National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Manufacturing

Internal Friction Reduction (IFR) Tool

Cost-effective pin tool for self-reacting friction stir welding

NASA's Marshall Space Flight Center has developed a cost-effective pin tool for use in self-reacting friction stir welding (SR-FSW), making the SR-FSW process significantly more robust and cost-effective. The IFR Tool mitigates the internal friction that occurs between the weld pin and crown-shoulder during a SR-FSW weld. Testing with the IFR tool has shown a significant reduction in the number of defects found in SR-FSW welds, and the tool allows significantly longer SR-FSW welds to be performed. Utilizing the IFR Tool can reduce SR-FSW welding costs by reducing scrap/rework rates, reducing the number of pin tools required per unit weld length, and reducing the time spent changing out SR-FSW pin tools per unit weld length. Along with improving the cost-effectiveness of existing SR-FSW applications, the IFR Tool may also further expand the applications for which SR-FSW is a commercially viable solution.

BENEFITS

- Reduces SR-FSW weld defect rates: in the same weld set-up, the IFR Tool achieved a 90% reduction in weld defects compared to a standard tool
- Enables longer SR-FSW weldments: the IFR Tool allowed for welds greater than twice as long as those with a standard tool
- Lowers SR-FSW welding costs: reductions in scrap/rework rates, number of pin tools used, and time spent changing out pin tools all contribute to lower welding costs
- Simple to produce and use: the IFR Tool is simple to produce and integrate into existing SR-FSW processes

APPLICATIONS

The technology has several potential applications:

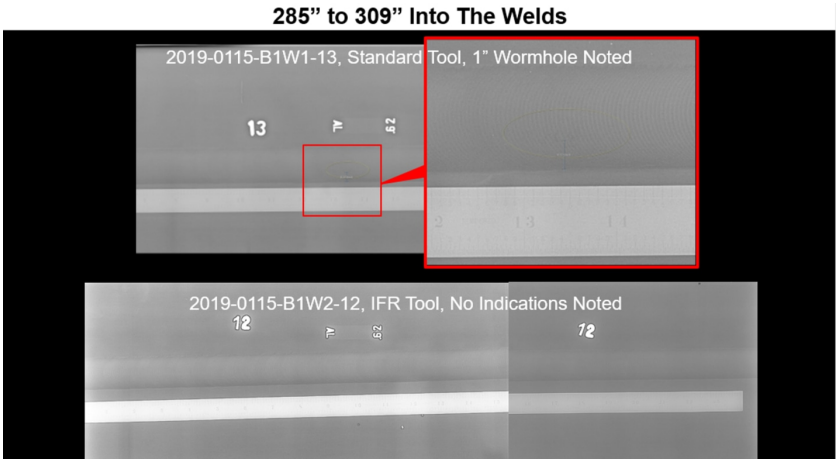
- Aerospace
- Railway cars
- Construction
- Storage tank or cylinder manufacture
- Ship building
- Plastic welding
- Micro-scale electronics

THE TECHNOLOGY

During SR-FSW, the wicking of substrate material into the gap between the crown shoulder and pin can lead to pinch load shifting–an increasing difference between the applied pin load and actual pinch load. NASA's IFR Tool mitigates pinch load shifting, enabling a more robust SR-FSW process due to better agreement between the applied pin load and the actual pinch load.

As pinch loads are not dynamically measured during welding, NASA has relied on defect rates and pin tool ejection loads to demonstrate the value of the IFR Tool. Large-scale welds were performed with both the IFR Tool and a standard pin tool. Weld inspections found a 90% reduction in defect generation rate for the IFR tool, and the first defect in the standard pin tool sample occurred at 300" compared to at 900" in the IFR Tool sample. There was also a drastic improvement in mechanical properties variations along the weld.

In another study, a series of 27.5' barrel welds were performed with both the IFR Tool and a standard pin tool. After welding, ejection forces required to remove the pin tools from their fixtures were measured. The standard pin tool ejection force was 9,400 lbs., nearly 5 times larger than that of the IFR Tool at 2,000 lbs . The large difference suggests that during welding, the standard pin tool would have been less responsive to substrate surface variations than the IFR Tool. Weld inspections supported this theory, as they found a significantly lower defect rate in the IFR Tool samples.



Weld inspection x-rays show a defect 300" into a SR-FSW weld made with a standard pin tool (top image). No defects were found in the first 900" of an IFR Tool weldment (bottom image).

The IFR Tool–shown performing a SR-FSW panel weld in the image above–enables a more robust and thereby cost-effective SR-FSW process.

PUBLICATIONS

Patent No: 11,331,747

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More Information

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