Proceedings of COBEM 2009

20th International Congress of Mechanical Engineering
November 15-20, 2009, Gramado, RS, Brazil

Advances in Solid Mechanics: Crashworthiness of aluminium structures - Modelling and validation

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Abstract. *Lightweight materials such as aluminium offer the automotive industry an opportunity to design and manufacture high-performance vehicles that are safe, energy-efficient and environmentally friendly, and much lighter than traditional designs. However, the introduction of these materials will challenge the automotive design engineers to explore and develop new solutions in design and production technology in order to fully realize the potential that can be gained in the interaction between these materials, product/structural design and the manufacturing process. Even though aluminium is an "old" material, it is relatively new as a load-carrying material in the automotive industry. This implies that material producers and parts suppliers have to develop new knowledge about these materials to gain an increased market share.*

In order to meet the future challenges with respect to the use of aluminium as a structural material in the automotive industry, the product development to day is increasingly carried out in virtual environments by using computational mechanics. Even though great advances have been made in modelling, the designer must still use knowledge about the physical mechanisms controlling the product performance. The designer must also know what simplifications can be made in the modelling and still retain sufficient reliability and accuracy. At all levels of modelling, experimental validation of the numerical models to be used is required before the models are accepted.

In the period 2007-2014 the SIMLab research group at NTNU is defined by the Research Council of Norway as a Centre for Research based Innovation (www.ntnu.no/simlab). One of the objectives with the centre is to provide the industrial partners with reliable and robust engineering models of aluminium to be used in crash analyses. Thus the present presentation will focus on some of the modelling activities carried out in the centre as well as the validation of these models and try to highlight some of the needs and challenges mentioned above by using aluminium in the automotive industry. In the introduction an overview of aluminium as a structural material will be given and the strong and weak points about the material will be defined. Examples will here be given on typical mechanical properties that have to be taken into account in the developed models in order to have good and reliable predictions. Then the use of aluminium in the automotive industry will be discussed as an introduction to the models developed by the SIMLab group on thermoplastics, aluminium foams, self-piercing rivets, aluminium extrusions and plates, aluminium castings and magnesium. Finally the developed models for aluminium and self piercing rivets will be validated against component tests in the laboratory. For the self-piercing riveting activity an engineering and research strategy will be shown in order to develop a shell-based model where an interaction between process and component testing and process and component numerical simulations are carried out.