Innovated Testing Equipment and the Influence of Two-Axis Loading on Comfort of Car Seats

Petr Lepšík(✉) and Vítězslav Fliegel

Faculty of Mechanical Engineerign, Technical Univerzity of Liberec,
Studentska 2, 461 17 Liberec, Czech Republic
petr.lepsik@tul.cz

Abstract. The car seat comfort depends on many parameters of the seat and the characteristics of the people sitting on the seat. Each person is different, behaves differently and feels differently. The seat cannot suit everyone, or it must be required the car seat to adapt automatically to the person sitting on it. That is why we test the car seat in real conditions in the car, i.e. in conditions of simultaneous loading of more axes. This paper describes the innovation of measuring equipment for car seats in laboratory conditions. The introduced innovated device allows realizing how vertical movement of the car seat as well as horizontal movement. The vertical movement can be realized independently or simultaneously with the horizontal movement. Measurement methodologies and test signals are also described in the paper.

Keywords: Car Seat · Testing · Multi-Axis Loading · Human · Measurement Methodologies

1 Introduction

Testing of car seats in laboratory conditions is performed according to the relevant standards [1–4]. These standards are numerous, and each corresponds to a specific mode that loads a car seat in the car. The comfort of sitting depends on the properties of the interaction of the car seat with the human body at the face of contact and so the level of fatigue after a long drive. Testing of car seats in laboratory conditions requires strict adherence to prescribed standards, i.e. simultaneous multi-axis loading. Therefore, the test equipment must be increasingly sophisticated, enabling the implementation of load signals in multiple axes. The possibility of comparing tests from different laboratories and their uniform evaluation also depends on the characteristics of the test signals. The aim of this paper is to introduce new laboratory test equipment for testing car seats and new testing possibilities.

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2 Materials and Methods

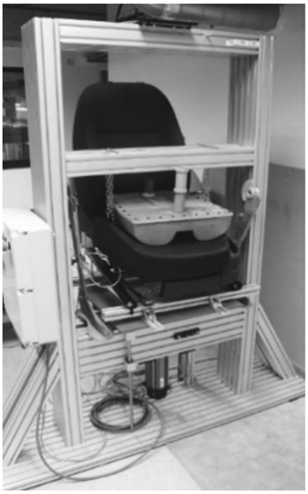
2.1 Old Testing Device

We have innovated the existing test equipment, which complied only with the standards prescribing uniaxial vertical loading of the car seat [1], i.e. only with a vertical load in the "z" axis (Fig. 1). We added another new horizontal direction of loading and increased the total height of the device to 2400 mm as the new height.

2.2 New Testing Device

The limited working height of the existing equipment did not allow tests with a standardized dummy. For testing complete car seats with full loading, it is necessary to increase this height to a minimum of 2000 mm. Also, according to current standards [2] prescribing the testing of car seats in laboratory conditions, it is necessary to add the horizontal movement of the seat during testing, i.e. forward and backward. The testing device was increased to 2400 mm working height (Fig. 2). The horizontal movement of the platform was designed from the existing two horizontal plates (Fig. 4), between which the linear servo motor actuator series GSM40 was placed. The linear motor servo actuator GSX60 ensures vertical movement. The new test equipment offers the possibility of both how vertical and so horizontal loading of the car seat, as well as their combination while moving. The methodology of testing car seats is based on the conditions of the corresponding standards. It will be evaluated by comparing how to change the properties seats when loaded only vertically and when loaded vertically and so at the same time horizontally. We definitely think that the required seating comfort will depend on the combination of movements.

Characteristics of the human body are highly individual, e.g. according to sex, age, corpulence, health, weight, body composition etc. The total load on the human body



Characteristics of the original laboratory testing equipment car seats, uniaxial loading.

Name: LAB 1500_2018-HD

Technical Data

Total height of device 1500mm

Vertical movement to 100mm

Loading full car seat with loading

Product Type 2018 testing actuators

Voltage Ratings 230 V

Technical University of Liberec

Fig. 1. Original testing equipment LAB 1500_2018-HD.

Characteristics of new laboratory equipment for testing car seats, bi-axial loading.

Name: LAB 2400_2020-HD

Technical Data

Total height of device 2400 mm

Vertical movement to 180 mm

Horizontal movement to 50 mm

Loading full car seat with dummy

Product Type 2020

Technical University of Liberec

Fig. 2. Innovated testing equipment LAB 2400_2020-HD.

is divided into static and dynamic loads, which in the end cause fatigue for both how the driver and so the passenger. Therefore, in our opinion, we should consider both how static fatigue “static tiredness” arising from static sitting, i.e. rigid position, bruises in the areas of support of the body buttocks, buttocks, back, and so dynamic fatigue “dynamic tiredness” arising from mechanical vibrations of low and high frequencies, i.e. low frequencies causing nausea “seasickness”, muscle stiffness, vibrations and a decrease in the organs in the axis of the spine, increases in body temperature, which is manifested by an increased rhythm of breathing, and high frequencies devastating the nervous system. These effects are unacceptable for drivers and passengers for a long time, so we must measure these harmful factors and then reduce their impact to a minimum. For the credibility of the test results and comparability, we have to combine the two forms of measurements in real traffic in a car and in laboratory conditions. Laboratory conditions are not so dependent on external conditions, such as weather, time of day, etc.; we can also ensure their good repeatability and comparison of measurements between laboratories. The influence of static and dynamic components causing fatigue is not sufficiently described in the literature. According to our measurements, we think that the effect of the static component on driver and passenger fatigue is dominant for a long time. The influence of mechanical vibrations of higher frequencies on the nervous system is indisputable and so from the point of view of short-term action.

The design concept of the innovated equipment (Fig. 2) was based on the assumption of using a Hybrid III test dummy and an H2015 H-point test dummy to load the car seat (Fig. 7). Therefore, we had to increase the total height of the device to 2400 mm. We added a second frame and placed a vertical motor with a platform between two frames. Therefore, a variable platform was created, in which it is possible to change the required working height according to the need the type of loading. For vertical drive, it was elected new linear actuator type GSX60.

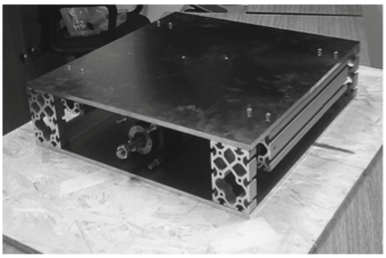
The technical characteristics are given in the technical description (Fig. 3). Now the vertical movement can be realized in the interval up to 180 mm with a total load up to 150 kg, i.e. the whole car seat with accessories and plus the load of about 100 kg. The concept of horizontal movement is based on the movement of two horizontal plates, which are connected via linear guides. A new linear moving was chosen for the drive actuator type GSX40. The lower horizontal plate is connected to the vertical actuator, the upper plate is used to fix the tested seat. The design allows the entire horizontal module to rotate, i.e. rotate in the "z" axis. The device so becomes universal. Now we can connect to the vertical test signal same horizontal test signal, both forward and backward and left and right, according to the rotation of the horizontal platforms. In the future, we are considering doing a change in the design, i.e. the addition of new another actuator for each horizontal movement forward and backward, left and right separately. Therefore, we could test car seats in three axes independently and independently. This will allow us to test the car seat according to all currently valid standards.

GSX Series integrated motor actuators integrate all the advantages of Exlar roller screw and T-LAM stator technologies to create powerful and robust solutions with long life. The specially designed roller screw mechanism efficiently converts electric motor power into linear motion. Planetary rollers, assembled around the extending rod, follow threads that are precisely machined on the inside of the actuators hollow rotor GSX60-1010.

Technical Data

Weight 63.5 kg
Manufacturer Exlar
Product Type Actuators
Frame Size 180 mm
Stroke Length 254 mm
Screw Length 24.5 mm
Linear Speed up to 952 mm/s
Voltage Ratings 115 – 460 VRMS
Approvals CE and UL Certifications, IP65S, UL Class 180H insulation

Fig. 3. Vertical movement of innovated equipment.



Technical Data
Weight 14kg
Frame Size 100 mm
Stroke Length 254 mm
Screw Length 19.05 mm
Linear Speed up to 952 mm/s
Voltage Ratings 115 – 460 VRMS
Approvals CE and UL Certifications, IP65S, UL Class 180H insulation

Fig. 4. Horizontal movement.

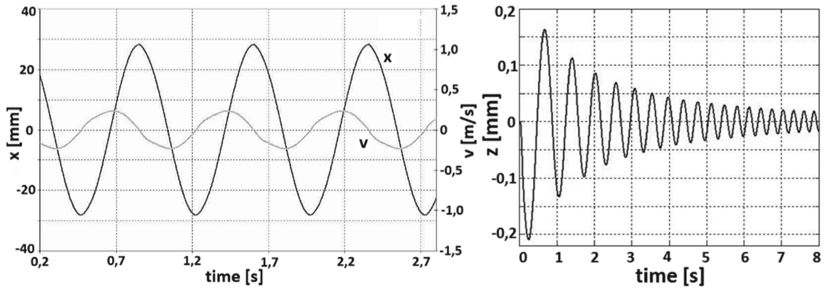


Fig. 5. Test signals for horizontal movement.

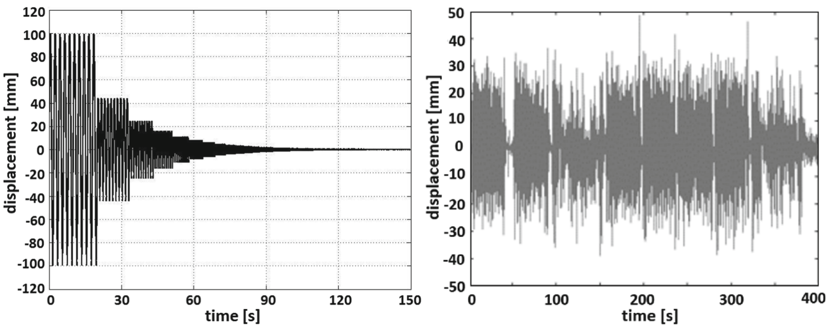


Fig. 6. Test signals for vertical movement.

2.3 Principle of Control and Testing Signals

A new software (LabVIEW from National Instrument) will be designed for the control and regulation of the innovated device. The Laboratory Virtual Instrument Engineering Workbench is a true development measurement environment with rich libraries for creating measurement-oriented applications. The main and important factor is the definition of test signals. The specifical J. Petrik application software was created, which enables programming and creating various forms of test signals from simple, e.g. sinusoidal, to a composite signal containing a frequency range from 0.5 to 20 Hz, also process signals obtained from the traffic operation on the vehicle frame car seats. The types of test signals are listed (Fig. 5) and (Fig. 6).

3 Results and Discussion

The innovated device allows increasing the working height of 500 mm 800 mm (Fig. 7). It realizes the possibility of vertical loading of the car seat up to 100 kg of load in the interval ± 90 mm; at the same time, it enables the realization of horizontal left and right movement of the car seat in the interval ± 25 mm. It corresponds to the currently valid regulations for laboratory testing of car seats with the load as [1–4]. This innovated device will provide the elimination of the shortcomings of the uniaxial loading described

Fig. 7. Final design testing equipment and testing dummy.

in [5, 6]. It would be necessary to use eg a hexapod device [7–9] with specialized control software [10] for testing in more than two axes.

4 Conclusions

The universal testing device was designed and assembled. The device is used for testing automobile seats in the two directions of movement, both vertical and horizontal forward and backward. This corresponds to the requirement of the current standard for determining the comfort properties of car seats. Another development of the device (Fig. 7) is the intention to add another direction of movement, namely the horizontal left and right. This solution will already be the content of further development and another paper.

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