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Horizontal Rivet Injector Design Used on A320 Upper Panel

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ABSTRACT

This paper will cover the design of the horizontal rivet injector use on the SA2 LVER designated for stage 0 production of Airbus A320 Upper Wing Panels. The injector design is intended to decrease cycle times and increase reliability while not reducing the functionality over previous rivet feed designs used by Electroimpact. Specific rivet handling methods and design features will be reviewed and their result on cycle time and reliability discussed.

INTRODUCTION

The SA2 machine is the latest in the Low Voltage Electromagnet Riveter family or LVER. This family is a series of wing panel fastening machines designed has been implemented for production of the Airbus A320 through A380 wing skin panels. The newly implemented SA2 machine incorporates many major design revisions intended to increase productivity and reliability. One of these major revisions involves the specific process used to move the rivet slug from the feed tube to the panel. This paper will review the specifics of the rivet injector it has improved both reliability of the riveting process and increased productivity by decreasing cycle times.

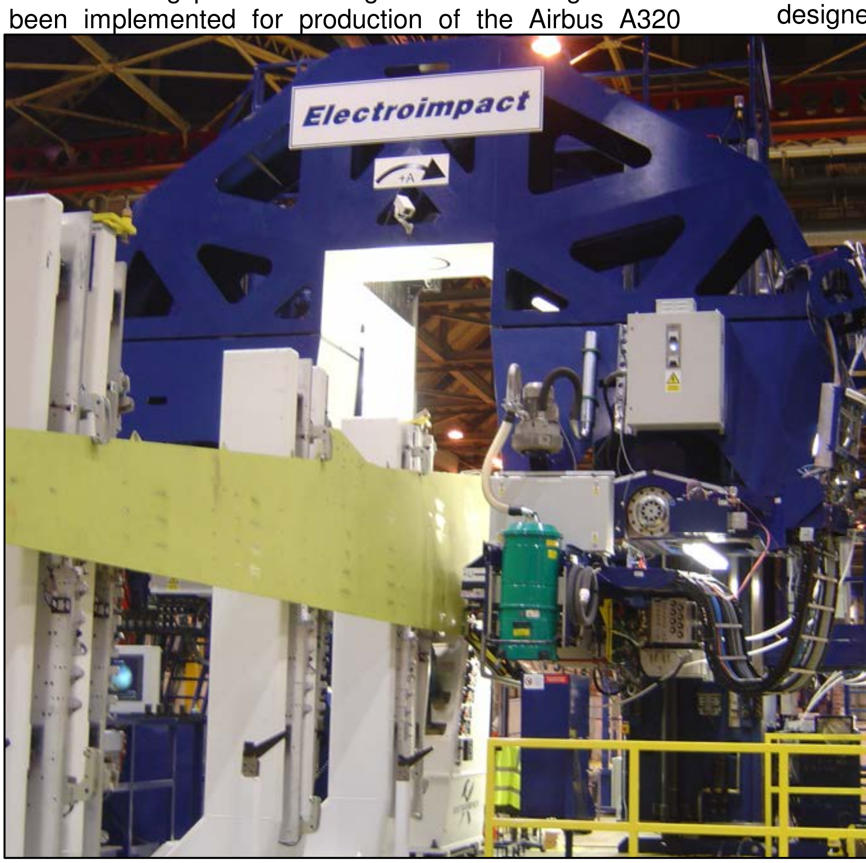

Figure 1: The SA2 machine in the Airbus factory in Broughton, UK Nov. 2006 showing the vertical orientation of the wing skin

BACKGROUND

LVER BASICS

Some details on how the electroimpact fastening machine works will be necessary in understanding the benefits of the new injector over the previous design. The LVER is a family of purpose built 5-axis machines designed to accurately fasten a vertically oriented wing skin and stringer. (see Figure 1) The LVER's use a pair of actuated fastening tables that drive forward to rigidly clamp the wing and stinger together between two clamping feet so subsequent drilling and fastening can be carried out without defects between the stringer and wing panel. The skin side fastening table carries the majority of the work tools which are carried on a movable axis allowing the transfer (or shuttle) between tools while remaining clamped. Here is a description of the rivet fastening cycle.

- Clamp up and measure the stack thickness
- Shuttle to drill spindle – drill hole
- Shuttle to EMR – Insert rivet, check rivet length and form rivet
- Shuttle to shave spindle – Shave skin side rivet head flush to panel
- Unclamp and move to next fastener position

PREVIOUS RIVET GRIPPER

Previous designs for transferring the rivet from the feed tubes to the panel have utilized a pneumatic gripper located on the front of the EMR. In addition the rivet feed path included a

Figure 2: The skin side process tools and clamping foot. The rivet injector is the blue rectangle left of center.

drop down chute called the U-turn which was located on the side of the clamping foot. This chute only lined up to the rivet gripper while the shuttle table was at the drill position. This often resulted in a delay in the cycle where the drill had completed drilling the hole but the rivet had yet to reach the rivet gripper. This delay was especially apparent in thin stacks and small diameter rivets where drill time was at its minimum.

THE SOLUTION – A NEW RIVET INJECTOR

The new injector design solution would incorporate a reduction of the frequency of adjustments and the elimination of delays in the cycle due to a fixed feed position as well as not removing any functionality from the original designs. First the solution to the fixed feed position required the new system to be located on the moving portion of the shuttle table. Second, the adjustments would be eliminated with a built-in or passive alignment features. The outcome of the design process was replacing the pneumatic gripper with a simple spring loaded rivet fingers, and replacing the U-turn with a new rivet injector.

The injector's job is to transfer the rivet from the feed tubes to the rivet fingers. The rivet fingers replaced the pneumatic gripper from previous machines and are very similar to designs used on other fastening machines. The only change is that the fingers hold a rivet horizontal instead of vertical. The purpose of the rivet fingers are simply to hold a rivet directly in front of the rivet die so when the EMR drives toward the panel, the rivet is inserted into the prepared hole. The entire device has no pneumatics or electronics and only relies on springs to hold the rivet and simple slots cut into the EMR driver for alignment. There was little design effort put into this assembly only a matter of fitting it to the existing hardware on the end of the EMR driver bearing. The majority of the design went into the new rivet injector which had to feed a horizontal rivet into the rivet fingers.

The rivet injector is positioned in a space underneath the EMR but above the sealant inserter. The It also had to be behind the clamping foot but far enough forward to minimize the travel of the EMR which also impacted cycle times. (see Figure 2 with the Injector as the blue and black rectangle Left of center, the sealant inserter the long black rectangle at an angle below center and the clamping foot the silver shape touching the wing panel just above center) The decision was to hang the injector underneath the EMR by a pair of support legs which reach around the outside of the EMR and down to the injector. (see Figure 3) Therefore the injector moves with the shuttle table axis but has a fixed z axis (toward and away from the wing panel) position on the EMR. When it comes time to feed a rivet, the EMR moves to the feed position on its Z axis and waits for the injector to place a rivet in the rivet fingers. The feed tubes blow the rivet to a chamber in the injector located about 75 mm below the rivet fingers. This location is as high as possible yet still allowing the EMR to pass over the top during the forming process. This chamber is just slightly

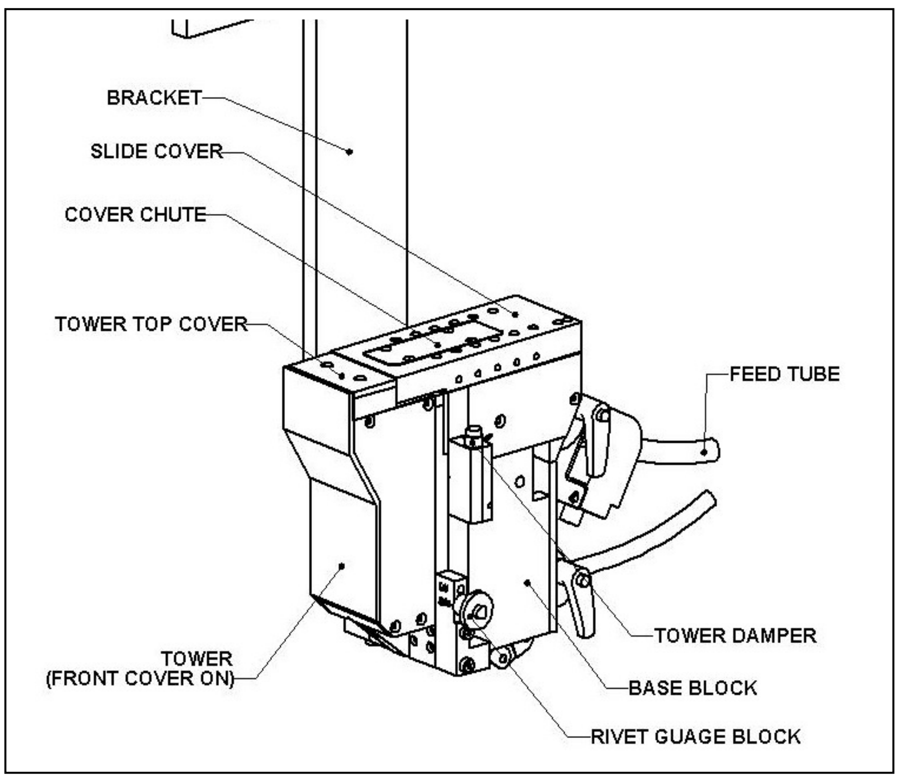

Figure 3: Diagram of the major components comprising the rivet injector

larger then the 1/4" rivet and is completely enclosed at this time by the cover. Next, the entrance of the chamber is blocked off with a pop-up stopper pin. Once the stopper pin is extended, then the grip bar would pinch the rivet axially between the stopper pin and the grip bar. (see Figure 4) Now that the rivet is captured, the cover retracts leaving the chamber open from the top and two sides. Next, the tower extends, translating the rivet the required 75mm to the rivet fingers. (see Figure 5) Once there, the spring loaded rivet fingers grip the rivet on two sides. Now the grip bar and stopper pin retract and the tower lowers, leaving the rivet in the fingers ready to be fed into the wing panel. The whole process takes about 0.92 seconds and can be done while the shuttle table is moving so there is no longer a delay in the rivet cycle.

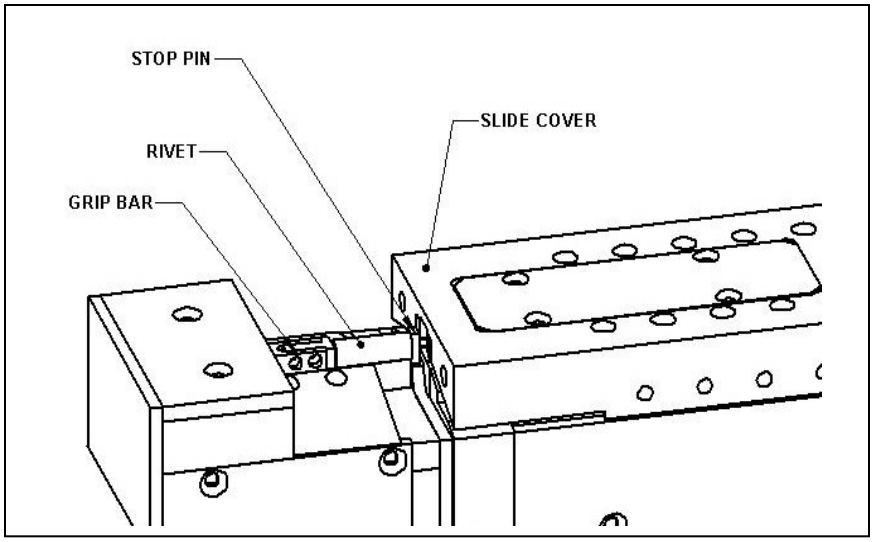

Figure 4: Diagram of the rivet chamber showing the rivet griped between the stop pin and grip bar

DESIGN FEATURES

Axial Rivet Gripping

One of the major design aspects of the rivet injector is the axial gripping of the rivet. This feature actually helps to eliminate nearly all of the alignment requirements between the injector and rivet finger by allowing some flexibility and tolerance to misalignment. If both the injector and fingers held the rivet on the sides, the rivet would be over constrained during the transfer. This would require a tight alignment between the two assemblies. Gripping the ends of the rivet releases this over constraining problem. It is possible that a loose alignment would cause the rivet to be mishandled where it would drop or caused to be tipped in the fingers. In addition the axial gripping also pushes the rivet toward the rivet die setting a fixed distance from the rivet die to the end of the rivet. This is opposed to setting the fixed distance on the panel side of the rivet. Putting the set distance on the die side reduces the length of the fingers since we always know where the end of the rivet will be located. In addition, this reduces the chance of marking the shank of the rivet because the fingers don't need to slide down the length of the rivet before contacting the rivet die.

Plastic Only Contact

Special considerations have been given to rivet marking with the new rivet injector. To reduce cycle times the rivet is blown through the feed tubs at very high speeds. At these speeds whenever the rivet contacts a metal surface, a small mark on the end of the rivet is produced. This mark simply a removal of the rivet coating, more then a gouge or scratch, but there is some concern with the long term problems associated with marked rivets. Therefore any surface the rivet can come in contact with is made of plastic and are all easily replaceable.

Air Vents

In the process of testing the rivet injector we discovered a need to increase the air flow through the feed tubes. The rivet is transferred down the feed tubes using compressed air. Increasing the speed of the air in the Feed tubes also increased the speed of the transferred rivet. However the rivet traveling at higher speed bounced off the end of the rivet chamber farther and farther as the air speed was increased. The result was a increase in cycle times due to longer settling times. To fix this problem, long vents were cut into the rivet chamber. This solution completely stopped all rivet

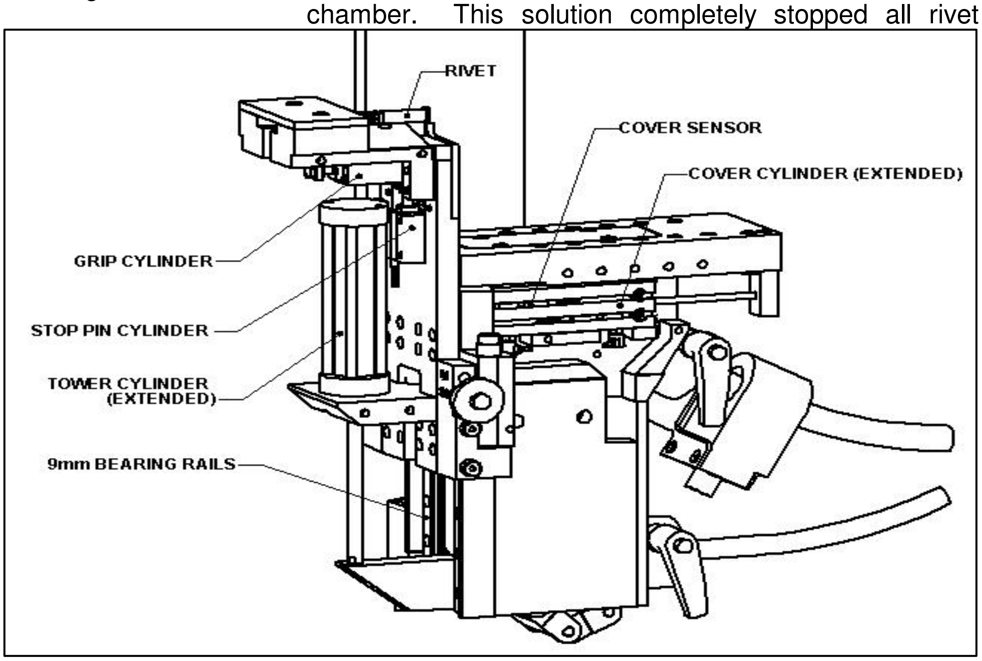

Figure 5: Diagram of the rivet injector in the raised position

bounce back no matter how fast the rivet was traveling, by allowing large amounts of air to pass around the rivet holding it against the end of the rivet chamber.

Double Rivet Check

Occasionally two rivets wind up in the feed tubes at the same time. The result is a situation where it is unknown which rivet is the correct for the prepared hole. A check for two rivets is preformed by the stopper when it extends to block the rivet chamber. The rivet chamber has been sized to only allow on rivet in the chamber. By being longer than the longest rivet but shorter than 2 times the shortest rivet. That if more then one rivet was fed then the stopper pin won't be able to reach the end of its travel. This triggers an automatic purge cycle where the rivet chamber is opened up, all the rivets are blown out of the system, and a new rivet is fed.

CONCLUSION

One of the major goals of the SA2 project was to decrease rivet cycle times over previous machines. It was clear that part of the solution to this required the old rivet gripper and U-turn assemblies had to be replaced. In November 2006 the SA2 machine began production of A320 upper wing skins in Broughton, UK for Airbus. Since then the SA2 machine regularly achieves 10 cycles per minute and up to 12 rivets per minute in speed tests. Previous machines achieved no more then 8.5 rivets per minute. This was partly achieved by decreasing the rivet feed time from about 2.50 seconds on previous machine to about 1.82 seconds for the SA2 machine. In addition, to a .68 second improvement the rivet fed is always the correct length because the rivet is based on the actual stack measurement and not pre-fed based upon the previous fed rivet. Lastly maintenance down time downtime due to the rivet feed hardware has been reduced from approximately 1 hrs per machine per month to 0.25 hrs per machine per month.

REFERENCES

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