MITIGATING STRESS CORROSION CRACKING IN AUSTENITIC STAINLESS-STEEL CANISTER WELDS USING PEENING TECHNIQUES

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ABSTRACT:

We propose to mitigate the possible initiation of pitting/ stress corrosion cracking (SCC) in the dry storage canisters (DSCs) austenitic stainless-steel welds by applying laser shock peening (LSP), shot peening (SP) and ultrasonic impact peening (UIP) as well as indirect laser shock surface patterning methods (LSSP). The main objective of this project is to understand the mechanisms of mitigation of pitting/SCC in stainless DSC welds as affected by the compressive stresses, surface texture and microstructural changes resulting from the proposed techniques.

We will develop austenitic stainless-steel weld surfaces exhibiting compressive stresses and surface texture that will be able to mitigate initiation and propagation of pitting/SCC compared to their as-welded counterparts. First, peening experiments will be carried out. The initial data for the model for predicting the induced compressive strain in the peened surfaces will be generated experimentally through a full factorial design of experiments (DOE), with the two input parameters (peening intensity and peening depth) at three levels. The strain (measured by neutron diffraction method) before and after peening process will be measured and considered in the model. A multiple linear regression analysis will be implemented. The model will provide data on the effects of processing parameters on the residual strain. Peening experiments will be carried out using (DOE) and multiple linear regression analysis recommended parameters.

The peened surfaces will be treated with laser surface patterning method, LSSP. A combination of cellular automata (CA) and finite element method (FEM) will be implemented to simulate the resulting pitting potential (E_{pit}) as affected by the textures generated by LSSP. The model assumes that pitting corrosion can be simplified to an electrochemical corrosion cell. In the model, CA decides the state of the corrosion cells that include the location, size of anode and cathode, and the texture on the anode while the FEM simulates the level of electrochemical activity at a discrete location on the surface represented by E_{pit} potential distribution. The LSSP process parameters resulting in the highest pitting resistance will be used for LSSP experiments.

The peened and surface patterned weld surfaces will be subjected to pitting and SCC experiments. The microstructural changes taking place in the peened and surface patterned samples will be evaluated and related to the pitting and SCC behavior. The peening and surface texture process parameters that resulted in mitigating the pitting/SCC initiation will be recommended for enhancing the reliability of long-term storage and maintenance of DSCs. Successful completion of this proposed research will enable mitigate the pit initiation and SCC growth in the austenitic stainless-steel canister welds by applying peening and surface texture techniques.