LIGHTWEIGHT DESIGN AND CRASH ANALYSIS OF COMPOSITE FRONTAL IMPACT ENERGY ABSORBING STRUCTURES

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Summary. Nowadays thin-walled components in CFRP composite materials are progressively replacing metals for crashworthy applications in the automotive industries, thank to their undoubted advantages among which high strength to weight ratio. The tubular devices have been shown to perform at their best when geometric, material and loading conditions are such that axial failure of the tubes is characterized by the progression of a destructive zone of constant size at the loaded end, called “crush zone”.

The challenge of design is to arrange the column of material such that the destructive zone can progress in a stable manner. The energy absorption must be as high as possible by allowing the development of a sustained high level crushing force, with little fluctuation in amplitude as the progress zone travels along the component’s axis.

Due to the complex mechanical behaviour of advanced composites, the capability of the existing analytical and numerical models to predict the crushing behaviour of composite structures is still limited and need more detailed scientific study to be fully understood.

Therefore the present paper is dealing with the implementation of analytical methods and explicit FE code LS-DYNA to the simulation of the crash behaviour and energy absorption characteristics of CFRP composite tubes subjected to dynamic axial impact loading. In order to do a complete comparative analysis the composite tubes have been also tested experimentally, through a drop weight test machine. Despite the complexity of the fracture phenomenon, a good agreement between analytical, numerical and experimental results has been achieved.

In order to ensure the driver’s safety in case of high-speed crashes, special impact structures are designed to absorb the race car’s kinetic energy and limit the deceleration acting on the human body. To reduce the development and testing costs of a new safety design, it is recommendable to use computational crash simulations for early evaluation of safety behavior under vehicle impact test.
This study, also covers the analysis of the crash behavior and the lightweight design of the composite nose cone as the Formula SAE racing car front impact structure. Quasi-static and dynamic experimental crash tests are performed and reported together with numerical simulation of dynamic stroke with explicit solver LS-DYNA. The main idea of the research was to demonstrate energy absorbing capabilities of a thin-walled crash box during the frontal impact, with the lowest initial deceleration. In order to initialize the collapse in a stable way, the design of the composite impact attenuator has been completed with a trigger which is consisted of a very simple smoothing (progressive reduction) of the wall thickness. The comparison and evaluation of results showed good agreement between experimental crash test data and numerical simulations. Initial requirements were set in accordance with the 2008 Formula SAE rules and they were satisfied with the final configuration.

REFERENCES