Poster

Residual stresses determination and analysis in dissimilar rotary friction joints using X-ray diffraction method

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Friction welding is a relatively fast joining process, which occurs in a solid-state manner and is often used due to the possibility of achieving lower residual stresses and distortions [1]. The study presented in this paper focuses on employing the direct drive friction welding process to join SAF 2205 duplex stainless steel and API X52 high strength low alloy material and aims to enhance the performance of this method to attain improved joining properties, particularly in terms of reduced residual stresses. During the process, frictional heat and intense deformations at joining interface, give rise to distinct zones and generate a varied temperature distribution, leading to alteration in microstructure from the interface to the parent metals. Additionally, significant residual stresses (RSs) are induced in different directions, as a result of the process.

Here, we present capabilities and results from the run of RSs measures at the CRTI materials analysis laboratory. The generated stresses were assessed by X-ray diffraction (XRD) procedure without any polishing of the cross sectional surfaces. This method is immensely used to measure the residual stress [2], as it is a non-destructive technique for characterizing crystalline materials and provides information on structures, phases, preferred crystal orientations (texture), and other structural parameters, such as average grain size, crystallinity, strain, and crystal defects [3].

The surface residual stress profiles from side to side of the weld interface (WI) were performed using a 4-circle goniometer from BRUKER Manufacturing Inc. The measurements were made using the conventional $d \sim sin^2\psi$ method, as significant residual shear stress co-exists with normal residual stress. The experiments consider interfacial and through weld RS distributions, on a macroscopic scale i.e. macro-*RS* or σ^I. The RSs were achieved along the axial direction of half rods, using Co-Ka1 radiations and power of 20 kV and 40 mA. The strains in axial direction were considered on the ferritic *(2 2 0)* reflection at the detector angle of $2\theta=123,916°$, with penetration depth of approximately *10-15µm.* The peaks were registered at eighteen ψ tilt angles for $\psi \leq 0°$ and $\psi \geq 0°$. The data were collected for two orthogonal orientations (longitudinal and transverse). The residual stresses were derived from the elastic strain measurements using Young's modulus and Poisson's ratio and the error measures were ± 20 MPa for all data.

The results show relatively high residual stresses with significant deviation across the weld interface due to varying thermal coefficients of expansion/contraction, subsequent from dissimilar metal joints. The process also generates normal and shear residual stresses at the weld interface, with predominantly tensile residual stresses noticed in both longitudinal and transverse directions near the weld line [4]. Particularly high tensile residual stresses ($\sigma 11$) were observed near the bond line on the SAF 2205 DSS side compared to the API X52 side. Analyzing residual stresses, which are highly sensitive parameters influenced by micro/nano-structure, offers valuable insights into the history of materials and structures.

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