NSF Phase IIB Inconel Superalloy Funding Advances Development

Phase IIB supplemental funding (awarded in October 2018) will enable faster and wider commercial adoption of components from the RAM nickel superalloy composites developed in Phase II. This NSF supplemental funding, paired with funding from investment and commercial sales, will be used towards developing an understanding of the mechanisms that affect performance variability. This will include developing standardized materials production and processing methods based on results analysis. Statistical reliability data will be used in part towards development of AMS specification and MMPDS design allowables. The developed production processes and controls will be evaluated and modified for reliability and the documented processes are necessary for a quality control system and later used towards accreditations such as ISO 9001 and AS9100.

3D printed inconel superalloy test parts using 247 LC as the base material.

3D printed inconel superalloy test parts using René 80 as the base material.

The Phase IIB funding will also enable development of additional applications for new markets including oil and gas. Additionally, the Phase IIB funding will enable development of processing conditions for other commercial AM equipment including larger scale platforms compared to the M290 AM system used for the Phase II development. Therefore, widespread adoption of the newly developed nickel superalloy composite components will be greatly accelerated by the proposed new research and development activities. The development work is encapsulated in a 4-pronged approach comprising development in powder production, statistical reliability, new application development, and extension to other AM platforms.

During NSF Phase I and Phase II work, we have developed RAM technology for high application temperature materials and developed a nickel superalloy MMC for additive manufacturing. In this work, the RAM produced nickel superalloy MMCs has shown reduced microstructural defects including reduced porosity and reduced microcracking compared to the non-MMC base alloy produced by laser powder bed fusion (L-PBF) AM. Mechanical testing found that the IN625-RAM2 specimens exhibited improved performance compared to the base alloy specimens produced by L-PBF AM and also compared to the traditionally processed alloy. The newly developed RAM superalloy MMC exhibited twice the room temperature yield strength of the cold rolled base alloy and had 60% higher yield strength at an operating temperature of 800°C. Even with these significant strength increases, the RAM produced superalloy also exhibited good ductility with room temperature elongations greater than 20% and greater than 40% at 800°C.

With this supplemental funding opportunity we have increased our work on producing nickel superalloy MMC parts from base materials such as 247 LC, René 80, and Inconel 625 and 718. New advanced AM centric designs will also be implemented. This work involves AM centric CAD design at Elementum 3D with collaboration from Frontline Aerospace and process development for printability of these complex designs from our new high operating temperature alloys. Developing suitable designs and materials processing capabilities will include theoretical and modeling approaches in addition to iterative development of designs and processing conditions. This application development is a prohibitive barrier for customers and the NSF TCEP program will enable us to overcome these obstacles to develop a product with commercial partner Frontline Aerospace to address the significant land-based turbine market. If this research is successful, the next steps will be for implementation of the developed product into application trial turbines to evaluate the product performance increase and service life.