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Investigation of Strength of V & U Groove Butt Joint by TIG Welding & its Analysis

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***Abstract*— Now a days in shipping, aerospace and in process industry aluminium and its alloys are commonly used because of their valuable properties such as light weight, better corrosion resistance and weld ability. The current study aim is to Investigation of Strength of V & U Groove Butt Joint on mechanical properties of AA2025 and AA7025 for different groove angle and bevel heights keeping root opening, voltage and current constant. The specimens are prepared by using V and U groove butt weld joints. In this work gas Tungsten Inert Gas (TIG) welding process has been selected because TIG welding is the process of joining different materials with high quality in the presence of inert gas. Alternating current power source has been selected because of better cleaning action and due to alternating current the high heat concentration on the material can be avoided. Mechanical tests such as tensile test, impact test, hardness test have been conducted to find out the mechanical properties such as tensile strength, impact strength, toughness of HAZ.**

***Keywords*— Single V-Groove Butt Weld Joint, Single U- Groove Butt Weld Joint, Mechanical Properties, Distortion, Groove Angle, TIG Welding.**

I. INTRODUCTION

Welding is one of the most important and versatile means of fabrication available to industry. Welding is used to join hundreds of different commercial alloys in many different shapes. Actually, many products could not even be made without the use of welding, for example, guided missiles, nuclear power plants, jet aircraft, pressure vessels, chemical processing equipment, transportation vehicle and literally thousands of others. Many of the problems that are inherent to welding can be avoided by proper consideration of the particular characteristics and requirements of the process. Proper design of the joint is critical. Selection of the specific process requires an understanding of the large number of available options, the variety of possible joint configurations, and the numerous variables that must be specified for each operation.

If the potential benefits of welding are to be obtained and harmful side effects are to be avoided, proper consideration should be given to the selection of the process and the design of the joint. Generally, the quality of a weld joint is strongly influenced by process parameters during the welding process. Groove angle was taken to analyze the mechanical properties and distortion in butt weld joints. In this paper detailed discussion is carried out on the Strength of Two Different Aluminium Alloy (AA 2025 & AA 7025) With Varying Groove Angle(V & U) and Bevel Heights Keeping other parameter constant.

II. EXPERIMENTAL METHODOLOGIES

From the critical discussion on literature survey and gaps identified from the literature, the problem statement for the current paper is Investigation Of Strength Of V & U Groove Butt Joint By TIG Welding & it's Analysis by using the finite element method and validate with experimental method. In experimental methodology detail discussion is carried out, about material used, specimen preparation and welding geometry used.

A. Materials

The materials used for experimental setup are AA7025 and AA2025 Plates Having Diamensions 8x300x300 mm. The experimental work is to be carried out to investigate the strength analysis of V and U groove butt weld joint for different aluminum alloy using TIG welding method. Focus of this project work is to identify the strength of single V-Groove and U-Groove butt welded joint by increasing the included angle up to 50^0. As included angle increases the contact area will also increases, therefore strength also increases. The composition and mechanical properties of work material AA7025 and AA2025 are given in following Table 1.1, 1.2, 1.3, 1.4 & The welding electrodes used for fabrication are 2.4mm in diameter 914 mm in length and the net weight of 100 pieces is about 10 kg. The filler material is of aluminum alloy IA5356 of EN 13479 grade. These electrodes operate with a quiet arc

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and deposits smooth bead with fine ripples. These electrodes are versatile in nature i.e. they are easy to operate in all positions

Table -1: Chemical composition of work material AA7025

Elements	(Si)	(Mg)	(Fe)	(Ti)	(Cu)	(Zn)	(Pb)	(Mn)	(Sn)	(Cr)	(Ni)
Weight	0.20	3.39	0.53	0.014	0.036	0.025	0.015	0.38	0.0023	0.0043	0.0004

Table 2: Mechanical properties of work material AA7025

Tensile Strength, min, (MPa)	572
Elongation, min (%),	11
Vickers Hardness (HV)	171

Table 3: Chemical composition of work material AA2025

Elements	(Si)	(Mg)	(Fe)	(Ti)	(Cu)	(Zn)	(Pb)	(Mn)	(Sn)	(Cr)	(Ni)
Weight	0.20	0.95	0.32	0.014	0.036	3.20	0.015	0.38	0.0023	0.26	0.0004

Table 4: Mechanical properties of work material AA2025

Tensile Strength, min, (MPa)	400
Elongation, min (%),	11
Vickers Hardness (HV)	138

Table 5: Chemical composition of welding electrodes

Elements	(Si)	(Mg)	(Fe)	(Ti)	(Cu)	(Zn)	(Br)	(Mn)	(Sn)	(Cr)	(Ni)
Weight	0.25	0.05-0.20	0.40	0.06-0.20	0.10	0.10	0.0003	4.5-5.5	0.0023	0.05-0.20	0.0004

Table 6: Mechanical properties of welding electrodes

Tensile Strength, min, (MPa)	310
Elongation, min (%),	22-28

III. PREPARATION OF SPECIMEN

Selection of a particular type of groove geometry is influenced by the compromise of two main factors a) machining cost to obtain desired groove geometry and b) cost of weld metal on the basis of volume need to be deposited, besides other factors such as welding speed, accessibility of groove for depositing the weld metal, residual stress and distortion control requirement. As we know there are different types of groove geometries are available but V & U groove geometries are more economical than Other grooves in term of volume of weld metal to be deposited, and offer less distortion and residual stress related problems. Considering above mentioned factors we have chosen ‘V & U’ Groove geometry edge preparation for our experiment. The Vertical milling machine, shaping machine and lathe machine are used to obtain various angles of ‘V & U’ groove butt weld joints. The groove angles produced after machining for experimental set up are given below.

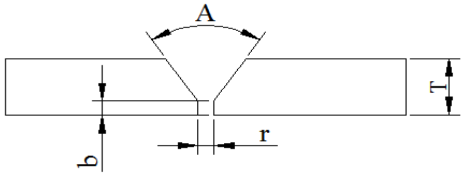

Fig. 3.1: V Groove Geometry dimensions as per standard of ASTM

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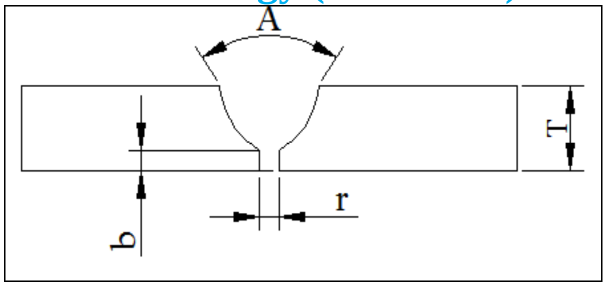

Fig. 3.2: U Groove Geometry dimensions as per standard of ASTM

Where,
A= Groove Angle
b= Bevel Height
r= Root Opening
T= Thickness

Table 3.1: Specimens dimensions for V-Groove

Sr.No.	Sample	Groove Angle (Degree)	Bevel Height (mm)	Material
1	V1	30^0	1	AA2025
2	V2	45^0	1.5	AA2025
3	V3	50^0	2	AA2025
4	V4	30^0	1	AA7025
5	V5	45^0	1.5	AA7025
6	V6	50^0	2	AA7025

Table 3.2: Specimens dimensions for U-Groove

Sr. No.	Sample	Groove Angle (Degree)	Bevel Height (mm)	Material
1	U1	30^0	1	AA2025
2	U2	45^0	1.5	AA2025
3	U3	50^0	2	AA2025
4	U4	30^0	1	AA7025
5	U5	45^0	1.5	AA7025
6	U6	50^0	2	AA7025

IV. TIG WELDING

Fig 4.1 Tungsten Inert Gas Welding Process

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A. Power sources for TIG welding

Power sources for use with TIG welding must be capable of delivering a constant current at a preset value. They are often called "drooping characteristic" units. Rectifier units are commonly used for Dc welding although motor generators may be more suitable for site use. Combined ac/dc power sources can be used where there is a mix of work.

B. Electrodes for TIG welding

Pure tungsten electrodes can be used for TIG welding. Thoriated and zirconiated types give easier starting and better arc stability and are generally preferred. Thoriated tungsten electrodes contain 2% thoria (thorium oxide) and are used for dc welding. Zirconiated tungsten electrodes contain 2% zirconia (zirconium oxide) and are recommended for AC welding of aluminum. The diameter of the electrode is chosen to match the current. The minimum current depends on arc stability. The maximum current a given diameter of electrode can carry is determined by the onset of overheating and melting.

C. Shielding gases for TIG welding

1) Pure argon - Suitable for all metals.
2) Alumaxx Plus- An argon helium mixture which allow the faster welding and deeper penetration on aluminum and its alloy.
3) Inomaxx TIG - An argon, helium, hydrogen mixture which gives lower ozone emissions, less surface oxidation, improves the weld profile, welding speed and penetration on stainless steel, cupro-nickel and nickel alloys.

D. Process variables in TIG welding

The following are some of the variables that affect weld penetration, bead geometry and overall weld quality:-

1) Welding current
2) Polarity (DCSP/DCRP)
3) Arc voltage (arc length)
4) Travel speed
5) Weld joint position
6) Electrode diameter
7) Shielding gas composition and flow rate

Knowledge and control of these variables is essential to consistently produce welds of satisfactory quality. These variables are not completely independent, and changing one generally requires changing one or more of the others to produce the desired results.

E. Welding electrodes

The welding electrodes used for fabrication are 2.4mm in diameter 914mm in length and the net weight of 100 pieces is about 10 kg. The filler material is of aluminium alloy IA5356 of EN 13479 grades. These electrodes operate with a quiet arc and deposits smooth bead with fine ripples. These electrodes are versatile in nature i.e. they are easy to operate in all positions.

V. EXPERIMENTAL TESTING

The tensile strength, impact strength and distortion are evaluated by using following test.

A. Tensile test

This test is used to find the values of Ultimate tensile strength to carry out this test we have to prepare standard specimen as per (As per IS: 1608-2005).

1) *Specimen preparation:* Longitudinal tension test specimens taken From Aluminium Plates conform to the requirements as to tensile properties. Tensile Test Specimen Prepared According to Following Standard

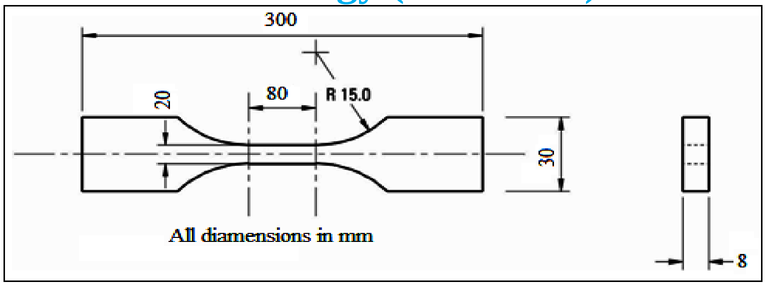


Fig.5.1: Tensile test specimen (As per IS:1608-2005)

2) *Process setup for tensile test:* The specimen is placed in the machine between the grips and an extensometer if required can automatically record the change in gauge length during the test. If an extensometer is not fitted, the machine itself can record the displacement between its cross heads on which the specimen is held. However, this method not only records the change in length of the specimen but also all other extending / elastic components of the testing machine and its drive systems including any slipping of the specimen in the grips. Once the machine is started it begins to apply an increasing load on specimen. Throughout the tests the control system and its associated software record the load and extension or compression of the specimen

Fig -5.2: Process setup for tensile test

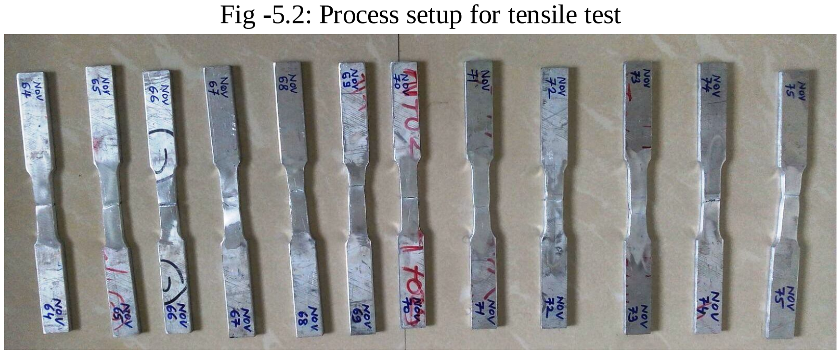


Fig-5.3 Standard Specimen After Test

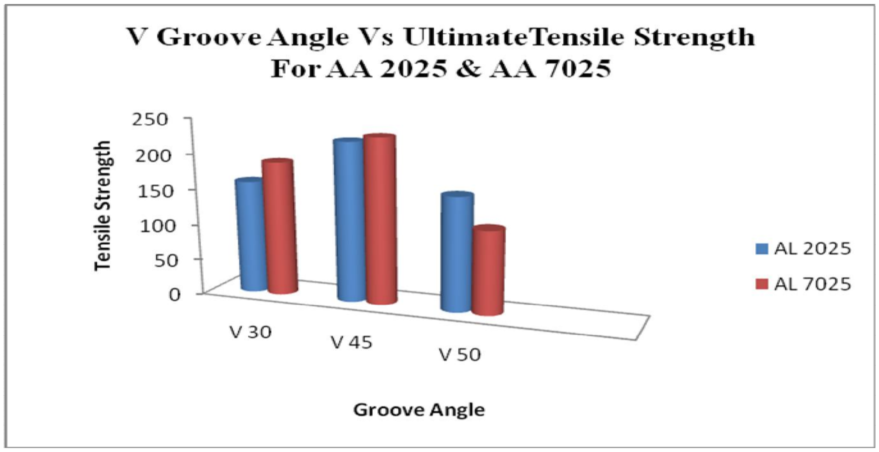
Table 5.1: Tensile test results of all specimens for AA2025

Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	UTS MPa	Failure location
1	AA	0	0	AA2025	400	Unwelded
2	V1	30^0	1	AA2025	159.88	In weld
3	V2	45^0	1.5	AA2025	223.45	In weld
4	V3	50^0	2	AA2025	158.69	In weld
5	U1	30^0	1	AA2025	234.67	In weld
6	U2	45^0	1.5	AA2025	232.23	In weld
7	U3	50^0	2	AA2025	235.99	In weld

Table 5.2: Tensile test results of all specimens for AA7025

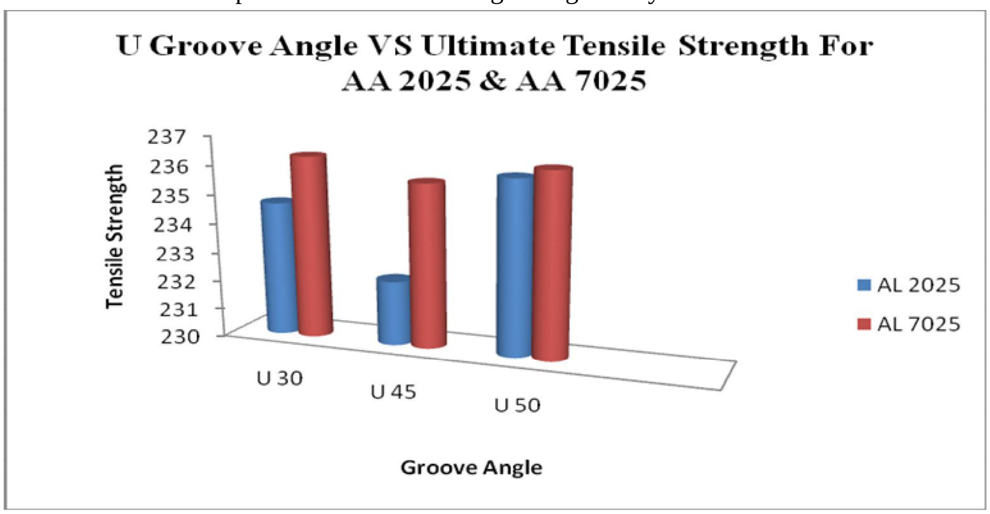
Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	UTS MPa	Failure location
1	BB	0	0	AA7025	572	Unwelded
2	V4	30^0	1	AA7025	189.25	In weld
3	V5	45^0	1.5	AA7025	231.54	In weld
4	V6	50^0	2	AA7025	116.23	In weld
5	U4	30^0	1	AA7025	236.33	In weld
6	U5	45^0	1.5	AA7025	235.65	In weld
7	U6	50^0	2	AA7025	236.31	In weld

3) *Discussion on results:* The following graphs shows the effect of bevel height, groove angle and groove geometry on strength of butt weld joint.



Graph 5.1 Groove angle Vs ultimate tensile strength for V groove weld butt joint

From experimental data, for groove angle Vs ultimate tensile strength graph, it shows that, as the groove angle increases the ultimate tensile strength of single V-groove butt weld joint increase and at 45^0 we have maximum ultimate tensile strength. Also it isobserved that the strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry.



Graph 5.2 Groove angle Vs ultimate tensile strength for U groove weld butt joint

From experimental data, for groove angle Vs ultimate tensile strength graph, it shows that, as the groove angle increases the ultimate tensile strength of single U-groove butt weld joint increase Also it is observed that the strength of material AA7025 is more as compare to AA2025 U-groove geometry.

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B. Impact test

This test is used to find the values of impact strength to carry out this test we have to prepare standard specimen as per standards. To find out the impact strength charpy impact is used.

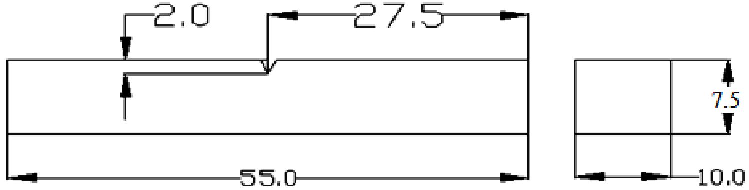

Fig. 5.5: Charpy impact test specimen (IS:1757-1988)

1) *Process set up for impact test:* Materials sometimes display brittleness which precludes their use in a given design. Brittleness is characterized by fracturing with low energy under impact. The fracture energy is proportional to the area under the tensile stress-strain curve and is called the toughness. Tough Aluminium is generally ductile and requires 100 ft-lbs of energy to cause failure. Brittle Aluminium does not deform very much during failure and requires less than 15 ft-lbs energy to cause failure. Characterizing the toughness of a material is done in several ways. The most common method is the notched bar impact test for which two types of specimens prevail, Charpy and Izod. By subjecting a specimen to an impact load, it will fail if the load exceeds the breaking strength of the marial. By using a swinging pendulum to impart the load, the energy required to fracture the specimen can be calculated by observing the height the pendulum swings after fracture, as shown in Fig.5.3

Fig -5.6: Charpy impact test machine

Fig 5.7: Impact Test specimens after Test

Table 5.5 Impact test results of all specimens for AA2025

Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	Impact Strength (J)
1	AA	0	0	AA2025	42
2	V1	30^0	1	AA2025	30
3	V2	45^0	1.5	AA2025	32
4	V3	50^0	2	AA2025	38
5	U1	30^0	1	AA2025	38
6	U2	45^0	1.5	AA2025	34
7	U3	50^0	2	AA2025	36

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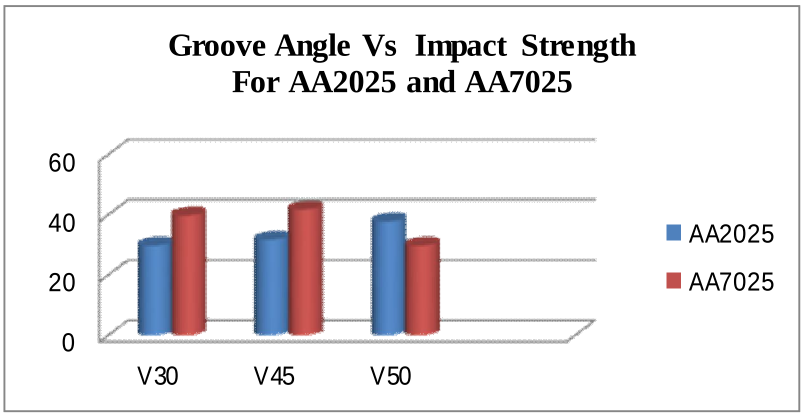
Table 5.6 Impact test results of all specimens for AA7025

Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	Impact Strength J
1	BB	0	0	AA7025	51
2	V4	30^0	1	AA7025	40
3	V5	45^0	1.5	AA7025	42
4	V6	50^0	2	AA7025	30
5	U4	30^0	1	AA7025	38
6	U5	45^0	1.5	AA7025	44
7	U6	50^0	2	AA7025	28

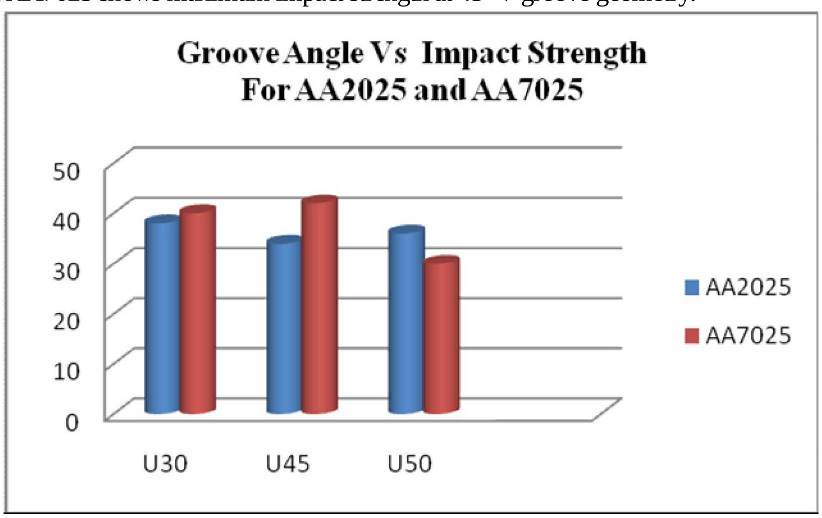
From the above experimental data we are going to compare experimental results Impact test was conducted in " Urja Laboratories"; the results are in the following form,

2) Discussion on results



Graph 5.3 Groove angle Vs impact strength for V groove weld butt joint

From experimental data, for groove angle Vs impact strength graph, it shows that, as the groove angle increases the impact strength of single V-groove butt weld joint increase and at 45^0 we have maximum impact strength. The impact strength of AA2025 and AA7025 increases with groove angle but AA7025 shows maximum impact strength at 45^0 V groove geometry.



Graph 5.4 Groove angle Vs impact strength for U groove weld butt joint

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From experimental data, for groove angle Vs impact strength graph, it shows that, as the groove angle increases the impact strength of single U-groove butt weld joint increase and at 45^0 we have maximum impact strength. The impact strength of AA2025 and AA7025 increases with groove angle but AA7025 shows maximum impact strength at 45^0 U groove geometry.

C. Vickers hardness test

1) Process setup for hardness test: The Vickers indenter usually produces a geometrically similar indentation at all test forces. Except for tests at very low forces that produce indentations with diagonals smaller than about 25 µm, the hardness number will be essentially the same as produced by Vickers machines with test forces greater than 1 kgf, as long as the material being tested is reasonably homogeneous. For isotropic materials, the two diagonals of a Vickers indentation are equal in size. Recommendations for low force micro indentation testing

Figure 5.8 Vickers hardness test in urja laboratories.

Figure 5.9 Vickers hardness Test Specimen As Per (IS:1500-2005)

2) Vickers hardness test results

Vickers hardness test was conducted in "Urja Laboratories"; the results are in the following form,

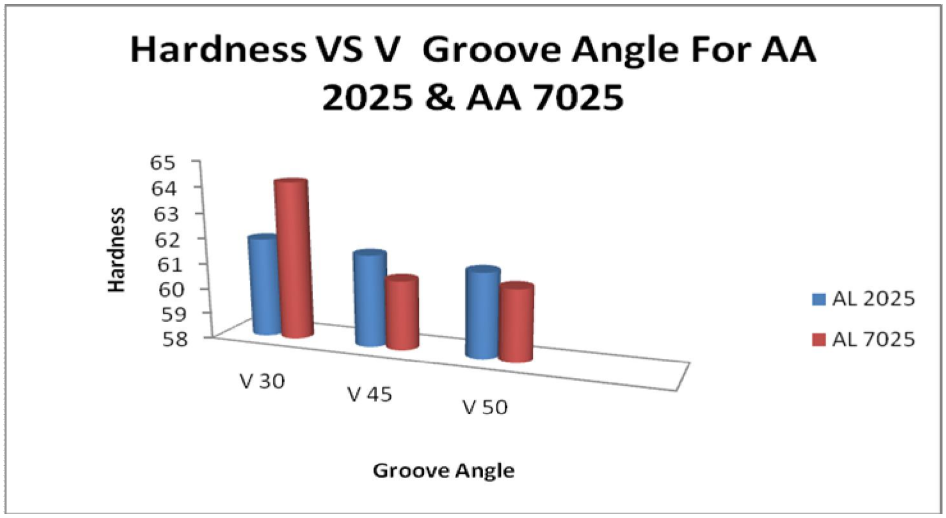
Table 5.7 Vickers hardness results of all specimens for AA2025

Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	Vickers Hardness HV
1	V1	30^0	1	AA2025	61.9
2	V2	45^0	1.5	AA2025	61.6
3	V3	50^0	2	AA2025	61.3
4	U1	30^0	1	AA2025	58
5	U2	45^0	1.5	AA2025	60
6	U3	50^0	2	AA2025	59

Table 5.8 Vickers hardness results of all specimens for AA7025

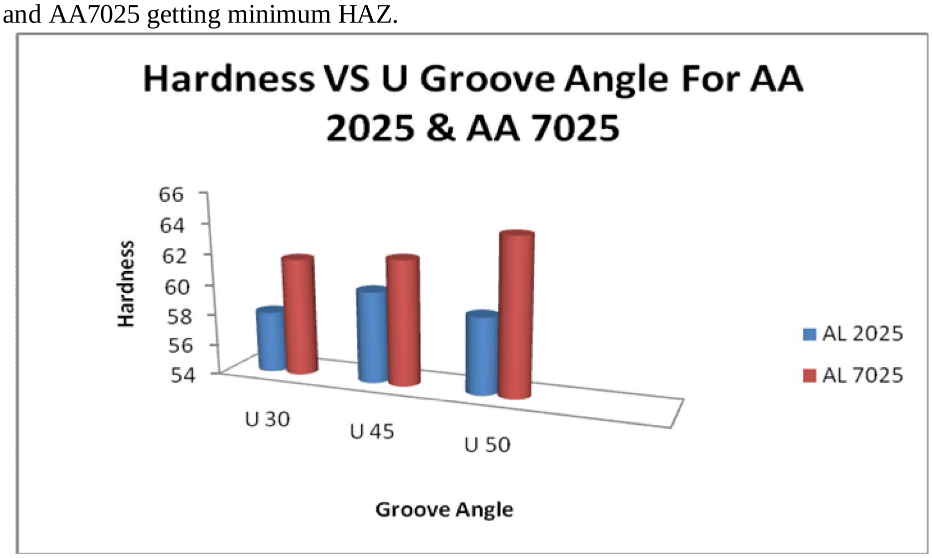
Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	Vickers Hardness HV
1	V4	30^0	1	AA7025	64.2
2	V5	45^0	1.5	AA7025	60.7
3	V6	50^0	2	AA7025	60.7
4	U4	30^0	1	AA7025	61.7
5	U5	45^0	1.5	AA7025	62.2
6	U6	50^0	2	AA7025	64.2

2) Discussion on results



Graph 5.5 Groove angle Vs Hardness of HAZ for V groove weld butt joint

From experimental data, for groove angle Vs Hardness of HAZ graph, it shows that, as the groove angle increases the HA decreases for 30^0 V groove geometry and AA7025 getting minimum HAZ.



Graph 5.6 Groove angle Vs Hardness of HAZ for U groove weld butt joint

From experimental data, for groove angle Vs Hardness of HAZ graph, it shows that, as the groove angle increases the HAZ Increases for 50^0 U groove geometry and AA7025 getting minimum HAZ

In HAZ material becomes hard as compare to base material. Therefore the ductility property is reduced in HAZ region and material becomes brittle in HAZ. So the possibility of failure in this region increases. So for better strength, the welded joint must have less HAZ. According to the results the AA7025 shows less hardness for 50^0 V groove geometry and AA2025 shows less hardness for 30^0 U groove geometry.

VI. CONCLUSIONS

From the results of this present investigation and the discussion presented in the earlier chapters, the following conclusions are drawn.

A. From the experimental results we can say that the tensile strength increases with increase in groove angle. At 45^0 V-groove geometry we are having maximum strength. Both the materials show maximum strength at 45^0 groove angle.

B. From the experimentation it is observed that as the groove angle increases the volume of filler material is increases so the impact strength also increases. We are getting maximum impact strength at 45^0 groove angle for AA7025. It is observed that with the increase in bevel height the impact also increase. So at 1.5mm bevel height we are getting maximum impact strength for AA7025.

C. In HAZ material becomes hard as compare to base material. Therefore the ductility property is reduced in HAZ region and material becomes brittle in HAZ. So the possibility of failure in this region increases. So for better strength, the welded joint must have less HAZ. According to the results the AA7025 shows less hardness for 50^0 V groove geometry and AA2025 shows less hardness for 30^0 U groove geometry.

D. From the above experimentation it is conclude that AA7025 is good in tensile, impact strength as compare to AA2025.

E. From the above experimentation it is conclude that V groove geometry with groove angle 45^0 is suitable for both the materials.

VII. ACKNOWLEDGMENT

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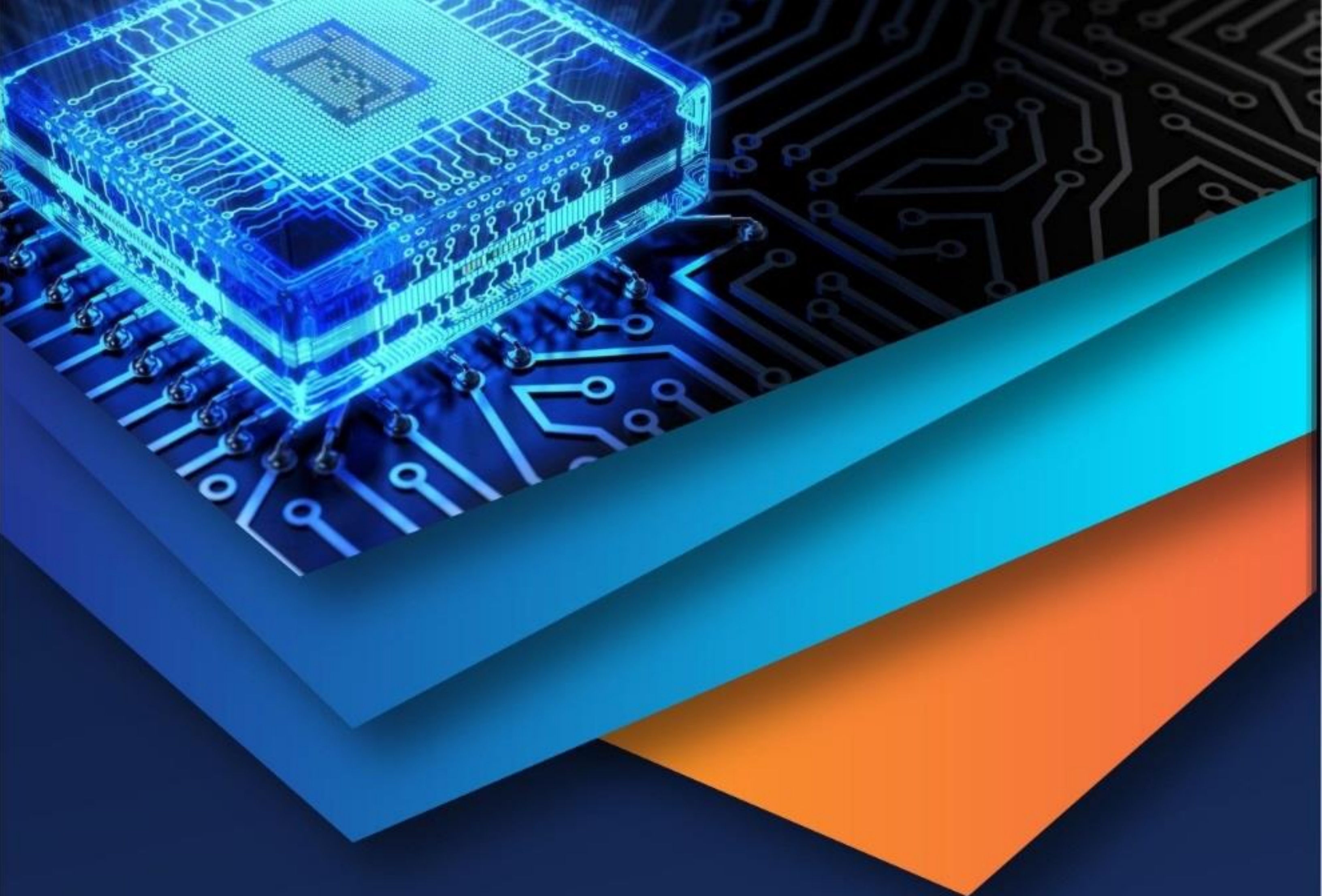

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