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Mechanical and Microstructure Properties Evaluation of Tig Welded Dissimilar Metal Ss304-Ss316

S. Raja Narayanan[1],M. Balakrishnan[2],G.K. Pradeep[3],M. Ragavan[4],S. Nirmal Kumar[5]

[1]AssistantProfessor, Department of Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India.E-mail: srajanarayanan1993@gmail.com

[2]Professor, Department of Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India.E-mail: balki2009@yahoo.com

[3]Student IV Year, Department of Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India.E-mail: gkpradeepak@gmail.com

[4]Student IV Year, Department of Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India.E-mail: ragavanmookkiah7@gmail.com

[5]Student IV Year, Department of Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India.E-mail: nirmalkumar1625@gmail.com

ABSTRACT

Different grades of stainless steel are used in the construction and manufacturing of fusion reactor and boiler parts. Experimentation, study, and optimization of TIG welding to connect dissimilar grades of stainless steel (SS 316-SS304) are the goals of this project.Variables in the work are parameters such as current. Mechanical properties such as tensile strength and microstructure properties such as scanning electron microscope (SEM) and Rockwell hardness test with varying welding current are used to evaluate the welding parameters. We study the mechanical properties and microstructure of austenitic stainless steel welds made from SS 316 and SS 304.The significance of welding parameters for mechanical properties is determined using the UTM computer. Welding is the most vital and common operation use for joining of two similar and dissimilar parts.

KEYWORDS

TIG Welding,Dissimilar Metals, SEM Analysis, Mechanical Properties, Rockwell Hardness Test, Tensile Test.

Introduction

Because of the stiff and cutthroat competitive market conditions in the manufacturing sectors, efficiency and productivity play an important role in today's manufacturing market. Industry's primary goal is to produce higher-quality products at the lowest possible cost while also increasing efficiency. Welding is the most important and widely used method of connecting two identical or dissimilar pieces. Since SS-316 has a low carbon content and a high weldability factor, it is commonly used in fabrication. It has good ductility and can withstand temperatures up to 1150°C in continuous operation. In the construction of nuclear fusion reactor and boiler components, as well as cryogenic structures, welding of SS-316 materials is a critical task. Penetration, microstructure, mechanical properties, and residual stresses all play a role in the efficiency and strength of the weld during the welding process. If any of the weld parameters are not properly chosen, the device can fail. The aim of this study is to look into the effect of various process parameters on TIG welding for SS 316l. Mechanical examination of the welded specimens was used to assess the accuracy of the weld. An optimal solution is sought using Taguchi and ANOVA techniques, which offers optimal results for the varying conditions. The arc welding process in which the arc is produced between the non-consumable tungsten electrode and the work piece is known as Tungsten Inert Gas (TIG) or Gas Tungsten Arc Welding (GTAW). An inert gas, such as argon or helium, shields the tungsten electrode and the weld reservoir. Precision joining of critical components that require managed heat inputs is typical with these tungsten arc welding processes. The regulated melting of the material is suitable for the limited intense heat sources given by the tungsten arc. Welding without filler material can be achieved with the GTAW Welding Processes since this electrode is not consumed during the process. This removes the need for constant compromise between the heat input from the arc and the melting of the filler metal. The number of welding parameters that affect the GTAW welding process are as follows: A. Welding Voltage B. Welding Current C. Welding Speed D. Arc lengthE. Choice of shielding gas and gas flow rate F. Filler wire. For optimal welding efficiency, the majority of these parameters must be matched to one another. The working point must fall inside the welding situation's working range or tolerance box. For an experienced welder, the time required for adjustment in a typical welding situation is usually small, but optimizing a

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weld for an automated production line can require more effort.

Material and Method

SS304 and SS316

Stainless steel 304 has a minimum weight of 7.81 g/cm3 and is a very light metal. In the automotive and aerospace industries, the use of stainless steel 304 lowers dead weight and energy consumption. By changing the composition of its alloys, the strength of stainless steel 304 can be increased to meet the requirements for different applications. Stainless steel 304 is a material that prevents corrosion well. Corrosion resistance can be improved further using different surface treatments. Stainless steel 304 is an outstanding heat and electricity conductor, and is almost twice as good as Stainless steel in terms of weight. As a result, stainless steel 304 has become the most common material for major power transmission lines. The stainless steel 304 has a low melting point and is ductile. It can be processed in a variety of ways while still molten. Because of its ductility, stainless steel 304 products can be formed almost to the end of their life cycle. Bolting, riveting (temporary joint), and welding are all options for joining stainless steel 316. (permanent methods). Stainless steel 304 and its alloys are welded in a number of ways in industry. Since stainless steel 304 has a high thermal conductivity, heat is easily transferred away from the welding field. The heat source must be strong enough to quickly exceed the melting point of stainless steel 316, which is 565 /1650oC. Stainless steel 304 is a reactive metal that forms an oxide layer on the surface easily, reducing the strength of the weld region. As a result, welding stainless steel 304 with a traditional arc welding process has become challenging. Stainless steel 304 and its alloys can be quickly welded if the welding properties are known and proper procedures are followed. The most popular commercial stainless steel 304 and stainless steel 304 alloy welding methods use an electric arc with either a continuously fed wire electrode [with DC Current, with and without pulsed Current] or an intermittently fed wire electrode [with DC Current, with and without pulsed Current]. There are two basic factors to consider when ensuring suitable weld quality: breaking loose and removing the oxide film, and preventing the creation of new oxide during the weld process. Before starting to weld, it is important to make the necessary preparations and take the necessary precautions. The surfaces to be joined, as well as the area around the weld zone [50 mm], must be degreased with a clean cloth and a solvent [acetone or toluene]. Grease and moisture can form gases and create pores in the welded joint, so the area must be clean and fully dry. According to previous studies, material selection in the manufacturing phase is the most critical factor to consider in terms of process availability and customer requirements. In modern manufacturing, a variety of materials are used, but stainless steel is commonly used because of its corrosion resistance and high strength. Mg AZ91D and Al were the components used in the experiment. The chemical make-up of SS304-316, as well as its mechanical properties.**Table 1 denotes Mechanical properties of SS304-SS316, Table 2 denotes the chemical composition of SS304-SS316, Fig 1 and fig 2 shows the welding of the pieces.**

Table 1

Type	Tensile Strength (MPa)	Yield Strength (MPa)	Elongation (50MM)	Hardness	
				HBW	HRB
304	≥515	≥205	≥40	≥201	≥92
316	≥485	≥170	≥40	≥201	≥92

Table 2

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Sample	Element	Concentration (%)
AISI 316	Carbon (C)	0.04
	Silicon (Si)	0.57
	Manganese (Mn)	1.64
	Phosphorus (P)	0.067
	Sulfur (S)	0.007
	Chrome (Cr)	18.01
	Molybdenum (Mo)	2.12
	Nickel (Ni)	10.31
AISI 304	Carbon (C)	0.07
	Silicon (Si)	0.50
	Manganese (Mn)	1.35
	Phosphorus (P)	0.077
	Sulfur (S)	0.022
	Chrome (Cr)	18.00
	Molybdenum (Mo)	0.218
	Níckel (Ni)	7.32

Fig. 1. Sample 1(SS304-SS316) at 100Amps**Fig. 2.** Sample 1(SS304-SS316) at 140Amps

TIG Welding and Parameters

The GTAW or TIG welding process is an arc welding process that produces welds with a non-replaceable tungsten electrode. A shielding gas, usually Argon or Helium, or a combination of Argon and Helium, protects the weld region from the atmosphere. For proper welding, a filler metal may also be manually fed. During WWII, the GTAW welding process, also known as TIG welding, was developed. Welding of difficult-to-weld materials such as stainless steel and stainless steel has become possible thanks to the invention of the TIG welding process. TIG is now used on a range of metals, including stainless steel, mild steel, high tensile steels, Al alloys, and Titanium alloys. TIG welding power sources, like other welding systems, have progressed from basic transformer forms to today's increasingly electronic regulated power sources. TIG welding is an arc welding method that produces welds with a non-consumable tungsten electrode. An inert shielding gas (argon or helium) shields the weld region from the atmosphere, and a filler metal is usually used. A constant-current welding power supply creates an electric arc between the tungsten electrode and the work piece, which is then performed through the arc by a column of strongly ionised gas and metal vapours. Inert gas shields the tungsten electrode and welding region from the ambient air. The electric arc can generate temperatures of up to 20,000oC, which can be centered to melt and join two separate materials. The base metal may be joined with or without filler material using the weld pool. TIG welding schematic diagram and TIG welding process Tungsten electrodes are widely

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available in diameters ranging from 0.5 to 6.4 mm and lengths ranging from 150 to 200 mm. If an electrode is attached to the negative or positive terminal of a DC power source determines its current carrying capacity. When the arc length is varies over several millimetres, the power source used to sustain the TIG arc has a drooping or constant Current characteristic, which provides an essentially constant Current output. As a result, in manual welding, natural variations in arc length have little impact on welding Current. When the electrode is short circuited to the work piece, the ability to restrict the Current to the set value is equally important; otherwise, excessively high Current may flow, destroying the electrode. The open circuit voltage of the power source is between 60 and 80 V. HITBOX TIG Welder Inverter Argon Digital TIG Welding Machine T2000 180amp Portable High Frequency 220V TIG MMA ARC Stick Consistency Equipment was used to conduct the experiment. HITBOX is the seller. TIG Stick Welder with 180 amps IGBT, tig torch, earth clamp, electrode holder, and gas tube. As compared to MOS technology, the new IGBT inverter technology significantly reduces breakdown. The technology is mature, and the frequency of the inverter will reach 100 kHz. TIG welding thickness 0.3-5.0mm, electrode diameter (MM): 2-3.2mm; simple arc ignition, litter spattering, and stable arc presently.**Fig 3 denotes the TIG welding hitbox TIG200.**

Fig. 3.TIG200 Hitbox

In TIG welding, a higher current can cause splatter and damage to the work piece. Again, in TIG welding, a lower current setting causes the filler wire to adhere. Higher temperatures must be applied for longer periods of time to deposit the same amount of filling materials, so lower welding current can often result in a larger heat affected region. In Fixed Current mode, the voltage is varied to keep the arc current steady. The method of welding Depending on the TIG welding equipment, the voltage may be set or adjustable. A high initial voltage facilitates arc initiation and allows for a wider range of working tip distance. Too much voltage will cause a lot of variation in welding efficiency. The welding cost, weld temperature, arc stability, weld speed, splatter, electrode life, and other factors all influence the shielding gas selection. It also has an effect on the depth of penetration and surface profile of the finished weld, as well as porosity. The welding cost, weld temperature, arc stability, weld speed, splatter, electrode life, and other factors all influence the shielding gas selection. It also has an effect on the depth of penetration and surface profile of the finished weld, as well as porosity. The weld material's corrosion resistance, strength, hardness, and brittleness. TIG welding can be done successfully with either Argon or Helium. Pure argon is used to weld very thin materials. Argon normally produces a smoother and quieter arc. When Argon is used to create an arc, it penetrates the arc less than when Helium is used. For these reasons, argon is preferred in most applications, with the exception of welding metals with high heat conductivity in larger thicknesses, where higher heat and penetration are needed. Welding speed is a key factor in TIG welding. When welding speed is increased, the power or heat input per unit length of weld decreases, resulting in less weld reinforcement and reduced welding penetration. Welding speed, also known as travel speed, is used to monitor weld bead size and penetration. Present is intertwined with it. Excessively fast welding speeds minimize wetting action, increase the likelihood of undercut, porosity, and irregular bead forms, whereas slower welding speeds reduce the likelihood of porosity. **Table 3 denotes the parameters involves in welding, Table 4 denotes Experimental planning carries in the welding in the specimen.**

Table 3. Parameters

Parameters	**Range**
Welding current	(100-140) A

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Voltage	50 v
Speed	(3.5-4) mm/s
Distance of tip from weld centre	3 mm
Gas flow rate	(8-10) l/min.
Current type	AC
Dimension	100mm*50mm*3mm

Table 4. Experimental Planning

Exp. No.	Electrode work piece distance(mm)	Argon Gas flow rate (I/min)	Voltage(v)	Welding Speed (mm/s)	Current (A)
1	3	8-10	50	3.50	100
2	3	8-10	50	3.50	140

Result and Discussion

Tensile Test

Tensile tests were performed on ASTM E-8M-compliant sub-size samples using a computer-controlled universal testing machine. Both welds were machined to a thickness of 6mm before making the tensile specimens, as shown in Figure 4.10 (plate thickness was 3 mm), removing the crown and part of the root of the weld to ensure that the fusion zone was being measured. All of the tensile values displayed were the sum of at least three specimens. The yield strength values shown were 0.2 percent proof strength values calculated by the machine's computer programme. The fractured tensile specimens were carefully assembled and placed for microstructural tests to determine where the fractures were located. **Fig 4 denotes the sample 1 (100A) Tensile strength, Fig 6 denotes the sample 2 (140A) Tensile strength. Fig 5 and fig 7 shows the work samples.**

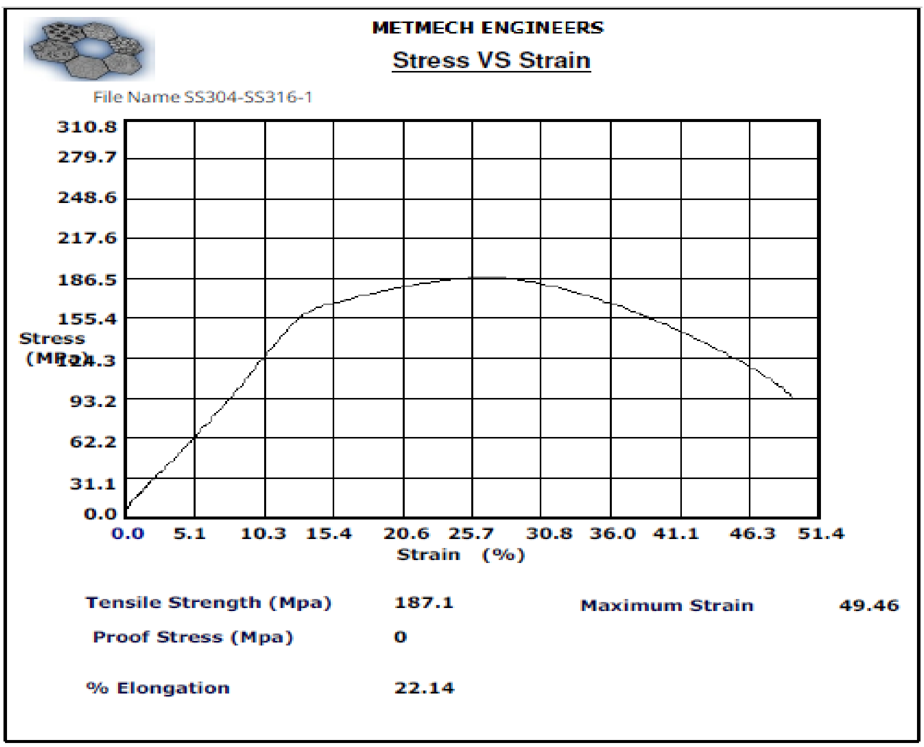

Fig. 4. Stress vs strain current (100A)

Fig. 5. Work sample 1

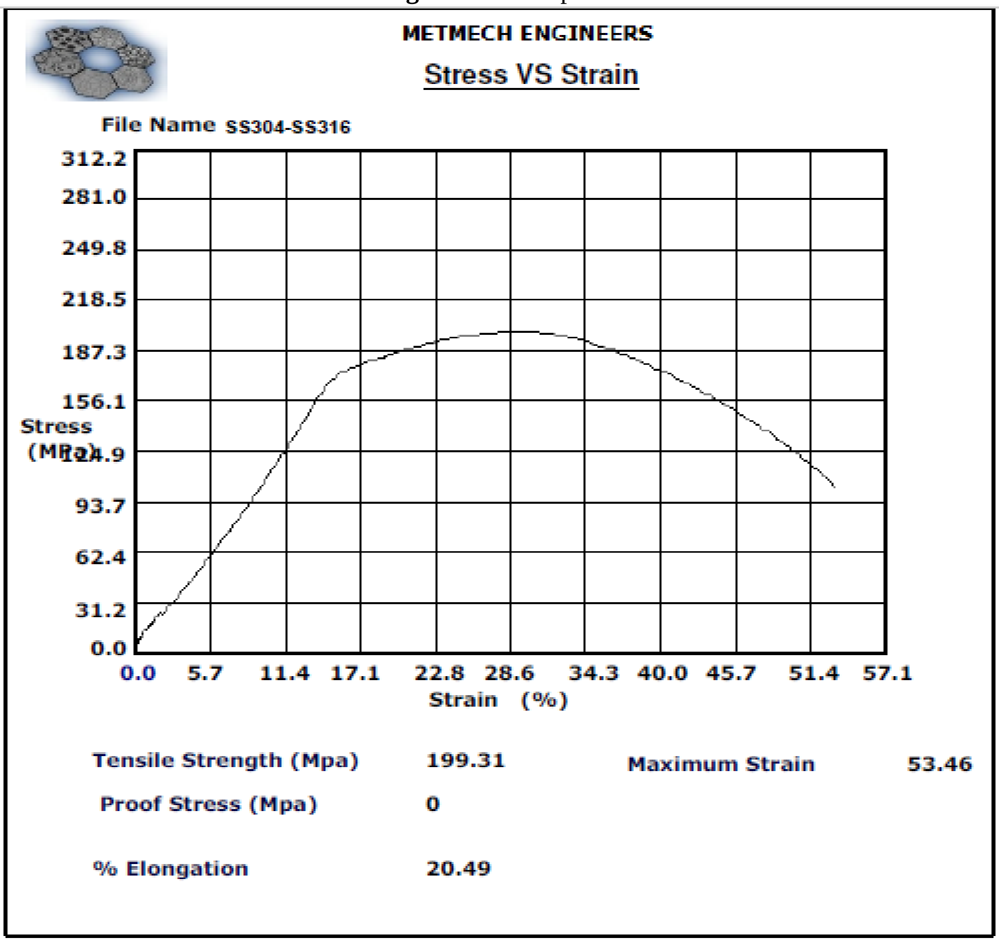

Fig. 6. Stress vs strain-Current 140A

Fig. 7. Work sample 2

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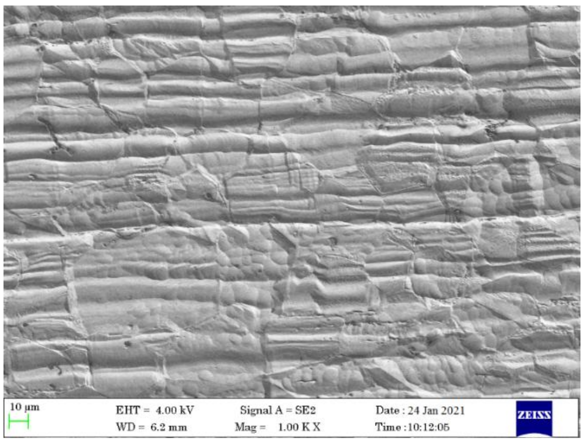
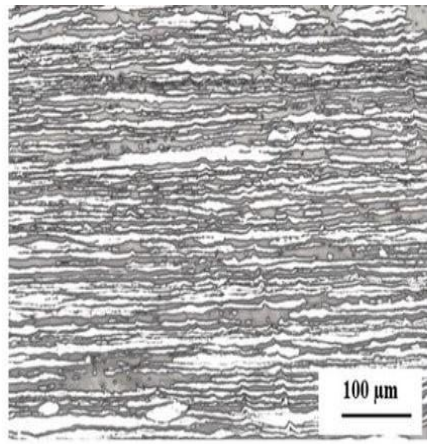
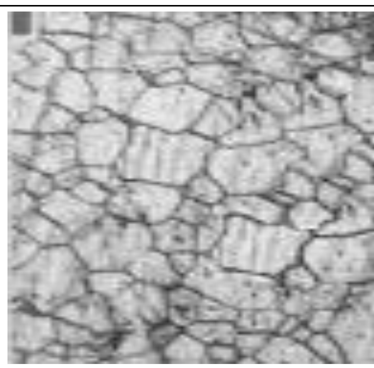
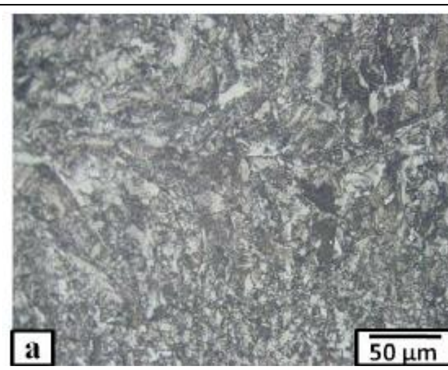
Scanning Electron Microscope (SEM)

A JEOL SEM (Scanning Electron Microscope) is used to classify the samples examined in all of the tests such as tensile, fatigue, wear, and corrosion. Intermetallic compounds in the weld region were also defined in terms of scale, thickness, and distribution. The following table shows the Microstructure of the Sample 1 and Sample 2 Work piece.**Fig 8 and fig 9 denotes the sample for SEM**.

Sample 1

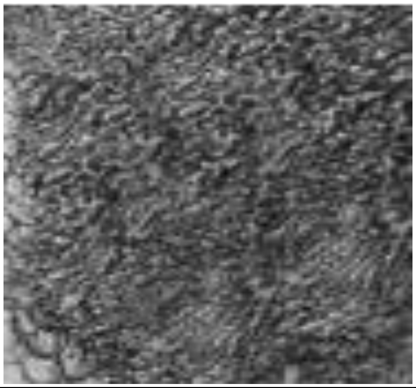
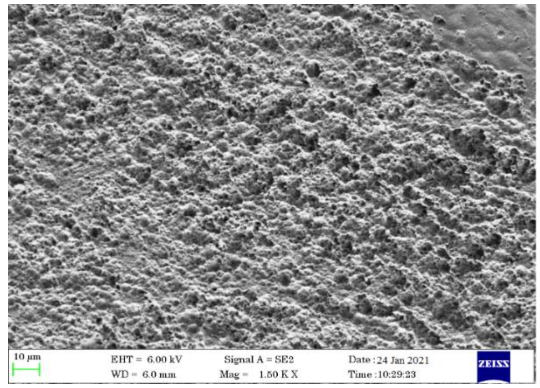
304	316
Parent zone	Parent zone
	

Sample 1

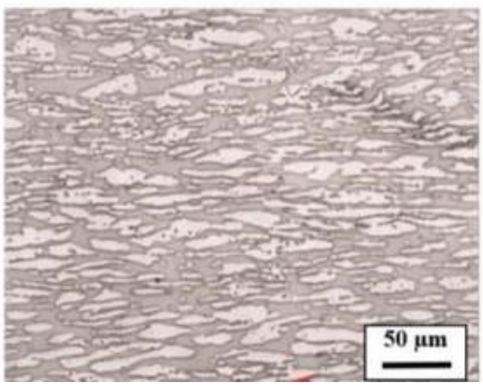
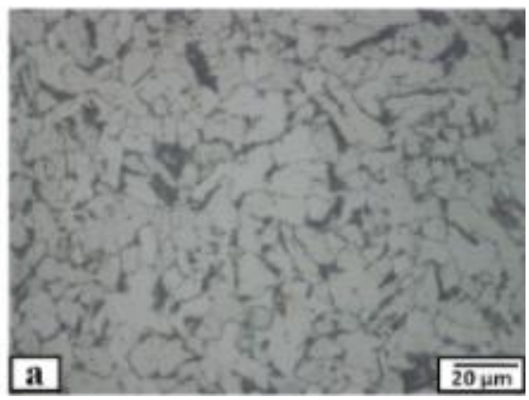
304	316
Welded zone	Welded zone
	

Sample 1

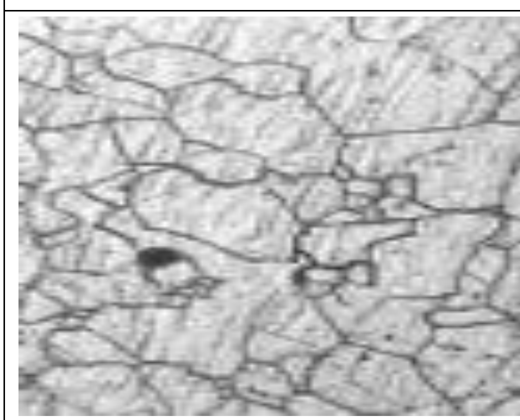
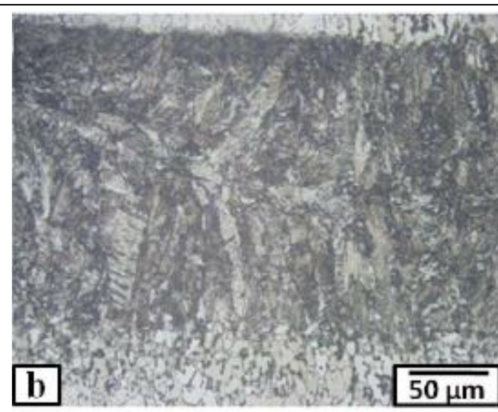
304	316
Heat affected Zone	Heat affected zone

Sample 2

304	316
Parent zone	Parent zone
	

Sample 2

304	316
Welded zone	Welded zone
	

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Sample 2

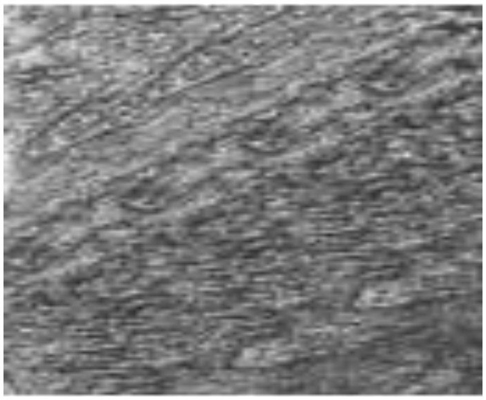
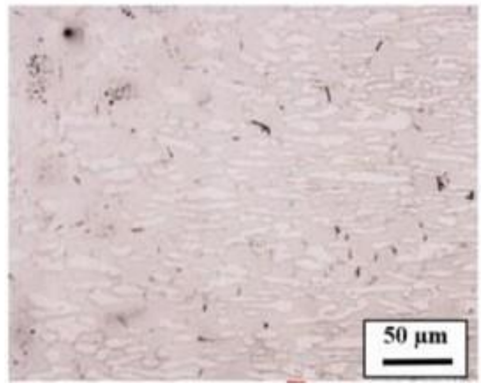
304	316
Heat affected Zone	Heat affected zone
	

Fig. 8. Sample 1**Fig.9.**Sample 2

Hardness Test

The most widely used hardness test method is the Rockwell hardness test method, as described by ASTM E-18. Before taking a Rockwell exam, you can obtain a copy of this standard and thoroughly read and comprehend it.**Table 5 denotes the sample 1, Table 6 denotes the sample 2.**

Table 5. Sample 1(100Amps)

S.No	**Heat affected Zone**	**Welded Zone**	**Parent Zone**
1	68 HRB	62 HRB	49 HRB
2	79 HRB	68 HRB	74 HRB
3	73 HRB	64 HRB	85 HRB
Average	73.3 HRB	65 HRB	69 HRB

Table 6. Sample 2(140 Amps)

S.No	**Heat affected zone**	**Welded Zone**	**Parent Zone**
1	81 HRB	74 HRB	73 HRB
2	83 HRB	73 HRB	70 HRB
3	78 HRB	80 HRB	75 HRB
Average	81 HRB	75 HRB	73 HRB

The parameter for the comparison is depends on the amperes 100and 140 respectively. We conclude that sample 2 is greater compared to the sample 1. So we can recommend sample 2 as the good quality.

Conclusion

The aim of this project was to weld stainless steel SS304-SS316 dissimilar materials together. TIG was found to be capable of joining a strong SS304-SS316 joint. The following conclusions were taken from the inquiry.The material's strength is entirely determined by particle grain size and heat treatment welding current. The addition of harder material to the advancing side has a major impact on material flow and mechanical properties. The tensile strength of the SS304-SS316 joint is 187 MPa for sample 1 and 199 MPa for sample 2. High hardness values and base material strength are almost equivalent to TIG welded parts due to the high boundary energy and hard brittle intermetallics. As the tool advances, the tougher stainless steel material on the advancing side can be quickly transported. This improves material flow and allows for defect-free weld zone formation. The high tensile strength is due to the uniformly distributed SS304 reinforcement particles in the SS316 weld. The parameter for the comparison is depends on the amperes 100and 140 respectively. We conclude that sample 2 is greater compared to the sample 1. So we can recommend sample 2 as the good quality.

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