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Investigation of an Alternative Crash Concept for Composite Transport Aircraft using Tension Absorption

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Abstract

Transport aircraft made of CFRP have to provide an equivalent crashworthiness compared to today´s aluminium aircraft designs. However, CFRP structures typically show brittle failure behaviour and limited energy absorption, whereas aluminium structures offer sufficient crashworthiness purely due to the ductile behaviour of metal. Specific crash designs have to be developed for CFRP fuselage structures that involve local crash devices for energy absorption and controlled failure mechanisms. Trigger mechanisms, energy absorbing devices and their positioning in the fuselage have to be defined.

In the past, several research activities concentrated on the 'bend-frame' concept that specifies a cargo crossbeam of high strength to allow energy absorption by progressive crushing below this crossbeam in the sub-cargo area. The research work on the bend-frame concept identified critical drawbacks which are mainly found in the mass penalty due to the need of a massive cargo crossbeam and frame design that is able to sustain the crush forces in the sub-cargo area.

In this context an alternative crash concept was investigated that concentrated on tension absorption mechanisms. The focus of this study was on a crash design that provides smooth energy absorption and a lightweight structural design leading to a significantly reduced mass penalty due to the crash sizing.

Numerical simulations were performed on the basis of a generic CFRP fuselage section. The tension absorbers are located in the cargo and the passenger crossbeams that benefit from the tension loads acting in the crossbeams. This is due to the global bending of the sub-cargo structure (cargo crossbeam) and the ovalisation of the fuselage respectively frame structure (passenger crossbeam). Further energy is absorbed in the frame structure.

In the scope of this numerical study potential tension absorber characteristics were determined that led to an optimised and smooth crash kinematics of the fuselage section. The statically pre-sized fuselage structure was adapted to the crash loads to identify the mass penalty caused by the crash sizing. Furthermore, the passenger loads were analysed and assessed with respect to potential injury risks. The results of this simulation study indicate significant benefits for the tension absorption concept compared to the bend-frame concept. The simulations were performed using the commercially available explicit FE code Abaqus/Explicit and the kinematics model approach.

Keywords: CFRP transport aircraft · crashworthiness · tension absorption · Finite element simulation · crash kinematics assessment

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