technology today

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Friction-Stir Welding

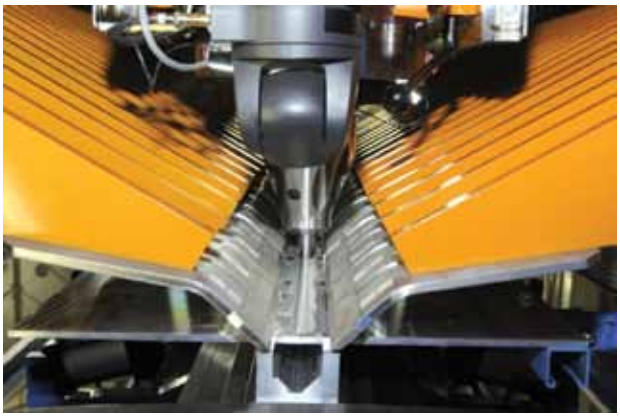
On January 23, 2012, a National Aeronautics and Space Administration (NASA) press release announced that two companies had recently commercialized NASA's friction-stir welding tools and systems. Friction-stir welding is a welding process that joins metals without melting them.

A historical perspective is needed before we look directly at how this process works. In 1991, technologists at the Welding Institute in England patented a new welding process that joined metals without melting them. Their friction-stir welding worked on metals including aluminum, a metal that cannot easily be joined using metal fusion processes. The Welding Institute process could only weld materials that were uniform in thickness. Their welding process left a hole, called a keyhole, in the material at the end of the weld. This hole, basically a welding defect, prevented the process from being used on pipes and cylinders. The hole was formed at the location where the tool was withdrawn from the material.

NASA engineers re-engineered this technology so that it can now be used on materials that vary in thickness and even weld objects with very complex shapes.

Lockheed Martin

Photo 1—The white line is the section of metal already welded together. The spinning pin tool is pressing against the metal. A computer control system constantly adjusts the tool's rotation speed, travel speed, and surface pressure.



NASA/MSFC/D. Stoffer

Photo 2—By zooming out from Photo 1, you can see the two metal plates that are being welded together and the fixture that holds everything in proper position.

It is NASA's Marshall Space Flight Center's development of an auto-adjustable spinning pin tool and metal-feeding computer system that probably made this process perfect for NASA's Technology Transfer Program.

The friction-stir welding process runs a spinning pin down the two pieces of metal that are to be joined. (See Photo 1.) Enough force is applied to the spinning pin for it to heat the location under it to the point that the metal in the area goes from a solid to a plastic state. It is important to note that the friction heating of the pin doesn't melt the metal—it just softens it up enough so that the molecules of the two separate metal pieces can mix together. To spin all the molecules in the area together, a great deal of pressure is placed at the exact point that is being joined.

You can compare what is going on here to what takes place during a tornado. In a tornado, extremely high swirling winds cause everything in the storm's wake to spin and move up and down throughout the vortex of spinning air. In friction-stir welding, the spinning rod in combination with 15,000 pounds of pressure causes all the metal molecules in the area of the pin to stir (spin/swirl) together to create a perfect bond. Just like in a tornado, the metal molecules move up, down, and in every conceivable direction so they completely mix together. They become frozen in their new location when the friction and pressure from the pin moves on down the line. (See Photo 2.)

More than Fun Answers

The NASA-designed computer feed system controls the auto-adjustable spinning pin tool's movement. At the end of the weld, the pin tool's rotation speed, travel speed, and pressure are carefully reduced by the computer control system so the molecules at the end of the weld turn back into a solid. (They don't collapse into a hole.) When a weld is completed, the molecular structure of the metal at the joint looks exactly the same as the structure anywhere else in the metal piece, as if the two parts were originally created out of one piece of metal.

This welding process is now being used by many industries because it produces a joint with the same fatigue properties as if the object was formed without any welds. What also makes it so attractive is the fact that the process doesn't require high electrical voltages, the use and storage of highly flammable gas welding tanks, create any need to handle liquefied metals, or produce environmentally unfriendly gaseous fumes. (See Photo 3.) You will find links to friction-stir welding videos at www.technologytoday.us/page13.html.

Recalling the Facts

1. How does friction-stir welding differ from other welding technologies?

2. The original friction-stir welding process produced a hole at the end of the weld. Brainstorm why this hole forms by comparing the sudden removal of the rotating tool and pressure at the end of the weld to what takes place during a tornado if the vortex and pressure of the swirling air suddenly collapses.

Photo 3—To safely observe this welding process, the technician only needs to wear standard safety glasses.

Alan Pierce, Ed.D., CSIT, is a technology education consultant. Visit www.technologytoday.us for past columns and teacher resources.