

Automated FML Manufacturing for Aircraft Fuselages

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ABSTRACT

As a new material FML, made by aluminum foils and Glasfiber-Prepreg, is a real alternative to common materials for fuselages of aircrafts like monolithic aluminum or CFRP. Since experiences within A380 this material has some really good advantages and develops to the status as alternative to aluminum and composite structures.

To become FML as a real alternative to aluminum and carbon structures there are many things to improve: design, material, costs and process chain. So following one of the main goals for an industrial application for high production rates of aircrafts is the automation of production processes inside the process chain for FML-parts like skins and panels for fuselages. To reach this goal for high production rates first steps of automation inside this new process chain have been developed in the last two years. Main steps is the automated lay-up of metallic foils and Glasfiber-Prepreg. Over this there are some more steps within positioning of i.e. stringers and doublers by automatic integration and also in parallel shorter process chain to reduce process cost significantly.

Different concepts and results of the last two years of development work will be shown in this presentation with the scope of much higher level of automation and reduced process steps for industrial application of FML for higher production rate. Over this next steps for demonstrating industrial ability of this manufacturing process are planned for the next time.

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INTRODUCTION

The amount of composite materials used for parts for an aircraft is constantly rising and challenges the civil aviation industry especially concerning manufacturing of big fuselage structures. Several panels of the A380 are made of "Fibre-Metal-Laminates" (FML), a part of them produced at sites of the Premium Aerotec GmbH (PAG, [Figure 1](#)).



Figure 1. FML-shells produced by Premium Aerotec GmbH for A380

The reasons for these laminates are the high advantage in mechanical properties of the material compared to today's standard aluminum alloys. Its lower density, higher strength and fatigue as well as the higher damage tolerance makes it predestined for large areal structures. Weight reduction of the structure leads to less fuel consumption and as a result to decreased costs for the customer.

Several years ago, the PAG started investigations to automate the layup process for a higher production rate of FML to be able to fulfill the requirements on the production of tomorrow.

STATE OF THE ART

Nowadays, all shells produced for the A380 are manually made including several production steps [1]. All aluminum sheets, needed for the process, have to pass through the trimming, pre-treatment and the application of the primer before getting layed up into the mould together with the prepreg. After curing the skin in an autoclave a NDT (Non-destructive-testing) is made. Subsequent, the skin is milled and positioned back into the mould. An additional bonding process is needed to implement stringers and other elements (e.g. doublers) into the shell. After the second curing and NDT, the shells gets its surface protection and are ready for assembly, see [Figure 2](#).



Figure 2. Process steps of the actual production

After preparation of the mould, the workers have to cut all layers of the prepreg manually [2]. All materials have to be provided at the right time in the right order to be layed up correctly as the instructions demand. Furthermore, all layers are placed manually with the help of an laser-projection-system into the mould. Even the adhesive film for metal-metal bonds have to be placed correctly by hand. The vacuum bagging is a manual step as well as the integration of stringers and doublers within the production. This leads to a low production rate, which have to be increased if future aviation programs will use FML for structural parts of the aircraft.

A possible approach is the automation of the lay-up process by handling the aluminum sheets and prepreg-webs. If you take a closer look at the lay-up process, the high effort in production is necessary to fulfill all requirements and the high standard in aviation industry. The aim of an automated process is to reach these standards and possibly exceed them. Therefore investigations concerning handling, positioning, measuring and controlling are made using technical features, know in automation processes and developing new features especially for this FML-process [3].

Next to the technical challenges, it will be necessary to improve the design of the shells and opti-mize the process-chain on the one hand and the applied material to reduce costs on the other.

AUTOMATION CONCEPT

The PAG started, within the technology development, to design an ATL-head for glasfibre-prepreg, suitable to lay up half of the width of the standard material in serial production. After further development, a second head is capable of laying-up material with a width of 460 mm. Therefore a full role of prepreg is loaded into the head, which is mounted onto a standard robot for positioning issues (see Figure 3). The prepreg is guided through the device (endeffector) until it passes a draping device, which presses the material with an adjustable force into the mould. The carrier (liner), needed to pull the prepreg through the endeffector, is rewinded at the end. The draping device is separated into smaller rolls, able to adjust the curvature of the mould. With the actual design it is possible to adjust radii down to $r=1600$ mm.



Figure 3. ATL head for glasfibre-prepreg

Pressing the prepreg on the surface with a distributed force guarantees a high quality of the lami-nate during the lay-up process. Two ultrasonic knives are able to cut the material automatically by length and width. Even contours like edges, corners or freeform-

shapes are possible with the new cutting device (see Figure 4). The cutting and draping device allows the endeffector to lay up prepreg in cylindrical and spherical parts of the mould as well.



Figure 4. Ultrasonic device for cutting and trimming

The data for the process control is generated directly from the CAD-model and contains the position, driveway for the robot and contour of the web. The direct coupling of design and manufacturing allows a better and easier quality management process, because every single layer can be checked in position, fibre direction and gap during the process.

A second endeffector handles all aluminum sheets needed to build up a FML-panel. These sheets are provided on a flat table equipped with a sensory system to detect the position and orientation of the sheet metal. This data is transferred to the robot and the handling device picks up the sheet metal, adjusts the endeffector shape to the curvature of the mould (see Figure 5) and places the sheet metals into the mould.



Figure 5. Sheet metal endeffector

APPLICATION TESTS

To verify the ATL- and Pick&Place technology, PAG build a test panel with a cylindrical contour measured 2×2 m. The skin design contains a 4/3 FML with all splice-geometries possible in aviation design.

The second milestone to fulfill was a spherical panel with a size of 2×2 m. Within this project PAG successfully layed up a skin with the same design as the cylindrical skin but much smaller radius ($r_{\min}=1600$ mm) taken from a more complex part of the aircraft. Afterwards another skin with a different design and pretreated aluminum sheets were build up and cured.