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The Kinematics Model – A Numerical Method for the Development of a Crashworthy Composite Fuselage Design of Transport Aircraft

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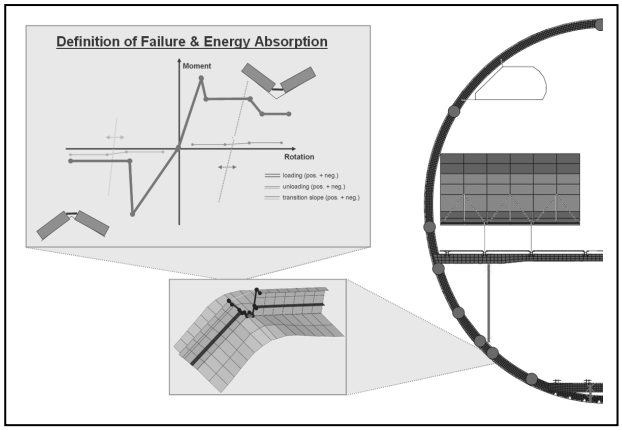
Abstract

Crashworthiness research for transport aircraft fuselage structures becomes more important particularly with regard to the increasing use of CFRP in primary structures. Whereas today´s aluminium fuselage structures offer sufficient crashworthiness purely due to the ductile behaviour of metal, the brittle behaviour of a CFRP fuselage structure implicates the risk of uncontrolled failure with little energy absorption.
Certification rules (special conditions) demand a crashworthiness of CFRP fuselages to be equivalent to that of a standard aluminium fuselage of the same size. To comply with these special conditions a specific crash design has to be developed for a CFRP fuselage structure. This involves the definition of trigger mechanisms, energy absorbing devices and their positioning in the fuselage and may lead to a mass increase of the structure.
The basis for the definition of the structural crash devices is a crash scenario assessment on fuselage section level. This approach considers a crash velocity purely in vertical direction. This simplified crash condition was selected to perform most of the previous crash tests on metallic fuselage structures and represents the basis for current certification routes.
For the numerical assessment of crash scenarios a Kinematics Model was developed based on commercial explicit finite element method. The essential of the Kinematics Model is the potential to define the behaviour of structural crash devices by characteristic input curves using macro elements in the frames, vertical struts and the sub-cargo structure (see Figure). Only by varying the load-deformation characteristics of the crash devices different crash scenarios can be defined, assessed and compared to each other.
Different potential crash scenarios for narrow-body fuselage structures were analysed using this modelling approach. Based on the finally selected crash scenario a pre-sized composite fuselage structure was re-sized to minimize the crash loads on passengers and structure and following to minimize the mass penalty.



Keywords: Transport Aircraft · CFRP Fuselage · Crashworthiness · Crash Scenario Assessment · Numerical Crash Simulation · Macro Modelling

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