Investigation of Process Parameters on Welding in Boiler Coils

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Abstract - The super heater coil's function is to transfer heat from flue gases to pressurised steam, which has a wide temperature range. Different materials are used to lessen the damage caused by the super heater coil's temperature variation while it is in operation. If the two materials' melting points differ and the welding parameters have an impact on the quality of the weld, it is not feasible to create a fusion weld using dissimilar material welding. Thus, austenitic stainless steel (AISI304) is used in this study to alloy steels (SA213T11).Tungsten inert gas (TIG) welding is carried out under various welding conditions when working with dissimilar materials. Study is done on the mechanical characteristics of similar and dissimilar metal welding.Additionally, proper welding parameters are crucial for improving weld geometry, where the Taguchi algorithm is used to determine the ideal weld condition.

Key word: Welding, Taguchi Algorithm

I. INTRODUCTION

Since their primary purpose is to provide heat transfer between the hot flue gas and the pressurised steam that is carried within them, the super heater coil is engaged to convert saturated steam into super heated steam and operate in the creep range. The choice of material is determined by combining sufficient corrosion resistance to flue gas and steam with ease of fabrication, especially in terms of welding [1]. These coils are typically constructed from alloy steel, such as SA213 T11, which has poor creep strength, poor corrosion resistance, and an inability to tolerate prolonged high temperatures needed to address the aforementioned issue. To propose this super heated coils, an alternative material like AISI 304 is tried. Carbon steels can withstand metal temperatures of up to 450°C and are both cost-effective and suitable. Low alloy steels like SA213 T11, which can withstand metal temperatures of up to 540°C, are used to make the super heater coils. With the increase in steam pressure and the need for dissimilar materials, SA213 T11 steel has been widely used for primary super heater operations at a temperature of 540°C and final stage super heater operations at a temperature of more than 565°C. Higher thermal fatigue strength, resistance to steam side oxidation, resistance to fire side corrosion, and a stream temperature of 650°C for the final super heater are just a few of AISI304's exceptional qualities [2].

The most significant and adaptable fabrication technique currently used by industry is welding. The process of Tungsten Inert Gas Welding involves the use of heat generated by an electric arc formed between the weld pool and a non-consumable tungsten electrode. Current flowing through a conductive ionised inert gas, which also shields the electrode, molten weld pool, and solidifying weld metal from atmospheric contamination, creates this electric arc [3]. Due to their varying degrees of hardness, dissimilar materials are typically more difficult to weld; the soft metal deforms significantly while the hard material deforms very little. A common issue that manufacturers have encountered is controlling the process input parameters to obtain a good welded joint with the required weld quality with minimal detrimental residual stresses and distortion. In general, the quality of a weld joint is directly influenced by the welding input parameters during the welding process. To achieve a welded joint meeting the necessary specifications, the weld input parameters for each new welded product must be ascertained [4].

Characterization of TIG-welded stainless steel joints has been the subject of numerous studies in the past. The primary areas of interest for researchers were mechanical characteristics, microstructure characteristics, and the impact of different input parameters on weld quality. The microstructure and mechanical characteristics of AISI304, welded by TIG welding with 308 grade filler metal, were investigated by Halil Ibrahim et al. [5]. Microscopy was used to examine the microstructures of the weld metal, heat-affected zone, and base metal. Observing chromium carbide precipitation and dendritic structure in TIG-welded metal has also been reported. The microstructural properties of tungsten inert gas welded AISI409 were proposed by Eslam Ranjbarnodeh et al. [6] and the impact of welding parameters on low angle grain boundaries and grain size local disorientation were examined. They came to the conclusion that low angle grain boundaries and local disorientation are exacerbated by welding plastic strain. It demonstrates how the competition between stress-relieving from recrystallization and welding plastic strains determines the ultimate state of strain.

The microstructure, mechanical characteristics, and corrosion resistance of a dissimilar welded joint between 2205 duplex stainless steel and 16MnR were examined by Shaogang et al. [7]. The need is satisfied by the mechanical properties of joints welded using the two types of welding technology. On the other hand, TIG produces a weld that is more corrosion resistant in a chloride solution than SMAW. They came to the conclusion that TIG is the best welding technique for fusing 16MnR and 2205 duplex stainless steel, two dissimilar metals. Arivazhagan et al.'s [8] investigation used friction welding, gas tungsten arc, and electron beam to examine AISI304 to AISI4140 dissimilar joints. Precipitation and strengthening behaviour of massive ferrite during massive phase transformation in dissimilar stainless steels were investigated by Chih Chun et al. [9]. This study aims to explore the mechanical properties and microstructural analysis of the weld metal in the different stainless steels during the TIG process. During the different stainless steel welding processes, the weld metal showed signs of austenite phases and massive precipitates. The crack growth study of dissimilar steel butt welded unions under cyclic loads was examined by Andres et al. [10]. The study demonstrates the investigation of the mechanisms underlying the formation and spread of fatigue cracks brought on by variations in mechanical tension stress in butt welded joints between dissimilar steels. The findings demonstrated appropriate mechanical steel behaviour under cyclic loads despite the presence of high microhardness values, primarily in the fusion line between the AISI 304L and the structural material, as well as inclusions between the two.

II. EXPERIMENTAL DETAILS

SA213 T11 and AISI304 are the materials chosen for dissimilar welding; Table 1 lists their chemical composition. Each tube measures 250 mm in length, 4.5 mm in thickness, and 60.3 mm in diameter. The electrode E309L was chosen for a comparable welding application. Its dimensions are 2.4 inches in diameter and 1 metre in length. When welding, argon is used as the gas, and its pressure is 3.5 kg/cm2. The SA213 T11 and AISI304 tubes are shown in Figure 1 both before and after welding.

Table 1 Chemical composition of the AISI304

AISI304								
C	Cr	Fe	Mn	Ni	P	S	Si	Mo
0.08	19	70	2	10	0.045	0.03	1	-
SA213T11								
0.1	1	-	0.45	-	0.025	0.025	0.75	0.55

Table 2 Factors and levels for similar and dissimilar welding

Factor/ Levels	Level I	Level II	Level III
Current (Amps)	100	115	130
Gas Flow Rate (ltr/min)	6	8	10
Speed (mm/sec)	2	2.5	3

III. RESULT AND DISCUSSION

Mechanical properties of AISI304 to SA213T11

Figure 1 displays mechanical properties under various conditions for the AISI304 to SA213T11 dissimilar metal weld, including yield strength, ultimate strength, and percentage elongation. At current 100 amps, gas flow rate 6 ltr/min, welding speed 2 mm/sec for dissimilar material welding, and condition 7, which also provides better yield strength, the best yield strength and ultimate strength are obtained. Under six conditions, such as current of 115 amps, gas flow rate of 6 ltr/min, and welding speed of 2 mm/sec, the percentage elongation is better.

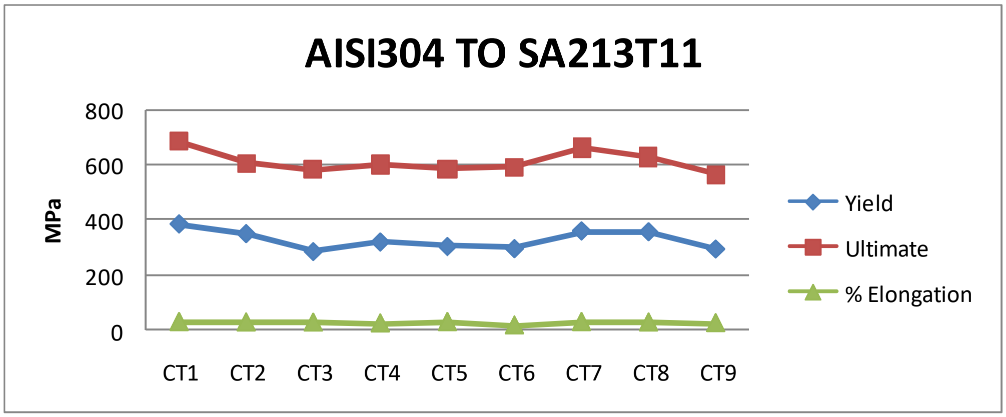

Fig.1 Mechanical properties of AISI304 to SA213T11

Optimum parameters for AISI304 to SA213T11

Table 3 provides the strength, ultimate strength, and elongation values for the AISI304 TO SA213T11 dissimilar metal weld. Table 6 presents the results of the Taguchi analysis for YS, US, and % EL for the AISI304 TO SA213T11 dissimilar metal weld. It is evident that the ideal welding parameters for maximising YS and US are 100 amps for the current, 6 lit/min for the gas flow rate, and 2 mm/sec for the welding speed. The ideal welding parameters are current of 115 amps, gas flow rate of 10 lit/min, and welding speed of 3 mm/sec for the minimization of %EL.

Table 3 Signal to noise ratio for AISI304 TO SA213T11dissimilar metal weld

AISI304 TO AISI304 similar metal weld						
Condition	A	B	C	YS-S/N	US-S/N	EL-S/N
CT1	1	1	1	51.72	56.67	-29.43
CT2	1	2	2	50.88	55.59	-28.96
CT3	1	3	3	49.06	55.28	-28.72
CT4	2	1	2	50.07	55.54	-27.80
CT5	2	2	3	49.62	55.32	-29.32
CT6	2	3	1	49.39	55.41	-24.81
CT7	3	1	3	51.12	56.40	-29.42
CT8	3	2	1	51.05	55.95	-28.96
CT9	3	3	2	49.35	55.02	-28.16

Table 4 Optimum condition for AISI304 TO SA213T11dissimilar metal weld

Level	Yield strength			Ultimate strength			% Elongation		
	A	B	C	A	B	C	A	B	C
1	50.56	50.97	50.72	55.85	56.20	56.01	-29.03	-28.88	-27.73
2	49.69	50.52	50.10	55.42	55.62	55.38	-27.31	-29.08	-28.31
3	50.51	49.27	49.93	55.79	55.24	55.67	-28.85	-27.23	-29.15
Delta	0.86	1.70	0.79	0.42	0.97	0.63	1.72	1.85	1.42
Rank	2	1	3	3	1	2	2	1	3
Optimum	A_1	B_1	C_1	A_1	B_1	C_1	A_2	B_3	C_1

Performance of similar and dissimilar material weld

Because of differences in composition, hardness, and melting temperature, the dissimilar material weld performs completely differently than the similar material weld. Based on mechanical properties, Figure 2 illustrates the performance variance of similar and dissimilar material welds. These analyses show that the dissimilar metal weld's strength and ultimate strength are higher than those of the similar metal.

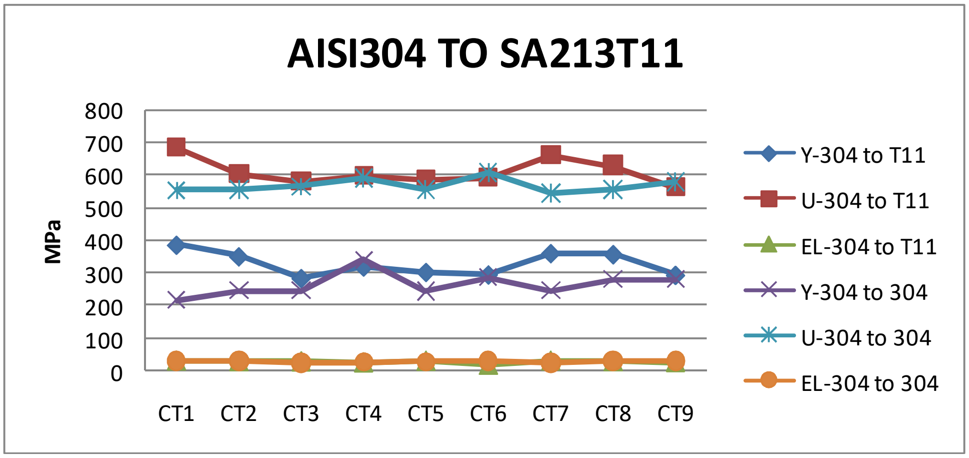

Fig.2 Performance of similar and dissimilar material weld

IV. CONCLUSION

The majority of researchers focus on alternative approaches for super heater coils, but at that time, dissimilar material welding was not done. The following conclusions are derived from the analysis of metal TIG welding that is similar to and different from one another. They are listed below.

• Compared to the similar material weld AISI304 to AISI304, the dissimilar material weld AISI304 to SA213T11 performs better.
• Dissimilar metal weld is not symmetrical, but similar metal weld with the heat source is positioned symmetrically around the centerline.
• Setting the current at 100 amps, the gas flow rate at 6 lit/min, and the welding speed at 2 mm/sec to maximise YS and US; AISI304 to SA213T11.

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