

# New Machine Expands Friction Welding Applications

The world's largest linear friction welding machine uses advanced controls, servo hydraulics and a high-speed, closed-loop fieldbus for critical applications such as securing the blades on jet engines

BY AL PRESHER, CONTRIBUTING EDITOR

**T**hompson Friction Welding's E100 extends the use of linear friction welding through its ability to weld an area nearly twice as large as previously achieved (a surface area of 10,000 mm<sup>2</sup>). It also uses sophisticated servo valve control to precisely apply a weld forge load of more than 100 tons (220,000 lb). These capabilities extend linear friction

welding into automotive and aerospace applications, and have helped advance friction welding to a point where it is viable for critical applications such as securing the blades on jet engines.

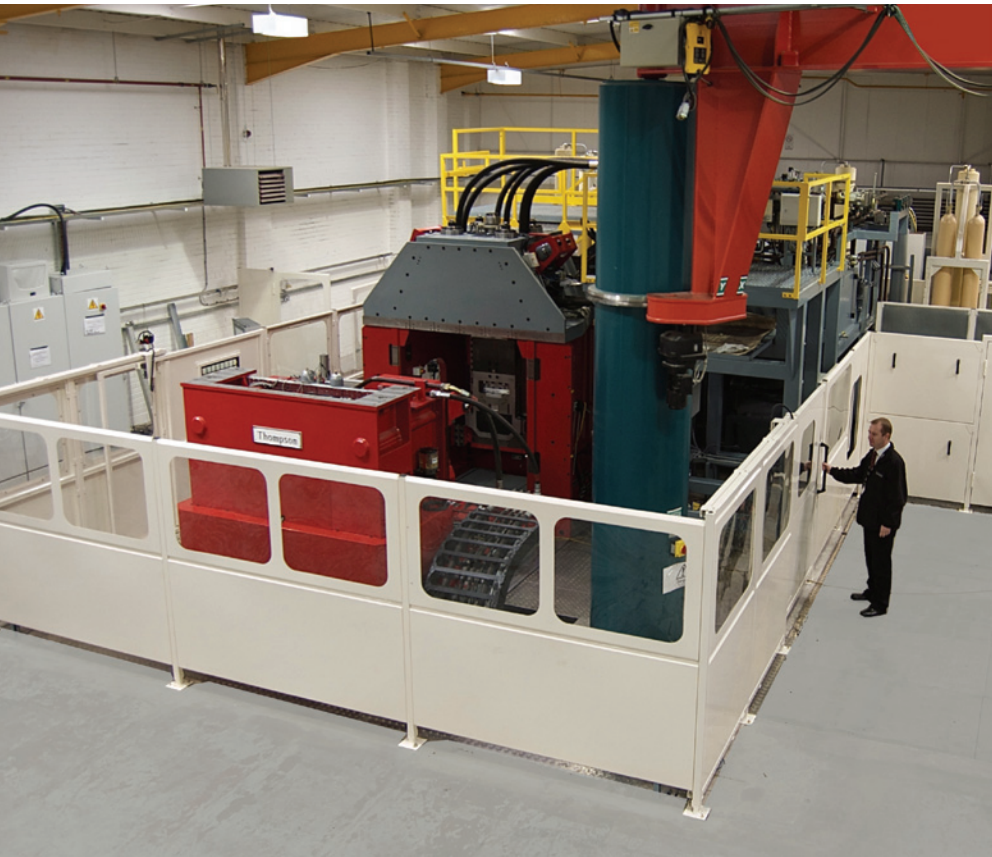
Automatic handling systems and rapid machine open/close features on the E100 cut production cycle times compared with traditional manual operations, and recharging of the accumulators takes

around 30 sec for the largest and longest welds, according to Stephen Darnell, regional business manager, Northwest Europe for Moog.

The E100 also allows for welded fabrication of parts that previously needed to be machined from solid metal, a process that can result in up to 80 percent material waste. It could "transform how jet engines are manufactured by cutting



A breakthrough in linear friction welding required expertise in servo hydraulics, hydrostatics and new control technology that could provide both micron-level precision and very fast frequency response.



**Thompson Friction Welding worked with Moog to produce the world's largest linear friction welding machine.**

production cycle times and dramatically reducing waste of expensive materials such as titanium,” says Darnell.

To enable friction welding technology for high accuracy and high frequency applications, the E100's hydraulic servo system (supplied by Moog) integrates a closed-loop control system with fast response at high amplitude and advanced digital control techniques for precise control over the weld process. Servo and proportional valves typically have a limitation in spool speed and acceleration which prevents the simultaneous delivery of high amplitude and frequency. For the E100, Moog valve spools perform three to four times faster than normal.

Moog's multiple, digitally controlled servo valves operate at peak flow rates of up to 1,200 gpm and a frequency range of 75 to 100 Hz for large scale welding. Use of multiple valves improves accuracy when the machine is turned down for smaller, lower force welds. The hydraulic system delivers more than 2 MW of instantaneous

power needed to drive the system, and seven gas volume accumulators (105 gal) each produce massive accumulation to provide the high peak oil flow rates.

## **PRE-FORM MANUFACTURING**

Linear friction welding requires a more complex machine and control architecture than rotary techniques, but has the advantage that pre-formed parts of any shape can be joined. A principal difference between linear friction welding and rotary welding is that, in linear friction welding, a moving chuck oscillates laterally instead of spinning and the two surfaces are in contact at much higher velocities. This means the two components being welded need to be kept under high pressure at all times.

The process of pre-form manufacturing by linear friction welding, sometimes known as solid-base additive manufacturing, allows complex shapes to be manufactured without wasting excess material normally associated with machining

**"AFTER MILLIONS OF FULL LOAD CYCLES, THE FACT THAT THE VALVES, INTERNALLY, ARE IN 'AS-NEW' CONDITION IS REMARKABLE."**

from a solid block, casting or forging, saving both manufacturing time and raw material costs. Manufactured parts are close to the final shape, so very little final machining is required to produce a fully functional component.

“Linear friction welding involves careful generation of localized heat into the two materials via friction induced by rubbing surfaces together,” says Darnell. “Regular oscillation of one of the two materials creates friction and, after a period of time, the materials are chemically joined by applying what is known as forge pressure which continues until the oscillation stops.”

The resulting joint, when cooled, has parent metal properties indistinguishable from either material. The key for Thompson Friction Welding is a level of precision in all the axes that creates an ability to join dissimilar materials such as copper and aluminum. “When you consider how the melting points of those two materials are so different, you get a small insight into just how strong a step forward has been made,” Darnell says.

## **HIGH-SPEED, CLOSED-LOOP FIELDBUS**

To achieve the machine's technical goals of increased accuracy and frequency, one key is the precision of the oscillator and its relationship to how a weld is actually performed. Another factor is that the hand-over, in control terms, to the forging process had to be extraordinarily precise down to micron-level precision.

One of the challenges to enabling this was to ensure that all data coming back from sensors on the machine was interpreted at the right speed and derived from the right information. The engineering team also developed a menu of operation functions

SOURCE: MOOG

in the machine, which allows Thompson's welding experts to pinpoint the type of recipe they need. This flexibility makes it possible for the control system to deliver comparable performance whether it is welding very different or similar materials.

The machine uses high-speed, closed-loop EtherCAT fieldbus communications to control the servo valves, sensors, analog and digital I/O modules, as well as communications between the Moog real-time controllers and Thompson's control and monitoring systems. Moog application

engineers were able to write a software control algorithms that permitted a fast loop closure with minimal overheads. The Moog MSD controller offers very fast processing times, but the software also had to be written to avoid excessive cycle time in the software routines.

Darnell says that the use of EtherCAT communications to all of the valves, coupled with a special laser etched design of the spool to reduce wear to negligible levels, were key enablers of the system's high performance capabilities.

"When you stand near the machine and watch the violent process of linear welding take place, it's one of the most impressive sights and sounds. And to think that after millions of full load cycles with huge flows of oil and large valve excursions, the valves internally are in 'as-new' condition is remarkable," Darnell says.

*For more information on Moog go to [www.moog.com/about/industrial-group](http://www.moog.com/about/industrial-group).*

*Thompson Friction Welding:  
[www.thompson-friction-welding.co.uk/](http://www.thompson-friction-welding.co.uk/)*

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