

NEW TECHNOLOGY

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MIRA 60

Celebrating 60 Years of Vehicle Engineering



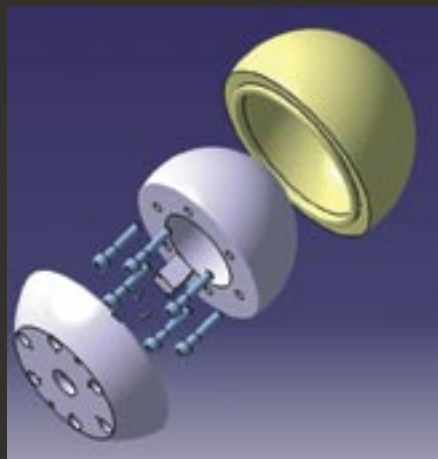
Pedestrian Protection - Oliver Tomlin

The implementation of EU legislation on Pedestrian Protection is now well advanced with the introduction of Phase 1 Directive 2003/102/EC in October 2005. A Phase 2 Directive is currently under review and nearing its conclusion for implementation of pedestrian protection requirements in 2010 and the proposed introduction of Brake Assist from 2008.

The legislation has taken several forms and many years to reach this stage. The first proposals were launched in 1991 with the EEVC WG10 document. It became obvious to MIRA that compliance with these requirements by vehicle manufacturers would not be done through testing alone and so the first generation of Finite Element (FE) impactors conforming to WG10 standards were developed and used for several years on customer research projects. Subsequent discussions concerning impactor biofidelity, robustness, injury limits and practical design considerations led to EEVC WG17 proposals and later the Industry Commitment, which ultimately led to the current EC Directive 2003/102/EC. In addition, the advent of consumer ratings via the EuroNCAP test programme placed differing requirements on the vehicle designers. Thus, the impactor designs were changed, which led MIRA to initiate the development of a second generation of pedestrian impactor FE models, which continue to be updated to take advantage of software upgrades and experience gained from their application.

There are various suppliers of Pedestrian Head FE models who quote very good correlation results and performance predictions. These models are a good starting point, but do not give a high confidence to the end user by virtue of the fact that they have been correlated to the impactor certification tests and are typically built using the legislative inertia properties.

The certification test is used to ensure that an impactor is still within its calibration and the resulting peak acceleration is more than twice what a compliant vehicle would be expected to achieve. The inertias defined in the legislation are given significant tolerances and of course do not represent exactly what is held in MIRA's laboratory. These commercially available FE Impactors are typically not subjected to any rotational acceleration during their correlation and this has been found to have a significant effect on the HIC calculation. MIRA is in a unique position; very few suppliers of FE analysis also maintain a laboratory of the current pedestrian impactors, so MIRA was able to capitalise on this position by using these physical test devices as the basis for the FE models.



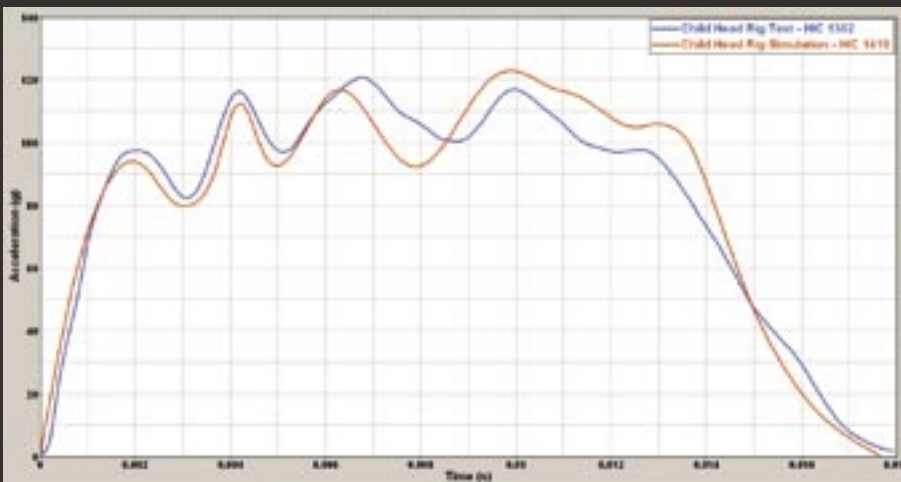
MIRA planned a large test and correlation programme to ensure that its pedestrian FE impactors would be industry leaders for accuracy and reliability. The testing programme began with simple drop tests of the impactors onto a rigid plate. This removed the influence of the impacted structure, any rotational effect and produced purely deformation of the rubber skin. This gave the FE engineers a basic starting point to assess the rubber skin model and the export of acceleration results.

Before any high-speed impacts were conducted, a rig was designed specifically for the testing of pedestrian heads. The concept of the rig was to produce a structure with a stiffness that was representative of a vehicle bonnet designed to meet the legislation. Within this rig, components were also added to represent a vehicle that failed to meet the legislation, by creating secondary contacts. This rig drew on previous experience and was thus simple to represent in the FE model, with very few potential variations between the simulation and test.

Test Scenarios

A total of 36 tests were carried out using the three different Pedestrian heads, with three scenarios for the child and small adult heads, four scenarios for the adult head and three tests per scenario. The test scenarios represented the likely attitude of the impactor when impacting compliant and non-compliant vehicles, with the third scenario being designed to represent a compliant vehicle with a steeply angled bonnet, thus the impact was perpendicular to the rig, producing no rotation of the head.

In parallel with the head testing phase a series of tests were carried out to determine the mechanical properties of the rubber skin. The skin was changed from a silicone rubber in the WG10 head to a PU rubber in the WG17 head. These tests were conducted at various strain rates in order to fully characterise the rubber's behaviour. Due to the inherent difficulties encountered when testing rubber materials at high rates in compression, a reliable mathematical model of the PU rubber was used to predict the results at the highest rates. These results were then used to create an LS-DYNA material model and an FE model of the test was built to ensure that this definition was reliable at all relevant



rates. In addition to the material testing, the coefficients of friction between the skin and the aluminium centre and a vehicle bonnet were tested. This was carried out at various velocities and the friction decay coefficient was defined using these test results.

The inertia properties of the aluminium components of the three heads were obtained by testing. This gave accurate values of precisely the impactors present in the laboratory. It also gave MIRA the opportunity to ensure that the influence of bolts, wires and accelerometers was included and that all the relevant components were measured.

Accelerometer Definition

Finally, before the entire test data could be brought together to build up the FE model, the accelerometer had to be defined. It had been noted in laboratory tests that there were differences between the HIC results for the WG10 and WG17 impactors. This had been traced to the radial orientation of the accelerometer about the axis of travel. The rotational acceleration induced in the head during an impact, could produce different HIC results between accelerometers, due to the

distance of the seismic masses from the C of G of the head. MIRA invested much effort in ensuring that the seismic masses were positioned in the FE models of the heads at the correct location and that this was then orientated in the same manner as the test laboratory.

The correlation of the FE models began with the drop tests. Sensitivity of the results to the friction coefficients and correct use of the rate sensitive rubber material model was noted. Confirmation of the orientation of the accelerometers was also made. Following this initial assessment of the performance of the FE models, MIRA was able to move on to compare their performance with rig tests. It was during this work that the difficulty in designing a rig to isolate the performance of an impactor was further noted. Following a detailed investigation in to the material and manufacturing techniques used for the test samples MIRA was able to correlate the impactors to the tests with a very high degree of confidence. The up front investment in a high level of detail, sub-system testing and correlation and the correct design of the FE model reaps its rewards when correlating. Very few parameters were modified in the impactor models to achieve the final corre-

lation. Having employed these impactors in live projects, correlation to HIC values has been within 9 per cent, with a very high degree of curve signature representation.

This work completes MIRA's family of FE pedestrian impactors, all of which have been subjected to a similarly detailed level of scrutiny and sub-system correlation before final impactor correlation. All of these impactors have been used extensively on live customer projects with great success. By combining a detailed knowledge of the simulation techniques and linking that with real world experience MIRA is able to offer a unique service in the design and engineering of vehicles to meet the legislative targets and achieve high EuroNCAP scores.

Indepth Understanding

Reliable, accurate and robust impactor models, coupled with sound FE modelling techniques and an indepth understanding of how to design for pedestrian protection are the necessary ingredients to ensure its successful integration into a modern vehicle. The blend of these factors brought to bear on a vehicle programme can greatly help manufacturers in the successful development of their vehicles and can help maximise opportunities for styling to create an attractive looking car that people will want to buy. ●

Oliver Tomlin graduated from Loughborough University with an Honours Degree in Mechanical Engineering in 1998. After gaining a strong foundation in composites manufacturing and motorsport engineering at Lotus Engineering, he joined MIRA's graduate training programme. After gaining chartered status he specialised in crash simulation. Currently a technical leader in structural simulation, he is heavily involved in managing MIRA's contribution to a major aerospace composites research project.