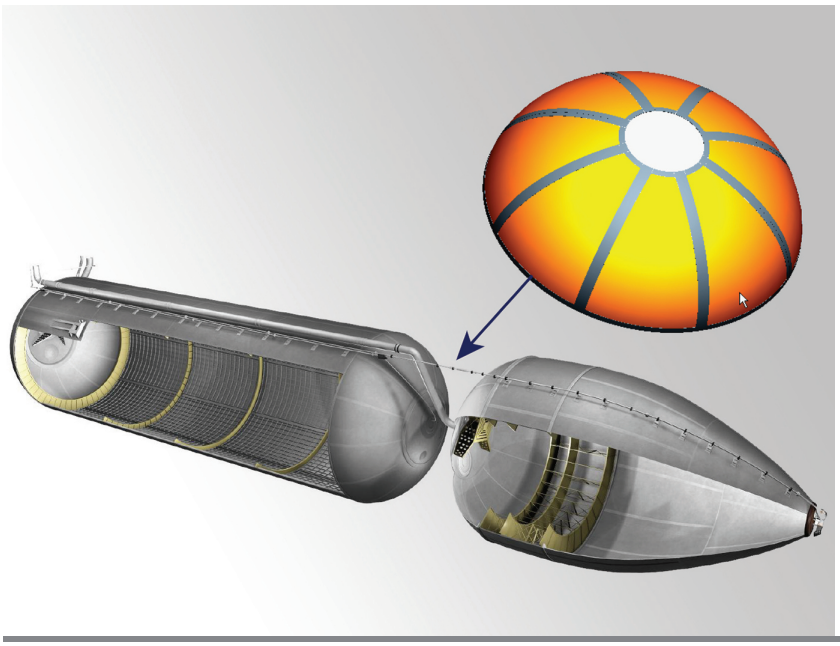


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Manufacturing

Improving Formability of Al-Li Alloys

Novel heat treatment enables spin forming and stretch forming of Al-Li 2195

NASA scientists have designed a novel heat treatment process that significantly improves the formability of high-performance aluminum-lithium (Al-Li) 2195 alloy plate stock. The heat treatment process dramatically reduces cracking and also improves the yield and range of product sizes/shapes that can be spin/stretch formed. The improved yields also provide lower costs.

The NASA innovation enables the use of Al-Li 2195 alloy for large structures like rocket domes or fuel tanks of much lighter weights than if made using a conventional aluminum-copper (Al-Cu) alloy. While specifically designed to address Al-Li 2195 alloy, similar heat treatments may possibly improve the formability of other high-performance Al-Li alloys as well.

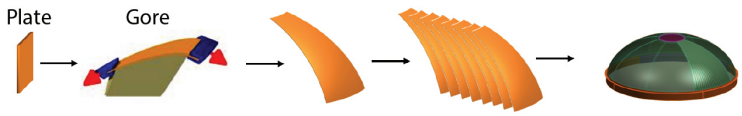
BENEFITS

- Enables the use of Al-Li alloys (Al-Li 2195) for the manufacture of large, lightweight aerospace structures via spin forming or stretch forming of a plate or extruded alloy.
- Dramatically reduces cracking during forming, thereby increasing yields and lowering costs.
- Has been used for producing actual parts; it is a proven technology ready for commercial implementation.

THE TECHNOLOGY

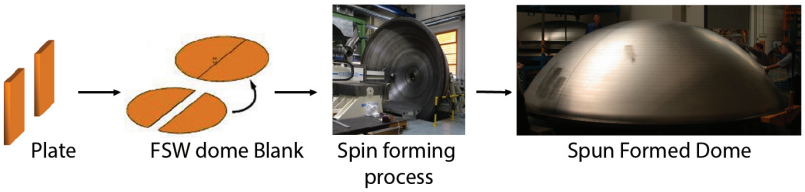
Via this NASA innovation, a product is first heated to a temperature within the range of 204 to 343 degrees C for an extended soak of up to 16 hours. The product is then slowly heated to a second temperature within the range of 371 to 482 degrees C for a second soak of up to 12 hours. Finally, the product is slowly cooled to a final soak temperature of 204 to 343 degrees C before cooling to room temperature. The product so treated will exhibit greatly improved formability.

To date, the low formability issue has limited the use of lightweight Al-Li alloys for large rocket fuel tank dome applications. Manufacturing a dome by stretch forming typically requires multiple panels as well as multiple welding and inspection steps to assemble these panels into a full-scale fuel tank dome. Complex tensile and bending stresses induced during the stretch forming operations of Al-Li alloys have resulted in high rates of failure for this process. To spin form a large rocket dome, the spin blank must be prepared by joining smaller plates together using friction stir welding. However, friction stir welding produces a distinct metallurgical structure inside and around the friction stir weld that makes it very susceptible to cracking during spin forming.



Multipiece dome construction by stretch forming the plate into a gore-shaped panel

Completion of stretch forming the part into gore configuration



Multipiece dome construction by spin forming the circular welded into a dome

APPLICATIONS

The technology has several potential applications:

- Al-Li alloys are used in aerospace for rocket and fuel tank domes and other large panels or extruded structures produced by stretch forming or spin forming. Improving heat treatments for other Al-Li alloys would expand potential applications in aerospace as well as in recreation, transportation, and other industries in which high-strength, lightweight structures are needed.

PUBLICATIONS

Patent No: 9,365,917

Chen, P., & Russell, C. (2012, May 15). Mitigating Abnormal Grain Growth for Friction Stir Welded Al-Li 2195 Spun Formed Domes. NASA Technical Reports.

Martin, P. V., Chen, P., Gorti, S., & Salvail, P. (2014, January 14). Al 2195 T8 Gore Development for SLS Core and Upper Stage. NASA ADO Report.

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