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EFFECT OF HEAT TREATMENT ON THE SENSITIZATION BEHAVIOR OF AUSTENITIC STAINLESS STEEL WELDED JOINT

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Abstract : The aim of this work is to study Sensitization Behavior of AISI 304L stainless steel with varying normalization time. Yield strength, Ultimate tensile strength, percentage of elongation and toughness across the weld has been reported. The tensile and impact properties of the welded joints have been evaluated using Electro mechanical controlled Universal Testing Machine and Pendulum type Impact Testing Machine. The microstructures of the sensitized samples, are analyzed using an optical microscopy. From this investigation, the following important results are derived: The yield strength, tensile strength, and impact toughness of austenitic stainless steel remarkably decreased as the temperature was increased. The microstructures of sensitized samples indicate that carbide precipitation increases with increasing time and normalization temperature; elements treated at 850°C with a 2 h holding time and then cooled in air are the most sensitized.

Key words: Non-destructive technique, microstructure, sensitization, Hardness.

I. INTRODUCTION

Sensitization refers to the breakdown in corrosion resistance due to depletion of chromium by the formation, growth, and precipitation of chromium rich carbide particles in the grain boundaries where the steel encounters temperatures in the range of about 450 °C to around 850 °C, most notably in the HAZ of a weld. In addition to the loss in corrosion resistance due to chromium depletion, weld sensitization also causes a loss of fracture toughness due to the fracture path provided by the complex carbides within and along HAZ grain boundaries. [1] Typically, the Cr carbide is Cr-enriched M23C6, in which M represents Cr and some small amount of Fe. Within the sensitization temperature range carbon atoms rapidly diffuse to grain boundaries, where they combine with Cr to form Cr carbide. Because of Cr carbide precipitation at the grain boundary, the areas adjacent to the grain boundary are depleted of Cr. These areas become anodic to the rest of the grain and hence are preferentially attacked in corrosive media, resulting in intergranular corrosion. It was also observed that deformation prior to welding or strain during cooling can enhance sensitization, this is perhaps due to the fact that dislocations can increase the carbide nucleation rate and the diffusion rate. [2] The sensitization below the sensitization temperature range is termed low temperature sensitization (LTS). The pre-existing tiny carbide particles were observed to grow in size when failed components were investigated, this was accompanied by severe chromium depletion from adjacent grain boundaries. [3]

1. MATERIALS AND METHODS

The material used in this study was austenitic stainless steel AISI 304L. Nine Plates of 5 mm thickness and dimensions of 250 mm (length) × 125 mm (width) was used for the gas tungstan arc welding process and the filler was 304L SS electrode of 3.0 mm diameter. **Table 1** shows the chemical composition of the base and the filler material used.

Table 1 Chemical composition of the base metal and the filler electrode (in wt. %) used in these investigations.

	C	Mn	Si	Cr	Ni	P	S	Mo
Base metal (304L)	0.02	1.10	0.40	17.00	8.0	-	-	-
Filler-electrode (304L)	0.02	1.2	0.9	18.0	9	0.03	0.02	0.65

2.1. Welding procedure.

Before start welding, the material was cleaned to remove rust, dust, oil, moisture etc. During welding the welding current and welding speed were varied to obtain different heat inputs and one end of the plate was fixed. The welding current which is used in this study was varied from 120A to 200A and the voltage was kept at approx 30V.

2.2. Sensitization treatment.

After compared the tensile strength, impact strength, micro hardness samples welded at lowest heat input was found to be the best among all the welded samples and base metal. Therefore, 210 A current was selected for sensitization studies. One sample of SS 304L, 250 mm long, 500 mm wide and 6 mm thick was prepared by using same parameters and procedure as mentioned above. 4

set of samples were extracted from the welded plate and sensitized by heat treatment (normalization) by varying the soaking time. Temperatures used for normalization are 850^{0}C. The soaking times for normalization are 1/2hour, 1 hour, 2 hours and 4 hours. Heat treatment was done in muffle furnace, all the 4 specimens (4 tensile specimens + 4 specimens for microstructure and microhardness+4 specimens for impact) taken from a plate welded at 210A and normalized by heat treatment.

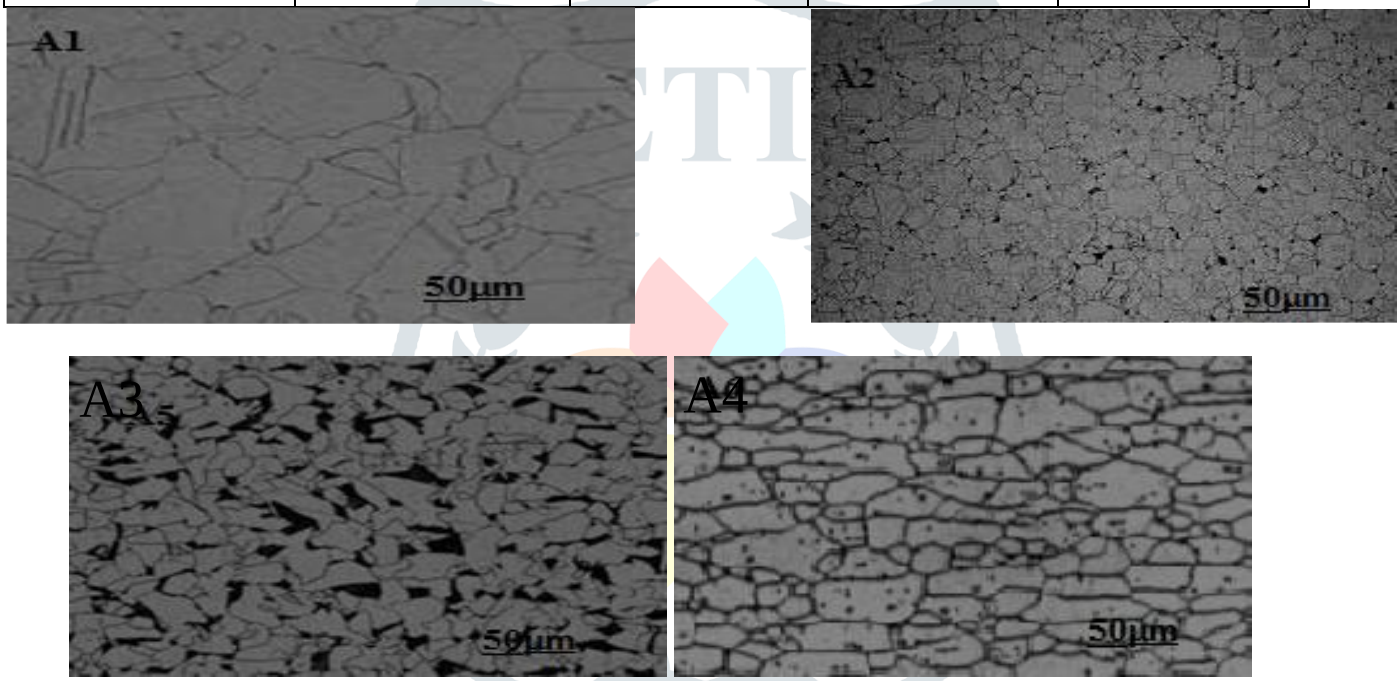
3. RESULTS AND DISCUSSION

3.1 Metallographic studies of specimen normalizing at 850^{0}C.

Figs **1(a-d)** shows the optical photographs of the specimen's heat treated at 850^{0}C and held at the soaking time for 1/2hr, 1hr and 2hr respectively. Chromium depleted zones could be seen here but increases when shocking time increased. Tensile strength and impact strength had decreased when temperature and normalizing time increased but hardness is increased. **Table 2** shows the Macro and microstructural details of the weld joints normalizing at 850^{0}C.

Table 2 Macro and microstructural details of the weld joints normalizing at 850^{0}C.

Description	Tensile Strength Mpa	Yield Strength Mpa	Micro hardness HV	Impact strength KJ/mm^2
Base metal	787.4	453.5	253	1.6
850^0 C for 30 min.	700.63	463.56	255	2.6
850^{0}C for 1 hour.	636.711	452.63	260	2.5
850^{0}C for 2 hour.	622.04	462.15	262	1.9



Figures 1. (a) Optical photograph showing the microstructure of Sample as Received condition (b) heated to 850 ^{0}C held for 30mins, (c) Sample heated to 850 ^{0}C held for 1hr, (d) Sample heated to 850 ^{0}C held for 2hrs.

4. CONCLUSION

The following conclusions can be drawn from the present work:-

SS 304L was observed to go into Sensitization when heated at 850^0 C for 30, 60 and 120 minutes. All the three welds showed good joint strength but best results were achieved under condition of lowest heat input. Tensile strength was found to be decreases with increasing normalization time and temperature. With increasing normalization time hardness increased but impact strength decreases.

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