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Unusual Weld Failures of Rotary Compressor during Hydraulic Tests: Analysis revealed Boron Induced Cracking in Fusion Zone

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Abstract : Rotary air compressors in air conditioners are used to suck excessive volume of air from the atmosphere in a small space to provide drive to the components attached to them. Hydraulic test is one of the most important methods to decide the suitability of these components for usage. In the present application, projection welding is used to join the hot rolled steel sheets after forming for manufacturing of air compressors. These sheets belong to two different high strength low alloy (HSLA) steel grades. It was observed that one batch of compressors made of a particular grade was cracking from the weld, whereas those made of another grade were passing the hydraulic tests. Cracking was repeatedly observed from the weld location. A detailed comparative study of the compressors which failed and successfully passed pressure tests has been presented. Location of crack initiation was identified to be the interface of fusion zone/heat affected zone. Shear dimples were observed on the fracture surface confirming the ductile mode of failure. Hardness profile across the weld revealed a sharp rise in hardness in the fusion zone. This was attributed to the presence of untempered martensitic lath in the fusion zone. A sharp metallurgical notch existed at the heat affected zone/fusion zone interface due to transition in microstructure from acicular ferrite and bainite in HAZ to untempered martensite in the fusion zone. In contrast, welds which did not fail during the pressure tests showed a smooth hardness profile with no abnormal rise in hardness in the fusion zone. The bainitic microstructure was observed in the fusion zone of successful welds. This difference in microstructural constituents in the fusion zone was attributed to the presence of a small amount of boron (0.002 wt. %) in the sheets which were cracking. Trace amount of boron is known to substantially increase the hardenability of HSLA steel, and cooling rate during resolidification in the fusion zone is sufficient to form martensite. Post-weld heat treatment was recommended to transform untempered martensite to tempered martensite with lower hardness.

Keywords : compressor, cracking, martensite, weld, boron, hardenability, high strength low alloy steel
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