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Title

Novel Scalable Infusion Approach, Utilizing Automated Preforming and Smart Mold with Microvibrations for Manufacture of Integral Aerospace Structures

Authors

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Abstract

One of the ongoing paradigm-shifts in manufacture of civilian aerostructures is the gradual departure from classic prepreg-autoclave manufacturing, and the identification of less energy intensive manufacturing routes.

To that end, a set of innovative technologies and alternate materials were implemented in a novel unified thermoset composite manufacturing scheme based on Liquid Resin Infusion. The individual technologies involved were – 1) Novel automated preforming strategies with dry unidirectional fabrics (IFB), 2) Optimized infusion processes at room temperature, with sustainable polymer resin and corresponding infusion strategies (IAI), 3) A novel smart mold with micro-vibrations for improved fiber wetting and integrated sensors (INVENT). Each technology was developed and matured, both independently and in confluence with the others. Finally, a 1700 mm x 700 mm stabilizer panel, with slight curvature and integrated Omega stiffener elements, was manufactured – demonstrating and validating the various technology developments (see Figure 1).

Typical vacuum infusion processing suffers from a number of intertwined drawbacks. A low viscosity resin is required for efficient preform infiltration. For high Tg resins, this typically requires infusion at elevated temperatures. Besides the energy required for infusion in an oven, this can shorten the pot-life of the resin, and in turn limit the time-window available for full infiltration of the preform. As infusion setups become more complex - in order to achieve structures integrating a few parts infused in a single process ("one-shot infusion") - the risk of an unfilled preform increases, and the appeal of vacuum infusion decreases. The use of a tool with integrated piezo actuators for active impregnation improvement was found to alleviate many of the constraints related to resin viscosity, process temperature and infusion time-window, while increasing the reliability of the infusion process for complex structures.

One of the prerequisites for a viable infusion process is an automated preforming strategy. For manufacture of the skin preform of the final demonstrator, the Advanced Ply Placement (APP) [1,2] process was selected (see Figure 2). In order to process dry fiber fabrics with the APP process, layup strategies were adapted and different deformation mechanisms during layup were studied. Furthermore, the automated processing of wide fabrics for the continuous preforming of omega shaped stiffener elements was studied.

Together with a broader search space for novel resins, different binder materials [3] were assessed, where resin-binder compatibility played a key role. The result is a fiber-binder-resin combination with excellent mechanical properties of the final composite, and minimal effect of binder on the Tg.

The broader framework for this activity is the Clean Sky 2 (CS2) research program, launched and funded by the European Union and its major aeronautics companies, to develop environmentally friendly production methods and improve the global competitiveness of the European aeronautical industry. Within CS2 the ecoTECH project involves the development of new materials, processes, methods and recycling technologies. The consortium includes twelve partners from Germany, Netherlands, Greece, and Spain and is led by IAI. This activity was carried out by the Thermoset technology stream of ecoTECH.

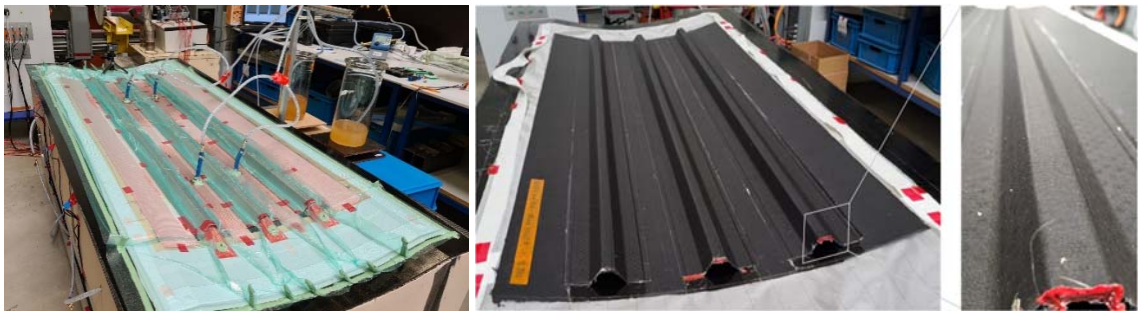

Fig. 1: Infusion setup and final ecoTECH demonstrator

Fig. 2: Advanced Ply Placement (APP)

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