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COMPARISON OF THE TENSILE STRENGTH OF V-GROOVED BUTT-WELDED ALUMINIUM ALLOYS

Pai Prashanth M.[1], Maruthi Prashanth B H[1], Pujar C. V.[1], Adithya P. N.[1*], Jithesh P[1], Abdul Razik[1], Fahad P. A.[1]

[1]Department of Mech. Engg., P. A. College of Engineering, Mangaluru, Karnataka, India.
*Corresponding Author: Adithya P N Email: adithyanagaraj32@gmail.com

Abstract:

Now-a-days shipping, aerospace and process industries commonly use aluminium and its alloys because of their valuable properties such as light weight, better corrosion resistance and weld-ability. This research investigates the influence of groove angle on the tensile strength of Tungsten Inert Gas (TIG) welded AA2024 and AA7075 alloy weldments. The work aims to examine the tensile-strength of V-grooved butt welded specimens of AA2024 and AA7075 for different groove angles keeping bevel height, root opening, voltage and current constant. TIG welding is employed as it joins different materials with high quality in the presence of inert gas. AC power source ensures better cleaning action and avoids the high heat concentration on the material. Tensile strength of the joint is tested by the universal tensile testing machine. From the tensile test conducted on the V-grooved, butt welded Al-alloys having varying groove angles, it is inferred that the 45˚ angle has the maximum ultimate tensile strength.

Key Words: Groove angle, V-groove, Butt-joint, Bevel height, Root opening, TIG welding, Ultimate tensile strength.

1. Introduction

AA 2024 is an Al-alloy containing Cu as the major alloying constituent. Its applications call for the situations involving high strength-to-weight ratio, good fatigue resistance and average machinability. Friction welding is used to weld this Al-alloy. To protect from corrosion, it can

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often be covered with Al, even though it may affect the fatigue strength. This Al-alloy is heat treatable and finds it applications majorly in aircraft industry.

AA7075 is also heat treatable, extensively used in aircraft industry and possesses high toughness to fracture in addition to high resistance to stress corrosion cracking. It maintains strength even in thicker sections, possesses lower sensitivity for quenching and hence is suitable for heavy plate applications. Aerospace components such as fuselage, frames, wing skins, etc. make use of this Al-alloy.

Literature survey of various works on welding of AA 2024 and 7075 is conducted. From the survey, process parameter that affects the weld strength are studied in detail. It is observed that the groove angle has significance importance on the strength of weld. G Venkateshwarlu et al. [1] have conducted the experiment on the assessment of mechanical properties of AA 6061. The standard cylindrical specimens of the alloy prepared as per ASTM E9 were subjected to compression on UTM at room-temperature. The strength and strain hardening coefficient are recorded to be 562.5 and 0.5487 respectively. Micro hardness obtained was 66.35-68.63 (HV). Study of microstructure witnessed uniform dispersal of the grain sizes in the alloy.

Brotzu et al. [2] have studied a cracked component made of Al 7050 alloy, emphasized that different kinds of intermetallic phase formed during solidification and hot-rolling probably do not disturb the mechanical resistance of the alloy, but appear to determine crack formation during material removal processes. Hence it is very important to establish an in-process check and after the shaping process, the components.

R. Balasubramanian et al. [3] compared the mechanical properties of non-heat treatable aluminum alloy AA5083 and heat treatable Aluminum alloy AA7020 using TIG welding. Mechanical tests like tensile, impact, flexure and hardness tests were conducted and the results were tabulated. Microstructural and SEM fractographic studies were conducted and correlated. The results witnessed better mechanical and metallurgical properties for AA 5083 as compared to AA 7020.

B.V.R.Ravikumar et al. [4] studied AA5083 and AA6082 TIG welds, using AA 5356 filler wire with non-pulsed current and pulsed current at different pulse frequencies. Non-destructive testing was done to study the porosity and surface cracks. The mechanical tests to study the

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ultimate tensile strength, yield strength and parentage elongation were carried out. The studies concluded that the pulse current produces more tensile strength than non-pulse current.

Baiju Sasidharan et al. [5] conducted a comparison study on tensile and microstructural features of joints prepared from Direct Current Straight Polarity (DCSP) TIG welding and Friction Stir Welding (FSW) on AA2219. The tensile strength of TIG welded and FSW joint was found to be 257.48MPa and 287.9MPa respectively. Elongation (%) for FSW joint was found to be more than that of parental metal. It was concluded that FSW offers efficient-joining of AA2219.

Arun Narayanan et al. [6] studied the best-combination of welding-parameters like current and flow rate of gas in TIG welding of AA 5083. Numerous tests for tensile behaviour, microhardness, macro and microstructure studies were conducted on the welded-specimens. The test results shows that AA 5083 gives better results at 200A current and 15 l/min gas flow rate.

2. Experimental Procedure

2.1 Material Selection

The materials procured are AA2024 and AA7075 plates having dimensions 300x300x8 mm. The aim is to compare the strength (tensile) of V-grooved, butt-welded AA2024 and AA7075 alloys using TIG welding method. Single V-grooved, butt-welded joints are prepared by varying groove angles from 0 to 60 degrees (0, 30, 45 and 60 degrees for both alloys). As included angle increases, the contact area also increases, and hence strength also increases. Figure 1 and 2 show the plates of AA 2024 and 7075 procured from Bangalore.

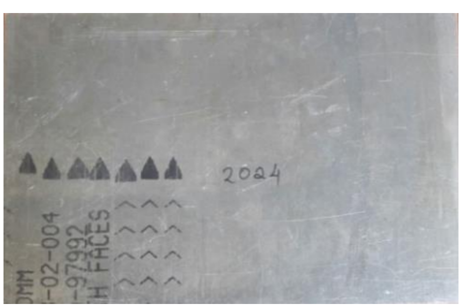

Figure 1. Procured AA 7075 alloy

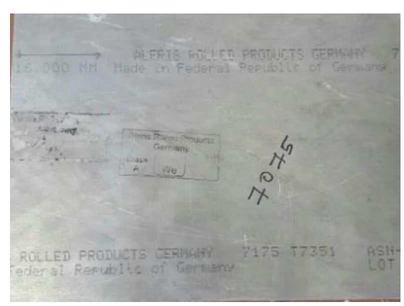

Figure 2. Procured AA 2024 alloy

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2.2 Machining Process

In machining, the raw material is finished into a desired final shape and size by controlled material removing process. The machining was done at Mangalore, using a universal milling machine as presented in Figure 3, the material is shaped to required dimensions. The figures 4 and 5 show the machined materials of dimensions 40*160mm.

Figure 3. Universal Milling Machine

Figure 4. Machined Al 7075

Figure 5. Machined Al 2024

2.3 Machined and Welded Workpieces

By using a milling machine, the workpieces are machined to 40*160mm. The final specimens are produced with the application of machining and TIG welding, having V-grooved,

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butt-welded joints with 0°, 30°, 45° and 60° groove angles and 0mm, 1mm, 1mm and 1mm bevel height.. The specimens of AA 7075 are shown in Figures 6. Process of TIG welding is presented in Figure 7. The materials are then machined to final shape according to ASTM standards. The final machined tensile test specimen is displayed in the Figure 8.

Figure 6. Final Specimens of AA 7075

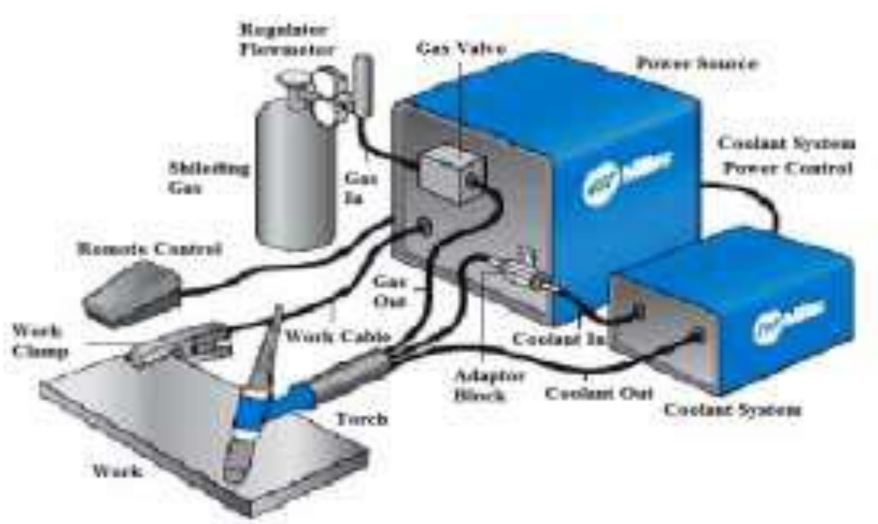

Figure 7. Process of TIG welding

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Figure 8. Tensile test specimen

2.4. Experimental testing

The specimen for tensile testing is positioned between the grippers of the UTM and provision of an extensometer automatically records the gauge length changes while testing. In the absence of an extensometer, the displacement can be recorded by the machine, between its crossheads where the test-specimen is fixed. After starting of the machine, a gradually-increasing load is applied on the specimen. The control system with installed software records the load and extension/compression of the test-specimen throughout the test duration. Figure 9 shows the process set-up for tensile test.

Figure 9. Tensile test – process set-up

3. Findings of the Study and Discussion

3.1 For Aluminium 2024 Alloy

The results are obtained from the tensile test conducted on AA 2024 alloy. The groove angles are 0º, 30º, 45º, & 60º. The bevel height is zero for 0º groove angle & 1mm for all other varying

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groove angles. Ultimate Tensile Strength (UTS) values observed to be 394MPa, 158.31MPa, 223.44MPa & 158.345MPa respectively. The graph is plotted as tensile strength vs groove angle. At 45° groove angle and 1mm bevel height, tensile strength (maximum) is obtained for AA 2024 alloy. Tensile test results of all specimens for AA2024 are presented in Table 1 and Figure 10.

Table 1: Tensile test results of all specimens for AA2024

Sl. No.	**Sample Name**	**Groove Angle (Degree)**	**Bevel Height (mm)**	**Materials**	**UTS (MPa)**			**Failure location**
					I	**II**	**Avg.**	
1	AA	0^0	0	AA2024	396	392	394	Unwelded
2	V1	30^0	1	AA2024	158.60	158.02	158.31	In weld
3	V2	45^0	1	AA2024	223.40	223.48	223.44	In weld
4	V3	60^0	1	AA2024	158.60	158.09	158.345	In weld

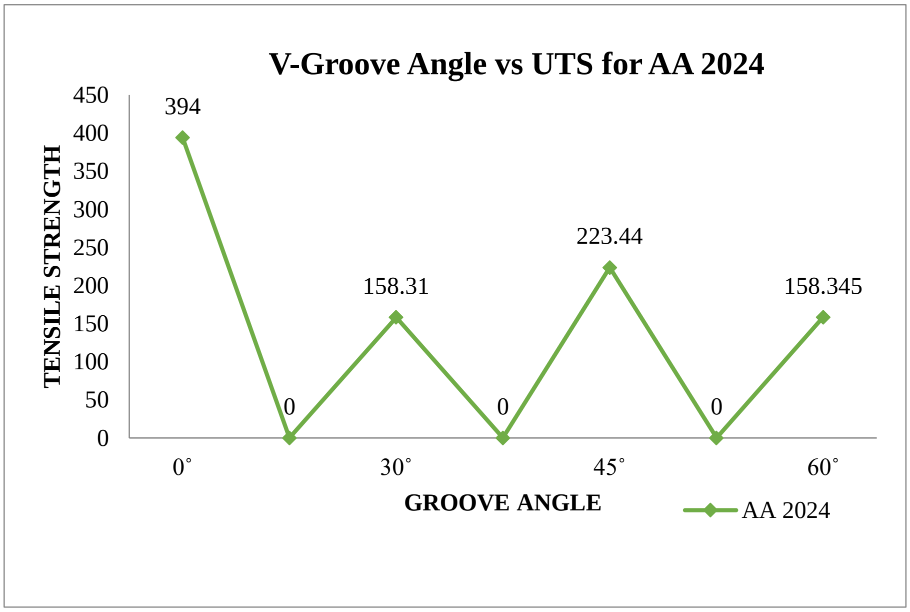

Figure 10. V-Groove Angle vs UTS for AA 2024

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3.2 Alumnimum 7075 Alloy

The results are obtained from the tensile test conducted on AA 7075 alloy. The groove angles are 0^0, 30^0, 45^0, & 60º. The bevel height is zero for 0^0 groove angle & 1mm for all other varying groove angles. Ultimate Tensile Strength (UTS) values found to be 601MPa, 219MPa, 265.29MPa & 155.14MPa respectively. The graph is plotted as tensile strength vs groove angle. At 45° groove angle and 1mm bevel height maximum tensile strength is obtained for AA 7075 alloy. Tensile test results of all specimens for AA7075 are shown in Table 2 and Figure 11.

Table 2: Tensile test results of all specimens for AA 7075

Sl. No.	**Sample Name**	**Groove Angle (Degree)**	**Bevel Height (mm)**	**Materials**	**UTS (MPa)**			**Failure location**
					I	**II**	**Avg.**	
1	BB	0	0	AA7075	601	603	602	Unwelded
2	V4	30^0	1	AA7075	217	221	219	In weld
3	V5	45^0	1	AA7075	265.04	265.54	265.29	In weld
4	V6	60^0	1	AA7075	154.06	156.22	155.14	In weld

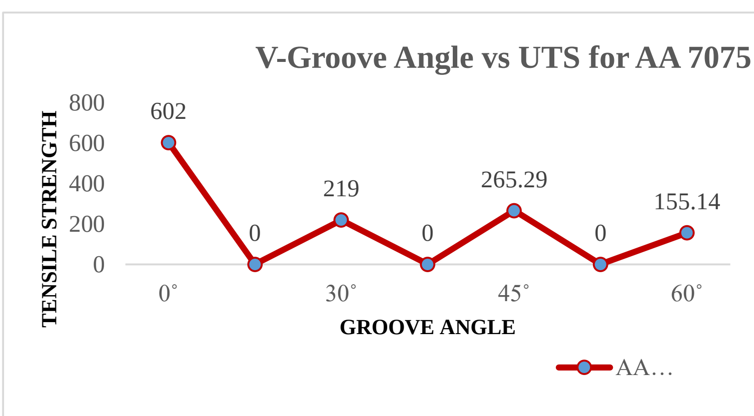

Figure 11. V-Groove Angle vs UTS for AA 7075

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After comparing the tensile strength values of both Al-alloys with varying V-groove angles, the comparison plot is drawn as presented in Figure 12. It is evident from Figure 13 that 45° groove angle produces maximum tensile strength for both alloys at 1mm bevel height.

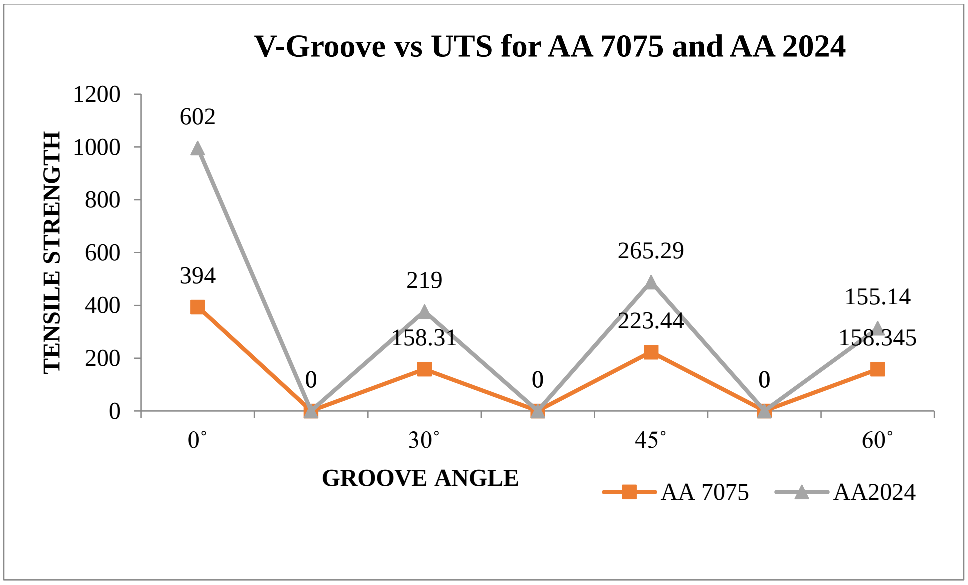

Figure 12. V-Groove Angle vs UTS for AA 7075 and AA 2024

4. Conclusion

This work is aimed to compare the UTS of V-Grooved, butt-welded AA 2024 and AA 7075 alloys with varying groove angles and same bevel height. The findings of this work as follows:

- From the tensile tests conducted on the two Al-alloys with varying groove angles and same bevel height, it is noticed that the tensile strength increases upto 45° groove angle and then it decreases. Both the alloys show maximum strength at 45^0 groove angle. Hence 45° groove angle is considered to be an optimum groove angle for both the alloys.
- Both the alloys in unwelded condition show the maximum tensile strength.
- From the above experimentation, it is determined that AA7075 is having good tensile strength compared to that of AA 2024.

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