ABSTRACT

Hot cracking is a major problem in arc welding of materials like high strength aluminum alloys, super austenitic stainless steel and nickel alloys. As the name indicates, this type of cracking occurs when the metal is still hot. Methods to control hot cracking are generally based on (i) controlling the mechanical effects like reducing the restraint level and reducing the residual stresses, (ii) controlling the thermal effects like increasing the cooling rate and decreasing the peak temperature and (iii) controlling the metallurgical effects like grain refinement and modifying the mode of solidification.

In this work, an attempt is made to control hot cracking by introducing vibratory treatment during welding. The vibratory treatment is expected to promote grain refinement in the weld metal and hence resist hot cracking. Materials that are generally known for hot cracking like Al-Cu, Al-Mg-Si, Al-Zn-Mg, super austenitic stainless steel and pure nickel are used for validation of this technique. Gas tungsten arc welding (GTAW) is used without filler wire for making test specimens. Hot cracking resistance of these materials is characterized by using Houldcroft test. The extent of grain refinement due to vibratory treatment is determined through micro structural

analysis and X-Ray Diffraction Technique for grain size measurement. Vibratory treatment promotes convective heat transfer which in turn enhances the cooling rate and solidification rate. This also helps in formation of fine grains. Fine grained structure leads to strengthen of metals also. These aspects are related by conducting two other tests, viz, cooling rate measurement and hardness measurement. All the characterization tests are conducted on specimens welded with vibration at different frequencies and without vibration.

From the Houldcroft test, it is found that the vibratory treatment applied during welding of high-strength aluminum alloys AA7075 alloy, AA2014 alloy, AA6061 alloy, AA2024 alloy and super austenitic stainless steel have resulted in a reduction of hot cracking at weld metal. Higher the frequency of the vibratory treatment lower is the level of hot cracking.

Microstructural characterization conducted on welded samples of AA7075 alloy, AA2014 alloy, super austenitic stainless steel and pure nickel show that the vibratory treatment has resulted in grain refinement in the weld metals.

The average grain size of AA6061 alloy and AA2024 alloy are measured by X-Ray Diffraction technique. The grain size of the vibrated specimens is found to be smaller than that of non-vibrated specimens.

Weld cooling rates were observed by using an infrared thermometer for the welded specimens of AA2014 alloy, AA6061 alloy and AA2024 alloy. The cooling rate is found to be higher in case of vibratory treatment samples compared to the non-vibrated samples.

The weld metal hardness is measured for high strength aluminum alloys, super austenitic stainless steel and pure nickel by using Vickers hardness test. The weld metal hardness values have improved due to vibratory treatment.