2005-01-3300

Sideways Collar Anvil For Use on A340-600

Scott Tomchick, Peter Zieve, Carter Boad
Electroimpact, Inc
Adam Wellsbury
Airbus UK

ABSTRACT

A new method of installing LGP collars onto titanium lock bolts has been brought into production in the Airbus wing manufacturing facility in Broughton, Wales. The feed system involves transporting the collar down a rectangular cross-sectioned hose, through a rectangular pathway in the machine clamp anvil to the swage die without the use of fingers or grippers. This method allows the reliable feeding the collars without needing to adjust the position of feed fingers or grippers relative to the tool centerline. Also, more than one fastener diameter can be fed through one anvil geometry, requiring only a die change to switch between certain fastener diameters. In our application, offset and straight stringer geometries are accommodated by the same anvil.

INTRODUCTION

The A340-600 wing panel assembly cell in Broughton, Wales, fastens the stringers to skin panels for the upper and lower panels for the A340-600 aircraft. The cell is comprised of four E4100 Low Voltage Electromagnetic Riveting machines that are, in total, set-up to handle 32 different panel configurations and install thousands of titanium LGP lock bolts in diameters from 1/4” to 7/16”.

The original collar feed system fed a single collar axially down a round hose and employed a gripper to present the collar in front of the swaging die cavity. This method required adjustments of the gripper to the tool centerline on the order of 0.08 mm radially and, as a result, a separate anvil had to be provided for each fastener diameter and for each machine. Also, an offset tool had to be manufactured to access under Z and J shaped stringers for the 1/4” and 5/16” sizes. The total number of anvil configurations needed for lock bolts in the entire cell is six, with at least four are needed on each machine to complete a wing panel.

With the new, sideways collar feed system we were able to combine the straight and offset tool into one anvil and to also combine two collar diameters in one anvil, thereby reducing the number of anvil configurations in the cell from six to two.

SYSTEM OVERVIEW

The sideways collar feed system proceeds as thus: First, the machine clamp tables apply about 5000 N of clamping force to hold the stringer and skin panels together. Next, the swaging ram retreats from the stringer surface and a hole is drilled in the work. Then, the ram and die moves toward the stringer surface to a preprogrammed feed position from the surface of the stringer. A single, lightweight groove proportioned (LGP) collar is escaped from a cartridge that is mounted on the side of the clamp table on the E4100 machine. The collar is transported to the machine clamp anvil by compressed air down a rectangular cross-sectioned hose. The rectangular profiled hose is employed since there is more surface area on the side than on the hollow end of the cylindrical collar. As a result, higher speeds and less air flow are possible with the sideways over axial approach.

Figure 1 - Collar anvil and cartridge feed system

The collar is blown from the hose into a rectangular cavity inside the clamp anvil. The cavity is formed between the outer surface of the ram and the inside surface of the clamp forks. These are designed such that when the ram is pulled back a channel is created that is slightly wider than the collar. The clamp forks create the channel on three sides, a raised feature on the ram form the fourth side. The width of the channel can be adjusted as desired by adjusting the raised feature on the ram and the slot in the forks. The curved slot rotates the collar axis so that at the apex of motion it is aligned with the axis of the swaging die. As the collar traverses the die face it encounters a soft, elastomeric centering sleeve that is mounted on the periphery of the swaging die. The sleeve has a v-notch molded on its face to help center the collar in the opening of the die.

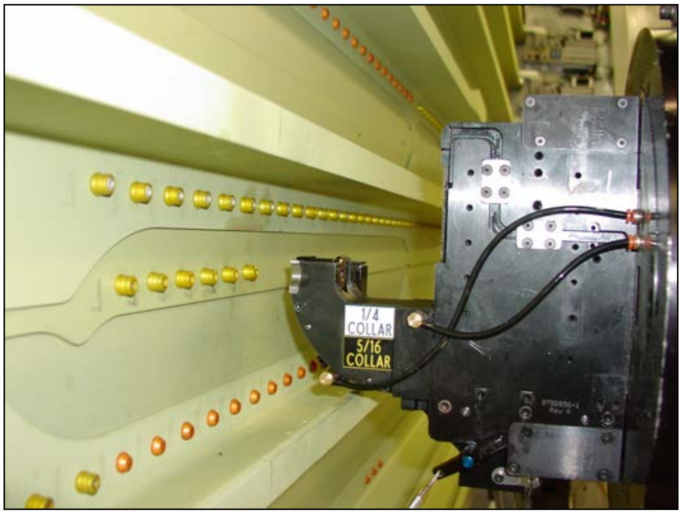

Figure 2 - 1/4 - 5/16 Combined anvil

For the LGP collar we incorporate a spring into the swaging die. This presents a flat surface to the sliding collar and prevents it from rotating, but backs up under the action of the bolt.

The next operation is to move the swaging ram toward the stringer flange to physically capture the collar against the work piece in the bell mouth of the die. At this instance, the E4100 machine controller measures the position of the swaging ram with a linear potentiometer. The measurement at this point is important, for if the collar has end damage, is out of length tolerance, is the incorrect diameter or has not been properly fed then it can be safely ejected and another can be fed.

If ejection is necessary, then a small, pneumatically actuated door is opened in the anvil and the collar is blown out of the rectangular anvil cavity. With a clear path, another collar can now be fed without having to unclamp the machine from the work piece. If the measured collar height is within the correct range, then the lock bolt is driven into the drilled hole and through the collar.

The swaging die has 0.8 mm of radial float but is "sticky". We refer to this as a sticky die. Note in Figure 9 that the capture nut for the die incorporates an o-ring. The effect of this o-ring is to make the die sticky. It can shift laterally but reluctantly. After the die is installed and the first bolt is installed the die becomes aligned with the tool centerline by the action of the tapered end of the bolt engaging the hole in the center of the collar. The die maintains this aligned position within the ram through the friction of a face mounted o-ring. Therefore, the die is self-aligning through the action of the first installed collar, normally on a setup coupon. The die remains in perfect alignment from that point forward. After the bolt head is fully seated then the collar swaging die strips off the formed collar thus completing the cycle.

Comparison With Gripper Feed Systems

The sideways collar feed system is unique in that it presents the collar transverse to the axis of the collar die without the aid of feed fingers or gripping elements. Hence, it does not rely on the alignment of fingers or grippers with the tool centerline. Also, there is no concern of the gripping element being trapped between the swaging die and the stringer surface. A plastic sleeve acts as a precision stop for the collar that rides on the swaging die and does not interfere with the swaging process. The sleeve is a simple, cheap consumable component and lasts for thousands of cycles and is easily changed out.

Another advantage of the sideways system is that its moving components are contained within the geometry of the clamp anvil. This ensures that, if the work can be clamped up, the collar can be fed and swaged without having to worry about performing actuations external to the clamp anvil. This allows for greater flexibility in the designs of intricate pathways and shapes of the clamp anvil to fit within a wide variety of stringer shapes. We were able to take advantage of this feature when designing an anvil to swage both straight clearance and offset clearance fasteners. Also, since the alignment of the collar to the die is performed at the die by the sleeve, the anvil feed path can be sized to handle two different diameters of collars.

To change between collar diameters, one only needs change out the swaging die and the sleeve. The feed hose is sized for the larger collar and, as long as it doesn’t tumble, the next size smaller collar can also be fed in the same hose. The ram feed position is different for each diameter, but this position is preprogrammed in the machine code and is changed when the operator selects the appropriate fastener diameter on the operator console during a tool change. By taking advantage of these features, we were able to reduce the number of distinct clamp anvils used for swaging four collar diameters from six to two. This has resulted in fewer machine tool changes per panel. Also, fewer numbers of spare parts are needed to support the same number of machines in production.

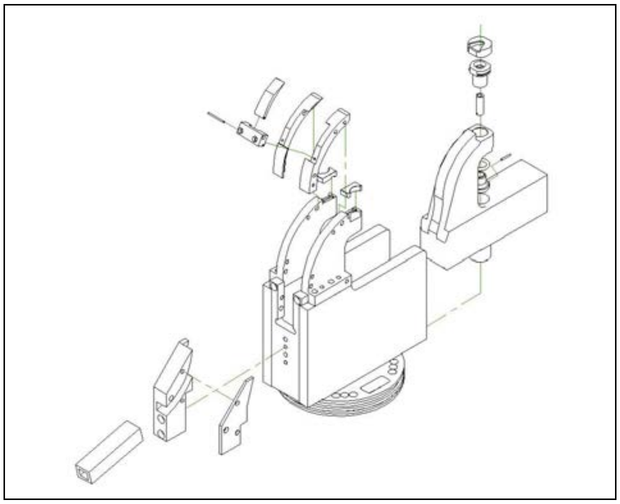

Figure 3 - Exploded view of anvil and ram assemblies

CONCLUSION

The sideways collar feed system provides a superior alternative for the installation of lock bolt collars. This method allows the reliable feeding the collars without needing to adjust the position of feed fingers or grippers relative to the tool centerline. Also, more than one fastener diameter can be fed through one anvil geometry, requiring only a die change to switch between certain fastener diameters. In addition, offset and straight stringer geometries can also be accommodated by the same anvil. In our application, we were able to reduce the number of distinct anvil designs for four collar sizes from six to two, resulting in fewer tool changes and a significant reduction in stocked spares.

Innovations for collar storage and feeding:

1. collars are stored side to side so they don't damage the seal ends
2. collars blow sideways so the hole in the center does not release pressure
3. cartridge of rectangular tubing is efficient and neat

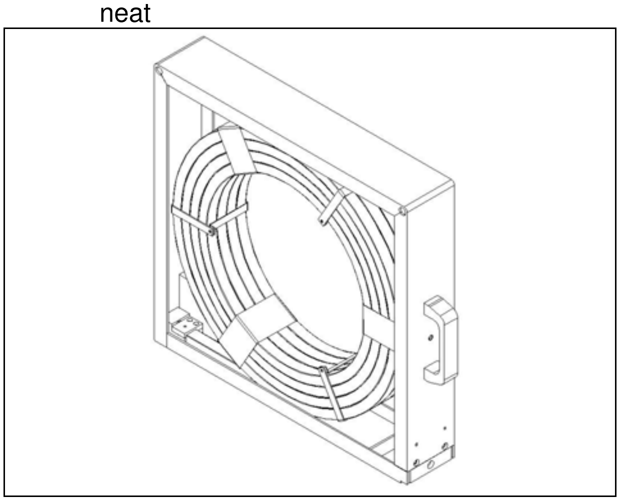

Figure 4 - Collar cartridge assembly

Innovations in the collar anvil

1. rectangular slot is created between the clamp-up forks and the ram
2. collar blows along the outer surface of the ram
3. when the collar gets to the tool axis it is centered by the polyurethane alignment sleeve
4. alignment sleeve centers the collar but does not interfere with the swaging process
5. die contains a central spring with a flat surface that prevents the collar from rotating at the hole location

Sequence of Operation

The sequence of operation is shown in 8 steps in the following figures.

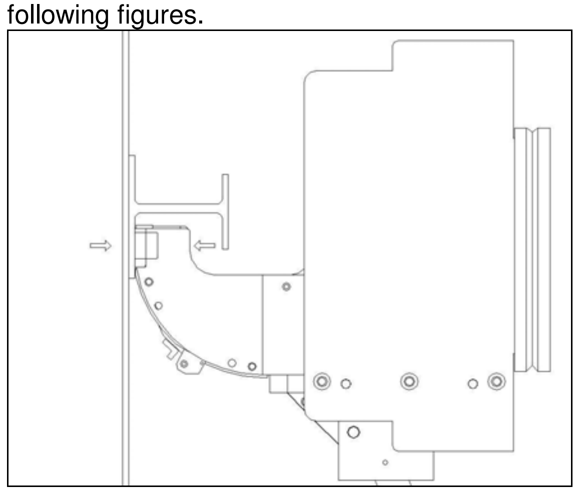

Figure 5 - Step 1: Machine clamps up at a location

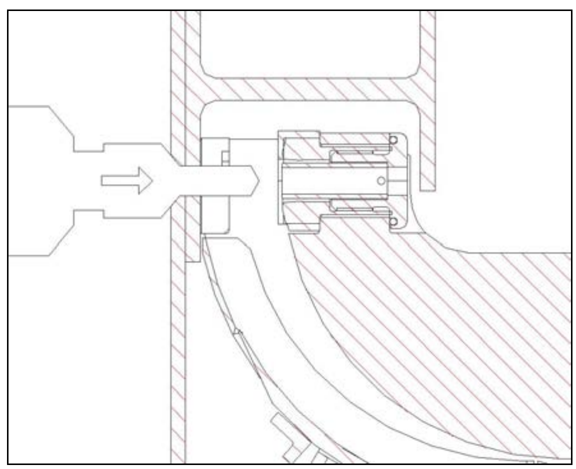

Figure 6 - Step 2: Ram pulls back to allow drill break-though

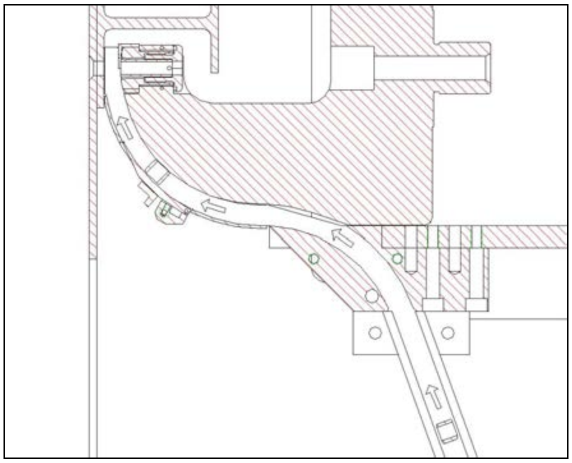

Figure 7 - Step 3: Ram is advanced to provide a specific clearance for the collar

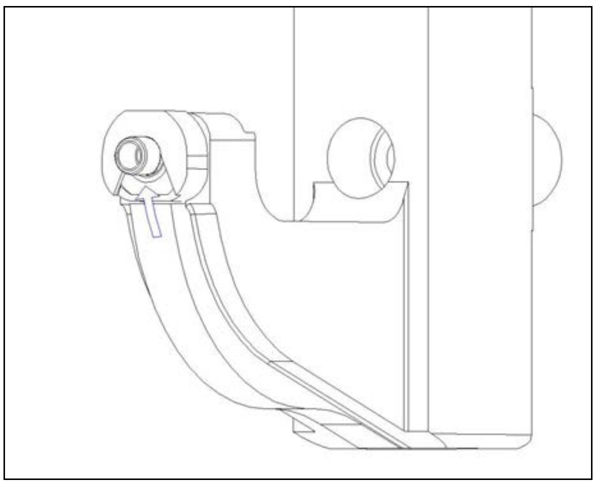

Figure 8 - Step 4: Collar is fed transverse through slot to sleeve. Sleeve has v-notch alignment feature to locate the collar

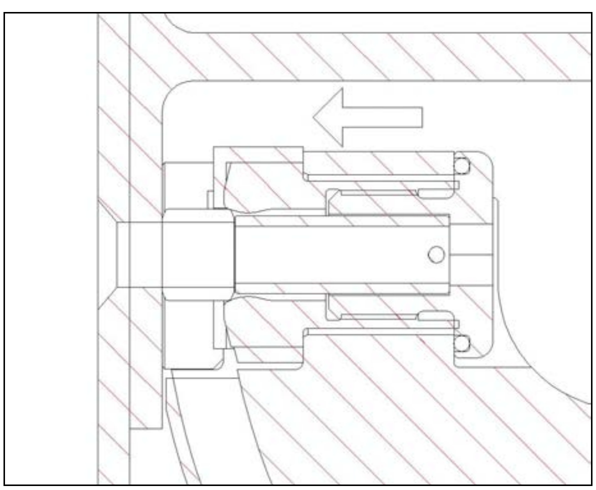

Figure 9 - Step 5: Ram moves toward work to capture collar against work piece in the bell-mouth of the die. Collar position and orientation verified via linear potentiometer

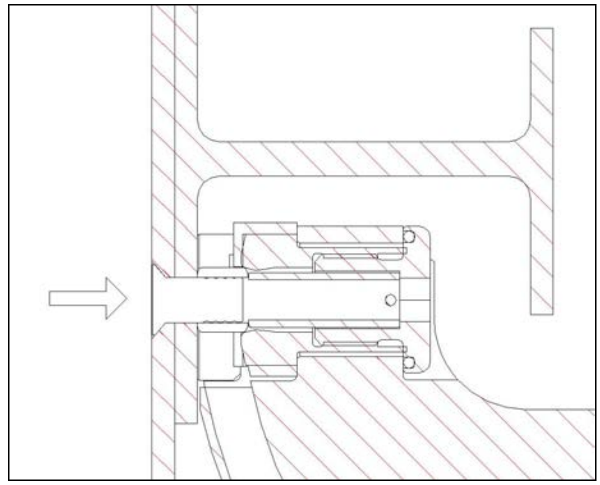

Figure 10 – Step 6: Bolt is driven through hole into collar. Tapered end of bolt aligns collar and die axis to bolt axis

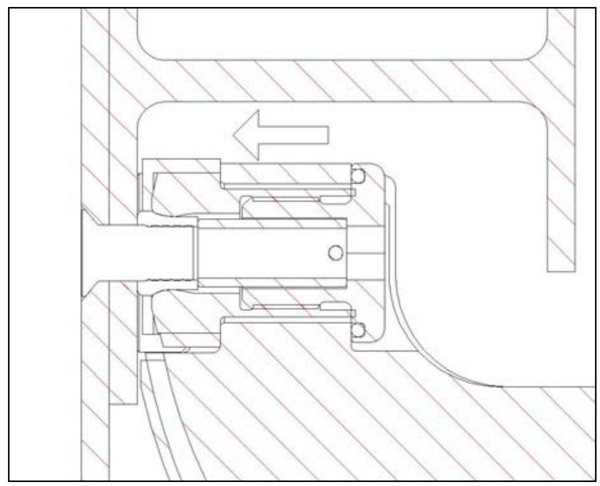

Figure 11 - Step 7: Swage collar with EMR

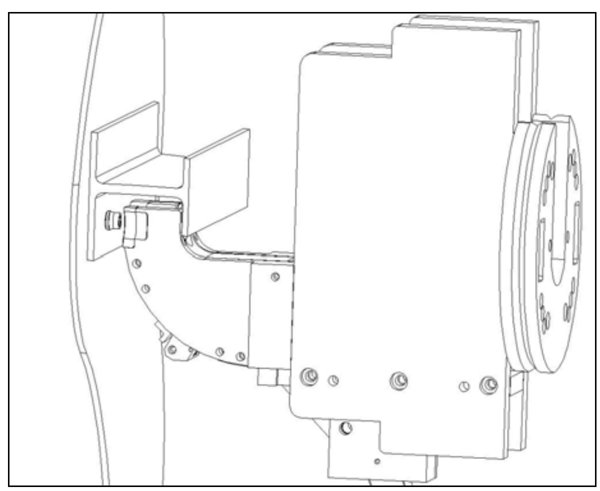

Figure 12 - Step 8: Strip die off of collar and unclamp

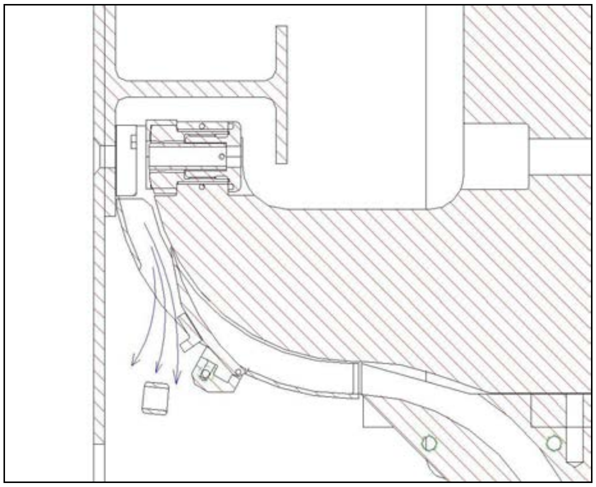

Figure 13 - Collar Purge

Sequence of Recovery from an unsuccessful collar feed

1. trap door is opened
2. ram is pulled back to provide clearance
3. collar is blown up the feed path and out the door
4. ram is advanced to provide a specific clearance for the collar
5. another collar is fed and its position and orientation is verified

CONTACT

Scott Tomchick, Project Engineer, Electroimpact, Inc., (425)-609-4896, scottt@electroimpact.com

Peter Zieve, President, Electroimpact, Inc., (425)-609-4889, peterz@electroimpact.com

Carter Boad, Project Engineer, Electroimpact, Inc., (425)-609-4972, carterb@electroimpact.com