Comparative Studies of the Behavior of Anthropometric Test Devices at Frontal Impact

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Abstract. The importance of motor vehicle testing stems from the fact that different types of testing, as an integral part of the process of research, development, construction, manufacture, operation and repair, make a decisive contribution to their continuous improvement at all stages. The tests are aimed at verifying that the main constructive, technical-economic parameters, quality of execution, performance, operational safety and wear resistance of the vehicle correspond to the technical documentation.

In most cases, the testing of motor vehicles solves the determination of the parameters and the research of the processes that characterize the operation of the different subassemblies and mechanisms, as well as in motor vehicles as a whole. Experimental research in polygon will be studied compared to virtual and laboratory.

Keywords: ATD · Frontal collision · Safety

1 Introduction

According to traffic police statistics, most accidents in Romania are due, in 29% of cases, to excessive speed and inadequate road conditions. The main cause of road accidents in our country is the misconduct adopted by a significant number of road users. Among the victims (dead and injured) of road accidents, in first place are drivers (64%).

A car accident simulation is a virtual recreation of a destructive impact test, using a computer simulation to examine the safety level of the car. Crash simulations are used by researchers using Computer Aided Engineering (CAE) analyzes for strength calculations in the CAD (Computer Aided Design) modeling process of vehicles. During such a simulation, the kinetic energy - the energy of motion that a car has before the impact is transformed into deformation energy, largely by plastic deformation of the body material, at the end of the impact.

Data from a crash simulation indicate the ability of a body structure to protect passengers during a collision. The important results obtained by such simulations are the deformations of the passenger space and the decelerations felt by them, which must

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be below the threshold values established in the legal regulations of car safety, to perform virtual impact tests, car accident simulations include virtual models of test dummies and passive safety devices.

The virtually determined data were corroborated with those obtained in the test site.

The vehicles to be tested shall be run-in, with all fillings made and checked, brought to the state of loading prescribed in the test program (usually the maximum permissible total weight).

Except for the determination of the maximum ramp, all tests of dynamics, stability - maneuverability, are performed on road sectors or test tracks (from the polygon), horizontal (local deviations of maximum 0.5%), rectilinear, with hard coating (concrete or asphalt) having at both ends sections of road long enough to achieve the acceleration at the desired speed and to obtain stabilized travel regimes, before the actual measurements begin.

The characteristic points, of the surface where the experimental test is carried out, will be signaled accordingly, for this purpose the kilometric and/or hectometric terminals of the public road can be used when the tests are made on these categories of roads.

2 Experimental Method

The experimental researches, carried out in order to realize the collision scenarios, in conditions as close as possible to the real ones, presupposed the following stages:

- analysis of the current level of experimental research;
- establishing the objectives of the test, the quantities to be measured and the types and modes of collision, respectively;
- choosing the respective manikin of the types of vehicle used;
- checking the operation of the vehicle with the related measuring installation; fixing the physical quantities to be tracked;
- selection or realization of the measuring equipment (network of sensors and transducers) corresponding to the intended purpose; preparation of vehicle for experimental tests;
- calibration and configuration of measuring devices (technical system) for the determination, recording, processing and interpretation of measured data;
- equipping the manikin and the vehicle for the experimental tests;

In the stage preceding the experimental tests, the assembly of sensors and transducers shall be installed together with the corresponding wiring for data recording and storage, taking measures to protect them and thus eliminating the possibility of disturbing the normal driving of the vehicle by them.

The vehicles are simultaneously equipped with redundant sensors, transducers and the proposed computer system for measuring the variables of interest at the level of the manikin but also at the level of the vehicles involved in the collision.

During the experimental tests, in order to measure the data of interest, inside the impacted vehicle, on the driver's seat, according to the procedures for solving the proposed objectives, a test model was placed, of male type, quite complex, reproducing

Fig. 1. Simulation of collision requests. The tree trunk installed on the clamp

the human body, mass), which complies with the standards of anthropomorphic testing devices FMVSS Nr. 208 for the evaluation and certification of occupancy movement limitation systems in a motor vehicle, being equipped with a network of sensors at the level of the head, neck, torso and limbs, which measure the load loads in three directions.

The cylindrical clamp can be used for all types of collisions (front, rear or side). The collisions were made according to the trajectories passing through the center of mass, but there were also non-centric trajectories (Fig. 1).

3 Virtual Method

SolidWorks software, which is specialized for mechanical engineering, was used to design the car but also the test model. The main module has been designed for the design of components and assemblies. Also, parts and assemblies can be automatically imported into the drawing generation module in which all documentation can be organized for a mechanical project [1].

For starters, the main parts and assemblies can be generated in the component definition module using flat sketches. Starting from these sketches, the solid bodies are later defined.

Several additional types of shapes can be attached to the basic shapes thus defined:

- additional shapes (all types of bosses) [2, 3];
- other forms such as bevels, connections, caps, “shell” shapes, etc.

These shapes can also be solid shapes or solid shapes. After several similar operations, the main components and assemblies of the studied car system were obtained. Fig. 2 shows some important components of the system.

Using this methodology all the necessary components of a mechanical system can be defined. Already defined components can be assembled using the parameterized assembly module. This CAD module is based on a main window where parts and subassemblies can be grouped and assembled.

The manikin model was introduced in the car system consisting of car, ground and obstacle. Figure 3 shows the model of the manikin attached to the studied system.

The complete model of the impact test system was exported in an analysis program that preserves the geometric links (motion constraints) [5, 6].

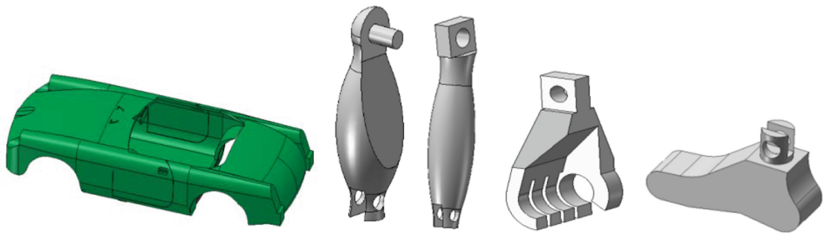

Fig. 2. Virtual models for car components and ATD

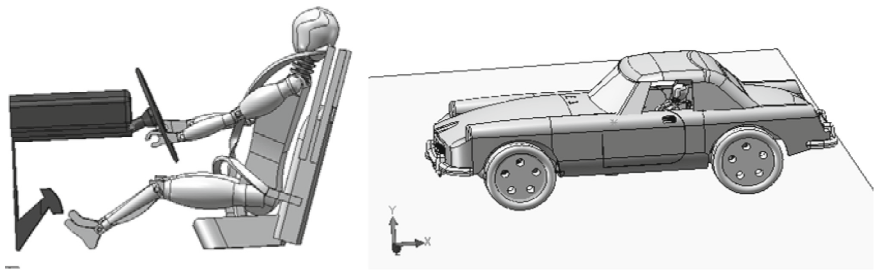

Fig. 3. ATD inserted in the car model

These have been supplemented with:

- necessary additional kinematic couplings (geometric links) to ensure the consistency and freedoms of movement of the studied system.
- materials similar to the real model were attached to the transferred solids.
- the initiation of the movement (initial speed of the car) was achieved by using an actuator with linear action. Its action takes place over a very short period, imprinting the initial speed of the car, and it will run freely on the ground until it meets the obstacle.
- the manikin's belt is attached to the seat by a virtual spring so as to simulate the flexibility of the protection system.
- between the legs and the torso of the manikin, on the one hand, and the seat and the belt, on the other hand, a Collide-type connection was defined having a contact friction coefficient of 0.5 and a restitution coefficient of 0.1.
- for the mannequin components the masses of the different components were considered based on the data from the specialized bibliography, [7–9].

4 Analysis of Theoretical and Experimental Data

Running the analytical models for the virtual simulation of the lateral collision from a certain angle and the experimental tests, in real conditions, allow the analysis of the load tasks and the dynamic behavior of the driver or the passenger on his right.

The virtual simulation and the experimental test tests, in polygon conditions, were performed for low speeds between 20 and 50 km/h, with the angles between different vehicles respectively between the vehicle and the fixed rigid vertical cylindrical obstacle.

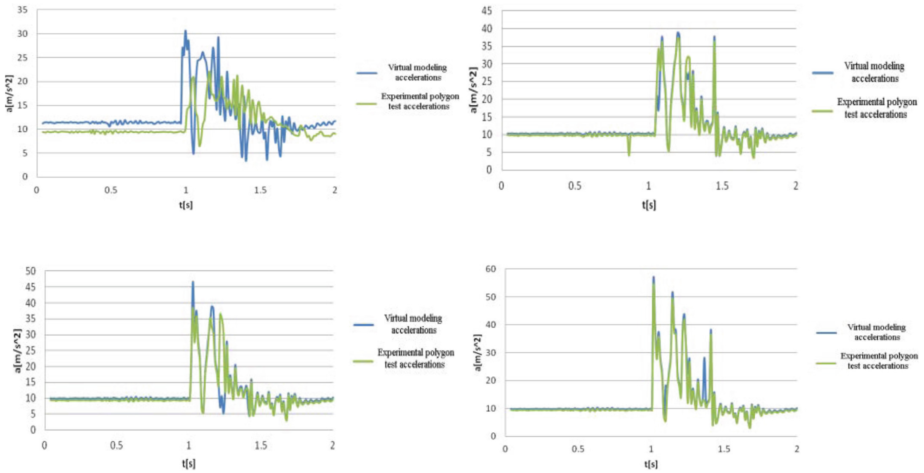

Fig. 4. Comparative diagram of accelerations at head level of the test dummy at a speed of 20–50 km/h

The study shows that in most collision tests on motor vehicles, in which the test dummies are used, the HIC criterion is considered as a reference for assessing the degree of head injury. Following the experimental collision tests, the results aimed at varying the components of the acceleration, speed, and linear displacement at the occupant level over time.

The severity or quantification of brain damage or a cranial fracture is given by both the size of the acceleration and its duration. Accelerations of 200 [g] exercised for 2 [ms], or accelerations of 80 [g] exercised for periods of up to 200 [ms] may be tolerated [10].

Figure 4 shows the data obtained in the experimental model corroborated with the data obtained in the virtual model.

5 Conclusions

The results obtained theoretically and experimentally allowed the establishment of tolerance curves, in which the severity of the lesions is defined by the variation of the acceleration depending on the load.

The diminution of the driver's post-traumatic consequences has led to the need to study the cranio-cervical area, so that, through virtual research and modeling, completed by experimental research, in the test site, the main dynamic parameters that appear in such situations can be determined. It can also be studied by replacing static dummies with robotic systems that may have reactions in the moment before the impact would be a real plus in the research of complex phenomena that occur during a collision [11, 12].

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