INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The accurate assessment of welding-induced residual stress is pivotal due to its detrimental effect on structural stability and mechanical performance of welded structure that can reduce the fatigue life and premature failure of the welded joints. Especially, the thin structure is susceptible to severe distortion and locked-in (residual) stress development due to relatively low stiffness and high heat input during the fusion welding process. In the current research, this takes as a window of opportunity to address all the challenges aiming at the amendment of tensile residual stress in the laser-welded thin structure of Ti6Al4V and SS304 stainless steel, as well as in shielded metal arc welding of thick 9Cr ferritic-martensitic steel. The volumetric dilation and thermodynamic property variation at the fusion zone and heat-affected zone are associated with phase change. The development of residual stresses is substantially governed by the diffusional and non-diffusional phase transformation kinetics and resulting microstructural morphologies. Coarse grain morphology, i.e., thick -lath within coarse prior -grain boundary or lathy -ferrite within austenite matrix, promotes tensile residual stress due to deformation incompatibility around the lamellae interface or due to highly localized stress field caused by heterogeneous microstructure. The present thesis is mainly oriented towards the directions that address the thermal-metallurgical-mechanical interaction to characterize the residual stress in the autogenous laser welding process. Fine -ferrite or acicular -martensitic lath accomplished at optimum heat input or sufficiently high cooling rate attributes less heterogeneity at weld zone microstructure. Hence, it finds a way not only to mitigate residual stress, even changes its nature from tensile to compressive. It is evident that the quantification of transient temperature growth and resulting metallurgical change is exceptionally complicated, and there is an ambiguity to precisely estimate the residual stresses. Hence, the computational model provides flexibility to simulate physical phenomena such as non-uniform temperature distribution, phase fraction, and mechanical response during modeling of the welding process. Thus, a finite element-based thermal-metallurgical-mechanical (TMM) model for the fusion welding process is attempted to develop in the present research work.

Overall, the microstructural morphology is more sensitive to residual stress pattern for Ti-alloy and P91 steels whereas the influence of solid-state phase transformation is minimum for stainless steel weldment. Thus, the developed computational framework not only act as a reliable method for residual stress calculation, but also acts as a directive to reduce tensile residual stress in a weldment which is sensitive to the choice of materials.