Development of a Manufacturing Process for a Natural Laminar Flow Wing Leading Edge

Manuel Buggisch, Olaf Steffen*, Erik Kappel*, Markus Kleineberg**
(*) German-Aerospace-Center (DLR), Institute of Composite Structures and Adaptive Systems
Corresponding Author: Manuel Buggisch, manuel.buggisch@dlr.de, Deutsches Zentrum für Luft- und Raumfahrt, Lilienthalplatz 7, 38108 Braunschweig, Germany

Drag reduction through laminar flow is one of the very few options to make air travelling more efficient and environmentally friendly. Extending laminar flow to about 50% chord length on the upper wing can potentially reduce the aerodynamic drag by approximately 8% and is therefore absolutely necessary for efficient future aircrafts. To maintain laminar flow as long as possible, extremely challenging step, gap and waviness requirements in the order of 0,1mm need to be met which means that surface disturbances due to bolts and rivets are not acceptable and all geometrical deviations need to be minimised.

One of the objectives within the CS2 project NACOR (**N**ew **A**ircraft **Co**nfigurations and **R**elated Issues) is to prove interchangeability of a Natural Laminar Flow (NLF) wing leading edge within the above-mentioned surface and joining tolerances on a "Ground Based Demonstrator". The development of a suitable manufacturing process for a multi-material leading edge is one of the main challenges. The basic manufacturing approach that has been chosen for the manufacturing verification is a prepreg-autoclave-process with a rigid CTE compatible, modular, outer mould line curing tool. In addition, a process-induced distortions simulation is carried out due to the complex 3D leading edge structure. In relation to the requirements, the shape of the curing mould is 2D compensated.

Besides the geometrical tolerances, the manufacturing process of the leading edge also takes into account the inclusion of an erosion and wing ice protection system. The erosion protection is considered by integrating a 0.1mm thick steel foil on top of the leading edge CFRP main structure. The Wing Ice Protection System (WIPS) includes a conductive carbon fibre layer embedded in several glass fibre layers, which act as an isolator. This de-icing protection system is positioned directly under the steel foil. All three components are placed one after the other in the curing mould. They are combined to a multi-material structure in just a single autoclave process. According to this manufacturing principle three leading edge structures with a realistic wingspan section of about 2.3m are manufactured. Through a detailed geometrical analysis with a GOM ATOS fringe projection system the leading edges are checked and the suitability for the upcoming tests on the "Ground Based Demonstrator" is given.

Überschrift deutsch:
Entwicklung eines Fertigungsprozesses für eine laminare Flügelvorderkante

Short Abstract englisch:
One of the objectives within the CS2 project NACOR (**N**ew **A**ircraft **Co**nfigurations and **R**elated Issues) was to prove interchangeability of a "Natural Laminar Flow" wing leading edge. The development of a suitable manufacturing process for a complex 3D multi-material leading edge, including erosion und de-icing protection, is the main challenge. The basic manufacturing approach is a one-shot prepreg-

autoclave-process using a rigid CTE compatible, modular, 2D compensated, outer mould line curing tool.

Short Abstract deutsch:
Eines der Ziele des CS2 Projekts NACOR ist der Nachweis der Austauschbarkeit von „Natural Laminar Flow“ Flügelvorderkanten. Die Entwicklung eines Herstellungsverfahrens für eine 3D multimaterial Flügelvorderkante, inklusive Erosions- und Vereisungsschutz, stellt dabei eine der zentralen Herausforderungen dar. Als Herstellungsansatz wurde ein einstufiger Prepreg-Autoklave-Prozess ausgewählt, welcher ein wärmeausdehnungskompatibles, modular aufgebautes Formwerkzeug mit einer 2D kompensierten Werkzeuginnenkontur nutzt.