Innovation of Car Seat Measurement Device

Vitezslav Fliegel, Petr Lepsik(✉), and Rudolf Martonka

Technical University of Liberec, Studentska 2, 461 17 Liberec, Czech Republic
petr.lepsik@tul.cz

Abstract. The car seat is tested in the conditions of real car operation, ie under the conditions of multi-axis loading. We will examine all the possible parameters and maybe find some objective conclusions for the car seat design. The content of this article is the innovation of car seat measurement device in laboratory conditions. The existing device allows only the vertical movement of the car seat to realize. The goal of the innovation is to complement the device so that the vertical movement of the car seat can be realized simultaneously with the horizontal movement.

Keywords: Car Seat · Multi-Axis Testing · Laboratory · Mechanical Vibration

1 Introduction

The car seat consists of many parts that perform different functions for the entire structure. Individual parts can be divided into structural groups, which we call the supporting group, vibro insulating, aesthetic. The supporting group includes a supporting frame with traverses and anchoring elements behind which the seat is attached to the car body. These parts are usually steel, the vibro insulation group includes seat cushions, which are usually made of PUR foam and the last aesthetic group includes upholstery fabric, which covers the entire seat from the front (see Fig. 1).

Each of these groups has a different goal, which is necessary to meet in the overall constriction. The load frame emphasizes safety in the event of a vehicle collision during operation. In such a case, it is necessary to prevent it from being an infringement. This frame is constructed with regard to strength and load capacity of the structure contrary to the weight of the supporting frame. In the design, these contradictory requirements need to be balanced. In a vibro insulating group, they are considered to be a requirement for responding to the input vibrations of an existing seat in a passenger. Construction materials are designed and checked for properties that utilize the vibration properties. The basic vibro insulation parameters that relate to the fact that it is a device that is located where the frequency, speed, and height of the foam fill are located – creep [1]. Vibration parameter values are influenced by the typical potential - textile, leather, spacing, etc. Testing of car seat using uniaxial loading is described in [2, 3]. Testing of car seats have to be is performed according to the standards as [4–7]. The aim of this paper is to introduce an innovation of the device so that the vertical movement of the car seat can be realized simultaneously with the horizontal movement. The aim of the study was Innovation of car seat measurement device.

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Fig. 1. The Car Seat – frame, PUR fillers.

2 Materials and Methods

Usually, the inspection of used parts is carried out in an experimental manner. For each experiment, it is always necessary to create a test device that can be repeated by a given experimental test.

2.1 Conditions

Conditions of Seat Frame. The level of safety of the carrier frame is carried out by simulating the load in the worst-case state gradually by gradually increasing force. In this test, the degree of deformation is simultaneously measured and controlled. The criterion for maximum safe deformation is not to exceed the maximum force (see Fig. 2).

An example record of the deformation on the loading force from the experimental test is shown in Fig. 3. The recording shows the direction of loading and subsequent unloading.

Conditions of Vibro Isolation Characteristic. The main influence on the vibro insulating properties of the car seat has the properties of the PUR foam. This discharge is tested and experimentally tested by several tests according to normative specifications [7–9]. PUR tests can be divided into two basic types - short-term dynamic test and long-term static test.

From the experimentally performed short-term dynamic test we get the so-called transfer function (see Fig. 4).

From this characteristic is indirectly define characteristic parameters – dynamics stiffness - kd a damping - b. this characteristic parameters is define from measured parameters – Transmissibility - T, natural frequency - fn, damping frequency - fd. Natural frequency fn is given by adjusting the dynamic equation with (1):

$$f_n = \frac{1}{2\pi} * \sqrt{\frac{k_d}{m}} \tag{1}$$

After treatment, we expression for dynamic stiffness (2):

$$k_d = 4\pi^2 * f_n^2 * m \tag{2}$$

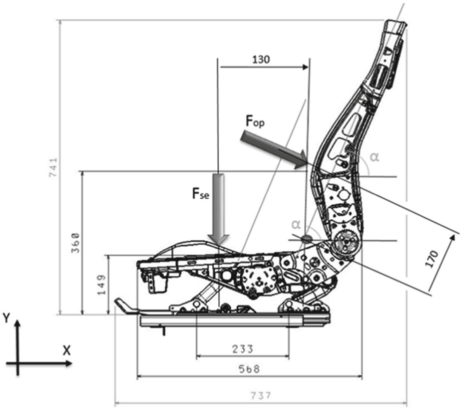

Fig. 2. Loading of seat frame.

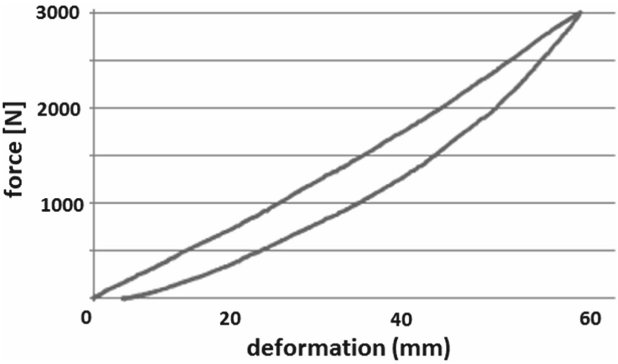

Fig. 3. Record of loading seat frame.

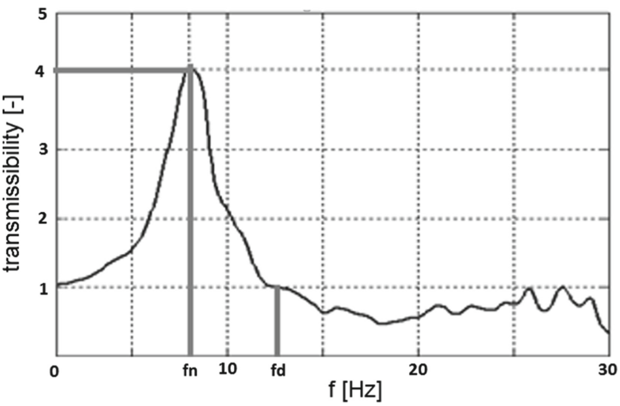

Fig. 4. Transmissibility characteristic.

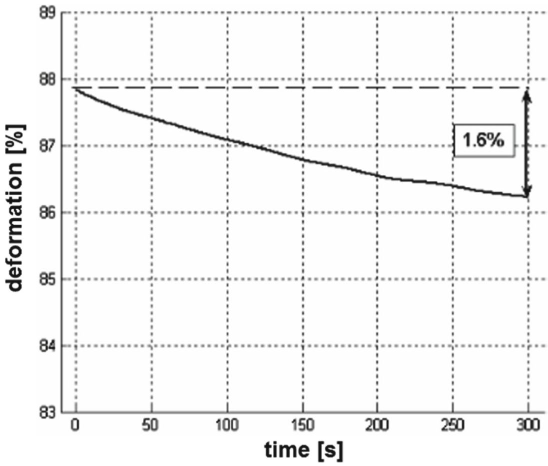

Fig. 5. Static long term loading – Creep.

where kd is dynamic stiffness, m is weight of loading, fn is natural frequency of dynamic system. The damping value - b is derived from the transmission magnitude and critical damping - bkrit, for which the relation (3) applies and for the damping value, the attenuation coefficient - ζ is applied for (4).

$$b_{krit} = 2 * \sqrt{k_d * m} \tag{3}$$

$$\zeta = \frac{b}{b_{krit}} = \frac{b}{2 * \sqrt{k_d * m}} \tag{4}$$

The second experimental test is the so-called height loss - Creep. This is a long-term, several-hour exam. In this test, the PUR filler is loaded with a loose load. The experiment determines the slump of this load over time. A typical record of this test is the graph shown in Fig. 5.

We describe by this experiment two basic values - relative deformation - δ (loss of height - Δδ) and asymptotic time ta. The relative deformation - δ is given by Eq. (5), the loss of height is given by Eq. (6):

$$\delta = \frac{h}{h_0} \tag{5}$$

$$\Delta\delta = 1 - \delta = 1 - \frac{h}{h_0} = \frac{h_0 - h}{h_0} = \frac{d}{h_0} \tag{6}$$

Asymptotic time is the value of the time interval when the relative loss of height Δδ is less than 0.1%, resp. The strain rate falls below 1%.

2.2 Experimental Equipment

Experimental Equipment for Static Loading – Creep. A unique testing device has

Fig. 6. Experimental equipment – Creep.

Fig. 7. Experimental equipment - Transmissibility – Electronics.

been proposed for the static loading of the PUR of the automobile seat which allows a freely vertically guided weight of defined shape and weight (see Fig. 6). The device is equipped with a set of optical position sensors. Measured signals are continuously recorded using a measuring computer with a measuring system.

Experimental Equipment for Dynamic Loading – Transmissibillity. For dynamic loading of automobile seats, a unique testing device has also been designed, which is driven in a vertical direction by a linear electric motor (see Fig. 7). The mass, which represents the equivalent weight of a seated person on the seat, oscillates freely in the vertical direction and, based on the measured acceleration of the input signal and the acceleration of free mass vibrations. It is possible to determine the transmission characteristic of the measured automobile seat. This device is again equipped with a measuring computer with measuring software. The measured signals are then processed using post processing mathematical software such as Matlab, etc.

3 Results and Discussing

In the previous chapter, the devices listed are unique to each of the measured characteristics. Such a measurement is no longer suitable in the design and control of automobile seats today. Manufacturers and suppliers of car seats and their components are trying to offer car manufacturers a better and more comfortable seat. In this case, it is also necessary to use the selected tests to get closer to the real use and thus the loading of the car seat. Not only is it necessary to choose a set of static and dynamic tests, but first and foremost their necessary timely continuity. This is impossible due to the use of more special testing equipment. Especially for dismantling and assembling the car seat on the test equipment.

The first variant of the new innovated device was to use an already existing and installed six-degree platform – Hexapod [11–13] with specialized control software [14] (see Fig. 8).

This device suited us in terms of excitation and overall capacity. The big disadvantage was the build-up height, respectively the construction and assembly of the vertical guide of loose material above the anchored seat. This construction would be large in its basic dimensions and thus the individual beam profiles used would have to be very robust. In this case, this type of construction would be very expensive. Also, the operation of the hexapod itself is very demanding, as it is necessary to move all six linear cylinders simultaneously for even the slightest and easier movement [11–13].

From this point of view, we have designed a combined complex test facility that is currently only implemented as a virtual model consisting of virtual models of real parts - beams, plates, joints, linear motors and other machine accessories. In principle, it is based on an experimental device for the measurement of transmission, but it is supplemented by another bridge structure due to the higher stiffness and bearing capacity of the whole structure. In addition, we added the vertical linear guides that can be locked in the selected position.

This allowed us to perform another quasi-static measurement on this device, from which a hysteresis curve can be obtained [10].

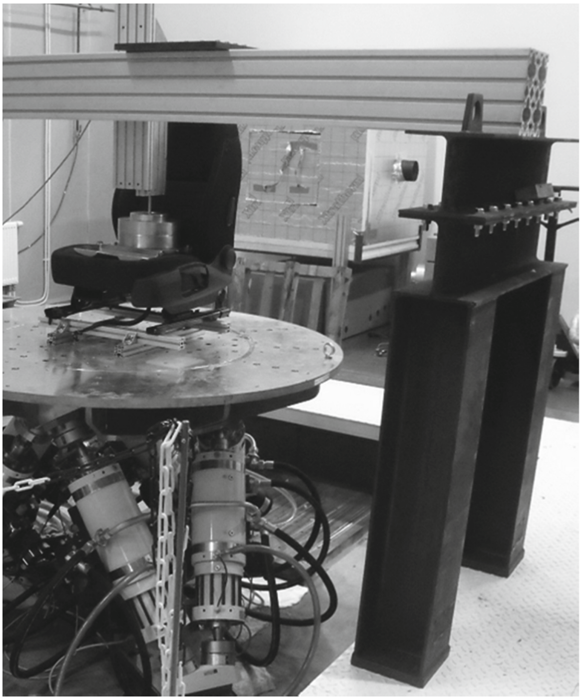

Fig. 8. Experimental equipment using hexapod.

At the same time, when designing this new innovated test facility, we took into account the current need and requirements of the automotive industry to load the seat in more directions simultaneously. So far, this idea is only in the internal rules of car manufacturers. This rule is not yet converted into a standard. It is believed that it will be preferable to load the seat with dominant vibrations in the vertical direction, and further one or both of the perpendicular horizontal directions will be transverse and subsequently longitudinal to the seat orientation. With this construction condition we designed the 3D model (see Fig. 9). The main vertical motion will be excited by a linear vertical electric motor. The second horizontal motion will be excited by a horizontal motor hidden between a pair of horizontal steel plates. In order that this horizontal motor is not subjected to additional force effects, a pair of linear ball guides is provided between the plates (see Fig. 9), which will just transmit any unwanted force effects.

An integral part of the design will be the programming and the creation of a special control software that will simultaneously control not only the pair of motors in parallel, but with the aid of measuring cards and measuring sensors to retrieve the measured data synchronized over time.

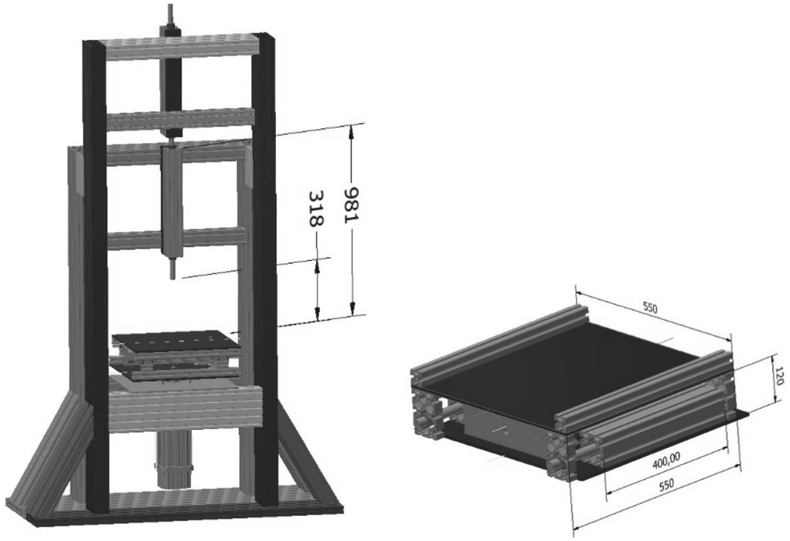

Fig. 9. 3D virtual model, linear ball guides.

4 Conclusion

The types of electric linear motors used enable very precise positioning and repetition of selected excitation signals. So it will not only be possible to perform measurements on whole assembled seats and individual components, but we also assume to perform measurements on PUR materials of smaller dimensions.

Another benefit will be to experimentally verify the independence of measured characteristics at various phase shifts of excitation signals. At this point, it can be assumed that the characteristics will be dependent on the phase shift of the two excitation signals, especially if they are harmonic signals of, for example, a sine wave.

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