Pacific Northwest
NATIONAL LABORATORY

Solid Phase Processing @ PNNL

REVOLUTIONIZING U.S. METALS MANUFACTURING FROM CONCEPTION TO DEMONSTRATION TO DELIVER BETTER, GREENER, AND MORE AFFORDABLE PRODUCTS.

Reaching a net-zero economy by 2050 will require new manufacturing approaches and technologies capable of producing greener, more cost-effective materials that can do more. Pacific Northwest National Laboratory (PNNL) is revolutionizing the manufacture of next-generation metal alloys and components with partners across industry, academia, and government sectors. Together, we are driving the discovery, development, and demonstration of scalable, advanced manufacturing approaches that will be key tools in unlocking the net-zero economy of the future.

A NEW APPROACH TO METALS MANUFACTURING

For the past 5,000 years, the manufacture of metals has required large amounts of energy in the form of heat. Heat is used to melt metals into alloys with specific performance characteristics. Traditionally, metals manufacturing has relied on fossil-based energy to generate that heat, resulting in a large carbon footprint.

In a radical new approach to metals manufacturing called Solid Phase Processing (SPP), PNNL smashes this age-old paradigm by applying mechanical energy instead of external heat to alloy and form metal products. This approach has given rise to a suite of scalable manufacturing processes that require less energy and are more environmentally sustainable than conventional methods. Because SPP approaches are fundamentally different, they enable the manufacture of entirely new metal products that cannot be produced through conventional processes while driving down the need for costly alloying elements.

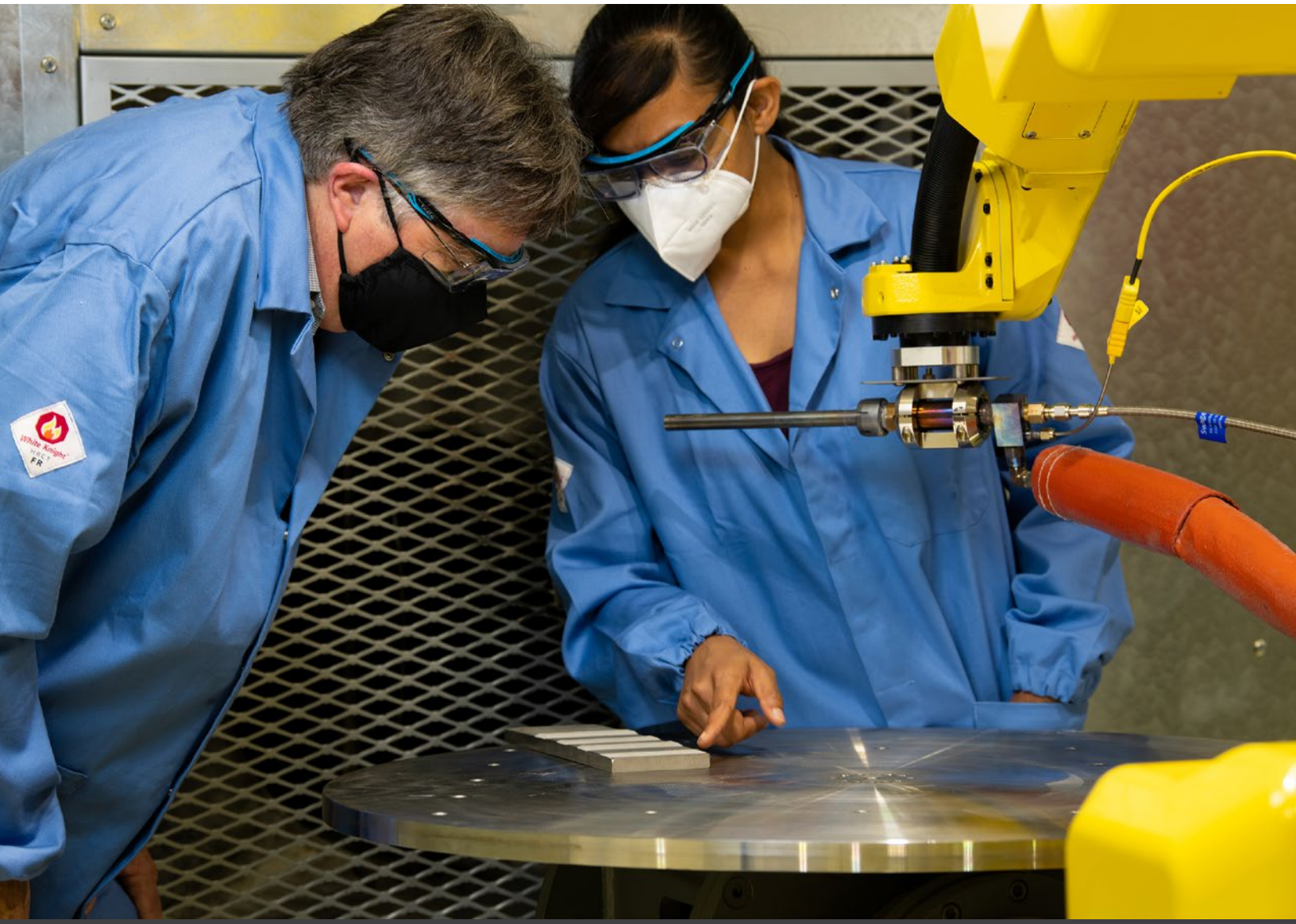
SPP METHODS AVAILABLE AT PNNL

Friction stir welding for joining similar and dissimilar metals without melting.

Shear Assisted Processing and Extrusion (ShAPE™) for metal alloying and extrusion.

Friction stir processing for locally modifying metal properties and healing defects.

Cold spray for coatings and infrastructure repair.



In cold spray processing, feedstock particles are propelled at supersonic velocities to impact surfaces with sufficient energy to form a strong bond and create a dense deposit that can be more effective than traditional welding for material repairs. *(Photo by Andrea Starr | Pacific Northwest National Laboratory)*

HIGH-PERFORMANCE PRODUCTS THAT REQUIRE LESS ENERGY AND RESOURCES

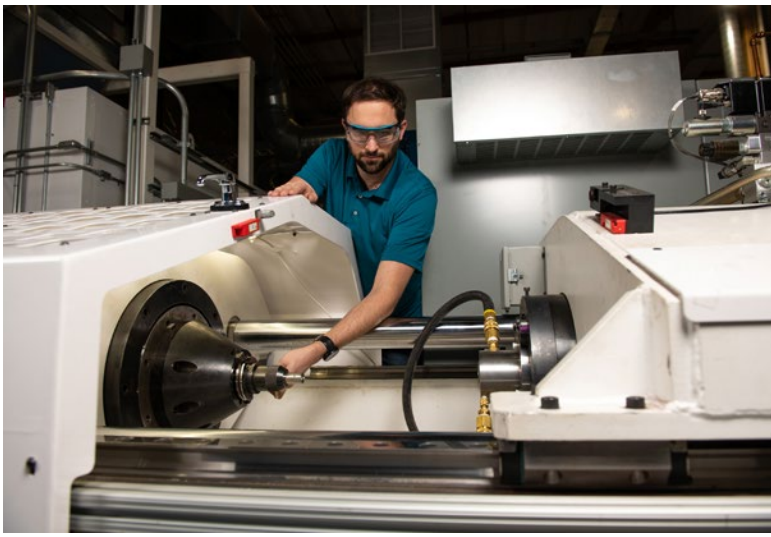
Because SPP methods eliminate the need to heat metals to high temperatures to form alloys, create welds, or produce specific forms, they require less time, energy, and expense than conventional metals manufacturing. This substantially decreases greenhouse gas (GHG) emissions while simultaneously delivering better products.

Less energy

SPP methods are greener and more energy efficient. Friction stir welding (FSW) can reduce the energy required to join metals by up to 80% compared to conventional gas arc welding. ShAPE™ reduces energy requirements by 85% compared to conventional extrusion processes—which can reduce greenhouse gas emissions by up to 92%.

Lower costs

SPP methods reduce the cost of manufacturing high-performance alloys, making them affordable for a broader range of applications. One example is high strength aluminum alloys, which have seen limited use because of their high manufacturing costs. Using ShAPE™ processing, these same aluminum alloys can be manufactured 10 times faster and without pre- and post-extrusion heat treatments, cutting costs by 60%.



ShAPE™ technology uses a combination of linear and rotational shear forces to produce extruded products like tubes, wires, and bars that have significantly improved properties. *(Photo by Andrea Starr | Pacific Northwest National Laboratory)*

SPP approaches can provide:

- **Reduced greenhouse gas emissions**—up to 92% less than conventional methods.
- **Significant energy savings**—an over 50% decrease in manufacturing energy, with as much as an 80% decrease using the FSW method and 85% using ShAPE™.
- **Lower manufacturing costs**—up to 60% less using ShAPE™.
- **Next-generation, high-performance products**—like ultra-conductive copper and aluminum metals via ShAPE™ and cast aluminum with 10 times improved fatigue life via friction stir processing.
- **Enhanced manufacturability**—including 10 times faster extrusion of aluminum alloys using ShAPE™.
- **Longer operational lifetime**—like cold spray coatings that increase wear resistance of stainless steel turbine blades by more than 300%.

Better products

SPP methods yield products that are impossible with conventional processes. FSW enables joining dissimilar materials that cannot be welded together by conventional means, supporting the fabrication of multi-material components. ShAPE™ can deliver copper and aluminum composites with higher conductivity, extrude brittle materials such as high-iron aluminum alloys and thermoelectric materials, and co-extrude 6000- and 7000-series aluminum alloys.

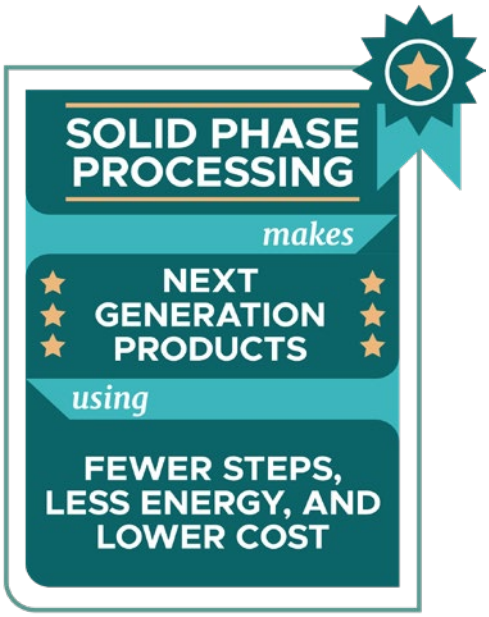
From scraps to high-performance materials

In collaboration with industry partner Magna International, PNNL demonstrated the direct conversion of 100% aluminum scrap into high-performance tubing via ShAPE™. In addition to lowering materials costs by recycling scrap, this process is estimated to use 30% less energy and reduce 90% of greenhouse gas emissions relative to the same tubing produced from primary aluminum.

To learn more about the suite of SPP approaches, visit ***https://www.pnnl.gov/solid-phase-processing***.

BE ON THE LEADING EDGE OF ADVANCED MANUFACTURING WITH SPP@PNNL

Leveraging innovation, expertise, and fundamental scientific understanding in SPP, PNNL scientists and engineers are working with industry partners to develop and demonstrate scalable, affordable, and green manufacturing approaches for a variety of metal alloys and applications. Translating these innovative approaches in metals manufacturing to commercial use will provide a significant competitive advantage to the domestic manufacturing sector, create thousands of new, high-quality jobs, and establish the United States as the global source for the best metals components.



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