

National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Manufacturing

Tailored Blank Method of Spin Forming Domes in Free-Space

Reduces Tooling Cost and Lead Time for Dome Manufacturing through Mandrel-Free Forming

Components such as launch vehicle fairings, aircraft radomes, and sonar domes rely on the fabrication of large, curved metallic shells. Spin forming these structures traditionally utilizes custom mandrels that create significant tooling costs and months-long lead times to manufacture. As mandrels rigidly define part geometry, rapid design iterations often require new tooling to reflect minor changes. Attempts to bypass mandrels by forming standard blanks in free space typically fail, yielding conical shapes instead of uniform curvature.

In response, NASA's Langley Research Center developed a tailored blank and subsequent spin forming method to create domes in free-space. This invention is a unique manufacturing process that utilizes a profiled metal preform to guide deformation on standard CNC spin forming equipment. By controlling how the metal bends, the target dome geometry is formed in free-space without internal mandrel support. This allows users to eliminate costly custom mandrels, reduce production lead times, and rapidly iterate designs using existing infrastructure.

BENEFITS

- Reduced Tooling Cost: Eliminates custom mandrel requirements that can exceed $1 million for large-scale aerospace domes, significantly lowering capital investment for dome manufacturing.
- Shortened Lead Time: Removes mandrel design and fabrication steps that require extensive development periods, accelerating production schedules and enabling faster response to design changes.
- Design Flexibility: Allows geometry modifications by adjusting the blank thickness profile, reducing new tooling requirements and supporting rapid design iteration during development phases.
- Standard Equipment Compatibility: Operates on conventional CNC spin forming or flow forming equipment without specialized machinery, reducing implementation barriers for existing manufacturing facilities.
- Scalable to Large Structures: Applicable to aerospace domes exceeding 16 feet in diameter where traditional mandrel-based approaches face the highest cost and schedule penalties.

THE TECHNOLOGY

The tailored blank method overcomes free-space forming limitations by engineering the initial thickness profile of the workpiece. It uses a circular metal blank with a customized thickness gradient. When processed on standard spin forming CNC equipment, this gradient controls where bending stresses concentrate under the forming roller. This programmable distribution prevents plastic hinge formation, guiding the metal into a precise dome geometry entirely in free space. Shifting the shape definition from a physical mandrel to the preform profile enables rapid production, lower costs, and greater design flexibility.

To validate the concept, researchers conducted a variety of subscale trials. Testing campaigns exercised the method across multiple aluminum alloys using a standard CNC spin forming setup. By iterating taper designs and forming parameters, the method successfully progressed workpieces from cone-like shapes into smooth, hemispherical domes. Empirical results confirm that the tailored approach provides consistent geometric control without relying on matched tooling.

While NASA originally envisioned the tailored blank method for forming large pressure vessel domes, the method may also enable rapid fabrication of metallic payload fairings for the commercial launch industry. Additionally, since the technology is capable of producing curved shells without custom mandrels, the naval sector may be interested in using it for submarine bow domes and radar enclosures. The industrial energy sector could also apply this technique to efficiently form wind turbine spinners and nacelle covers. The technology is available for patent licensing.



Artemis II propellant tank for NASA's Space Launch System rocket, featuring the domed nose structure. Credit: NASA

APPLICATIONS

The technology has several potential applications:

- Aerospace Dome Structures: Forming aerospace radomes, propeller spinner domes, aft pressure bulkheads, and curved nacelle or fairing structures where mandrel costs and lead times create barriers to rapid prototyping and low-volume production.
- Launch Vehicle Structures: Producing payload fairings, fairing half-shells, reusable fairing structures, and curved launch-vehicle shell sections where reducing shape-defining tooling provides clear production benefits and enables faster response to mission requirement changes.
- Naval Dome Structures: Manufacturing submarine bow domes, surface-ship sonar domes, shipboard SATCOM radomes, shipboard radar radomes, and marine antenna covers where custom mandrel tooling is cost-prohibitive and design flexibility is critical for specialized naval applications.
- Wind Turbine Components: Fabricating wind turbine spinner covers, hub covers, and nacelle fairings where large-scale production requires reduced tooling investment and the ability to accommodate design variations across different turbine models and manufacturers.

PUBLICATIONS

Patent Pending

More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Langley Research Center

Mail Stop 020
Hampton, VA 23681
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

NP-2026-01-6716-HQ

technology.nasa.gov

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