

Solution for Automated Drilling and Lockbolt Installation in Carbon Fiber Structures

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ABSTRACT

Manual drilling and Lockbolt installation in carbon fiber structures is a labor intensive process. To reduce man hour requirements while concurrently improving throughput and process quality levels BROETJE-Automation developed a gantry positioning system with high performance multi-function end effectors for this application.

This paper presents a unique solution featuring fully automated drilling and Lockbolt installation (inclusive of automated collar installation) for the vertical tail plane (vertical stabilizer) of large commercial aircraft. A flexible and reconfigurable assembly jig facilitates high access of the end effectors and increases the equipment efficiency. The described system fulfils the demand for affordable yet flexible precision manufacturing with the capacity to handle different aircraft model panels within the work envelope.

INTRODUCTION

The aircraft industry is constantly optimizing its existing production approach with regard to economic and quality aspects. The assembly of the vertical tail plane in this approach is based primarily on mechanizing a manual process. The vertical tail plane (VTP) is completely made out of CFRP including all stringers and ties. These stringers and ties are fastened with Lockbolts to the panel.

The pre-assembly of the VTP mandates adaptive positioning capability to overcome the tolerance build-up

resultant during the CRFP production process. The skill and resource allocation in terms of labor hours is significant to manually meet the product quality requirements and production cost targets. Safety within the work environment was another reason for automation to alleviate exposure of workers to process generated CRFP dust. To achieve the safety, quality and economic aspects of our customer a state-of-the-art fastening machine was recommended and produced. The automation solution generated covers today's requirements along with yet to be announced programs and future products. The objectives and requirements established at the onset of this project are:

- **Multi-task end-effector** based on proven technology
- **High speed** fastening cycle
- **High precision opposed systems for fully automated collar installation**
- **Flexible tooling system** to support different products

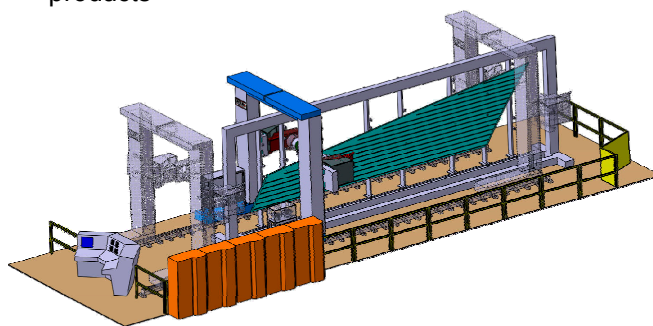


Figure 1 Vertical Panel Assembly Cell - VPAC

CONCEPT

Together with a team comprised of the customer and BROETJE-Automation engineers, a direct response to the aforementioned requirements was developed resulting in the Vertical Panel Assembly Cell (VPAC).

The design includes the following main components:

- A “linked” light weight gantry system comprised of inner and outer systems each with 6 NC controlled axis.
- Outer System Multi-Task End-Effector for drilling and Lockbolt insertion including sensor equipment to achieve positioning normality to the product.
- Inner System Multi-Task End-Effector for clamp generation and collar installation. It is equipped with a laser line sensor for product feature referencing.
- Flexible tooling to support the left and right panel of the vertical tail plane for two different aircraft programs providing nearly 100% accessibility.

Furthermore the system is equipped with a dust removal system for CFRP material, an automated drill chuck changer and automated fastener Lockbolt and collar feeding systems.

To increase the efficiency of the automated solution and to ensure the needed performance criteria were met, the following tasks had to be automated:

- Drilling and countersinking
- Bolt insertion and collar installation
- Determination of stack thickness to feed the right fastener length

- Achieving normality on the outer mold line
- Detection of tie and stringer positions and automatic correction of hole positions to ensure maintenance of edge distances to engineering criteria.
- Automated reconfiguration of the flexible tooling for the different products (adjustment of vertical beams and vacuum pads).

VERTICAL PANEL ASSEMBLY CELL (VPAC)

The basic layout of the vertical panel assembly cell is shown in Figure 2. The overall dimensions of the whole cell are:

- length: 72ft (21800mm)
- width: 23ft (7100mm)
- height: 19ft (5800mm)

POSITIONING SYSTEM

The gantry of the positioning system is characterized by a light weight design to minimize foundation requirements and cost. This approach is possible because of the low process force of the Lockbolt pull-type installation compared to the higher process forces of machine swaged collars.

The positioning system has for each side has X-, Y- and Z linear axes as well as A-, B- and C- rotating axes. The B- and C- Axes are rotating about the tool center point of the inner and outer end-effectors. The upper gantry beam is equipped with an additional passive X_3 axes to disjoin the inner from the outer positioning system.

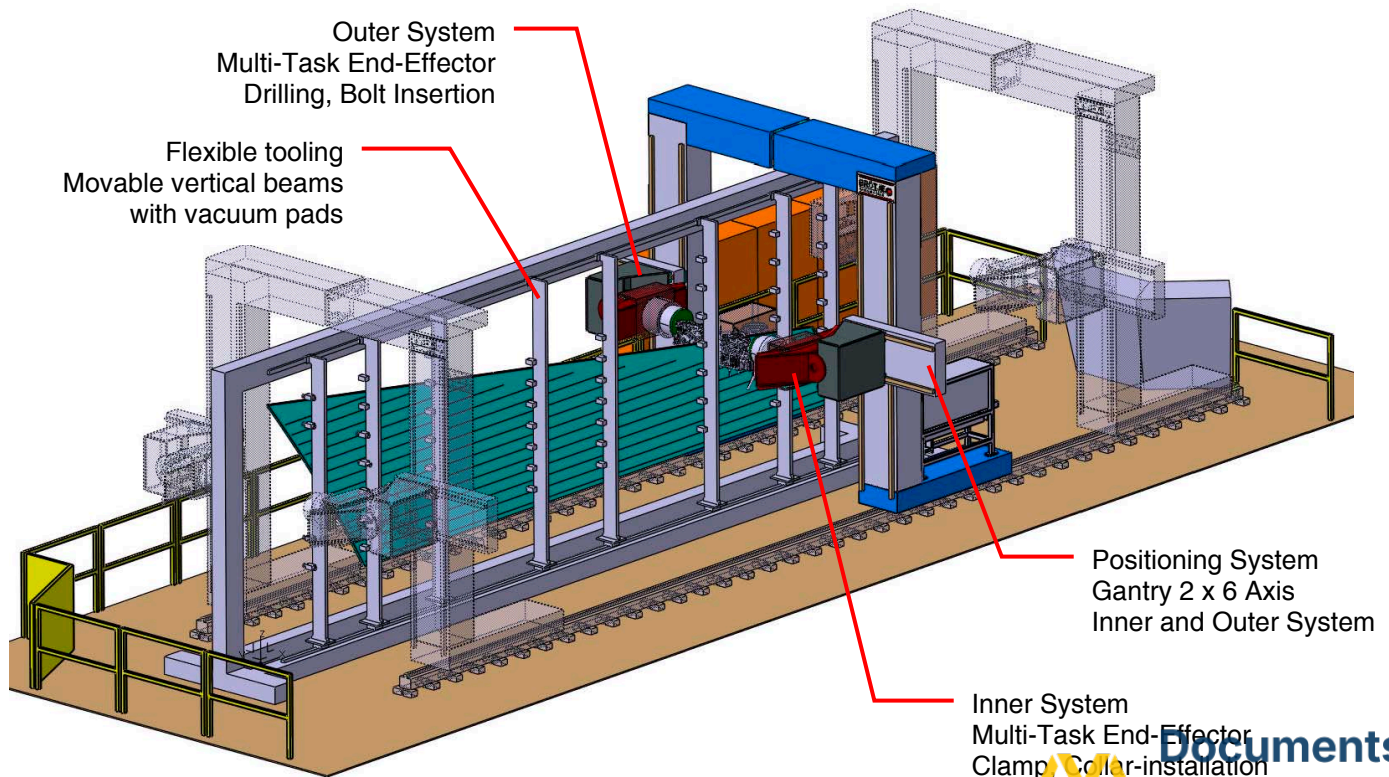


Figure 2 Vertical Panel Assembly Cell - VPAC