

Automatic Feeding of Temporary Fasteners in Confined Spaces

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ABSTRACT

Single Sided Slave Fasteners (SSSF) or Single Sided Temporary Fasteners (SSTF) are increasingly replacing more cumbersome and manual tools for temporary doweling and clamping of aerospace components during assembly. Their ability to clamp provide doweling and clamping reduce the amount of tooling required. Due to their low profile and blind (one-sided) capability, the key benefit of this new technology is the ability to install these fasteners with automated machines. Electroimpact has developed machines to feed primarily SSTF bolts made application-specific by Centrix LLC [1]. The application discussed in this paper presented problems of confined spaces where a variety of fasteners were required to be fed automatically. To address this, Electroimpact developed new Bolt Injector and Bolt Inserter technology to feed multiple diameters of SSTF bolts in a very small package. Application-specific SSTF were designed such that multiple diameters could be fed through one feed tube. Additionally, the new technology produced diameter and length checking ability. Previously, ancillary systems were often needed to provide this functionality or the functionality was not offered at all. The tools developed for this application provide automatic feeding of a variety of fasteners through one tube into a confined space. Length checking, diameter checking and absence of tool change are further benefits of this system. The resulting tools provide increased functionality in an increasingly smaller package.

INTRODUCTION

The origin of the bolt feed system discussed in this paper was developed to address a confined space application where multiple diameters of SSTF bolts were required to be fed automatically. For a sense of scale, the drilling and fastening machine developed to solve this problem has an end effector measuring less than one square foot in cross section. Bolts of

diameter ranging from 3/16" to 3/8" with considerable length variation were required to be fed automatically. This paper will focus on the Bolt Injector and Bolt Inserter which are process tools which take the bolts from feed tube to installation into a drilled hole. These tools were developed to solve the challenges of feeding fasteners automatically and the need for a variety of fasteners to be fed into a confined space. Additional challenges included the need for diameter checking, length checking, and the problem of access for tool change between fastener diameters.

SYSTEM OVERVIEW

An Electroimpact bolt feed system is tasked with delivering fasteners to the machine's head from a loading station some distance away from the end effector. The loading station allows access for resupplying fasteners and typically consists of hopper or Stick-style [2] Fastener Feed system. The fasteners are sent from the Fastener Feed system to the machine's head through plastic feed tube. On the machine's end effector are a Bolt Injector and a Bolt Inserter. These process tools take the bolt from the feed tube and install it in the drilled hole.

The Bolt Injector is a pneumatically actuated tool which resides on the clamp table whose task is to catch the incoming fastener traveling through the feed tube and present it to the Bolt Inserter. The Bolt Inserter is a process tool which resides on the machine's shuttle table and is tasked with picking up a fastener from the Bolt Injector and installing it in the drilled hole. The Bolt Inserter is primarily driven by a ballscrew and additional functions are actuated pneumatically. In addition to typical Electroimpact Bolt Inserter functions, Bolt Inserters for SSSF/SSTF applications also actuate the fasteners after inserting them into the drilled hole. To do this, they are equipped with a socket which keeps the head of the bolt from rotating and an inner driver used to

deliver torque to the bolt which in turn applies clamping force to the workpiece.

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 SSSF bolts' small head also allows them to be fed through plastic feed tube. Also, the bolt's blind or one-sided capability makes them easily installed automatically. These features make the fasteners reduce the amount of tooling required for assembly but also allow them to be installed by an automated machine. [Figure 1 \[1\]](#) shows some of the key features of the SSSF/SSTF bolts.

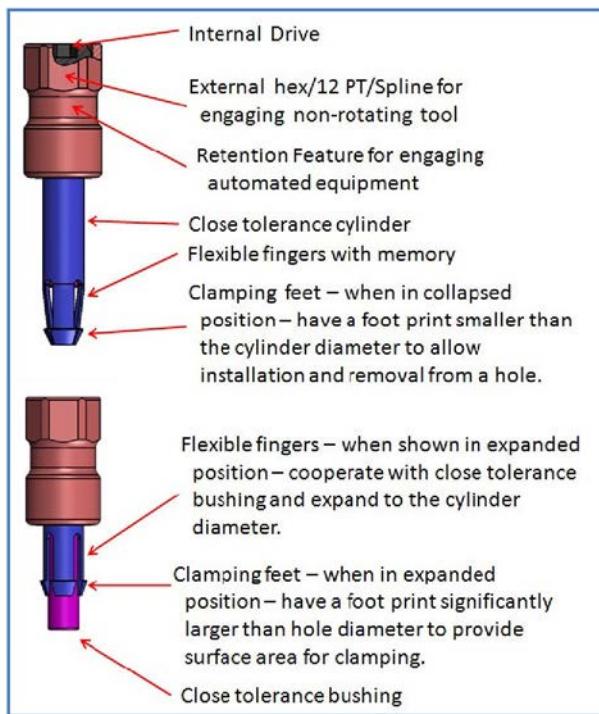


Figure 1. SSSF/SSTF Bolt Features. Adapted from [1]

CYCLES OF FUNCTION

The function of the Bolt Injector is to receive the SSSF bolt after it has been fed to the machine head through plastic feed tube. The Bolt Injector catches the bolt and presents it to the Bolt Inserter. The first step in the bolt feed process is the bolt's release into the feed tube by the Fastener Feed system.

After that, pressurized “blast air” moves the bolt through the tube up to the process tools which are the focus here.

The final section of the feed tube is an extension, known as the Chamber, which is part of the Bolt Injector. [Figure 2](#) shows, in the bottom right, the bolt traveling (up) into the Chamber. For orientation, the Bolt Inserter, a separate process tool, is in the bottom center, represented by blue cylindrical bodies.

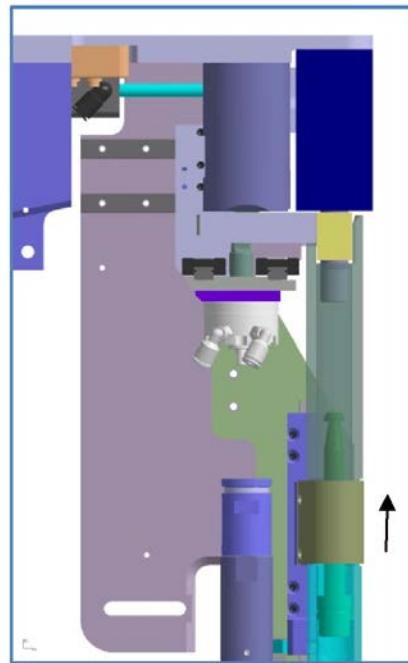


Figure 2. Bolt Entering Chamber

At the end of the feed tube, the bolt's motion is stopped with a soft Polyurethane rod. The rod is part of a damping mechanism that has additional features to give it a dashpot effect instead of purely a pneumatic spring effect. This mechanism functions to stop the bolt's travel softly protecting the SSTF bolt and reduce wear on the Bolt Injector. Additionally, this mechanism reduces bolt feed cycle time in that the time it takes a bolt to bounce after impact is mostly eliminated. [Figure 3](#) shows the SSTF bolt upon impact with the Polyurethane rod.

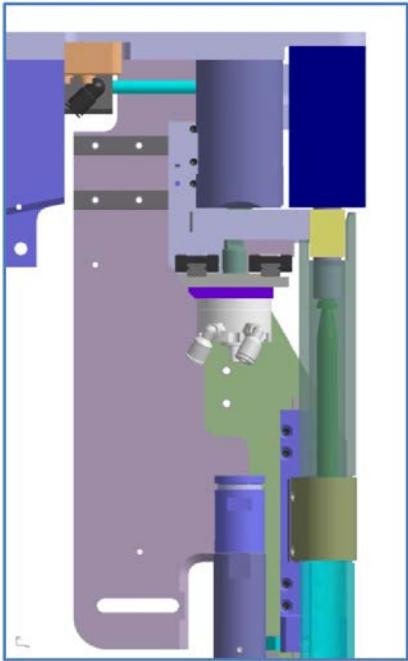


Figure 3. Bolt Impacts Polyurethane Rod

At this point, the damping mechanism is retracted. The bolt, with the pressurized blast air behind it, moves to this retracted position maintaining contact with the Polyurethane rod. [Figure 4](#) shows the bolt in this position. Also, during this step, a mechanism termed “Bolt Jaws”, seen conceptually in [Figure 5](#), close around the bolt and secure it from moving. The blast air in the tube is now turned off. Here, the diameter check is achieved. The Bolt Jaws are attached to a 0-10 Volt analog position sensor through which their position can be correlated to the diameter of the SSTF bolt being held.

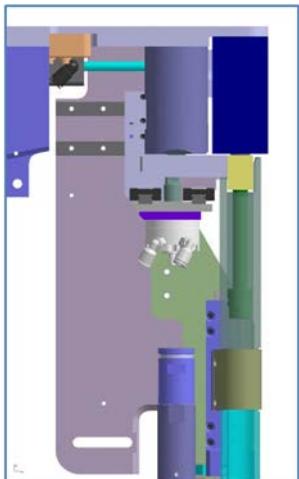


Figure 4. Damping Mechanism Retracted

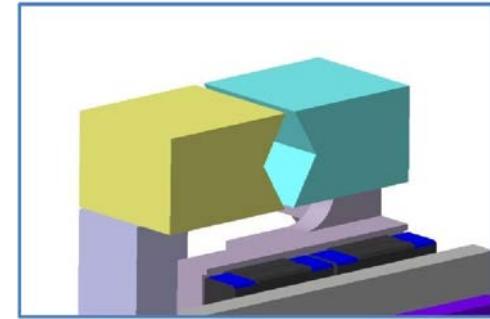


Figure 5. Bolt Jaws

With the SSTF bolt held securely by the Bolt Jaws, the Chamber is retracted pneumatically to clear the head of the bolt, see [Figure 6](#). The bolt, at this point, is coaxial with the feed tube and not the Bolt Inserter, so retracting the Chamber also allows the bolt to be moved from this position.

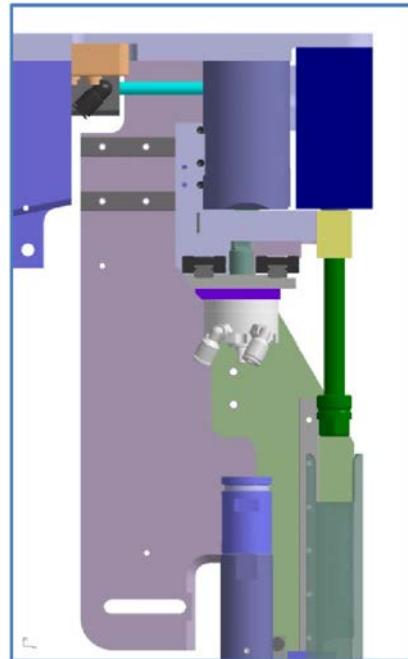


Figure 6. Chamber Retracted

The next move brings the bolt in-line with the bolt Inserter. Directly in front of the bolt is a spring-loaded pad captured in an Aluminum housing, see [Figure 7](#).

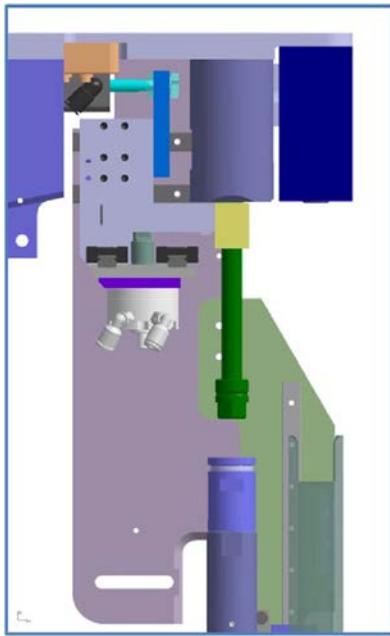


Figure 7. Bolt in-line with Bolt Inserter

The Bolt Inserter has a fixed socket front end that snaps onto the bolt as presented on the spring-loaded pad. The bolt is “socketed” when the Bolt Inserter ballscrew drives the tool forward until the bolt has been snapped into the socket, see [Figure 8](#). A groove in the bolt head and spring loaded ball bearings in the socket keep the bolt in the socket once it has been socketed. The preload in the spring-loaded pad provides enough force for the bolt to be snapped into the socket.

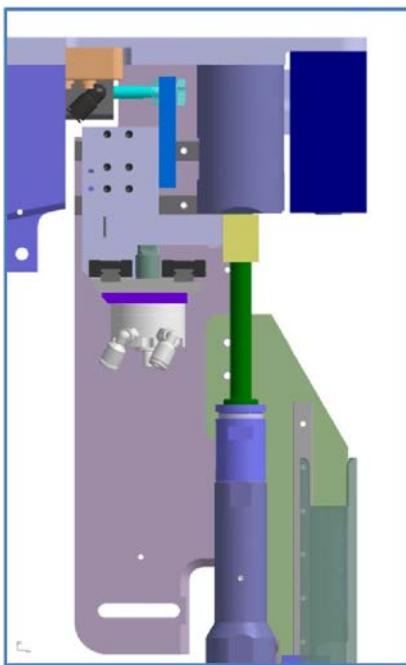


Figure 8. Bolt in Socket

Next, the inner driver of the Bolt Inserter engages the internal mandrel of the SSTF. The Bolt Inserter, at this point, can actuate the SSTF. For safety and to confirm the bolt is present, the Bolt Inserter unwinds the SSTF bolt. The Bolt Inserter provides torque to the fastener through an electric nutrunner.

From this step, the Bolt Jaws open and release the bolt. Next, the Bolt Inserter drives forward with the bolt and triggers a proximity switch linked to the spring-loaded pad. Combining the servo-motor's encoder feedback with the proximity switch's triggering, bolt length is checked.

From here, the Inserter retracts with the bolt, see [Figure 9](#). At this point, these process tools have checked diameter, checked length, and confirmed that the bolt is fully unwound confirming that the bolt is ready to be installed into the workpiece.

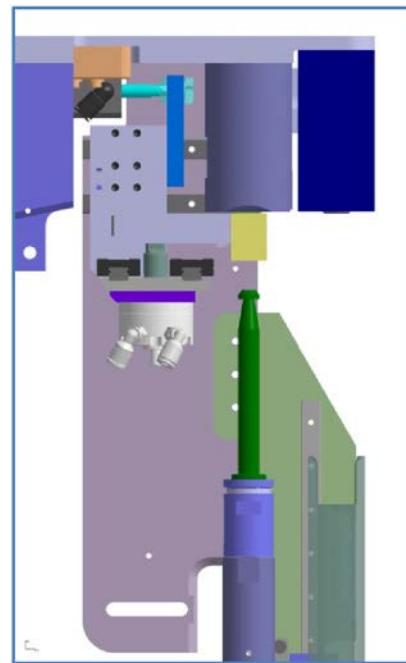


Figure 9. Bolt Inserter retracted with Bolt

With the Bolt Inserter retracted, it is now clear to shuttle to the position where the hole was drilled and install the SSTF. With the fixed socket preventing head rotation, the inner drive actuates the SSTF. The fastener is wound by the electric nutrunner until a preset torque value is reached. The torque value is predetermined to give an appropriate amount of clamping force to the aerospace components that are being assembled.

SUMMARY/CONCLUSIONS

This summarizes the new technology of installing doweling, clamping temporary fasteners with automated machines in

confined spaces. The process tools developed to address these challenges provide addition functionality in a confined space while maintaining high reliability. Working with Centrix, LLC yielded fasteners from 3/16" diameter to 3/8" that shared a common head size allowing them to all be fed through a single size feed tube and eliminated the need for tool change between diameters. Elimination of the tool change contributed greatly to fitting all the mechanicals into the small package. Diameter checking was facilitated with Bolt Jaws gripping mechanism combined with an analog position sensor. Length checking is achieved with a Touch-Off mechanism in the injector used in combination with Inserter's servomotor feedback. Installation of the SSTF fasteners is executed using a nutrunner. The Bolt Injector and Bolt Inserter make up the front end of an automatic feed system for the SSTF temporary fasteners that provides even more functionality in a confined space.

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DEFINITIONS/ABBREVIATIONS

Bolt Injector

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

Bolt Inserter

Process tool on shuttle table that installs fastener in drilled hole

End Effector

Device or tool connected to the end of robotic arm

Socketed

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

SSTF or SSSF

Temporary fastener that provides clamping and doweling of aerospace components 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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