Seminar

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Institute for Plasma Research

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Title: Joining of thick Cu plate using Hot Wire Gas Tungsten Arc Welding

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Abstract

Cu is the oldest metal known the civilization to mankind, and the contribution of Cu to the development of various systems is tremendous, Cu is widely used in industries. The applications of Cu are due to its properties, ductility, moderate strength, thermal and electrical conductivities. It is widely used for heat-exchanging units, providing adequate cooling. Because of the excellent thermal conductivity, Cu is very effective in fusion reactors. Due to the plasma generation, an extreme amount of heat is generated, which needs to be dissipated quickly. Cu provides the optimum solution for the specific application due to its thermal conductivity. A specific application of the Cu for this talk is in the International Thermonuclear Experimental Reactor, in which the hydraulic grid was designed to take away the heat in the Diagnostic Neutral Beam. The hydraulic grid was designed in which the Material of Construction is pure Cu having 15 mm thickness. The most stringent requirement of this work was obtaining 90 % joint efficiency. Considering this application of Cu, today's talk is on the efforts which were made to develop the Cu welding procedure using Hot wire GTAW.

During this development, based on the literature it was concluded that there was not much literature (research articles) available on the welding of Cu using Gas Tungsten Arc Welding (GTAW). Considering this fact, the experiment campaign started with the bead-onplate configuration, autogenous mode, and with the varying filler wire parameters, and composition of the shielding gas. After the bead-on-plate experiments, groove welding procedures were developed for 6 mm, 12 mm, and 15 mm thick electrolytic tough pitch and oxygen-free Cu. However, the increment in the thickness of the Cu was gradual which started from 6 mm thick Cu, then 12 mm thick Cu, and at the end, 15 mm thick Cu was joined using a hot wire GTAW process. 6 mm thick Cu weld joint was tested with two different cross head travel speeds, i.e., 0.5 mm/min and 2 mm/min. 12 mm thick Cu joined with 100 % He, 60 % He – 40 % Ar, and with V groove and U groove configuration. However, despite studying various parameters for improving joint efficiency, it was limited between 75 % to 82 %. To increase the joint efficiency further, feasibility experiments were performed using 12 mm thick Cu in which "Cold Stretching" was introduced which provided 90 % joint efficiency. This revised procedure (including the cold stretching) was implemented for the 15 mm thick oxygen-free copper, during the testing 202 N/mm2 tensile strength was obtained against the base metal tensile strength of 221 N/mm^2 . The side bend test also got cleared, and the weld joint was further characterized for

the metallurgical structure. Not only 15 mm thick weld joints but all the weld joints starting from bead-on-plate to all groove weld joints characterized for the metallurgical structure using optical microscopy, scanning electron microscopy, and energy dispersive X-ray spectroscopy, optical emission spectroscopy also involved for the crosssection of the weld joint. During the metallurgical characterization of the weld joints, the grain coarsening was observed in the Heat Affected Zones (HAZs) of all the welds, and the weld region was also noticed with coarsening in the welds which performed autogenously. Obtained microstructure of the welds was mostly cellular/columnar with epitaxial solidification, however, in a 15 mm thick Cu weld joint equiaxed dendrites were noticed along with a few deformed regions in the weld and HAZ. In the groove comparison study, the U groove weld had a larger HAZ region and thin fusion line, unlike the V groove in which a small HAZ and thick fusion line were observed which produced better properties over the U groove joint. Apart from the morphology, Ni segregation (coring) was also observed during the optical microscopy and energy-dispersive X-ray spectroscopy, quite a good amount of dilution was also observed which made the fusion line stronger.

A major outcome of this work was obtaining 90 % joint efficiency for the Cu weld joint using Hot Wire GTAW. In this talk, these experiments along with their testing and characterization are discussed.

Keywords:
Cu welding, Hot Wire GTAW, 6 mm, 12 mm, 15 mm thick Cu, Cold Stretching, Joint Efficiency.
