ABSTRACT

Super Austenitic Stainless Steel (SASS) is a group of iron-base alloys that contain chromium (Cr), nickel (Ni), molybdenum (Mo) and nitrogen (N) and have a purely stable austenitic structure. The demands of these alloys for use in various naval and petrochemical applications have been increasing, especially in the last decade, because of their excellent pitting and crevice corrosion resistances at elevated temperatures as well as in harsh environments. Generally SASS contain 19-28 wt % Cr , 17-24 wt % Ni, 4-8 wt % Mo and 0.2 -0.5 wt% N.

These steels have the dual advantages of excellent mechanical properties and very good corrosion resistance, especially in chloride media. The excellent pitting and crevice resistance in these alloys is due to the higher alloying additions of Cr, Mo and N. Pitting ability is quantified by Pitting Resistance Equivalent Number (PREN) and higher proportion of these elements increase PREN, it is denoted as, PREN = % Cr + 3.3 (%Mo) + 30 (%N).

It is generally assumed that PREN values above 40 improve pitting resistance. Given the large amount of alloying additions, it is not surprising that extended use at elevated temperatures results in precipitation of a number of second phases, including carbides, nitrides and intermetallic phases. The most commonly observed secondary phases include $M_{23}C_6$ carbide, and intermetallic phases like sigma, chi and Laves.

Present research work consists of two parts. In the first part, six SASS alloys with different Cr, Mo, Ni and N contents were produced using an air induction melting furnace under normal atmospheric condition. The effect of alloying elements on nitrogen solubility in SASS was studied experimentally. All the as-cast alloys were characterized for micro structure and hardness. All the cast alloys were subjected to solution-annealing at 1250^{o}C for 3 hours to eliminate the in-homogeneities present in the microstructure. The solution heat treated cast alloys were characterized for microstructure, hardness, elemental analysis of precipitates and phases (EDS analysis), tensile properties, impact toughness, fractography of fractured tensile and impact samples and for corrosion resistance.

The microstructures of alloys 1, 2, 3 and 4 in the solution-annealed condition contain austenite with more volume fraction of sigma phase.. This can be attributed to the inappropriate chemistry caused by the increased Mo content without the appropriate increase in Ni and N contents. The alloy 5 and alloy 6 shows fully austenitic structure in the same solution-annealed condition due to the increased amount of nitrogen content.

Of the six alloys tested, the alloy 6 has better mechanical properties, particularly, yields strength (450-550 MPa), impact toughness (180-210 J) and elongation (35-42 %). This result is attributed to the presence of higher amount of nitrogen content. Similarly, the pitting resistance measured by corrosion rate millions of penetration per year (mpy) and Critical Pitting Temperature (CPT) of alloy 6 in 3.5 % NaCl solution is found to be much superior than the alloys 1, 2, 3, 4, 5. This increased pitting resistance of alloy 6 is attributed to the presence of high nitrogen content and homogenous austenitic phase.

In the second part of the study, one of the six heat treated cast SASS (0.44 wt % N) was subjected to welding by SMAW process with E316L and ENiCrMo-3 electrodes and by GTAW process with autogenous and ERNiCrMo-3 filler metal using at different welding parameters. The welded samples were characterized for microstructure, hardness and corrosion resistance. In the case of welding with SMAW process, ENiCrMo-3 electrode was found to be better in terms of microstructures and pitting corrosion resistance. In the case of GTAW process, using ERNiCrMo-3 filler metal was found to be better than autogenous process in terms of microstructures and pitting corrosion resistance.