ABSTRACT

Presently, welding of 90/10 and 70/30 Cu-Ni alloys in ship building industries can be performed adequately only by GTAW which uses ER Cu-Ni 70/30 filler wire. Earlier investigations explained on CC GTAW of 70º-80º single V butt 90/10 Cu-Ni alloys welds revealed excessive grain size in FZ & HAZ. This large grain size tends to promote ductility-dip cracking, distortion, hot cracking sensitivity, increase in width of HAZ and residual stresses. Because of the above mentioned problems, CC GATW of Cupronickel alloy welds exhibits inferior mechanical properties.

The objective of the present work is to investigate the effects of the various welding parameters on the welding quality of PC GTAW of 90/10 & 70/30 Cu-Ni alloy welds and to obtain the optimal sets of welding parameters so that the quality of welding can be enhanced.

In this, firstly investigation on CC GTAW and PC GTAW of 90/10 & 70/30 Cu-Ni alloy welds with same filler wire ERCu-Ni (70/30) is made use for both the welding techniques and alloys. Identification of PC GTAW process parameters such as Peak Current (PC), Base Current(BC), Pulse frequency(PF) & Welding speed(WS) and considering four levels from each welding parameter such as 200A,210A,220A,& 230A for PC, 95A,105A,115A, & 125A for BC, 0.5Hz,1Hz,3Hz,& 5Hz for PF and 140 mm/min,150 mm/min,160 mm/min, & 170 mm/min for WS. 

Taguchi’s method of approach to design of experiment has been used during optimization of selected parameters & levels for predicting the ultimate tensile strength (UTS) of the PC GTAW joints at 95% confidence level. Analysis of variance (ANOVA) conformation test was carried out for analysing the predicted ultimate tensile strength values obtained from Taguchi method with that of the experimental values of PC GTAW of 90/10 and 70/30 Cu-Ni alloy welds. Experiments were conducted to observe the influence of PC GTAW process parameters on mechanical properties and microstructures of 90/10 and 70/30 Cu-Ni alloy welds.
In addition to the above, LASER Beam Welding (LBW) was also used for conducting the experiments at various welding speeds (1 m/min, 1.5 m/min, 2 m/min, & 2.5 m/min) on 90/10 and 70/30 Cu-Ni alloy welds for further improvement in mechanical properties (tensile strength and hardness) of the weld joints. Finally, an attempt had been made for finding out pitting and corrosion resistance for CC GTAW, PC GTAW, & LBW of 90/10 & 70/30 Cu-Ni welds.

This investigation has proved that it is feasible to develop strength of 90/10 and 70/30 Cu-Ni alloy welds by PC GTAW process with ERCu-Ni 70/30 filler wire in order to get virtually double welding production in the shipyard. Initial results showed an improvement in mechanical properties of 90/10 and 70/30 Cu-Ni alloy welds with ERCu-Ni 70/30 filler wire by PC GTAW. No cracks were observed either in the weld metal or in HAZ of the PC GTAW of 90/10 and 70/30 Cu-Ni alloy welds. Chemical compositions of undiluted weld metal were present much within the CC GTAW joints that results porosity and spatter. Although transverse-to-weld tensile specimens failed in the weld metal; the fractures always exhibited ductile-dimpled micro void coalescence.

PC GTAW of 90/10 & 70/30 Cu-Ni alloy welds exhibited good strength compared to CC GTAW and therefore PC GTAW technique can be implemented in Ship building works.

In addition to PCGTAW, LASER Beam Welding (LBW) experiments were conducted at various welding speeds (1 m/min, 1.5 m/min, 2 m/min, & 2.5 m/min) on 90/10 and 70/30 Cu-Ni alloy welds and found an improvement in mechanical properties (tensile strength and hardness).

The tensile strength values of LBW joints of 90/10 Cu-Ni alloy welds were less than PC GTAW joints but the difference in values were minute because copper cannot be melted easily by LBW because of its high reflectivity & high thermal conductivity and %age of copper is 20% more when compared to that of 70/30 Cu-Ni alloy.
LBW of 70/30 Cu-Ni alloy welds exhibited better mechanical properties than PC GTAW joints. Economically the cost of LBW is more than PC GTAW. So, PC GTAW was mostly preferred for welding of both 90/10 and 70/30 Cu-Ni alloy welds. If 70/30 Cu-Ni alloy welds are particular about the tensile strength, in such case LBW is preferred.

From the earlier investigations, there was no thorough study reported so far on the use of PC GTAW & LBW for joining 90/10 & 70/30 Cu-Ni alloy welds. Tensile strength of Base Metal (BM) has exhibited superior mechanical properties than CC GTAW, PC GTAW & LBW joints.

CC GTAW, PC GTAW & LBW joints of dimensions (100 mm length x 30 mm width x 5 mm thk.) were bent an angle of 180º through bend test namely root bend and face bend. There was no cracking observed, irrespective of whether the weld face was on the compression side or on the tension side.

Finally, dynamic polarisation testing was done to determine the pitting corrosion resistance of the welds. All pitting corrosion experiments were conducted in aerated 3.5% NaCl solution and the exposure area of FZ for these experiments is 1 cm². Specimens exhibiting relatively more positive corrosion potential Ecorr (or less negative potentials) were considered to have better pitting corrosion resistance. Pitting corrosion resistance of LBW of 90/10 & 70/30 Cu-Ni alloy welds were comparatively higher than CC GTAW & PC GTAW joints.

Microstructures, tensile fractures, & pitting corrosion structures were observed using both optical microscope and Scanning Electron microscope (SEM).