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Riveting Thin A320 Stacks

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Abstract

The E7000 riveting machine installs NAS1097KE5-5.5 rivets into A320 Section 18 fuselage side panels. For the thinnest stacks where the panel skin is under 2mm (2024) and the stringer is under 2mm (7075), the normal process of riveting will cause deformation of the panel or dimpling. The authors found a solution to this problem by forming the rivet with the upper pressure foot extended, and it has been tested and approved for production.

Introduction

The E7000 riveting machine installs NAS1097KE5-5.5 rivets into A320 Section 18 fuselage side panels. For the thinnest stacks, where the panel skin is under 2mm (2024) and the stringer is under 2mm (7075) the normal process of riveting will cause deformation of the panel or dimpling. The authors found a solution to this problem by forming the rivet with the upper pressure foot extended, and it has been tested and approved.

Riveting Thin A320 Stacks

The E7000 riveting machine installs NAS1097KE5-5.5 rivets into A320 Section 18 fuselage side panels. The rivet is dimensioned in Figure 1 for grip 5.5 and grip 6. The max stack for grip 5.5 is 3.65mm. Max stack for grip 6 is 4.365mm.

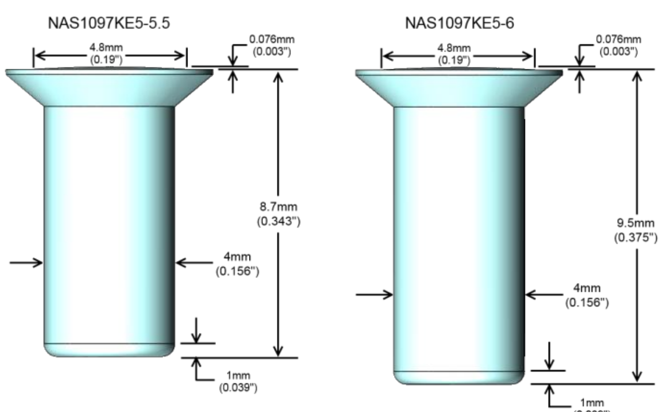

Figure 1. NAS1097KE5 rivets with dimensions.

The normal way to install a skin flush rivet is shown schematically in Figure 2. The lower clamp presses the material to be riveted up against the rivet head. The lower clamp is the tubular portion of the riveting anvil shown in Figure 3. A photograph of the range of lower anvil tooling is shown in Figure 4. For the thinnest stacks, where the panel skin is under 2mm (2024) and the stringer is under 2mm (7075) the normal process of riveting will cause deformation of the panel or dimpling.

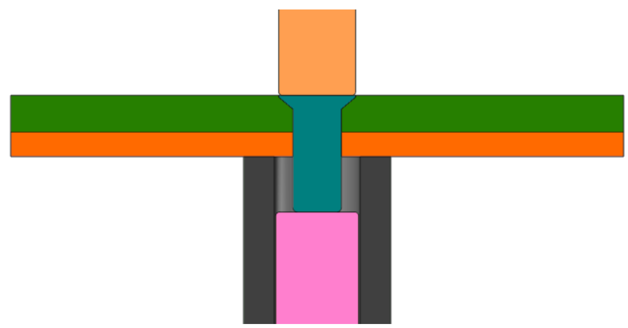

Figure 2. Schematic of normal rivet installation

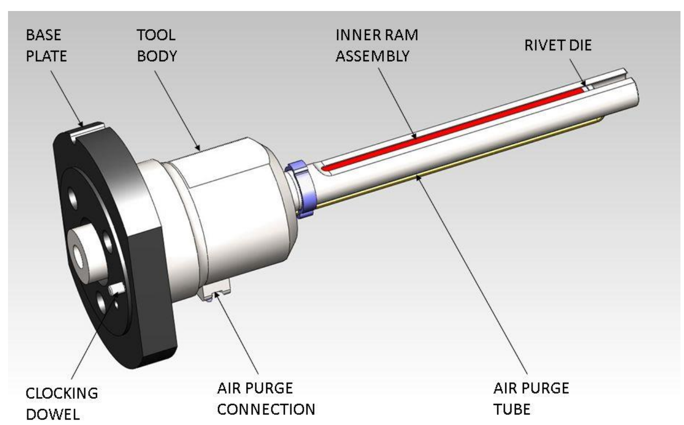

Figure 3. Lower tubular clamp inside riveting anvil.

Figure 4. Range of lower anvil tooling.

The dimpling is caused by uneven interference, more under the formed rivet tail on the stringer side, less on the skin panel side shown schematically in Figure 5. Due to the large number of these thin stacks on A320 Section 18 a solution was needed to keep the panel flat.

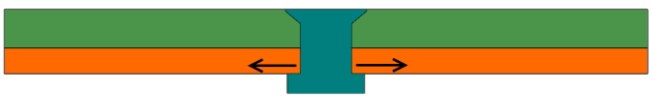

Figure 5. Force causing uneven interference on stringer side near formed rivet tail.

Figure 6 shows the measurement of the problem which occurs for stacks of 4mm and less. Thin stacks readily bend out of plane. The flushness spec of the rivet is 0 to +0.127mm and in Figure 6 you can see that the head height goes negative due to dimpling and is therefore out of spec.

Figure 6. Measurements showing dimpling in stacks thinner than 4mm.

Figure 7 is production data taken from the data collection system (DCS) on the E7000 machine before the fix proposed here was implemented. The stack measurement is measured with a precision Heidenhain pencil encoder built into the lower pedestal. The rivet flushness is measured each cycle by a Keyence LK-H157 laser micrometer mounted on the transfer plate. As stacks go under 4mm the dimpling becomes severe.

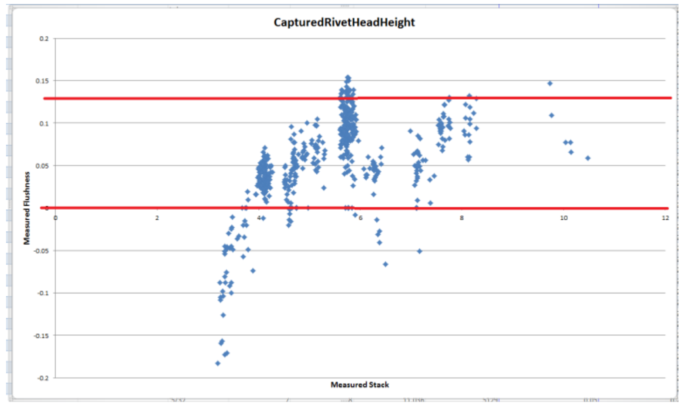

Figure 7. DCS on E7000 showing production data before proposed fix

We found a solution by forming the rivet with the upper pressure foot extended. The upper pressure foot is shown in Figure 8. In the photograph the observer is looking up from the bottom. The upper clamp foot is driven up and down by four Compact Automation custom cylinders with square body. They are 2.5" bore and 0.5" stroke. The upper anvil and fingers can be seen above two of the four clamp cylinders in Figure 9.

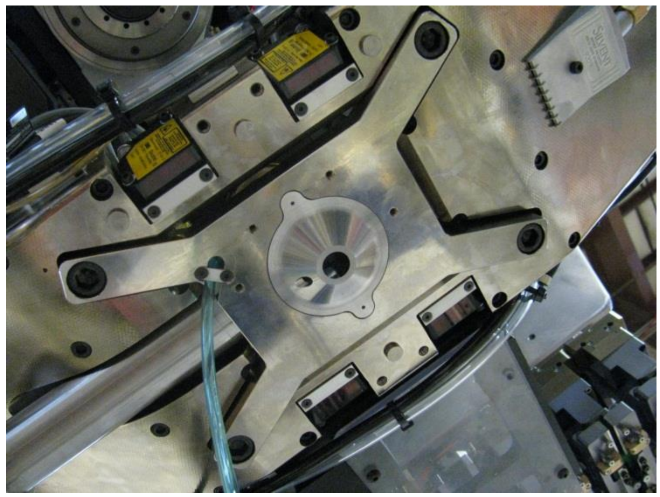

Figure 8. Upper pressure foot.

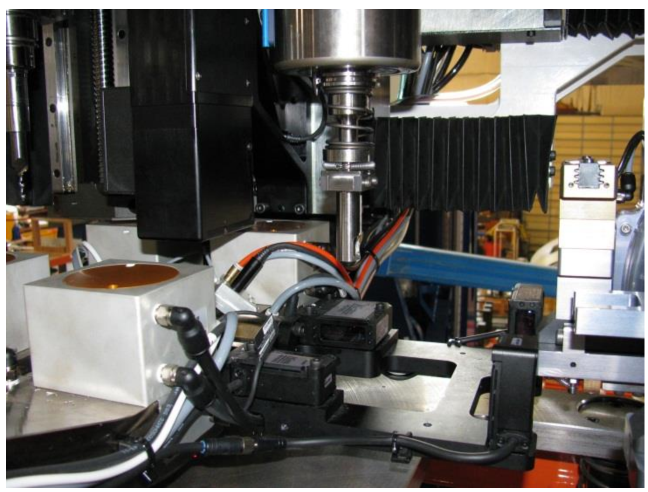

Figure 9. Upper anvil and fingers above two of the four clamp cylinders.

We determined that the effect of the uneven rivet interference could be ironed out by forming the rivet with the clamp nose extended and with the upper anvil face slightly behind the clamp nose. We form the rivet with the upper anvil slightly retracted. See the label “DISTANCE BACK FROM PANEL” in Figure 10.

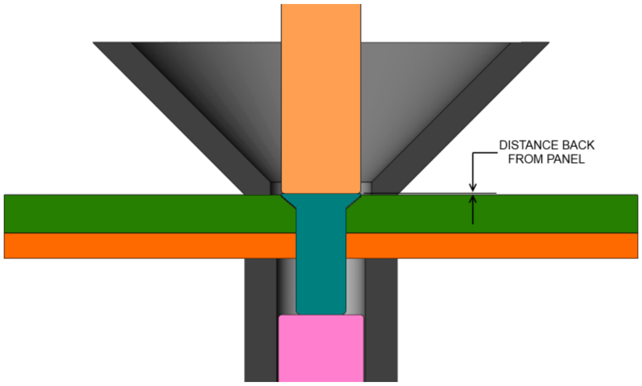

Figure 10. Upper anvil slightly retracted and DISTANCE BACK FROM PANEL..

Table 1 shows the results of varying the DISTANCE BACK FROM PANEL. An optimum was found at 0.3mm. At that dimension the dimpling effect for the panel adjacent to the rivet is eliminated. At 0.3mm the flushness measurement of the rivet head is .06mm which is exactly in the middle of the flushness tolerance. The machine is running in this mode for grips 5.5 and 6 only. The specification for measured tail height is 1.6mm to 2.4mm so all of the table entries are within specification.”

Table 1. Results from varying DISTANCE BACK FROM PANEL.

WZ position (mm)	Distance back from panel (mm)	Measured flushness (mm)	Measured Tail (mm)	Dimple depth (mm)
-132.95	0	-0.03	2.36	0.015
-132.85	0.1	-0.012	2.33	0.01
-132.75	0.2	0.01	2.29	0.005
-132.65	0.3	0.06	2.21	0
-132.55	0.4	0.13	2.13	0
-132.45	0.5	0.23	2.05	0

We asked the customer to check gaps under the rivet heads. This is a potential risk for switching from the method in Figure 2 to the method in Figure 10. For the DISTANCE BACK FROM PANEL dimension of 0.3mm no gaps under rivet heads were found. The methodology is approved and is now used in production.

Resynch Improvements

The E7000 riveting machine with an A320 side panel loaded is shown in Figure 11. The machine installs fasteners into stringers, shear ties and frames tacked to the skin with temporary blind rivets (Cherry CCR284ASR-3-04). In order to make a straight fastener line and to eliminate a long-short condition between tack and rivet it is necessary to accurately resynch on the tack fastener locations. Error in resynch can also lead to a snowman hole condition when the tack is drilled out to be replaced by a permanent fastener. This results in a concession.

Figure 11. E7000 machine with an A320 side panel loaded.

The E7000 uses the Basler Scout scA1400-17gc GIGE camera mounted on the transfer head. The camera enclosure with the lens cover closed can be seen just to the left of the rivet fingers in Figure 9. Putting the camera on the transfer slide eliminates parallax error. The lens is a Schneider Optics Macro Componon Series (28-100m). An internal view of the resynch camera can be seen in Figure 12. The machine control opens the pneumatically actuated lens cover only when required to reduce contamination. The high power light ring is a separate development. Twelve Lumiled C LEDs are mounted to a forced air cooled copper ring. Each LED provides in excess of 100 Lumens. This development was necessary because bright factory lights and shadows may play on the part. The light from the LED ring swamps out the effect of factory lighting. Cognex vision software is used. With this equipment on the E7000 we can guarantee a resynch accuracy of 0.13mm. Figure 13 shows the Cherry tack rivet that E7000 resynchs on installed in a panel.

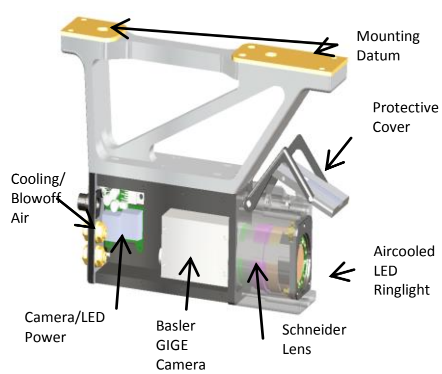

Figure 12. Internal view of the resynch camera..

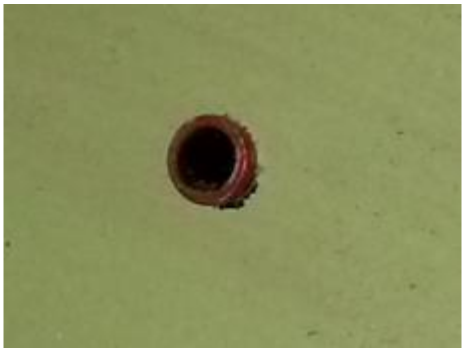

Figure 13. Cherry tack rivet used for resynching installed in panel.

A second process is drilling out the Cherry tack rivet. Pecking is necessary to prevent the cutaway head from sliding onto and chocking the drill bit. We found a peck increment of 2mm per cycle was optimum. Hole diameter was maintained. Smaller (and more numerous) pecks resulted in an oversized hole. The bolts that should have had interference dropped into the holes. Larger peck increments will create a solid ring that slides up onto the drill bit and blocks chip removal. The ideal increment was found by trial and error.

Conclusions

The dimpling problem inherent in forming rivets in stacks less than 4mm has been solved by forming the rivet with the upper pressure foot extended, and it has been tested and approved for production on the E7000 riveting machine installing NAS1097KE5-5.5 rivets into A320 Section 18 fuselage side panels.

Contact Information

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