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Role of residual elements on through-thickness properties of carbon steel plates*

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While the importance of through-thickness ductility in minimizing lamellar tearing during the welding of carbon steel plates is well known, the importance of through-thickness toughness has not yet been fully realized. Examination of several cracked fillet weldments has clearly identified two distinct modes of lamellar tearing, one dependent on ductility and the other on toughness.

Correlations with multiple linear regression techniques were established for through-thickness elongation, reduction of area, fracture strength and toughness with chemistry, inclusion characteristics and microstructure. About 80 cracked weldments and plates were examined and it was found that both inclusion characteristics such as size, thickness and area and chemical characteristics such as Al, Mn, P and Si influence the through-thickness mechanical properties of the plates.

To examine further, the effect of sulphur content, 333 plates from 185 different heats were analysed and tested. The beneficial effect of lower sulphur content (fewer sulphides) on through-thickness elongation, reduction of area, fracture strength and charpy V-notch impact strength was confirmed.

Among the approaches that have been used successfully in the steel industry to lower sulphur content is the treatment of molten steel with rare earth metals (r.e.m.). Comparison of a large number of r.e.m. treated plates with conventional plates has shown the former to be significantly lower in sulphur content and better in through-thickness properties. In addition, because of the lower plasticity of r.e.m. treated inclusions, the through-thickness properties of r.e.m. treated plates were found to be independent of plate thickness, whereas normal plates showed a decrease in these properties with decrease in plate thickness.

Stress rupture tests performed over long times at 400–430 °C showed that r.e.m. additions do not detract from stress rupture strength, minimum creep rate or creep ductility. No sign of any microstructural instability during creep tests run up to 20000 h was noted.

* Extended abstract.