

Self Contained Portable AFDE With On-Board CNC, Custom Operator Interface and RF Network

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ABSTRACT

Automated Floor Drilling Equipment (AFDE) have been used at Boeing for drilling floor panel, galley, lavatory and other holes in Boeing planes. New controller and drill spindle designs made it possible to redesign the AFDE as a self-contained unit with on-board CNC, custom operator interface, RF network and more compact drill spindles for increased robustness and versatility.

INTRODUCTION

Electroimpact was contracted by Boeing Wichita to build a second Automatic Floor Drilling Equipment unit (AFDE) for the 737. The AFDE loads through the door of the airplane and drills the floor panels, galley and lavatory and other holes in the floor of the built-up 737 fuselage. Several previous generations of AFDE exist at Boeing for drilling the 737, 777, 767 and 747 airplanes.

Aerofast paper #972809 about the previous Electroimpact AFDE design for the 737 was presented at the '97 Aerofast meeting. The authors were Bill Bankston of Boeing and Peter Vogeli of Electroimpact. This new AFDE is a significant departure from the previous model.

The traditional AFDE design has a crawler unit with nine CNC axes and four spindles. There is also a 1500 lb. control cabinet which carries all the controls and is connected to the crawler with either 2 or 3 umbilical cables with a total of approximately 250 pins. Electroimpact has delivered four units to Boeing with this previous design, three for the 777 and one for the 737. This paper describes the fifth AFDE delivered.

Electroimpact determined that new technology was available to improve the reliability of the AFDE by carrying all of the controls on the machine, thereby eliminating the umbilical cords and separate controller cart. The self-contained AFDE with all controls on-board is referred to in this paper as AFDE2. A number of other

significant improvements were made to the spindles and controls.

CNC AND SERVO AMPS ON THE CRAWLER

A photograph of the front of AFDE2 is shown in Figure 1. A drawing is shown in Figure 4. The CNC monitor can be seen on the front. The controls enclosure is mounted on the back side of the crawler. The backside of AFDE2 is shown in the photographs shown in Figure 2 and Figure 3, and a corresponding drawing is shown in Figure 5. Note the metal partition in the center of the enclosure. The left side of the enclosure, shown in Figure 2, contains the power componentry. The right side, shown in Figure 3, contains the controls hardware. The completed AFDE2 weighs 1200 pounds.

The Fanuc 15i CNC and servo drives are compact. The color screen and button panel, shown in the photo, is a 10" color LCD flat panel. The dimensions of the CNC screen are 270x520 mm with a depth of about 50mm. This incorporates the screen and the MDI keypad. To the right of the Fanuc display is a custom button panel.

The AFDE2 incorporates nine servo controlled axes and four spindles. Connections to the drives are made through fiber-optic cables which simplify the interfaces. The Fanuc 15i was not yet available at the time of the order but Fanuc delivered the control within the required timeframe. Consequently, this AFDE2 has the first FANUC 15i CNC released in the US. The 15i is the largest CNC offered by Fanuc and can control up to 24 CNC axes. The AFDE2 requires nine servo drives. The next smaller Fanuc CNC is the 16i which can control only eight axes. The availability of the 15i therefore enabled Electroimpact to put all of the controls on the crawler.

Fanuc provides compact servo drives, each of which controls three servo motors. Both the spindle feed axes and the spindle transverse axes (Y,W,U,V) use Alpha 2 motors which are powered by a 12 amp drive. The X axis uses an Alpha 3 motor which requires a 40 amp drive. The drives utilized are:

- two SVM3-12/12/12 Triple Servo Drive: 3.5" wide x 15" tall x 6.75" deep
- one SVM3-12/12/40 Triple Servo Drive: 3.5" wide x 15" tall x 12" deep

All three of these triple drives are powered by a single power supply:

- one PSM-30 Fanuc Servo Drive Power Supply: 5.9" wide x 15" tall x 12" deep

The four Fanuc enclosures, mounted in the order listed above, are shown on the right side in Figure 2.

RF NETWORK FOR DNC

The AFDE2 is a portable machine and is moved around the factory in a transporter with casters (not shown). The transporter fits through the door of the 737 aircraft. The transporter features a pneumatic drive system to raise and lower the AFDE2 onto either the aircraft floor grid or onto a test plate as desired.

Since the AFDE2 would be used at over a dozen different workstations at Boeing, the provision of multiple DNC connection points was a challenge. To resolve this problem the AFDE2 was equipped with a radio link to the Boeing network which could be used anywhere in the factory. Due to the compact size of the AFDE2 design, carrying a PC was not desirable. Fortunately the Fanuc 15i supports Ethernet and can connect directly to the factory network.

An RF Ethernet bridge is mounted behind the CNC monitor. This bridge communicates with antennas that are mounted inside the factory. The Ethernet bridge is connected to the Ethernet port on the Fanuc CNC. Software for FTP is provided by Fanuc and is accessed through the front panel and the MDI keypad. Part programs can be downloaded off of the Boeing network from any desired location and moved either to the CNC memory or to an optional hard drive. The supplied 2 gigabyte hard drive can be seen on the right side of Figure 3.

In practice the hard drive is not utilized since it is convenient to move programs directly from the factory network to the CNC memory.

SPINDLE DRIVE DESIGN

The AFDE carries four spindles which run at 8500 RPM for drilling aluminum and are capable of 120 in-lbs. of torque for drilling titanium. Four 100 amp drives are required. To minimize the interference between adjacent spindle envelopes, Electroimpact requested that our spindle drive supplier, Motion Control Systems, Inc. of New River, Virginia (MCS), provide us with a more compact drive than was used on previous AFDEs.

The previous MCS drive was the SA2000, which was 8.5" wide x 16" tall x 10.5" deep. We asked MCS to narrow the drive design so we could mount all four drives on the back of the AFDE2 machine. MCS provided us with the DA3000 which is 6.5" wide x 16" tall x 10.5" deep. We therefore saved 2" of width per MCS drive which allows a total savings of 8" when four are considered. This provided additional versatility for simultaneous adjacent hole drilling by adjacent spindles.

The four SA-2000 drives can be seen on the left side of Figure 2. These drives supplied more than enough power for all of the drilling requirements of the AFDE2.

SPINDLE MECHANICAL DESIGN

The AFDE2 incorporates four spindles, each with servo controlled feed and in the Electroimpact configuration a servoed spindle. The spindles must be narrow to allow the spindles to move close together. The Electroimpact design incorporates an integral feed axis. In comparison with the previously supplied 737AFDE1 some changes had to be incorporated into the spindle design:

In order to use the integrated Fanuc 15i control it was necessary to redesign the spindle feed axis to utilize the Fanuc Alpha 2 servo motor. The Fanuc motor is larger than the previously used Moog motor so some rearrangement of the spindle was required.

An HSK 40-C tool holder was incorporated. The HSK clamp system allows for convenient use of a 3 mm Allen key for tool removal and replacement. The HSK 40-C allows for precision control of runout and of countersink depth. The holders are of a standard design which are available from a wide variety of suppliers.

Figure 6 shows the AFDE2 spindle with a tool holder removed from the taper.

CUSTOM CNC SCREENS

The 15i CNC allows for the development of custom screens including graphical display. The screens are displayed on the CNC. The display is switched from the standard Fanuc CNC screens to the various custom screens by a button on the MDI panel. Once activated the screens provide labels for the softkeys below the LCD display. These buttons can then be utilized to toggle bits for maintenance functions and for altering machine operation. There is also a cursor on the screen, which is moved around with arrow keys. With the cursor placed on a value the MDI number buttons can be used to alter that value.

The following custom screens were supplied with AFDE2:

1. drill digitize
2. feed-speeds

3. home adjust
4. homing
5. main
6. maintenance
7. password
8. power-up
9. sample
10. spindle adjust
11. timer-counter

Figure 7 shows the "Maintenance Functions" screen which allows maintenance personnel to turn the spindle drives, lube, brakes and blowoff on and off. Figure 8 shows the "Drill Digitizing" screen which allows setting the end of rapid point for the four spindle feeds. Figure 9 shows the "Drill Cycle Parameters" screen, which allows viewing the drill cycle parameters that are input via a macro program. Figure 10 shows the "System Timers and Counters" screen which keeps track of the AFDE2 machine operation history.

CONCLUSION

Automated Floor Drilling Equipment (AFDE) has been used for several years at Boeing for drilling floor panel, galley, lavatory and other holes in Boeing planes. The

new controller and drill spindle designs available made it possible to redesign the AFDE as a self-contained unit with on-board CNC, custom operator interface, RF network and more compact drill spindles for increased robustness and versatility.

ACKNOWLEDGMENTS

The authors would like to acknowledge the assistance of Boeing Commercial Airplane Group in providing material for this paper.

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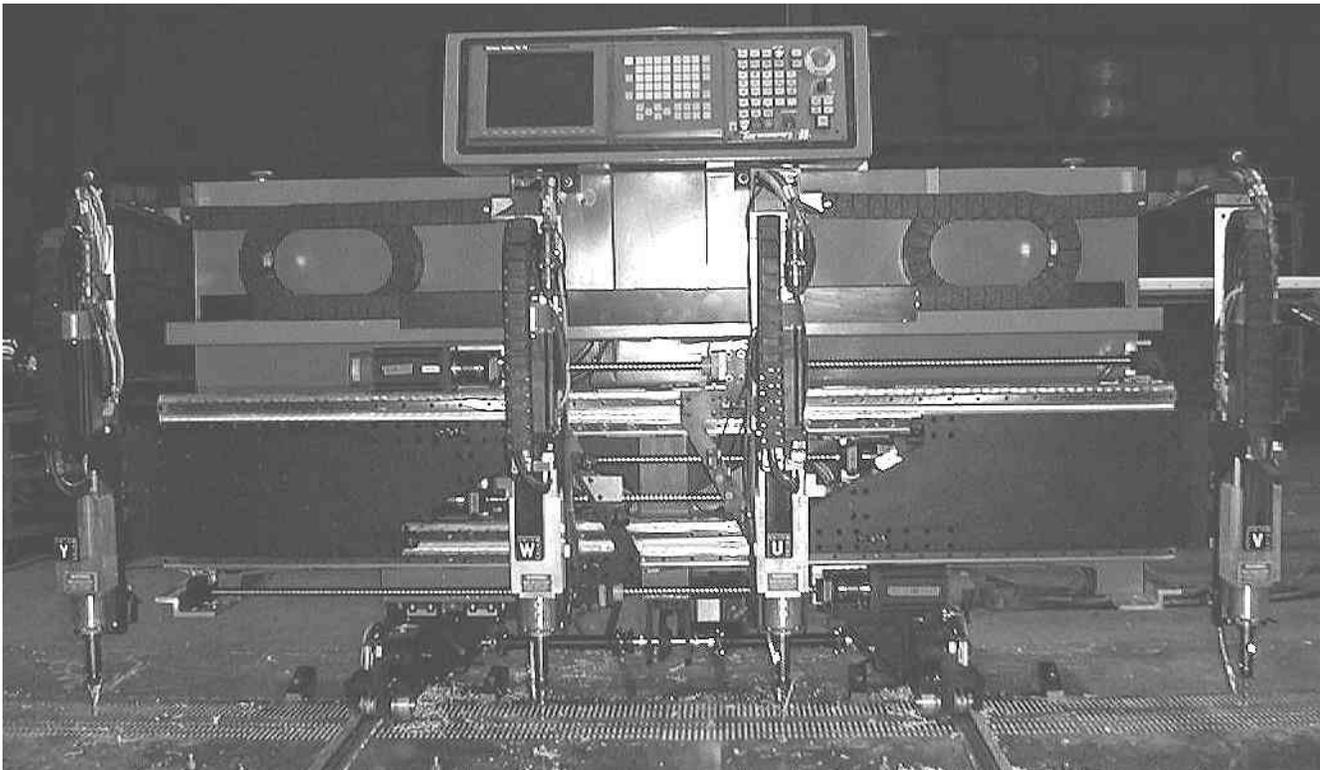
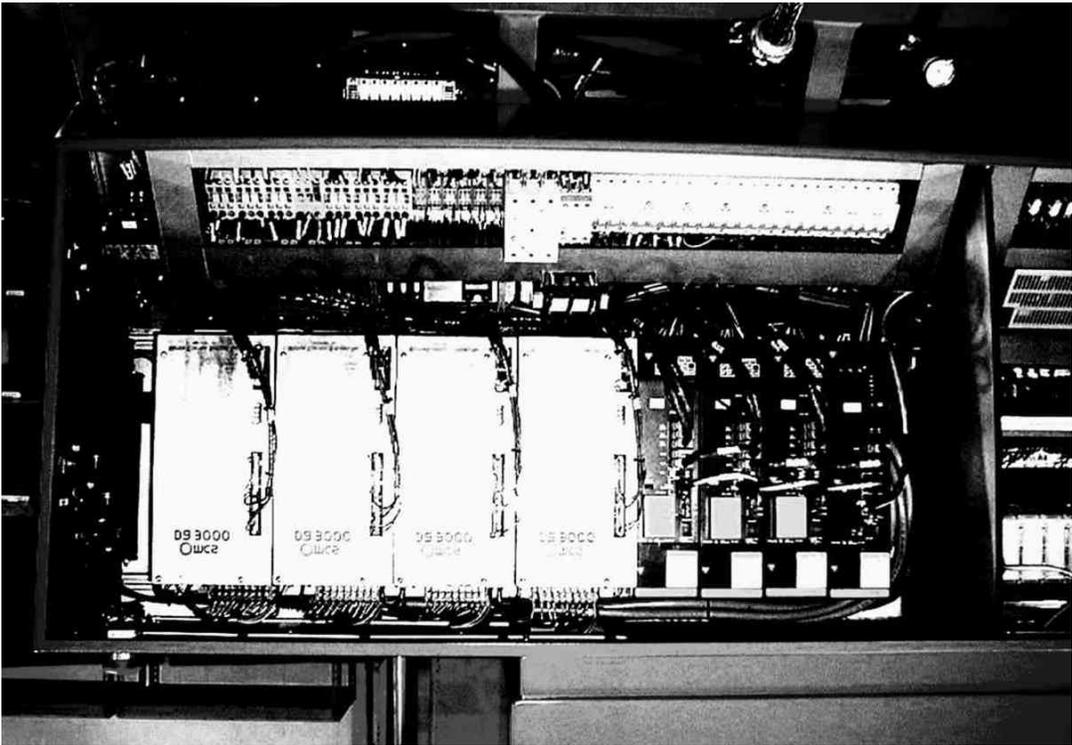


Figure 1: Front photo of AFDE2 showing CNC monitor and drills



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