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Experimental Investigation of Welding Characteristics of EN8 and EN31 Alloy Steel Using GTA Welding Process

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Abstract. Welds made using a non-consumable electrode are known as "TIG" or "Tungsten Inert Gas" welds, and the two terms refer to the same method. The shielding gas (typically an inert gas like as argon) protects the weld region from ambient contamination, and a filler metal is generally utilized, however certain welding known as autogenous welds do not need it. As the welding current increases, so does the amount of plasma created by the constant–current welding power source. In this experiment, constant current TIG welding was used to make EN8 and EN31 weldments, as well as dissimilar composition metal weldments (EN8&EN31). All of these weldments were subjected to destructive and non-destructive testing, including liquid penetrant, radiography, hardness and tensile strength evaluations. We finish by comparing weldments made from metals of the same and different compositions that were made using the Gas Tungsten Arc Welding technique.

Keywords: Alloy steel EN8, Alloy steel EN31, Gas Tungsten Arc Welding, Constant Current Welding.

INTRODUCTION

Gas to form the weld, the Tungsten Arc Welding (GTAW) procedure makes use of a non-consumable electrode, commonly known as Tungsten Inert Gas (TIG) welding. Although autogenous welds do not need a filler metal, shielding gas (typically an inert gas such as argon) protects the weld region from air contamination. A plasma is a column of highly ionized gas and metal vapor that conducts energy across the arc in a constant current welding power source. GTAW is most typically used to complete operations such as shielded metal arc welding and gas metal arc welding by welding tiny pieces of stainless steel and non-ferrous metals such as aluminium, magnesium and over the weld metal. GTAW, on the other hand, is a lot more complicated and harder to learn. It's a lot slower than the majority of the other welding methods [1-3].

WELDING DISSIMILAR COMPOSITION METALS

Due to the difficulty in fusing different metal types, GTAW welding faces a new set of challenges. There are several uses for welding dissimilar metals in production, maintenance operations, and corrosion and oxidation prevention [4-5]. It is possible to use a filler metal that is the same as or different from the base metal when connecting stainless steel and carbon steel, such as utilising nickel filler metal to join cast iron and steel. In some of these connections, the bed is formed using a filler metal. When cladding or putting down incompatible materials, GTAW may be used to coat or butter the materials with a substance suitable with a certain filler metal. There must be a precise fit between the different metals in order to weld them. Pulsed current is especially advantageous for these applications

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because it reduces the amount of heat that is absorbed by the base material. To avoid diluting the base metals, the filler metal should be applied fast and a huge weldpool should be avoided [6-7].

PULSED CURRENT WELDING

The welding current quickly varies between two levels while using pulsed current [8-9]. Pulsed current is a higher current condition during which the weld area is required and fusion takes place. Dropping the welding current allows the weld to cool and harden. PWM GTAW provides many benefits, including a decreased heat input and as a result more efficient operation. Reduced distortion and warpage in thin work pieces. Increased penetration, speed, and quality of the weld may all be achieved. It is possible to set a precise rate and magnitude of current fluctuations in GTAW, making it beneficial for specific applications [10].

EXPERIMENTAL PROCEDURE

EN31 and EN8 6mm thick work parts were used. Using Gas Tungsten Arc Welding, the test specimens were machined to 150mmx300mm and welded. There were less weld fractures when ER70S2 filler wire was utilised during welding compared to other metals. This copper alloy filler is used. The method gives the operator the ability to make their own decisions. In order to weld work parts of EN8 and EN31, a Mastering AC/DC 3500W GTAW machine was employed. Selecting the correct Tungsten electrode relies on the kind of welding current being used. For DCSP welding, zirconated tungsten electrodes (EWZr) work best because they maintain a hemispherical form, whereas thoriated tungsten electrodes (EWTh-2) that have been ground to a taper work best. We used a 2mm, 3mm diameter, 2% zirconated tungsten electrode to weld the work pieces. Tables 6 and 7 provide the welding settings for two distinct materials. Figure 1 depicts the weld specimens' edge preparation. After the welding process was completed, the weldments were subjected to radiography, liquid Penetrant testing, and mechanical testing (fig. 3), all in accordance with ASTM standards (section viii, division 2, for radiography, and ASTME-1417, for liquid Penetrant testing, as noted above). Tables 8 and 9 provide the non-destructive testing settings [11-12].
It was studied mechanically and microstructurally. All welding current and gas 95 % trust in the model Welding current and welding speed were significant process variables. Corrosion affects tensile pro 2219 Al alloy gas welded This research employs two methodologies: numeric Weld tensile strength decreases with penetration depth. A tighter capping weld prevents fractures. Helium or voltage boosts assist. [13] studied SAF2205/AISISS316. To achieve defect-free dissimilar connections, the torch should be deviated by 0-1 mm. It outperforms the AISI SS316 base steel. Astenite phase fraction enhances strength. For SAF2205 and AISISS316 stainless steel connectors. Jorg Baumgartner These tests assess joint stress. Welds and other structural elements need careful documentation. Oxidation was observed solely on the backsides of the samples to better understand their microstructures and microhardness's. TIG joints: 3 zones (WNZ, HAZ, and BMZ). A mix of WD and NM in the WNZ. The first and third joints lack the section microstructure top surface. The second is a mix. The three FSSP characteristics are 7% harder than base material. With ERSS316 alloy filler material, they optimized DSS 2205 tungsten inert gas arc welding settings Weld thickness and tensile characteristics are examined to find the optimal process parameters [14-16].
ANOVA and Taguchi orthogonal arrays find the best research model. It increases the weld joint quality. Author investigated the microstructure and mechanical properties of TIG–CMT hybrid 6061-T6 aluminium joints. Improving hybrid CMT-TIG welds microstructural and mechanical TIG arc improves weld penetration and reduces CMT Our current expands grain and HAZ. Alloy hybrid welding saves T. TIG welded unusual metals [17]. Mechanical and metallurgical properties of a MoO3 flux welded joint Anodized TIG welding lowers the length of carbon-enriched/depleted zones at the P22 steel-weld contact. Testing of all P22 steel base metal joints failed. Improves impact toughness Masoud Sabzi and colleagues investigated a TIG-welded Ni-tungsten carbide nanocomposite coating on St37 steel.
TIG 150 Amps St37 steel with wrought iron nanoparticles and pure nickel powder (in 5, 10, 15, and 20 percent wt percent). Wear and corrosion resistance increased by tungsten carbide nanoparticles. When the amount of Ni-tungsten carbide nanocomposite covering tungsten carbide nanoparticles expanded, the wear process changed to adhesive-oxidation. Hui Li et colleagues studied A-TIG and VPTIG TIG joints. These active compounds may minimise porosity, heat-affected zone, and thermal impact in base metal welds. Porous VPTIG metal TIG and VPTIG welded DCEN A-TIG Wang et al. Hotter than TIG weld pool. Auxiliary flow regulation (0–100 Pa). A-TIG weld pool heat convection is induced. TIG welding produces a weld pool that is shallow yet deep. DK A2O3 had the least penetration and weld breadth in Gope et al's investigation. The varying cooling rates affect the microstructures. A-hardness But

BM, HAZ, and FZ altered. AA6082 Ti/Sr TIGW w/AA4043 w/ Ti and Sr coupled may impact (Al) dendrites and eutectic Si phases. Welds with 0.08 Ti and 0.025 Sr additional [18-19].

Protecting the weld area from oxidation and contamination is the goal of GTAW. GTAW is often used to join metals. Recent GTA welding studies demonstrate that depending on heat input, a combination of welding parameters (welding speed, voltage, and current) results in sub-optimal welded connections. The size of an electrode determines the size of the DC power source. Tolerances in TIG arc length might be centimeters. Changing arc length has no influence on welding current while hand welding. If the electrode is not shorted, too much current kills it. A/R sup Intercepted alternating electricity is rectified and raised above the utility grid's. Before welding, high voltage alternating current is rectified. smaller transformers, inductors, and capacitors It is a parameter. Faster welding reduces penetration and weld strength. Weld penetration, bead size Affects current Reduces undercut, porosity and irregular bead morphologies while increasing wetting action. Rapid heating and cooling may cause material loss. The permissible weld speed range decreases with thickness. and arc length Each affects voltage. Inflating and flattening the arc Weld re-en Porous, arc-instable material. Longer arcs use less current. It was 342.2 MPa in compression at 95 amps, 60 mm/s speed, and 17 volts arc voltage. Welding considerations include filler diameter, material, and argon flow rate. Changing one of these parameters generally alters others [20].

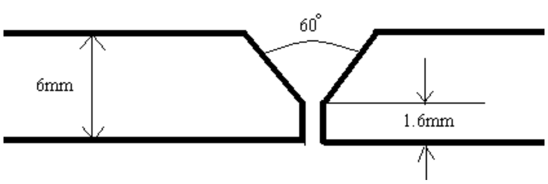

Figure 1. Edge preparation of weld specimen

Figure 2. Master TIGAC/DC3500W

Figure 3. Welded Specimen

Table 1. Chemical Compositions of work material EN8

EN8 Material Chemical Composition %wt								
Material	C	Mn	Si	S	P	Mo	Ni	Cr
EN8	0.35-0.45	0.6-1.0	0.1-0.35	0.05	0.05	---	--	--

Table 2. Chemical Composition of work material EN31

Material	C	Mn	Si	S	P	Cr
EN31	0.9-1.2	0.3-0.75	0.1-0.35	0.04	0.04	1.0-1.6

Table 3. Chemical Compositions of filler wire ER70S2

	Chemical Composition %wt					
Material	C	Mn	Si	Titanium	Zr	Al
ER70S2	0.07	0.9-1.4	0.4-0.7	0.05-0.15	0.02-0.12	.05-0.15

Table 4. Mechanical properties of EN8 & EN31Alloy steels at heat treated condition

Material	UTS (N/mm^2)	0.2%Y.S (N/mm^2)	%Elongation
EN8	700-850	465	16
EN31	250-300	186	12

Table 5. Welding Parameters of constant current welding of EN8 Alloy Steel

Material Thickness(mm)	Weld Layer	Filler Wire dia (mm)	Polarity	I (amp)	V (volts)	ARC Travel Speed(cm/min)
6	Root	1.6	DCSP	81	10	7.0
6	1^{st} Layer	2.5	DCSP	83	12	8.0
6	2^{nd} Layer	2.5	DCSP	83	12	7.5

Table 6. Welding Parameters of constant current welding of EN31 Alloy Steel

Material Thickness (mm)	Weld Layer	Filler Wire dia (mm)	Polarity	I (amp)	V (volts)	ARC Travel speed(cm/min)
6	Root	1.6	DCSP	83	11	8.0
6	Ist Layer	2.5	DCSP	84	12	8.5
6	2nd Layer	2.5	DCSP	85	12	8.6

Table 7. Welding parameters for constant current welding of dissimilar chemical composition Alloy steels EN8 & EN31.

Materia lThickn ess(mm)	Weld Layer	Filler Wiredia(mm)	Polarit y	I(amp)	V (volts)	ARC Travel Speed(cm/min)
6	Root	1.6	DCSP	81	10	7.5
6	Ist Layer	2.5	DCSP	82	12	8.0
6	2nd Layer	2.5	DCSP	84	12	8.5

Table 8. Radiography test parameters EN8 & EN31 Alloy steels

Exposure Parameters	Voltage(KV)	145
	Current(mA)	3.5
	Time(min)	3.5
	Film Used	AA400
	SFD (min)	0.7
	Penetra meter	A1-10-16
Processing Parameters	Developer Time in)	5.0
	Stop Bath Time min)	0.5
	Fixer Time(min)	10

Table 9. Liquid Penetrate Test parameters

DPDIT	MAGNAFLUX
Penetrant Used	SKL-SP
Cleaner Used	SKC-1
Developer Used	SKD-S2
Dwell Time 3 (at room temp)	10min
Viewing Media	Normal Light
Sensitivity	30 microns

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Table 10. The radiography test results

S.No	Weldments	Result
1	EN8&EN8	Cluster porosity(3mm)
2	EN8&EN8	Cluster porosity(3.2mm)
3	EN8&EN8	Cluster porosity(3.3mm)
4	EN31&EN31	Cluster porosity(3.2mm)
5	EN31&EN31	Cluster porosity(3.4mm)
6	EN31&EN31	Cluster porosity(3.3mm)
7	EN8&EN31	Cluster porosity(3.6mm)
8	EN8&EN31	Cluster porosity(3.8mm)
9	EN8&EN31	Cluster porosity(3.6mm)
Sensitivity 2%		

Table 11. Liquid Penetrate test results

S.No	Weldments	Result
1	EN8 & EN8	No defect observed on welded area
2	EN31 & EN31	No defect observed on welded area
3	EN8 & EN31	No defect observed on welded area

Table 12. Hardness test results

S.No	Weldments	Hardness (BHN)
1	EN8 & EN8	166-171
2	EN31 & EN31	466-513
3	EN8 & EN31	271-304

Table 13. Tensile strength test results

S.no	Weldments	Tensile strength(N/mm^2)
1	EN8 & EN8	765
2	EN31 & EN31	292
3	EN8 & EN31	334

Metal yields while cooling because its melting temperature is lower than that of base metals, owing to its greater flexibility and capacity to tolerate contraction forces that may lead to cracking. Detailed information on the chemical composition and mechanical properties of the work material and filler wires is provided in tables 1 to 4. After rough polishing using 400-grit EN8, EN31 abrasive paper and a pneumatic rotary brush to remove surface flaws, the parts were washed in acetone to remove any remaining residue.

RESULTS AND DISCUSSIONS

A lack of control over heat input, i.e. excessive melting at the base metal by continuous current Gas Tungsten Arc Welding, may explain the porous weldments. The results of the liquid Penetrant test showed no flaws at all, EN8 & EN31 welds have a hardness rating that is halfway between EN8 & EN8 welds and EN31 & EN31 welds. Because EN31 weldments have a higher amount of carbon, their tensile strength is lower than that of EN8 & EN8 weldments or EN8 & EN31 weldments.

CONCLUSIONS

Welding properties of the weldments were studied in this experimental study by welding EN8 and EN31 plates of 6mm thickness with constant current GTAW, radiography, liquid Penetrant, hardness and tensile testing. Constant current Gas Tungsten Arc welding produces weldments that are porous. Pulsed Current TIG welding may eliminate this issue. To minimize excessive base metal melting while welding metals of different composition, pulsed current welding is a preferred method (controls heat input to base metal). There are many benefits to using pulsed current GTAW, including decreased heat input, less distortion, and reduced warpage in thin work components. As a result of this, the weld pool can be better controlled, and penetration, welding speed, and quality may all be improved.

REFERENCES

1. U Natarajan, R Malayala murthi,‘ Evaluating mechanical and metallurgical properties of gas tungsten arc welded AA5059aluminium alloy joints’,MaterialsToday:Proceeding, 2019.
2. Arun kumar Sivaraman, Sathiya Paulraj, ‘Multi-Response Optimization of Process Parameters for MIG Welding of AA2219-T87by Taguchi Grey Relational Analysis’, Materials Today: Proceedings, 4:8892–8900(2017).
3. Konda, Jayarami Reddy, et al. "Effect of non-uniform heat source/sink on MHD boundary layer flow and melting heat transfer of Williamson nanofluid in porous medium." Multidiscipline Modeling in Materials and Structures 15(2): 452-472 (2018).
4. Jorg Baumgartner, HalidCan Yıldırım,& ZuheirBarsoum,‘Fatigue strength assessment of TIG-dressed welded steel joints by local approaches’, International Journal of Fatigue, vol,126,pp, 72-78,2019.
5. Xia-Wei Yang, Wen-ya LI, Hong-Yu Li, Shuo-tian YA, Oyi-Xuan Sun,Yi-Xian Sun, &Lumei, ‘Microstructures and micro hardness for sheets and TIG welded joints of TA15 alloy using friction stir spot processing’, Transactions of Nonferrous Metals Society of China,vol,28,no,1,pp,55-65, 2018.
6. A.Balaram Naik, A, Chennakeshava Reddy, ‘Optimization of tensile strength in TIG welding using the Taguchi method and analysis of variance (ANOVA)’,ThermalScienceandEngineeringprogress,vol,8,pp,327-339, 2018.
7. Ying Liang, Junqi Shen, Shengsun Hu, Haichao, Wang, &Jie Pang,‘Effectof TIG current on microstructural and mechanical propertiesof 6061-T6 aluminium alloy joints by TIG–CMT hybrid welding’, Journal of Materials Processing Technology, vol, 255, pp,161-174, 2018.
8. Verma, Tikendra Nath, et al. "Experimental and empirical investigation of a CI engine fuelled with blends of diesel and roselle biodiesel." Scientific Reports 11(1): 1-23 (2021).
9. Masoud Sabzi, Saeid Mersagh Dezfuli, & Sadegh Moeini Far, “Deposition of Ni-tungsten carbide nano composite coating by TIG Welding, Ceramics International, vol, 44, no, 18, pp, 22816-22829, 2018.
10. Kumar, Ch Ashok, S. Udaya Bhaskar, and N. Srinivasa Rajneesh. "Fatigue analysis of four cylinder engine crank shaft." AIP Conference Proceedings. Vol. 2358. No. 1. AIP Publishing LLC, 2021.
11. Rajneesh, N. Srinivasa, et al. "Investigation on mechanical properties of composite for different proportion of natural fibres with epoxy resin." AIP Conference Proceedings. Vol. 2358. No. 1. AIP Publishing LLC, 2021.

12. Dasore, Abhishek, K. Ramakrishna, and B. Kiran Naik. "Evaluation of heat and mass transfer coefficients at beetroot-air interface during convective drying." Interfacial Phenomena and Heat Transfer 8(4):303-319 (2020).
13. Rajneesh, N. Srinivasa, Ch Ashok Kumar, and S. Udaya Bhaskar. "Analysis of surface finish and residual stresses with shot peening on cylindrical specimens." Materials Today: Proceedings 44 (2021): 2606-2610
14. Subramanyam Pavuluri, B.Sidda Reddy, B.Durga Prasad, "An Experimental Investigation on the Performance, Combustion and Emission Characteristics of CI Diesel Engine at Various Compression Ratios with Different Ethanol-Biodiesel Blends", International Journal of Advanced Science and Technology, Vol. 29, No.5, pp. 2215-2226, 2020.
15. Gupta, Sachin, et al. "Thermodynamic analysis and effects of replacing HFC by fourth-generation refrigerants in VCR systems." International Journal of Air-Conditioning and Refrigeration 26.02 (2018): 1850013.
16. Returi, Madhuri Charulatha, Ramakrishna Konijeti, and Abhishek Dasore. "Heat transfer enhancement using hybrid nanofluids in spiral plate heat exchangers." Heat Transfer—Asian Research 48(7):3128-3143,(2019).
17. Subramanyam Pavuluri, Dr.B.Sidda Reddy, Dr.B.Durga Prasad. (2020). An Experimental Investigation on the Performance, Combustion and Emission Characteristics of CI Diesel Engine at Various Compression Ratios with Different Ethanol-Biodiesel Blends. International Journal of Advanced Science and Technology, 29(05), 2215-2226.
18. B. Sidda Reddy, A. Aruna Kumari, J. Suresh Kumar, K. Vijaya Kumar Reddy. Application Of Taguchi and Response Surface Methodology For Biodiesel Production From Alkali Catalysed Transesterification Of Waste Cooking Oil, International Journal of Applied Engineering Research, Vol. 4 (7), pp. 1169–1184, 2009.
19. B. Sidda Reddy, A. V. Hari Babu, S. Sreenivaslulu, K. Vijaya Kumar Reddy, Prediction of C. I. Engine Performance and NOX Emission Using CANFISInternational Journal of Applied Engineering Research, Vol. 5 (5), pp. 763–778, 2010.
20. B. Sidda Reddy, J. Suresh Kumar and K. Vijaya Kumar Reddy, "Response Surface Methodology As A Predictive Tool For C. I Engine Performance and Exhaust Emissions of Methyl Esters of Mahua Oil", Journal on future Engineering & Technology, Vol.4, No.3, PP. 51-58, Februaryt-April2009. https://doi.org/10.26634/jfet.4.3.280