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Refurbishment of 767 ASAT Drill-Rivet-Lockbolt Machines

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ABSTRACT

Boeing has relied upon the 767 ASAT (ASAT1) since 1983 to fasten the chords, stiffeners and rib posts to the web of the four 767 wing spars. The machine was originally commissioned with a Terra five axis CNC control. The Terra company went out of business and the controls were replaced with a custom DOS application in 1990. These are now hard to support so Boeing solicited proposals. Electroimpact proposed to retrofit with a Fanuc 31I CNC, and in addition, to replace all associated sensors, cables and feedback systems. This work is now complete on two of the four machines. Both left front and right front are in production with the new CNC control.

INTRODUCTION

The ASAT1 is a dual carriage system which travels down the spar jig and installs fasteners in the chord to web. The ASAT also fastens stiffeners and rib posts to the web. There are four spar jigs, one for each of the wing spars, left front (LF), right front (RF), left rear (LR) and right rear (RR). All parts are located by the jig or by DA holes. The RF machine is shown in Figure 1. The front spars are 25 meters long, 4.5 meters inboard, 19.8 meters outboard and 0.6 meters in the curved transition zone. For the front spars there is a 5.4 degree bend between the inboard and outboard sections. The radius of curvature in the transition zone is 5 meters.

The machine was originally commissioned with a Terra five axis CNC control. The Electromagnetic riveter (EMR) was built by Boeing and the EMR power supply was purchased from Maxwell Laboratory. In 1991 the machine was refurbished by Boeing with a PC based CNC. Motion control was via Galil cards. Electroimpact supplied a Low Voltage EMR (LVER) power supply and made modifications to the vintage EMRs to allow the LVER to work. We also supplied an electric spindle.

Figure 1 Inboard end right front machine

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There were three separate servo systems on the machine plus the EMR control. Furthermore there is a fixture with considerable I/O. In addition a large fastener feed system with 60 different hoppers. All of these systems would be controlled by the new Fanuc control. The large I/O count from the automated fixture and fastener feed system was readily handled by the Profibus.

Although production rates are low it is not acceptable to Boeing that the ASAT1 might not be operable due to parts no longer available. Some of the older control system is 19 years old and some is 27 years old, yet all four sets of carriages must operate in order to produce a 767 aircraft. The control system operates under DOS 2.63 and the computer accessories are not readily available. Boeing determined to first retrofit the more complicated front machines LF and RF. The released parts would serve as spares for the RF and RR machines.

MAIN SECTION

In the retrofit configuration the CNC is configured as an eight axis control. Table 1 show that absolute scales are employed on every axis. These functions were previously controlled by three separate servo systems. The five axes machine tool, the drill feed (Z) and the Buca clamp (W).

X	Longitudinal dry side	rack and pinion	Renishaw LM10 tape scale distance coded marker
U	Longitudinal wet side	rack and pinion	Renishaw LM10 tape scale distance coded marker
Y	Vertical dry side	roller screw	Battery backed encoder
V	Vertical wet side	roller screw	Battery backed encoder
Z	Spindle feed axis	ball screw	Heidenhein LC493F
B	Beta beam	ball screw	Renishaw LM10 tape scale
W	Wet side clamp axis (servoed)	roller screw	Newall Spherosyn Fanuc absolute
C	Dry side clamp axis (air cylinder)	air cylinder	Newall Spherosyn Fanuc absolute

Table 1: Axis, description, drive and feedback

Linear Scale - The 28.9 meter long LM10 install was quite successful. The scale was installed underneath the machine by Renishaw, and follows the curved section of track. The scale is read through the "bend" and used for feedback along the entire length of the machine.

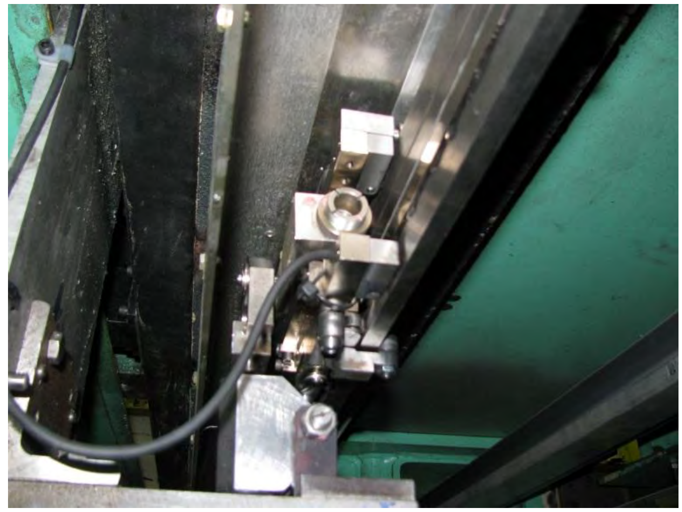

Figure 2: Installation of LM10 linear scale

The LM10 is the latest style of magnetic linear scale from Renishaw. In Figure 2 you can see what the scale read-head looks like from underneath. The distance coded marker has been reliable and saves time. In order to home the long X and U axes the machine only needs to be jogged minus thirty centimeters anywhere along the length. Electroimpact had to prove that the 27 year old ASAT1 machine could position within .010" over the workspace. This accuracy was achieved with use of the Fanuc Straightness Compensation and a laser tracker.

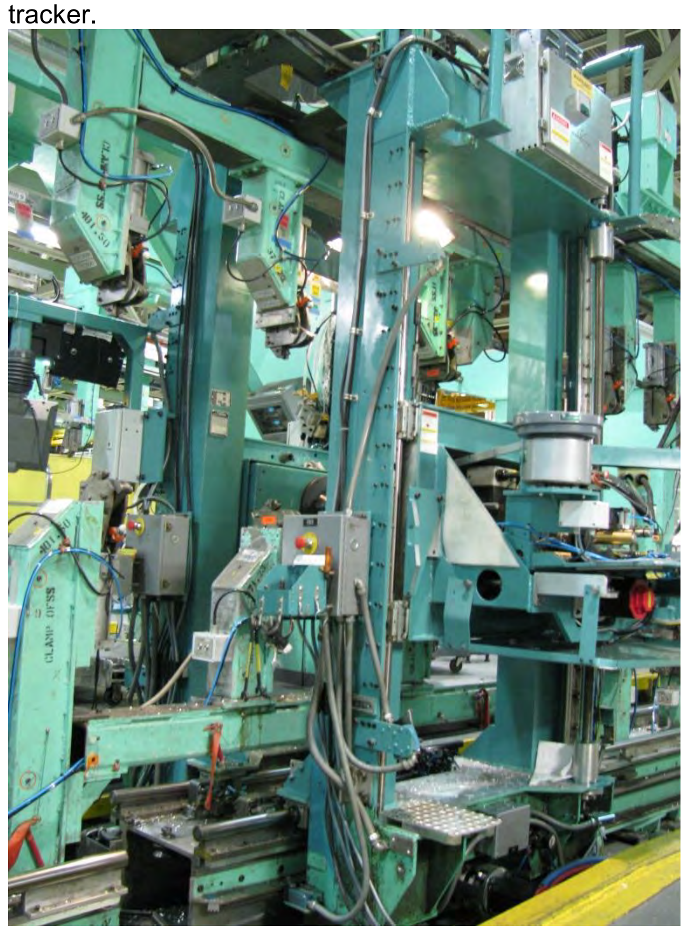

Figure 3: Wet side carriage clamped onto the Beta Beam

Beta Beam - Figure 3 illustrates the wet side carriage clamped onto the Beta Beam. Note the “beam” transfers both carriages around a radius. After the carriages both drive onto the beam, they then lock onto the beam and the beam drives around a radius. The drilling, riveting and bolting devices all work around the bend. The spar is divided into three sections; inboard, outboard and the beam section in between.

The X/U axes round way (see Figure 3) close tight and allow the carriage to transfer either to the inboard track or the outboard track. The machine also drills, bolts and rivets through the bend area. The Beta Beam is conveyed from inboard to outboard by a ball screw. The desire was for the ball screw to get feedback from the same LM10 tape scale as the X/U axes. To achieve this result the quadrature signal from the X tape scale was split and fed to both axes, the X and the B. This was effective and allowed the Beta Beam to work effectively.

Buca Probe - On ASAT1 the moving carriage on the inner surface (fuel side of the spar) is called the wet side carriage. The moving carriage on the outer surface is called the dry side carriage. On ASAT1 all drilling is from the dry side. Also, all fasteners are driven in from the dry side. The wet side clamp table is accurately advanced with a probe originally (1970s) referred to as the Buca probe (backup carriage advance). This is now the W axis but the Buca name remains. The Buca has a proximity switch on the distal end and it “sees” the aluminum spar surface 0.72” before the nosepiece contacts. The signal goes into the Fanuc and the control than drives the W axis forward 0.72” and stops the W axis. Subsequently the air cylinder driven C axis pushes forward and creates the clampup. The Buca probe is the tool on the right in Figure 4. With the Fanuc control the Buca probe is wired into the high speed skip input (probe port) in order to get most accuracy.

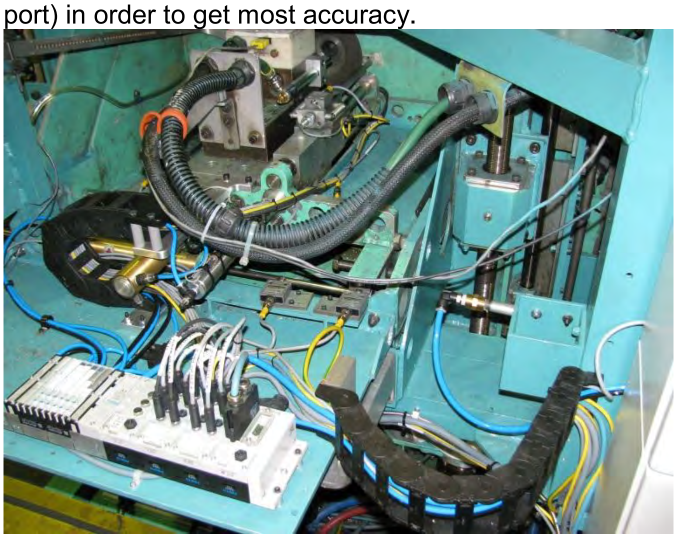

Figure 4 The Buca probe is the tool on the right of the wet side shuttle table.

Drill Spindle - Boeing decided to add the proposed drill spindle after the program start. In order to fit the Precise SD 60124 E0708 120mm diameter spindle we had to implement a new shuttle table. See the drill spindle on the right side in Figure 5. Adding the Heidenhein LC493F 20 micron scale to the drill improved the accuracy of chamfer compared to previous.

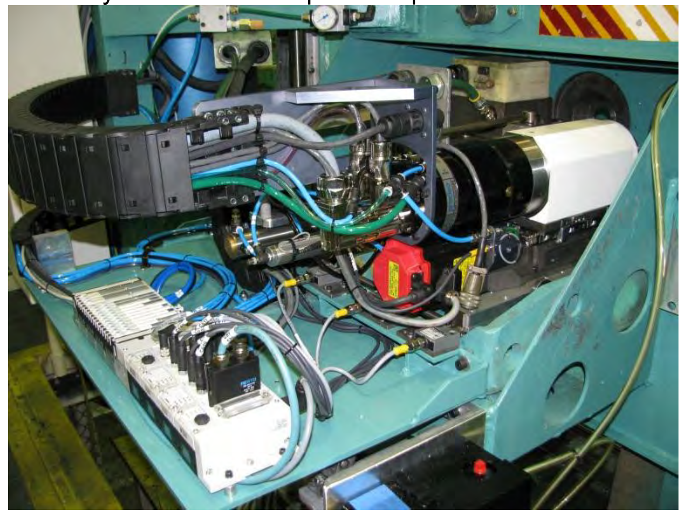

Figure 5 Precise drill spindle mounted on the new dry side shuttle table

Fanuc Picture – Electroimpact provided touch screen monitors running a custom Fanuc Picture application written for ASAT1. Fanuc Picture is a customizable application provided as part of the Fanuc system. The 15” color monitor at the control station is shown in Figure 6. The customer helped us refine the information stream shown on Fanuc Picture.

Figure 6 Fanuc Picture display for ASAT1

Figure 7 The author in front of the first fasteners installed with the new control system

CONCLUSION

With the refurbishment complete on ASAT1 left front and right front all electronics and control components are of the latest style available. The machine first commissioned in 1983 is provided with a significant life extension in 2010. The machines will still be current in 2023.

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