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Automatic Temporary Fastener Installation System for Wingbox Assembly

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ABSTRACT

The automation cycle time of wing assembly can be shortened by the automated installation of single-sided temporary fasteners to provide temporary part clamping and doweling during panel drilling. Feeding these fasteners poses problems due to their complexity in design and overall heavy weight. In the past, Electroimpact has remotely fed these fasteners by blowing them through pneumatic tubing. This technique has resulted in occasional damage to fasteners during delivery and a complex feed system that requires frequent maintenance.

Due to these issues, Electroimpact has developed a new fully automated single-sided temporary fastening system for installation of the LISI Clampberry fasteners in wing panels for the C919 wing factory in Yanliang, China. The feed system stores fasteners in gravity-fed cartridges on the end effector near the point of installation. The cartridge placement at the end effector eliminates the need for pneumatic feed tubes in addition to limiting input sensors to cartridge identification only. By reducing pneumatics, sensors, and controls, less maintenance is expected for the fastener storage system. When a fastener is requested by the machine, a pick and place mechanism grabs the correct fastener from the cartridge and loads the fastener into the fastener inserter. The fastener inserter then installs the fastener into the wing panel using a servo nut-runner to wind the fastener until the grippers pull the stack together with a specified preload. Diameter, grip length, and fastener integrity are all checked during the feed process.

Extensive prototyping yielded results of 99.9% reliability across the spectrum of fasteners. Production hardware for this system has also passed Preliminary Acceptance Testing with Xi'an Aircraft Industry (Group) Company (XAC) and is currently installed and ready to start production.

INTRODUCTION

This fastener system was developed to automate the temporary fastening requirement for the assembly of XAC's new C919 aircraft wing and is used on the Lean Technology Drilling (LTD) machine.[1] The LTD machine accurately drills holes, inspects the drilled holes, and installs temporary fasteners in the wing's upper and lower panel in a vertical build major assembly jig. By using these temporary fasteners, the LTD machine is able to drill full size holes, install a fastener, and keep the panel clamped and located as it continues on to further holes. This system is able to install temporary fastener diameters ranging from 3/16" to 1/2" in stack thicknesses ranging from 0.12" (3mm) to 2.00" (51mm).

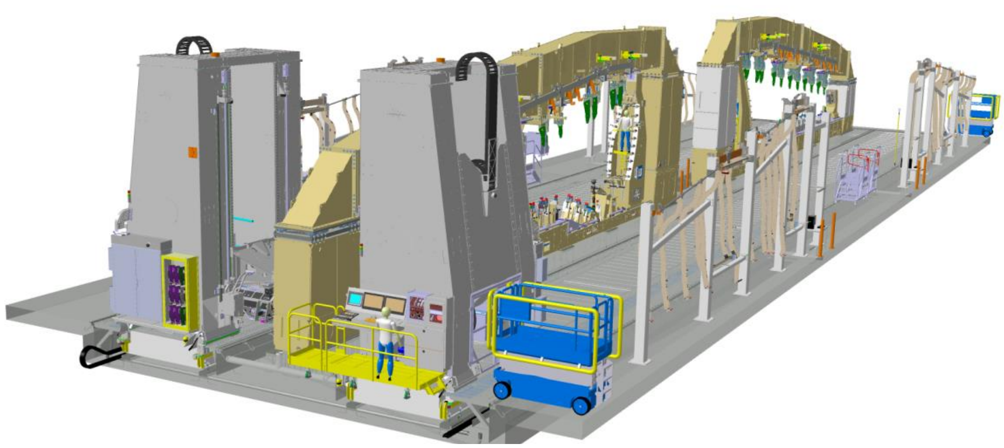

Figure 1: LTD Machine Cell

SINGLE-SIDED TEMPORARY FASTENERS

Single-sided temporary fasteners (SSTF) are frequently used to provide clamp up and doweling during an assembly operation. The SSTFs installed by this system are the CLY™-61s from LISI Aerospace.

Figure 2: LISI CLY™-61 Fasteners

These SSTFs provide a large grip range compared to other automated SSTFs. The head consists of a splined outer diameter and a drive nut on top which actuates the fastener. The SSTFs have grippers similar to a traditional Cleco fastener which in the unactuated condition are smaller than the spreader bar. The grippers expand and retract over the spreader bar when the drive nut is tightened.

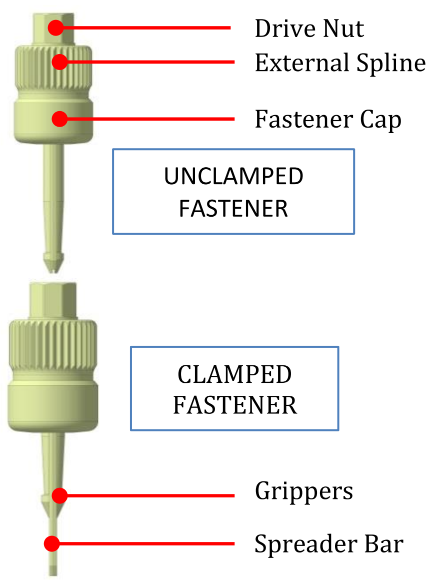

Figure 3: Key Fastener Features

CARTRIDGE ASSEMBLY

SSTFs are stored in cartridges that are loaded into a receiver assembly next to the fastener injector. Each cartridge is associated with a nominal diameter. Each guide row in the cartridge holds a specific fastener type determined by the grip length and whether it is a full sized or undersized fastener. Fasteners move through the guide rows using gravity to fall when a fastener is pulled out from the indexing exit point at the bottom. At the exit point, fasteners are held onto a V-block using a magnet underneath.

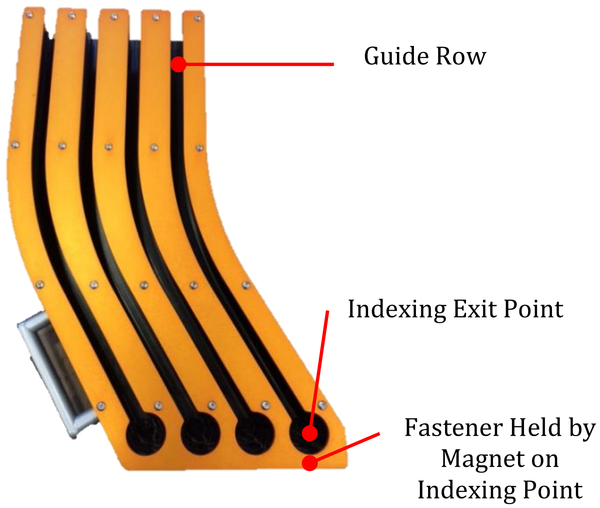

Figure 4: Cartridge Assembly

CARTRIDGE LOAD AND UNLOAD

During panel drilling, multiple tool changes need to occur and the correct fastener diameter must follow. To keep the process running, the cartridges must be installed and uninstalled quickly to a repeatable location. The design discussed is an iteration of a previous cartridge design by Electroimpact.[2] The cartridge receiver assembly has two guide ways that allow the cartridge to slide in and out horizontally. Once it slides into the correct position a spring plunger lands into a bushing to lock the cartridge into place. Four sensors read the loader assembly code to determine which cartridge has been installed on the machine. Cartridges can quickly be unlocked and removed by pulling a handle on the spring plunger to retract it and sliding the cartridge back out.

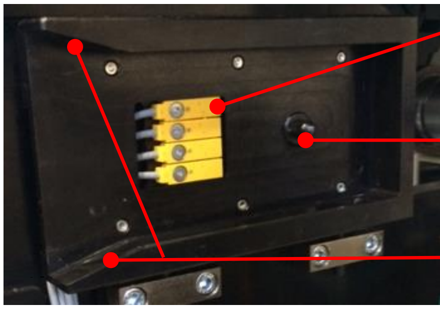

Figure 5: Cartridge Receiver Assembly

On the cartridge side, the loader assembly uses dowels and keyways to slide in and out of the receiver assembly. The spring plunger is pushed into its retracted position by a ramp until it reaches the alignment bushing and redeploys. The cartridge ID sensors use the hole pattern to create a binary code for the machine to read.

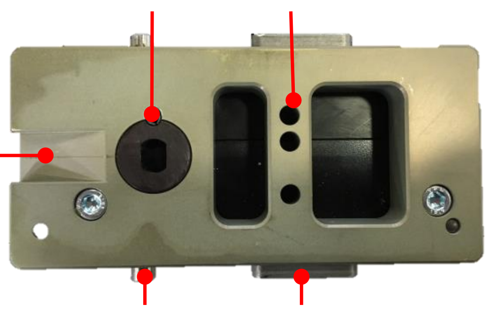

Figure 6: Cartridge Loader Assembly

FASTENER INJECTOR ASSEMBLY

The fastener injector assembly consists of the cartridge receiver assembly, grabber assembly, injector axis, and fastener reject bin.

Figure 7: Injector Assembly Components

The injector is designed to be a pick and place mechanism by using the grabber assembly to transport the fastener from the cartridge to the feednose along the injector axis. The grabber assembly can extend and retract by using a guided rodless cylinder. The injector axis is a servo driven monocarrier which allows for multiple different positions on the axis.

FASTENER INJECTION PROCESS

The injection process begins with the machine using the drill diameter and programmed stack thickness to determine which fastener to grab from the cartridge. The grabber assembly will then move to the correct row and extend to the full-forward cylinder stroke with the jaws open. The jaws will then close on the fastener shank and retract, thereby pulling the fastener with it. The grabber assembly will then be shuttled over to the load position in order to load the fastener into the fastener installation feednose. At this point the diameter of the fastener is measured using a sensor that measures the position of the jaws. The fastener is loaded into the feednose even if it does not pass the diameter check because a rejected fastener will be delivered to a reject bin from the feednose.

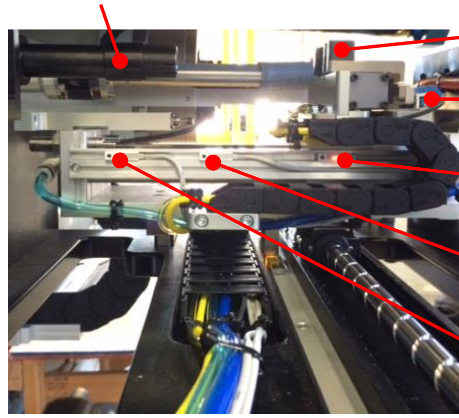

Figure 8: Grabber Assembly

The feednose on the fastener inserter will also move to the load position at this point. The grabber assembly then extends to load the fastener into the feednose. The feednose compresses and turns to account for misalignment of the splines. In the instance of a successful load, the grabber assembly will reach the load proximity sensor and the feednose will retract to its uncompressed state. The nut runner will then ensure fastener engagement with a few turns. At this point, the jaws will open and the grabber assembly will retract.

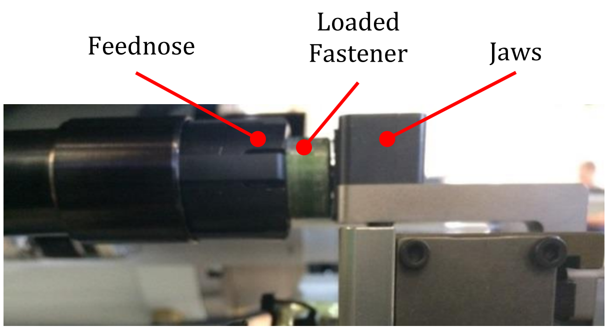

Figure 9: Loaded Fastener

FASTENER INSTALLATION FEEDNOSE

To account for the different diameters of SSTFs, multiple installation tools are needed. To cover the range from 3/16" to 1/2", three feednose tools were needed. Development was made with LISI Aerospace to bring a design applicable to automated loading and installation with a manual tool change. The feednoses work as the interface between the static bolt inserter and the SSTFs. The feednoses are manually changed along with the other process tool changes needed for operating at a different diameter. The manual change is accomplished quickly through a ball detent quick connect.

Figure 10: Fastener Installation Feednose

NUT RUNNER CONTROLLER

Located on the back of the End Effector is the nut runner controller. This controller communicates with the CNC and controls the tightening of the SSTFs. Programmed parameter sets (PSets) specify a fastener tightening process. The parameter sets include target ranges for many factors such as angular rotation, speed, torque, etc… Error checking is accomplished during installation through the monitoring of the parameter values. If the values remain within the limits, the controller sends a confirmation signal to the CNC to proceed.

PRE-INSTALLATION CHECKS

Once the fastener injector sends the signal of completed loading, an engagement PSet is run while the fastener is still in the fastener injector jaws and in the feednose. The PSet engages the feednose drive socket to the fastener drive nut. A successful PSet signals the fastener injector jaws to release and retract. The fastener inserter, while waiting for the drill and probe cycles to end, runs more PSets to check the fastener is functioning properly. When it is time for the installation of the fastener, the fastener inserter is shuttled into place, and the fastener is measured to assure it is the proper grip length. If any of the pre-installation tests fail, a reject cycle is initiated. The fastener inserter rejects the fastener through the use of a built in pneumatic cylinder to eject the fastener into a reject bin. The loading process begins again to load a new fastener and the checks are repeated for the new fastener.

FASTENER INSTALL

The installation process begins after the fastener has passed its preliminary checks and the drill cycles are completed. The fastener inserter is positioned in line with the hole. The fastener inserter drives forward to a panel position based on the fastener and consequently inserts the fastener into the hole. Limit switches are used to assure the fastener is fully inserted and tightening will not damage the work piece. If the fastener is successfully loaded in the work piece, the machine tells the controller to run the installation PSet. The controller monitors the process parameters and confirms proper tightening is achieved. The fastener inserter retracts leaving the fastener in the work piece.

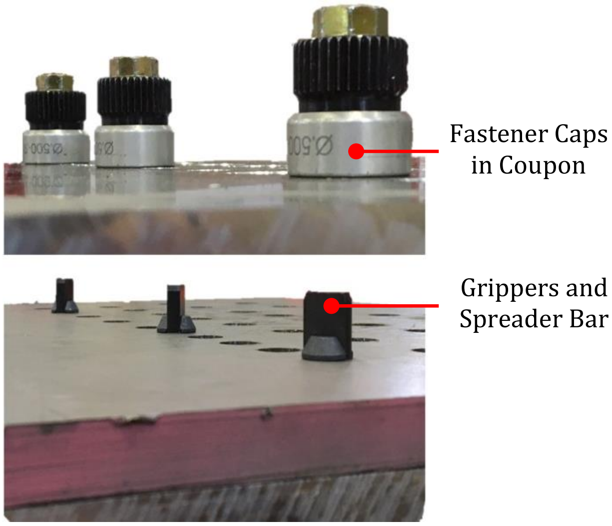

Figure 11: Fasteners Clamped on Coupon

SUMMARY

SSTFs provide an opportunity to reduce the cycle time for wing assembly. Automation of SSTFs presents challenges due to the size and complexity which can cause damage to fasteners and a feed system requiring frequent maintenance. Electroimpact has reduced these problems by simplifying the feed system for the LISI CLY™-61 fasteners. This system aids in the manufacture of the new C919 wing manufactured in Yanliang, China.

REFERENCES

1. Peck, J. and Massey, K., “Next Generation Composite Wing Drilling Machine for Vertical Builds” SAE Technical Paper 2011-01-2613, 2011

2. Krejci, C. and Westley, J. “Automatic Bolt Feeding on a Multifunction Flextrack”, SAE Technical Paper 2011-01-2773, 2011

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