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DESIGN AND MICROSTRUCTURE ANALYSIS OF TIG WELDING WITH TWO DIS-SIMILAR MATERIALS

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Abstract: GTAW, known as tungsten inert gas welding (TIG), is commonly used to join thin sections of nonferrous metals like magnesium, copper, and aluminum alloys. Allowing for more substantial, higher quality welds, the welding operator needs great control of the welding process. Because of the short arc length, the filler electrode's contact gap has to be maintained in an even way to maintain equal speed and depositing methods. Present work focuses on the TIG welding process and microstructure analysis of welding flaws and evaluates the mechanical properties of welded joints. Materials selected for the present TIG welded process are SS316, and Alumina mixed with SIC as composite. Special filler rods are known as Alum steel with a diameter of 3mm in a two-step process for the work. Power conditions also varied to check the sample's durability with optimized DOE parameters. The samples were prepared as per ASTM weld samples; the extracted samples were tested for microstructure, penetration and other mechanical tests. The results are showing well in the area of the weld.

***Keywords*—** GTAW, dissimilar metal welds, SEM

I. INTRODUCTION

Welding is a common process for joining metals using a large variety ofapplications. Welding occurs in several locations, from outdoors settings onrural farms and construction sites to inside locations, such as factories and job shops.

Welding processes are fairly simple to understand, and basic techniques an be learned quickly Welding is the joining of metals at a molecular level. A weld is a homogeneous bond between two or more pieces of metal, where the strength of the welded joint exceeds the strength of the base pieces of metal. At the simplest level, welding involves the use of four components: the metals, a heat source, filler metal, and some kind of shield from the air. The metals are heated to their melting point while being shielded from the air, and then a filler metal is added to the heated area to produce a single piece of metal. It can be performed with or without filler metal and with or without pressure

II. LITERATURE REVIEW

1) Paul Kah, Raimo Suoranta: Techniques for joining lightweight dissimilar materials, particularly metals and polymers, are becoming increasingly important in the manufacturing of hybrid structures and components for engineering applications.The recent drive towards lightweight construction in the aerospace and automotive industries has led to increased exploitation of lightweight metallic and non-metallic materials with the aim of achieving specifically optimized versatility. Hence, suitable joining methods are necessary in order to reliably join these dissimilar materials and to integrate them in engineering structures. Understanding of the various joining technologies that exist for multi-material metal-to-metal, polymer-to-polymer, and metal-to-polymer hybrid structures is consequently important.metal-to-polymer hybrid structures is consequently important

2) M. Ravichandran, A. Naveen Sait : TIG welding process parameters were analysed for joining duplex stainless-steel plates. Signal to noise (SN) ratio and Analysis of Variance (ANOVA) analyses were applied for investigating the selected

welding parameters. The selected parameters were current (A),gas flow rate (L/min) and speed (mm/min). The purpose of this work is to produce weld joints with maximum impact of strength and hardness. L9 orthogonal array was selected

according to the aforementioned factors with three levels. The impact strength of the joints was found using the Izord impact testing machine and hardness of all joints was measured using the Brinell hardness machine

3) I.O. OLADELE, O.T. BETIKU : .The demand of joints of dissimilar metal combination is rapidly increasing in many structural and industrial applications for special optimization of properties as well as to save cost. Welding of dissimilar metals between stainless steel and carbon steel has been widely used in engineering practice over the years. To date, the majority of welded structures is fabricated in the form of dissimilar metal weld because it is more economical compared to the ones made of stainless steel only.

III RESEARCH METHODOLOGY

The materials Al6061 with SS316 is taken and as welding components for dissimilar weld amendment where the materials are machined for proper sampling for tests. In TIG welding a differentiation is made between two variants.

On the one hand, it is welding with direct current, which is the most frequently used type. The tungsten electrode is positioned on the negative pole.This form of welding is used to join alloyed steels as well as non-ferrous metals such as copper or brass. On the other hand, it is welding with alternating current. This type of welding is used to join lightweight metals such as aluminium and magnesium, as the oxide layer is broken up. In exceptional cases, however, lightweight metals are also welded with direct current, in which case the electrode is attached to the positive pole. In general, however, it can be stated that each metal suitable for fusion welding procedure can be welded using the WIG procedure. As tungsten inert gas welding can be used both manually and as an automated process, this procedure is used in very many areas. Large opportunities for its use are found in the aerospace industry, in structural steelwork and railing construction as well as in pipe laying. TIG welding is always used if particularly high weld quality and properties are required. This work can be done using two hands in manual welding. One hand is used to add the filler metal while the other hand holds the welding torch. As the skill requirements are very high, these tasks are only carried out by specialised welders.

Table: Tig welding specifications

Model	TIG 200AC/DC
Rated Input Voltage (V)	220±15%
Input Frequency (Hz)	50
Rated Power at Max. Current (KVA)	6.2
Duty Cycle	60%
Weight (Kg)	22.1
Dimension (L x W x H) mm	498 x 328 x 365

Figure: Aluma-steel filler rod

Procedures of weldingAll specimen are planed with 3mm thickness x80mm width x150mm length ofplates of Al6061-T6 and SS316, materials with good surface treatment. Initially the two plates are fixed to the base plate and brazed at two ends.Welding rods of Ø2.4 mm alumina-steel are used as filler metal i.e Filler 01 &02 for suitability of joint. At 60 A to 85 A process current and the recommended beginningtemperatures, argon as an inert gas, with DCEN polarization by two-stepwelding, the TIG welding equipment Fig. was used to weld.Filter gas lens 3/32 and #6 diffuser cup, and 3/32 tungsten are used for initialweld and for bead formation towards steel side with no pulse. After the weld bead is formed, attach the steel plate as a first layer and theadjacent layer is welded on second step. Press foot control to starting weld current i.e. about 60-85 A, deposit one fulldroplet (liberally).Move weld rod back a little but keep it in the coverage zone to preventoxidation on rod. Press foot control rapidly at controlled amperage.A complete pulse cycle should be done quickly about 4-6 seconds and evenless.Direct the torch angle towards aluminium and deposit weld puddle overlapping the 1st pass midway and partially onto aluminium. Set temperature to 60 amps. (DC same as steel or stainless steel) Watch for droplet to flatten out, to have smooth surface, medium height, and rounded edge. Increase temperature by 5-10 degrees and continue the process. When the surface of the droplet is no longer smooth, it will resemble the moon or a head of cauliflower. The aluminum will be deformed around the hexagonal pattern if it is heated to a temperature that is too extreme. Reduce the temperature back to normal setting with best appearance. Once initial trial samples of welding after conducting the breaking load test if it is satisfied it will be continued or any minor variables may be changed for consistence of test results in all respect

Table: Properties of AL6061-T6

Component	Wt. %	Component	Wt. %	Component	Wt. %
Al	95.8 - 98.6	Mg	0.8 - 1.2	Si	0.4 - 0.8
Cr	0.04 - 0.35	Mn	Max 0.15	Ti	Max 0.15
Cu	0.15 - 0.4	Other, each	Max 0.05	Zn	Max 0.25
Fe	Max 0.7	Other, total	Max 0.15		

Table: Chemical Composition of SS316 material

	Ni	C	Mn	Cr	Si	P	Mo	S	Fe
SS316	10-14	<0.03	<2	16-18.5	<0.1	<0.045	2-3	0.03	Bal

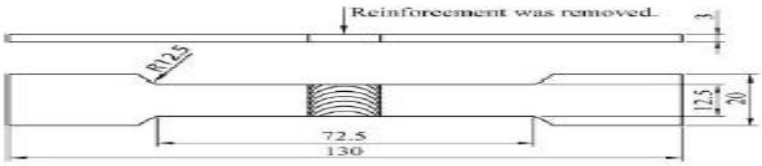


Figure: preparation drawing for tensile test

Figure: Sample combination AL 6061-SS316-welded samples

.Preparation of samples

Figure: Tensile and hardness testing samples

Figure: Sample after etching for micro hardness

Figure: Sample combination Al 6061-SS316- Microstructure weld zones

IV. CATIA WILDFIRE BENEFITS:

Unsurpassed geometry creation capabilities allow superior product differentiation and manufacturability

• Fully integrated applications allow you to develop everything from concept to manufacturing within one application

• Automatic propagation of design changes to all downstream deliverables allows you to design with confidence

• Complete virtual simulation capabilities enable you to improve product performance and exceed product quality goals

• Automated generation of associative tooling design, assembly instructions, and machine code allow for maximum production efficiency

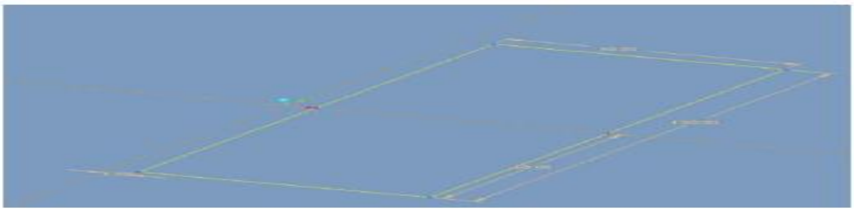


Figure: Drawing model

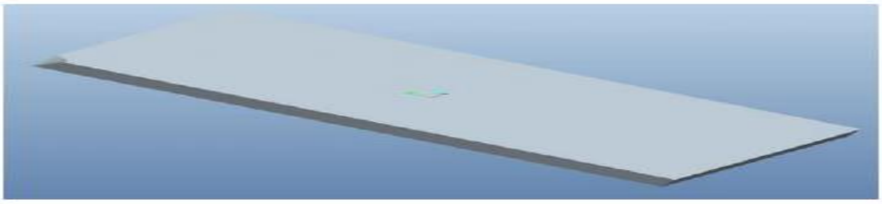


Figure: Al6061-T6 plate

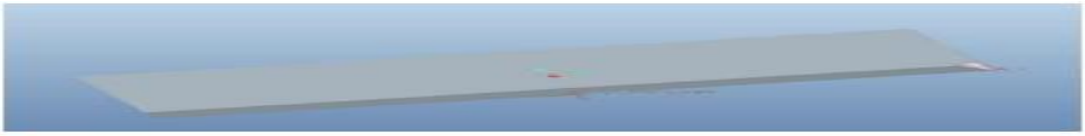


Figure: SS316 Plate

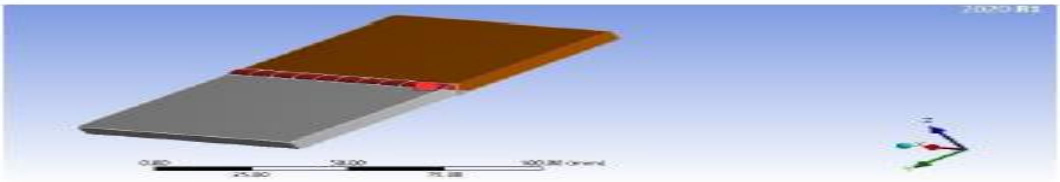


Figure: Assembled view

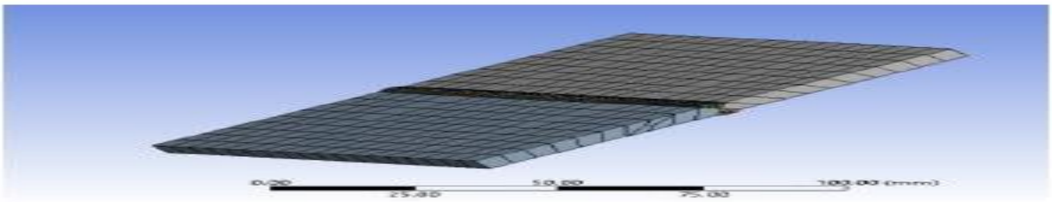
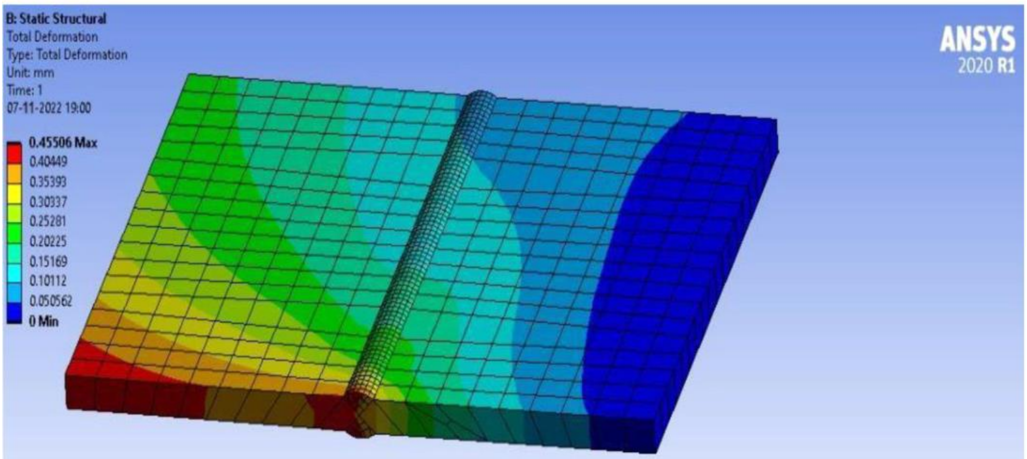


Figure: Meshed view

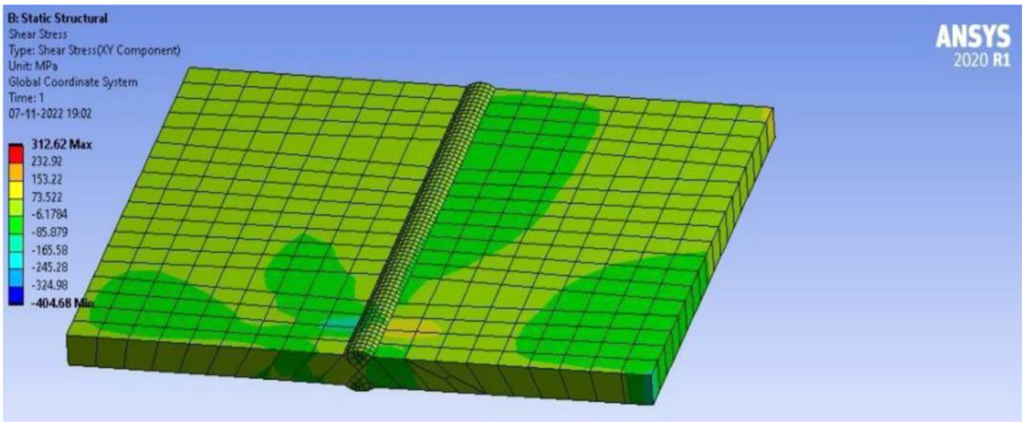
V. RESULTS AND DISCUSSIONS

Metallographic analysis of the bonding interface: A static structural analysis calculates the effect of steady (or static) loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time varying loads

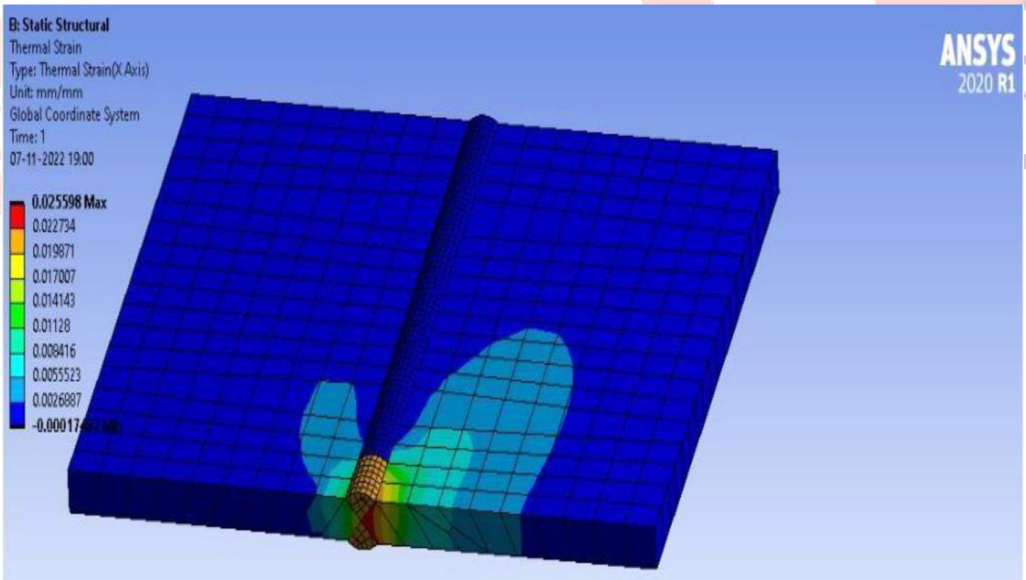
The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study,Data and Sources of Data, study's variables and analytical framework. The detailsare as follows;



TOTAL DEFORMATION



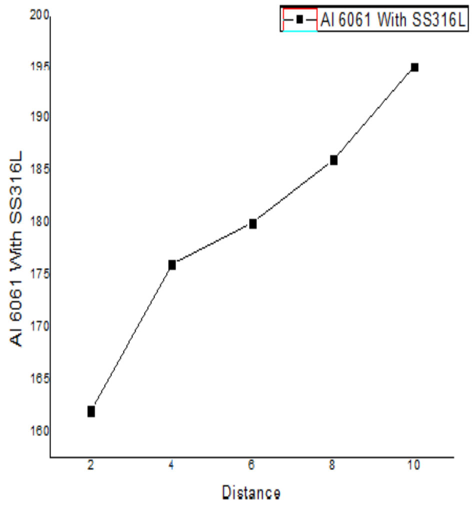
SHEAR STRESS



THERMAL STRAIN

Table: Observed strengthening conditions for welded samples:

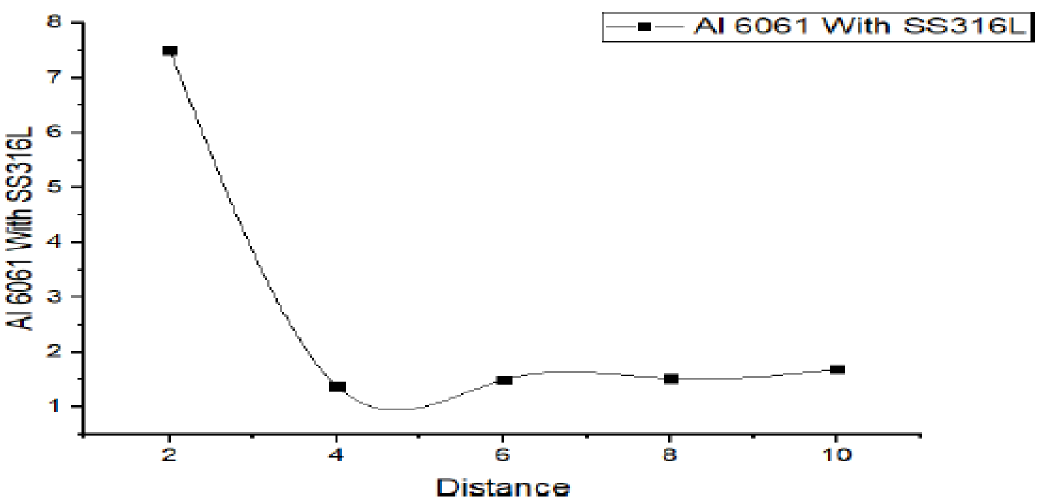
Distance	Al 6061 With SS316L
2	162
4	176
6	180
8	186
10	195



Graph: Variation in Weld Strengths for all dissimilar welds

Table: Observed Crack propagation rate (m/cycle) for welded samples:

Distance	Al 6061 With SS316L
2	0.000075
4	0.000138
6	0.000150
8	0.000152
10	0.000169



Graph: Crack propagation rate for different welded samples

MICRO STRUCTURAL RESULTS

Figure: Case -1 Sample Combination Al 6061-SS316- Microstructure weld zones

Figure: Al6061+SS316 Weld joint with various weld zones at 60 A

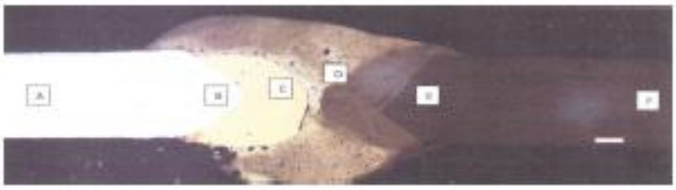


Figure: Al6061+SS316 Weld joint with various weld zones at 70 A

TENSILE STRENGTH RESULTS

Initial & Final Parameters

Serial No		:	04
Specimen Type		:	Flat
Specimen Width	(mm)	:	15.69
Specimen Thickness	(mm)	:	4.95
C/S Area	(mm^2)	:	77.67
Original Gaugelength	(mm)	:	25.00
Final Gaugelength	(mm)	:	25.94
Test Time	(min)	:	0:00.09

Observed Data

				Speci. Values
Ultimate Load	(kN)	:	4.88	
Ult Tensile Strength	(MPa)	:	62.83	0
Disp at Ult Load	(mm)	:	3.60	
Maximum Disp	(mm)	:	3.60	
% Elongation	(%)	:	3.76	0
% Red in Area	(%)	:	20.97	
Breaking Load	(kN)	:	4.88	
Breaking Stress	(MPa)	:	62.83	
Yield Load	(kN)	:	1.72	
Yield Stress	(MPa)	:	22.14	0
Stress Rate	(MPa/S)	:	5.14	

SAMPLE-1 60 AMPS (AL6061-T6 & SS316)

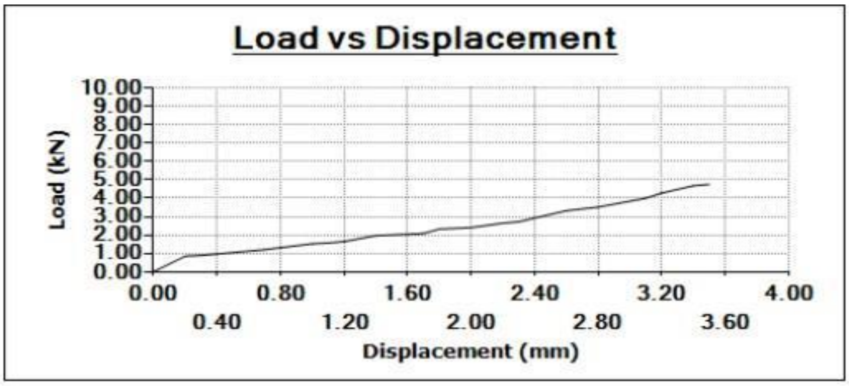


FIGURE: LOAD VS DISPLACEMENT

SAMPLE-2 70 AMPS (AL6061&SS316)

Initial & Final Parameters				Observed Data				Speci. Values
Serial No		:	06	Ultimate Load	(kN)	:	1.40	
Specimen Type		:	Flat	Ult Tensile Strength	(MPa)	:	22.70	0
Specimen Width	(mm)	:	12.46	Disp at Ult Load	(mm)	:	1.20	
Specimen Thickness	(mm)	:	4.95	Maximum Disp	(mm)	:	1.20	
C/S Area	(mm²)	:	61.68	% Elongation	(%)	:	0.08	0
Original Gaugelength	(mm)	:	25.00	% Red in Area	(%)	:	0.78	
Final Gaugelength	(mm)	:	25.02	Breaking Load	(kN)	:	1.40	
Test Time	(min)	:	0:00.04	Breaking Stress	(MPa)	:	22.70	
				Yield Load	(kN)	:	0.00	
				Yield Stress	(MPa)	:	0.00	0
				Stress Rate	(MPa/S)	:	10.40	

Figure: Load vs Displacement

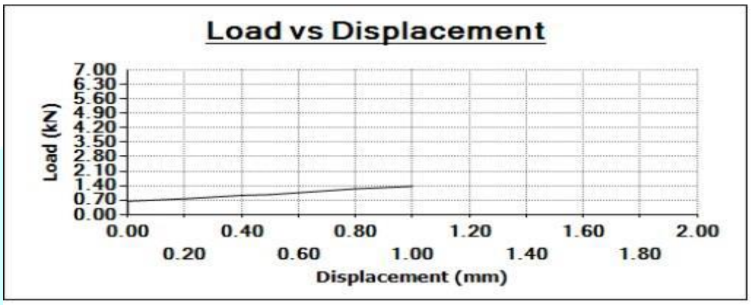


Figure: Load vs Displacement

SAMPLE-3 80 AMPS (AL6061&SS316L)

Initial & Final Parameters				Observed Data				Speci. Values
Serial No		:	09	Ultimate Load	(kN)	:	2.64	
Specimen Type		:	Flat	Ult Tensile Strength	(MPa)	:	42.80	0
Specimen Width	(mm)	:	12.46	Disp at Ult Load	(mm)	:	1.80	
Specimen Thickness	(mm)	:	4.95	Maximum Disp	(mm)	:	1.80	
C/S Area	(mm²)	:	61.68	% Elongation	(%)	:	0.36	0
Original Gaugelength	(mm)	:	25.00	% Red in Area	(%)	:	0.86	
Final Gaugelength	(mm)	:	25.09	Breaking Load	(kN)	:	2.64	
Test Time	(min)	:	0:00.05	Breaking Stress	(MPa)	:	42.80	
				Yield Load	(kN)	:	1.96	
				Yield Stress	(MPa)	:	31.78	0
				Stress Rate	(MPa/S)	:	9.62	

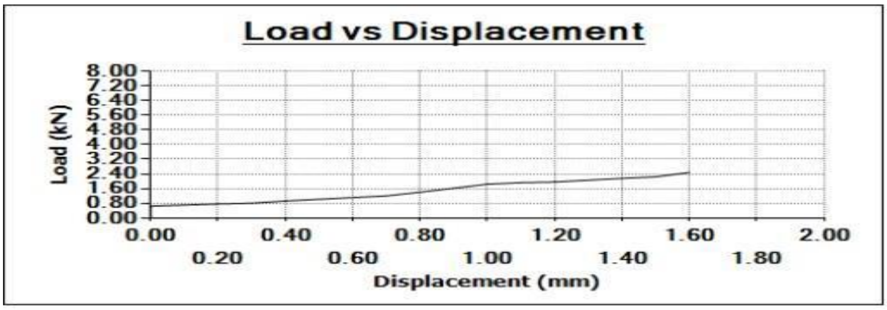


Figure: load vs displacement

HARDNESS TEST RESULTS:

Table: Hardness test results in AA6061& SS316 Samples

S.ID	Sample ID	Observed Values in HV			
		WELD 1	WELD 2	HAZ AA6061	BM AA6061
1	AA6061& SS316 (60Amps)	131	101	33	37
2	AA6061& SS316 (70Amps)	128	108	29	37
3	AA6061& SS316 (80Amps)	160	103	36	39

DISCUSSIONS :

As per the specimens observed from the experiment's a flow has been taken from the initiation that dissimilar metal weld possibilities and its strengthening properties observed in a proper manner with the researched filler rods. The filler electrodes used in final Al 6061-T6 with SS316L weldment pre observed with dissimilar welds A bigattractiveness of these joining methods results from many technical and economic advantages, such as high efficiency and stability of the process or better conditions of occupational safety and health than in the case of traditional welding technologies.

However, recently, the most important seems to be the possibility of joining materials with different properties. Due to the fact that in the fusion zone between the two different materials the intermetallic compounds are formed and the joining process of dissimilar materials is often very difficult. To obtain high-quality joint it is necessary to know and analyze phase diagram of the two welded materials. Furthermore, the microstructure and different properties of intermetallic phases, such as crack sensitivity, ductility, and corrosion resistance, are also very important.

VI. CONCLUSIONS AND FUTURE SCOPE

The dissimilar joining between Al 6061-T6 with SS316 alloys by TIG weldingprocess using Aluma-Steel welding rods.

• The main conclusion and aim to control the weld defects in dissimilar metal welds, the percentage of SS316 with 0.15 control the thermal defect in aluminium, the procedure followed for TIG weld should be in a continuous manner.

• The temperature should be down to 60to 800c after each layer formed to reduce thermal cracking for next addition. By observing micro structures and mechanical properties TIG weld has speed and frequency on response variables such as weld bead hardness and impact strength has been thoroughly studied. The weld amendment is more significant process parameters for responses, weld bead hardness and impact strength.

• The process tested with all relevant materials before aluminium and SS316 metal welding. The thickness of materials varied by 4mm to 3mm respectively to check the irregularities of the filling.

• When there is misalignment, stress distribution becomes more complex.During the axial loading, eccentricity rises bending stresses near the vicinity of the weld. Therefore, total stress on the welded joint becomes the sum of axial stress as well as bending stress.

FUTURE SCOPE

• Present study given a base scope of elaborating aluminium and Ferro metal welds in a proper manner; this should be encouraged in an economical way for industries

• More researches needed in filler materials i.e electrodes develop in such way to control weld cost in structural sectors.

• When there is misalignment, stress distribution becomes more complex.During the axial loading, eccentricity rises bending stresses near the vicinity of the weld. Therefore, total stress on the welded joint becomes the sum of axial stress as well as bending stress.

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