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Automatically feeding and installing Single Side Slave Fasteners

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ABSTRACT

The use of two piece temporary fasteners is not an option on some build methodologies, processes, or techniques because of limited accessibility. To solve this problem the use of Single Side Slave fasteners (SSSF) were used. With the development of the SSSF, new process tools also needed to be developed to automatically feed and install these fasteners. This paper will cover the development of the process tools used to feed and install SSSF. The tools were designed to automatically insert and torque 1/4" - 5/8" SSSFs. This paper will cover both the development of the Bolt injector and Bolt inserter.

Introduction

New single-sided (blind) slave (temporary) fasteners (SSSF) were developed to provide clamp up and doweling and are a significant improvement over traditional Cleco style temporary fasteners. The SSSFs were developed with Travis McClure of Centrix LLC. SSSFs design and development are discussed at length in the SAE technical paper 2009-01-3184 (see Reference 1). This paper discusses automated installation of SSSFs.

The primary drawback of SSSFs are their expense. The overriding design concern was to minimize the cost of the fasteners. Not the initial cost but the real cost: cost per shipset. The customer wanted the SSSFs to last for 500 installs. If they can be utilized this number of cycles then the cost per install is reasonably low. But cost per install is not complete, the real cost is better understood in terms of cost per shipset. By lowering the installation torque of the SSSFs they would last longer but would reduce the clamp-up of the fasteners thus a higher percentage of the drilled holes would need to be slaved, which would increase the overall number of fasteners and more importantly it would increase the cycle time of each shipset. So maximizing the performance and longevity of the SSSFs should minimize the real cost of the SSSF technology.

A minimal understanding of the SSSF is needed in order to understand the requirements of an automated installation tool.

Figure 1 single sided slave fastener

The SSSFs provides both clamp-up and doweling. The SSSFs have a limited grip range. They consist of a fixed non-rotating outer head and an inner bolt which actuates the SSSF. The SSSF has feet which are collapsed to a diameter just under the shank diameter the when the inner bolt is fully unwound, the feet expand when the inner bolt is tightened like a traditional cleo fastener. The dimensions of the head were limited in size by a number of external factors; the height that it could protrude from the panel was limited to 19mm. The shape of the SSSF head was undefined, but the most practical option was a six point hex or a 12 point. A six point hex head was selected as it was the least expensive to manufacture. A female hex head was selected for the head of the inner bolt for the same reason and others discussed later. Thought the simple hex feature of a female featured bolt head is outdated by the torx head in terms of maximum torque the hex is still decent. More importantly with a hex the driver and bolt head will last longer. Furthermore drivers for this process tool will obviously be wear parts and should be cheap to make.

MAIN SECTION

INJECTOR DESIGN FEATURES

Electroimpact designed a push style bolt injector to inject SSSF bolt into the bolt inserter. The basic framework of the design was based off the pinch bolt injector. To learn about the pinch bolt injector read SAE technical paper 09ACT-0182. The goal in designing this injector was to design a highly reliable and operator friendly injector. The injector needed to be able to feed in any orientation and feed SSSF bolt diameters from a 1/4" through 5/8".

Figure 2 push bolt injector

The injector is mounted to the bolt inserter and transfers the bolt into the inserter. Bolts are fed from feed system down plastics tube lines to the injector. The injector assembly can be broken up into three section known as the sled, chamber and post.

The Sled is the frame of the assembly. It is where all the hardware that makes up the injector get mounted. The sled moves from the feed position to the inject position.

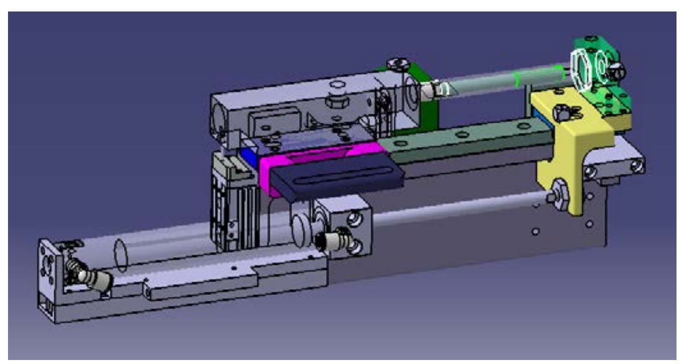

Figure 3 Sled

The chamber is where the bolt is contained in the injector. It is a molded polyurethane part to help prevent damage to the bolt. The bolt is blown down the fed tubes at a high rate of speed and enters the chamber. The chamber changes out depending on what diameter

SSSF is being fed. It also helps aligns the bolt before it is injected into the bolt inserter.

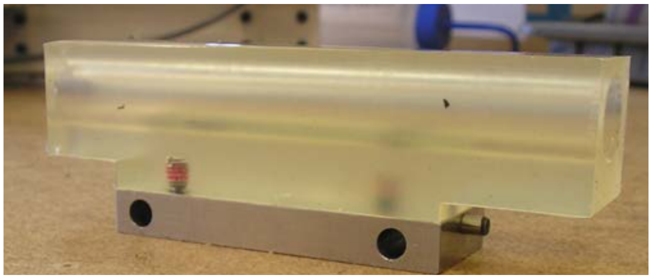
Figure 4 Chamber

The post absorbs the energy of the bolt being fed and it pushes the bolt into the bolt inserter. The post assembly is a air damper with a plastic nylon tip to prevent damage to the SSSF.


Figure 5 Post

INJECTOR SEQUENCE

Step 1: The bolt is blown down the feed tube at a high velocity: between 25-45 mph depending on bolt size. The velocity was measure using two ring sensor place at the end of the feed tube. The air flow in the feed tubes was set between 15-25 CFM.

Step2: The bolt enters the chamber and contacts the plastic nylon tip, transferring the incoming energy into the post assembly.

Step 3: The post air is turned off allowing the bolt fully enter the chamber

Step 4: A pin extends at the entrance of the chamber to keep the bolt from sliding out and back into the feed tube

Step 5: The sled extends and aligns the chamber to the bolt inserter

Step 6: The pin blocking the fed tube retracts

Step 7: The post cylinder retracts and pushes the SSSF into the socket of the inserter. A analog position sensor tells us when the bolt is seated in the socket and measures its length.

Step 8: The bolt inserter servos back pulling the SSSF out of the chamber. The post and sled cylinders both retract, finishing the injection cycle.

INSERTER DESIGN FEATURES

An automated installation tool needs to hold the SSSF securely enough to put it in a hole and keep the outer head from rotating while running in the inner bolt to the desired torque. Furthermore the SSSFs need to be back-driven prior to install to ensure that they are fully unwound with the feet completely collapsed, otherwise there would be the possibility of trying to insert a SSSF with unclasped feet. Thus the inserter needs to keep the SSSF head from rotating in either direction. This makes the exchange of the bolt from the injector to the inserter difficult, because the outer hex head of the SSSF would be clocked at any random angle when it is fed. The inserter tip is a 12 point socket with self alignment features which guide the SSSF to the correct clocking as it is being pushed into the socket so that it does not jam. When the bolt is in the socket the socket has spring detents which fall into a groove in the head of the SSSF and keep it from falling out. The detents are not standard purchased parts, they are three single ball bearings which slide in and out in slots that cut in the shank of the socket, they are held in by a C shaped spring as shown in 6. This design was used in order to minimize the outer diameter of the socket. There are set screws in the sockets as can be seen in Figure 7: Socket Change out Parts which keep the C shaped spring from rotating.

The seven diameters of bolts were divided into three different head sizes in order to reduce the installation hardware and tool change frequency. The 1/4" and 5/16" SSSF share a common head size, as do 3/8" and 7/16", and 1/2"-5/8". The bolts have a common inner bolt hex size too. The minimum O.D of the head was determined by the shank diameter, the maximum O.D of the head was limited by the minimum distance between the centerlines of adjacent holes which was four times the hole diameter. These considerations are what restricted the degree to which the SSSFs head sizes could be combined. The three head sizes have corresponding tips for the inserter as shown in 7 and 8, which can be changed out quickly by the machine operator without using any tools. The inserter uses an electric nutrunner made by Atlas Copco to torque the SSSFs.

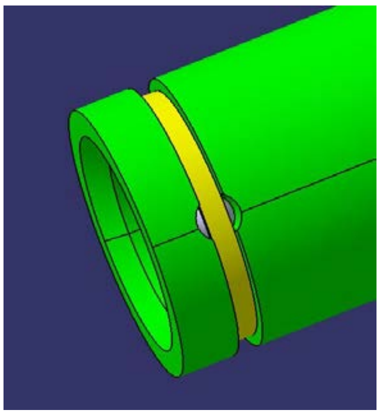

Figure 6: Socket Detent

Figure 7: Socket Change out Parts

Figure 8: Driver Change out Parts

The injector pushes the SSSF into the socket of the inserter. The inserter's inner driver is retracted so that it does not interfere with engaging the SSSF in the socket. The inner driver then extends while rotating slowly counter-clockwise to engage the inner driver with the SSSF 's inner bolt until the nutrunner achieves a preselected torque. This torque being reached combined with the cylinder hitting the extend switch indicates that the driver is properly engaged and functions to verify that the SSSF is fully unwound hence ready to place in the panel. The inserter then servos back to clear the SSSF from the chamber the injector sled then extends so that the chamber is out of the way of the inserter. The bolt can be fed, injected and bolt diameter measured while the machine is drilling a hole. Once the machine is ready to insert a SSSF the inserter servos to a location where the bolt head will be against the countersink. The nutrunner then spins the inner bolt actuating the clamp feet and torques the SSSF.

The SSSFs for this build are slip fit so there should not be any significant resistance to the bolt being put in a hole, if for any reason there is interference (the wrong size bolt is used, the hole is nonexistent etc., despite the numerous and often redundant checks) the panel will not be damaged because the inserter has a crash slide. If the machine attempts to put a bolt in a nonexistent hole for instance the crash slide will allow the inserter moving assembly to slide back compressing an air cylinder which functions as a spring, once the crash slide moves it puts the inserter servo motor into feed hold . An air cylinder is used instead of a spring so that the pressure can be controlled with a CNC regulated to the optimal pressure for each diameter bolt.

ACKNOWLEDGMENTS

REFERENCES

1. 2009-01-3184, "New Blind, Doweling, Temporary Fastener Design and Testing," by Samuel O. Smith of ElectroImpact Inc and Travis McClure of Centrix LLC. Also see http://www.sae.org/technical/papers/2009-01-3184 or http://www.electroimpact.com/research/2009-01-3184.pdf

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DEFINITION, ACRONYMS, ABBREVIATIONS

Bolt inserter: process tool that puts bolts into drilled holes

Inserter injector: what holds the bolt when the Bolt inserter puts the bolt into the panel

SSSF: Single side slave fastener