

Force Controlled Robotic System for Drilling and Riveting One Way Assembly

2011-01-2537

Published
10/18/2011Pascal Ple and Jean-Francois Gabory
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doi:[10.4271/2011-01-2537](https://doi.org/10.4271/2011-01-2537)

ABSTRACT

Drilling and riveting needs high accuracy for aircraft parts assembly. Major manufacturers look for flexible solutions to match their modern requirements and specific process.

SPIE & ABB have developed an innovative force controlled robotic system with high clamping force to allow drilling and riveting multi-material structures. It will fulfill the one-way assembly requirements in several types of aeronautics applications.

Normality and anti-slipping are solved using force-control solution: a 6 components force sensor measures forces and moments at the pressure foot to correct normality and to avoid slipping. A high pressure clamping force directly controlled by robot allows a one-way drilling and riveting cycle. Accuracy is performed by absolute calibration and optical reference setting directly on aircraft part.

The new drilling, sealing and riveting end effector achieves peak drilling, stack thickness measurement, cutting condition adjustment and drill break detection. It is based on a linear motor feed axis in order to optimise accuracy and dynamic. Movement without mechanical parts leads to better accuracy, less wear and altered settings.

SPIE FX-Robotic Cell combines all these technological advance to propose a new flexible and efficient drilling-riveting robotic cell

INTRODUCTION

The FX100 drilling and riveting effector has been designed to be used either with robots or cartesian machines, most often 5 axis machines ([figure 1](#)).



Figure 1. SPIE end effector on cartesian machine (2002)

The reasons that can restrict the use of robots for drilling and riveting operations in the aerospace industry are:

- Limited work volume,
- Insufficient absolute accuracy in the work envelope of the robot
- Lack of stiffness of the robot and plays in the joints.

These difficulties are also influenced by payload, robot posture, clamping force, machining effort and other variables

The needed accuracy for most aerospace industry applications is:

- $\pm 0.5\text{mm}$ (0.02") or better in space absolute positioning,
- $\pm 0.1^\circ$ in normality with respect to the surface to machine

A robot holding an effector with a weight of more than 100kg cannot directly meet these requirements. The absolute accuracy can be enhanced in several ways:

- Over-dimensioning the robot to use,
- Adding supplementary axis in the aim to limit the span of movements,
- Calibrating the robot in its working area, thanks to an external measuring mean.
- Calibrating the robot in relation with the jigs, and locally on small portions of the part to machine.

The main advantages of using a standard robot over a cartesian machine are;

- The cost of robot,
- Robots availability, which are 'on the shelf' products
- The ease of commissioning
- Low operation cost compared to a cartesian machine.

FX-ROBOTIC CELL

SPIE FX-Robotic cell has been designed to realise all or some of the following functions:

- Clamping (up to 150 daN)
- Drilling/countersinking
- Sealing
- Riveting (blind rivet, LGP, Hi-Lite(R))
- Chips vacuum
- Automatic drill changing
- Effector automatic change

To increase robot work envelope, a 7th axis can be added:

- Linear ground axis
- Linear vertical axis

To increase production flexibility, robot can be placed on a mobile platform. Operator will place the platform in front of part to be machined on ground reference and the platform will be leveled and clamped (manually or automatically).

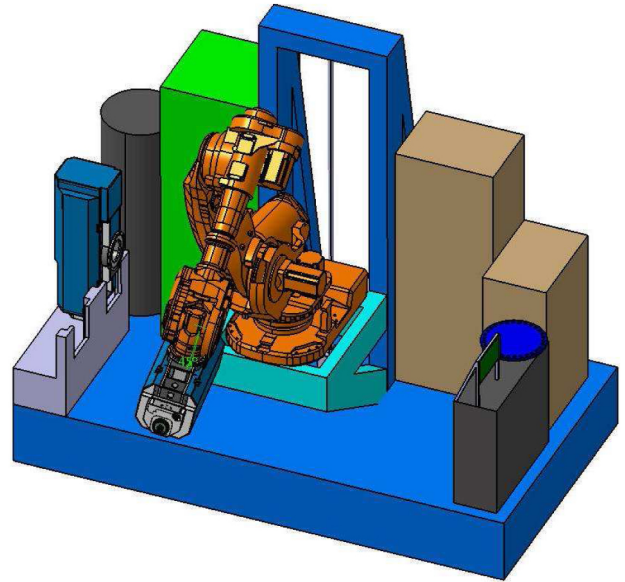


Figure 2. Mobile Drilling-Riveting robotic Platform

ACCURACY AND FORCE CONTROL CONFIGURATION OF THE ROBOT

The robot used in the cell is an ABB IRB7600-325/3.1 model with 325kg payload & 3.1m span. Robot is calibrated with absolute accuracy package.

Robot controller is equipped with the RobotWare Force Control package. This feature consists of:

- A 6 axes force sensor mounted on effector pressure foot
- A real time software to adjust the robot position and orientation. The calculations are done so that the tip of the effector in contact with the part does not move. As the software is integrated in the CNC of the robot, it ensures very high dynamic performances.

SPIE and ABB have adapted force control originally developed for the automotive industry (clutch assembly, piston installation and bearings installation) to integrate aircraft parts normality sensing in FX robotic Cell. This servo control permits to override robot stiffness and plays in joints.