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A Review of Metal Inert Gas Welding on Aluminium Alloy

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***Abstract*: Welding is a manufacturing process, which is carried out by joining two similar and dissimilar metals. MIG welding is one of the mostly used method in industry. This review paper is based on the experimental analysis of MIG welding of aluminum alloy and comparison of MIG welding of aluminum alloy with FSW and MIG welding.**

***Keywords*: Joining metals, Aluminum alloy, MIG welding, FEW welding.**

1. Introduction

Metal inert gas welding (MIG) is also known as gas metal arc welding(GMAW).The MIG welding process was developed and commercially available in 1948,whereas the basic concept was actually introduced in the year 1920's.MIG welding process is carried out by creating the electric arc between the consumable electrode wire and work piece. During this process inert gas is introduced which shield the welding location from contamination. This is the main advantage of this method and make it different from the other welding process. This process can be carried out semi-automatic or fully automatic. MIG welding provides the better weld pool visibility and loss of alloying element is somewhat little in this method. Large variety of metals can be joined by this method. Continuously fed wire improves the weld quality and speed of operation and overall control. Fatigue life prediction of welded joints is currently addressed in fracture mechanics terms for aluminium alloys via codes like Eurocode which are generically applicable and largely independent of alloy composition, strength level and load conditions. They also have to cover possible effects of residual stress, which may vary and cannot be determined a priori by modelling as they are influenced by factors like weld shrinkage, lack of fit at assembly and imposed forced displacements from other parts of the structure. As well as being highly variable residual stresses have also been experimentally complex to measure, particularly near to stress raisers such as weld toe regions where many fatigue cracks initiate. Thus it is not surprising that our knowledge of residual stresses in structural components, and the effect of fatigue cycling on their magnitude, is incomplete. The design codes are therefore, of necessity, lower bound curves to large sets of experimental data which may be highly conservative, particularly in the long life region that is of prime interest to the integrity of engineering structures. If the factors influencing the typical form and magnitudes of the residual stress distribution associated with welds were sufficiently well characterized, then it may become possible to relate the effects of fabrication variability to fatigue performance for a particular set of welds. This would potentially enable more accurate estimation of fatigue life that took account of the influences of residual stresses in a realistic way. The first step in this process is better and more detailed information on residual stress fields and their modification by fatigue loading. This is now possible using advanced experimental techniques, such as synchrotron diffraction, which offer the ability to more completely characterize the residual stresses in large-scale welded specimens. Residual stress and strain profiles can be obtained at various cross-sectional positions for a number of specimens during a single synchrotron diffraction experiment. Measurements can be made in both the as-welded state and after the application of a number of cycles of fatigue cycling. Such data can then be linked to finite element analysis to provide full field predictive tools, although this is not a trivial undertaking. The intention in this work was to take advantage of advanced synchrotron diffraction experimental techniques and to perform a relatively comprehensive set of measurements of residual stress and strain profiles both in as-welded specimens and in the same specimens after the application of a sequence of cyclic loads. The work was done using 8 mm 5083-H321 aluminium plates joined by gas metal arc (MIG) welding. This paper presents the results of

Table 1
Material composition

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Other	Al
AA6060	0.3-0.6	0.1-0.3	0.1	0.1	0.35-0.6	0.05	0.15	0.15	Balanced
AA6082	0.7-1.3	0.5	0.1	0.4-0.1	0.6-1.2	0.25	0.2	0.15	Balanced

Table 2
Residual stress

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Other	Al
AA5083	0.25	0.15	0.06	0.60	4.20	0.09	0.09	0.15	Balanced

the work primarily as single-line residual stress profiles and considers two aspects related to weld residual strain and stress.

2. Corrosion test

A. Material composition

AA6060 metal sheet has been welded by FSW and AA6082 has been welded by MIG. From the welded sheets approximately 1.5cm*10cm were cut off for experimental purpose. For the two different welded components different areas where concentrated for MIG base material, interface zone between base material and thermal affected zone, interface between the thermal affected zone and weld bead and area inside the weld bead. For FSW area of interest are base material far enough from the welding zone and the weld bead. Aluminium alloy are sensible to chloride environment which leads to corrosion and then corrosion behavior was tested in acid salt solution. From the resulting values that are obtained FSW has better results than that of the MIG welding.

B. Residual stress

Aluminum alloy 5083 of 0.5m by 0.5m with the above combination are joined together by the MIG welding mechanism. Samples were cut off from the welded components. Samples are examined using the synchrotron diffraction strain scanning before and after applying the fatigue loads. The results were found to be the maximum increase in longitudinal residual stress occurs around the thermal affected zone (HAZ) and parent plate boundary. Peak values of longitudinal residual stress after applying the fatigue loading occurs at the middle of the HAZ at some distance from the center line of weld. Peak positive value of transverse residual stress progressively move from the HAZ parent plate boundary to the fusion boundary as the peak applied fatigue stress increases.

C. Fatigue test

All the welding process leads to a decrease in properties of welded zone than that of the parent material. Welding has been made in both MIG and FSW using the two aluminium alloys AL6082 and AL6061 of 3mm thickness. Fatigue load has been applied on the specimens. Afterwards the specimen is examined under the scanning electron microscopy (SEM).Result where found to be that the yield and rupture stress of MIG and FSW welded components are lesser than that of the parent material. On comparing the two welding process MIG welding has the more loss of properties of material. Fatigue scatter is somewhat higher in the MIG welding specimens. Its fatigue lives are lower than the FSW. The MIG welded AL6061 presented the higher fatigue lives than the MIG welded AL6082 specimen which shows the material composition also play a major role in improving the welding quality.

D. Mechanical properties

Material used in this welding was AL6061with dimensions of 5mm thick and 300mm in length. Surface appearance obtained in the FSW was similar to that of the surface obtained in the milling process. Whereas in MIG welding surface was appeared to be a casted component and has a rough surface. Tensile strength was 7% less than that of the base material in FSW and in MIG welding the tensile strength is 24% lesser than the base material. This shows that the tensile strength of the FSW is higher than the MIG welding. Study in literature says that the FSW welded component has the refined structure whereas the MIG welded component has the cast structure. Fine structure of FSW was due to the stirring effect during the metal joining process. This refined structure leads to increase the mechanical properties of the welded component. Higher the heat input in MIG welding process negatively affect the mechanical properties of the welded material.

3. Microstructure characteristics

A non-heat treatable aluminium alloy AL5086-H32 has been selected for the experiment. Specimen has been welded using MIG, TIG and FSW. Afterwards the specimen was subjected to the distortion measurement. Microstructural examination of welded zone has been done using the light optical microscope(LOM) and transmission electron microscope(TEM).To determine the fracture mode of welded joints, fracture surface of specimens were examined using the scanning electron microscope(SEM).After the visual examination of plates, MIG and TIG welding were consist of porosity in their surfaces. In FSW welding the microstructure of double stir zones mainly composed of onion rings structure in the nuggest zone with fine and equiaxed grains has been generated due to the plastic deformation and frictional heating. Further the tensile properties of FS welded specimen is satisfactory than the fusion welded specimens. LOM and SEM examination of fracture surfaces exhibited porosities in MIG a TIG welds that have caused the strength value to decrease; however FS welds does not include the weld defects.

4. Conclusion

Wide research has been made on optimization of the MIG welding. However the results that are found in the above experiments shown that the MIG welding of aluminium alloy has defect than that of MIG and FSW. Although the MIG welding has the defect all are within the certain limit and does not affect the performance of the welded specimen. It is up to us to select the appropriate welding method for appropriate operations. Cost is another parameter we have to consider it also.

- The microstructure of double stir zones was mainly composed of onion ring structures in double nugget zones with fine and equiaxed grains and TMAZ were observed.
- The hardness of the weld zone confirmed the joint efficiencies of welded plates as observed in tensile test.
- The present study has demonstrated that the tensile properties of FS welded joints were satisfactory as/than TIG and MIG welded joints. Though all failure locations were detected as weld metal in fusion welding processes, all failure locations of FS welded specimens were occurred at TMAZ advancing side.
- Bend tests of welded plates have shown that FS welded specimens do not include any defect like fusion welded specimens.
- The LM and SEM examination of fracture surfaces revealed porosities in MIG and TIG welds that have caused mechanical results to decrease; however FS welds do not include any weld defects. Furthermore, ductile-brittle mixed type fracture has been occurred in FS welded joints weld zones as layers from the onion rings.
- No filler metal and groove preparation were needed in FSW process, the surface appearance approaches to that of a rough-machined surface. This situation reduces the production costs.
- The FSW process is a solid state welding process with process temperatures lower than fusion techniques, thus avoiding problems such as porosity, cracking and distortion. These are also the advantages of FSW process in comparison with fusion welding processes such as MIG and TIG.

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