Microstructure and mechanism based lifetime predictions in stress relief cracking of SS347 weldment under complex thermomechanical conditions

Zhili Feng and Yanfei Gao, Session II – 2:20pm

Stress relief cracking of 347H stainless steels is a major issue dictating structural integrity and performance of many energy and power industries. Complex synergetic factors affect the generation and evolution of welding residual stress, such as post-weld heat treatment (PWHT), precipitation kinetics, or long-term service (ageing), which in turn controls the lifetime. Various mechanisms have been proposed in the past, but a direct and quantitative connection between laboratory tests and actual lifetime prediction is still lacking. Two critical issues are identified and addressed by our research team. First, a quantitative prediction of welding residual stress is very sensitive to the dynamic strain hardening behavior in the material constitutive law. Characterization of such a property and also non-destructive residual stress measurements by advanced diffraction techniques are needed along this line. Second, a microstructure-based lifetime prediction framework has been developed that simulates the entire processes of intergranular cavity nucleation and growth, together their coalescence into grain boundary cracks. The roles of precipitate kinetics on or near grain boundaries, and stress relaxation due to precipitate-dependent viscoplastic deformation can also be incorporated and quantitatively investigated.

Challenges Obtaining and Implementing Welding Alloys for High Temperature Stainless and Super Nickel Steel Weldments

Bill Newell, Session II – 2:05pm

High temperature stainless and nickel welding alloys inventories are small when compared with low carbon and 300 series stainless steels. This is due to the fact that commercial use is limited and they are typically expensive to manufacture. Many of these special products are being discontinued as a result of mergers, sagging sales, or reallocation of inventory funds. Lead times can be extensive. Planning and early procurement are a must, now more than ever.

It is often challenging to separate alloy versus welding technique issues. High carbon stainless steel can offer similar difficulties as many of the nickel and super nickel alloys. Control of weld metal dilution and weld bead/layer geometry become critical for avoiding cracking and microfissuring. Approaches such as EPRI's Power Ratio methodology to monitor or evaluate whether weld metal is melted and not just remelting previously deposited weld metal or HAZ become important. Dissimilar weldments create even more challenges.

Traditional test coupons and specimens may not provide meaningful results when determining cracking potential, especially on the super nickel alloys. Creative test evaluation schemes that induce fabrication/installation-like stresses encountered in actual components will probably be needed to prevent cracking and microfissuring. Each of these challenging areas will be discussed in brief.