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CONSTRUCTION OF A TEST STAND AND A METHOD FOR THE ASSESSMENT OF SAFETY BELTS' MOUNTING POINTS IN TERMS OF VALID RULES

Key words

Test stand, measurement method, fixing points, safety belts, seat homologation.

Abstract

Apart from a threat to human life and health, traffic accidents involve economic and social costs. Although the number of accidents is on a decrease, the number of fatalities is still very high. Therefore, new traffic rules are being introduced which are supposed to ensure the safety of passengers. The costs of accidents also include those involved in tests of new devices to be used for checking whether they meet the requirements set out in norms and regulations, including homologation tests. In this study, requirements for seats mounted in medical ambulances are discussed.

A procedure for an assessment of safety belt mounting points for a doctor's seat in an ambulance has been presented.

The aim of this study was to develop a test stand for the assessment of a seat prototype and its verification in terms of traffic rules and regulations.

Introduction

An increase in the number of requirements that are to be met by elements of vehicles is dictated by concern for passengers' safety. In addition to threat to human health and life, traffic accidents produce costs connected with the treatment of victims and the loss of the work productivity of people injured in them. These costs, referred to as indirect costs, are often neglected, but they appear to be relatively high, since treatment and care of injured or disabled people are expensive and time consuming. According to a WHO report, the costs involved in traffic accidents account for 1 to 3% of gross domestic product [1, 2].

Statistics concerning road accidents confirm the necessity of using homologation and certification procedures, that is, a confirmation of producers that their products provide passengers with an appropriate level of safety [1, 2].

Allowing an ambulance, which is constructed based on another vehicle, to use the road imposes the necessity to repeat homologation. The assessment of such elements as seats, stretchers, medical instruments, and the arrangement of medical space are required as well. Manufacturers of ambulances demand that the seats they purchase meet relevant norms, which are needed for homologation of the vehicle. Moreover, the seats have to meet weight, ergonomic, and visual criteria.

Searching for new solutions involves the need to repeatedly perform tests on prototypes.

The performance of such checks through repeating homologation and certification tests involves very high costs. Thus, it is advisable and cost effective to build a test stand for this purpose [2, 3].

In this work, the requirements to be met by vehicle seats have been studied based on an ambulance seat for a doctor and a test stand for the assessment of mounting points of seat belts has been developed and analysed.

1. The research object

The research object was a frame of a doctor's seat in a medical ambulance (Fig. 1). The characteristic feature of this kind of seat is its ability to rotate in relation to the fixed base; consequentially, the mounting points are located on the frame of the seat and must be considered. In connection with the above, manufacturers of seats need to perform tests on the seat belt mounting points and on the systems of the seat adjustment and control. These are tests of compliance with requirements provided, respectively, in Regulation no. 14 of the European Economic Committee of the United Nations Organization (EKG ONZ) and Regulation no.17 EKG ONZ. Verification of appropriate safety belt mounting is presented in Point 8 of Regulation no.16 EKG ONZ. A vehicle, as a whole, has to meet requirements of European Norm EN 1789+A1:2011 [4].

a) b)

Fig. 1. Exemplary solutions of a doctor's seat in an ambulance, (a) with a base that allows installation, and (b) without a base [5]

2. Homologation requirements connected with belt mounting points

Homologation tests are done to rule out the possibility of detachment of a mounting point due to displacement of a passenger during an accident. The belt can be fixed to the vehicle body, floor, or the seat.

The procedure for testing a safety belt mounting points, according to regulation 14 EKG ONZ, involves the application of forces to the shoulder belt and to the lap belt using a special traction device shown in Figure 2.

a) b)

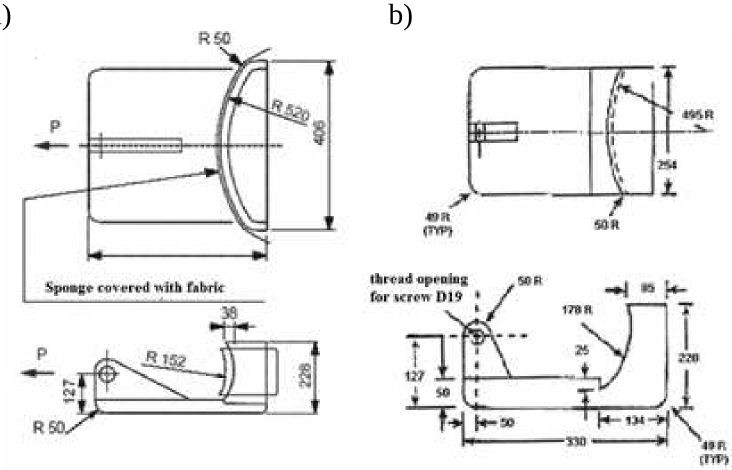

Fig. 2. Traction devices: (a) for the shoulder belt, and (b) for the lap belt [4]

Forces applied to the belts depend on the orientation of the seat and where it is attached in relation to the direction of motion. A seat in the configuration of a three-point mounting, facing the direction of motion, is loaded by forces equal to 1350 ± 20 daN.

When at least one mounting point is located on the seat, as in the case of a doctor's seat in an ambulance, it is necessary to account for the impact of the seat inertia, with the addition of loading with value equal to a mass twenty times higher than the mass of the whole seat. The distribution of additional loading onto the shoulder belt and the lap belt is provided by the manufacturer in consultation with a technician.

The mass of the tested seat was 30 kg; therefore, the value of additional loading was accepted to be 600 daN.

Forces should act in the middle plane of the seat, at an angle 10°±5° from the horizontal plane and be applied in accordance with the direction of motion. The value of initial loading should be 10% ± 30% of the target loading (Fig. 3).

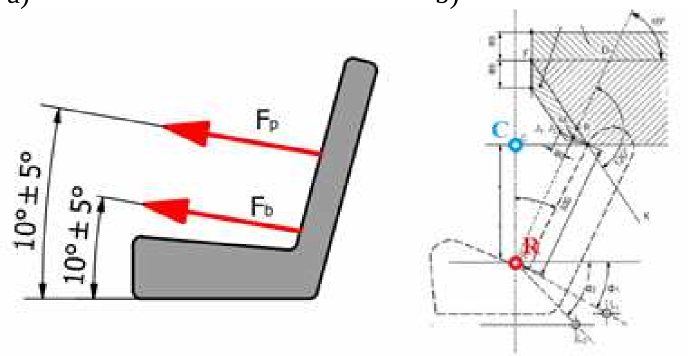

Fig. 3. (a) the direction of the applied loadings with Fb for the shoulder belt, and (b) the position of point R and point C [4]

The time of the application of the primary load should be a maximum of 60s from an increase in the initial loading to the intended maximum value. A manufacturer can demand that the loading is applied in a shorter time. The minimum time is 4s [4].

A positive outcome requires at least a time equal to 0.2 s, during which the belt mounting points have to withstand full loading [4]. Another criterion that has to be met by the seat is the condition that the upper mounting point cannot shift in front of the transverse plane that crosses point R and point C. Point R is 'the seat reference point', and it defines the theoretical position of the torso rotation point in relation to thighs. Point C is a point lying at the distance of 450mm or 500 mm vertically above point R (Fig. 3) [4].

The regulations provide that a permanent deformations, cracks, and fractures are not considered to be defects as long as the force was withstood for the minimum required time [4].

The changes of traction forces used during tests of an exemplary seat with a mass of 30 kg are presented as a function of time in the diagram (Fig. 4). The same value of the final force was accepted for the shoulder belt, Fp, and the lap belt, Fb, to be 1650 daN, and it is presented in part D of the diagram. The seat must carry the load produced by this force for minimum 0.2 s. Part B of the diagram shows a loading force equal to 165 daN. During application of initial loading, it is possible to set up the test stand and check the correctness of the applied forces directions. Duration time of part A and B can be of random character. Part C is connected with the growth of loading from the initial load to the final load. The minimum time of part C duration is 4 s, and the maximum is 60 s [4].

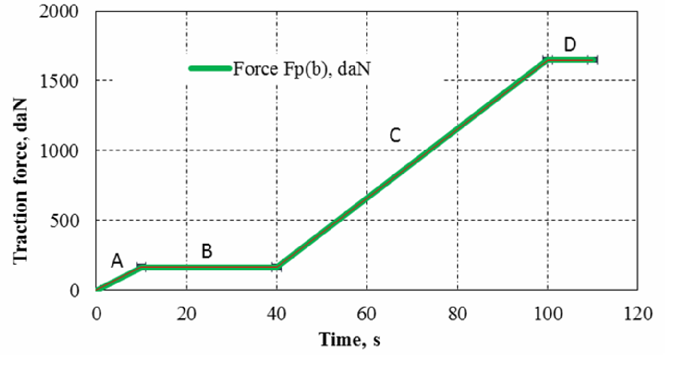

Fig. 4. Diagram of dependency of loading value on the test duration time

3. Structure of a tests stand for testing the mounting points of safety belts

The aim of the test stand was to reduce costs connected with testing prototypes of seats. The bearing structure of the seat was subject to earlier numerical analyses, which were supposed to be experimentally verified.

It was assumed that the stand should be used for tests before homologation and making it possible to obtain results as early as in the first attempt. As a result of this, a reduction of homologation costs was expected as well as a shortening of the time needed to obtain information about the prototype.

In connection with the above, it was assumed that the test stand should reflect the conditions of the homologation test and, at the same time, have a simple structure and be inexpensive to construct. Additionally, it will be possible to collect information about the prototype properties during testing.

This will allow one to compare the experimental results with a numerical analysis and introduce further modifications into the structure.

The stand framework (1) was supported on foundation plate (2) (Fig. 5a), and hydraulic motor (3) was fixed to the base. Seat (4) was mounted to the base plate by means of support (5), whose mounting surface inclination angle to a vertical axis was 10°, thanks to which it was possible to provide the required clearance angle of the loading in relation to the seat.

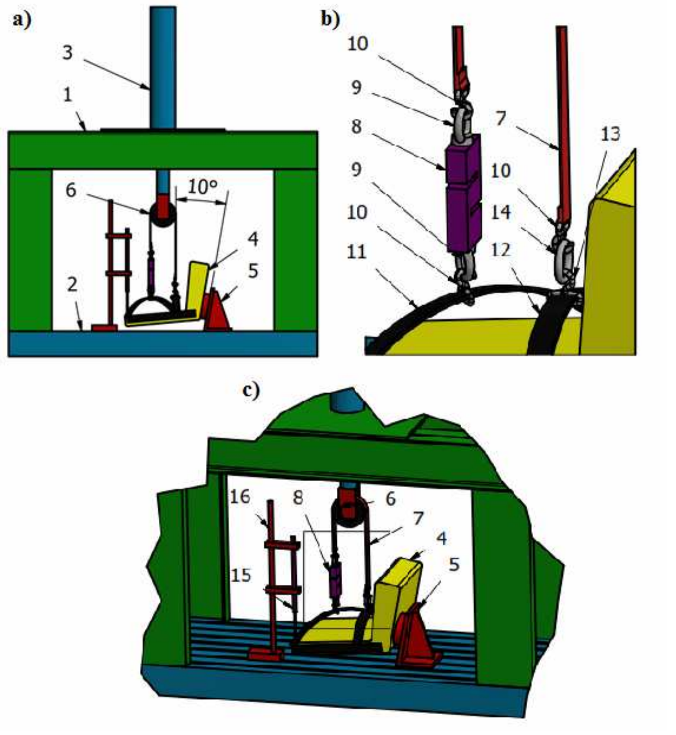

Fig. 5. The structure of a test stand for the assessment of mounting point strength for safety belts

Head block (6) was mounted to a hydraulic cylinder whose task was to uniformly spread the force onto both parts of the seat belt (7) (Figs. 5b,c). The belt that was attached to the head block was able to withstand 50 kN. A force sensor (8) with a measurement range from 0-20 kN was fixed to one end of safety belt in order to measure tensile forces. Eye nuts M20 (9) were fitted in the force sensor on both sides, and then it was hung between two hooks (10). One of the hooks was suspended on the end of one part of the belt that was hung over the head block, whereas the other hook was attached on the shoulder part of safety belt (11). Hook (13) was also mounted to the lap part of the safety belt (12), which, by means of eye (14), was hung on hook (10) situated on the other part of the belt hanging from the head block.

In order to control displacement of the belt upper mounting point, an induction sensor of displacement (15) was introduced to the system. This was attached to the foundation plate by means of grip (16).

The figure does not include a hydraulic power unit, the hydraulic amplifier with an analogue-digital converter, or a computer. Sensors of force and displacement were calibrated before tests. The displacement sensor was set to the initial position providing operation within the range of highest measurement accuracy.

The test stand was equipped with video cameras to record the tests. One of the cameras was placed at the height of point R, which allows checking whether the upper mounting point moved or not beyond the permitted zone.

Conclusion

The proposed test stand performs all the expected functions. The testing method complies with the majority of requirements provided in Regulation no 14 EKG ONZ. The lack of specific traction devices makes it unique; however, they were substituted by a hook stretching the safety belt. Once the test stand is completed with traction devices, shown in Figure 2, it will meet all the needed requirements.

Initial tests of the seat enabled positive verification of the stand operation, however, due to confidentiality requirements, this paper does not include diagrams of displacement and force changes.

During tests, it was observed that the safety belt was significantly extended and the winding system was damaged. The extension of seat belts can cause a different distribution of forces affecting the mounting points. Therefore, it seems to be advisable to use a reusable safety belt designed for prototype testing. The test stand provides a uniform distribution of forces in both parts of the safety belt. This assumption is correct for small friction forces between the bolt and the head block disk. In order to verify the correctness of the accepted assumption, the measurement should be performed on both parts of the safety belt. Measurement of the upper mounting point allows one to verify the numerical analyses that were performed before the tests.

References

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5. https://uesint.com.

Budowa stanowiska oraz metoda badania punktów kotwiczenia pasów bezpieczeństwa w świetle obowiązujących przepisów

Słowa kluczowe

Stanowisko badawcze, metoda pomiarowa, punkty kotwiczenia, pasy bezpieczeństwa, homologacja siedzeń.

Streszczenie

Wypadki komunikacyjne oprócz życia i zdrowia ofiar powodują koszty ekonomiczne i społeczne. Pomimo zmniejszającej się liczby wypadków komunikacyjnych liczba ofiar śmiertelnych pozostaje wysoka. W związku z powyższym wprowadzane są nowe przepisy gwarantujące podniesienie bezpieczeństwa pasażerów. Między innymi są to badania homologacyjne mające na celu weryfikację, czy nowe konstrukcje spełniają wymagania zawarte w normach i regulaminach. W pracy przedstawiono wymagania homologacyjne stawiane siedzeniom montowanym w ambulansach medycznych. Omówiono procedurę badania wytrzymałości punktów kotwiczenia pasów bezpieczeństwa dla fotela lekarza. Celem pracy jest opracowanie stanowiska do badań prototypów siedzeń i jego weryfikacja na postawie przeanalizowanych obowiązujących przepisów.