

Project:

MRTN-CT-2009-ESR11 MYMOSA  
Deliverable 3.2: Design of protective equipment

**EUROPEAN COMMISSION**  
**RESEARCH**

**SIXTH FRAMEWORK PROGRAMME**  
**MARIE CURIE RESEARCH TRAINING NETWORKS**



# MYMOSA

**Motorcycle and motorcyclist safety**

<b>Deliverable no.</b>	<b>3.2 Part 2</b>
<b>Dissemination level</b>	<b>Public/Consortium/</b>
<b>Work Package</b>	<b>WP 3: Personal protective equipment</b>
<b>Author(s)</b>	<b>David Hailoua Blanco, Alessandro Cernicchi: Dainese S.p.a</b> <b>Ugo Galvanetto: Imperial College London</b>
<b>Title</b>	<b>Design of protective equipment</b>
<b>Status (Final, Draft)</b>	<b>Final</b>
<b>File Name</b>	<b>WP32_part2-abstract.pdf</b>
<b>Project Start Date and Duration</b>	<b>01 October 2006 - 30 September 2010</b>



Project:

MRTN-CT-2009-ESR11 MYMOSA  
Deliverable 3.2: Design of protective equipment

ABSTRACT

The goal of the current project was to evaluate new energy absorbing materials for the manufacture of safety helmets by defining a procedure based on the execution of Finite Element analyses. The project was mainly focused on the helmet energy absorbing liner, which is the component that absorbs the greatest amount of energy during an impact. The innovative liner consisted of an ABS plastic lamina with deformable cones. Energy was absorbed via a combination of folding and collapsing of the cones. The work aimed at studying this new liner as alternative to the current EPS foams.

During the research period, multivariable optimization tools were used (Optimus and LS-OPT) to select the safest design configurations among all the technologically feasible possibilities. A new computerized approach including automated CAD update design, meshing and job submission to the finite element solver LS-DYNA was established at Dainese S.p.a. This technique allowed for a quick parameter evaluation and subsequent liner design optimization.

The strategy of the investigation led to the identification of the most relevant cone design parameters in order to proceed with a global helmet optimization. Several geometrical parameters besides cone thickness were considered. Design of experiments (DOE) and Response surface methodology (RSM) were used to evaluate the effect of the various cone parameters on the impact energy absorption as well as peak force. From the numerical results, statistical correlations and mathematical models were created to identify a reduced set of design parameters.

Simulations of the parameterized helmet were carried out with LS-DYNA according to the European standards ECE 22.05. The maximum acceleration and head injury criterion (HIC) were computed for impacts prescribed by standards. Further data for the helmet design analysis and optimization was obtained with the DOE and RSM. Eventually, an optimized geometry minimizing the peak acceleration and HIC was suggested.

First results indicated that kerbstone impact was critical compared to that on flat anvil for this specific liner. Furthermore, simulation results showed the importance of tying the cones to the shell in impact conditions. Numerical impacts carried out on the front side put in evidence that the cones bent in the compression stage if no constrained was applied. This was attributed to the existing shear forces that appeared between the cones and shell interface. Therefore, the onset of cones bending resulted in a less efficient energy absorption folding mode as compared to the cone axial collapse. Due to geometrical reasons, bending may be more relevant in helmet regions with lower radius of curvature (front and rear).

Optimized impact results showed better helmet performance on front and rear areas compared to side and top regions. This was due to the fact that on large radius areas (flat), the shell suffered from premature buckling compared to areas with smaller radius of curvature, making more difficult to properly spread the impact load. Hence, kerbstone impact became even more critical on side and top regions compared to the front and rear areas. Problems regarding excess in stiffness were found at the crown site. Potential solutions included new cones liner distribution to comply with the standards. According to the current design, there may be a notable difference when the kerbstone impacts the helmet between the cones or on a cone area. Shell stiffness was proved to partially solve this problem increasing its stiffness and thus better spreading the impact load. It has to be pointed out that the choice of this design was made in accordance to a possible manufacturing design which established 21.5 mm of base radius for a

Project:

MRTN-CT-2009-ESR11 MYMOSA  
Deliverable 3.2: Design of protective equipment

height about 35mm. Another possibility to be studied is to make smaller cones and further cover the shell area in order to better manage the kerbstone impact.

The comparison between the new liner and the EPS in impact conditions showed promising results. In general, there was a reduction in peak acceleration and especially HIC values. The main advantage that this helmet may introduce to motorcycle community besides impact management is the comfort. A decrease in weight is expected and no need of special ventilations may be necessary as air could easily flow between the cones. Furthermore, 100 % recyclable materials would be employed for the manufacturing of such liner (engineering plastics: ABS, PC). On the other hand, the main drawbacks or technological issues to be solved are the manufacturing and gluing process of the liner.