AMMTO & IEDO JOINT PEER REVIEW

May 16th-18th, 2023 Washington, D.C.

ShAPE 2.0 Next Generation Process Technology for the Manufacture of Low Cost **Lightweight Metals - AMMTO**

Presenter

Pacific

Northwest

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PNNL is operated by Battelle for the U.S. Department of Energy



Phase PROCESSING



Project Overview

Primary Innovation

- Development of Shear Assisted Processing and Extrusion (ShAPE) at industrial demonstration scale on new ShAPE 2.0 platform
- Scalable process for manufacturing high-performance materials with fewer steps, lower energy, and reduced carbon footprint

E	nergy, Emissions, & Environment:	Cost & Competitiveness:
•	Use of 100% secondary aluminum scrap eliminates need for primary aluminum thereby reducing embodied energy <u>and</u> lifecycle GHG by >90% Fewer heat treatment and manufacturing process steps	 More efficient manufactur energy consumption lowe Use secondary aluminum lower cost feedstock
<u>T</u> e	echnical & Scientific: Extreme microstructural refinement improves structural and functional material properties	<u>Other Impacts:</u> 5-10x increase in throughput conventional extrusion for dif aluminum alloys

Performers

- The overall ShAPE 2.0 project is a collaboration between DOE-AMMTO, DOE-VTO, WA State Department of Commerce, and PNNL
- PNNL is the only performer on the AMMTO scope of work



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compared to fficult to extrude



- Innovation: Scalable process for manufacturing high-performance materials with fewer steps, less energy, and reduced GHG **PNNL** • Lead:
- Partners: None

Pacific

• Timeline: FY20-25, 40% Progress

	FY21 Costs	FY22 Costs	FY23 Costs	Total F Fun
DOE Funded (AMMTO)	\$1K	\$2K	\$117K	\$5
Other DOE (VTO)	\$31K	\$45K	\$276K	\$8
WA State Cost Share	\$0K	\$0K	\$453K	\$93

• End Project Goal: Demonstrate scaled-up ShAPE extrusion of two different components to spur commercialization opportunities



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Background & Strategic Approach

What is ShAPE?

- New extrusion process for manufacturing high performance materials more efficiently
- Linear and rotational motion are combined to impart extreme deformation during extrusion

What are the benefits of ShAPE?

- Accepts a variety feedstock forms
- Refines microstructure and aligns texture
- Improves properties (structural/functional)
- Reduces process energy/carbon
- Enables recycling of secondary scrap

What are the project objectives?

- Demonstrate the next level of scaling
- Generate commercialization opportunities







for aluminum

Background & Strategic Approach

ShAPE 1.0 built in 2016

2,100 ft-lb torque 100 ton press

Tailstock

Purpose built First-of-its-kind Profiles limited to <1.0" diameter</td>

Headstock

ShAPE 2.0 fall of 2023

8,400 ft-lb torque 150 ton press Future proofed for 25,000 ft-lb



Profiles up to 3.0" diameter expected for aluminum











ShAPE of Aluminum Alloy 7075

Speed limited by surface tearing caused by 2nd phase incipient melting at die surface



S. Whalen, M. Olszta, Md. Reza-E-Rabby, T. Roosendaal, T. Wang, D. Herling, B. Taysom, S. Suffield, N. Overman, "High Speed Manufacturing of Aluminum Alloy 7075 Tubing by Shear Assisted Processing and Extrusion (ShAPE)," Journal of Manufacturing Processes, 71, pg. 699-710, 2021.



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Background & Strategic Approach

Collaboration between WA state Department of Commerce, DOE-VTO, DOE-AMMTO

Purchase of ShAPE 2.0



\$937.8K



\$350K

Startup and Operation

U.S. DEPARTMENT OF =N=Ren

Energy Efficiency & Renewable Energy

VEHICLE TECHNOLOGIES OFFICE

\$500K

- **Technical specification**
- Equipment installation
- Process development
 - Materials characterization



- \bullet

- Process development



ADVANCED MANUFACTURING OFFICE



Commissioning Scaled up tooling Instrumentation



Results and Achievements

Typical ShAPE 1.0 Tooling



ShAPE 1.0 tooling is being re-designed and scaled-up for ShAPE 2.0 • Achieve larger extrusion profiles Produce profiles identical to existing industrial components Survive full torque and ram force





arkets/automotive/ For illustration purposes only

Results and Achievements

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- loads



Tooling components have been re-designed for larger scale and to survive full machine

Full FEA performed on all components to ensure robust design

Most components are currently in procurement



Results and Achievements

Roof Rail Use-Case



Cross Member Use-Case ShAPE 1.0





AA 6061 / 6063









Future Work, Technology Transfer, & Impact

Future Work:

- Complete design and fabrication of tooling and fixtures •
- Commission ShAPE 2.0 machine at PNNL facility •
- Integrate advanced instrumentation and sensing capability
- Perform research on process development and scalability

Technology Transfer:



- Commercialization in process with Magna International, largest Tier 1 automotive supplier in North America
- PNNL has identified ShAPE as the pilot technology for a new lab-level technology deployment program aimed at identifying commercialization opportunities and accelerating tech-to-market
- ShAPE 2.0 utilized on multiple industry led proposals currently under evaluation by AMMTO
- ShAPE 2.0 to be utilized on multiple active projects after commissioning •

Impact:

• ShAPE 2.0 is an advanced manufacturing platform for creating high-performance materials with lower embodied energy, reduced lifecycle carbon emissions, and lower cost



ShAPE 2.0: AMMTO

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ShAPE 2.0 under construction by Bond Technologies located in Elkhart, Indiana









COMING SOON: A New Space for Solid Phase Processing

Displays

We are moving to a newly renovated space in the 3475 Building by September 2023

FEATURED TOOLS:

- ShAPE 1.0
- New! ShAPE 2.0
- Gantry Friction Stir Welding (FSW) System
- Robotic Friction Stir Welding (FSW) System
- New! High-Speed Friction Stir Welding (FSW) System
- Cold Spray System

FACILITY UPGRADES:

- Footprint expansion from 4,700 sq. ft. to 6,100 sq. ft. (with room to grow)
- Fully climate-controlled
- Quieter than current location
- Configured for future crane additions
- Upgraded cooling water system
- Bottle dock tube truck-ready
- Moving to PNNL-Richland campus
- Close to supporting characterization facilities in 3410









Shears Furnaces and Presses