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Gas Tungsten Arc Welding of AISI 304 Austenitic Stainless Steels

Abhirav Mathur[1], Md Areeb Muneer[2],
S. S. Sricharan[3],
[1,2,3]B. Tech (Mechanical) Student, Vignan Institute of Technology and Science,
Hyderabad-508284, India.

K. Chandra Shekar[4]
[4]Associate Professor, Department of Mechanical Engineering,
Vignan Institute of Technology and Science,
Hyderabad-508284, India.

***Abstract*-The aim of this present experimental work is to evaluate the effect of welding when similar metals of AISI 304 austenitic stainless steel are joined. Gas tungsten arc welding (GTAW) was employed to join the plates. GTAW is an electric arc welding process, which produces an arc between a non-consumable tungsten electrode and the work to be welded in an inert gas atmosphere mainly to avoid atmospheric contamination. Plates of 6mm thickness were joined using a double v-groove in the presence of filler material. The mechanical properties including tensile properties and hardness were analyzed. This experimental study reveals that the ultimate tensile strength of the weld zone is marginally decreased as compared to base metal and the ductility of the base metal is predominantly higher as compared to weld bead. All the properties were correlated with their microstructural analysis.**

Keywords*: *AISI 304; GTAW; Tensile strength.

I. INTRODUCTION

Stainless steels play an important role in the modern world owing to its excellent corrosion resistance. Austenitic stainless steels represent more than 70% of the total stainless steel production in the world. These stainless steels are preferred more than other stainless steel types due to their good weldability [1]. Austenitic stainless steels gathered wide acceptance in the fabrication of pipelines, power plants, refineries, pressure vessels, nuclear reactors, building & bridges, automotive, trucks & trains, ships, offshore structures, aerospace structures and microelectronics [2].They are used in a wide variety of applications when enhanced properties, like corrosion and oxidation resistance, coupled to good mechanical characteristics, are required [3]. According to the classical definition, welding is a process of joining two materials (usually metals) through localized coalescence resulting from a suitable combination of temperature, pressure and metallurgical conditions [4]. Weldability is of great importance for this alloy as welding is largely used for joining of structural components. The preferred welding process for stainless steel is frequently GTAW due to its comparatively easier applicability and better economy. The heat of the arc produced melts the base metal and produces a weld pool. In contrast to normal arc welding, in GTAW, an inert gas shields the weld area in order to prevent air from contaminating the weld. This shielding gas prevents oxidation of the tungsten electrode, the molten weld puddle and the heat-affected zone adjacent to the weld bead [5]. For the thinner section of this alloy, the pulsed current has been found beneficial due to its advantages over the conventional continuous current process [6].Another advantage of GTAW method is, that it allows obtaining a uniform surface which is free of empty spaces, has cellular structure and good quality of the surface [7,8]. Besides the equipment, most important aspect of the GTAW process is the welding parameters used. A weld program consists of a list of welding parameters developed to achieve a specific weld quality and production output. A change in any parameter will have an effect on the final weld quality, so the welding variables normally are written down or stored in the welding equipment memory. For welding in many precision or high-purity applications, a specification may already be written that outlines the recommended welding parameters, including the base material; part diameter(s); weld joint and part fit-up requirements; shield gas type and purity; arc length; and tungsten electrode material, tip geometry, and surface condition [9]. Lenin et al. [10] optimized 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. Du et al. examined the effect of weld bead geometry on tensile strength behavior of thin metal sheet and observed that the geometry of weld bead has significant effect on mechanical properties and micro-structure [11]. In the present experiment the welding parameters were kept constant throughout for all the samples. The specific aim of this experiment is to study the mechanical properties of base metal and its weld bead. All the mechanical properties were correlated with microscopic studies.

II. EXPERIMENTAL

A.Materials

Austenitic stainless steels of AISI 304 were used to study the weldability characteristics. The spectroscopy analysis was performed on the samples and the result is illustrated in Table I.

TABLE I.CHEMICAL COMPOSITION OF AISI 304 ALLOYS

	C%	Mn%	Si%	P%	Cr%	Ni%	Mo%	S%
SS 304	0.03	1.08	0.32	0.026	18.32	8.14	0.12	0.01

B. Specimen Preparation

The test specimens of 6mm thickness were welded using GTAW with a double V groove as shown in the Figure 1. The continuous GTAW was employed to join the materials with the same filler material. The filler material have melting point less than that of the parent metal and are more elastic than the parent metal therefore they prevent cracking (since less contraction stress is produced). Various researchers studied about the effect of filler material on austenitic stainless steel alloys [12]. The double-v groove of the specimens is shown in Fig. 1.

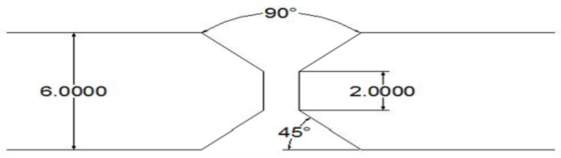


Fig 1.Weld joint preparation

C. Tensile Test

All the tensile properties were calculated as per the ASTM standard A370. The tensile test specimen configuration is shown in Fig. 2 .The specimens were carefully machined using a wire cut electrical discharge machine. The test was carried out using a FIE/UTN-40 universal testing machine. The properties like ultimate tensile strength, percentage of elongation, proof stress and load were calculated.

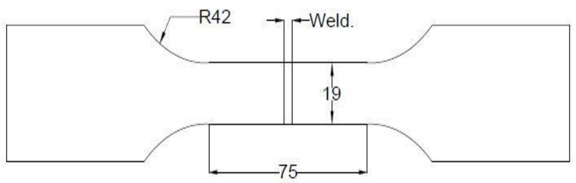


Fig. 2 Specimen configuration for tensile testing

D. Microstructure

In order to predict the reasons behind the variation of properties, microstructure analysis was carried out and volume fraction analysis also evaluated as per the ASTM E 562.

E. Hardness

The standard Brinell test was conducted according to the standard specified by the ASTM.

III. RESULTS AND DISCUSIONS

A. Tensile Test

The maximum load bearing capacity is 50kN,74kN for AISI 304 parent metal and welded sample respectively.The ultimate tensile strength of base metal is slightly higer , this may be due to the lower amount of ferrite. The amount of ductility of the base metal is significantly higher as compared to the weld bead. This is unambiguously reflected in the microstructure analysis i.e. more amount of ferrite and less amount of austinite phase in the base metal.this is clearly shown in Table III.All the tensile properties are shown in Table II. The load vs. diaplacement plot of base metal is shown in Fig.4. The plot clearly shows stable crack extension after attaining peak load. This clearly indicates toughninhg mechanism is amenable for this material .The weld bead load vs. displacement plot shows sudden faliure of material after reaching the peak load . This may be due to the fact that less amount of ferrite (most ductile) phase in the weld bead. This may be resulted because of post weld heat treatment .

TABLE II. TENSILE TEST RESULTS OF SS 304 AND ITS WELD BEAD

Material	Ultimate tensile strength N/mm2	Ultimate Load kN	% in elongation
SS 304 Base Metal	682.861	50.320	49.600
SS 304 Weld Bead	670.255	74.7200	4.00.

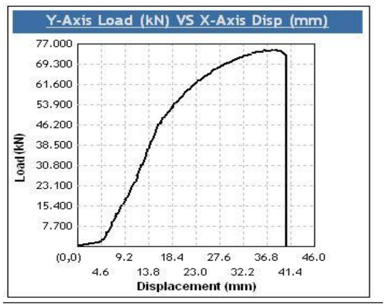


Fig.3 Load vs displacement plot

of Weld bead

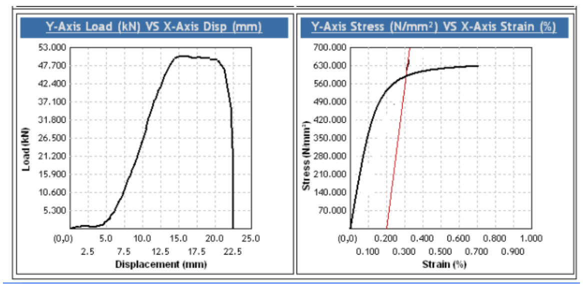


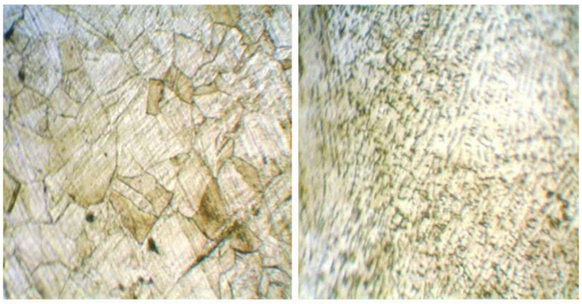
Fig.4 Base metal

B. Hardness.

The hardness value of base metal and weld bead were evaluated by using Brinell hardness. The obtained hardness value for 304 Base metals is 165BHN; the same for its weld bead is 190BHN. The enhancement is weld bead hardness due to the change in phases after welding process. The Table III and Figure 5 and Figure 6 reveal that Base metal consists of more amount of ferrite than weld bead. This may be due to normalizing process after welding process. The lower hardness of Base metal is owing to the presence of ductile phase in the matrix

TABLE III. DISTRIBUTION OF PHASE OF 304 METAL

	Ferrite %	Austenite %
Base Metal	40	58
Weld bead	31	67



Micrographs of Fig. 5 Base metal and Fig.6 Weld bead

IV. CONCLUSION

The AISI 304 stainless steel plates were successfully joined by using GTAW. In these study properties of GTAW welds have been studied. The tensile strength of base metal is marginally greater as compared to weld bead. The amount of ductility is significantly higher for base metal as compared to weld bead, this may be due to post weld heat treatment and due to the presence of various alloying elements especially lower amount of molybdenum and nickel.

V. REFERENCES

[1] Sharifitabar M, Halvaee A, KhorshahianS. Microstructure and mechanical properties of resistance upset butt welded 304 austenitic stainless steel joints [J]. *Materials and Design, 2011, 32: 3854–38*

[2] Prasad Rao K, G.M. Reddy and A.A. Gokhale, Grain refinement and improvement of strength and ductility of welds by pulsed current and magnetic arc oscillation techniques, *International Welding Conference, New Delhi, 1999 : 1050-105564*

[3] M. Rosso, Contribution to study and development of PM stainless steels with improved properties, *Journal of Achievements in Materials and Manufacturing Engineering 24 (2007) 178–187*

[4] *ASM Handbook, Welding, Brazing, Soldering; vol6, ISBN: 0-87170-377-7*(V.1), Printed in USA.

[5] Olson D.L., Siewert T.A., Liu S. & Edwards G.R, *"ASM Hand-Book Vol.6, Welding, Brazing and Soldering, Fourth Edition, (1997),*The Materials Information Society, U.S.A

[6] L.A. Dobrzański, Z. Brytan, M. Actis Grande, M. Rosso, Corrosion resistance of sintered duplex stainless steel evaluated by electrochemical method, Worldwide *Journal of Achievements in Materials and Manufacturing 17 (2006) 317–320.*

[7] A. Wrońska, A. Dudek, J. Selejdak, Surface re melting of multiphase sintered steel, *Communications: Scientific Letters of the University of Zilina 14 (4A) (2012) 48–53.*

[8] A. Wrońska, A. Dudek, E. Wijata, Wpływprzetapianiametodą TIG namikrostrukturę i własnościspiekanychstali duplex, in: *XIII International Scientific Conference New Technologies and Achievements in Metallurgy and Materials Engineering, Częstochowa, 2012, pp. 728–731.*

[9] Determining parameters for Gas Tungsten Arc Welding Starting points for success, By Bernard Mannion and Jack Heinzman .

[10] Lenin N., Sivakumar M., Vigneshkumar.D, "Process parameter optimization in ARC welding of dissimilar metals", *ThammasatInt.J.Sc. Tech, Vol.15, No.3, 2010.*

[11] Du J,Longobardi J,LathamWP,KarA. Weld geometry and tensile strength in laser welded thin sheet metals .*Sci Technology Weld Joining 20005/5:304–9.*

[12] L. Hollandthe properties of some reactively sputtered metal oxide films Vacuum, *Volume 3, Issue 4, Pages 375-391.*