



Contribution ID: 295

Type: **not specified**

Experimental and Constitutive Modeling of ULCF/LCF Behavior in GRCo-42 for Aerospace Applications

Wednesday 2 September 2026 12:30 (15 minutes)

Modern rocket launchers are designed to be reused, which means their parts must withstand many missions in extreme heat and mechanical stress. In these propulsion systems, the materials used in combustion chambers must maintain their structural integrity while also dissipating heat quickly and effectively, especially during the launching phases.

Among the available materials, GRCo-42 has emerged as one of the most promising copper-based alloys, given its excellent thermal conductivity and mechanical performance at elevated temperatures. However, there is still a lack of comprehensive experimental data and reliable computational models capable of accurately describing its cyclic plasticity behaviour, particularly under cyclic loading conditions relevant to service environments.

The aim of this study is to investigate the ultra-low cycle fatigue (ULCF) and low cycle fatigue (LCF) behavior of GRCo-42, with the objective of ensuring a minimum number of successful missions for reusable propulsion systems. The experimental campaign carried out included strain-controlled fatigue tests under different loading conditions and baseline tensile tests, at several temperature levels representative of operational scenarios. The experimental results are used to characterize the material response and identify the damage mechanics parameters governing fatigue life.

In parallel, a constitutive model has been developed and calibrated to reproduce the cyclic plasticity and damage evolution of GRCo-42. The model integrates experimental observations and aims to provide accurate life predictions. The combined experimental-numerical approach allows for a deeper understanding of the material behavior and contributes to the development of more reliable design methodologies.

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Session Classification: Additive Manufacturing

Track Classification: Additive Manufacturing