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Answer the following about this paper

Original submittal? Yes ☒ No☐ Progress report? Yes ☐ No☒ Review paper? Yes ☐ No☒ Tutorial? Yes ☐ No☒
What welding processes are used? FCAW-S, GTAW, LASER
What materials are used? FE-C-AL-MN STEEL
What is the main emphasis of this paper? Process Oriented ☐ Materials Oriented ☒
To what industry segments is this paper most applicable? CONSUMABLE MANUFACTURER
Has material in this paper ever been published or presented previously? Yes ☐ No☒
If "Yes", when and where?

Keywords: Please indicate the top four keywords associated with your research below

NONEQUILIBRIUM SOLIDIFICATION WELD MICROSTRUCTURE MODEL
IN-SITU SYNCHROTRON DIFFRACTION PHASE TRANSFORMATIONS

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Proposed Title (max. 100 characters): Modeling Of Fe-C-Al-Mn Steel Weld Microstructure

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Abstract:

Introduction (100 words or 1000 characters max)

In self-shielded flux cored arc welds containing greater than 1 wt.% aluminum, the final weld microstructures contains a large fraction of delta-ferrite. This microstructure evolution is related to increased phase stability of delta-ferrite. Previous, in-situ time-resolved X-ray diffraction investigations showed that, in the same weld, austenite solidification may occur at high cooling rates. In this research, a coupled thermal, geometrical, solidification and microstructure model was developed to rationalize previously published microstructure evolution results.

Technical Approach, for technical papers only (100 words or 1000 characters max.) Both moving (1 in/min to 100 in/min speed) laser (Nd-Yag) and stationary arc welds were made on a steel cylinder of composition Fe – 0.28C – 0.45 Mn – 3.70 Al – 0.39 Si – 0.01 Ni – 0.004 Ti – 0.003 O – 0.035 N (wt.%). The microstructure evolution was studied with optical microscopy. The phase evolution was predicted using ThermoCalc® software and diffusion controlled transformation models. Thermal cycles were modeled using finite different method. Interface response function models were used to describe the solidification modes.

Results/Discussion (300 words or 5000 characters max.) The moving laser welds did not show a change in solidification mode from equilibriumm ferrite to nonequilibrium austentic solidification. With an increase in welding speed, only a change in dendrite arm spacing was observed. Similar observations were made even in stationary welds with no imposed change in liquid-solid interface velocity. However, stationary welds with an imposed rapid increase in liquid-solid interface velocity led to a transition from equilibrium delta-ferrite to austenite mode of solidification. The above result suggests that the liquid-solid interface velocity in laser welds did not increase above a critical velocity to induce a change in solidification mode. A geometric model for single crystal weld growth was used to evaluate the interface velocities as a function of weld pool geometry. The above analysis was coupled with multicomponent dendrite growth theories to rationalize the observed phase selection phenomena. Additional experiments showed that the above changes in solidification mode were also associated with weld ripples.

Conclusions (100 words or 1000 characters max.) The solidification microstructure evolution in Fe-C-Al-Mn steel welds was described by coupling geometrical model for crystal growth with multicomponent dendrite growth. The analysis shows a complex relation between liquid-solid interface velocities, phase selection phenomena, aluminum and carbon concentrations in these welds. The approaches to use these models will be highlighted.

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