Joining of Dissimilar Material Using Gas Metal Arc Welding

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ABSTRACT

Joining of thin sheet metals by welding was once said to be difficult as it usually burns through hole at the base metal. High welding temperature exerted on the base metal lead to cause undesirable distortion. Further challenges on joining of dissimilar materials by using fusion welding are when both base metals have different melting temperature and also might lead to breakdown of their mechanical properties. This research objective was to study the weldability of dissimilar selected metals sheet namely mild steel and galvanized iron. It was to determine the suitable welding parameters to join both metals sheet with thickness of 1.0 mm, each. Two welding parameters identified as the welding current with a range of 34.0 – 55.5 A and wire feed speed ranging from 2.0 – 4.0 m/min, the Gas Metal Arc Welding (GMAW) process was thus employed. The samples were later tested for its tensile strength in order to get the safe welding parameter that could meet the tensile strength of the joint. It was determined that the range of safe GMAW welding parameters for both metals was 44.9 – 55.5 A of the welding current and 3.0 m/min wire feed speed.

Keywords: *Joining dissimilar material, thin sheet welding, welding parameter, gas metal arc welding*

1.0 INTRODUCTION

Joining of two dissimilar materials by welding process can be quite tricky since they both have different material properties and also due to the formation of intermetallic layers which depends on the interaction of joining materials and process parameters [1, 2]. This is a process which involves the joining together of two metals that possess different chemical or mechanical properties, and so aren't necessarily a natural fit for each other. In fact, two metals with the same name can be welded together, but if they have different core properties, they are classed as dissimilar metals. For example, two austenitic steel metals can be weld together, but they may still be different enough to be considered dissimilar. However, with the aid of welding technology and continuous studies of method and parameters allow this joining process to be performed with expected quality.

Dissimilar metal welding can be performed with gas metal arc welding (GMAW) which is one of common selection for sheet welding [3]. In addition, friction stir welding (FSW) [4] and cold metal transfer welding (CMT) [5] are also popular choice of joining process, however, depending on the application.

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In GMAW, the depth of penetration increases as the welding current increases. Increase in welding voltage also increases the depth of penetration but not significant as the current. It is also known that for increase in welding speed would decrease the depth of penetration.

Nowadays, it can be hard to see such a huge industry applied only one type of metal in their company. This is because each material offers its own unique qualities and benefits. Even though roughly it easier to manufacture by using only one material instead of many, but by combining materials will offer a new way in manufacturing and also enhance the manufacturer product in different ways.

The operating experience of major power plant (NPP) pressure boundary components has recently shown that dissimilar metal weld joints can jeopardize the plant availability and safety because of increased incidences of environment-assisted cracking (EAC, PWSCC) of *Alloy 600* and corresponding weld metals (*Alloys 182/82*) as described by Hannu Hänninen *et al*. (2006) [6].

2.0 MATERIALS AND EXPERIMENTAL PROCEDURE

Mild steel and galvanized steel were used for this experiment in which both have different for its mechanical and chemical properties. There are specific mechanical and chemical properties for mild steel and for galvanized steel; it is basically steel which coated with zinc layer on top of its surface through some process called hot dip process.

Table 1 shows the mechanical and chemical properties of mild steel sheet metal and it has highest composition of Fe (Iron) in producing this steel with 1.4% Manganese in its overall composition [7].

Table1: Mechanical and chemical properties of sheet metal [7]

ISO	Tensile strength (N/mm^2)	Yield point (N/mm^2)	Chemical composition (%)					
			C max	Si max	Cr max	Mn max	Ni max	Fe
Fe360-A	370-500	235	0.22	0.35	0.3	1.4	0.3	Rest

In this research, a total of 25 samples have been used to collect all data and needed for the purpose of this research. All 25 samples were configured by stacking the galvanized steel with mild steel and using lap joint with a gap of 10 mm as shown in Figure 1; the samples were joined by using GMAW.

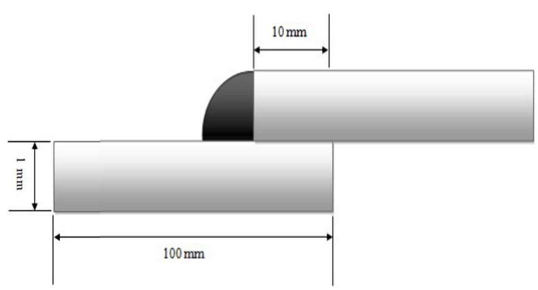

Figure 1: Stacking order and the dimension of samples tested

Before starting the experiment, there are some procedures needed to be done in order to make sure that there are no impurities exist on the sample when the experiment was conducted [8]. The samples were first cleaned using sand paper first and later washed with acetone to remove its impurities. The experiment process was started by first determining the range of suitable parameters of current (A) and wire feed speed (m/min) that can be used to joint both metals. Next, the samples were joined by using the GMAW technique. The dimension of the tensile test to-cut sample is shown in Figure 2.

For the achievement of experimental tests, Hero Tech Inverter Welding Machine *IM 1680* welding source was chosen with the frequency of 60 Hz and input voltage of 220 V. The set of welding parameter were referred from previous research.

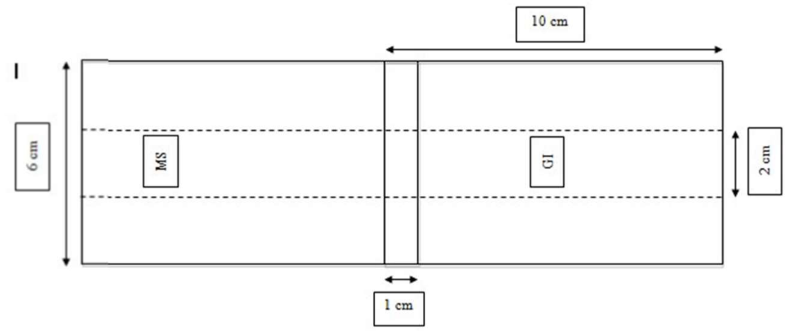

Figure 2: Sample dimension

3.0 RESULTS AND DISCUSSION

Based from the results obtain from the experiment using GMAW, we could see that all the samples were successfully welded together. Roughly observation from the welding results shows that all welding samples do not experience burn through and distortion. Further analysis was done using stereo microscope to observe the surface of its welding joint. All welding joint surfaces shows the existence of white fume or known as zinc fume occur on top of galvanized steel. The formation of white fume is due to low vaporization temperature of the zinc coating. Since zinc melts at the temperature of about 900°F or 482°C and vaporized at about 1650°F or 899°C, the zinc coating which is near to the welding area vaporized due to the high welding temperature. The vaporized zinc increases the volume of welding fumes and smokes which might adversely affect one's health [9-11]. Other than that, the zinc at and near any weld is actually burnt off by the heat of the arc, thereafter removing the protective zinc coating [12].

Figure 3: 2D welding sample

Figure 4: Observation of weld bead using stereo microscope

The samples later being cut to 2 cm as shown in Figure 2 before they were tested using the tensile strength test in order to get the actual value of safe welding parameter. The testing was carried out using the Universal Testing Machine *Instron 600DX*

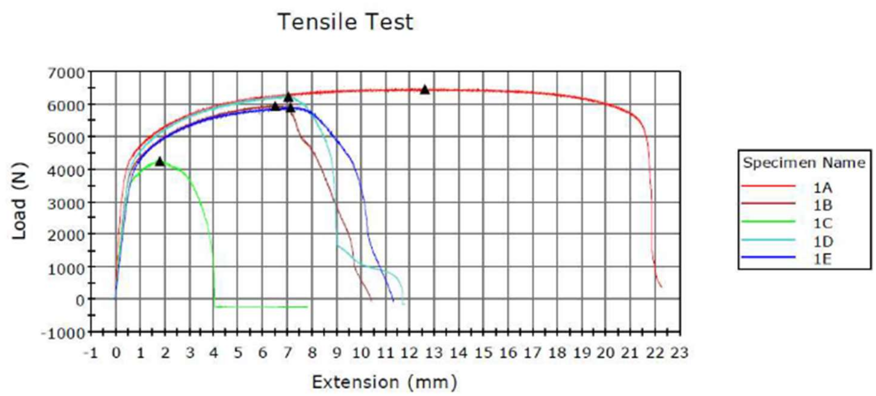

Figure 5: Graph of tensile test for Sample 1

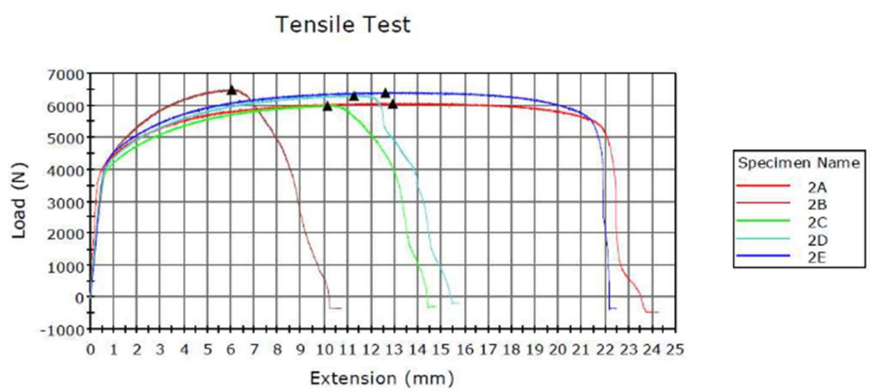

Figure 6: Graphs of tensile test for Sample 2

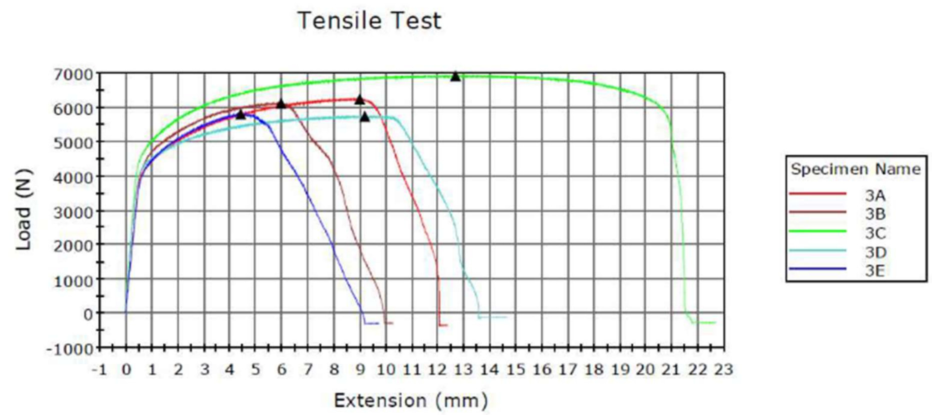

Figure 7: Graphs of tensile test for Sample 3

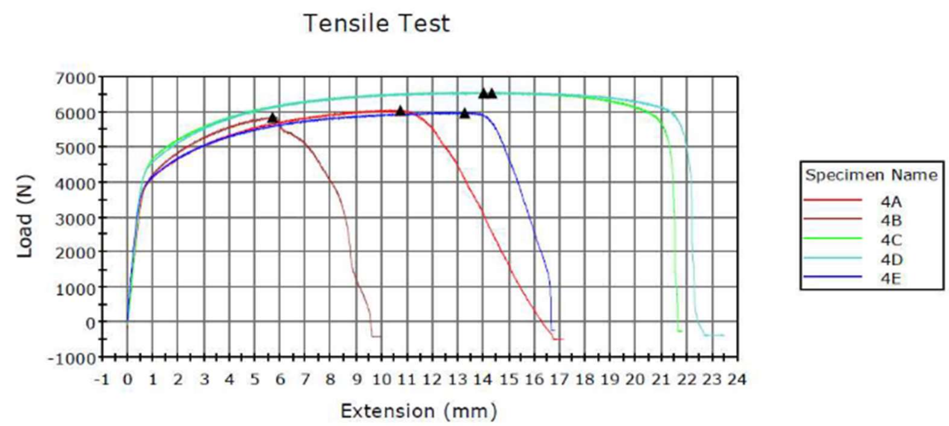

Figure 8: Graphs of tensile test for Sample 4

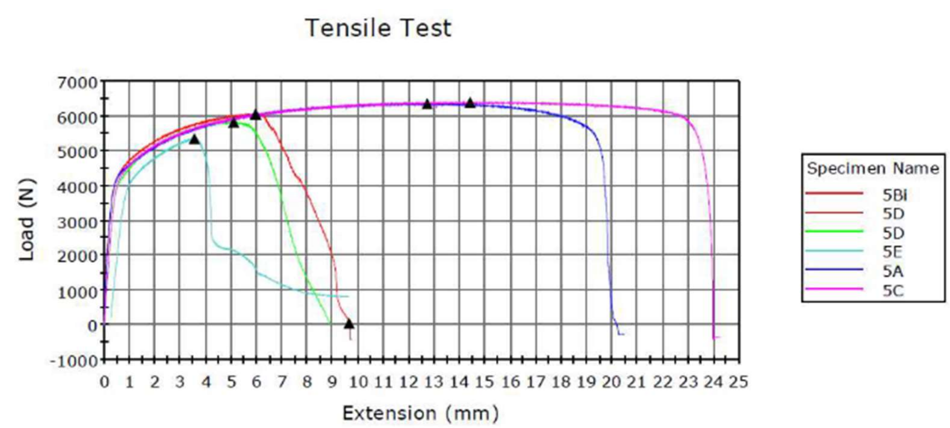

Figure 9: Graphs of tensile test for Sample 5

Figures 5 to 9 show the graphs related to the loadings for the tensile strength test. Based on the results, a total of 15 samples fractured at the heat affected zone (HAZ), nine of which fractured at the base metal which is mild steel and one sample fractured at the weldment. Among the nine samples that were fractured at the base metal, a further analysis was done to the samples in order to determine the safest welding parameter that should be used. The analysis was conducted on the maximum tensile load that it could withstand and also the elongation (extension) at its maximum load.

Table 2: Tensile data based on the samples fractured at the base metal

Sample	Welding current (A)	Wire feed speed (m/min)	Extension (mm)	Load (N)
1A	34.0	2.0	12.6	6454.3
2A	44.8	20	12.9	6061.8
2E	44.8	4.0	12.6	6396.2
3C	44.9	3.0	12.7	6919.8
4A	54.9	2.0	10.7	6041.0
4C	54.9	3.0	14.3	6547.8
4D	54.9	3.5	14.0	6546.6
5A	55.5	2.0	12.7	6352.4
5C	55.5	3.0	14.4	6394.2

With reference to the graphs of Figure 10, there are a total of three samples that can be categorized as the best safe welding parameter that could be used and it was Samples 3C, 4C and 5C. Sample 3C has the highest maximum load with 6919.8 N suitable to be used when the requirement in the real industry is about the strength. Meanwhile, for Sample 5C, it has the longest elongation at maximum load with 14.4 mm and it is suitable to be used when the requirement in the industry is about the strain of the welding [13].

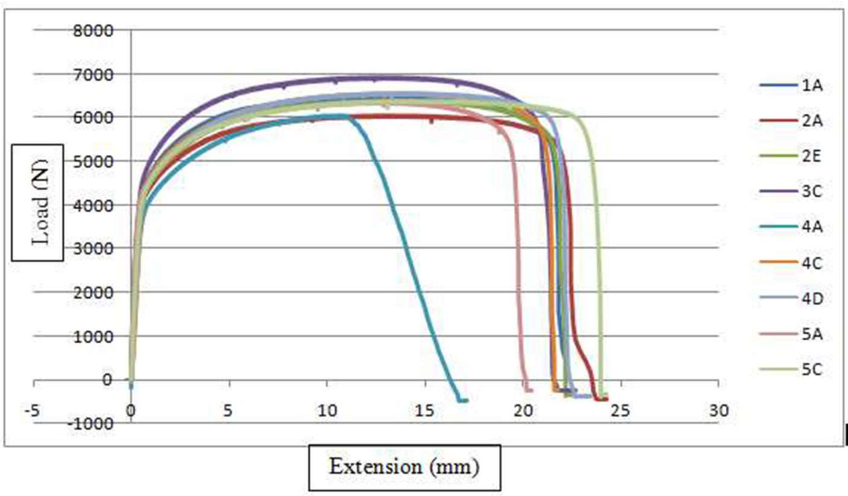

Figure 10: Graphs of *Load* against *Extension* for the samples fractured at the base metal

4.0 CONCLUSION

It can be inferred that the safe welding parameters that can be used in order to fuse/weld both mild steel and galvanized iron together was by setting the operating welding current within the range, 44.9 to 55.5 A with a 3.0 m/min wire feed speed. The higher welding current beyond the range might lead to a possible weld failure at the HAZ. Other welding defects might be due to undercuts, lack of welding fusion and lack of penetration. The formation of white or zinc fume occur when the welding process was done on galvanized iron due to its zinc coating that was vaporized when received excess heat from welding arc temperature. When the welder inhaled too much amount of the fume, it might have an adverse effect on human health, contributing to ‘metal fume fever’ though it does not lead to a long term health effect.

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