Low Energy Welding for Ni-Based Superalloy Repair in Aerospace Applications

Pablo D. Enrique *[a], Zhen Jiao [b], Nigel Scotchmer [b], Ehsan Toyserkani [a], Norman Y. Zhou [a]

*Corresponding author: pdenriqu@uwaterloo.ca
[a] University of Waterloo, 200 University Ave W, Waterloo, Ontario, N2L 3G1, Canada.
[b] Huys Industries Ltd., 175 Toryork Drive, Unit 35 Weston, Ontario, M9L 1X9, Canada.

Presentation Abstract

Nickel-based superalloys are widely used in components capable of withstanding extreme conditions, including high temperatures, pressures and stresses. Of interest is a class of nickel-based superalloys known as Inconel, previously used in the Saturn V F-1 engine's thrust chamber and currently used by SpaceX for their engine manifolds, combustion chambers and other components. Fatigue failure is a significant issue in the aerospace industry, especially with the recent trend towards fully reusable vehicles. High material and manufacturing costs make Inconel component repair an attractive option, avoiding the need to scrap parts when defects are detected. However, most welding repair processes introduce considerable heat-affected zones that weaken the base metal and reduce the component's flight reliability.

The Low Energy Welding (LEW) used in this study is a micro-welding process that uses short duration electrical pulses to deposit electrode materials onto conductive substrates. The LEW process offers several advantages in repairing sensitive high-cost components. A relatively low energy input eliminates the presence of heat-affected zones, while achieving depositions with metallurgical bonding and low porosity. A study into LEW repair of traditional and additive manufactured Inconel 718 and 625 is presented, with a focus on deposition quality. Microstructural features of deposited Inconel are investigated, and several mechanical properties of repaired cavities are evaluated to assess the use of LEW for nickel-based superalloy repair in aerospace applications.