SIMULATION OF FOOT WELL INTRUSION FOR SLED TESTING

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ABSTRACT

There is a high risk of the lower extremities being injured in frontal crashes of passenger cars. Head and chest are well protected nowadays due to safety features like airbags, seat belts and absorbing materials in the interior, while only limited safety improvements have been achieved in the leg area.

In order to investigate the injury mechanism of lower legs, to define development targets and for the assessment of safety devices, PARS developed a tool to reproduce the measured dynamic crash intrusion of the foot well in static and in sled tests. This foot well intrusion system (patent pending) allows the adjustment of both movements of the firewall, parallel intrusion and rotation effects, nearly independent and in a wide range.

In this paper the functioning principle of this device will be presented. A comparison between real crash tests and experimental simulations with sled tests will be reviewed.

INTRODUCTION

The evaluation of several accident statistics point out, that the lower extremities are the second most endangered body region in frontal crashes. Only the head area is injured more often. The Goal of PARS was to develop a cost effective and reproducible testing tool for further research on protection devices for lower extremities. This goal was met by a mechanical foot well intrusion system for static laboratory testing and also for sled testing on an impact or a reverse sled. To receive the required data for initialization of the intrusion system there is only one baseline crash necessary. Expensive crash testing can be avoided by using this system without any loss of information. Development of new protection systems for legs and feet can be carried out faster and more effectivly. Further major advantages are the easy assembly, the low production and operating costs and the universal use (e.g. steering column intrusion, etc.).

KINEMATICS OF FOOT WELL INTRUSION IN CRASHES

Through extensive analysis of static and dynamic deformation data the principle kinematics of the foot well were discovered. Mainly the following two movements were found out (Fig.1.): on one hand a rotation of the firewall around y-axis and on the other hand a translation of the foot well in direction of the x-axis.

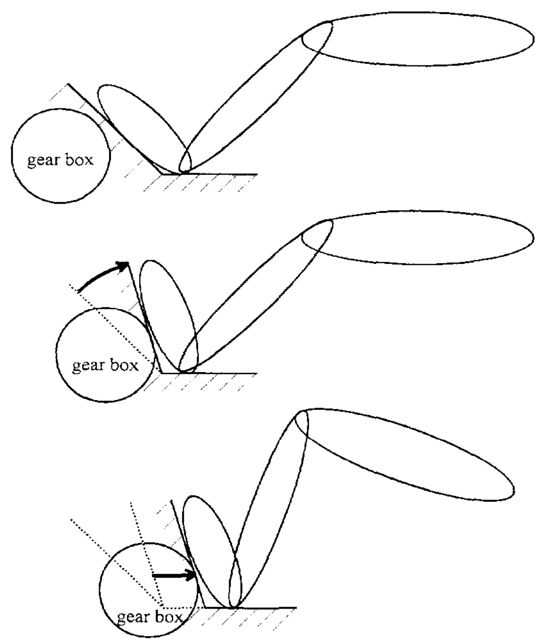

Figure 1. Principle of foot well intrusion during crash.

The two movements are not proceeding one after the other but combined. Based on this knowledge, the conditions for the intrusion system were defined. The system has to perform the measured movements and accelerations so that the dummy loads are similar to the crash.

ASSEMBLY OF THE FOOT WELL INTRUSION SYSTEM

An analysis of the pros and cons of several construction possibilities pointed out that only a system which is independent of the kinetic sled energy will reach the demanded repeatability. For the acceptance of automobile manufacturers it has to be cost effective and reliable. PARS uses a pyrotechnical driving unit for the intrusion system which fulfills both criteria.

The principle assembly of the foot well intrusion system with its major parts is shown in Figure 2.

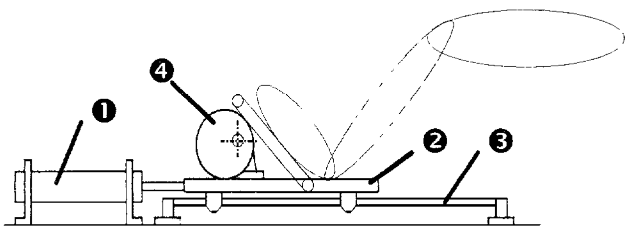

Figure 2. Principle assembly of the foot well intrusion system.

The drive of the system is a pneumatic cylinder ❶ which is charged by a pyrotechnical unit. The load of the cylinder is applied over a piston rod to the sled ❷. The sled is mounted on a shaft ❸ so that it is able to perform a linear movement in direction of the x-axis. The rotation of the firewall is realized by a curve disc ❹, which is assembled on a splineshaft. A gear drive is the connection between the linear movement and the rotation. At the end of the linear movement a deformation tube absorbs the remaining kinetic energy of the sled and the system is fixed in the reached position. Otherwise the HYGE-sled acceleration would cause a shifting of the intrusion system backwards due to inertia.

TESTING WITH THE FOOT WELL INTRUSION SYSTEM

The intrusion system can be used in static tests as well as in sledtests. The test setup will be described in the following paragraphs.

Static laboratory testing

For static laboratory tests the intrusion system will be mounted on a platform or in a body in white (see Fig. 3.). With such an assembly protection devices can be tested and developed as well as analysis about the intrusion of the foot controls can be performed.

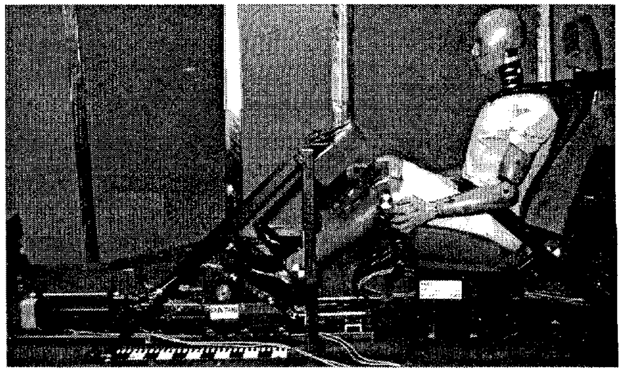

Figure 3. Foot well intrusion system mounted on a platform

Sled testing

PARS realized multiple sledtests on its HYGE-sled. Therefore the system will be integrated in a body in white (see Fig. 4.). The dummy and the feet have to be placed in the requested position.

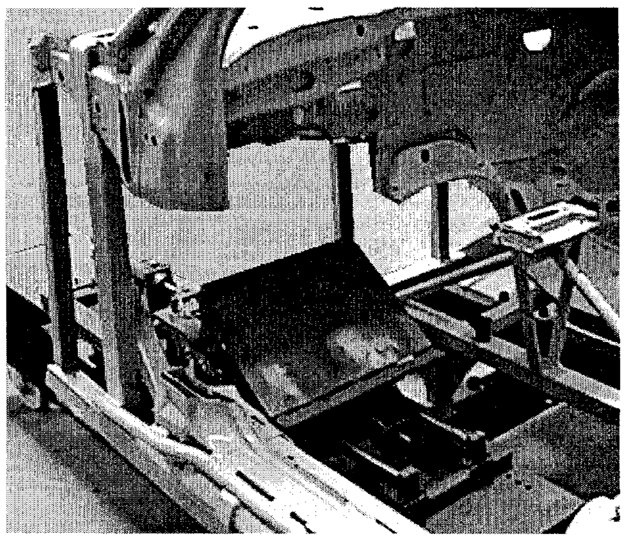

Figure 4. Foot well intrusion system mounted in a sled buck.

The system is actuated by timer ignition independent of the sled pulse. It carries out a combined movement of a linear intrusion and a rotation around y-axis.

Setup parameters

By changing several adjustable parameters the system could be varied in a wide range. So it could be adapted to nearly every kind of intrusion movement in order to represent crash behavior of different cars.

- The relation between the linear movement and the rotation can be changed by a different transmission ratio.
- Curve discs with a geometric cam could be used.
- To achieve different accelerations of the system the charge of the pyrotechnical drive can be changed.
- The movement of the sled can be adjusted from 50 mm to 250 mm with a stopper.
- The position of the firewall before crash can be fixed with a distance holder in an area between 30° and 45°.
- The angle of rotation of the foot panel can be adjusted from 0° to 45°.

To compare the results of the sledtests with the crash it is necessary to place measurement equipment in a similar position compared to the crash.

COMPARISON BETWEEN THE RESULTS OF A CRASHTEST AND A SLEDTEST

During a study several crashtests were performed at PARS. A baseline setup for the HYGE-sled was defined by these crashtests. A comparison between the crashtest and the sledtest is shown in Fig. 5. and Fig. 6. The foot acceleration, tibiaforce and tibiamoment are shown representative in the diagram. The left and right foot are presented in separate diagrams.

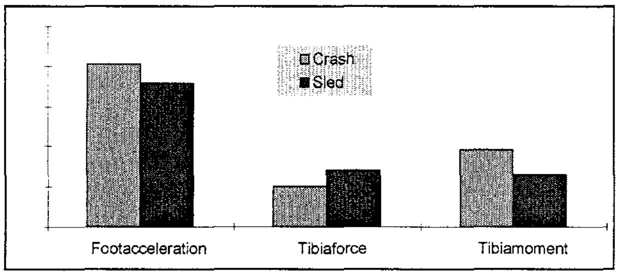

Figure 5. Comparison between crash and sledtest for the right leg.

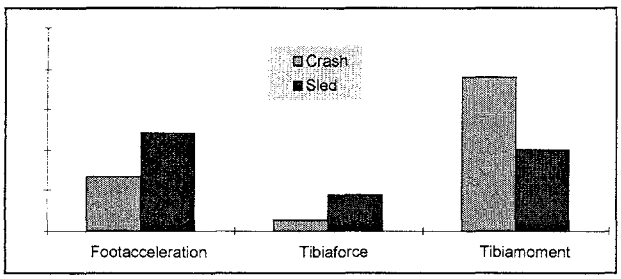

Figure 6. Comparison between crash and sledtest for the left leg.

Due to the fact that the intrusion system has only one platform for moving both feet a priority which feet will be reproduced has to be set. In the shown test the optimization was made for the right leg. In this case the loads between sled and crashtest are very close, which is verified in Fig.5. In comparison to that the loads on the left leg shows more differences (Fig.6).

SUMMARY AND CONCLUSION

PARS owns with the intrusion system a test tool which is utilized in static laboratory tests as well as in sledtests. The intrusion system is in use for several studies to develop protective devices for lower extremities. These are for example foam, airbag, optimized foot controls and other constructive solutions.

At this time PARS works out a second state of development of the foot well intrusion system. This system will be fitted out with two foot panels to reproduce the different loads and movements of each foot. Further development goals are the reduction of the accelerated mass as well as modifications on the mechanical parts.

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