AUTOMATED SYSTEMS FOR THE MANUFACTURE OF AIRBUS VERTICAL STABILIZER SPAR BOX IN COMPOSITE MATERIALS

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Abstract

At MBB, the vertical Stabilizer Spar Box for the AIRBUS A310-300 has been successfully developed and tested. A new method of construction called "Module Technique" was adopted which allows a high degree of automation to reduce the manufacturing costs.
After a description of this technique the production systems are presented. For the integral stiffened components new technologies had to be investigated. The majorit are now in production From the results achieved the target of lower production costs in comparison with an all-metal construction is within sight.

1. INTRODUCTION

Components from fiber - reinforced plastics have established a good reputation in the European Aircraft Industry. Since the beginning of the AIRBUS program, a wide range of so-called Secondary Structures have been produced using these composite materials (eg. leading edges, access panels, fairings) and, in addition, the main Floor Panels of the Passenger compartment, comprising part of the Primary Structure.
With improvements in materials, some of these were subsequently re-designed, while others were specially designed to take advantage of the improved characteristics offered.

By the end of the Seventies, the initial steps had been taken to replace an all-metal primary structural component of the AIRBUS by a composite structure. Under a Government-sponsored Project (BMFT) by the German Ministry of Research and Technology, the Vertical Stabilizer Spar Box has been successfully developed and tested, using Carbon-Fiber reinforced plastic (CFRP) composite construction in a pre-impregnated material process. The results achieved led to the decision for series production of the AIRBUS A310-300 Spar Box employing these materials.

This paper deals with the Production Concept which was established to develop automated systems for the production of these componentes, and shows some of the successful results of those manufacturing techniques.

2. PRINCIPLES OF DESIGN WITH COMPOSITES

There are two main considerations when selecting Fiber-Composite materials in preference to metals:

- Lower Structural Weight
- Lower Production Costs

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Both these factors influence the Direct Operating Costs (DOC) of a commercial aircraft in service.
MBB studies showed that there were very real possibilities for reducing Production Costs by careful attention to the following:

- Efficient utilization of Material
- Limited range of Production Systems
- Integrated Manufacturing (CIM)
- Shortest possible Production Cycle time
- Use of latest Production Technology
- Efficient Handling and Transport Systems.

During the Design Study Phase of the CFRP Stabilizer Spar Box, a method of construction called "Module Technique" was developed, and this was adopted for the Test components. Subsequently, this led to MBB planning a highly-mechanized Production System Technology.

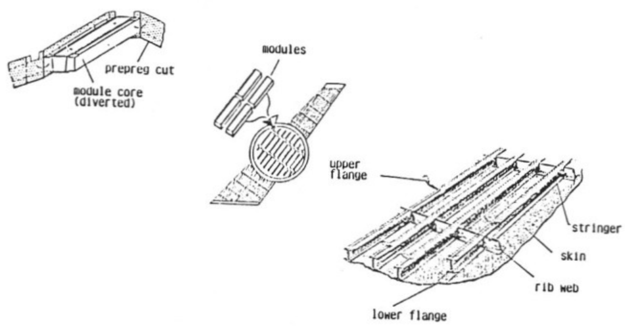

Figure 1: Module Principle

This Module Technique is characterized by a number of similar elements being employed, these being called Modules.

Each individual module is produced by draping CFRP cut-out patterns around a split light-alloy core. A number of these elements are then placed in position on a "Module Jig" to form a grid of integral stiffeners for the structural component. The Skin Panel laying-up is carried out in the Forming Mould itself, and the completed inner structure is then transferred into the forming mould. The Stringer Flanges are then laid in position, the entire component is then cured in the Autoclave in what is termed a "One-Shot Process".

To achieve satisfactory laminating quality, the difference in thermal expansion between the composite material and the light-alloy cores is used to apply certain compressive loads.

Figure 2: Spar Box Side-Shell in the Mould

Both of the stiffened "half-shell" assemblies for the Spar Box are produced in this manner, as are the Spars and a number of the Ribs. These components are later joined by riveting operations.

In comparison with an all-metal Spar Box, the total number of individual parts required has been reduced from some 2072 to just 96, and the number of rivets from 60,000 previously, to a mere 5,800!

3. PRODUCTION CONCEPT

The following explanation describes the sequence of production for a Vertical Stabilizer Side-Shell Assembly by the Module technique- the procedure is also applicable to the other "Modular Components".

The initial stage is the cutting of the PREPREG material for the laying-up of the Skin panels, and for the module cores. As the stiffener grid has to transfer shear loads, a plus/minus 45 degree fiber orientation is required for the web sections.

Because material in this form is not procurable, it must be cut out of pre-impregnated fabric material, at the required angle. Each module bandage consists of between two and five layers of CFRP fabric, each layer at a different fiber orientation. Further, to ensure that, during the wrapping operations, the necessary layer overlapping is obtained, the PREPREG rolls are also displaced by individual specific amounts on the cutting table.

For this multi-layer cutting operation, many different technologies were investigated and tested. Finally, an NC-System employing a reciprocating knife (the "GERBER" cutter) was selected and later installed in the production process.

Each separate cut "pattern" is identified alphanumerically and with a Bar-Code, as both types are needed in the subsequent steps to control the layering-up operations: for laminating by hand, and for computerized control functions.

All the PREPREG cut patterns are kitted into special pallets for transport to the next workstation, for this the stacking-sequences are all programmed.

These pallets are brought to the working areas where the module-core bandaging operation will be carried out.

For one Vertical Stabilizer Spar Box for the A310-300, a total of 827 cores are needed to form the stiffeners of the components.

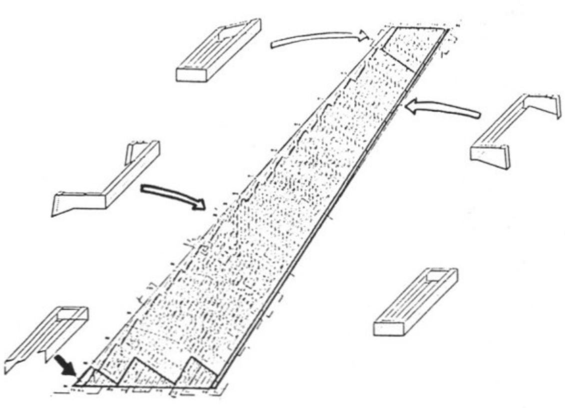

Figure 3: Types of Modules used in the Side-Shell Assemblies

The "Standard" type of module is used over the whole of the center area of the spar box shells, and these are produced on a round table, where a robot has placed the light alloy core.

The operator selects a cut strip for the module from a nearby pallet, and wraps it around the outside of the core. The cuts in the CFRP strip must match exactly with the corners of the core. After the module has been transferred to the next workstation, elastic pressure bars fold the upright edges of the PREPREG to form upper and lower flanges.

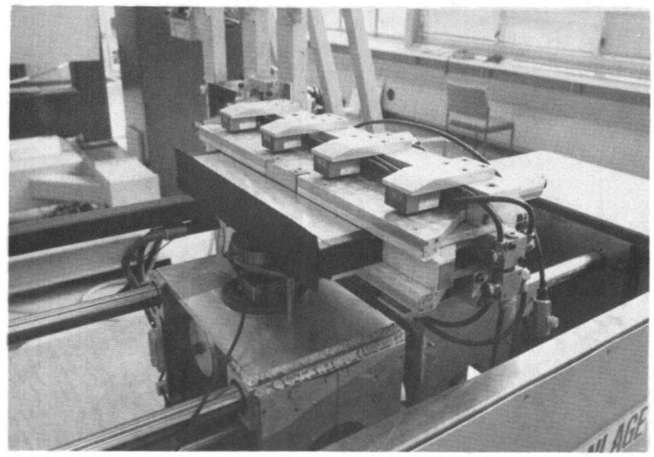

Figure 4: Folding the Flanges on Standard Type Modules

The special-type Modules (see figure 3) are produced in a similar manner except that the folding operation is achieved using a special rubber blanket.

The final step in the module-bandaging sequence is removal of module by another Robot, which then places it in an spcified position in the module grid fixture.

For ease of handling, this module grid frame has been split into pallets, each of which represents one transverse row of the actual stiffener grid. After clamping and pressing, the pallets are transferred to the module support frame and finally fixed. The assembly of all seventeen of these pallets together forms the internal structure of one side-shell of the Spar Box.

For the laying-up of the flanges of the I-section beams, MBB has developed a special tape laying head.

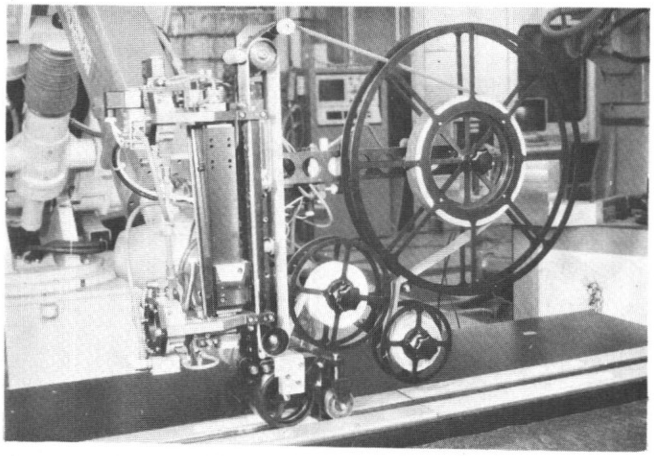

Figure 5: Robot-adapted Tape-Laying Head

This unit is capable of working with CFRP fabrics in addition to its normal handling of tape material. Due to its low weight, it can be operated directly by the robot.

In the meantime, laying-up of the skin panels is carried out in the forming mould by hand. This huge mould is also constructed from carbon fiber materials, for reasons of campatability and to ensure a final close-tolerance contour quality.

The Spar Box/Fuselage attach fittings are integral with the side-shell skin panels, being bonded and ured with up to 121 layers of Carbon Fiber material. These complex Patterns can be stacked with another special tool also developed by MBB, enabling a single PREPREG cut pattern to be picked up, without removing adjacent layers in the stack, and then depositing the pattern in the correct place. When all the pallets are ready, the forming mould is brought under the module support frame on air-cushions, and after the entire frame is rotated, the module core adaptors are released, and the frame can be detached and removed.

Prior to curing, the inner stringer flanges must be laid-up, in the same way as for the outer flanges, and the component prepared for the curing cycle, this is carried out in a large autoclave. The entire process is controlled and monitored by a computerized system, this checks all the temperature differences for example, and controls the mximum temperature increase.

After curing, the module cores are released by removing the center core element, followed by the two outer elements. This is carried out manually, as it was found that a mechanized operation, employing specially developed tooling, proved to be uneconomical.

The component can then be passed on to the next stage in production.

All handling, transport and conveying of Material, Tooling, Pallets etc. in the Bonding areas and Work-Stations will eventually be performed by remotely-controlled robot vehicles, with Computers controlling all Material Flows to meet the demands at the work-stations.

Before the light-alloy cores can be used again, all residual resin must be removed from the surfaces, for this, the elements are arranged on pallets and dipped into a chemical bath.
After cleaning, a release agent is applied in the same manner: this will later prevent the laminate from adhering to the cores during the curing process.

The cured parts are then mechanically worked (contour-routing, drilling etc.)-again, as the Carbon Fiber material is extremely abrasive, special tools were developed by MBB to ensure the final required fine tolerances.

The attachment lugs of the Spar Box to the Fuselage require to be drilled to provide 65 mm diameter holes to a depth of 60 mm. This is achieved using a core drill with an internal air supply, and with an external dust-extraction system.

The principal Assembly operation is that of attaching the Ribs to the Side-Shells of the Spar Box. At present, this is carried out in the horizontal position, but the limited access available hinders the work considerably. Altough this stip is completed manually up to now, a planned concept for mechanization has been developed and tested in the Laboratory.

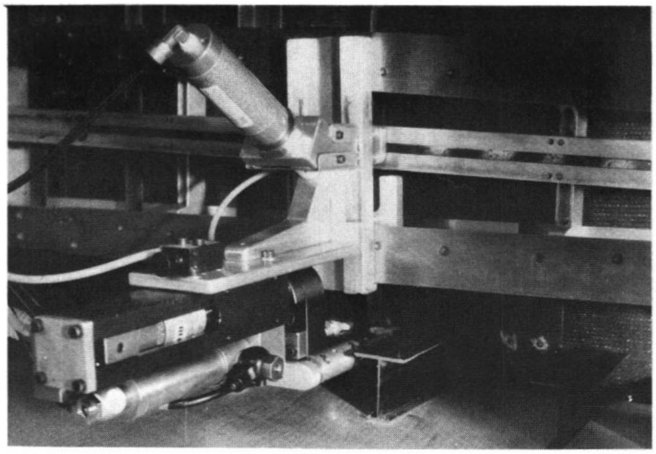

Figure 6: Prototype for drilling the Rib-Side-Shell connections

Surface protection and finishing is finally applied, using conventional methods and materials.

In parallel with all the manufacturing processes, the most critical steps are subjected to strict Quality Control to detect any discrepancies at once. All cured components are Ultrasonically inspected to ensure that only fully satisfactory components are used in the production of these important structures.

4. REALIZATION

At the present time, the majority of the advanced Production Technologies have been specified, and a number of them are employed in current production.
The NC-Cutting System has been in operation since early 1985. A fully-automated module-bandaging workstation will be completed towards the end of this year.
The Tooling System for clamping and pressing the individual modules that form the grid was recently installed, and is now in operation.
Many of the production processes, such as NC-Routing and Drilling, were already fully developed by MBB and required only direct basic tooling investment.
Automated Assembly Stations are currently being installed, and will be completed in 1987.

5. CONCLUSIONS

A full series of AIRBUS Vertical Stabilizers with Spar Boxes in CFRP has already been produced using this Module Technique. Altough many of the productions steps are still carried out by hand, Quality is to a very high standard.

Following the "learning curve", production times have come down to a reasonsable level, and we at MBB are now convinced that, with full mechanization and automation, Production Costs for the CFRP Spar Box will not exceed those for a comparable all-metal structure.

Following this accumulated successful experience with the first production Design, the decision for go-ahead with the AIRBUS A320 Vertical Stabilizer Spar Box in CFRP was a logical one.
Thus, in the near future, both A310 and A320 Spar Boxes will be produced concurrently by MBB, employing the same manufacturing technology and systems.