99FAS-13

Rivet Gripper and Offset Collar Gripper for Wing Panel Riveting

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ABSTRACT

Robotic gripper technology has been integrated into CNC riveting machines. Handling fasteners efficiently is critical in automated wing panel riveting. Computer controlled rivet gripper and collar gripper technology has been developed that demonstrates high reliability and decreased fastener cycle times

INTRODUCTION

In automated wing panel riveting, fastener handling is critical. Developments in robotics have provided computer controlled fastener gripper assemblies. The computer has inputs and outputs which open and close the gripper and also sense gripper position. This has improved automated fastening machine quality and reliability.

The rivet gripper is attached to the front bearing of the rivet upset ram. Compressed air blows a rivet through tubing and through a U-shaped channel until it stops against the die face. A ring sensor in the machine indicates when the rivet has blown out to the gripper. The gripper is then closed by the computer control (CNC or PLC). As the gripper closes the rivet diameter is measured and the gripper fingers capture the rivet.

An additional linear slide is used to open up a gap behind the rivet and in front of the die face. The rivet is advanced forward of the die toward the hole with a small pneumatic cylinder using five pounds of pressure to push the rivet into the hole. The computer senses when the rivet is fully in the hole. If the slide backdrives before the insertion is complete a misfeed is declared and another rivet is fed. This mechanism eliminates panel and stringer damage due to obstructions in the hole, deformed rivets or rivets which are not held straight in the gripper fingers.

The collar gripper is another computer controlled mechanism which has enhanced aircraft assembly. The collar is blown through a channel in the stringer side anvil. The computer closes the gripper. The computer control has inputs which permit the sensing of the pneumatic pressure and the gripper is ported so that the back pressure indicates the presence of a collar. Once collar presence is confirmed and the hole is drilled the collar is transferred up to the hole centerline and the bolt is inserted. Once the bolt is inserted the computer opens the gripper and transfers the collar gripper out of the way for swaging.

These robotic mechanisms have demonstrated high reliability

AUTOMATIC RIVETING MACHINE

The automatic riveting machine is shown on a wing panel (Figure 1). The wing panel shown is about eight feet fore/aft and about fifty feet long. The automatic riveting machine is equipped with drive motors to move the riveting anvils to the required fastener locations on the panel.

To install a rivet the riveting machine first clamps the panel and stringer together, drills a hole and inserts a rivet. Then the rams approach on the central axis of the fastener, press on the opposing ends of the rivet and upset the heads.

To install a lockbolt the riveting machine first clamps the panel and stringer together, then drills a hole. Next a collar is pre-staged up against the panel on axis on the stringer side. Optionally, sealant can be applied to the countersink. The lockbolt is then driven in from the skin-side with a vibrating gun. In the final step, a ram is pressed forward on the stringer-side with a swaging die. At the same time a ram is pressed forward on the skin-side to firmly hold the lockbolt head in place while the collar is swaged.

RIVET GRIPPER

In previous machines spring-closed rivet fingers were used. The rivet was either blown in from the back or pressed (injected) into the fingers. The fingers were spring closed metal tabs mounted on the end of the rivet die. The fingers carried the fastener to the hole, kept the fastener from falling off the ram and held the fastener axis parallel to and concentric with the anvil axis. The ram then pushed the rivet into the hole and the fingers slid back for upset. With this new system the spring-closed mechanism is replaced by a pneumatic motor under computer control.

The robotic rivet gripper is shown exploded in Figure 2 and assembled in Figure 3. The rivet gripping assembly is secured by means of a mounting plate to the front bearing of the riveter. The riveter illustrated is an electromagnetic riveter (EMR) but it could also be a hydraulic upset type. Both types of riveters use a front bearing which guides the upset ram. On the end of the ram is a rivet die that is usually cup shaped.

Mounted to the lower surface of the mounting plate is a pneumatic powered linear slide. The linear slide uses compressed air to move the gripper mechanism forward and back. A Hall Effect sensor, mounted on the slider member, detects the closing of the gap between the die and the rivet if excessive force is required to push the rivet into the hole.

The robotic gripper actuator is mounted on the extending end of the linear slide. The gripper actuator features synchronized pads which move toward and away from each other by compressed air. Rivet gripper fingers are mounted to the pads. Rivet gripper fingers extend initially directly forward of finger mounting members, and then inward directly toward each other, each terminating in V-notched free ends. A linear potentiometer is mounted to the gripper. The potentiometer measures the spacing between the pads and is used to determine the presence and diameter of the rivet which is fed to the gripping assembly.

Figures 4-7 show the sequence of operation for the rivet gripping system. At the start of the gripping action the rivet gripper fingers are open. The fingers are in front of the die and directly behind the opening in the rivet U-turn. The rivets are blown from a nearby storage bin by compressed air and then blow through one of several openings in the U-turn. The rivet blows into the die as shown, contacting the rear surface. At this point the gripping fingers are actuated open away from the rivet.

The rivet passes a magnetic ring sensor which sends a signal to the system controller to indicate that the rivet will soon contact the die. The controller sends out an electrical control signal to a solenoid, sending compressed air that closes the gripper fingers. Gearing inside the robotic gripper actuator ensures synchronized motion as the fingers move toward each other. Robotic grippers are an off-the-shelf product available from a number of sources.

The gripper fingers are mounted to the actuator pads. The fingers grip the rivet with about twenty pounds of pressure, resulting in the rivet being positively and firmly clamped between the opposing gripper fingers. The V-notch in the end of each gripper finger aligns the rivet with the ram axis regardless of the rivet diameter. A linear potentiometer measures the diameter of the rivet. It is mounted upon and responds to the distance between the two actuator pads.

If for some reason there is no rivet between the fingers, such as a failure of the rivet feed system, the fingers will overclose and the linear potentiometer will indicate this fact. Further, if the rivet diameter is too large or too small, or if the rivet is not positioned exactly straight between the gripping fingers, the potentiometer will indicate an error and the rivet will be rejected. Once an incorrectly sized or oriented rivet is detected it is simply dropped by opening the gripper fingers. A new rivet is then fed to the gripping assembly.

In the next step of the process the rivet gripping system is moved rearward away from the rivet feed system U-turn channel. At the end of this step the rivet clears the U-turn channel. This distance moved depends on the length of the rivet. In the next step the U-turn channel moves upward and out of the way of the rivet gripping system. A linear slide then moves the rivet gripping system on axis toward the workpiece. This motion creates a gap between the head end of the rivet and the inner surface of the cup die. This gap is shown in Figure 5 and is approximately 1 inch.

At the same point in the cycle, (Figure 6) the rivet ram is shuttled to be on axis with a previously drilled hole in the workpiece. The ram, the rivet and the drilled hole are now all on the same axis with a gap between the rivet and the die at the end of the ram.

The linear slide is equipped with forward and back switches which provide feedback to the computer controller (CNC or PLC). In Figure 7 the EMR has moved the rivet into the drilled opening. The drilled hole is typically several thousandths of an inch larger in diameter than the rivet, so that the rivet will move into the opening with a minimum of pressure if everything is in order. However, sometimes a burr from the drilling will partially block the opening, and the rivet will not be able to readily slide in. Also, the hole may not be complete due to either a short drill bit or an incorrect drilling depth. All of these situations can damage the workpiece during the attempted insertion of the rivet into the opening. If the ram moves forward enough that the rivet is fully inserted but the gap between the rivet and the die at the end of the ram has closed due to insertion resistance, the CNC declares an error. The rivet is then rejected and replaced by another rivet. An alarm can be provided indicating that the workpiece should be inspected. This allows for manual inspection to determine whether the hole is not fully or properly drilled, for a defect in the rivet or the wrong size rivet, or for misalignment between the rivet and the hole.

If the gripping fingers move fully forward, indicating that the rivet is fully inserted in the opening, the fingers are released by a command from the controller and then move apart to allow the ram to pass through as shown in Figure 8. The ram is now moved up to contact the head of the rivet, as shown in Figure 9. Once on the die the rivet can be driven with great force, resulting in upset of the rivet and completion of the riveting operation. The ram and the gripping mechanism are then returned to their initial position. The process is repeated for the next rivet.

COLLAR GRIPPER

The general procedure for installing stump lockbolts under offset flanges is to clampup and drill a hole, measure the hole if required, put sealant into the countersink if required, pre-stage the collar behind the hole, insert the pin through the collar and finally swage the collar onto the pin. The collar gripper is used for the step of pre-staging the collar behind the hole.

In the case of the lockbolt process, the collar is a hollow cylinder of aluminum that is placed over the extended tail of the lockbolt. The axial motion of the ram squeezes down on the collar and compresses it tightly over the extended threads of the lockbolt. The collar holds the parts together.

The collar is blown through a channel in the stringer side anvil into the open collar gripper. The computer closes the gripper. The computer control has inputs which permit the sensing of the pneumatic pressure. The gripper is ported so that the back pressure indicates the presence of a collar. Once the presence of the collar is confirmed and the hole is drilled the collar is transferred up to the hole centerline and the bolt is inserted. Once the bolt is inserted the computer opens the gripper and transfers the flag out of the way for swaging.

An exploded view of the collar mechanism can be seen in Figure 10. Note that the collar gripper needs to transfer the collar in between the clamp forks. The complete assembly can be seen in Figure 11.

The gripper arm incorporates an interior opening which extends approximately the length of the body. A connecting rod is positioned in the opening with a return spring which maintains the rod in a given position. At the end of the gripper arm is a collar receiving cup portion. The collar receiving portion includes a U-shaped opening at the extreme end. A gripping finger is mounted on a pivot pin at one side of the collar receiving portion. The gripping finger is curved to fit against the exterior surface of a collar. As the rod moves back and forth the gripping finger moves about the pivot pin so that the upper end portion moves into and out of the U-shaped opening. At the other end of the connecting rod is a piston element, a piston stop and a set-screw (Figure 12).

The sequential operation can be seen in Figures 13-16. In the first step (Figure 13), a collar is fed into the U-shaped opening of the gripper body. The opening is just large enough to accept the collar without allowing it to tumble. Collar feeding is accomplished by compressed air, the collar being blown through a feed tube (not shown) into the U-shaped opening, with the gripping finger open and away from the receiving portion and maintained in that position by a spring on the rod. With the gripping finger in the open position the collar blows easily into the cavity and is then gripped. The collar is prevented from blowing through the gripper by a physical stop that has the shape of a beak.

As the collar moves along the feed tube, it passes a ring sensor (not shown) which sends a signal to the system controller. After a preselected period following the input signal, during which the collar reaches the gripping assembly, the controller commands a solenoid which controls the flow of compressed air into the gripper body. The compressed air operates against a piston, forcing the rod against the bias of the spring, and causes the gripper finger to pivot and securely grip the collar (Figures 15).

In the event that there is no collar in the cup when the gripping assembly is activated by compressed air the connecting rod and finger will move to their extreme position (Figure 14). This will uncover an opening in the bottom of the gripper body allowing compressed air to escape. The escape of compressed air from the opening is detected by a digital pressure indicator. For example, if the collar is in place the sensed back pressure will exceed 80 psi. With the collar absent the back pressure will be about 60 psi. If the collar is absent an error message is sent to the system controller. The controller can attempt to resend the collar or notify the operator to determine the reason for the absence of a collar.

While the collar is being fed into the gripper a hole is drilled in the wing panel. Once the hole is drilled there are optional processes such as hole inspection and sealant application to the hole countersink. The gripped collar is then sequentially transferred perpendicular and then parallel to the hole axis. This pre-positions the collar up against the back side of the hole and up against the workpiece (stringer.) Perpendicular staged actuators provide the required motion (Figure 16). The collar side ram, usually the stringer side, is then driven forward to securely pin the collar up against the panel.

Once the collar is pre-positioned the lockbolt is driven into the hole and the tail of the lockbolt extends into the collar. The compressed air is shut off and the gripper finger moves to the open position (Figure 17). The gripper is then moved away from the hole axis and the collar stays on the lockbolt tail so that the collar can now be swaged onto the lockbolt to complete the joint.

CONCLUSION

Computer controlled rivet gripper and collar gripper technology has been developed that demonstrates high reliability and decreased fastener cycle times, and provides benefits for current aerospace manufacturers using automated fastening technologies and for potential fastener feeding applications in other industries requiring reliability and rapid cycle times.

CONTACT

For more informartion contact Peter Zieve at Electroimpact at (425)348-8090. Fax to (425)348-0716 or email to peterz@electroimpact.com. The website for more information is www.electroimpact.com.

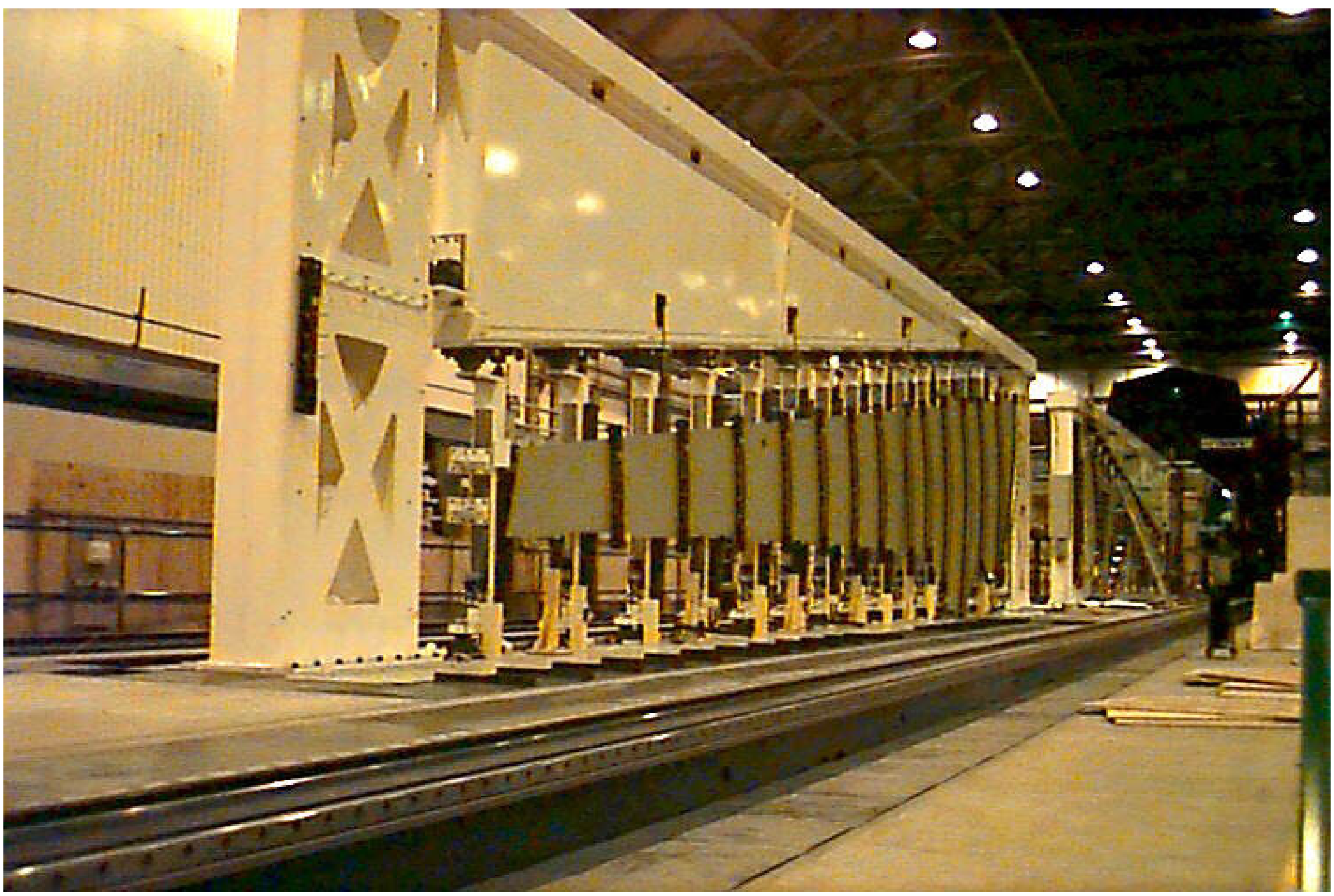


Figure 1: automated riveting machine on 8' x 50' wing panel

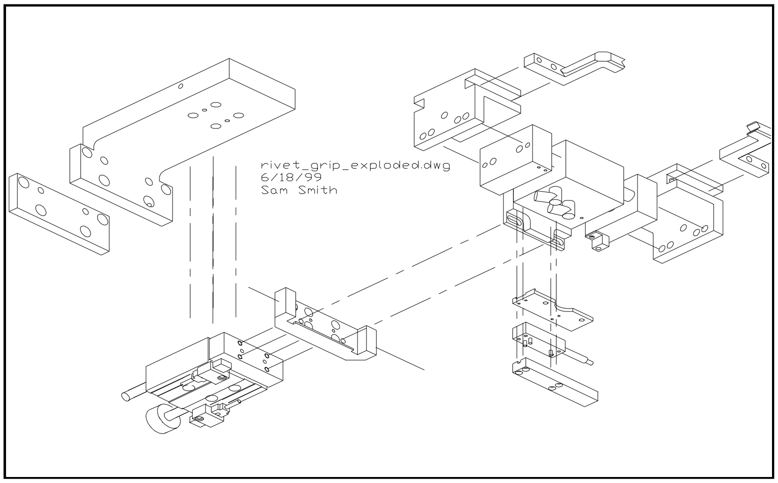


Figure 2: Exploded view of rivet gripper assembly

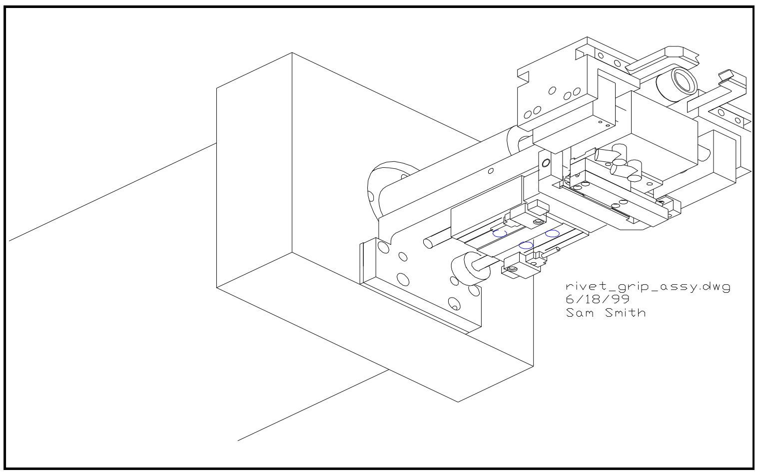


Figure 3: rivet gripper assembled

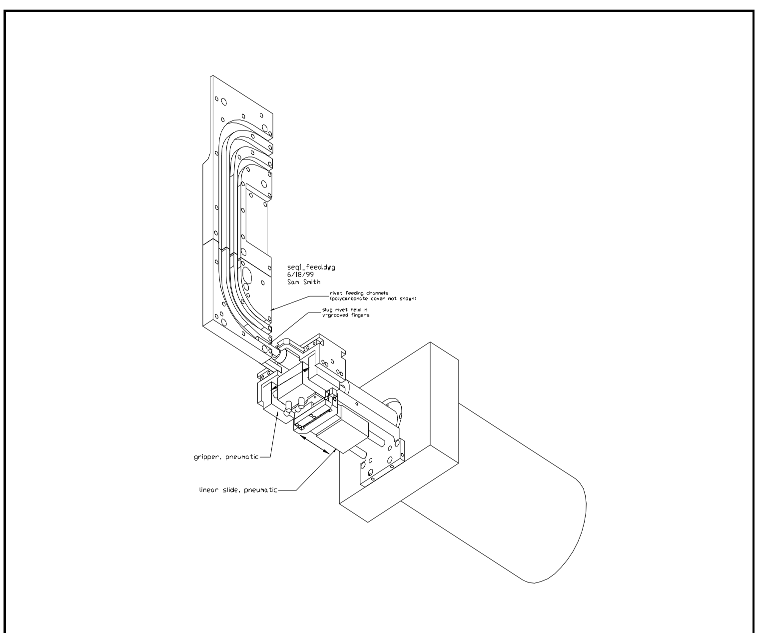


Figure 4: sequence of operation for the rivet gripper #1

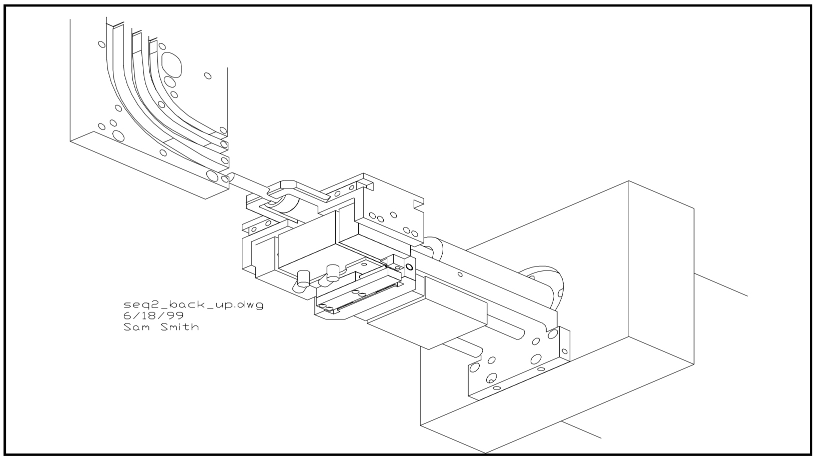


Figure 5: sequence of operation for the rivet gripper #2 showing 1" gap

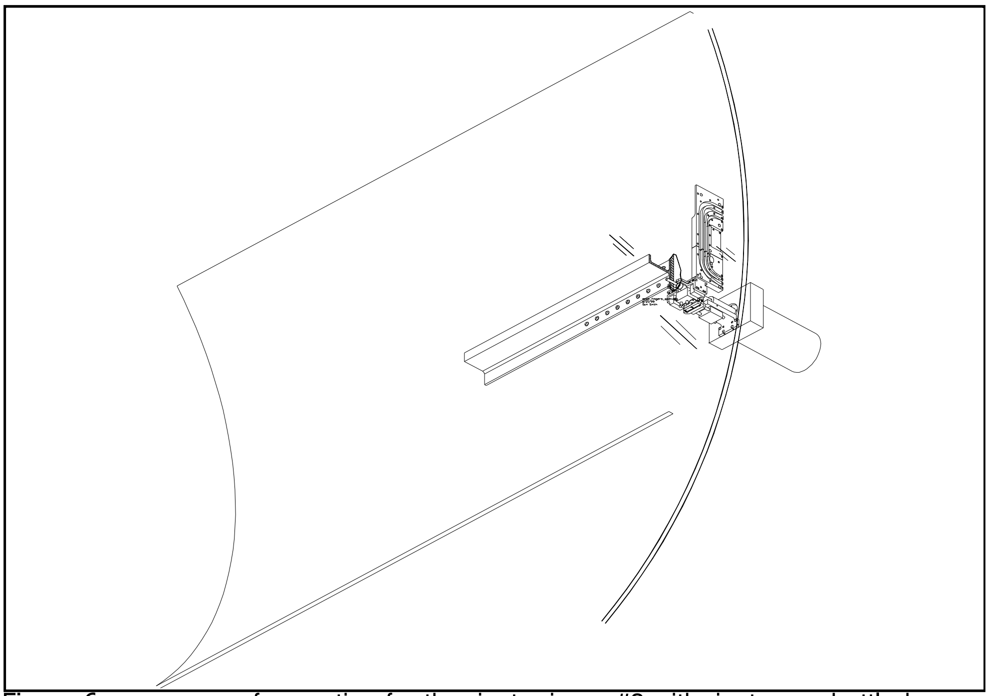


Figure 6: sequence of operation for the rivet gripper #3 with rivet ram shuttled

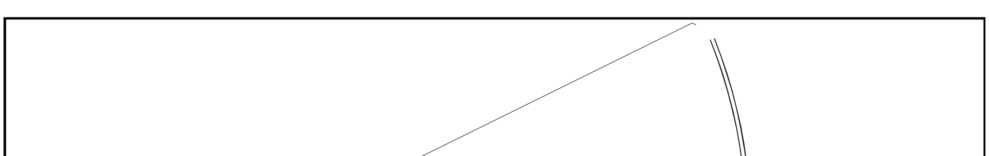


Figure 7: sequence of operation for the rivet gripper #4 with rivet in hole

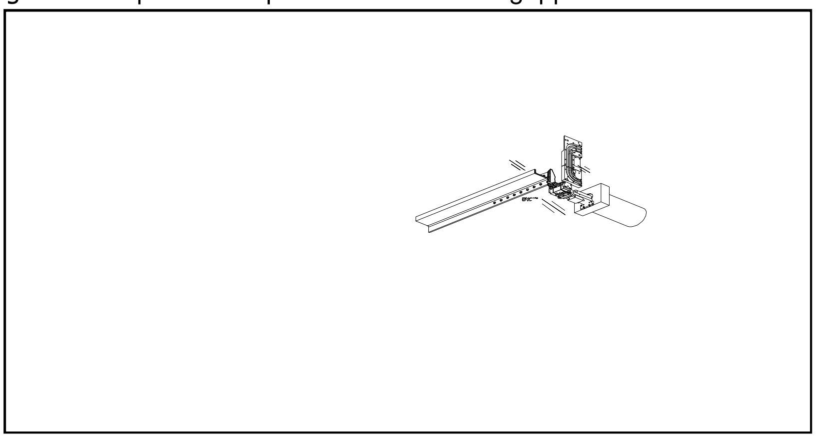


Figure 8: fingers opened and moved apart for ram

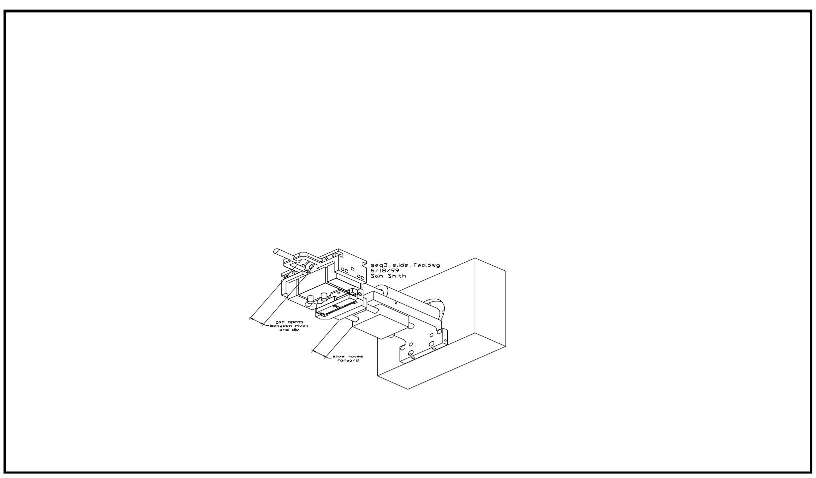


Figure 9: ram contacting rivet

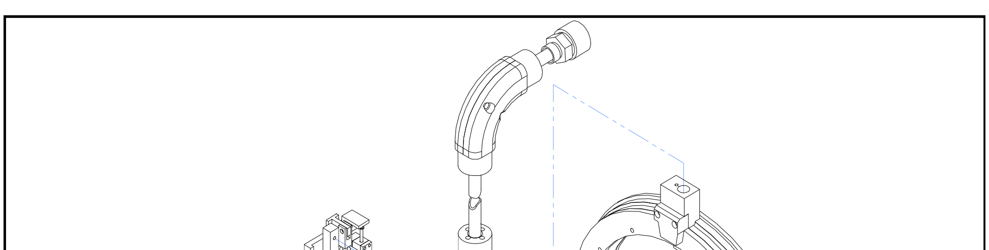
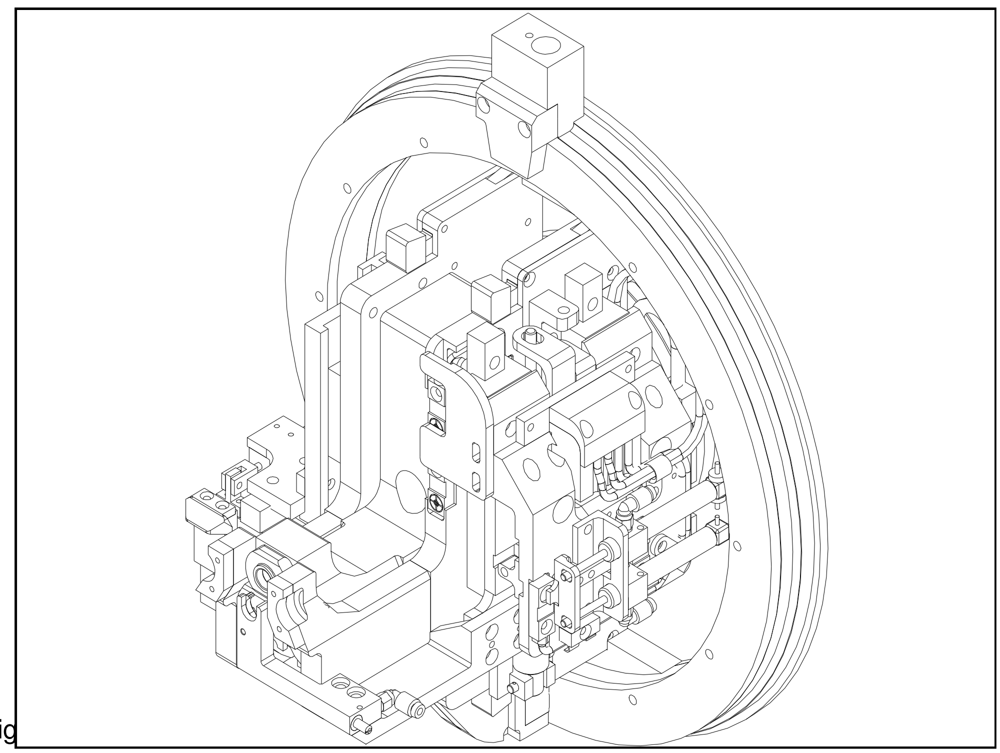


Figure 10: Exploded view of collar assembly



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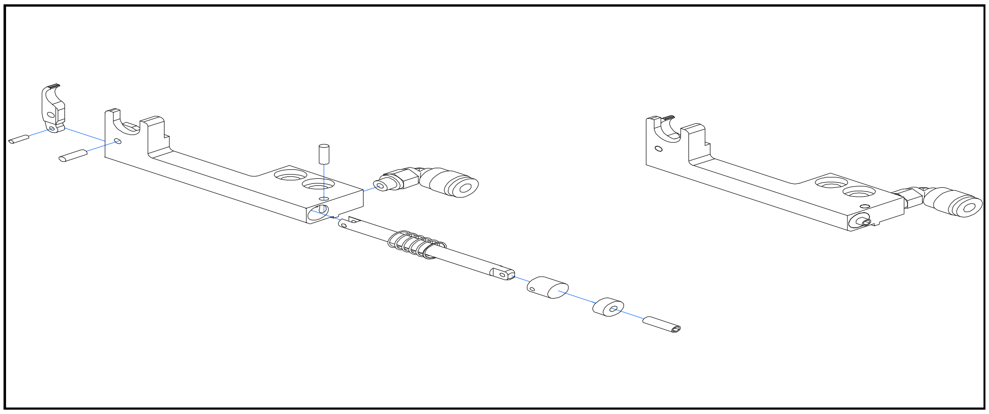

Figure 12: collar gripper (exploded)

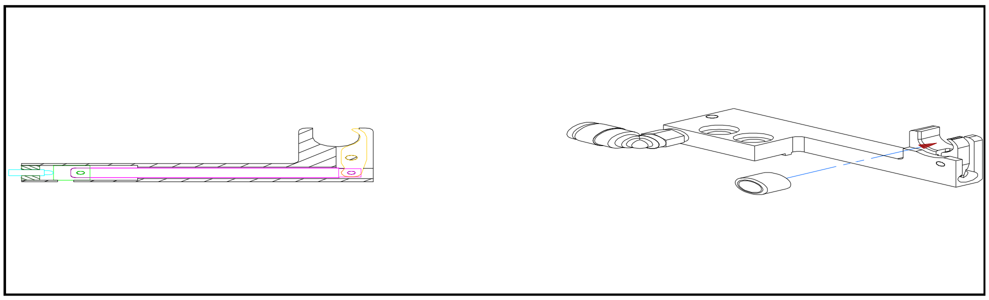

Figure 13: collar fed into U-shaped opening of gripper body

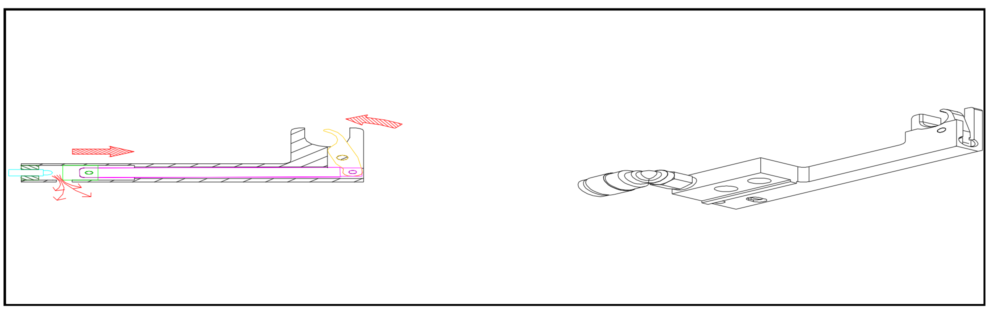

Figure 14: gripper detecting that no collar is present

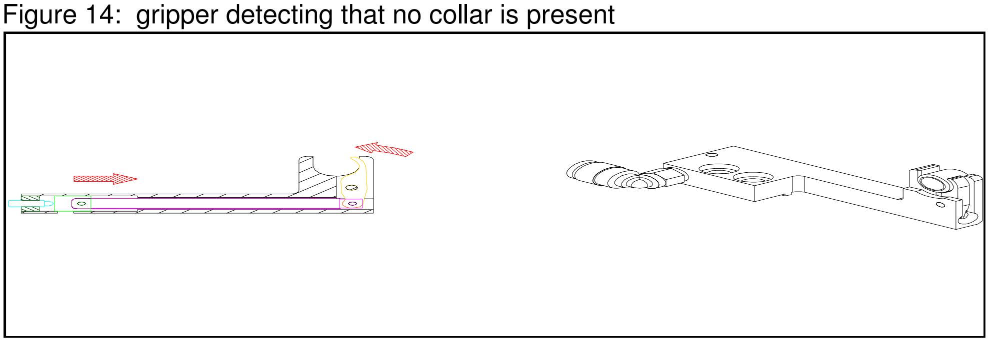

Figure 15: gripper fingers gripping collar

Figure 16: gripper pre-staging collar on panel

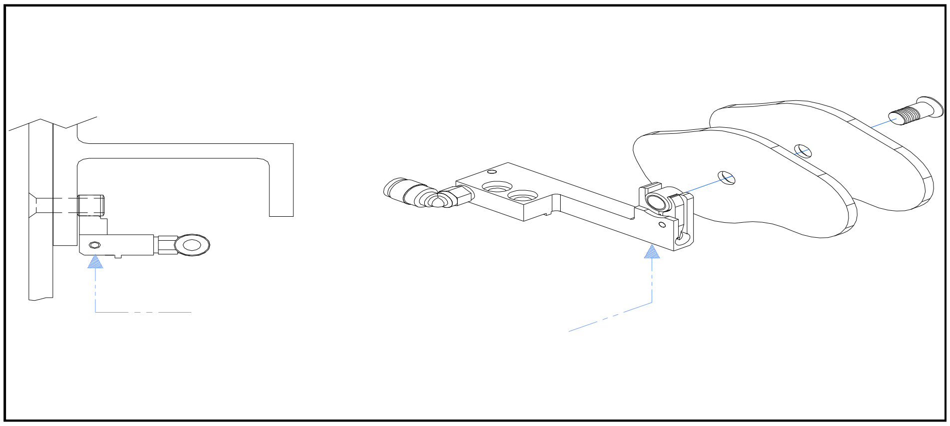

Figure 17: gripper finger opened and collar released