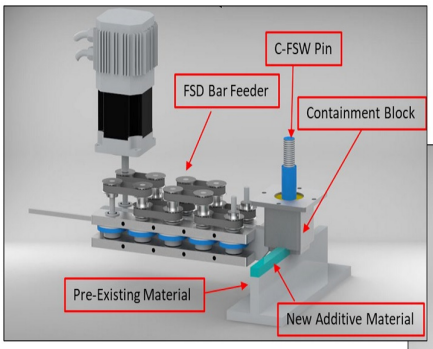
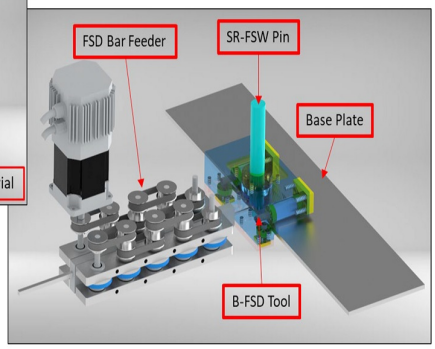



Conventional Friction Stir Deposition (C-FSD)

Bobbin Friction Stir Deposition (B-FSD)




National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Manufacturing

# Friction Stir Deposition Innovations

## Two approaches for additive manufacturing with equipment modifications

Innovators at the NASA Marshall Space Flight Center have developed two new friction stir deposition (FSD) add-on tools that allow a conventional friction stir welding (C-FSW) system to be reversibly adapted for deposition within minutes. Both FSD end effectors use the rotating pin of the FSW tool to heat and plasticly deform metal feedstock for solid-state additive processes.

The first tool—Conventional Friction Stir Deposition (C-FSD)—allows for layer-by-layer addition of extruded metal to an existing part using a C-FSW system plus a side-loading metal bar feeder device and containment block. The exit shape of the containment sets the final geometry of the part, enabling complex shapes (e.g., domes, barrels) to be deposited directly on a substrate (e.g., stiffeners to panels).

The second tool—Bobbin Friction Stir Deposition (B-FSD)—makes use of a self-reacting tool design to contain the metal on two sides with the filler material fed between the shoulders. When paired with an FSW machine with a Self-Reacting Friction Stir Weld (SR-FSW) adjustable pin axis, continuously varying thickness parts are printable, as well as free-forming printing of complex curvatures.

### BENEFITS

- Reduced capital costs: both technologies are add-on tools to be quickly installed onto friction stir welding machines without permanent alteration (10-minute change-out)
- Large part additive manufacturing: these technologies are not limited to a print bed for additive manufacturing may be used to produce large-scale metal components.
- Higher quality surface finishes: both FSD processes result in high-quality surface finishes with reduced or removed need for post-processing.
- Reduced need for fasteners: the FSD processes may print new material (e.g., a stiffener) directly onto existing material (e.g., an aircraft skin) without the need for additional fasteners.
- Reduced preparation for more complex structures: the design of the B-FSD tool allows for creating hollow or complex metal structures without the need of a bulky anvil.
- Enables low cost to machine design: Both the C-FSD and B-FSD end-effectors bolster low-cost-to-machine design.

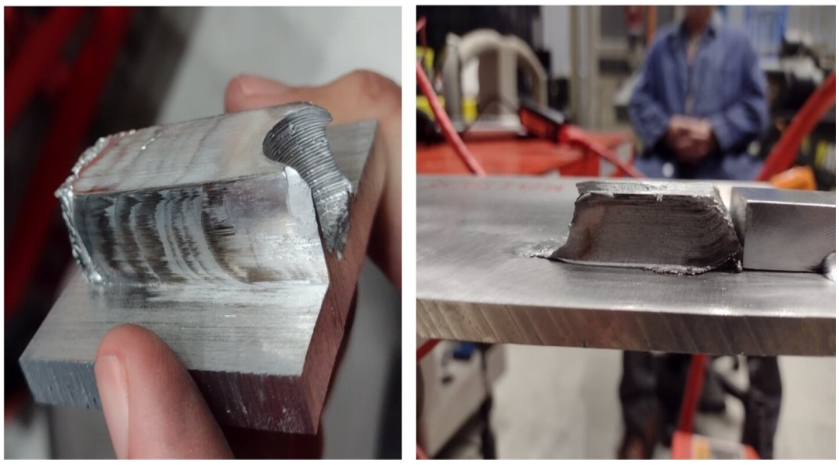
## THE TECHNOLOGY

Metal additive manufacturing may be limited by build volumes (i.e., it can be hard to make large parts), post-processing requirements, and upfront costs to buy capital equipment. The two NASA-developed technologies are add-on tools for FSW systems (reducing costs), do not require a printer or print bed, and produce parts with high quality surface finishes.

The C-FSD attachment includes a non-rotating block through which the C-FSW rotating pin is threaded, and a containment plate to hold the plasticized metal within the system. In this technique, raw metal feedstock is fed into one end of the non-rotating block, is heated and plasticized by the C-FSW pin, and is driven out the other side of the block. The C-FSW pin is used to join the new material to the pre-existing layer.

The B-FSD tool uses a dual-shoulder design to print outward from the edge of the base panel. The B-FSD process uses the same feed system as the C-FSD, but utilizes the bobbin/SR-FSW pin's dual shoulders (i.e., containing the metal on both the top and bottom) enabling more complex structures to be made, and the ability to print varying thickness depositions in a single pass.

The Additive C-FSD and B-FSD end effector tools are both at technology readiness level (TRL) 4 (component and/or breadboard validation in laboratory environment) and are available for patent licensing.



Demonstration articles of the additive friction stir deposition processes.

## APPLICATIONS

The technology has several potential applications:

- Aerospace: metal component (e.g., rib stiffeners) and structure (e.g., walls, domes, cylinders) additive manufacturing
- Automotive: metal part additive manufacturing
- Railway cars: metal part additive manufacturing
- Ship building: metal part additive manufacturing
- All industries: metal component repair by direct metal deposition

## PUBLICATIONS

Patent Pending

**technology.nasa.gov**

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

MFS-34175-1, MFS-34373-1, MFS-TOPS-127

## More Information

National Aeronautics and Space Administration

**Agency Licensing Concierge**

**Marshall Space Flight Center**

Huntsville, AL 35812
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

**www.nasa.gov**

NP-2023-09-3174-HQ