The Effects of Power Input and Welding Speed on Corrosion Rate of Steel Welds in Acidic Medium

Comment [Dr. Nas1]: The title is suggested to be changed, because there is a similarity with the title: EFFECT OF WELDING HEAT INPUT ON THE CORROSION RATE OF CARBON STEEL MMA WELDING
in the journal: International Journal of Innovation in Mechanical Engineering & Advanced Materials (IJIMEAM), Vol.3 (No.1). 2021.pp. 26-31, Published online: June 4, 2021. ISSN: 2477-541X
Link:
https://www.researchgate.net/publication/352154406_EFFECT_OF_WELDING_HEAT_INPUT_ON_THE_CORROSION_RATE_OF_CARBON_STEEL_MMA_WELDING/link/60bd791f299bf10dffa14096/download

Abstract

This work investigated the effects of power input and welding speed on the corrosion rate of low carbon steel welds in one molar tetraoxosulphate (VI) acid (H_2SO_4) solution. Locally available low carbon steel rod (Ø12mm) used for this study was cut into various samples Ø12mm × 50mm with the aid of hacksaw. The samples were further processed through machining and categorized as plane face and double-V edge after machining. Shielded Metal Arc Welding (SMAW) was used for welding those joints at different power input and welding speed. Weight loss method was employed to evaluate the corrosion rate of the welded joints in the tested medium. It was discovered from the study that welding speed and power input have significant roles to play in either lowering or increasing the corrosion rate of the low carbon steel welded joints in one molartetraoxosulphate (VI) acid solution. The plane face and double-V edge low carbon steel welded joints corrodes less at moderately medium power input/welding speed and more at higher power input/welding speed.

Comment [Dr. Nas2]: It is recommended to write down the number of samples used, so that the statements conveyed can be measured
The number of samples determines the results of the study

Comment [Dr. Nas3]:

Comment [Dr. Nas4]: at moderate power input/weld speeds and even more so at higher power input/weld speeds.

Keywords: Power input, Welding speed, Low carbon steel, Tetraoxosulphate (IV) acid, Corrosion rate

Comment [Dr. Nas5]: keywords are suggested to be written in alphabetical order

1. Introduction

Comment [Dr. Nas6]: It is necessary to add the novelty and superiority of this research from previous studies

Welding is one of the different processes used in the fabrication of metal structure to produce a design or desired shape. It is a process of joining two or more similar or/and dissimilar metals to achieve complete coalescence [9]. There are different types of welding, among others are shielded metal arc welding, submerge arc welding, gas metal arc welding, plasma arc welding, gas tungsten arc welding, projection welding, resistance welding [7].Shielded metal arc welding (SMAW) technique is preferable to the other techniques because of its low cost, flexibility, portability and versatility. Both the equipment and electrodes are low in cost and very simple. SMAW is very flexible in terms of the material thicknesses that can be welded (materials from 1/16" thick to several inches thick can be

Comment [Dr. Nas7]: references are written sequentially, why does it start with the number 9. Follow the rules for writing references

Comment [Dr. Nas8]: It is recommended to use Mendeley for writing references welded with the same machine and different settings). It is a very portable process because all that's required is a portable power supply (i.e. generator). Finally, it's quite versatile because it can weld many different types of metals, including cast iron, steel, nickel & aluminum. However, its limitations are that it produces a lot of smoke & sparks, there is a lot of post-weld clean-up needed if the welded areas are to look presentable, it is a fairly slow welding process and it requires a lot of operator skill to produce consistent quality welds[6].

Comment [Dr. Nas9]: This sentence is too long, it is recommended to correct it

During welding, the work pieces to be joined are melted at the joining interface and usually a filler material is added to form a pool of molten material (the weld pool) that solidifies to become a strong joint. Welding is currently used for fabrication and construction of a variety of structures in buildings, bridges, ships, offshore structures, boilers, storage tanks, pressure vessels, pipelines, automobiles and rolling stock [4] [5].

Comment [Dr. Nas10]: filler material that is usually used should be written down. So the statement has certainty

Comment [Dr. Nas11]: Follow the way of writing references according to scientific rules

Welding involves a wide range of scientific variables such as time, temperature, electrode, power input and welding speed [11] [13] [14] [12].Omiogbemi[15] investigated the effects of gas metal arc welding parameters on the mechanical and corrosion behavior of ASS in some environments using design expert software. Gharibshahiyan et al. [8] investigated that with the increase in voltage, the grain size number decreased in case of low carbon welded steel using inert gas welding. Afolabi [1] also investigated the effect of electric arc welding (Shielded Metal Arc Welding) parameters (power input, weld geometry, welding speed and post-weld heat treatment) on the corrosion behavior of austenitic stainless steel in chloride medium. The results show that the best electrode for welding stainless steel is a stainless steel-core electrode.

Comment [Dr. Nas12]: Follow the way of writing references according to scientific rules

Comment [Dr. Nas13]: This statement is for which research results

Many research findings have proved that improper techniques employed in welding may lead to serious consequences of the structures [2] [16]. Failures as a result of poor mechanical properties and corrosion resistance have also found their places in the annals of times, from household equipment to industrial structures such as railways, road bridges, storage tanks and ocean liners. One of such failures is the

Comment [Dr. Nas14]: Follow the way of writing references according to scientific rules corrosion cracking of a grade 304 stainless steel pipe improperly seam welded and meant for the conveying of glucose solution in Illinois USA [10]. The Point Pleasant bridge disaster in Ohio was also traced to stress corrosion initiated during welding [3]. Many other failures have proved to be welding prone or propagated. It is therefore of great importance to study the effects of some selected welding variables such as power input and welding speed on the corrosion behavior of steel welds in one molar tetraoxosulphate (VI) acid solution.

2. Materials and Methods

2.1 Materials and Equipment

Comment [Dr. Nas15]: add the origin of the material and the specification of the material used

The materials used for this study include mild steel rodØ12mm,emery cloth, electrode gauge 12 and one molar tetraoxosulphate (VI) acid solution (H_2SO_4). The equipment used includesShielded Metal Arc Welding machine (SMAW), measuring cylinders, beakers, vice, hacksaw, digital weighing machine and blower. The chemical analysis of the steel rod was carried out to show its composition and the result is presented in Table 1. The table shows that the rod contains 0.1821% carbon and 98.1339% iron.

Table 1: Chemical Composition of the Low Carbon SteelSteel Used

Elements	Composition (%)	Element	Composition (%)
C	0.1821	As	0.0044
Si	0.2412	W	0.0032
Mn	0.7210	Pb	0.0017
P	0.0341	Sn	0.0428
S	0.0398	Co	0.0095
Cr	0.1082	Al	0.0092
Ni	0.1120	Ca	0.0001
Mo	0.0140	Zn	0.0064
Cu	0.3412	Fe	98.1339
V	0.00165		

2.2 Sample Preparation

The mild steel rod Ø12mm was cut into various samples Ø12mm by 50mm each with the aid of hacksaw. Facing and turning operations of the samples were done on the lathe machine. The samples were cleaned from dirt using emery cloth. Edge preparations were carried out in order to have samples such as double V edge and plane face as shown in Fig. 1.

Comment [Dr. Nas16]: If this sample preparation was referenced from a journal or other source, write it down

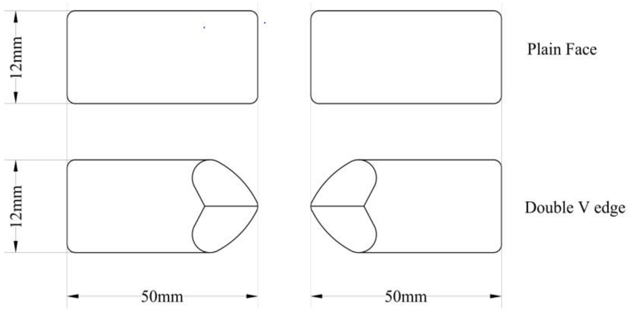

Fig. 1: Joint Samples for the Corrosion Test

2.3 Welding Technique

The welding technique employed in this work is Shielded Metal Arc Welding (SMAW). Electrode gauge 12 was used as welding electrode while the welding current were varied with the voltage fixed at 220V to obtain welding at different power input and welding speed.

Comment [Dr. Nas17]: write down the reference

2.4Corrosion Test

The method of corrosion test employed is laboratory test which involves full immersion of the samples and coupons weight loss determination in line with American Standard of Testing and Materials (ASTM, 2004). Weight loss method was used to evaluate the corrosion rate. Weight loss is the measure of difference between the original mass of the sample before immersion (m_1) and the mass of the same sample after immersion and cleaning (m_2). The corrosion rate is calculated in mils per year using the formula given by

Comment [Dr. Nas18]: Add ASTM number

$Corrosion\ Rate = \frac{KW}{DAT}$mpy

Comment [Dr. Nas19]: If the formula used is quoted from a reference, write it down

Comment [Dr. Nas20]:

Where K=534 (corrosion rate constant), W= weight loss in gram, D = 7.86g/cm^3 for mild steel (density of the material), A = total area of exposure = 4cm^2, T = exposure time in hours, mpy = mils per year (corrosion rate unit)

3. Results and Discussion

Comment [Dr. Nas21]: Add quotes to the discussion, to strengthen statements

The chemical analysis of the steel rod was carried out by X-ray Spectrometer to show its composition and the result is shown in Table 1. The table shows that the rod is low carbon steel that contains 0.182% carbon and 98.1339% iron.

Comment [Dr. Nas22]: This X-Ray Spectrometer specification is added to the research method

Tables 2 and 3 show the corrosion rate of the various welded joints obtained by weight loss method at an interval of 120 hours (5 days) and for a period of 840 hours (35 days) of full immersion of each welded joint in tetraoxosulphate (VI) acid solution.

Comment [Dr. Nas23]: The specifications of the welding equipment used are added to the research method

Table 2: Corrosion Rate of Plain Face Welded Samples at Different Power Input and Welding Speed in tetraoxosulphate (VI) acid solution

POWER INPUT/ WELDING SPEED	CORROSION RATE (mpy)						
	120hrs	**240hrs**	**360hrs**	**480hrs**	**600hrs**	**720hrs**	**840hrs**
16.5kW 15cm/min	0.1597	0.1598	0.1598	0.1598	0.1598	0.1598	0.1599
16.5kW 12cm/min	0.1413	0.1415	0.1415	0.1415	0.1415	0.1415	0.1415
16.5kW 10cm/min	0.149	0.149	0.149	0.149	0.1605	0.149	0.149
19.8kW 15cm/min	0.3002	0.3003	0.3004	0.3007	0.3003	0.3005	0.3004
19.8kW 12cm/min	0.1731	0.1731	0.1744	0.1745	0.1747	0.1747	0.1745
19.8kW 10cm/min	0.1995	0.1995	0.1995	0.1995	0.1995	0.1995	0.1997

Table 3: Corrosion Rate of Double-V Edge Welded Samples at Different Power Input and Welding Speed in tetraoxosulphate (VI) acid solution

POWER INPUT/ WELDING SPEED	CORROSION RATE (mpy)						
	120hrs	240hrs	360hrs	480hrs	600hrs	720hrs	840hrs
16.5kW 15cm/min	0.1119	0.1125	0.1127	0.1128	0.1128	0.1128	0.1129
16.5kW 12cm/min	0.0644	0.0644	0.0644	0.0645	0.0645	0.0645	0.0645
16.5kW 10cm/min	0.1245	0.1182	0.1161	0.1151	0.1145	0.1141	0.1138
19.8kW 15cm/min	0.1376	0.1377	0.138	0.1381	0.1381	0.1381	0.1382
19.8kW 12cm/min	0.0914	0.1079	0.1134	0.1162	0.1179	0.119	0.1198
19.8kW 10cm/min	0.1327	0.1328	0.1329	0.1328	0.1328	0.1328	0.1328

Table 4 shows the average corrosion rates of both plane face and double V edge welded joints at different power input and welding speed in tetraoxosulphate (VI) acid solution.

Table 4: Average Corrosion Rates of both Plain Face and Double-V Edge Shape Welded Samples at Different Power Inputs and Welding Speeds in tetraoxosulphate (VI) acid solution

POWER INPUT/ WELDING SPEED	AVERAGE CORROSION RATE (mpy)	
	PLAIN FACE	DOUBLE V EDGE
16.5kW 15cm/min	0.1598	0.1126
16.5kW 12cm/min	0.1415	0.0645
16.5kW 10cm/min	0.1506	0.1166
19.8kW 15cm/min	0.3004	0.138
19.8kW 12cm/min	0.1741	0.1122
19.8kW 10cm/min	0.1995	0.1328

Figures 2 and 3 present further result processing of the corrosion rates of the two considered welding geometries in tetraoxosulphate (VI) acid solution at the various power input and welding speed. Figure 4 gives the average corrosion rates of both welding geometries.

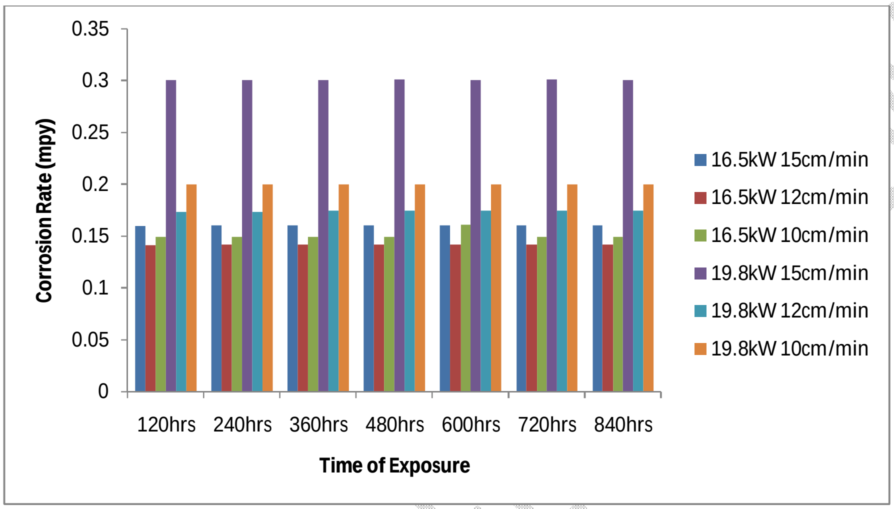

Fig. 2: Corrosion Rate of Plain Face Welded Samples at Different Power Input and Welding Speed in tetraoxosulphate (VI) acid solution

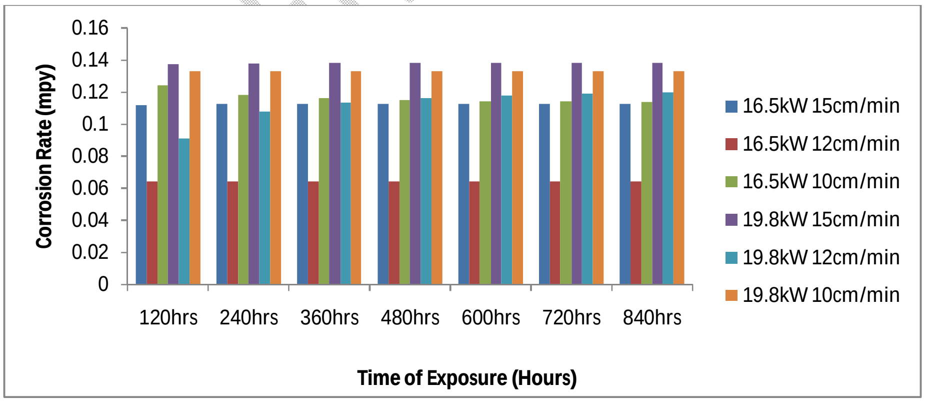

Fig. 3: Corrosion Rate of Double-V Edge Welded Samples at Different Power Input and Welding Speed in tetraoxosulphate (VI) acid solution

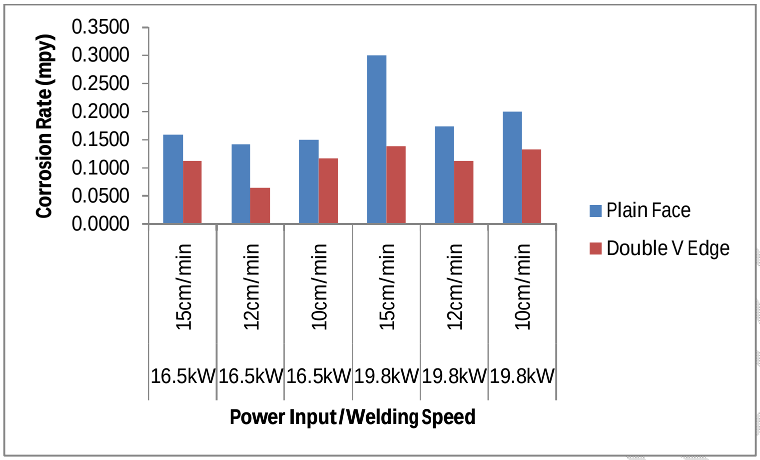

Fig. 4: Average Corrosion Rates of both Plain Face and Double-V Edge Shape Welded Samples at Different Power Inputs and Welding Speeds in Concentrated H_2SO_4

It can be deduced from Tables 2 and 4, Figures 2 and 4 that the corrosion rate of the plane face welded joints at 16.5KW power input in conc. H_2SO_4 increases in the order of the welding speed 12cm/min (0.1415mpy) < 10cm/min (0.1506mpy) < 15cm/min (0.1598mpy). This implies that welding the plane face welded joint at moderately high power input and medium welding speed of 16.5KW and 12cm/min respectively lowers the corrosion rate of the welded joints.

Comment [Dr. Nas24]: The conclusion statement is not written in the results and discussion section.

In addition, tables 3 and 4, figures 3 and 4 also reveal the corrosion rate of double V shape welded joints in conc. H_2SO_4. The corrosion rate of double V edge welded joint at 16.5KW power input has the least value of 0.0645mpy at the welding speed of 12cm/min. the corrosion rate of the double V welded joint increases in the order of the welding speed 12cm/min (0.0645mpy) < 15cm/min (0.1126mpy) < 10cm/min (0.1166mpy). Welding double V edge joints at moderate power input 16.5KW and medium welding speed 12cm/min lowers the corrosion rate of double V joint than any other welding speed at the same power input.

Comment [Dr. Nas25]: Add quotes to the discussion, to strengthen statements

Welding at higher power input of 19.8KW at all the selected welding speed gives higher corrosion rates than welding at lower power input 16.5KW for both plane face double V welded joints in conc. H_2SO_4 as shown in Tables 2, 3 and 4 and Figures 2, 3 and 4.

Table 4 and Figure 4 compared the corrosion rate of both plane face and double V edge welded joints at different power inputs and welding speeds in conc. H_2SO_4. The plane face welded joints corrode at a higher rate than the double V edge welded joints at each of the selected power input and welding speed as indicated in Table 4 and Figure 4. The higher corrosion rate of the plane face welded joints in conc. H_2SO_4 could be attributed to its higher area of exposure to the corrosion medium.

Comment [Dr. Nas26]: Add quotes to the discussion, to strengthen statements

4. Conclusion

It can be concluded from the study that:

- Welding variables such as power input, welding speed and welding geometry have a vital role to play in either lowering or increasing the corrosion rate of low carbon steel welded joints in a corrosion medium.
- Plane face and double V edge low carbon steel welded joints corrode less when produced at moderately medium power input and welding speed.
- Plane face and double V edge low carbon steel welded joints corrodes more when formed at higher power input and welding speed.
- The corrosion rate of any low carbon steel welded joints in a corrosion medium depends on its geometry.

………

5. References

[1] Afolabi, A.S. Effect of electric arc welding parameters on corrosion behavior of austenitic stainless steel in chloride medium. AU J.T. 11(3): 171-180, 2008

[2] Avery, C.H. Heat Treatment of Stainless Steel. Metal Handbook, 8th ed. Amer. Soc. Metals, Ohio. 2:243, 1963.

[3] Chamberlain, J. and Trethewey, A.R. Corrosion for student of science and engineering. Longman Scientific and technology Books, London, England, 1988

[4] Chen L. Effect of TTP temperature on mechanical properties of High-Cr ferritic heatresistant steel weld metal. Welding in the World, Vol.56, pp 1-2, January-February, 2012.

[5] Daramola, O. O., Adewuyi, B. O. and Oladele, I. O. Effects of heat treatment on the mechanical properties of rolled medium carbon steel,Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.8, pp.693-708, 2010.

[6] Design and Manufacturing Laboratory. Retrieved from http://www2.mae.ufl.edu/designlab/Lab Assignments/EML2322L-Welding

[7] Funk Edward, HandBookofWelding, Boston Publishers, 2012.

[8] Gharibshahiyan E., Honarbakhsh A.R., Parvin N., Rehimian M. The effect of microstructure on hardness and toughness of low carbon welded steel using inert gas welding. Journal of Material and Design, 2042-48, 2011

[9] Hendesen J.G, Metallurgical Dictionary, Rheinhold Publishers Corporations, New York, 2004.

[10] James, G.K. Chronology of corrosion disasters. Amer. Metal Soc. Handbook 5, New York, NY, USA, 2000

Comment [Dr. Nas27]: It is recommended before the reference to add "**Acknowledgments**" especially for those who have helped in this research activity

Comment [Dr. Nas28]: Follow the directions for writing references. Only the library used is written
Follow the directions for writing the reference number

Comment [Dr. Nas29]: This reference is 15 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas30]: This reference is 60 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas31]: This reference is 35 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas32]: add year of publication

Comment [Dr. Nas33]: This textbook is 23 years old, it is advisable to replace it with a new one, to keep abreast of scientific developments

[11] Jariyabon, M., Davenport, A.J. and Ambert, R., Connolly, B.J., Williams, S.W. and Price, D.A. The effect of welding parameters on the corrosion behavior of friction stir welded AA2024-T351. Corrosion Sci. 49: 877-909, 2007

[12] Karadeniz, E., Ozsarac, U. and Yildiz, C. The effects of process parameters on penetration in gas metal arc welding processes. Mater. Design 28: 649-56, 2007

[13] Lothongkum, G., Viyanit, E., and Bhandhubanyong, P. Study on the effects of pilsed TIG welding parameters on delta-ferrite content, shape factor and bead quality in orbital welding of AISI 316L stainless steel plate. J. Mater. Proc. Technol. 110:233-38, 2001

[14] Lothongkum, G., Chaou bai, P., and Bhandhubanyong, P. TIG pulse welding of the 304L stainless steel in flat, vertical and overhead positions. J. Mater. Process Technol. 89-90:410-4, 1999

[15] Omiogbemi, M.B. effects of gas metal arc welding parameters on the mechanical and corrosion behavior of austenitic stainless steel in some environments. M.Sc. Thesis, Mechanical Engineering, Ahmadu Bello University, Zaria. May 2015

[16] Parijslaam, R. Welding stainless steels: Techniques and Principles- An electronic manual (www.cimeth.org//stainless.htm), 2002

Comment [Dr. Nas34]: This reference is 16 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas35]: This reference is 16 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas36]: This reference is 22 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas37]: This reference is 24 years old, it is recommended to replace it with a reference from the latest journal

Comment [Dr. Nas38]: This reference is 21 years old, it is recommended to replace it with a reference from the latest journal