

Since there are interferences of various oscillations during the test, it is desirable that the frame of the device should be relatively robust. The test consists of

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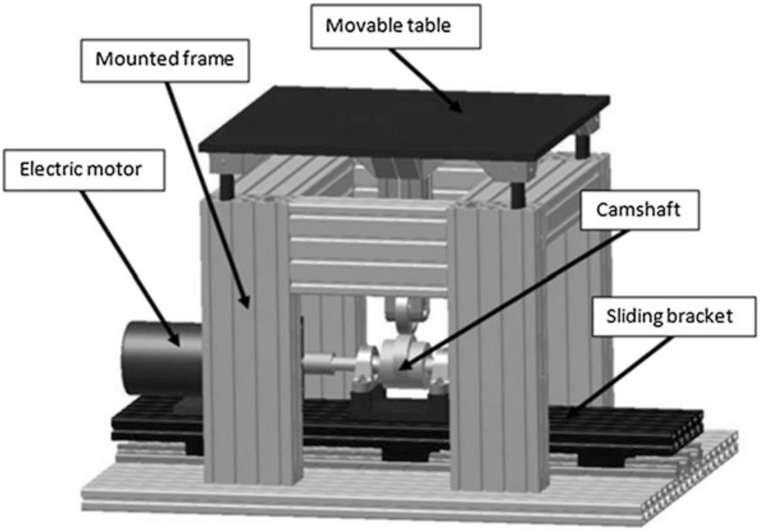


Fig. 1 First concept of vibration device

sections with different frequencies e.g. 5,000 × 0.5 Hz + 20,000 × 2 Hz + 40,000 × 5 Hz, pulse frequency does not have to be kept accurately (±20 %), it is desirable that the device can work continuously for several days, frequency rearrangement does not have to be automatic, but it would be an advantage. The device should not make impossible later equipment of scanning the current position of the indentor, that would extend the use of the device for different types of tests.

2 Description of the First Concept

The first concept of the vibration device is shown in Fig. 1. Main part is a mounted frame made of aluminium profiles (Item 2007). On a base plate is placed a sliding bracket. On the sliding bracket is fastened an electric step motor which is connected to a camshaft module by flexible coupling. The camshaft module contains three changeable cams. Into the frame is inserted a movable table which is secured in four points. In the middle of the table is placed a support with a roller cam follower which transfers rotation of the camshaft to reciprocating move of the table.

Table 1 Revolutions and acceleration for each cam

	Frequency (Hz)	Revolutions (rpm)	Maximal acceleration (ms^{-2})
Cam 1	1	30	0, 6
	2	60	2, 2
	3	90	5
Cam 2	4	120	3, 3
	5	150	5, 2
	6	180	7, 5
	7	210	10
	8	240	7, 1
Cam 3	9	270	9
	10	300	11
	11	330	13, 4
	12	360	16
	13	390	18, 8
	14	420	21, 8
	15	450	25

3 Camshaft Design

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

The detailed design of the cam mechanism was made using a design accelerator which is integrated in the software Autodesk Inventor Professional 2012.

The course of acceleration was chosen so that there will be two pulses of positive acceleration during one rotation of the cam symmetrically distributed after 180° rotation of the cam as shown in Fig. 2.

There were designed three cams for nominal values of acceleration 5, 10 and 25 ms^{-2}, with diameter of the base circle 80 mm and for diameter of the roller follower 90 mm. For a strength check it was calculated with accelerating weight 80 kg. The cams and the camshaft shown in Fig. 3 were designed so that they could be changed easily e.g. due to changes in the required characteristics of acceleration.

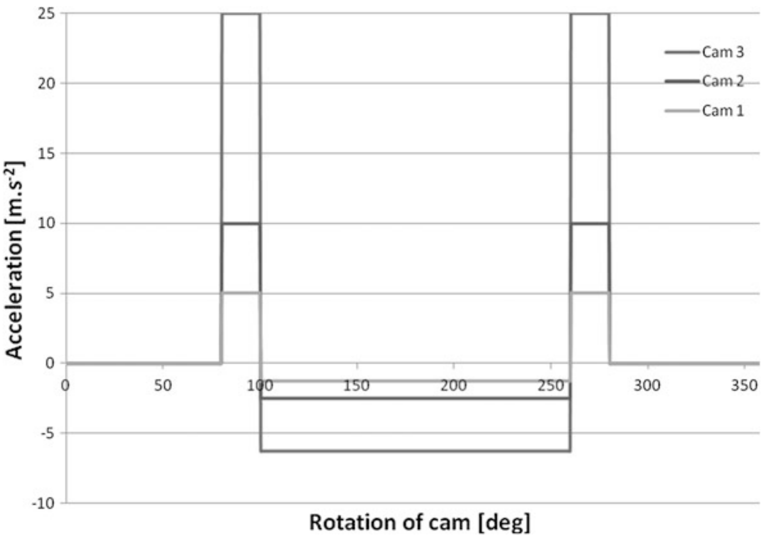
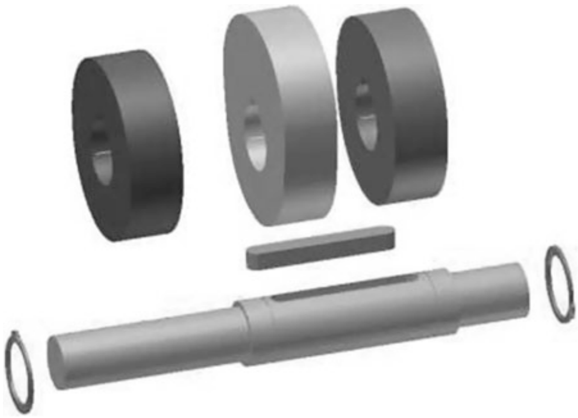


Fig. 2 Course of acceleration of each cam

Fig. 3 Shaft with changeable cams



4 Electric Equipment

The vibration device is powered by a pair of three-phase stepper electric motors YK31328A (Fig. 4) with maximal torque 50 Nm. Motors are connected in tandem mode and controlled by YKB3722MA stepping driver with microstep (Fig. 4). The stepping driver is operated by computer by RS323 protocol.

The vibration device is equipped by two position sensors and two accelerometers. Data capturing of measured quantifies supports an external multifunction data acquisition device connected to the computer by USB protocol (Petřík 2011).

Fig. 4 Stepping electric motor (*left*), microstep stepping driver (*right*)

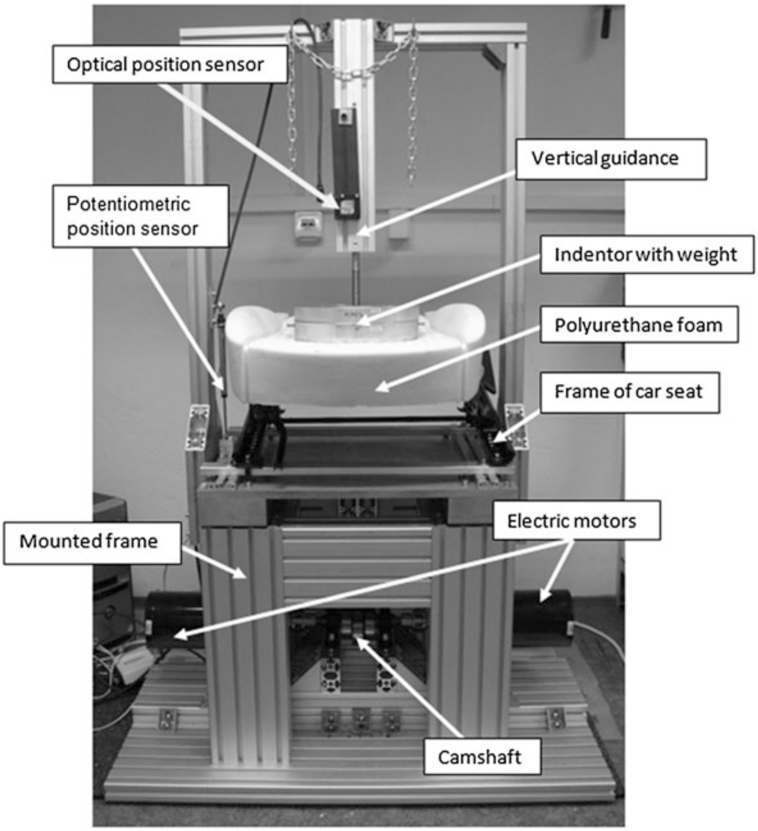


Fig. 5 Final design of the vibration device

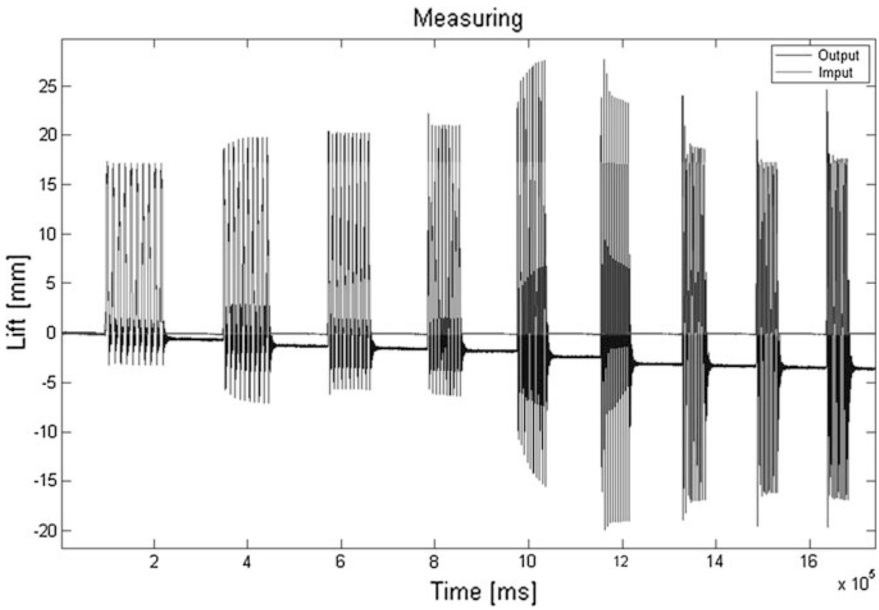


Fig. 6 Example of measurement cycle

5 Final Design

The final design is shown in Fig. 5. Unlike the first design there were used two step motors connected into tandem for greater power. An upper frame allowing vertical guidance of load was added to the construction and another frame was added to the table easy mounting of the seat.

Replacement of the cams is possible manually. After locking the table in the upper position it is possible to move the console with motors and cams to the position for running concrete cam.

6 Conclusion

The device allows performing dynamic tests of foam parts as well as whole seats in the frequency range 1–15 Hz, lifting range 3–17 mm (Fig. 6 shows an example of measurement cycle). The excitation signal generated on the cam is determined by its profile and rotation. While respecting permanent contact of the cam with the table (there is no bounce), the excitation signal is very stable even in long-term interval. This device is particularly suitable for the performing of long-term durability tests of car seats that are relatively expensive in real traffic (approx 80,000 km).

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