Phase Selection Phenomena During Low Alloy Steel Weld Solidification

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Phase selection of nonequilibrium austenite phase at rapid liquid/solid interface velocities instead of equilibrium delta-ferrite in stainless-steel weld is a well-known phenomenon. Although, such transitions are possible even in low-alloy steel weld solidification, experimental observations of such transitions have been very difficult due to subsequent low-temperature solid-state transformation. Recently, transitions from the ferrite to austenite mode of solidification by increasing the liquid-solid interface velocities were measured in Fe-C-Al-Mn spot welds with different aluminum concentrations. The measurements were made through in-situ Synchrotron time-resolved X-ray diffraction investigations. Since spot-welds experience uncontrollable increasing liquid-solid interface velocity, additional laser welding experiments were performed to obtain well-controlled liquid-solid interface velocities. In these welds, the transition from ferrite to austenite phase selection did not occur due to the geometry of the weld pool restricting the liquid-solid interface velocity below a critical level. In this paper, these transitions were evaluated with computational thermodynamic calculations. The calculations showed that the T_o temperature for liquid - ferrite phase equilibria was always higher than that of the T_o temperature for liquid - austenite phase equilibria indicating the improbability of transition from ferrite to austenite mode of solidification. In addition, a multicomponent interface-response function model was used to evaluate the dendrite tip temperature of ferrite and austenite as a function of interface velocity. The calculations showed that the change in ferrite to austenite mode of solidification in these steels could only be predicted by modifying Gibbs Thompson coefficients (Γ) or stability parameter (σ^*). The implication of these results and practical application of these models on prediction of low-alloy steel weld microstructure will be discussed.

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