



ISSN: 0976-3031

Available Online at <http://www.recentscientific.com>

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 10, Issue, 04(A), pp. 31678-31683, April, 2019

**International Journal of
Recent Scientific
Research**

DOI: 10.24327/IJRSR

Research Article

EXPERIMENTAL INVESTIGATION AND COMPARATIVE STUDY OF MIG & TIG WELDING ON SS202 AND SS304 MATERIALS

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DOI: <http://dx.doi.org/10.24327/ijrsr.2019.1004.3312>

ARTICLE INFO

Article History:

Received 06th January, 2019
Received in revised form 14th
February, 2019
Accepted 23rd March, 2019
Published online 28th April, 2019

Key Words:

MIG welding, TIG welding, SS202, SS304,
Butt Joint, Tensile Test, Bending Test,
Micro structural Test, Grain Size Test
etc.

ABSTRACT

Welding is considered as one of the most commonly used fabrication methods in today's industrial applications. TIG and MIG welding methods are modern welding methods in which inert and active gases are used to prevent the weld pool from atmospheric oxidation. Both these methods are arc welding methods in which electric spark is used to generate required thermal energy for fusing the parent metals. TIG uses argon and helium gases to protect the weld pool while MIG uses CO₂ gas. In TIG welding process, a non-consumable tungsten electrode is used while a consumable feed wire is used in MIG welding. In most common the industries uses the welding process for make the permanent joints between the materials. In this present study mainly focuses on the MIG and TIG welding process. In this paper, stainless steel of grades of SS202 & SS304 of dimensions (40×50×6) mm were welded by butt joint by Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) welding processes. Then various tests were conducted to the joints such as tensile strength, bending test, micro structural test, grain size test etc and finally results, physical as well as mechanical properties were investigated.

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1. INTRODUCTION

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. Welding is a common process for joining metals using a large variety of applications. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material which after solidification gives a strong bond between the materials. Weld ability of a material depends on different factors like the metallurgical changes that occur during welding, changes in hardness in weld zone due to rapid solidification, extent of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position. Welding occurs in several locations, from outdoors settings on rural farms and construction sites to inside locations, such as factories and job shops. Welding processes are fairly simple to understand, and basic techniques can be learned quickly. Welding is the joining of metals at a molecular level. A weld is a homogeneous bond between two or more pieces of metal, where the strength of the welded joint exceeds the strength of the base pieces of metal. At the simplest level, welding

involves the use of four components: the metals, a heat source, filler metal, and some kind of shield from the air. The metals are heated to their melting point while being shielded from the air, and then a filler metal is added to the heated area to produce a single piece of metal. It can be performed with or without filler metal and with or without pressure. There are several types of welding that are used today. Gas Metal Arc Welding (GMAW) or MIG, Gas Tungsten Arc Welding (GTAW) or TIG, Flux Core Arc Welding, and Stick Welding are the most common found types in industrial environments.

It is suitable for everything from hobbies and small fabrications or repairs, through to large structures, shipbuilding and robotic welding. MIG can be used on a broad range of materials and thicknesses, and the latest Super Pulse technology enables MIG to give a finish that is similar to that obtained with TIG (tungsten inert gas) welding, yet with the speed for which MIG is renowned. Concept underlying MIG welding is simple, with the arc being struck between the tip of the reel-fed wire as it emerges from the torch, and the work piece. A shielding gas prevents oxidation forming, or the use of some flux-cored wires avoids the need for a shielding gas. With most MIG welding sets, the user sets the wire feed speed, which determines the current; then the user sets the voltage to suit that current.

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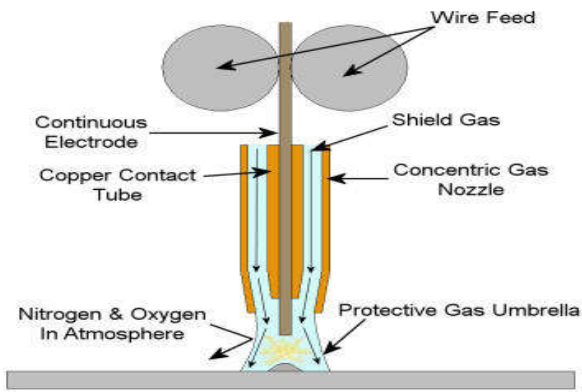


Fig 1 principle of MIG welding

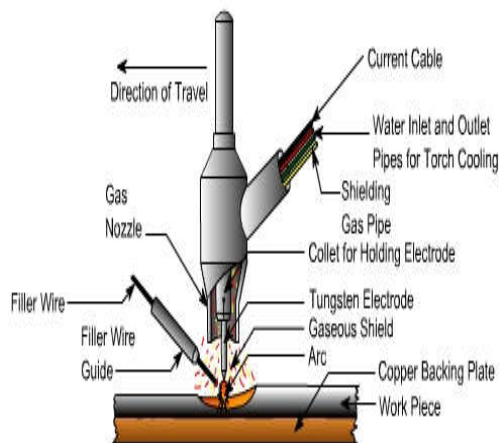


Fig 2 principle of TIG welding

GTAW or TIG welding process is an arc welding process uses a non consumable tungsten electrode to produce the weld. The weld area is protected from atmosphere with a shielding gas generally Argon or Helium or sometimes mixture of Argon and Helium. filler metal may also feed manually for proper welding. GTAW most commonly called TIG welding process was developed during Second World War. With the development of TIG welding process, welding of difficult to weld materials e.g. Aluminium and Magnesium become possible. The use of TIG today has spread to a variety of metals like stainless steel, mild steel and high tensile steels, Al alloy, Titanium alloy. Like other welding system, TIG welding power sources have also improved from basic transformer types to the highly electronic controlled power source today. TIG welding is an extremely versatile process; it can be used with virtually any weldable metals, including dissimilar metals, and thicknesses from 0.5mm upwards. TIG welding machines are typically available in current ratings from 150A to 350A and they are capable of operating at currents as low as, typically, 3A for a 150A machine. In addition, TIG machines can be used for brazing and MMA welding, which helps to improve the return on an investment in TIG equipment. The most commonly used shielding gas for TIG welding is pure argon for all materials including aluminium. For thick aluminium and copper, argon/helium would be used for the added heat from the helium. TIG operatives do need to be aware that the correct tungsten electrode must be used, otherwise problems can be experienced with striking the arc and maintaining a stable arc.

The stainless steel is one of the most popular materials for structural applications, due to their excellent physical properties but increase the structural cost. The additional benefits and the design codes of stainless steels have focused their industrial use for conventional structural engineering applications such as civil construction, nuclear reactors, thermal power plants, vessels and heat exchangers for several industrial applications .

S.P.Gadewar *et al.* [2] investigated the effect of process parameters of TIG welding like weld current, gas flow rate, work piece thickness on the bead geometry of SS304. They were found that the process parameters considered affected the mechanical properties with great extent. Radha Raman Mishra *et al.* [3] investigated the tensile strength of MIG and TIG welded dissimilar joints of mild steel and stainless steel. TIG and MIG welding process were used for welding different grades of steel with mild steel. Four test samples were prepared by welding SS202, SS304, SS310 and SS316 with mild steel and found that TIG is more suitable than MIG for dissimilar metal welding of mild steel and stainless steel as it provides better strength. Also, the dilution percentage in stainless steel is found to be higher in MIG welded dissimilar joints. Lokesh Kumar G, *et al.* [4] studied some fundamental observations on the microstructure and the mechanical properties, formed by AISI 304 (ASS) and AISI 430 (FSS) with AWS E308L austenitic stainless steel covered electrode. Thus, forming a dissimilar weld joint with the use of filler material. The welding processes carried out in the experiment are shielded metal arc welding (SMAW) and tungsten inert gas welding (TIG). The results obtained were analyzed for welding processes of dissimilar welded joints of stainless steel. From the results obtained it was concluded that the better tensile strength is obtained from TIG process when it is compared to SMAW process .Madduru Phanindra Reddy, *et al.* [5] investigated on bimetallic joint of low alloys and stainless steel commonly used in high temperature corrosion environments applications are formed using TIG welding. In this investigation, attempts have been made to investigate the weld ability of AISI 4140 and AISI 316 by TIG welding process with and without using filler metal. For joining this dissimilar metals ER 309L was used as filler material. Hardness and tensile strength are the properties considered for the study. Vikas Chauhan, *et al.* [6] studied the parametric optimization of MIG welding for stainless steel (SS-304) and low carbon steel using Taguchi design method. Three parameters of MIG welding viz. current, voltage and travel speed are taken for the analysis. A plan of experiments based on Taguchi technique has been used to acquire the data. MIG welding process is very successful to join stainless steel (SS304) and low carbon steel. Taguchi method is used to discover the influence of process parameters (current, voltage and welding speed) on the ultimate tensile strength. Cheng-Hsien Kuo *et al.* [7] studied the effect of TIG flux on the performance of dissimilar welds between mild steel G3131 and stainless steel 316L. The experiments were conducted to investigate the effect of CaO, Fe₂O₃, Cr₂O₃ and SiO₂. The surface appearance of TIG welds produced with oxide flux tended to form the residual slag. Improvements in joint penetration and increased weld depth to width ratio were obtained by using SiO₂ powder. Singh N *et al.* [8] performed TIG welding of grade 202 AISI stainless steel and compare the single V butt and double V butt joint at different current rates

by keeping other parameters constant. On the basis of tensile strength, micro hardness and microstructure of weldments it was obtained that the double v joint obtained at high current has more tensile strength, hardness and toughness than the single V joint. Raveendra et. al [9] done experiments to study the effect of pulsed current on the characteristics of weldments by GTAW. To weld 3 mm thick 304 stainless steel welding current 80-83 A and arc travel speed 700-1230 mm/min. More hardness found in the HAZ zone of all the weldments may be due to grain refinement. Higher tensile strength found in the non-pulsed current weldments. It was observed that UTS and YS value of non-pulsed current were more than the parent metal and pulsed current weldments. Arun Nanda et.al[10] investigated the tensile strength of welding joint is maximum 320.4 n/mm² at wire speed 3m/min and 250 amps welding current. The maximum value of micro hardness for weld joint is 444.9 gf/mm² at 3m/min wire speed and 250 amps welding current and for HAZ 431.2 at 250 amp & 3m/min wire speed.

Various Properties of & Applications of SS 202 & SS 304

Grade 202 stain less steel a type of Cr-Ni-Mn stainless with similar properties to A240/SUS 302 stainless steel. The toughness of grade 202 at low temperatures is excellent. It is one of the most widely used precipitation hardening grades, and possesses good corrosion resistance, toughness, high harness, and strength. The following datasheet provides an overview of grade 202 B stainless steel.

Chemical Composition

The chemical composition of grade 202 stainless steel are Iron:68%,chromium:17-19%,Manganese:7.50-10,Nickel:4-6%,Silicon:≤1%,Nitrogen:≤0.25%,Carbon:≤0.15%,Phosphorous:≤0.060 and Sulfur:≤0.030%.

Mechanical Properties

The mechanical properties of grade 202 stainless steel are Tensile strength is 515 MPa, Yield strength is 275 MPa,Elastic modulus is 207 GPa, Poisson's ratio is 0.27-0.30 and Elongation at break is 40%.

Manufacturing Process

The machinability of grade 202 stainless steel produces long, gummy chips. Machining can also be performed in the annealed condition. For heat treatment, the material has to be soaked at 1038°C (1900°F) for 30 min and cooled below 16°C (60°F) for full martensite transformation. The material can be welded by common fusion and resistance methods; however, this steel should not be joined using oxyacetylene welding method. The recommended filler metal is AWS E/ER630. Forging can be done by pre-soaking for 1 h at 1177°C (2150°F). Forging below 1010°C (1850°F) is not advisable.

Applications

The grade 202 steel can be made into plates, sheets, and coils to be used in the following:1.Restaurant equipment,2.Cooking utensils,3.Sinks,4.Automotive trim,5.Architectural applications such as windows and doors,6.Railway cars,7.Trailers and 8.Hose clamps etc.

Properties of Stainless Steel 304

Mechanical Properties for 304 stainless steel alloys - sheet up to 8 mm thick ,Tensile Strength (MPa) is 540 – 750, Proof Stress (MPa) is 230 Min and Elongation A50 mm is 45 Min %.

Mechanical properties for 304 stainless steel alloys - plate from 8 - 75 mm thick, Tensile Strength (MPa) is 520 – 720, Proof Stress (MPa) is 210 Min and Elongation A50 mm is 45 Min %.

Mechanical properties for 304 stainless steel alloys - bar and section up to 160 mm diameter / thickness, Tensile Strength (MPa) is 500-700, Proof Stress (MPa) is 190, Elongation A50 mm is 45 Min %, Hardness Brinell is 215 Max HB.

Physical properties for 304 stainless steel alloys such as Melting point is 1450 °C , Modulus of Elasticity is 193 GPa , Electrical Resistivity is 0.072 x 10⁻⁶ Ω.m , Thermal Conductivity is 16.2 W/m.K , Thermal Expansion is 17.2 x 10⁻⁶ /K and Density is 8.00 g/cm³ .

Corrosion Resistance of Stainless Steel 304

Stainless steel 304 has excellent corrosion resistance in a wide variety of environments and when in contact with different corrosive media. Pitting and crevice corrosion can occur in environments containing chlorides. Stress corrosion cracking can occur at temperatures over 60°C.

Heat Resistance of Stainless Steel 304

Stainless steel 304 has good resistance to oxidation in intermittent service up to 870°C and in continuous service to 925°C. However, continuous use at 425-860°C is not recommended if corrosion resistance in water is required. In this instance 304L is recommended due to its resistance to carbide precipitation. Where high strength is required at temperatures above 500°C and up to 800°C, grade 304H is recommended. This material will retain aqueous corrosion resistance.

Fabrication of Stainless Steel 304

Fabrication of all stainless steels should be done only with tools dedicated to stainless steel materials. Tooling and work surfaces must be thoroughly cleaned before use. These precautions are necessary to avoid cross contamination of stainless steel by easily corroded metals that may discolor the surface of the fabricated product.

Cold Working of Stainless Steel 304

Stainless steel 304 readily work hardens. Fabrication methods involving cold working may require an intermediate annealing stage to alleviate work hardening and avoid tearing or cracking. At the completion of fabrication a full annealing operation should be employed to reduce internal stresses and optimize corrosion resistance.

Hot Working of Stainless Steel 304

Fabrication methods, like forging, that involve hot working should occur after uniform heating to 1149-1260°C. The fabricated components should then be rapidly cooled to ensure maximum corrosion resistance.

Heat Treatment of Stainless Steel 304

Stainless steel 304 cannot be hardened by heat treatment. Solution treatment or annealing can be done by rapid cooling after heating to 1010-1120°C.

Machinability

Stainless steel 304 has good machinability. Machining can be enhanced by using the following rules:

- Cutting edges must be kept sharp. Dull edges cause excess work hardening.
- Cuts should be light but deep enough to prevent work hardening by riding on the surface of the material.
- Chip breakers should be employed to assist in ensuring swarf remains clear of the work.
- Low thermal conductivity of austenitic alloys results in heat concentrating at the cutting edges. This means coolants and lubricants are necessary and must be used in large quantities.

Welding of Stainless Steel 304

Fusion welding performance for Stainless steel 304 is excellent both with and without fillers. Recommended filler rods and electrodes for stainless steel 304 is grade 308 stainless steel. For 304L the recommended filler is 308L. Heavy welded sections may require post-weld annealing. This step is not required for 304L. Grade 321 may be used if post-weld heat treatment is not possible.

Applications of Stainless Steel 304

Stainless steel 304 is typically used in: 1.Sinks and splash backs, 2.Saucepans, 3.Cutlery and flatware, 4. Architectural paneling, 5.Sanitary ware and Troughs, 6.Tubing, 7.Brewery,8. Dairy,9. Food and pharmaceutical production equipment, 10. Springs, 11. Nuts, 12. Bolts and 13. screws.

Supplied Forms

Stainless steel 304 is typically supplied by Aalco in a range of finishes in the following forms: Sheet, Strip, Tube, Quarto plate, Bar, Fittings & Flanges, Pipe and Plate.

The major differences between 202 and 304 stainless steels are in the nickel and chromium contents. SS202 has 16-18% chromium and 0.5-4.0% nickel, whilst SS304 has 18-20% chromium and 8-10.5% nickel. Both are austenitic steels and are essentially non-magnetic, but will become temporarily magnetic by working them. The chemical composition of grade 304 stainless steel is Carbon:0.0-0.07%,Manganese:0.0-1.00%, Silicon:0.0 -1.00%, Phosphorous:0.0-0.05%, Sulfur:0.0 to 0.02%,chromium:17.05-19.50%,Nickel:8.00-10.50%,Nitrogen:0.0-0.11 & Iron: Balance %.

2.EXPERIMENTAL SETUP

Firstly, the stainless steel plates such as SS304 & SS202 of dimensions (40×50×6) mm. Then the Preparation of edge is done to do butt joint welding by TIG & MIG as shown in figure-3,4 & 5.



Fig 3 TIG & MIG Equipments





Fig 4 Alignment of specimen in welding



Fig 5 Butt Joint of SS202 and SS304 by TIG & MIG

Inspection, Testing and Results

Tensile Test

In this experiment, the tensile test has been done both TIG and MIG welded of SS304 and SS202 Plates. The experimental values of both TIG and MIG are as follows.

S.no	Test parameter	Tig welding	Mig welding
1	Tensile load ,n	13290	20142



Fig 6 Specimen under the Tensile Test

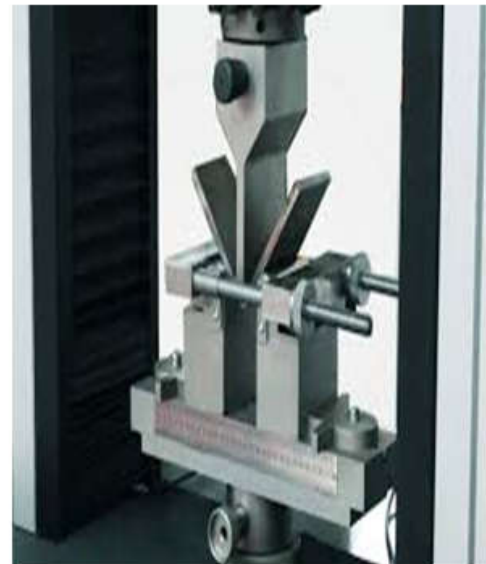


Fig 7 Specimen under the Bending Test

Bending Test

In this experiment, the bending test has been done both TIG and MIG welded of SS304 and SS202 plates . The experimental values of both TIG and MIG welding are as follows.

S.no	Test parameter	Tig welding	Mig welding
1	BEND TEST	Broke at 5123 Newton	Broken at 5523 Newton

Micro Structural Test

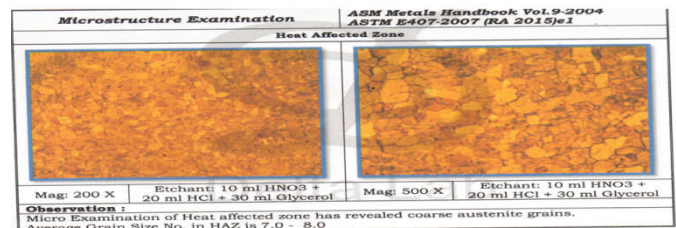


Fig 8 Microstructure Test

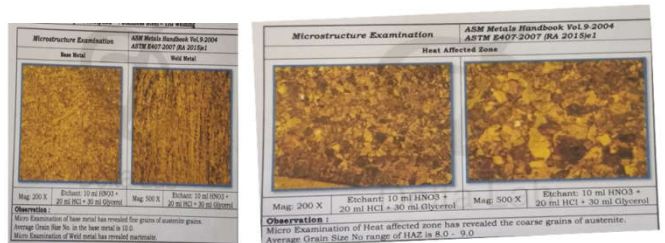


Fig 9 Heat Affected Zone on TIG Welding:

3.CONCLUSION

From the above experiments, the following conclusions have been drawn. In MIG welding micro examination of base metal

has revealed fine uniform austenite grains, average grain size no. in is 9.0-10.0, Micro examination of weld metal has revealed martensite. In micro examination of heat affected zone (HAZ) has revealed coarse austenite grains and average grain size is 7.0-8.0. Similarly in TIG, micro examination of base metal has revealed fine austenite grains, average grain size no. in is 10.0, and micro examination of weld metal has revealed martensite. Micro examination of heat affected zone (HAZ) has revealed the coarse grains of austenite and average grain size no. is 9.0 -10.0. In this experiment from the tensile test, the maximum load carrying capacity of MIG welding is 20142N and in TIG welding is 13290N. During the bending test TIG welded joint is broken at 5123N load whereas MIG welded metal is broken at 5523N. The micro structural test has been done on both MIG and TIG welding with chemical composition of 10 ml of HNO₃+ 20 ml HCL +30 ml Glycerol and finding the values grain size of base metal, weld metal, heat affected zone. It is also observed that, the tensile value is MIG is higher than the TIG as well as bending value of MIG welding is higher than the TIG welding. But the grain size value of TIG is higher than the MIG. The input parameters of MIG and TIG welding such as welding current, arc voltage, welding speed is used as varying process parameters, which plays a vital role in the determination of different properties.

4. FUTURE SCOPE

1. Taguchi method can be used to formulate the experimental layout to control various factors viz., arc voltage, arc current, welding speed, nozzle to work distance and gas pressure predominantly influence weld quality, even plate thickness and backing plate too have their own effect.
2. Investigation can be done on high cycle and low cycle fatigue properties of SS202 and SS 304 welded plates by MIG & TIG welding process.
3. In the welded plates Eddy Current, Radiography and Hardness testing can be done to detect presence of defects like LOP, LOF, Blowhole, and Cracks.
4. Investigation can be done, effect of MIG & TIG processes on weld morphology, angular distortion, delta ferrite content and hardness of welded plates of SS202 & SS304 stainless steel by using different flux like TiO₂, MnO₂, MoO₃, SiO₂ and Al₂O₃ etc.
5. The welded plates can be predicted the hardness, impact strength, depth of penetrations by using MINITAB software.
6. Prediction of the weld pool geometry of SS202 & SS304 stainless steel welded plates using MIG & TIG welding by using fuzzy logic controller.
7. Fume composition and fume generation rate can be analyzed and SEM XEDS & XRF analysis can be done to identify the particle characterization on SS202 & SS304 welded Plates.
8. Tensile load, HAZ, area of penetration, bead width, bead height & bead geometry are greatly improved or optimization can be done by using Taguchi method and Grey relation analysis methods & by ANOVA Method.

Analysis can be Done on SS202 & SS304 Steel Plates by MIG & TIG welded

- ✓ On the basis of effect of process parameters.

- ✓ On the basis of optimization technique.
- ✓ On the basis of residual stress formation during welding process.
- ✓ On the basis of microstructure effect.

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