IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⋇ Vol. 9, Issue 5, May 2022

DOI: 10.17148/IARJSET.2022.9526

The Effects of Welding Current and Electrode Specifications on the Hardness Properties of Mild Steel Welded Joints

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Abstract: The paper discussed the effect of welding parameters on the hardness properties of welded mild steel rod (Ø10) using Shielded Metal Arc Welding (SMAW) method. Welding current and electrode specifications were the investigated welding parameters. The mild steel rod was cut into various samples Ø10 by 50mm each with the aid of hacksaw. The samples were machined to some configurations such as single-v edge, chamfered and plain face. Each similar pair of those configurations was welded by arc welding at various welding current with electrode gauge 10 and 12 respectively to produce the needed joints for hardness test. The result showed that increased in the arc welding current resulted in increased hardness of the welded joints for all the selected welding geometries. With respect to electrode specification, electrode gauge 12 gives better/higher hardness value of the welded joints than gauge 10 at the various selected welding currents 120, 160, 200 and 240A. The study therefore recommends that welding at higher current with electrode gauge 12 should be encouraged if higher hardness value of the mild steel welded joint is required.

Keywords: Welding current, Electrode gauge, Shielded Metal Arc Welding, Hardness, Welded joints.

INTRODUCTION

Welded joints are finding applications in critical components where failures are catastrophe. Hence, inspection methods and adherence to acceptable standards are increasing. These acceptance standards represent the minimum weld quality which is based upon test of welded specimen containing some discontinuities. Welding, involves a wide range of variables such as time, temperature, electrode, current, pulse frequency, power input and welding speed that influence the eventual properties of the weld metal [1] [2] [3] [4] [5].
Welding is often done by melting the work pieces and filler material is added to form a pool of molten material that cools to become a strong joint, with the pressure, sometimes used in conjunction with heat, or by itself, to produce the weld. The history of joining metals goes back several millennia, with the earliest examples of welding from the Bronze Age and Iron Age in Europe and the Middle East [6].
Welding technology which is a high productive and practical joining method is widely used in modern manufacturing industry such as ship building, automobile, bridge and pressure vessel industry [7]. It is also a type of fabrication or sculptural process that joins materials usually metals or thermoplastics, by causing coalescence [6]. Welding as a fabrication method is one of the simplest ways to make a gas or liquid tight joint. The common types of welding are such as oxy fuel gas welding, arc welding and resistance welding [8]. For arc welding there are plasma arc welding and carbon arc welding. Gas welding includes Tungsten inert Gas (TIG) welding and Metal Inert Gas (MIG) welding. In addition, resistance welding includes spot and seam welding [8].
Welding of steel is not always easy. There is the need to properly select welding parameters for a given task to provide a good weld quality [9]. Therefore, the use of the control system in arc welding can eliminate much of the guess work often employed by welders to specify welding parameters for a given task [10]. Hence the study investigates the influence of welding parameters such as welding current and electrode specifications on the hardness properties of mild steel welded joints.

MATERIALS AND EQUIPMENT

The materials used for this study include mild steel rod (Ø10mm), emery cloth and gauge 10 and 12 electrodes. The equipment and apparatus used for this study include Brinell hardness testing machine, lathe machine, vice, hacksaw, file and Shielded arc welding machine.

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Samples Preparation

The mild steel rod (Ø10mm) was cut into various samples Ø10mm by 50mm each with the aid of hacksaw. Facing of the samples were done on the lathe machine. The samples were cleaned from dirt, grease and other foreign materials to obtain a clean surface using emery cloth. Edge preparations were done to have samples categorized as single-v edge, chamfered and plain face as shown in Fig.1. The plain face had 16 samples (i.e. 8 welded joints: 4 welded joints for each of the electrode gauge). Ditto to chamfered face and single-v edge. There were 24 welded joint prepared for the hardness test.

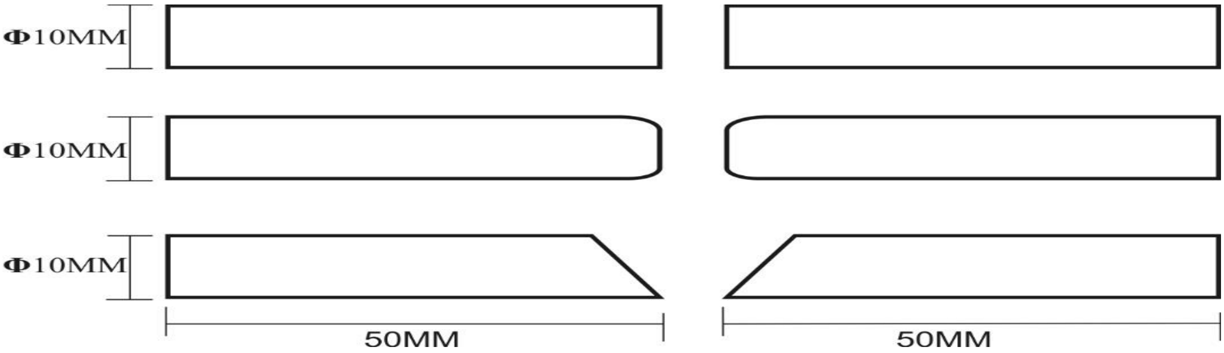

Fig.1: Shape of the Mild Steel Rod Welding Samples.

Hardness Test

Hardness test was carried out on the whole width of weldment of the welded joint by using Rockwell Hardness Testing Machine at National Centre for Agriculture Mechanization, Ilorin (NCAM) to determine the hardness properties in the welded area. The results were shown in Tables 1 and 2.

Table 1: Some of the Hardness Properties of Steel Welds with Electrode Gauge 10.

Specimens		**Brinell Hardness (kg/ m²)**	**Def. @ Peak (mm)**	**Force @ Peak (kgf)**
Current 120	Plain Face	138415.171	0.878	1001.109
	Chamfered	110181.999	0.700	1000.698
	V-Edge	111030.880	0.710	1001.110
Current 160	Plain Face	138435.664	0.883	1001.157
	Chamfered	110201.001	0.810	1000.730
	V-Edge	111030.880	0.740	1001.110
Current 220	Plain Face	138550.111	0.960	1001.225
	Chamfered	110281.428	0.933	1000.953
	V-Edge	111030.880	0.806	1001.110
Current 240	Plain Face	138500.122	0.930	1191.195
	Chamfered	110261.202	0.790	1000.880
	V-Edge	111030.880	0.765	1001.110

Table 2: Some of the Hardness Properties of Steel Welds with Electrode Gauge 12

Specimens	**Brinell Hardness (kg/ m²)**	**Def. @ Peak (mm)**	**Force @ Peak (kgf)**

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Current 120	Plain Face	138415.171	0.878	1001.110
	Chamfered	110184.999	0.790	1000.780
	V-Edge	138415.171	0.730	1001.889
Current 160	Plain Face	138435.664	0.883	1001.167
	Chamfered	110201.190	0.870	1000.810
	V-Edge	138435.664	0.750	1031.007
Current 220	Plain Face	138550.111	0.945	1001.230
	Chamfered	110281.511	0.939	1000.990
	V-Edge	138550.111	0.808	1221.225
Current 240	Plain Face	138500.122	0.899	1001.200
	Chamfered	110261.299	0.799	1000.889

RESULTS AND DISCUSSION

The chemical compositions of the mild steel as it was revealed by the x-ray spectrometer are shown in Table 3.

Table 3: Chemical Composition of the As-Received Mild Steel

Element	C	Si	Mn	P	S	Cr	Ni	Mo	Al
%	0.0041	0.0001	0.347	0.0022	0.020	0.018	0.045	0.0029	0.013
Element	Cu	Co	Ti	Nb	V	W	Pb	B	Sn
%	0.053	0.0011	0.0001	0.0031	0.0011	0.0056	0.0012	0.0007	0.0022
Element	Zn	As	Bi	Ca	Ce	Zr	La	Fe	
%	0.0022	0.0001	0.0009	0.0001	0.0001	0.0001	0.0001	99.4	

It can be confirmed from the table that the type of steel used for this work is mild steel.
Table 1 revealed the hardness properties of the steel welds while welding with the electrode gauge 10 (Φ2.5) under a selected range of welding currents. The Brinell hardness number of the specimens with plain face weld joints increase steadily from 138415.17kg/m^2 (120A, E. G 10) to 138550.111kg/m^2 (200A, EG 10) with a sudden decrease to 138500kg/m^2 (240A, E.G 10).This indicates that the welding current should be tuned to around 200A in order to get a plain face weld joint with better hardness. This steady increase along the current range also applicable to the chamfered face weld joints with a sudden decrease at the welding current 240A. The specimens with V-edge weld joint have a unique characteristic of constant Brinell hardness 111030.880kg/m^2 throughout the welding current range. This could be attributed to the constant gradient/slope across the V-edge.
Table 2 shows the Brinell hardness of the steel welds while welding with electrode gauge 12 (Φ3.25) under a selected range of welding currents. The Brinell hardness of the specimens with plain face weld joints increases as the welding current increases from 138415.171kg/m^2 to 138550.111kg/m^2 at welding current 120A and 200A respectively with a sudden reduction to 138500.122kg/m^2 at 240A. This reveals that plain face weld joints of better hardness quality could be achieved with welding electrode gauge 12 while turning the welding current to a value between 120A and 200A.This considerable increase along the current range also applicable to the chamfered face and V-edge weld joint with a significant decrease at current 240A at both welding joint respectively. Fig. 2 shows the chart comparing the Brinell hardness of various welded joints with electrode gauge 10 and 12.

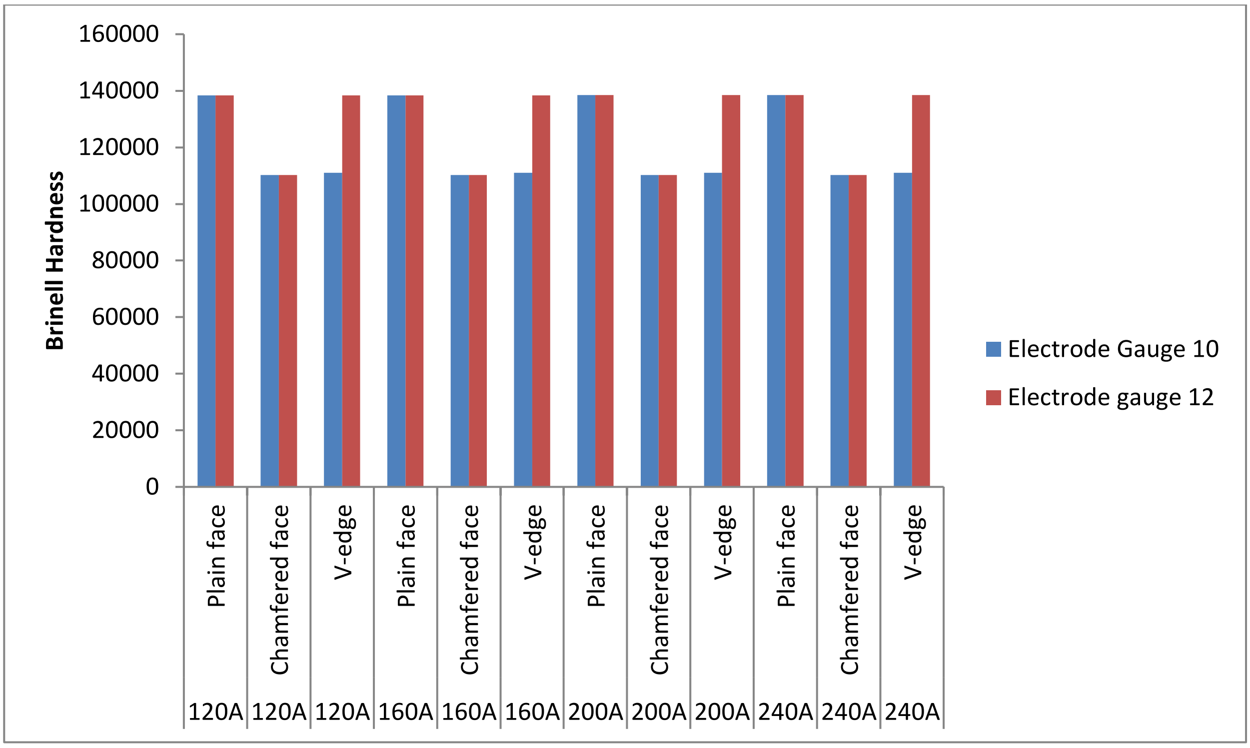

Fig. 2: Chart Comparing the Brinell hardness of various Welded Joints with Electrode Gauges

It can be deduced from Fig. 2 that electrode gauge 12 performs better at various welding currents 120, 160, 200 and 240A than gauge 10 in terms of hardness of the mild steel welded joints for the selected geometries. Although, both electrode gauges 10 and 12 could be considered for plain face welded joints at welding currents 120, 160, 200 and 240A.

CONCLUSION

The following facts can be derived from the study:

- In terms of hardness of the mild steel welded joints of all the selected welding geometries, electrode gauge 12 performs better than gauge 10 at the various welding currents 120, 160, 200 and 240A. This means that welding with electrode gauge 12 will be very appropriate if better or higher hardness of mild steel welded joint is required.
- In the absence of electrode gauge 12, gauge 10 could be adopted for welding plain face welded joints at all the selected welding currents.
- The higher the arc welding current; the higher the hardness of the hardness of the mild steel welded joints for all the selected welding geometries.

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