Paper Titles

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Abstract:

The aimed of this research is to investigate the effect of T-Joint's root gap on physical and mechanical properties of weld metal. Low carbon steel were joined in T-joint types using MIG (Metal Inert Gas) with variation of root gap. The root gap used were 0 mm, 3 mm and 6 mm. The physical properties examined with chemical composition, microstructure and corrosion using optical microscope. The mechanical properties were measured with respect to the strength and hardness using Universal testing machine and Vickers Microhardness. The results show that the highest value found in welds with a gap of 3 mm with a value of 163.57 MPa. Hardness value is directly proportional to the tensile strength of the material. The highest value found in welds with root gap of 3 mm, followed by root gap of 6 mm, and 0 mm Hardness values in the welding area is higher than the parent metal and HAZ because the number of Si, Mn and Cu elements in the welding metals are bigger than base metal. Weld with all variation of root gap have a good corrosion resistance because the corrosion rate in welds with various root gap have a value below 0.02 mmpy. Microstructure of weld metals were Accicular ferrite, Widmanstatten ferrite, and grain boundary ferrite, while microstructure of base metal and HAZ were ferrite and perlite.

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An Experimental Study on Effect of T-Joint's Root Gap on Welding Properties

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Keywords: Root Gap, T-joint, MIG, Tensile strength, Microstructure, Hardness, Corrosion

Abstract. The aimed of this research is to investigate the effect of T-Joint's root gap on physical and mechanical properties of weld metal. Low carbon steel were joined in T-joint types using MIG (Metal Inert Gas) with variation of root gap. The root gap used were 0 mm, 3 mm and 6 mm. The physical properties examined with chemical composition, microstructure and corrosion using optical microscope. The mechanical properties were measured with respect to the strength and hardness using Universal testing machine and Vickers Microhardness. The results show that the highest value found in welds with a gap of 3 mm with a value of 163.57 MPa. Hardness value is directly proportional to the tensile strength of the material. The highest value found in welds with root gap of 3 mm, followed by root gap of 6 mm, and 0 mm Hardness values in the welding area is higher than the parent metal and HAZ because the number of Si, Mn and Cu elements in the welding metals are bigger than base metal. Weld with all variation of root gap have a good corrosion resistance because the corrosion rate in welds with various root gap have a value below 0.02 mmpy. Microstructure of weld metals were Accicular ferrite, Widmanstatten ferrite, and grain boundary ferrite, while microstructure of base metal and HAZ were ferrite and perlite.

Introduction

Metal Inert Gas(MIG) is a process of welding that uses a consumable metal electrode and a shielding gas. It is the process in which source of heat is an arc formed between a workpiece and consumable metal electrode (filler). The arc and molten metal are protected from contamination by the atmosphere with an externally supplied gaseous shield of inert gas or active gas[1].

The properties of weld joints influenced by the welding process parameters such as weld current, voltage, weld shield, shielding gas, gas flow rate and root gap [2-4]. The mechanical properties and quality of weld metals were determined by the weld geometry [5].

Inaccuracies such as an excessive root gap due to cutting precision and welding deformation often occurs in welding processes [6]. This root gap is a very important parameter influencing the depth of penetration and the dimensions of the weld pool [7]. Previous research have shown that root gaps have a significant effect on weld size, penetration, cracks, and lack of fusion [8]. Gaps therefore could be root cause for the consumable usage and longer operation time [9].

Experimental Procedures

Materials. In this experiment, the workpiece used 3 pieces of low carbon steel LR Gr A with dimension of 140 mm x 60 mm x 12 mm. The chemical composition of steel are shown in Table 1. This specimen was joint with T-Joint Welding. The Variation of root gap that used were 0 mm, 3 mm and 6 mm [6].

Welding Processes. Fillet T-Joints of 12 mm thick sheets were formed by MIG welding with multilayer passes at a speed as high as 6.35 mm/s. The welding current and welding voltage were 180 A and 24 V. This experiments used metal electrode ER 70S-6 with diameter 1.2 mm. In this process argon is used as shielding gas at a constant flow rate 20 L/min. The root gap size that used were 0 mm, 3 mm and 6 mm (Fig. 1).

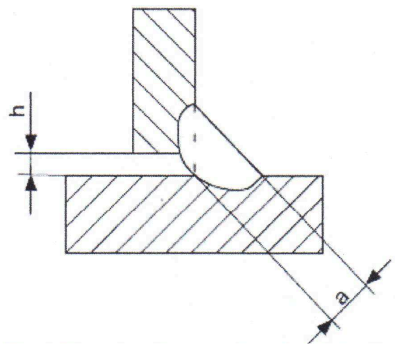

Fig. 1 Illustration of weld size (a) and root gap (h) [9].

Joints Characterizations. The hardness distribution and tensile properties were investigated through Vickers microhardness tests and tensile tests. To characterize the hardness distribution along the weld width multiple indentations were made on the weld cross section, using a Vickers indenter under a 200g force for 10 seconds. The dimension of tensile properties shows in Fig. 2.

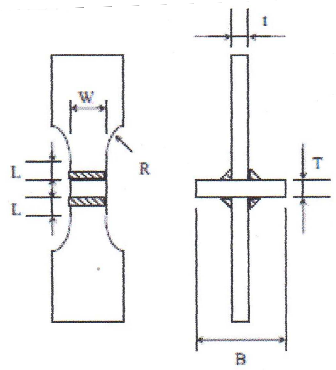

Fig. 2 Dimension of tensile specimen [6].

The surfaces of samples for metallographic examination were ground and polished. HNO_3 2.5% used to reveal the microstructure of LR Gr A steel. Microstructure test was carried out using an optical microscope.

Corrosion testing is done by soaking the specimen in seawater afterwards for 10, 20, and 30 days, afterwards the specimen weighed.

Results and Discussions

Chemical Compositions. The chemical composition of base metal and welding metal can be seen in Table 1. There are differences in the chemical composition of the welds and base metal, it is because the filler used in the welding process. The number of elements increased in the welding process are Si, Mn and Cu.

Table 1. Chemical Compostions.

	Fe	S	Al	C	Ni	Si	Cr	Mn	P	N	Cu
Base Metal	99.493	0.019	0.043	0.051	0.015	0.006	0.178	0.286	0.013	0.016	0.001
Welding Metal	98.685	0.018	0.026	0.058	0.010	0.332	0.021	0.764	0.014	0.026	0.063

Microstructures. Fig. 3 shows microstructure of weld metals. Microstructure test using a magnification of 100 X, 10 strips in the figure shows a 100 micron. The base metal and HAZ have the similar microstructure is ferrite and pearlite. The microstructure of HAZ are smaller than base metal. It is caused by the effect of heat on the welding process

(a) (b)

Fig. 3 Microstructure of Weld Metals
(a) Base Metal (b) HAZ

(a) (b) (c)

Fig. 4 Microstructure of Welding Zone.
(a) Gap 0 mm (b) Gap 3 mm (c) Gap 6 mm

The microstructure of welding zone are Accicular Ferrite, Widmanstatten Ferrite and Grain Boundary Ferrite (Fig. 4). Microstructure formed because of the additional electrode filler and a temperature's welding is higher than the critical point temperature of the base metal used.

Tensile Strength. Tensile test results can be seen in Fig. 5. The graph shows that the highest value found in welds with a gap of 3 mm with a value of 163.57 MPa. This is consistent with observations of the microstructure which indicate a joint with the root gap of 3 mm has microstructure that dominated by accicular ferrite. Acicular ferrite has the shape of small and random orientation so that it will inhibit cracking that occurred. The tensile strength of weld with root gap 3 mm have a value are more than 300 % than the weld with root gap 0 mm that have a value of 55.32 Mpa.

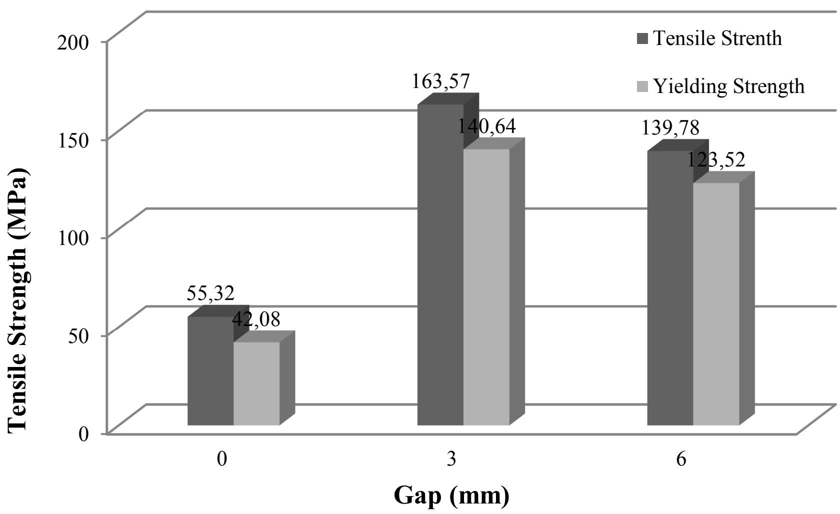

Fig. 5 Tensile strength of welding metals.

Hardness. The distribution of hardness are presented in Fig. 6. The weld metal with a root gap 0 mm has a hardness value is the lowest for all region of the weld (base metal, HAZ, and welding zone). A low value of hardness is due microstructure of weld metal with a gap of 0 mm is dominated by Widmanstatten ferrite. Hardness values in the welding area is higher than the parent metal and HAZ. It accords with the results of testing the chemical composition shows an increase elements Si and Mn.

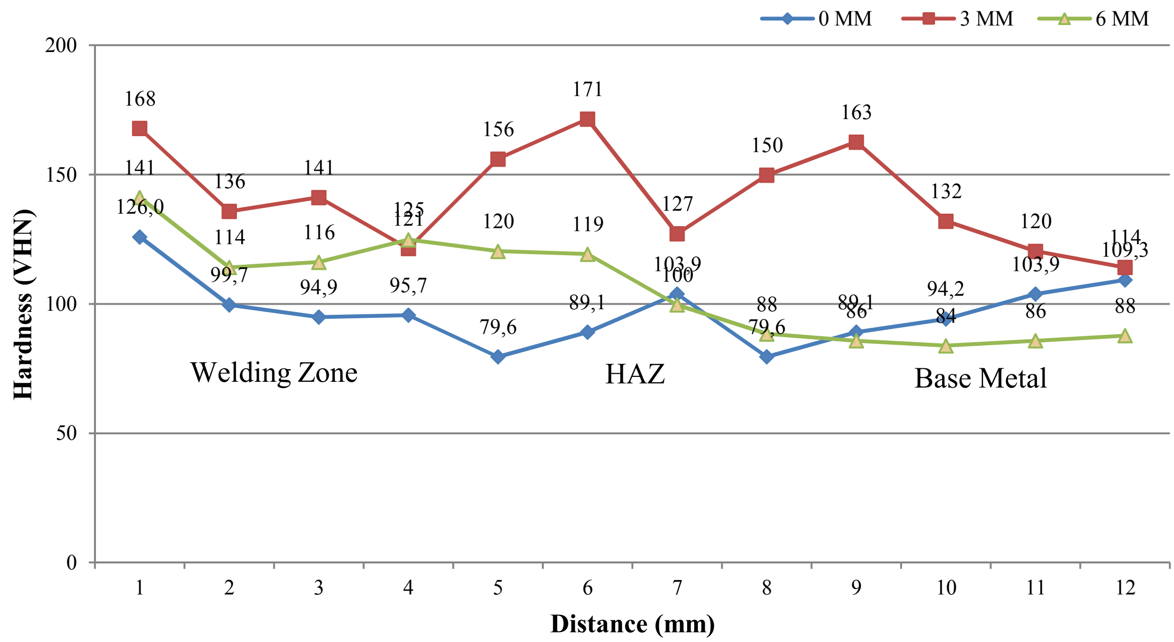

Fig. 6 Distribution of Hardness.

Corrosion. The value of corrosion rate of weld metals given in Fig. 7. The corrosion rate of weld metals with various root gap categorized as materials having good corrosion resistance because it has a value between 0.1 – 0.2 mmpy [10]. This indicates that the weld is good because there are no defects in welds. Defects in the welding causes high corrosion rate.

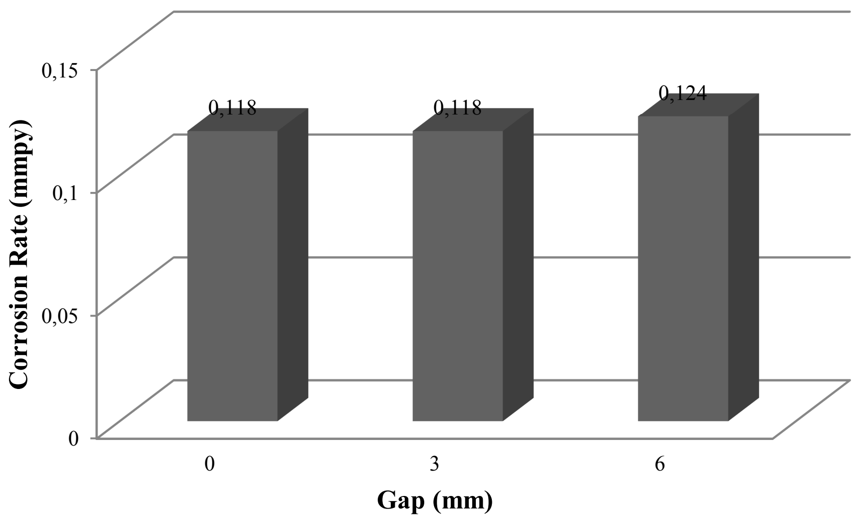

Fig. 7 Corrosion rate of weld metals.

Summary

The conclusions of this researches are :

1. The microstructure of weld zone are accicular ferrite, widmanstatten ferrite and grain boundary ferrite. The structure is formed on all welds with various root gap.

2. The highest value of tensile strength found in welds with a gap of 3 mm with a value of 163.57 MPa. While the tensile strength welds with root gap 0 and 6 mm have value 55.32 and 139.78 respectively.
3. The rate of corrosion in welds with various root gap having low values of below 0.02 mmpy and can be categorized as a material with good corrosion resistance.
4. The weld metal with a root gap 0 mm has a hardness value is the lowest for all region of the weld.

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