GTAW WELDS OF TITANIUM ALLOYS

A NOVEL STUDY OF MICROSTRUCTURES

This poster won the second prize in the 2004 Jacquet-Lucas Photomicrograph Competition sponsored by the International Metallographic Society, an Affiliate Society of ASM International.

G. Venkataraman
Consultant to Thermax, Babcock and Wilcox Ltd. Pune, India.

Gas tungsten arc welding (GTAW) is the method of choice to fabricate titanium alloy sheets. To measure the transverse tensile strength and bend ductility of welded sheet, trial test plates of 2 to 3 mm thickness are made with the weld at the root of the bend. The cut section microstructure is evaluated to find prior beta grain size and martensite, as well as other features.

The specimens were welded under pure argon gas shielding at the trailing edge, as well as at the bottom side, under an argon gas hood. Matching filler metal wire was used for each titanium alloy. Based upon detailed studies of many titanium alloys, it is well known that prior beta grain size and transformed martensite control strength and ductility. Microstructural preparation of each section takes a long cycle time and delays the work.

New method

To overcome the difficulty of long cycle times for microstructure studies, color tinting of a bright and shiny single pass weld bead was contemplated for seeing the structure of the top surface. The bead was tinted by heating the top bead with an oxy-acetylene torch at a temperature of about 873 to 973K (600 to 700°C, 1100 to 1300°F) for 10 to 15 seconds. The surface temperature was monitored by an infrared sensor with digital temperature readout immediately after heating, and it was controlled to provide the ideal blue or purple contrast, as shown in Fig. 1.

One major difficulty is how to handle long plates with curved surfaces on the microscope stage, because the shape leads to partial focus and sudden, jerky shifts. This was overcome by machining a novel spherical seat assembly made

---

**Fig. 1** — Test plates of GTAW of Ti alloy samples after single-bead welding. Oxide color tinting was done at 873 to 973K (600 to 700°C, 1100 to 1300°F) for 10 to 15 sec to reveal surface microstructure.

**Fig. 2** — Titanium sheet showing ripples of heat flow, H. A well-defined prior beta grain boundary B is visible.

**Fig. 3** — The structure of Ti-3Al-2.5V showing prior beta grains and bands of martensically transformed alpha with deep color contrast in some locations.
of Al 7075 alloy. The assembly was 20 cm diameter, and it was capable of universal tilting and rotation of the specimen. The assembly was fitted to the top stage of the DIC microscope Zeiss Axiovert 100. The stage can handle samples weighing up to 3 kg and lengths up to 30 cm. Focusing is easy at 50X to 200X magnification.

**Study results**

GTAW microstructures are shown after color tinting various titanium alloys in Fig. 2 to Fig. 8. In pure titanium, mainly prior beta grains are seen. In other alpha-beta titanium alloys, complex and interesting microstructures are observed, as shown Fig. 3 to Fig. 8. It has been found that there is a reasonable agreement in prior beta grain size between this new method and conventional section metallography. The comparison is also reasonable for the observation of martensite.

The new method of oxide tinting of a shiny weld bead of titanium, and examination under a microscope with a newly developed sample stage having universal tilting and rotation, yielded good results in revealing the microstructure in a very short time for quality control of weld beads.

**For more information:** Dr. G. Venkataraman, Consultant to Thermax, Babcock and Wilcox Ltd., Pune, India; e-mail: drgv@satyam.net.in.

**Reference**