

Automatic Bolt Feeding on a Multifunction Flextrack

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ABSTRACT

One of the largest advancements in the use of the Flextrack technology is the addition of automated fastener installation on the Multifunction Flextrack made by Electroimpact. The new Flextrack installs SSTF (Single Sided Temporary Fasteners) into the holes it drills without removing clamp-up force from the workpiece. This is the first Flextrack to drill and install fasteners and its functionality goes beyond even these functions. The fasteners, SSTF bolts, are increasingly replacing more cumbersome and manual tools for temporary fastening of aerospace components during assembly. They provide doweling, clamp-up, and feature a compact head to facilitate machine installation

The new Multifunction Flextrack carries the bolts on the machine head as opposed to being fed through a feed tube. A Bolt Cartridge System carries up to 80 bolts onboard the Flextrack and the Cartridges can be quick changed for use with several different diameters. In its debut configuration, it is setup to carry 4 different bolt diameters, 1/4" through 7/16" in multiple grip lengths. The Flextrack Bolt Injector can receive a bolt from one of four banks in a fastener feed cartridge and presents it to the Bolt Inserter where length and diameter are checked. The Bolt Injector is mainly made up of a Cart that has multiple stop positions and transfers the bolt from the fastener bank to where the Inserter can pick it up. The Bolt Inserter resides on a shuttle table and the machine shuttles to the hole after drilling without losing clamp-up. The Inserter is driven to and from the panel with an air cylinder and installs the bolts with an electric nutrunner. To actuate the temporary fasteners, the nutrunner applies a torque to the inner hex drive while holding the outer head

static. The bolts are actuated to specific torque values for different amounts of clamp-up force.

INTRODUCTION

The origin of the bolt feed system discussed in this paper was developed to address temporary fastening requirements of a fuselage joining cell used to build Boeing's new 787 airplane. The circular fuselage join has hundreds of locations where temporary fastening is required. The Multifunction Flextrack was developed to drill the circular join. Additional tools make this new Flextrack multifunctional by adding automatic bolt insertion, an onboard fastener feed system along with including hole inspection and onboard photo resynchronization. Photo resynchronization previously required a tool change. Bolts required were of diameter ranging from 3/16" to 7/16" for stack thicknesses ranging from 1/2" to 1 1/2". [Figure 1](#) shows the Multifunction Flextrack.

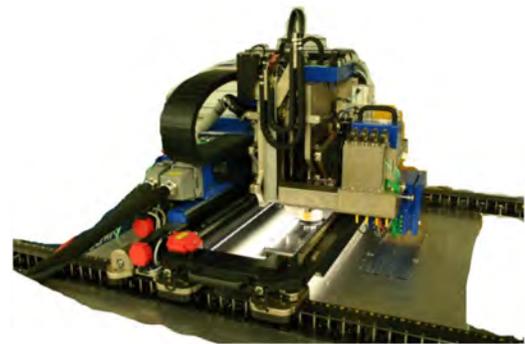


Figure 1. The Multifunction Flextrack

SYSTEM OVERVIEW

The Bolt Inserter is an evolved design stemming from the Confined Spaces Bolt Inserter discussed in SAE paper 2010-01-1879 [1], however it now is driven along its primary axis pneumatically instead of with a servo motor and ballscrew. The Bolt Inserter on the Multifunction Flextrack provides the same basic functions in an even more compact form. The Inserter picks up the bolt from the Injector by snapping the Socket over the head of the bolt. Diameter is checked by the Inserter when the bolt is socketed. This is accomplished by measuring the height of the bolt head as it protrudes from the Bolt Injector. The holes in which these fasteners are installed are countersunk and therefore the fasteners go deeper into the larger holes than the smaller holes. The fastener is designed to have a constant height above the panel after installation, so by these factors, an apparent head height difference is seen by the Inserter when it is held by the Injector. In this way, the Flextrack can check diameter of the bolt.

The Bolt is carried from the Injector to the Bolt Inserter on the machine's shuttle table. When the shuttle position is above the hole, the Inserter extends with the bolt and slips it through the hole. The fastener is held captive by the Bolt Inserter's Socket and an inner hex driver applies torque to the fastener to actuate it. Torque is applied with an electric nutrunner and the transmission mechanism can sense engagement with the bolt. The Socket reacts the torque holding the outer head of the SSTF static. The bolts are actuated to specific torque values for different amounts of clamp-up force.

The Bolt Cartridge System is a new design specifically tailored to carry SSTF temporary fasteners onboard the Flextrack drawing on some features from Stick-style faster feed racks [3] also made by Electroimpact. Typically, an Electroimpact bolt feed system delivers fasteners through a plastic tube to the machine's head from a loading station some distance away from the end effector. In contrast, on the Flextrack system fasteners are stored and carried onboard the machine head. The Bolt Cartridge System can be loaded offline and quickly changed out, typically to be done when changing between drill diameters. It features 4 different slots, or banks. The Flextrack can call a fastener from any one of the four banks which can be loaded with up to 20 fasteners of a particular grip length. The Bolt Feed Cartridges feature an RFID system in which the machine can identify the bolt diameter, grip length, and the number of fasteners loaded in each of the four banks of the Cartridge. [Figure 2](#) shows the Bolt Cartridges loaded onto the Bolt Injector and [Figure 3](#) has the Cartridges removed showing the parts to detach for the quick change for reloading or diameter change.

The Flextrack's Bolt Injector is a new design developed specifically for this application. It features a spring loaded

Cart which traverses between five different positions pneumatically. It can stop under any of the four Cartridge banks to receive a fastener. From there, it carries the SSTF bolt to the extent of its travel which places the bolt under the Bolt Inserter. The Inserter resides on the shuttle table and is aligned with the Bolt Injector while the machine is drilling a hole. In addition to checking diameter, the Injector also checks the bolt length after it has been socketed by the Bolt Inserter. This is done using an analog position sensor.



Figure 2. Bolt Cartridges loaded

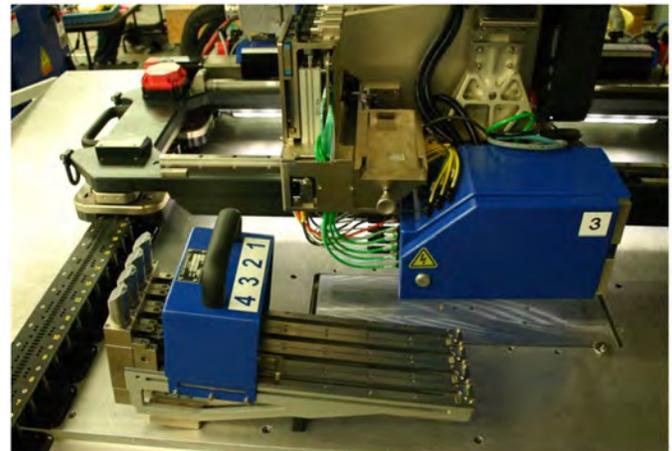


Figure 3. Bolt Cartridges detached

SINGLE SIDED TEMPORARY FASTENERS

Single Sided Slave/Temporary Fasteners are designed to clamp and dowel components for drilling in aerospace applications. They are replacing separate tools used for each of the clamping and the doweling processes. Furthermore, these bolts have been designed with a low profile head such that, after installation, they sit considerably closer to flush to the workpiece than their counterparts. This allows an automated machine to “fly over” them. The bolts can be used

in countersunk and non-countersunk holes. The SSTF bolts' relatively small head facilitate them to be automatically fed and installed. Their “blind” or one-sided capability also makes them a fit to be installed by automated machines. With these features, the fasteners reduce the amount of tooling required for assembly and allow them to be installed by machine. [Figure 4](#) [2] shows some of the key features of the SSTF bolts.

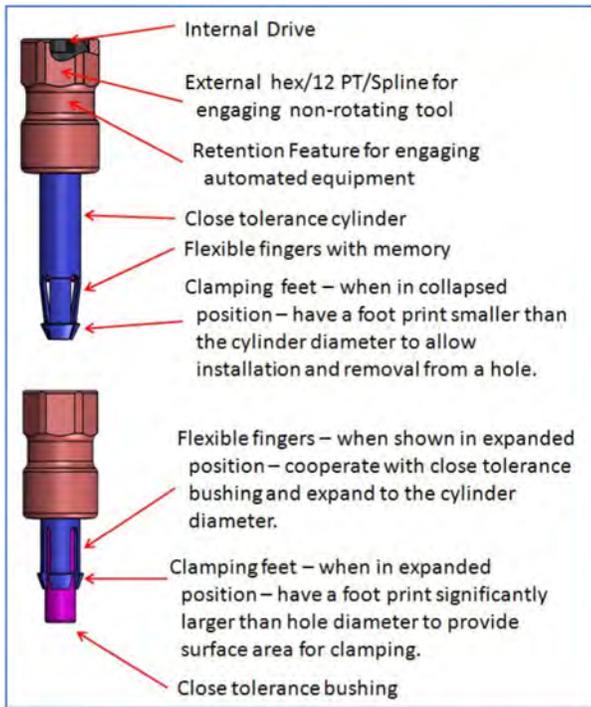


Figure 4. SSTF Bolt Features. Adapted from [2]

CYCLES OF FUNCTION

The first step is the bolt feed process is the diameter selection. The machine is set to drill one diameter and correct tool holder is setup. Also, the appropriate cartridge is selected by an operator and latched onto the machine. The CNC reads the RFID information to confirm the cartridge loaded contains the correct diameter bolts.

Next, as the machine begins drilling, the NC programmed stack data for the hole is used to call the appropriate fastener grip. The Cartridge System has four banks allowing multiple grips to be carried onboard the machine for use while drilling the selected diameter. The Multifunction Flextrack also has a Hole Probe on the shuttle table which, in addition to gathering precision hole diameter data, can also measure the stack thickness. This allows the machine to double check the programmed stack thickness and the selected grip length.

Now, with the grip length determined, the Injector Cart is sent to one of the four bank positions on the Cartridge

corresponding to the correct grip length. While the Cart is hidden from view, [Figure 5](#) shows the Cartridge System. The Injector Cart is stopped under one on the banks.

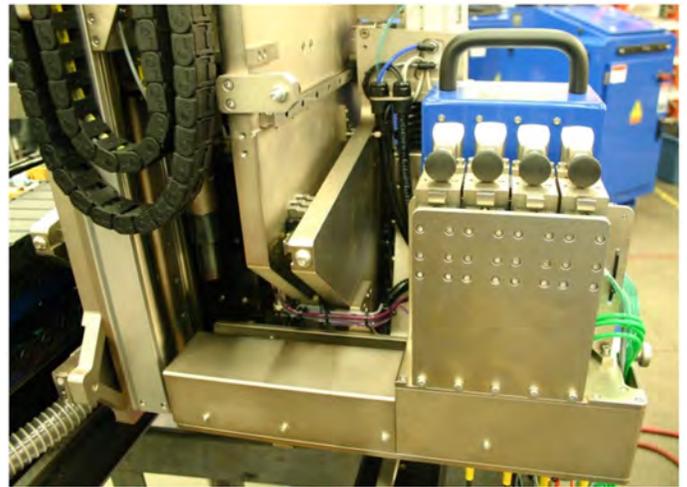


Figure 5. Four Cartridge banks ready to release bolt

When the Injector Cart is in position, the Cartridge can now be actuated to press a bolt into the cart. Upon actuation, the “kicker” is extended up and one bolt is guided off its track ([Figure 6](#)). A fraction of a second later, the kicker retracts, pushing the bolt down into the spring loaded cart. The head of the bolt stops when it hits a countersunk plate matching the contour of the bolt head's underside. At this point, the kicker moves up slightly to give clearance for the Injector Cart to carry the bolt away.



Figure 6. Cartridge kicker is extended releasing a bolt

At this point, the bolt is held in place and the Injector Cart is sent to its extended position, see [Figure 7](#). This position places the bolt directly under the Bolt Inserter's Socket. The

Bolt Inserter is shuttled to this position when the machine is drilling a hole.



Figure 7. Injector Cart extended placing bolt under Socket

Next, the Bolt Inserter extends via pneumatic cylinder and the Socket snaps onto the head of the SSTF bolt. The motion is stopped when the Inserter bottoms out on the bolt. The bolt is stopped by a steel plate on the Cart. Using the plane of the steel plate as an interim datum, the machine can check diameter indirectly as described in the previous section. The Inserter uses a magnetic tape scale to measure position in Z.

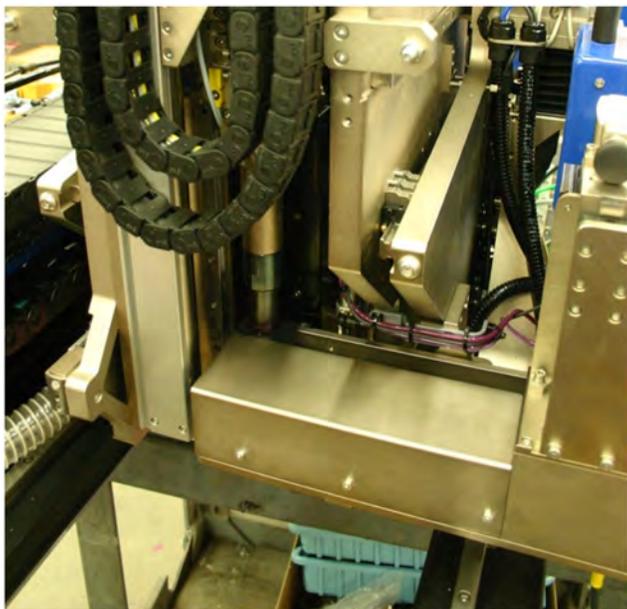


Figure 8. Bolt is Socketed

Now with the bolt held down onto the Injector Cart by the Inserter, the length is checked. This is done using a small foot underneath the bolt's tail. This foot is connected to a small air cylinder and an analog 0-10 VDC position sensor. With this, the grip length can be checked. [Figure 9](#) shows the length check mechanism.



Figure 9. Length check mechanism

At this point, the Bolt Inserter retracts with the Bolt held captive in the Socket ([Figure 10](#)). A spring retaining feature prevents hold the bolt in the Socket.

Next, when the drilling operation is complete, the shuttle table moves. [Figure 11](#) shows the Inserter shuttled toward the drilled hole. An arrow illustrates the shuttle direction. Before inserting the bolt into the drilled hole the Hole Probe measures the hole. Then the shuttle table moves the rest of the way aligning the Bolt Inserter with the hole.

The Inserter's air cylinder is then energized and it extends all the way through the nosepiece and slips the bolt into the hole. When it reaches this position, the nutrunner is commanded to actuate the SSTF bolt. The bolts are actuated to specific torque values for different amounts of clamp-up force. Next the Bolt Inserter is retracted leaving the installed bolt in the hole and the machine can unclamp and proceed to the next hole.

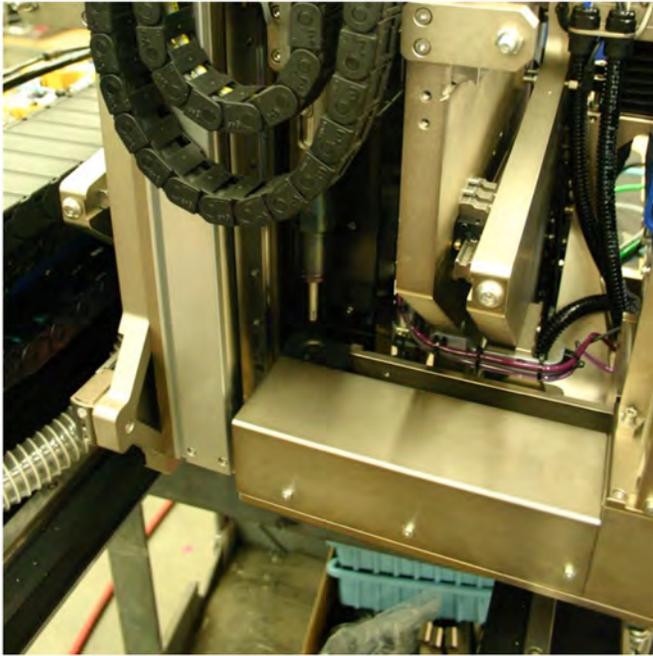


Figure 10. Bolt Inserter carrying fastener

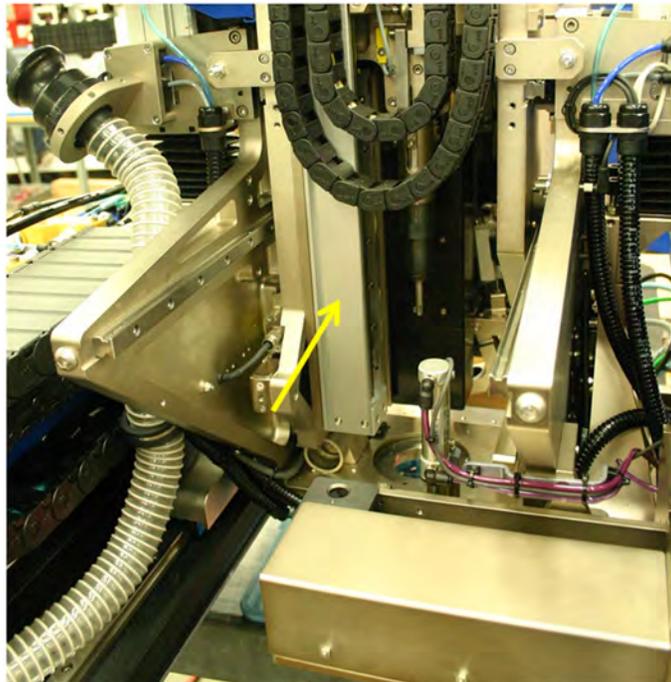


Figure 11. Inserter moving in shuttle direction

aerospace components during assembly providing doweling and clamp-up. The Flextrack does this while remaining clamped up to the workpiece to ensure not part movement between drilling and fastener installation. The new Multifunction Flextrack carries the bolts with the machine head as opposed to being fed bolts through a feed tube. A Bolt Cartridge System carries up to 80 bolts onboard the Flextrack and the Cartridges can be quick changed for use with several different diameters, 1/4" through 7/16" and in multiple grip lengths. The Flextrack Bolt Injector can receive a bolt from one of four banks in a fastener feed cartridge and presents it to the Bolt Inserter where length and diameter are checked. The Bolt Inserter resides on a shuttle table and installs the bolts after drilling and probing the hole. The Inserter is driven to and from the panel with an air cylinder and installs the bolts with an electric nutrunner. To actuate the temporary fasteners, the nutrunner applies a torque to the inner hex drive while holding the outer head static. The bolts are actuated to specific torque values for different amounts of clamp-up force. The new automatic bolt feeding system on the Multifunction Flextrack advances the Flextrack technology and provides state-of-the-art solutions for today's automated aerospace assembly applications.

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DEFINITIONS/ABBREVIATIONS

Bolt Injector

Process tool that catches fastener travelling through feed tube and presents it to Bolt Inserter

SUMMARY/CONCLUSIONS

This summarized the new Multifunction Flextrack's bolt feed system, the first Flextrack to automatically install bolts. The new Flextrack installs SSTF (Single Sided Temporary Fasteners) which are increasingly replacing more cumbersome and manual tools for temporary fastening of

Bolt Inserter

Process tool on shuttle table that installs fastener in drilled hole

Socketed

The state in which the bolt's head has been secured in the Bolt Inserter's socket

SSTF

Temporary fastener that provides clamping and doweling primarily available from Centrix, LLC

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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