

## Offset Fastening Flex Track

2012-01-1850

Published  
09/10/2012

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doi:10.4271/2012-01-1850

### ABSTRACT

Flex Track Drilling systems have been successfully implemented into several production environments and scenarios over the past couple of years. They continue to see a high demand where traditional machine tool implementations might be prohibitive due to cost or existing jig structures. This demand for innovation has led to a unique Flex Track design termed an Offset Flex Track that not only works between the vacuum rails, but can work beyond the envelope of the rails. This allows the machine to be used in situations such as the leading edge of wings where the vacuum rails cannot straddle the work envelope. The next evolution of this Offset machine is the introduction of final fastener installation onto the head using an onboard rivet gun. In addition, the camera used to locate datum points on the fuselage is now integrated into the nose piece, eliminating the need for a tool change to a spindle mounted camera. The next generation of Flex Track machines will continue to push the boundary of lightweight, portable automation solutions in the aerospace manufacturing environment.

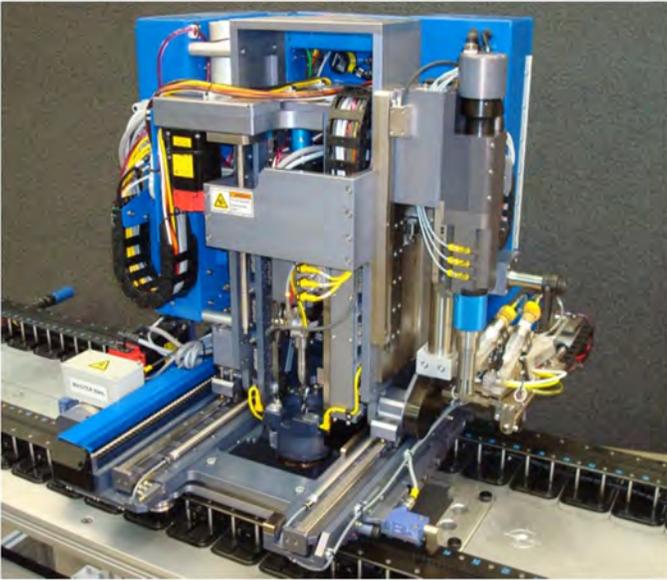
### INTRODUCTION

The Flex Track system is a full CNC machine used for a myriad of aerospace manufacturing production solutions. The system consists of a head that rides along flexible steel tracks adhered to the work piece using vacuum cups. Global datum points are located on the work piece using a camera; this allows the system to align its coordinate system with that of the part. For increased local accuracy, or to account for hand located parts, local datum points can also be located using the camera to ensure proper hole pattern alignment and edge margin. Because the machine is attached directly to the work piece, movement of the part within the jig due to environmental variables such as thermal expansion have little effect on machine accuracy.

Boeing has been increasing the production rate of the 777 over the past several years to meet increasing demand by customers. The existing jig structures for 777 assembly prohibit the implementation of traditional automation machine tools. Boeing has turned to Flex Track automation solutions to aid in the increased rate requirements, while balancing cost and working around or minimizing modification to existing jigs. The recent successful implementation of 12 Flex Tracks for fuselage joins and the resultant increase in production, led Boeing to consider Flex Tracks for use in the Splice Stringers and Wing Majors Panel to Spar builds for the 777 wings. The first phase of machines are a drill only application with a concurrent R&D machine that will contain a full fastener feed and installation system. Once the final fastening process is proven in the lab, the production machines will be retrofit with the final fastening system. The machine will apply sealant to the shank of the bolt and be capable of installing 0.005" interference 7/16" lockbolts and hiloks through a maximum stack of 1.5".

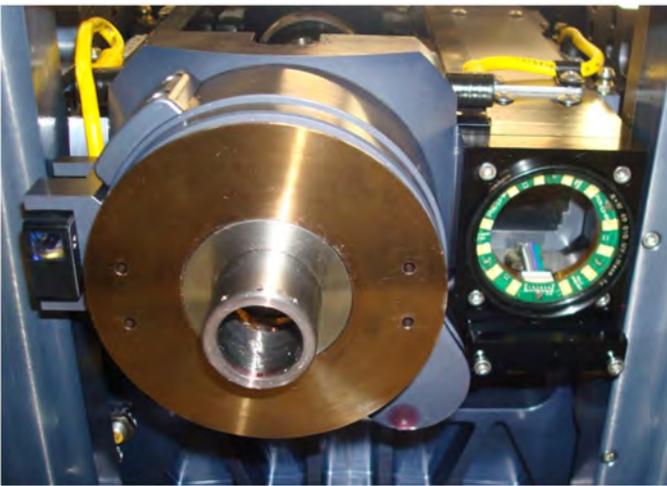
### OFFSET FLEX TRACK

The Offset Flex Track was developed specifically to work on areas of a fuselage that cannot be straddled by two vacuum rails of a traditional Flex Track. Potential applications include wing ribs, spars, panel joins, etc. The latest variant of this design allows for 6" of Y-axis travel both between and outside of the tracks (Figure 1). Normality sensors mounted in the nose piece and  $+12.5^{\circ}/-2.5^{\circ}$  of A-axis travel, allow the machine to normalize to the surface to within  $\pm 0.1^{\circ}$  both between the rails and in the offset position.



*Figure 1. Flex Track.*

## INTEGRATED CAMERA



*Figure 2. Offset mounted camera.*

Due to mechanical design constraints, previous Flex Track versions incorporated a spindle mounted camera to locate datum points on the work piece. In order to use the camera, the operator had to perform a manual tool change, locate the datum points and then another tool change to the required cutter. This system required that all datum points be located at the beginning of the part program. Recent advancements in commercially available high resolution cameras, in small packaging have allowed for a machine design that incorporates a built in camera. The camera is mounted next to the nose piece, offset straight along the X-axis (Figure 2). By incorporating the camera onto the machine, operators are no longer required to locate all datum points at the beginning of the part program. This will allow the operator to jump to any point in a part program, locate the necessary local datums and

immediately start drilling. There are several positions within the jigs where the machine will be used, but the operator cannot be very close to visually inspect sealant squeeze out after the fastener is inserted. In these situations, the camera can also be used to inspect sealant squeeze out and the operator can adjust the amount of sealant applied.

## FASTENER INSTALLATION

The Offset Fastening Flex Track will be equipped with a fastener feed system, sealant applicator and fastener inserter. Fasteners will be fed to the head by a portable fastener feed cart through feed tubes. Once the fastener arrives at the head, sealant is applied to the shank and the bolt is presented to the inserter (Figure 3). The bolt inserter is offset straight along the X-axis. In effect, the entire head acts as the shuttle table. While the hole is being drilled, the fastener is fed from the cart and sealant is applied. Once the drill cycle completes, the machine centers the inserter over the drilled hole and inserts the bolt (Figure 4). The bolt inserter position is monitored through a linear scale to insure the fastener is fully seated, but not being overdriven and damaging the work piece.



*Figure 3. Sealant application.*



*Figure 4. Bolt inserter.*

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## **SUMMARY**

These latest advancements to the Flex Track system continue to push the boundary of lightweight, portable automation solutions. The introduction of the onboard camera will both save operator setup time and allow for a much more flexible machine usage plan. The integration of the fastener feed system, sealant applicator and bolt inserter will advance the Flex Track into the realm of one up final fastening. Combined, this system provides most of the features of a much larger automation solution into a package that is portable and easily implemented into existing jig structures.

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The Engineering Meetings Board has approved this paper for publication. It has successfully completed SAE's peer review process under the supervision of the session organizer. This process requires a minimum of three (3) reviews by industry experts.

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ISSN 0148-7191

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