CHAPTER-1

INTRODUCTION

Copper–nickel (Cu–Ni) alloys are widely accepted materials for application in marine and chemical environments for ship and boat hulls, desalination plants, heat exchange equipment, seawater and hydraulic pipelines, oil rigs and platforms, fish farming cages, seawater intake screens etc. because of their superior corrosion resistance [Agarwal D. C et al.(2009) and Aida Varea et al.(2012)]. However, this material also has been reported to have failed well before their expected lifetime (Agarwal D.C et al. 2002). Investigations had revealed that a majority of these failures occurred when the pipes in question were subjected to widely varying fluid flow rates and were exposed to polluted seawaters.

Gas Tungsten Arc welding (GTAW) process techniques are Continuous Current (CC) and Pulsed Current (PC). CC GTAW processes are very often used for welding of Cu-Ni alloys in ship building industries. However, distortion, porosity and cracking are the major problems in CC GTAW of Cu-Ni alloy welds. It offers high heat energy required to melt the base material and this excessive heat input imposes the problems such as melt through, distortion etc.

Therefore, to produce high quality weldments, PC GTAW is preferred over CC GTAW. Presently, PC GTAW process is one of the most well established processes which can not only weld all metals of industrial use but also produces the best quality welds amongst the CC GTAW processes. In PC GTAW process, the current is supplied in pulses rather than at a constant magnitude. A typical variation of welding current with time is shown in Fig. 1.1. The aim of pulsing is mainly to achieve maximum penetration without excessive heat build-up, by using the high current pulses to penetrate deeply and then allowing the weld pool to dissipate some of the heat during relatively longer arc period at a low current [Y.L. Liu et al. (1997), R. Manti et al. (2007)].
Distortion, porosity and cracking can be controlled in pulsed current GTAW process. Earlier investigations frequently reported on metallurgical advantages of Pulsed Current Gas Tungsten Arc Welding (PC GTAW) of aluminum alloys, mild steel, stainless steel, titanium alloys and magnesium alloys in the literature includes grain refinement in the fusion zone, reduced width of HAZ, less distortion, control of segregation, reduced hot cracking sensitivity and reduced residual stresses which often results in the superior mechanical properties such as hardness and tensile strength and corrosion resistance than the CC GTAW welds [Kumar. A et al. (2009), Rajesh Manti et al. (2008), Kishore Babu N et al. (2007), Madhusudhan Reddy G et al. (1998), Madusudhan Reddy G et al. (1997), Kou S et al. (1986), Tseng CF et al. (1971)]

The purpose of the present investigation is to optimize the pulsed current GTA welding (PC GTAW) process parameters for increasing the mechanical properties using Taguchi method. Taguchi method is a systematic approach to design and analyze experiments for improving the quality characteristics. Taguchi method [Kumar A et al. (2006), Ross PJ (1998), Montgomery Douglas C (1997)] permits evaluation of the effects of individual parameters independent of other parameters and interactions on the identified quality characteristics, i.e. Ultimate Tensile Strength, Yield Strength, Hardness, etc. Nowadays, Taguchi method has become a practical tool for improving the quality of the output without increasing the cost of experimentation by reducing the number of experiments.
From the earlier investigations, there was no thorough study reported so far on the use of the influence of pulse parameters of GTAW on microstructure and mechanical properties (Hardness, Tensile Strength) of Cu-Ni alloy weldment. Therefore, an attempt has been made to investigate the influence of the pulse parameters such as pulse frequency, peak current, base current and welding speed on the microstructure and microhardness of 90/10 & 70/30 Cupronickel alloy weld joints produced by PC GTAW.

Mechanical properties of the alloy welds are largely governed by its microstructural characteristics apart from the mechanical constraints. The microstructure includes types of phases, their relative amounts and distribution besides grain structure. The grain structure of the weld metal shows the size, shape and the distribution of phases in the alloy.

The microstructures characterisations are carried out by an optical microscopy (OM) and a scanning electron microscopy (SEM). Tensile fracture structures are observed by using Scanning Electron microscope (SEM).

In addition to the above, LASER Beam Welding (LBW) has also been used for conducting the experiments at various welding speeds on 90/10 and 70/30 Cu-Ni alloy welds for further improvement in mechanical properties (Hardness, Tensile Strength) of the weld joints. CO₂ laser beam welding with a continuous wave is a high energy density and low heat input process.

Earlier reports explained on the effect of CO₂ Laser beam welding (LBW) joints other than Cupronickel (Cu-Ni) alloy welds such as magnesium alloys, titanium alloys, stainless steel alloy, aluminum alloys, and nickel alloys, welding process parameter such as welding speed exhibited superior in mechanical properties. It reported an improvement in mechanical properties and microstructures by using different laser welding speeds [Phanikumar. G et al. (2005), El-Batahgy A et al. (2009), Lakshminarayanan A. K. et al. (2009), Seyed Mahdi Hamidinejad et al. (20120, Mohammad M. Hailat et al. (2012) and Santillan Esquivel. A et al. (2012)]
There was no evidence observed from the earlier investigations on the use of LBW for joining Cupronickel (Cu-Ni) alloys.

Finally, an attempt has been made for finding out pitting and corrosion resistance for CC GTAW, PC GTAW, & LBW of 90/10 & 70/30 Cu-Ni welds. Dynamic polarisation testing was done to determine the pitting corrosion resistance of the Cupronickel (Cu-Ni) alloy welds. Specimens exhibiting relatively more positive corrosion potential Ecorr (or less negative potentials) were considered to have better pitting corrosion resistance [Venugopal A et al. (2012)].

This thesis is structured as follows:

Chapter-2 deals with a comprehensive study of the literature on Cupronickel alloys, GTAW of Cupronickel alloys, CC GTAW, PC GTAW and LBW on other alloys such as aluminum alloys, mild steel, stainless steel, titanium alloys and magnesium alloys, Optimisation of welding parameters by Taguchi method and pitting corrosion.

Chapter-3 deals with objective and scope of work.

Chapter-4 deals with details of experimentation works of CC GTAW, PC GTAW and LBW of 90/10 and 70/30 Cu-Ni alloys welds.

Chapter-5 deals with results and discussions.

Chapter-6 deals with the conclusions drawn from the present work and scope for future work.