Insights into weld metal hot cracking of austenitic stainless steels: Atomistic characterization of crack surfaces

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Austenitic stainless steels often undergo weld metal hot-cracking as a result of detrimental segregation of elements such as S, P, Nb and Ti. Accurate quantification of these segregating elements is central to comprehend the underlying mechanisms involved in hot-cracking phenomenon. Till now there were no attempts to characterize the hot-crack surfaces at atomistic scale as this partly involves complex crack opening protocols.

In the current scenario, using novel crack-opening methods, we successfully opened weld metal cracks in single and multi-pass ASS welds. In a single-pass weld the crack is located along the center line and has a length of about 20 mm. In case of multi-pass weld a 3 mm long crack is located near the abutting weld-pass interfaces. These opened crack surfaces were later protected with ~ 500 nm Ag deposition prior to SEM, TEM and APT investigations.

The SEM fractographic investigations implied dendritic nature of the crack surfaces, further confirming the observed cracks can be attributed to hot cracks.. The TEM and APT investigations showed 25-33 at. % S segregation at single and multi-pass crack surfaces. The multi-pass crack additionally showed ~ 14 at. % C, 0.4 at. % Nb and 0.4 at. % Ti segregation. All these elements are concluded to be segregated towards the last stages of weld pool solidification and thus caused cracking of interdendritic interfaces. Further, these cracks occurred without phase formation, as possible stoichiometric phases such as M_2S and M_3S are thermodynamically unstable under weld pool conditions. There was no P detected and thus herein P did not contribute to the weld crack formation.