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Frame-Clip Riveting End Effector

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ABSTRACT

A frame-clip riveting end effector has been developed for installing 3.97mm (5/32) and 4.6mm (3/16) universal head aluminum rivets. The end effector can be mounted on the end of a robot arm. The end effector provides 35.6 kNt (8000 lbs) of rivet upset. Rivets can be installed fifteen millimeters from the IML. The clearance allowed to rivet centerline is 150 millimeters. The riveting process features a unique style of rivet fingers for the universal head rivet. These fingers allow the rivet to be brought in with the ram. This differentiates from some styles of frame-clip end effectors in which the rivet is blown into the hole. The paper shows the technical components of the end effector in sequence: the pneumatic clamp, rivet insert and upset. The end effector will be used for riveting shear ties to frames on the IML of fuselage panels.

INTRODUCTION

A new design of frame-clip riveting end effector has been developed. The frame-clip end effector installs rivets that connect between the shear ties and the frames.

DESCRIPTION

A new design of frame-clip riveting end effector has been developed. The frame-clip end effector installs rivets that connect between the shear ties and the frames. These are universal head aluminum rivets in diameters 3.97mm (5/32) and 4.6mm (3/16). The end effector clamps up, drills a hole, inserts and upset a rivet with 35.6 kNt (8000 lbs) of upset force. A primary design goal is that the end effector needs to be manipulated by a conventional robot arm. The Kuka Titan robot can manipulate 1000 kg. The frame-clip end effector currently weighs less than 500 kg so that goal has been achieved. Figure 1 shows the clearance requirements. The rivet heads can be close to upstanding parts as shown, therefore the clamp foot on the head side is narrow.

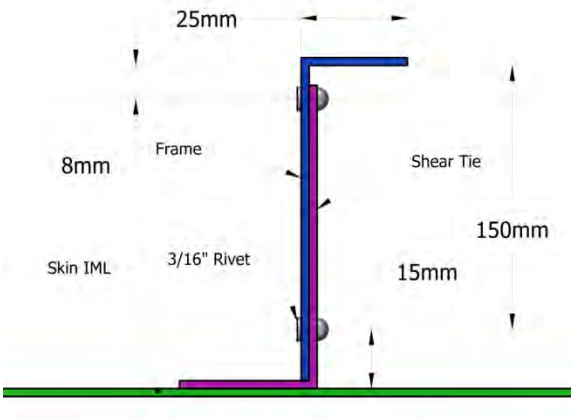

Figure 1: Clearance requirements

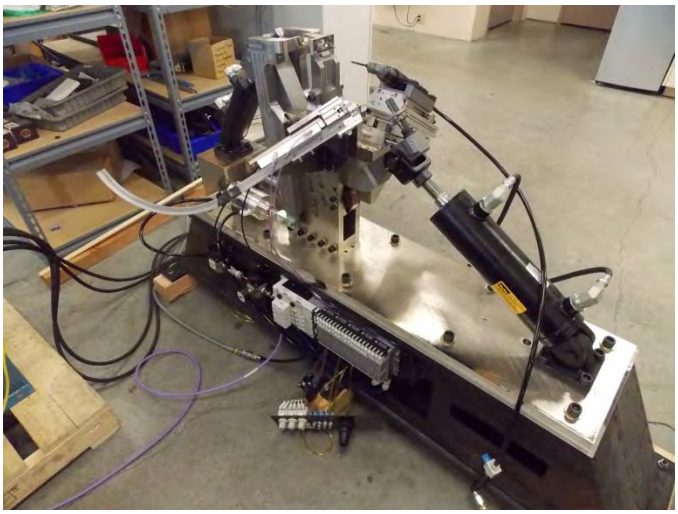

Figure 2: Frame-clip prototype from head side

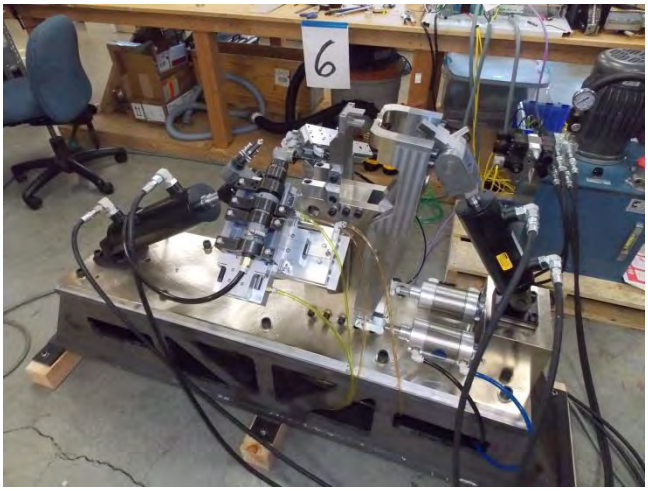

Figure 3: Frame-clip prototype from tail side

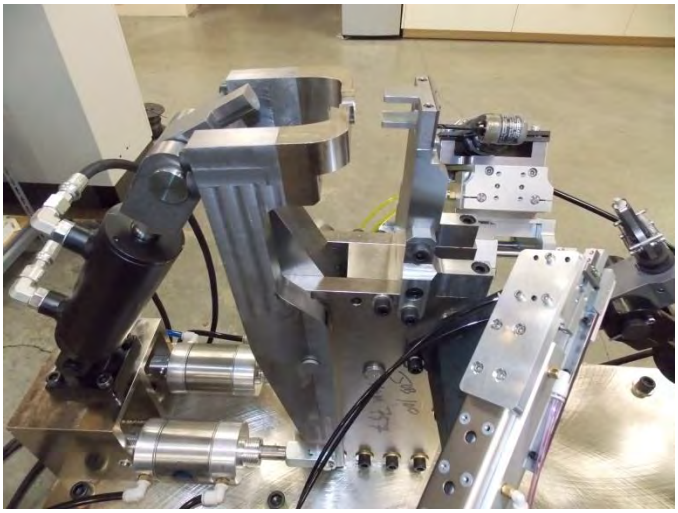

Figure 4: Close-up of prototype

Design

The primary arrangement of panels is with the frames vertical but the frame-clip riveting end effector is equally effective in any orientation. The rivet feed system was designed to work in any orientation. The raking back of the cylinders from the toolpoint is a unique design feature and allows generous clearance for adjacent frames in both directions (typically 508mm (20") to 607mm (24") spacing frame to frame).

Clampup

The clampup has a fixed foot on the rivet head side. The fixed foot allows accurate control of the rivet push-away. The opposite side is a moving foot actuated by dual air cylinders to provide 1.1 kNt (250 pounds) of clamp pressure (Figure 5). To simplify robot positioning the fixed foot is positioned proud of the skin and the moving foot pulls the end effector into contact. The robot mount has compliance for this purpose.

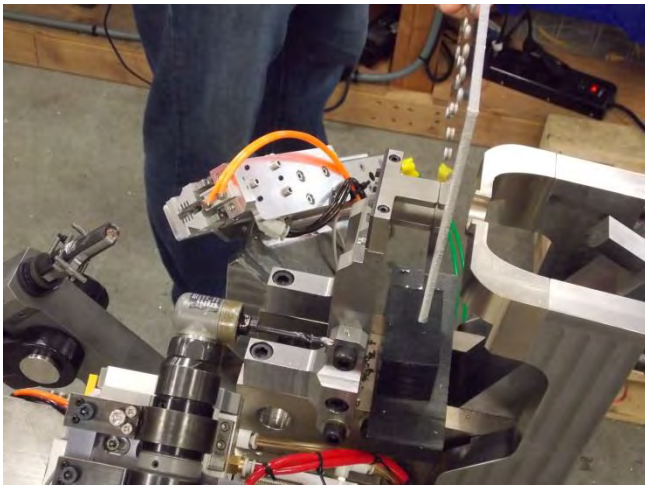

Figure 5: Before clampup

Drilling

The prototype uses a right angle pneumatic drill motor made by Dotco. The drill motor is mounted on perpendicular air slides. The first air slide raises the drill axis to be concentric to the rivet axis. Next the second air slide drives the drill forward to drill the hole (Figure 5). A damper controls the breakthrough. When the drill is full forward a limit switch is engaged and the drill is withdrawn and dropped back below rivet centerline. A high speed electric spindle will be substituted at a later date.

Figure 6 Rivet is blown down a shaped tube to prevent tumbling

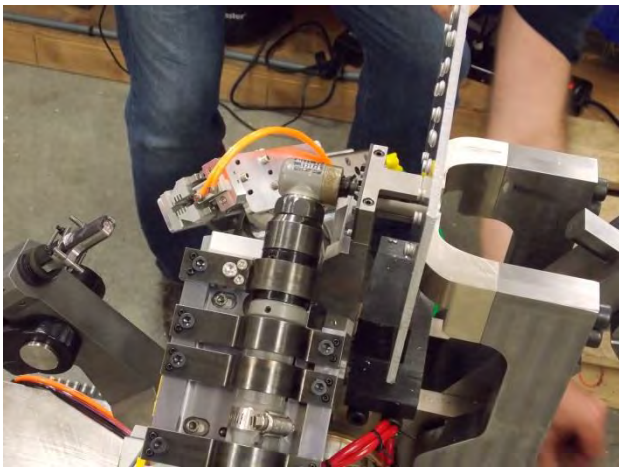

Figure 7: Clampup and drill to breakthrough position

Rivet Feed and Insertion

A rivet is blown down the shaped tube shown in Figure 6. This allows the feeding of square rivets. A gripper pushes the rivet into the fingers. Special rivet fingers have been designed which engage the MS20470 rivet head. The fingers snap over the head of the rivet as shown in Figure 9. With this scheme, short rivets such as 6-4s can be reliably fed despite the fact that they are square. The hydraulic head side cylinder then actuates forward to place the rivet into the drilled hole. The rivet is advanced such that the panel is pushed 1mm away from the clamp foot.

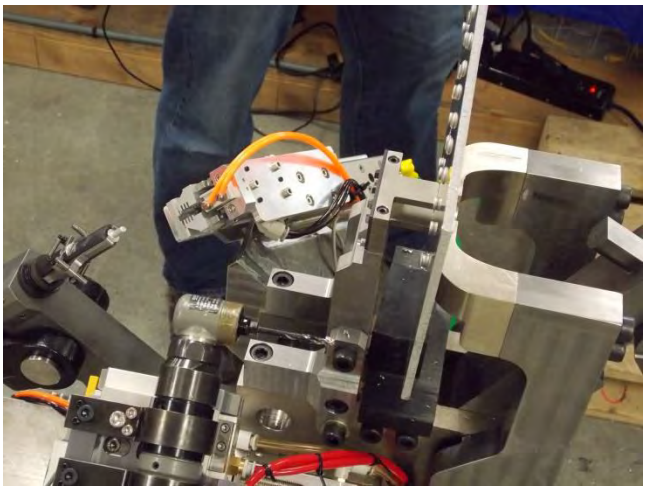

Figure 8: Rivet is fed into the rivet fingers

Rivet Upset

The rivet head is held down by an 82.5mm (3.25") diameter hydraulic cylinder. The tail upset side is a 63.5mm (2.5") diameter cylinder, so the tail side cannot displace the head side. A critical feature of the riveter is holding the rivet head down against the work piece throughout the upset process. This is accomplished by push-away, pushing the underside of the rivet head past the plane of the fixed clamp foot so the clamp pressure is between the underside of the rivet head and the tail side clamp foot. This results in the rivet head being held down during the install process. After the rivet head is fully inserted the tail side hydraulic cylinder actuates forming the tail of the rivet. The tail side cylinder is 63.5mm (2.5 inch) diameter and is mounted at approximately 45 degrees so at 2300 psi the rivet has 8000 pounds of upset.

Figure 10 shows close-up photographs of the rivets heads and tails formed by the frame-clip end effector. There is good consistency from rivet to rivet.

Figure 11 shows the robot cell with fuselage panels in place in the tooling. Mounting the end effector on a Kuka robot as shown will result in a low cost automation solution.

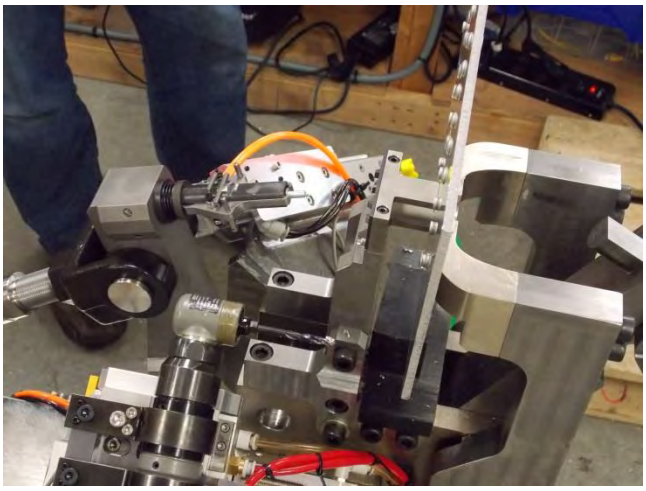

Figure 9: Rivet is advanced in the fingers

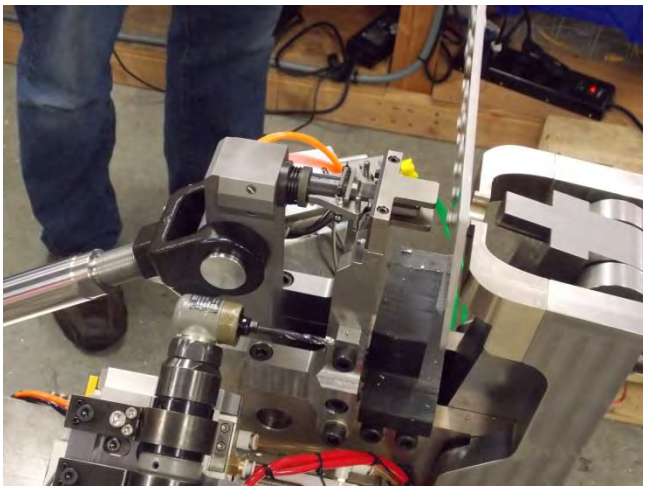

Figure 10: Unclamp after the rivet is formed

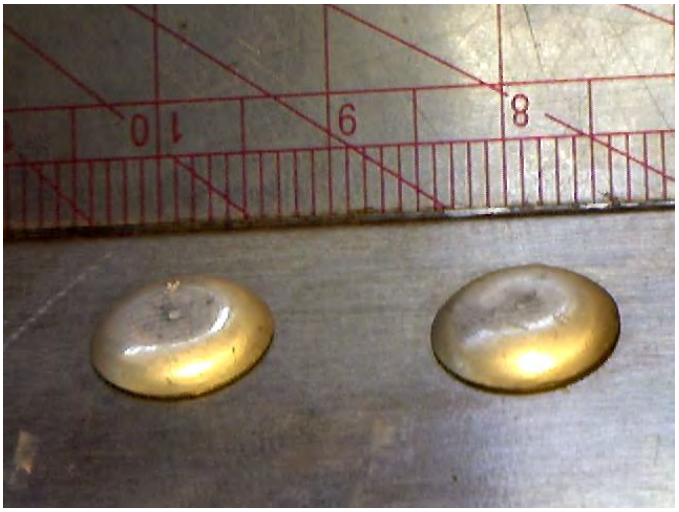

Figure 11: Heads of 3/16 universal head rivets are consistent

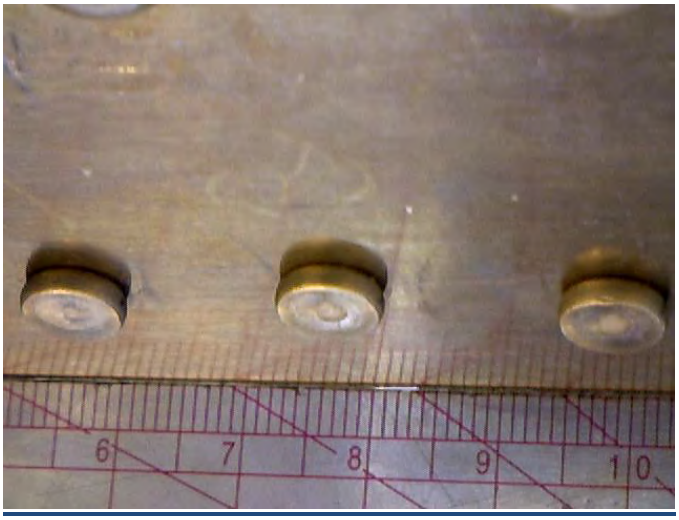

Figure 12: Formed tails of 3/16 universal head rivets are consistent

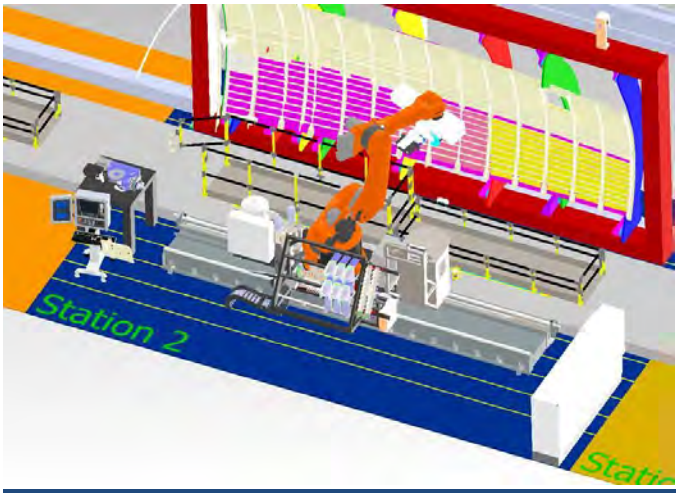

Figure 13: Application of the frame-clip end effector on a robot

SUMMARY/CONCLUSIONS

The frame-clip riveting end effector will allow automatic installation of rivets with relatively low capital cost. Positioning of the end effector is achieved with an off-the-shelf standard robot arm. The robot arm is lower cost than a custom built positioner. In addition the design allow for the installation of square rivets.

CONTACT INFORMATION

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