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V-Groove Shape Effect on Tensile Strength of Metal Inert Gas Aluminum to Steel Welding Process

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Abstract:*The objective of this research to study the impact of v-groove shape on Metal Inert Gas welding procedure of 6mm thickness A6061 aluminum combination and 304 Stainless steel in overlap configuration with welding parameters as; voltage, wire feed rate and shielding gas are 17 volts, 2m/min and 15L/min respectively, the experiment was performed in which the aluminum is upper. 1-mm diameter of ER4042 filler material and pure argon gas as shielded gas. V-groove shapes in steel samples were made with angle 45^0. The experiment conducted using SYNERGIC.PRO^2 450-4 machine. Tensile test was carried out for each welded sample Universal Testing Machine of MIG welding processes with and without v-grove in steel side. Tensile strengths of welded test samples vary from 15.8 N/mm^2 to 26.24 N/mm^2 contingents on the welding conditions. The results indicated that v-groove specimens have a maximum strength of tensile strength of 26,24 N / mm2 compared to v-groove samples. It shows the ability to mount inert gas / brazing process aluminum to steel by means of a reversed groove angle and to maximize welding parameters. In conjunction with the half-V-shaped groove the smallest temperature gradient along the steel interface was noted to the smallest difference from top to bottom with IMC thicken values. Tensile test results showed that, owing to its outstanding diffusion behavior of filled filler material, the maximum bonding interface and the correct IMC interface distribution on the steel surface.*

Keywords: MIG (Metal Inert Gas), V-Grooves, Tensile Test.

I. INTRODUCTION

The joining of different metals is commonly a major testing due to contrast in the properties, for example, physical, mechanical and metallurgical. The incredible specialists accomplishing for the material with a high solidarity to-weight proportion in building industry, a great deal of interest have paid on joining of aluminum combination to steel to deliver a one section has various properties like warm conductivity and electrical conductivity. In any case, the trouble to join steel to aluminum because of the arrangement of inhibit intermetallic compound (IMCs) [2]. Metal Inert Gas welding (MIG) welding is a welding procedure that is broadly utilized for welding an assortment of materials, ferrous and non-ferrous. In manual welding activity, the welder must have power over the welding factors parameters like the protecting gas. Hardened steel and aluminum are the most normally utilized metals in nearly applications because of their superb physical properties, for example, common development, atomic reactors, warm power plants and vessels.

Present and possible dissimilar welding applications in the automotive business incorporate breeze shield outline, focus column, and floor skillet. Specifically, the way toward consolidating slight materials, for example, aluminum and high quality materials such as ferrous compounds has experienced broad research due to its potential for the car and other modern areas. Such weldments profit by the unbending nature of steels and aluminum, incorporating the better of the two universes [1].

Various reports on weld procedures to redesign dissolvability and inhibit intermetallic compound (IMC) development are likewise examined. At long last, these examinations contends for the noteworthiness of warmth contribution to the welding technique and recommend a crossover strategy for preheating before circular segment welding to enhance the joint quality of aluminum–steel different welding. The accompanying areas are partitioned into several category which consolidates issues in aluminum–steel different welding, current advancement in the improvement of joint quality, and preheating strategy as a novel way to deal with weld joint improvement.

II. MATERIAL PROPERTIES

Stainless steel 304 and A6061 aluminum alloy are generally utilized in ventures were picked as a material for welding process. Elements piece of both the examples and filler material got from the phantom investigation are recorded in Table 1.

Table-I: Elements Compositions

Materials	*Elements (%)*							
304 Stainless Steel	Fe Bal	Cr 18.22	Ni 8.19	C 0.06	Mn 0.96	S 0.002	P 0.027	Si 0.06
A6061 aluminum	Al Bal	Fe 0.7	Cr 0.05	Mn 0.15	Si 0.4	Mg 0.8	Cu 0.15	

The joining of aluminum-stael requires soldering contact because the soldering temperature is greater than that of aluminum (the soldering articulation) but lower than that of metal.

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III. PROBLEM IN ALUMINUM–STEEL DISSIMILAR WELDING

Due to the close to zero solvencies as described above, an IMC layer is eventually formed through the materials ' contact surface. It is difficult to combine these two metal sets. Many peculiar aspects of mechanical properties which complicate the procedure; in general, the liquefying and breaking points of the two metals and their oxides are extraordinary; aluminum has approximately double the warm extension coefficient and multiple times the warm conductivity coefficient compared with steel; The aluminum's general heat is double that of steel, and the aluminum strength element is multiple times that of steel [5]. Such distinctions represent a noteworthy problem in view of the fact that, particularly in the weld region, a particular degree of twisting, metallurgical precipitation and deformity is envisaged.

The IMC thickness is expressed as follows in the diffusion control process:

$$X = K\sqrt{t} \qquad \text{Eq 1}$$

$$k = ko\exp\left(-\frac{Q}{RT}\right) \qquad \text{Eq 2}$$

In which X was the thickness of the IMC (mm), t is the time (s) for diffusion, Ko is a fixed, Q is the energy of stimulation (J) for substrate development, R is gas constant, and T is the absolute temperature (K). The near to zero solvencies between aluminum and steel is one of the important reasons behind the limited research papers on aluminum–iron differential welding. This state result in the formation of a thin layer of IMC between the two sheets. This layer has been extensively studied and several papers generally consider this layer as the weakest area, the dividing point and the cause for the mechanical properties to decay [7]. The last yet seemingly most important factor to consider in strengthening the joint between aluminum and steel is the heat output from the welding cycle. For arc welding, heat input is expressed by the following equation.

$$y = \frac{\mu \times UI}{1000 \times V} \qquad \text{Eq 3}$$

In which J is the source of energy (kJ= mm), g is the welding coefficient, U is the current (A), I is the voltage (V) and V is the level of circulation (mm= s). The variations in the input temperature can affect the penetration, length, defects, and contorsion of the solder, as well as the IMC thickness antagonistically. In order to evaluate the ideal temperature input function, parameter improvement is important.

IV. WELDING AND MATERIAL PREPARATION

Until exploration, an exhaustive readiness to weld is necessary. In addition to basic necessities such as oxide layer and oil removal, an increase in product preparation preceding the curve welding process is the use of a non-corrosive transition. In light of the fact that such motions have a melting temperature point just below filler metals, fluxes have been shown to enhance the wetting and spreading of filler metals by evacuating aluminum and steel oxides (565–572C). Once melted during the welding process, fluxes break down the aluminum oxide layer, thereby allowing direct contact between aluminum (fluid state) and steel (strong state) just as it stops molten aluminum from oxidizing.

V. EXPERIMENTAL PROCEDURE

The experiment is initiated with cutting sample work piece into small pieces for the purpose of getting same dimensions (length x width x thickness). Then, before running the MIG welding the angle of every work piece is measured. Following the setting in accordance to DOE, with the help of Taguchi method DOE is implemented to the plasma arc cutting system. After every cutting trial, the angle of the work piece will be measured again. So, the different angle can be calculated before and after the process of machining. This obtained information can help calculating the signal to noise ratio. After that the work piece will be testing the joint strength between the aluminum and stainless steel using Universal Tensile Test machine [9]. The 304 stainless steel alloys make a grove with 45° in one side and cut with a size of 100mm × 40mm and the thickness fixed of 6mm, aluminum ER4043 with 1mm diameter as filler material the surface of materials cleaned by the sandpapers to remove the oxidization layer.

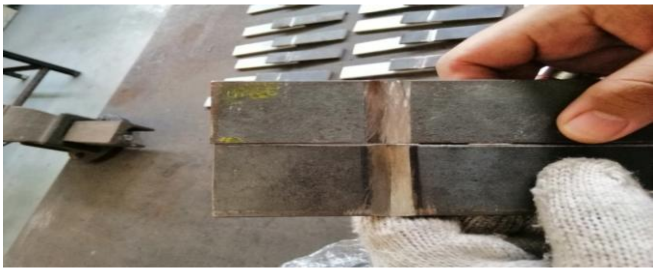

Figure – I: Groove preparation

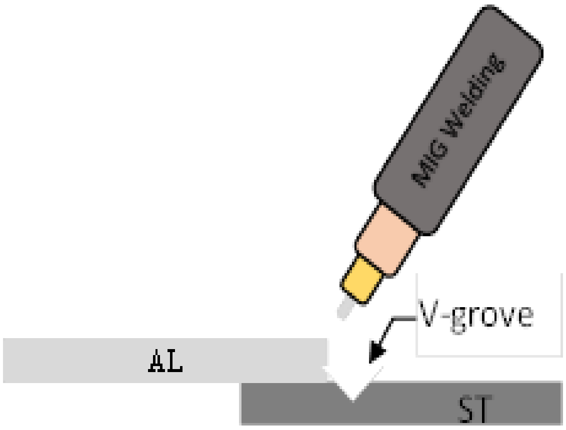

Figure II: Schematic of A6061 aluminum alloy/SUS304 stainless steel by the MIG welding process.

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Table-II: Welding conditions

Working parameter	*Description*
Machine	SYNERGIC.PRO^2 450-4 MIG welding
Shielding gas	17 L/min- Pure Argon
specimen dimension	Al 6061-100 × 40 × 6mm SS 304-100 × 40 × 6mm
Filler metal	ER4043 (1.0mm-diam)
Wire feed rate	2 m/min
Current	115 A
Voltage	17.5 V

VI. RESULT AND DISCUSSION

The achievability of metal inert gas welding aluminum to stainless steel was examined for each welded example by leading a tensile test. The variety of every quality test is broke down from chart 2. From this diagram, it was seen that quality of joint increments by utilizing forest in hardened steel spacemen. The quality of joint is somewhat increments or diminished rely upon changes of parameters, for example, welding pace and bend separation in light of the fact that the manual welding process. So it very well may be expressed that, by utilizing forest in hardened steel test, the quality of the joint of aluminum to steel will improve as well.

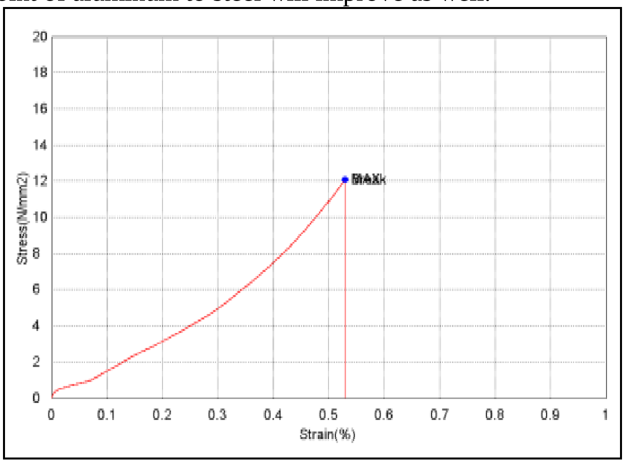

Figure III: Tensile test result sample 1

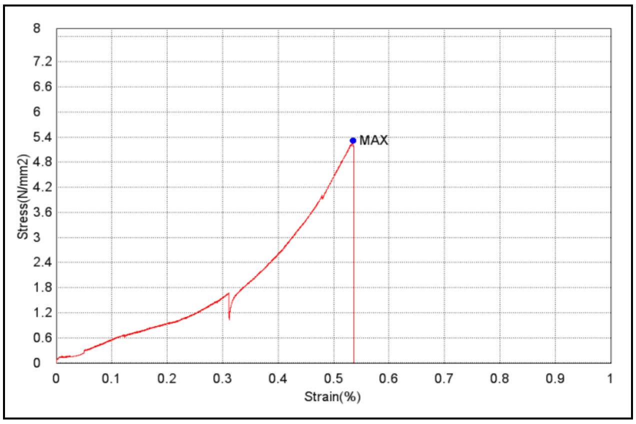

Figure IV: Tensile test result sample 2

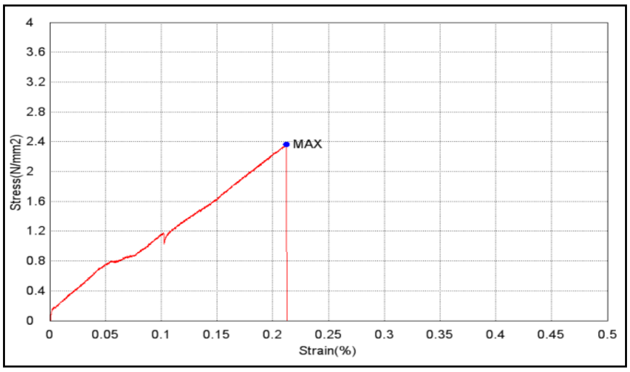

Figure V: Tensile test result sample 3

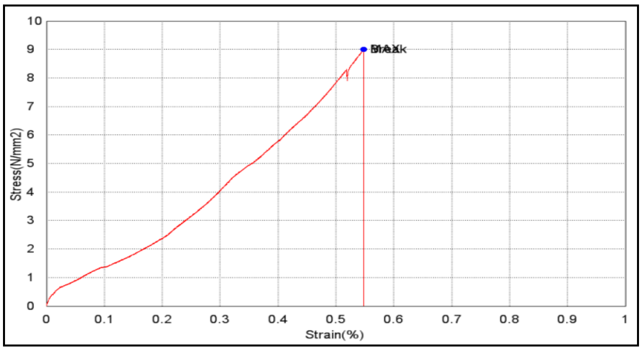

Figure VI: Tensile test result sample 4

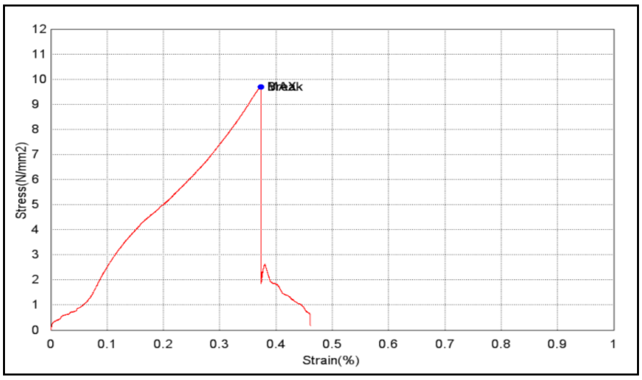

Figure VII: Tensile test result sample 5

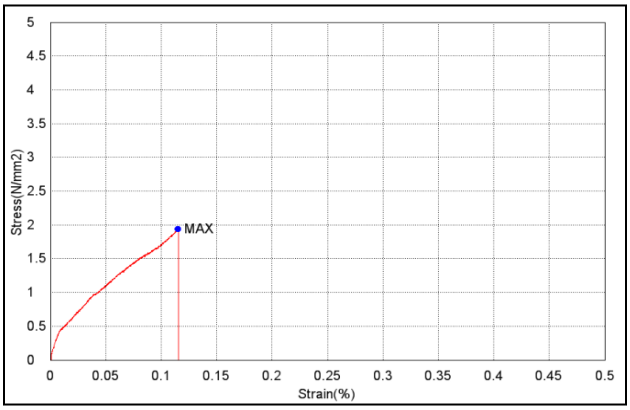

Figure VIII: Tensile test result sample 6

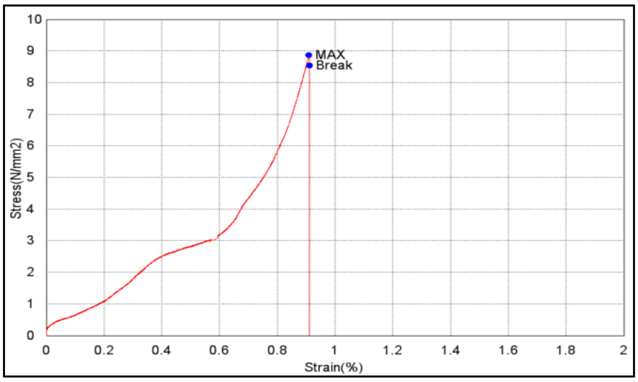

Figure IX: Tensile test result sample 7

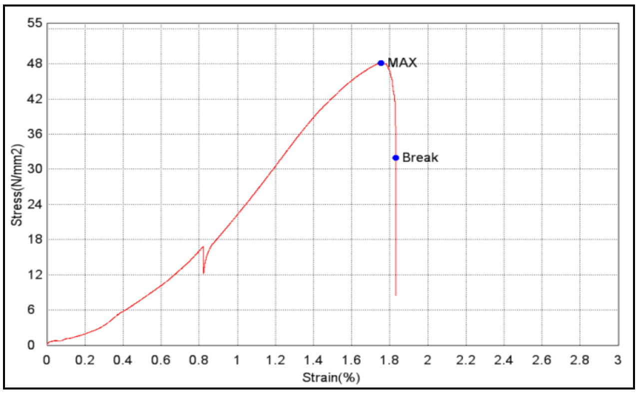

Figure X: Tensile test result sample 8

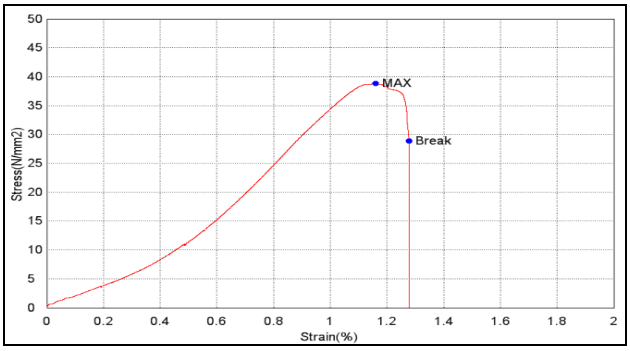

Figure XI: Tensile test result sample 9

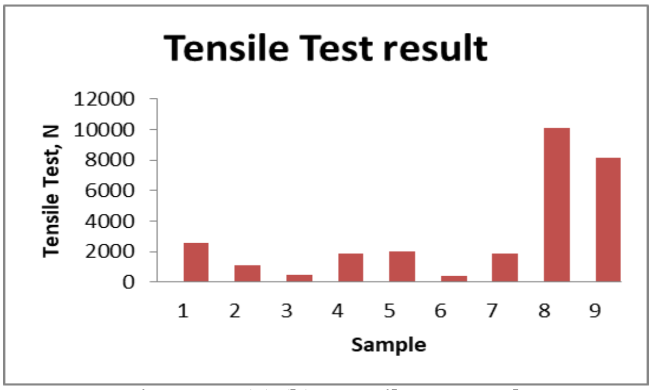

Figure III (a) (b): Tensile test result

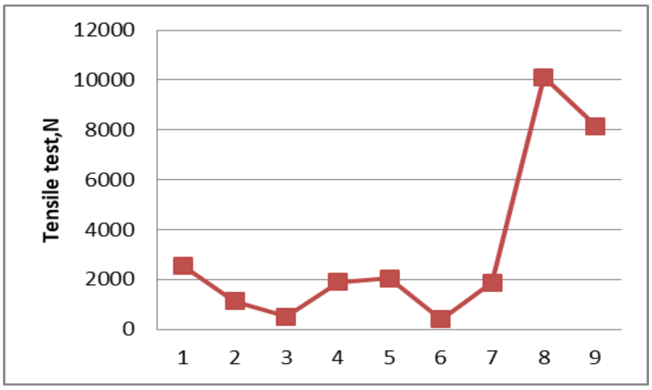

Figure III (a) (b): Tensile test result

VII. CONCLUSION

In conclusion, this investigation displays the impact of v-groove shape to evaluate the disparate welding process by utilizing metal inert gas machine. Using the V groove in stainless steel samples, the quality of the joint was improved. These outcomes will be increasingly powerful by advancing the welding parameters that can impact on welding process. Utilizing diverse v-groove angle would more be able to improve for the joint.

VIII. ACKNOWLEDGEMENT

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