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Investigation of mechanical properties and microstructure of GTAW on dissimilar metals

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Abstract
In this study was to join and assess the development of gas tungsten arc welding (GTAW) on dissimilar materials like austenitic stainless steel and low carbon steel. This GTAW weld is best suited for the thin cross-section metals. This welding process can be used for continuous, spot or intermittent weld joints. The combination of mild steel and austenitic steel are used in various industries namely valves, furnace parts, tanks, heat treatment pots and baskets, kiln cooler plates. Tests were conducted effect of different welding process parameters on arc voltage, gas flow rate and torch distance. The mechanical properties and microstructures and the chemical composition of the joint of the gas tungsten arc welding joints will be examined using universal testing machine, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDAX).

Keywords: GTAW, Dissimilar Materials, UTM, SEM, EDAX.

1. Introduction

Gas tungsten arc welding (GTAW) process is an important process in many industrial operations. It is possible to weld on both non-ferrous and ferrous materials with the gas tungsten arc welding process. Depending upon the amperage used, a variety of plate thicknesses can be welded. The process can be used for welding anything from thick material down to very thin material and produce high quality welds. The effect of welding parameter namely arc voltage, gas flow rate and torch distance on weld strength metals namely stainless steel and low carbon steel.

Many applications exist in industry that requires joining of carbon steel to stainless steel. A typical example can be found in power generation applications. The primary boilers and heat exchangers in coal fired power plants operate at high temperatures and environments that permit the use of inexpensive ferritic alloy steels, while the super heater and reheater areas operate at higher temperatures and under more severe corrosion conditions that require the use of austenitic stainless steels. A dissimilar metal weld must be made at the alloy steel-to-stainless steel transition region. These dissimilar metal welds are often prone premature failure when exposed to elevated service temperature. Much work has done to understand the mechanism of dissimilar metal weld failures in such applications [1]. When chromium content is increased to about 11%, the resulting material is generally classified as a stainless steel. This is because at this minimum level of chromium, a thin protective passive film forms spontaneously on steel, which acts as a barrier to protect the steel from corrosion. On further increase in chromium content, the passive film is strengthened and achieves the ability to repair itself, if it gets damaged in the corrosive environment. Nickel addition in stainless steel improves corrosion resistance in reducing environments such as sulphuric acid. It also changes the crystal structure from BCC to FCC thereby improving its ductility, toughness and weldability. Mo increases pitting and crevice corrosion in chloride environments. Stainless steel is provides a combined effect of aesthetics, strength and durability. The investigate effect of process parameters of TIG welding like weld current, gas flow rate, work piece thickness on the bead geometry of SS304. It was found that the process parameters considered affected the mechanical properties with great extent [2]. The welding input process parameters for obtaining greater welding strength in manual metal arc welding of dissimilar metals. The higher the better quality characteristic was considered in the weld strength prediction. Taguchi method was used to analyze the effect of each welding process parameters and optimal process parameters were obtained [3]. The process of Pulsed TIG weld was exhibited lower notch tensile strength and impact toughness than the parent metal due to interdendritic network microstructure features. Taguchi method was used to optimize the pulsed TIG welding process parameters of heat-treatable (Al-Mg-Si) aluminum alloy weldments for maximizing the mechanical properties [4]. The effect of post weld heat treatment on the interfacial microstructure of as-welded and PWHTed type 316L N/C-steel joint welded with Inconel 182 was investigated. These joint were PWHTed to various temperatures between 898 to 973K for 1h results were evaluated [5].

2. Experimental Procedure

2.1 Stainless Steel Chemical Composition

The chemical composition of stainless steel specimen 316L is given in the Table 1.

Table 1: Chemical composition of stainless steel 316L

Elements	C	Si	Mn	P	S	Cr	Mo	Ni
Wt%	0.02	0.29	1.58	0.027	0.003	16.25	2.27	11.90

2.1.1 Tensile Testing Observation for Stainless Steel Specimen

Table 2: Tensile test observation of SS specimen

Test parameters	Values
Ultimate tensile strength	513.18Mpa
Yield strength	255.90Mpa
% Elongation in 50mm GL	55.50%

2.2 low carbon steel Chemical Composition

The chemical composition of low carbon steel specimen is given in the table3.

Table 3: Chemical composition of low carbon steel

Elements	C	Si	Mn	P	S	Al	Ce
Wt%(max)	0.14	0.19	0.7	0.02	0.021	0.022	0.257

3.2.1 Tensile Testing Observation for low carbon steel

The micro alloying elements, such as niobium, boron, vanadium and titanium added singly or in combination to obtain higher strength to weight ratio combined with better toughness, formability and weld ability as compared to unalloyed steel of similar strength level.

Table 4: Tensile test observation of low carbon steel

Test parameters	Values
Ultimate tensile strength	468 Mpa
Yield Stress	352 Mpa
% Elongation	28 %

2.3 Filler Metal

The filler metal used in this project is a stainless steel 316L grade filler rod of Ø2.5mm x 1000mm. This filler rod having 490 Mpa ultimate tensile strength 40% elongation. The chemical composition of filler rod is given below

Table 5: Chemical Composition of Filler Rod

Elements	C	Si	Mn	P	Cu	S	Cr	Mo	Ni
Wt% (max)	0.3	0.30-0.65	2.0-3.0	0.03	0.75	0.03	18.0-20.0	23.15	11.0-14.0

2.4 Process parameters

The factors which have a significant influence on weld strength of tungsten inert gas welding were identified. They are weld shielding gas flow rate, arc voltage, torch distance of GTAW.

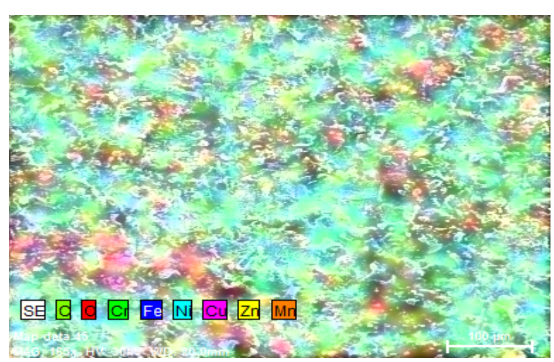
Table 6: Parameters

Factors	Gas flow rate	Torch distance	Voltage
Notation	G	T	V
Unit	lpm	mm	volts
Level	12.5	1.5	170

3. Result and Discussion

Fig 1: SEM micrograph of fusion zone.

Micro structural analysis is made on a small volume weld zone and heat affected zone of the test specimen. Pearlite and ferrite phases appear in the microstructure analysis. It was found that the pearlite percentage was always higher than the ferrite in both weld and heat affected zones. The hardness value is lower than the weld zone because the percentage of ferrite is higher in the heat affected zone. The higher amount of ferrite influences the softening of the heat affected zone [6]. The energy disperse X-ray (EDX) finding was conducted to differentiate the chemical composition of the fusion zone. Figures 2 and 3 are showing the EDX test results for dissimilar material GTAW joint. The results are showing that the chromium to nickel ratio was increased so more ferrite phases were induced at the welded zone. It can be said in another way the vermicular and lathy ferrite increase during welding process [6]. It has been noticed from the energy disperse X-ray test EDX that the carbon content is significantly increased at the fusion zones although the carbon content at fusion zone is (17.07).



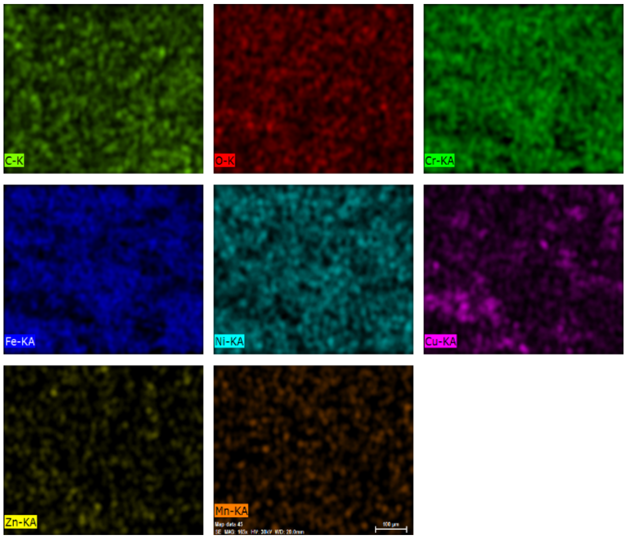


Fig 2: EDX mapping analysis of fusion zone.

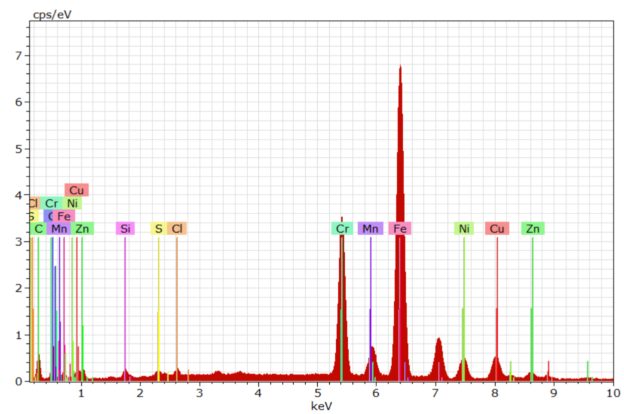


Fig 3: EDX Chemical composition on fusion zone

The heating process dissipates some of the chemical compositions during welding and therefore carbon content was increased in percentage [7]. Besides the chromium content from stainless steel side (18%) is also reduced to 13.53% and the nickel content is from 14% to 4.36%. however the primary content (iron-Fe) occupies the zones with major percentage [8]

4. Conclusion

This study was to join and assess the development of gas tungsten arc welding (GTAW) on dissimilar materials like austenitic stainless steel and low carbon steel. Tests were conducted effect of welding process parameters on arc voltage, gas flow rate and torch distance.

- The mechanical properties and microstructures and the chemical composition of the joint of the gas tungsten arc welding joints will be examined using universal testing machine, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDAX).
- The tensile strength and elongation of the weld are approximately identical with those of Base metal and the fracture of tensile specimen occurs at the base metal from the heat affected zone.
- The fully penetrated weld are obtained at the GTAW voltage of (170 volts) and the gas flow rate (12.5 lpm) and the torch distance (1.5 mm) respectively.
- The chromium to nickel ratio was increased so more ferrite phases were induced at the fusion zone, it gives high corrosion resistance

5. Reference

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