Automated net-shape preforming of MAAXIMUS C73 frames

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Introduction

High-performance composite structures are increasingly used in today's airframes due to the excellent weight-specific mechanical performance. The announced ramp-up for next-generation aircrafts demands the next step in composite manufacturing in order to produce parts with excellent geometrical accuracy in high-rate processes. Within the European FP7 project MAAXIMUS a side shell structure was chosen as demonstrator. As part of MAAXIMUS fuselage panel, two door-surrounding frames have been manufactured by an automated preforming cell which is part of a fully automated Resin-Transfer-Molding (RTM) production line.

Workpackage description

In one work package of the EU-Project MAAXIMUS two curved composite Z-shaped frames made of dry carbon fibre woven fabric have been manufactured while the projects ambitious cost-saving goals have been followed consequently. The frames are part of the project's wide-body sideshell demonstrator, see figure 1.

DLR's "EVo-research facility", a new and unique RTM- production line [1] - was used for the near net-shaped preforming of the two C73 frames for the door-surrounding structure.

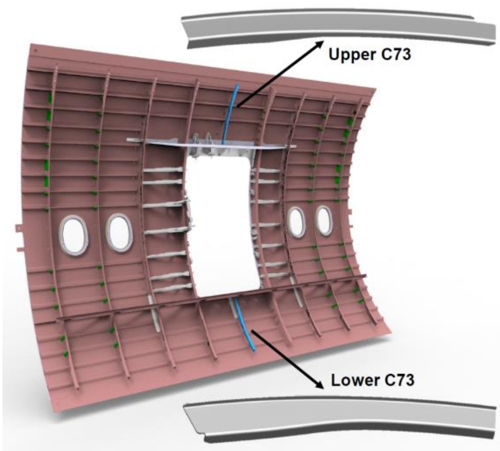

Figure 1: MAAXIMUS fuselage panel with C73 frames

This automated process consists of the sub-processes ply preparation, robotic action of picking and draping, local binder activation, consolidation and preform fine-trimming to net shape, see figure 2. After net-shape preforming at the DLR, the frames were injected and isothermally cured at the site of Airbus Helicopters (project partner). Besides the automated net-shape-preforming and isothermal RTM-process, a probabilistic tool geometry compensation has been applied in tool design in order to compensate inevitable process-induced distortion of the composite frames by DLR.

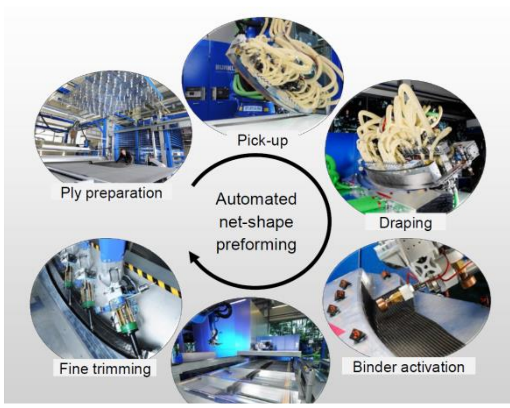

Figure 2: Process chain of automated net-shape preforming

Design of C73 frames

Both frames have a Z-shaped cross section and a length of approximately 1000 mm. The inner and outer flange widths are in the range between 15 mm and 45 mm. The upper frame has a constant web height of around 80 mm whereas the web height of the lower frame increases from 80 mm to 115 mm along the profile. The frame layup is composed of dry, carbon- and glass-fibre woven fabric. Additionally, both frames are reinforced by several patches in the inner flange and the web.

Preforming trials

Several preforming trials regarding the woven fabrics' behaviour of draping, consolidating and fine trimming were performed to ensure geometry requirements. To determine the trimming quality, process parameters e.g. trimming speed, blade angle, amplitude and consolidation influences were evaluated [2]. In addition to the physical trials, the team analysed the feasibility of the robotic movements during draping and fine trimming by simulation, see figure 3.

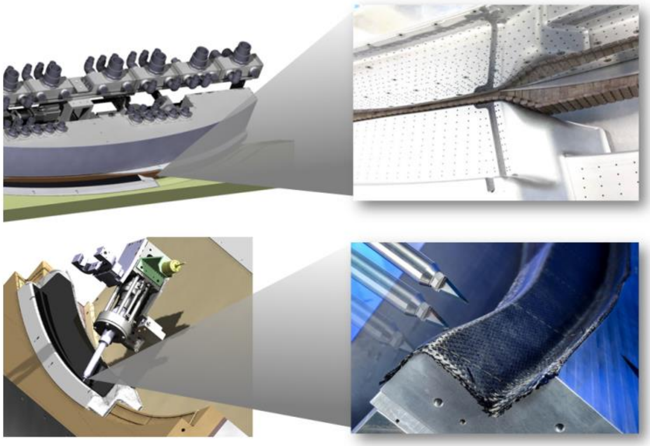

Figure 3: Virtual feasibility analysis

A major challenge of the work package was adjusting the production line for parallel production of two different frames. Therefore, multifunctional preforming tools were designed. The objective was to demonstrate the feasibility of a cheaper multifunctional concept, using only one mold instead of three molds for draping, consolidating and fine trimming.

Another challenge was draping both frames with the same endeffector. Since the target parts have a curved Z-profile geometry, all layers must be draped one by one, because otherwise the inner layers might show wrinkles and ondulations. Regarding the different geometries of the frames (e.g. varying web height) an adaptable endeffector was realised, see figure 3. With this endeffector varying ply geometries and patches could be successfully handled by controlling several suction areas.

Additionally a new electric binder activation system (attached to a robot), was developed to achieve the required stiffness of the preform for a reliable handling [3]. The robot's movement data for binder activation, draping and fine trimming was generated within a CAD environment. Due to this, the robot's position accuracy was increased.

Manufacturing

After adjusting robotic movements and program parameters, nesting data for the cutter and positions of vacuum grippers as well as the development of multifunctional molds and binder activation system, both Z-frames could be successfully handled, draped, consolidated and fine trimmed to the net shape in order to fit in the injection tool cavity.

During the automated net-shape production of ten preforms each, the preforming results were documented in a life data sheet and analyzed after every production step. Hence, a continuous improvement concerning robot movements and process parameters led to significantly reduced process time and to improved preform quality.

Figure 4: EVo facility – fully automated RTM production line

Results

In this work package a fully-automated net-shape preforming of 20 frame preforms was realized. DLR-researchers proofed a high process stability of the preforming process as well as a highly reproducible preform quality. The EVo-facility as a technology-demonstration platform for production of composite parts in large quantities provides evidence of its flexibility towards an adaption to different frame geometries. Two of the manufactured preforms are shown in figure 5.

Figure 5: Net-shape preforms (left: upper C73 frame; right: lower C73 frame)

Acknowledgements

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Literature

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