

CASTABLE HIGH-STRENGTH ALLOY FROM ALUMINUM SCRAP

A process for recycling AA7075 scrap enhances prospects for recovering waste material from the aerospace industry.



recycling AA7075, a wrought aluminum alloy commonly used for aircraft components. The process converts AA7075 scrap directly into a high-strength, castable secondary alloy with mechanical properties comparable to premium aluminum casting alloys including those used in the automotive sector.

PROJECT DESCRIPTION

The goal of this 18-month project was to develop a process that allows casting of scrap AA7075 aerospace alloys directly into high-strength products. Wrought products like AA7075 are rolled or otherwise mechanically shaped using energy-intensive thermomechanical processing routes. Cast aluminum, where the melted alloy is poured into a mold, is usually lower in cost and more energy efficient.

Each year, about 700 commercial aircraft retire, joining more than 16,000 planes that are grounded for good.¹ Given that aluminum makes up some 80% of an average aircraft by weight,² the world's decommissioned fleet is a valuable material resource. While most of the aluminum used in industrial markets like autos or buildings is recycled,³ aerospace aluminum remains a relatively untapped resource.⁴

Aerospace aluminum alloys are tough and lightweight, making them desirable for a variety of industrial uses, but they pose significant recycling challenges. Because they are relatively high in alloying elements, most of those elements are retained in the liquid metal during remelting. This limits recovery and recycling options for these alloys to the production of extrusions or rolled sheets, which carry associated embodied-energy costs and in-process material losses. Finally, aerospace alloys are difficult to cast into complex shapes and are susceptible to cracking.

A team from the University of Illinois at Urbana-Champaign (UIUC) and Eck Industries, Inc. (Eck) has developed a new process for

7075 alloys tend to exhibit hot tearing, or the formation of irreversible cracks in the still semi-solid casting. The team set out to mitigate this tendency and enhance the castability of the primary wrought aluminum scrap feedstock through dilution and alloying additions.

First, wrought AA7075 scrap was collected to identify the range of compositions that could serve as feedstock for the cast alloy. Based on that information, UIUC determined the necessary compositional modifications to enhance castability. Second, UIUC conducted CALPHAD simulations to identify the solidification paths of cast alloys and to guide the selection of compositions for small-scale casting trials. Third, UIUC used thermal analysis to evaluate castability and validate the modeling work. Finally, the most promising compositions were selected for pilot-scale casting at Eck and further property enhancement using pulsating electric current melt treatments at Eck. In a pilot-scale casting trial, a composition labeled SN72-M was successfully cast into defect-free automotive cylinder heads.

¹ International Air Transport Association (IATA). Helping Aircraft Decommissioning. <https://www.iata.org/en/programs/environment/aircraft-decommissioning/>. Accessed March 5, 2023.

² The International Aluminium Institute. Aircraft: Bringing the World Closer With Aluminium. <https://transport.world-aluminium.org/modes/aircraft/>. Accessed March 5, 2023.

³ The Aluminum Association. Infinitely Recyclable. <https://www.aluminum.org/Recycling>. Accessed March 5, 2023.

⁴ Zhao, D. et al. Research on Scrap Recycling of Retired Civil Aircraft. 2021 IOP Conf. Ser.: Earth Environ. Sci. 657 012062. doi:10.1088/1755-1315/657/1/012062.



The hot tearing index of scrap AA7075 was reduced from 26 to 4. The developed secondary 7075 alloy also satisfied preset target mechanical properties with strength levels exceeding 250 MPa and elongation levels higher than 3%. The detailed process and results are outlined in the final project report, which is referenced in the Publications section.

PROJECT IMPACT

With thousands of aircraft already decommissioned and at least 11,000 more expected to retire within the next decade,⁵ new technologies are needed to make use of this large and growing source of recoverable aluminum. This project has the potential to recycle 35,000 metric tons of secondary aluminum. By avoiding the need to produce more primary aluminum, energy consumption could be reduced by up to 6.5 petajoules, and carbon-dioxide-equivalent emissions could be reduced by 370,000 metric tons.

NEXT STEPS

The validity of this approach and its readiness for transition to commercial practice was demonstrated by the successful casting of cylinder heads directly from the modified 7075 scrap. The cylinder head castings were free from cracks or internal defects, and their mechanical properties satisfied performance targets.

The modified 7075 scrap alloy has yield strengths superior to commercial alloys with similar casting characteristics and equivalent cost, which will be favorable for broader commercialization after some additional development. Eck plans to continue development to improve the elongation of the alloy while maintaining the yield strength.

⁵ IATA.



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Acknowledgment: "This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Advanced Manufacturing Office Award Number DE-EE0007897."

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PROJECT PARTNERS



Principal Investigator:

Mohamed Aboukhatwa | mkhatwa@illinois.edu



David Weiss

PUBLICATIONS

Aboukhatwa, M.; Weiss, D. *Upcycling of Aerospace Aluminum Scrap*. March 2023. REMADE Circular Economy Tech Summit and Conference, Washington, D.C.

Aboukhatwa, M.; Weiss, D. *Development of a Castable High Strength Secondary Aluminum Alloy from Recycled Wrought Aluminum Scrap: Final Report for REMADE Project: 18-02-MM-09*. August 2021. <https://www.osti.gov/biblio/1872215>. Accessed March 4, 2023.

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EMAIL US AT CONTACT@REMADEINSTITUTE.ORG

OR VISIT US AT REMADEINSTITUTE.ORG