DEVELOPMENT OF FLEXIBLE MATRIX COMPOSITES (FMC) FOR FLUIDIC ACTUATORS IN MORPHING SYSTEMS

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Abstract
Investigations and results will be presented which have been carried out in the SADE (**Sma**rt High Lift **De**vices for Next Generation Wings) project as part of the 7th Framework Programme (FP7) of the European Commission. The project's aim is to create a seamless and gapless high lift device (droop nose) at the wing's leading edge with the goal to reduce the airframe's noise and drag and enable laminar wing flow (Monner *et al.*, 2009).
To create such a new high lift device a new actuation system for the high lift device has to be developed, keeping in mind that a laminar wing has a lower thickness than a conventional wing and also requires a very smooth surface. As the droop nose is to be an integral part of the wing, the active part needs a flexible skin. To still be able to meet the surface requirements (e.g. very low waviness) the skin has to be supported in many positions leading to a quite complex mechanical actuation system. To reduce system-complexity and also to achieve the required surface shape, the idea is to continuously support the skin through a system of inflatable actuation-tubes. This actuation concept will work pneumatically and make use of flexible matrix composites (FMC) (Shan and Bakis, 2004), which will be presented in the paper.
These FMCs are a combination of highly flexible materials such as rubber and very stiff continuous fibres (carbon or glass fibres). These materials enable a high flexibility in one direction while being very stiff in the other. Combining a tube-like geometry and a variable fibre-angle lay-up enables a wide range of deformation possibilities.
This paper focuses on the possible material combinations for the manufacturing of FMCs and the production methods thereof. Tested were rubber, silicone and thermoplastic elastomer matrices with carbon fibres using different production methods. One focus was to create the production capability for large quantities of easy to use off-the-shelf material, similar to prepreg material for "classical" composite materials. Test specimen based on the gained knowledge were manufactured and characterized for mechanical properties.

Keywords: Morphing structures, flexible composites, carbon fibers, thermoplastic elastomers (TPE), pneumatic actuation

1. Introduction

Most aircraft today are designed for a very specific flight profile and are less efficient if flown outside of that profile (Perkins *et al.*, 2004). To increase the overall efficiency (e.g. drag reduction) and to make the aircraft more flexible in their flight profiles, possibilities have to be found which enable such adaptive aircraft (and also evaluated these changes upon their impact on the overall performance) (Wittman *et al.*, 2009). Literature presents a lot of ideas, e.g. wing-morphing in camber, span-wise or cord-wise direction and the benefit therefrom (Bae *et al.*, 2004; Cesnik *et al.*, 2004; Thill *et al.*, 2008), but the actual technology to achieve the described morphing is in most cases still missing or being developed (Philen *et al.*, 2006, 2007; Murray *et al.*, 2007; Lan *et al.*, 2009).
The SADE project aims to develop technologies for high-lift systems which still enable laminar flow over the wings of a future passenger aircraft. Laminarisation is one of the technologies which can significantly reduce drag and is also within the scope of today's capabilities (Saeed *et al.*, 2009). The project's focus is on the leading