Environmental Cracking and Irradiation Resistant Stainless Steel by Additive Manufacturing

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ABSTRACT:

Stress corrosion cracking (SCC) and irradiation damage are two key degradation modes that increase the life cycle cost of the component made of austenitic stainless steel in the nuclear reactor. The failures of the internal components in the reactor also influence the plant reliability and safety, and increase the maintenance cost and the radiation dose on the workers during the repairing operation. In this program, we will demonstrate that the non-equilibrium nanostructure created by the laser melting process can significantly benefit the nuclear specific material properties of 316L stainless steel, such as stress corrosion cracking (SCC) resistance and irradiation resistance. By understanding the relationship between laser process and microstructure, we will be able to tune the microstructure and create a super 316L stainless steel with improved SCC and irradiation resistance during additive manufacturing without changing the material's bulk chemistry. It is generally agreed that additive manufacturing can accelerate the deployment schedule by directly making a near net-shape structure from design. However, the process is usually more costly than the conventional fabrication process which limits its application in nuclear area. The improved 316L stainless steel by laser melting can make additive manufacturing less costly than conventional manufacturing by extending the component service life and eliminating the welding and cladding operation of the advanced alloy on stainless steel component. The same concept can also be easily transferred to other austenitic solid solution nickel based alloys like alloy 600, alloy 690, alloy 800 to further improve their performance.

The program will also fully evaluate the stress corrosion cracking susceptibility, corrosion fatigue, and irradiation resistance of the additively manufactured 316L stainless steel in nuclear environment, which has never been investigated before. Through this program, the team will work with GE Hitachi Nuclear Energy to develop the nuclear material specification for additive manufacturing, lay out a business plan for regulatory approval and commercialization.