AMC

AMERICAN METALCASTING CONSORTIUM

WELDING OF CAST PRECIPITATION HARDENED STAINLESS STEELS

Lehigh University, through the American Metalcasting Consortium's (AMC's) Casting Solutions for Readiness program, has developed welding procedures that retain the strength of welds as closely as possible to the base metal level. Precipitation hardened stainless steels 17-4 and 13-8+ Mo are used in applications that require high strength and moderate corrosion resistance. Figure 1 is an example of a 17-4 PH stainless steel casting. The mechanical properties of these alloys are controlled by the strengthening precipitates. The high temperature during welding dissolves these precipitates causing a decrease in strength. A post weld heat treatment (PWHT) is needed to restore the mechanical properties; however, PWHTs are expensive and cannot always be applied in the field. The objectives of this research project were to: 1) develop effective PWHT schedules and 2) evaluate if controlled, multi-pass welding procedures could be developed to reform strengthening precipitates that dissolve during welding for use when PWHTs are not possible.

Figure 1

SUCCESS STORY

Problem: 17-4 and 13-8+ Mo stainless steel alloys exhibit a significant reduction in strength due to the heat from welding. Effective PWHT schedules and optimized welding procedures, used when PWHTs cannot be done in the field, are needed for optimizing strength.

Solution: Lehigh University developed effective PWHT schedules and a multi-pass welding procedure to improve the strength of welds without using a PWHT by restoring the strengthening precipitates that dissolved during the primary welding thermal cycle using the heat from subsequent weld passes. Figure 2 shows an etched cross-section of a multi-pass weld and illustrates each weld pass and subsequent heat affected zones. The hardness map is overlaid on the micrograph in Figure 3.

Figure 2

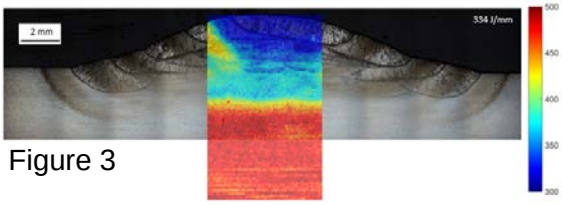

Figure 3

Benefit: Without controlled PWHT schedules, the strength in the weld area of these alloys is only slightly over 70% of the base metal strength. With the developed welding sequence and PWHT schedules, weld strengths over 90% of the base metal strength were achieved with a simultaneous reduction in the number of fabrication steps. For cases where a PWHT is not possible, heat input ranges were identified that produced a 20% increase in strength relative to uncontrolled weld heat inputs.

"Optimized welding procedures, including cases where PWHT cannot be done, are critical in improving performance and manufacturability of these precipitation hardening stainless steel castings."
Jim Myers, Technical Director, MetalTek International – Wisconsin Investcast Division.

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