CHALLENGES FOR THE MANUFACTURING OF A LATTICE STRUCTURE FUSELAGE SECTION WITH PREPREG LAY-UP TECHNOLOGY

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1 Introduction

An increasing number of metal structures of an aircraft are replaced with composite materials. Within this project an aluminum fuselage section is manufactured in a full composite structure design. The used lattice structure could be the next step in the aircraft design. [1] Within this project different sections of the lattice structure, such as the crossing sections or the connection to the attachment frame, were analyzed in detail.

2 Assumptions and determined parameters

2.1 Requirements definition

As reference aircraft the Piaggio Aero P180 is used. This aircraft has a fuselage diameter from nearly 1.90 meter. Within this project a metallic section of 2 m length are substituted with a carbon fiber fuselage section. All required information about the load cases for the new lattice structure can be taken from the P180.

2.2 Manufacturing processes

Two different manufacturing processes are the focus of research within this project. Wet filament winding (FW) [2] and automated fiber placement (AFP) with prepreg are under investigation. *Institut fuer Verbundwerkstoffe GmbH* is work package leader for the manufacturing and within this package responsible for the automated fiber process.

2.3 Material selection

For the selected processes, FW and the AFP, an epoxy resin and a carbon fiber (HTS040 / HTS 5631) were chosen. The brand name for the AFP material is MTM44-1 from CYTEC (formerly Advanced Composite Group). For the AFP-Process the curing without an autoclave "Out of Autoclave" was defined.

3 Results for the automated fiber placement process

3.1 Rib- manufacturing

Each of the two manufacturing processes inside the project has their own requirements. For the AFP-Process it is not feasible to produce a rib with a triangular geometry. The used material is available in all width, but a permanent material width change inside the lay-up is not efficient. With this requirement the simulation partners developed a new lattice structure with only 1 ° draft angle, which is enough for the demoulding and realizable for prepreg material. For the ribs nearly 200 prepreg layers need to be layed-up in the height. Considering the economical manufacturing it is not reasonable to compact after every 20 layers with vacuum before the next layers were layed up. With well-chosen parameters the void content could be reduced to a minimum.

3.2 Crossing Sections

For lattice structures the crossing points of ribs are significant. Within these points two or more ribs are crossing each other. [2] Inside the crossing section a higher volume of fibers and matrix is the result. To compensate this, the crossing area needs to be increased. Four different solutions for the crossing section were analyzed. In two crossing sections the fibers were cut every alternating layer. Both other variants have a fiber deflection into the height and fiber deflection into the width. With a computer tomography the void content was analyzed inside the crossing sections. First tests are showing a void content lower than 2 % in the crossing section.

3.3 Lay-up tool

The complete fuselage section, ribs for the structure and the surface of the fuselage section, should be manufactured in one step. This results in different problems. The main focus is the compaction of the prepreg material during the “Out of Autoclave” curing process. Due to the material compaction during the curing process the prepreg height of a rib decreases (maximum 20 %). For the “Out of Autoclave” curing the differential pressure is maximum 1 bar. The vacuum bag needs to follow the rib decrease. The pressure for the compaction is generated only by the differential pressure. Different mandrel materials were analyzed and tested.

3.4 Reel lay-up

Special feature of the project is the implementation of reels / washers at the end of a fuselage section. [3] With these structures, different sections of an aircraft can be added to a larger section. The prepreg material is layed around the reel / washer in a loop. To compact the material different solutions are developed and analyzed.

4 Summary

Difficulties in the manufacturing of lattice structures for a fuselage section with the AFP process were analyzed and described. The paper will describe the characteristics to solve the problems within the crossing sections and the reel / washer implementation for prepreg UD tapes.

5 Acknowledgment

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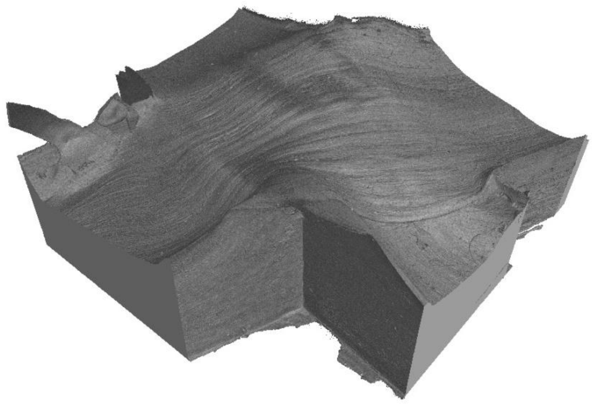

Fig. 1. Rib crossing section – deflection into the height

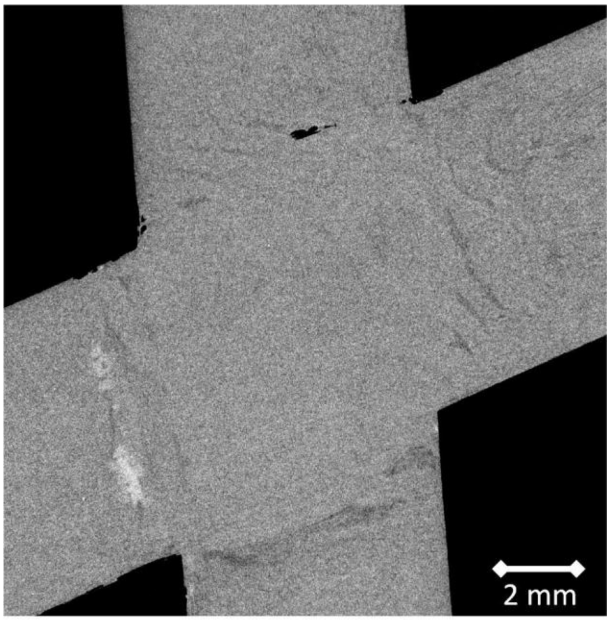

Fig. 2. CT-analyses of a crossing section