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Title

Implications of extended hybrid laminar flow control suction panels on structural wing design

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Abstract

Drag reduction by means of laminar flow technology has an unparalleled potential for energy saving on transport aircraft. Beck et. al state that for a state-of-the-art mid-range aircraft with fully laminar wings, tails and fuselage the total cruise drag can be reduced by up to 50% [1]. Therefore, maximizing the areas with laminar boundary layer is an important step towards significantly reducing emissions and achieving the goals of Flightpath 2050.

Natural laminar flow (NLF) by passive means and laminar flow control (LFC) by active suction are the two major approaches for delaying the laminar-turbulent transition and hybrid laminar flow control (HLFC) is a promising compromise, combining advantages from both. In most HLFC concepts, boundary layer suction is applied on the leading edge, resulting in laminar flow of up to 36 % in flight tests on commercial aircraft [2]. Fully laminar wings have only been achieved without economic benefit using complex LFC systems, yet.

The Cluster of Excellence Sustainable and Energy-Efficient Aviation (SE²A) is developing an extended HLFC suction panel (xHLFC), where in contrast to common HLFC concepts, the arrangement of LFC on the leading edge and NLF in the rear part of the wing is inversed [3]. Using suction on the rear part of the wing, the concept aims at maintaining laminar flow up to 80 % of the chord length on the wing upper cover.

The suction device consists of three functional components. The outer component is a thin, micro-perforated suction skin and the underlying core structure consists of triply periodic minimal surface structures (TPMS) that stiffen the skins and allow a mass flow. Both components make use of new possibilities offered by additive manufacturing. The third component is the load-carrying wing structure made from carbon fiber reinforced polymer, where the suction panel is attached. The xHLFC concept has two advantages compared to existing concepts. Integral manufacturing of suction skin and TPMS core structures avoids joining of the two components and consequently hole blockage at the interface. Additionally, the TPMS cores allow for a passive suction rate control by modifying their relative density along the chord-wise position.

This presentation investigates implications of xHLFC suction panels on the main wing structure. Therefore, a wing model including the sink for the suction panel is automatically derived from an aircraft wing defined in the common parametric aircraft configuration schema (CPACS). In the simulation, the suction panel components are represented by separate parts. The material model for the core structure hereby depends on its relative density and can be used as a variable in the design process. A fully stressed design of the main wing structure

under a set of selected load cases shows the minor contribution of the suction panel to the load transfer in the wing and the associated additional mass caused by the suction panel depending on its relative density.

References

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