Paper ID: 86527

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Manufacturing and industrialization for Launch Vehicle and Space Vehicle Structures and components (High volume production, industrialization, automatization and digitalization) (7)

Author: Dr. Peter Böhlke
KME Germany GmbH, Germany

NOVEL MANUFACTURING APPROACH FOR COPPER-ALLOY MATERIAL USED IN THE MANUFACTURE OF COMBUSTION-FACING THRUST CHAMBER ASSEMBLY COMPONENTS

Abstract

Globally, over 30 reusable launch vehicles are either operational or under active development. As the lifespan of the engines powering these reusable vehicles gets pushed further and further, material choice and manufacturing quality come to the forefront. The endurance of engine components, especially under thermal and mechanical stress, is now critical as operational durations extend from hundreds to thousands of seconds.

The inner liners of the thrust chamber assembly endure the highest thermomechanical loads. The former have the central task of transferring heat to cooling channels and out of the engine's main structure. The variation of material strength with temperature is particularly significant, and fatigue and creep related drop-off is often exacerbated by reuse. Fully-reusable vehicles escalate these challenges, due to the added heat of re-entry, especially in the case of flow-facing propulsive retardation during descent.

In response, the industry is exploring new materials and manufacturing approaches, especially for the critical engine components noted above. Copper alloys have emerged as a leading and cost-effective choice, used by major players in the market. Nevertheless, the manufacturing and quality assurance processes for these copper alloys are still areas of active research, with current production methods often leading to low structural uniformity and high defect rates, impacting fatigue resistance, and leading to material waste.

This paper presents the benefits of a novel, flight-proven manufacturing approach for producing large copper-chromium-zirconium shapes with high uniformity advanced microstructure and minimal defects, suitable for fabricating components for the thrust chamber assembly, like combustion chambers and nozzle liners, and injector plates. This material can undergo comprehensive ultrasonic inspection, ensuring zero material or energy waste in the final production of the copper-based engine components. This method also offers significant improvements over competing conventional processes, which are prone to anomalies that significantly reduce the overall lifespan of the components. The enhanced thermomechanical performance offered by this process to manufacture the most strained parts of a rocket engine is crucial for advancing the reusability of launch vehicles as the industry pushes towards full reusability.