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The influence of shielded metal arc welding (SMAW) inter-pass temperature on the ferrite number of weld joints made on AISI 304H stainless steel

Ngonyoza, Ntsikelelo

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ABSTRACT

The research focused on the influence of welding inter-pass temperature in 304H type austenitic stainless steel weld joints in the as-welded condition. The shielded metal arc welding process was used to weld the joints. The following was evaluated: the theoretical and measured ferrite numbers, solidification mode and delta ferrite morphology, as well as the evolution and precipitation of secondary phases i.e. sigma phase in the weld, chromium carbides in the heat affected zone. After the evaluation, it was clear that the inter-pass temperature had an effect on solute distribution during cooling and subsequent calculated ferrite numbers of the welds. The calculated ferrite numbers, that were determined using the weld metal chemistry of each joint and the WRC-1992 constitution diagram, increased from FN of 1 to FN of 3 with the increase in welding inter-pass temperature from 105°C-100°C and to 195°C-200°C respectively. The measured ferrite number showed no correlation with the increases in interpass temperature. The highest measured ferrite number of 3.8 was obtained when welding at an inter-pass temperature of 135°C – 140°C which was closest to the FN of 5 required minimum, as specified by the SAPREF Refinery, to prevent solidification cracking. No solidification cracking was observed in any of the specimens evaluated in this study even though all the specimens had ferrite contents well below FN 5. This observation supports research that indicates that controlling of the primary solidification mode as delta ferrite is more important a factor in preventing solidification cracking than trying to control the actual ferrite content of the weld metal. The primary solidification mode of the weld was a combination of the austenite-ferrite (AF) to predominantly ferrite-austenite (FA) with the FA solidification mode dominating with the increase in inter-pass temperature. The nature of the carbides formed due to low temperature sensitization in the heat affected zone of the base metal changed with the increase in inter-pass temperature. The precipitated chromium carbides only formed discontinuous carbide networks at the interpass temperature of 195°C-200°C. The transformation of sigma from delta ferrite was not observed in the columnar dendritic and mushy zones of the weld metal. This research revealed the optimum welding inter-pass temperature for welding 304H austenitic stainless steel with 308H electrode to be 135-140°C.