P2 Hardfacing Delamination During Laser Weld Repair: Brittle Phases Revewaled by LOM, EMPA and AEM

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Introduction

As the mainseats in a valve experience wear, the valve's sealing performance may degrade, giving unacceptable leakage rates. When this occurs, the valve seating surfaces must be refinished, repaired, or replaced to restore the desired performance. For typical seating surfaces, repair via arc-based welding processes is often not a viable alternative, due to distortion and cracking that can arise from the thermal energy and stresses involved. Laser beam welding (LBW) was evaluated as a method to repair worn Stellite (CoCrW alloy) surfaces of discs from large gate valves. However, initial trials resulted in the localized delamination of the underlying hardfacing deposit.

Technical Approach & Results

The delamination was initially characterized using optical metallography, which revealed several different phases and constituents in the Stellite and near the Stellite / carbon steel fusion line. The fusion line region was further analyzed using electron probe microanalysis (EPMA) and analytical electron microscopy (AEM). The EPMA characterization included both wavelength dispersive x-ray (WDX) maps and linescans to assess compositional variations near the fusion zone, as well as WDX quantitative spot analyses at several locations within the ~2 micron-thick intermixing zone. The focused ion beam (FIB) technique was used to obtain site-specific specimens for AEM analysis. AEM revealed a complex microstructure which included a martensitic-type phase containing precipitates of a Co-Cr-W-enriched phase (possibly bcc) adjacent to the fusion line and a multiphase region consisting of a bcc Fe-Co-enriched phase with an interconnected Cr-enriched phase located beyond the martensitic phase. The Cr-enriched phase resembled the alpha-prime bcc phase formed during aging in Fe-Cr-Co alloys. Diffraction analysis also indicated that the phase may be body-centered tetragonal, consistent with sigma phase. Both the alpha-prime bcc phase and the sigma phase are associated with hardening and embrittlement.

Conclusions

Microstructural analysis revealed that the delamination occurred within the complex microstructure near the fusion line, apparently related to the interface between a martensitic-type phase and a multi-phase Cr-enriched / Fe-Co-enriched region. The LBW repair induced considerable tensile stresses across the Stellite / carbon steel interface, because of the low heat input and preheat temperatures involved. These stresses caused the delamination of the original Stellite deposit from the carbon steel, which would not have occurred otherwise. Stresses of this magnitude and orientation are not expected during normal service. Therefore this delamination event should pose no concern for in-service component failure.