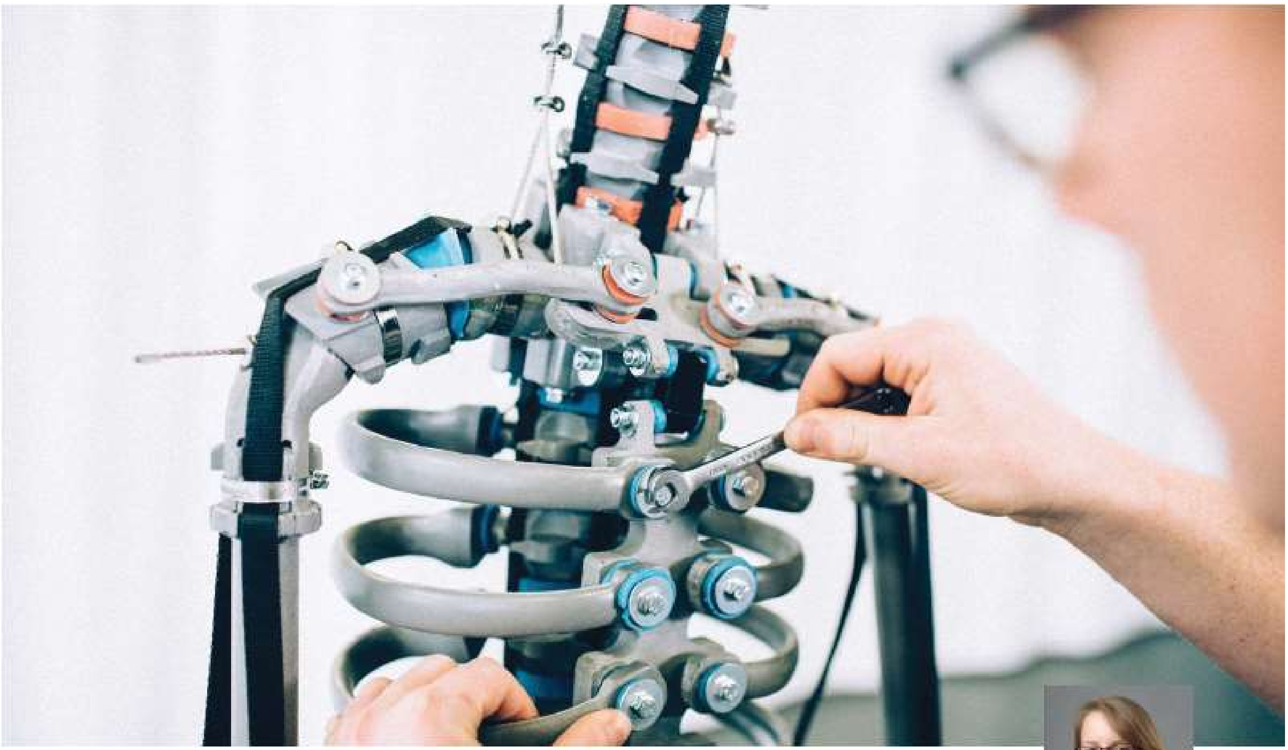

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Crash behaviour in crash test comparison: the new Biofidelic Dummy

In the reconstruction of passenger car-pedestrian accidents, the vehicle damages and the pedestrians injuries are important indications, which can now be realistically reproduced by means of the new biofidelic dummy.

Pedestrian accidents require a detailed reconstruction of the accident happenings due to the severe injury consequences often caused to the unprotected road traffic user. For this reason, in modern accident reconstruction crash tests in which dummies are used are increasingly resorted to. In particularly important for limiting the collision velocity of the passenger car are, inter alia, the vehicle damages caused.

The dummies previously used for such crash tests usually have a “bone structure”, which mainly consists of aluminium and steel, so that the extremely hard construction of the dummy much greater damages to the vehicle causes than in real pedestrian accidents at the same collision speed. The comparability of crash tests therefore has significant uncertainties.

The biofidelic dummy as a real replacement

Since the beginning of 2017, the company crashtest-service.com GmbH (short CTS) has, in cooperation with the HTW Dresden and the TU Berlin, taken over the construction and development of the so-called biofidelic dummy from Dr. Michael Weyde and have since July 2017 their own manufacturing laboratory, see figure 1.

Due to the special construction, the biofidelic dummy has a very good comparability with the real human body. The materials used are selected according to their physical properties in order to reproduce the human “body parts” as precisely as possible. The “bones” of the dummy are, for example, made of epoxy resin and an admixture of aluminium powder in order to be able to reproduce the breaking resistance of human bones as realistically as possible. Also ligaments and tendons in the form of polypropylene straps form part of the biofidelic dummy. The reproduction of the soft tissues is accomplished by silicone and acrylic.

Figure 1: Production process in the new dummy laboratory

Since every dummy is assembled by hand, step for step (see figure 2), is it also possible to deviate from the standard construction of the dummy with a height of 1,75 m and a weight of 79 kg to make custom-made models in terms of height and weight. The production time of a standard biofidelic dummy is approximately 2 weeks, custom-made products can be achieved in around 4 weeks. Due to the in house production at the company CTS, the dummy can be equipped with measuring technology during the finishing procedure, so that, for example, collision induced accelerations and forces occurring in the area of the cervical spine can be measured. By installing special sensors, the pressure can be measured which impacts, inter alia, areas such as the chest or individual segments of the spine during the collision.

Crash behaviour in crash comparison

In order to make the differences in the crash behaviour of the conventional dummy in steel-construction compared with the biofidelic dummy visible, a crash test was carried out in which a VW Golf III collided head on with an urban-usual speed of 50 km/h simultaneously with the two dummies. Figure 3 shows the impact configuration with a conventional (NAMI-) dummy in vehicle plan view on the left side. The biofidelic dummy is on the right side.

The differences in the movement sequences of the dummies during the collision, in particularly in the carrying-phase, were filmed separately and are shown in figure 4 and figure 5. Figure 4 shows the movement sequences of the conventional dummy. Immediately after the impact, the legs of the dummy raise from the ground, a pedestrian accidents' typical "undergoing" of the legs does not take place. Due to the rigid construction of the NAMI-dummy, the dummy does not cling to the car bonnet and collides in an almost stretched out position with the head against the windshield. In the last image in figure 4 it is clear to see that the body of the NAMI during the impact of the head has a significant clearance to the bonnet.

Figure 2: Production stages of a Biofidelic Dummy

Figure 3: Impact configuration: conventional dummy left, biofidelic dummy right

The movement sequences of the biofidelic dummy by the impact of a passenger car (figure 5) resembles the impact behaviour of a real pedestrian, by which the standing leg is pulled under the passenger car and the dummy clings to the bonnet during the course of the collision. The head impact occurs with a movement from the top downwards whilst the body makes contact with the bonnet.

Damage characteristics on passenger car

Also the comparison of the damages on the left and right side of the passenger car after the collision gives a much more realistic accident representation through the use of the biofidelic dummy. Figure 6 shows a top view of the vehicle front of the VW Golf III after the collision: left the damage pattern made by the NAMI, right the damage pattern caused by the biofidelic dummy. It clearly shows that the passenger car in the contact area with the NAMI is much more severely damaged. Also the fracture pattern in the windscreen is diffused on the left side and the detail view in figure 7 shows clearly that the NAMI, in comparison to the biofidelic dummy, actually penetrates the windscreen with its head. As a result of the clinging of the biofidelic dummies body during the collision, the contact of the hips and shoulder can be recognised afterwards in the damages caused to the bonnet, see figure 8 (right image). During the impact of the NAMI on the car bonnet, the damages caused are extensive and also include several scratches, which would not occur in a real pedestrian accident (figure 8, left image).

In particular, at higher collision velocities, where the dummies contact the roof edge, the most commonly used NAMI or Hybrid II-dummy cause significantly more damages in contrast to an impact in the same area with a human body. For this reason, the estimation of the collision speed in accident reconstruction is made difficult.

Injury characteristics of the pedestrian

Besides the damages caused to the passenger car, the use of the biofidelic dummy makes it now also possible to compare the injuries of the pedestrian in a real accident with those caused to the dummy.

Through the addition of aluminium powder in the epoxy it is possible to x-ray the biofidelic dummy after the collision in order to see any fractures or breaks resulting from the crash test. This principal is presented in figure 9 in form of a CT-scan of the predecessor model of the biofidelic dummy. In this case, the collision velocity at impact with the dummy was approximately 70 km/h.


Figure 4: Movement sequence of the NAMI-dummy in crash test


Figure 5: Movement sequence of the biofidelic dummy in crash test (mirrored)

Figure 6: Overview of the damaged passenger car

Figure 7: Fracture pattern on the windscreen

Figure 8: Contakt marks on the bonnet from the NAMI (L) and the biofidelic dummy (R)

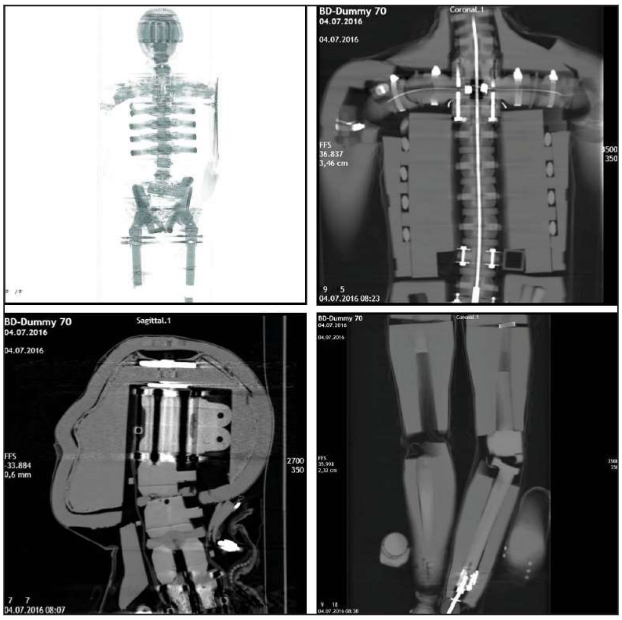

Figure 9: CT-scan of a biofidelic dummy (1)

The x-ray examination can be carried out after the crash test at and in cooperation with the veterinary clinic in Telgte, who obtained an official authorisation from the district government for undertaking such examinations. If required, an autopsy of the biofidelic dummy can also be done after the collision. After carrying out crash tests for the reconstruction of passenger car-pedestrian accidents, it is possible for the biofidelic dummy to be repaired by CTS, so that the cost of the dummy for the crash test is only limited to the rental fee and therefore the dummy must not be completely charged for.

Conclusion

In modern accident reconstruction the biofidelic dummy is a great benefit in order to limit the collision speed based on the damage characteristics of the passenger car. With the construction design of the biofidelic dummy and the physical properties that resemble those of the human it is possible to also realistically recreate the injuries of a pedestrian. The use of various types of measuring technology also offers extensive possibilities to record forces acting on the body, acceleration and pressures. The biofidelic dummy is constantly being further developed, so that, for example, the mobility is continuously improved and at the beginning of 2018 the dummy also received (among others) a new face with a bone structure made of epoxy. For accident reconstruction is it thus preferable that the biofidelic dummy be used in order to create sound expert reports based on comprehensive and visual documentation of damage patterns to the passenger car and the dummy and any measurement data obtained.

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(Please note that this document is a translation of the original publication "Crashverhalten im Crashvergleich: der neue Biofidel-Dummy" from the Ureko Spiegel 20/2018)