INVESTIGATION OF STRENGTH OF V & U GROOVE BUTT JOINT BY TIG WELDING & IT'S ANALYSIS

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ABSTRACT

Welding, one of the most convenient and rapid method used for joining metals in navy, process industry in fabrication, maintenance, repair of parts and structures. The plates used in process industry has welding strength as its important parameter. In this paper investigation of V & U groove geometry to find out tensile and impact strength in case of butt weld joint will be done. For V & U groove geometry different models of plates with varying included angle from 30^0, 45^0, 50^0 will be made. Currently the V-groove geometry with included angle up to 30^0 is in use, after studying the Indian Welding Journal, Indian Welding Society it is observed that distortion and residual stresses increases with increase in groove angle and its strength also increases with groove angle increasing the weld material which affect the economy of welding. In this paper we aim at overcoming these disadvantages by making use of V & U groove. Tensile test to check maximum tensile force sustaining capacity and micro and macro inspection test to check welding quality and other parameters has been conducted. Other tests carried out includes impact test to check maximum energy absorbing capacity, we also measured dimensions of specimen before and after welding to find out longitudinal and transverse distortion if any by making use of four specimens. Finally, an experimental result simulates with Finite Element Analysis results.

Keyword: *V-Groove Butt Weld Joint, U- Groove Butt Weld Joint, Mechanical Properties, Bevel Height, Groove Angle, TIG Welding.*

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1. 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.

2. 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 experimental method and validate with finite element method In experimental methodology detail discussion is carried out, about material used, specimen preparation and welding geometry used.

3. SIMULATION OF BUTT WELD JOINT

Finite element analysis (FEA) involves the solution of engineering problems using computers. Engineering structures that have complex geometry and loads, are either very difficult to analyze or have no theoretical solution. However, in FEA, a structure of this type can be easily analyzed. Commercial FEA programs, written so that a user can solve a complex engineering problems without knowing the governing equations or the mathematics; the user is required only to know the geometry of the structure and its boundary conditions. FEA software provides a complete solution including deflections, stresses, reactions, etc. In this technique the structure is divided into very small but finite size elements (hence the name finite element analysis). Individual behavior of these elements is known and, based on this knowledge; behavior of the entire structure is to be determined. FEA solution of engineering problems, such as finding deflections and stresses in a structure, requires three steps:

1. Pre-process or modeling the structure
2. Analysis
3. Post processing

3.1 Procedure to perform the FEA tool to determine the stresses in tensile and impact specimen

ANSYS is a sophisticated and comprehensive finite element program that has capabilities in many different physics fields such as static structural, nonlinear, thermal, implicit and explicit dynamics, fluid flow, electro-magnetic, and electric field analysis. The following procedure was conducted in ANSYS to measure the stresses inside the single V&U groove butt weld joint.

3.1.1 Importing geometry

ANSYS comes with IGES support by default but there are Geometry Interfaces available for Pro/E, CATIA, UG, Solidwork, Parasolid, etc. IGES is the oldest of these formats and does not work very well for solids, but is ok for wireframe geometry.

3.1.2 Creating material properties

While selecting the material properties it is assume that the material is to be isotropic in nature. The properties select for structural analysis are given in Table as follows

Table 1: Chemical composition of material 7025

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: Properties of material 7025

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

Table 3: Chemical composition of material 2025

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: Properties of material 2025

Tensile Strength, min, (MPa)	400
Elongation, min (%),	11
Vickers Hardness (HV)	171

3.1.3 Selecting an element type

ANSYS has a large library of element types. Elements are organized into groups of similar characteristics. These group names make up the first part 49 of the element name (BEAM, SOLID, SHELL, etc). The second part of the element name is a number that is more or less (but not exactly) chronological. As elements have been created over the past 30 years the element numbers have simply been incremented. The earliest and simplest elements have the lowest numbers (LINK1, BEAM3, etc), the more recently developed ones have higher numbers. For this paper select the SOLID as element type and then select the number for this element SOLID186 is a suitable for analyzing thin to moderately-thick shell structures. The element is defined as 1600 node shaving six degrees of freedom at each node: translations in the x, y, and z directions, and rotations about the x, y, and z-axes. (If the membrane option is used, the element has translational degrees of freedom only). The degenerate triangular option should only be used as filler elements in mesh generation. SHELL181 is well-suited for linear, large rotation, and/or large strain nonlinear applications. Change in shell thickness is accounted for in nonlinear analyses. In the element domain, both full and reduced integration schemes are supported. SOLID186 accounts for follower (load stiffness) effects of distributed pressures.

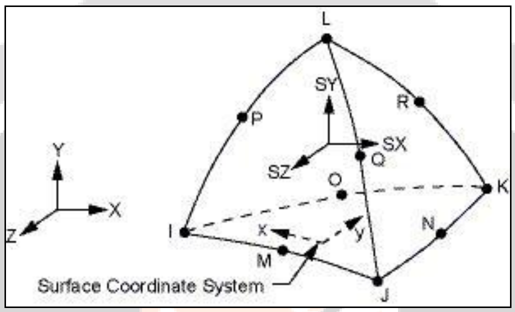


Fig -1: SOLID186 Geometry

3.1.4 Creating finite element model-meshing

In the finite element method take an arbitrarily complex domain, impossible to describe fully with a classical equation, and break it down into small pieces that can be describe with an equation. These small pieces are called finite elements. Sum up the response of all these little pieces into the response of entire structure. The solver works with the elements. For meshing the hex dominant mesh was selected because it has maximum accuracy during the solution. The model made in CREO software is shown in Fig

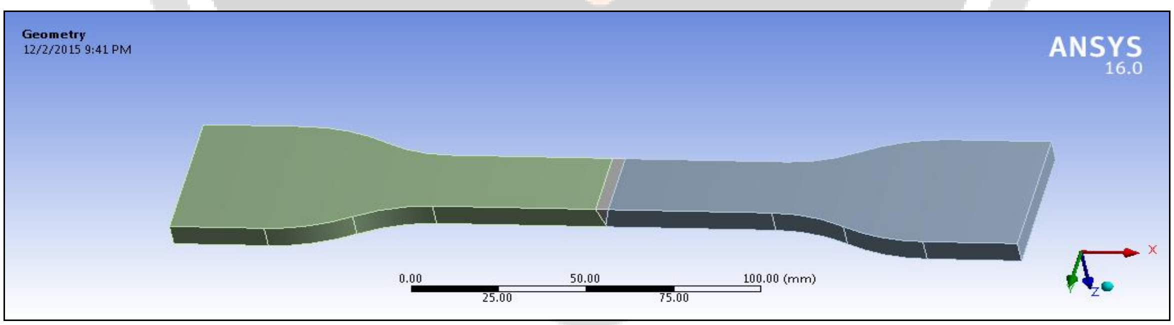


Fig. 2: Geometrical model of tensile specimen for V Groove butt joint in SOLID WORKS-2013

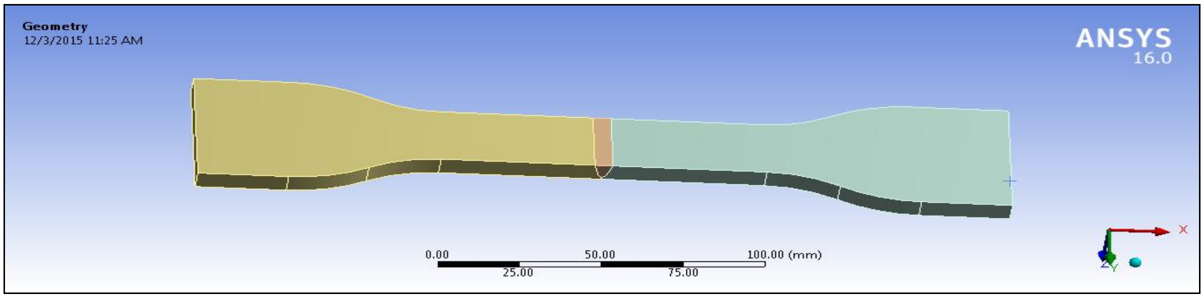


Fig. 3: Geometrical model of tensile specimen for U Groove butt joint in SOLID WORKS-2013

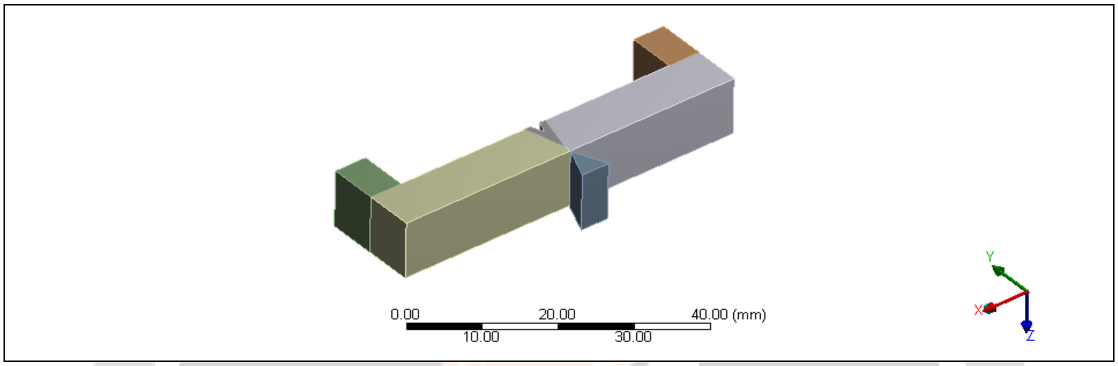


Fig. 4: Geometrical model of impact specimen in SOLID WORKS-2013

Steps for Creating the Finite Elements

1. Assign Attributes to Geometry (materials, real constants, etc)
2. Specify Mesh Controls on the Geometry (element size 5mm).
3. Mesh. (Uniform Quad Method)

The meshing is done on base metal as well as weld metal. One end of specimen is free and other end of specimen is fixed and we apply force on fixed end. Also for impact specimen meshing is done on weld as well as weld material.

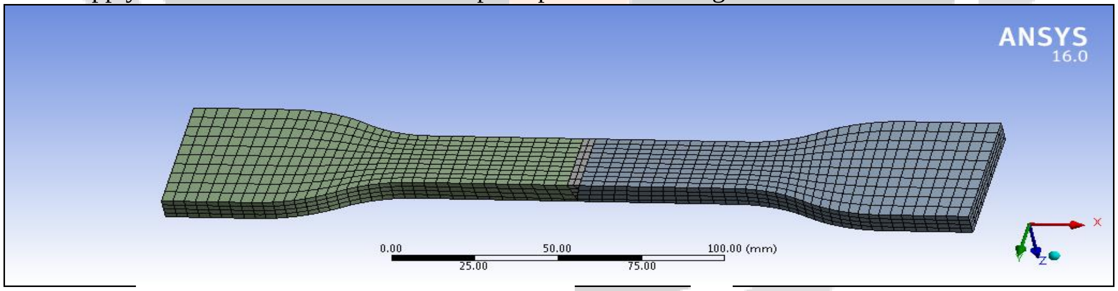


Fig.5: Meshing of tensile specimen for V Groove by uniform quad method

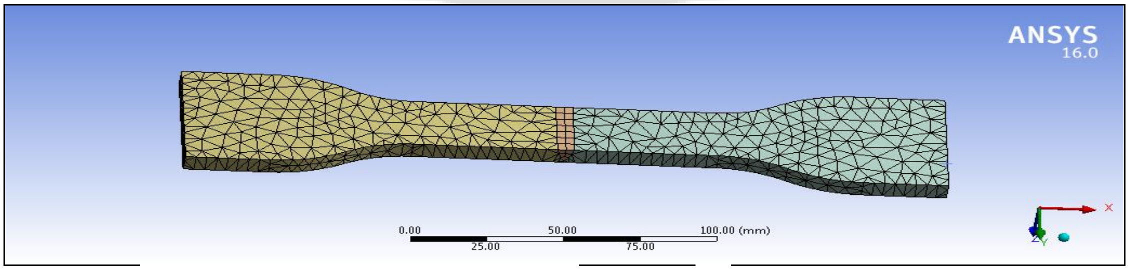


Fig.6: Meshing of tensile specimen for U Groove by uniform quad method.

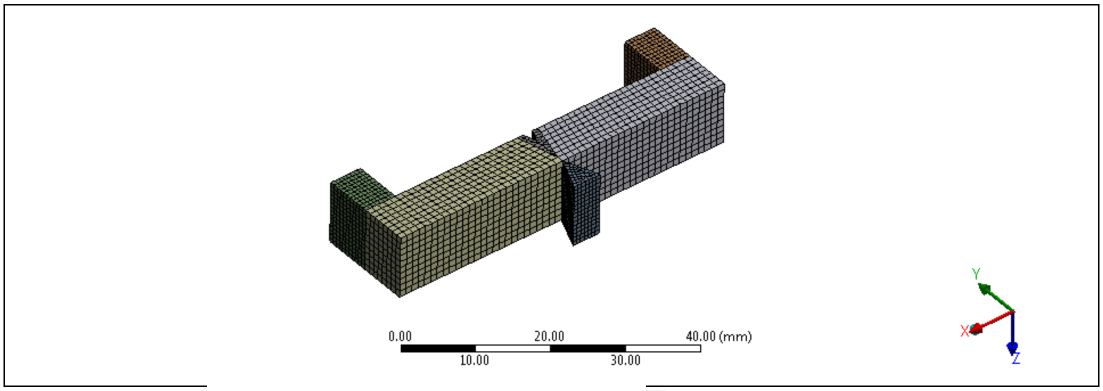


Fig.7: Meshing of impact specimen by uniform quad method

3.2 Applying load and boundary conditions

Loads and boundary conditions can be applied in both the
Pre-processor and the Solution processor.

1. Apply remote force on the body with specific magnitude and direction

2. Selection of the faces where fixed support was applied, because in tensile test we have to apply equal and opposite force on the specimen

Loads: - For tensile test we apply 33750 N forces and for impact test we apply velocity 5.9 m/s

Constraints: **-** For tensile test a fixed support was applied at one end of specimen and for impact test two side faces of the specimen consider as a fixed as follows.

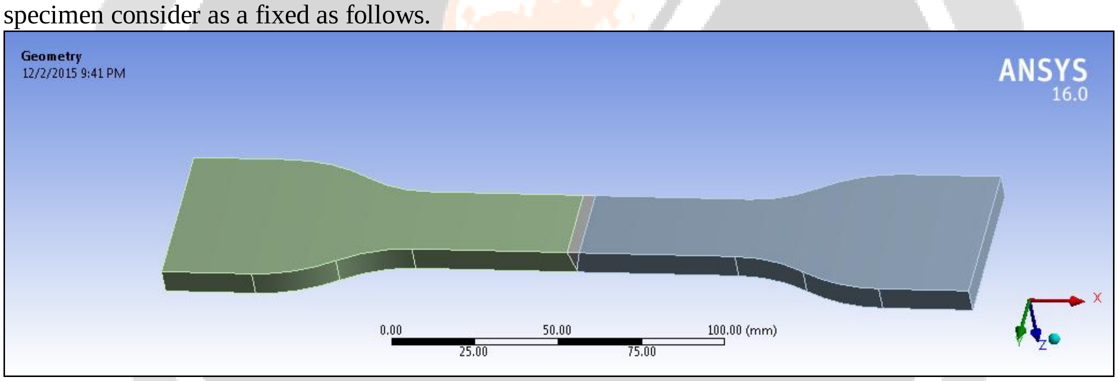


Fig.8: When 33750N force is applied in X direction

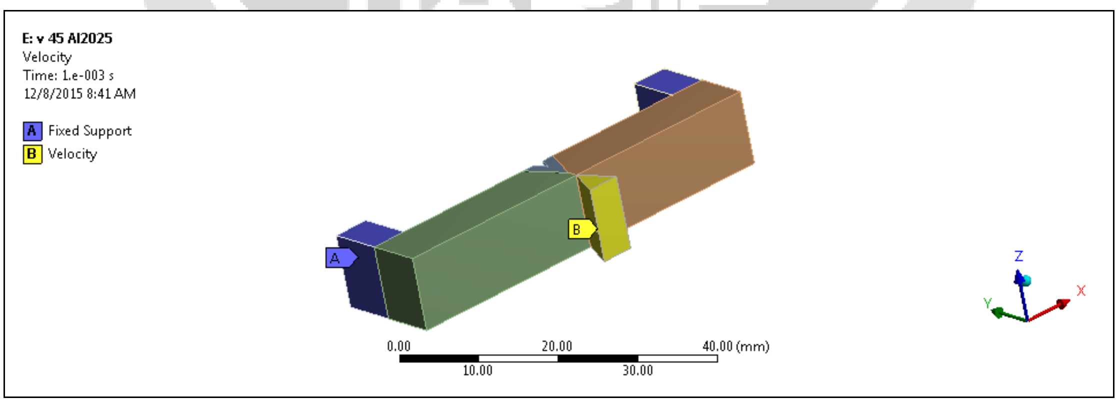


Fig.9: When faces impact specimen are fixed & Hammer with velocity 5.9 m/s

3.3 Solving:

Solution is the term given to the actual simultaneous equation solving of the mathematical model. The basic equation of the finite element method used for solving was, [K]{u}={F}, where [K] is the assembled stiffness matrix of the structure, {u} is the vector of displacements at each node, and {F} is the applied load vector. This is analogous to a simple spring and is the essence of small deflection theory.

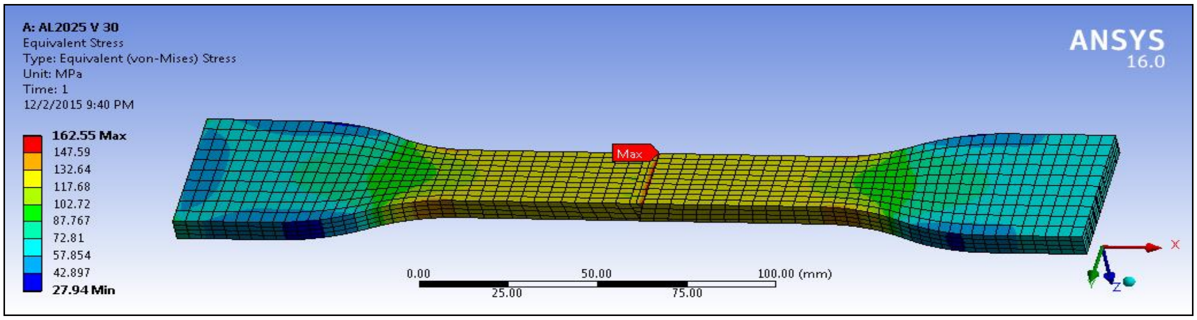


Fig.10: Total deformation and equivalent stress for V Groove in tensile test specimen

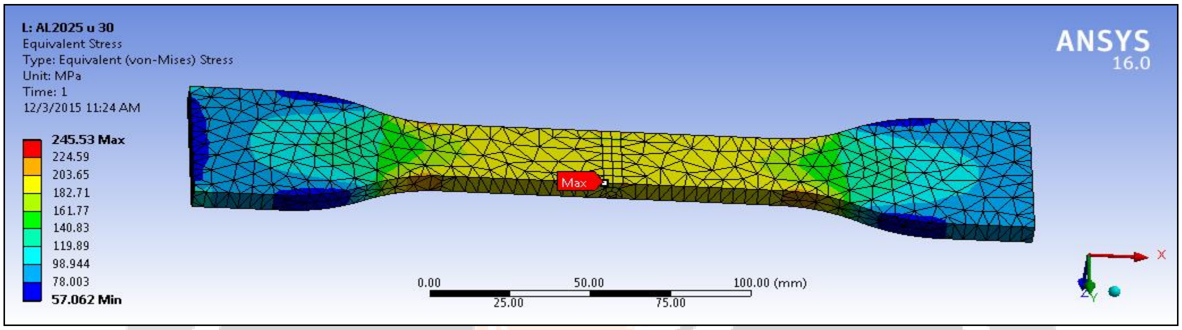


Fig.11: Total deformation and equivalent stress for U Groove in tensile test specimen

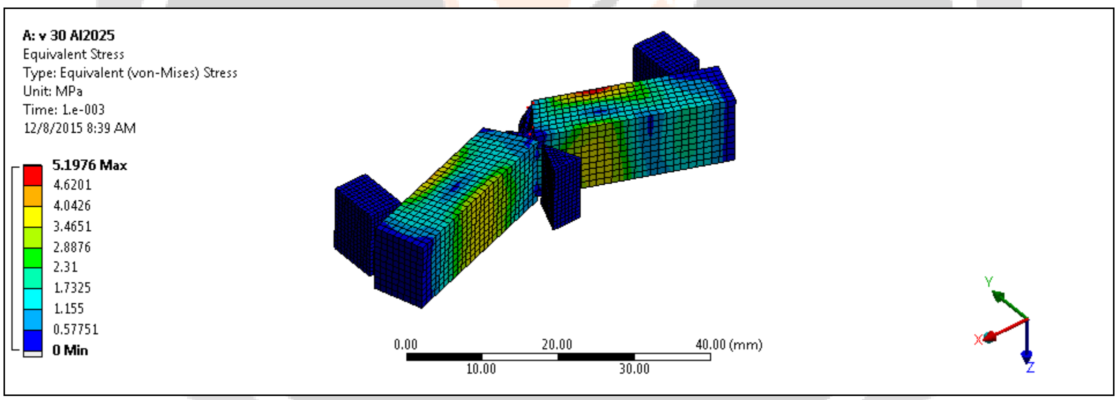


Fig.12: Total deformation and equivalent stress in impact test specimen

To submit the model to ANSYS for solving, a load step is a loading condition. This is a single set of defined loads and boundary conditions. Within an interactive session the first solve is load step 1, the next solution is load step 2, etc. There are several solvers in ANSYS that differ in the way that the system of equations is solved for the unknown displacements. The two main solvers are the sparse solver and the PCG solver. If the choice of solvers is left to "program chosen" then generally ANSYS will use the sparse solver. The PCG (preconditioned conjugate gradient) solver works well for models using all solid elements. From a practical perspective one thing to consider is that the sparse solver doesn't require a lot of RAM but swaps out to the disk a lot.

3.4 Post processing

The General Postprocessor was used to look at the results over the whole model at one point in time.In the present validation, the commercial FEA software ANSYS 16.0 was used to simulate the process. A numerical model of single V & U -groove butt weld joint is employed with the objective of measuring the ultimate tensile stress and impact strength at 30^0,45^0,50^0 groove angles. The FEA observations as shown in table below

Table 5: Tensile test results of all specimens for AA2025 by FEA

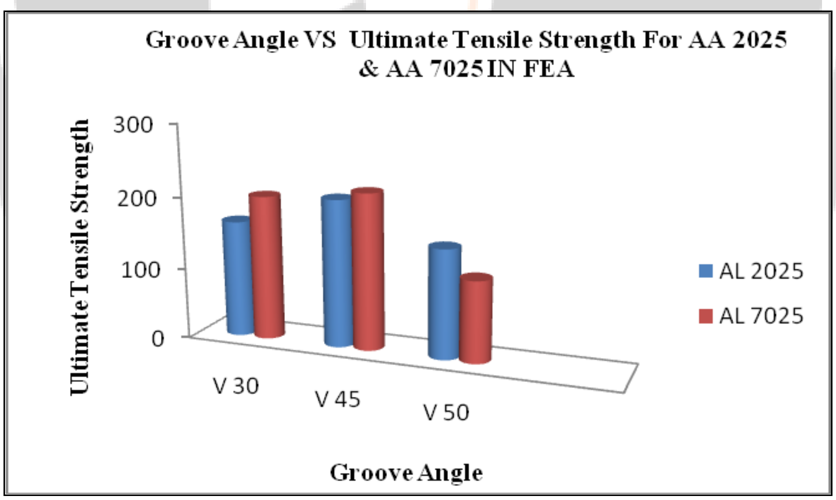
Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	UTS MPa	Failure location
1	AA	0	0	AA2025	400	Unwelded
2	V1	30^0	1	AA2025	162.55	In weld
3	V2	45^0	1.5	AA2025	204.6	In weld
4	V3	50^0	2	AA2025	150.92	In weld
5	U1	30^0	1	AA2025	245.33	In weld
6	U2	45^0	1.5	AA2025	239.41	In weld
7	U3	50^0	2	AA2025	242.32	In weld

Table.6: Tensile test results of all specimens for AA7025 by FEA

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	201.01	In weld
3	V5	45^0	1.5	AA7025	216.44	In weld
4	V6	50^0	2	AA7025	112.6	In weld
5	U4	30^0	1	AA7025	254.41	In weld
6	U5	45^0	1.5	AA7025	268.39	In weld
7	U6	50^0	2	AA7025	246.86	In weld

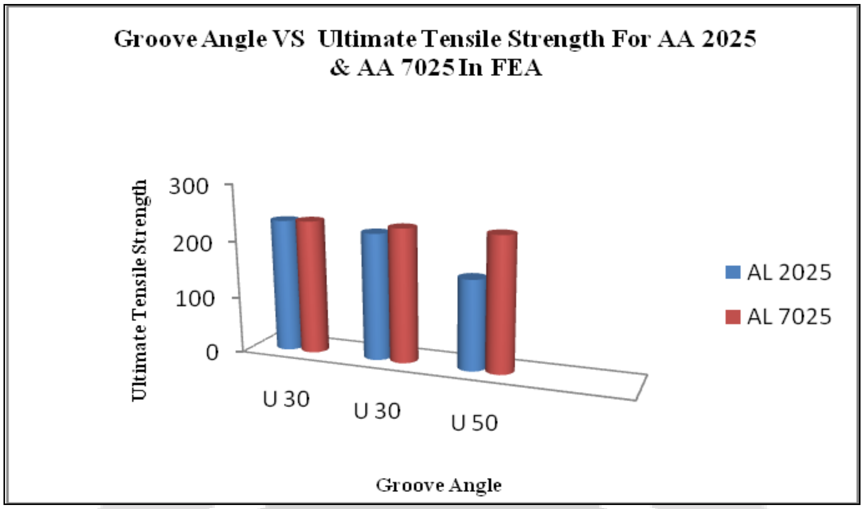
3. RESULTS AND DISCUSSION

From the above computational data, we are going present computational results.



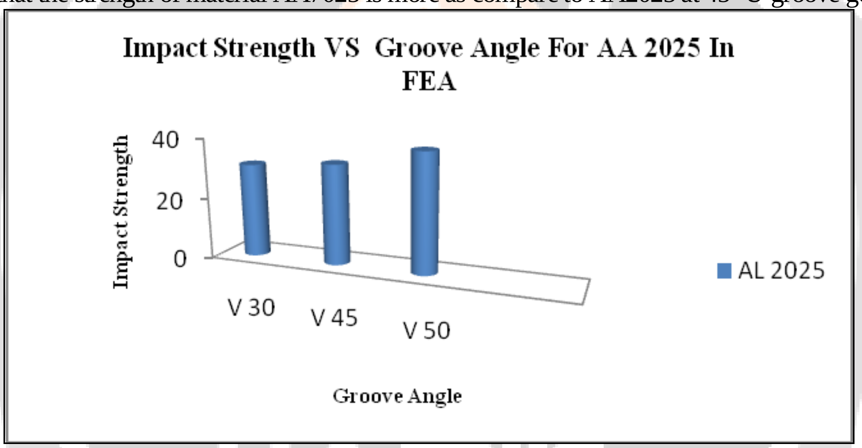
Graph .1 Groove angle Vs ultimate tensile strength for V groove weld butt joint

From FEA 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 is observed that the strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry.



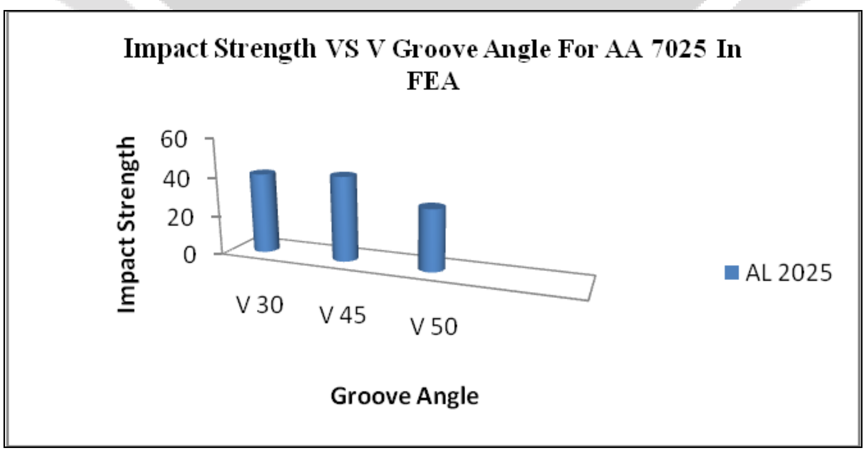
Graph 2 Groove angle Vs ultimate tensile strength for U groove weld butt joint

From FEA 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 and at 45^0 we have maximum ultimate tensile strength. Also it is observed that the strength of material AA7025 is more as compare to AA2025 at 45^0 U-groove geometry.



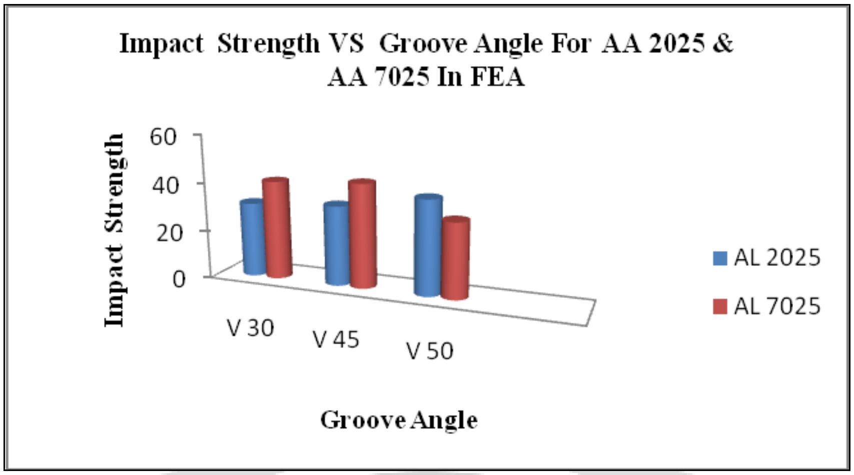
Graph: 3 Groove angle Vs Impact strength of butt joint in FEA for V-groove

From FEA data, for groove angle Vs ultimate tensile strength graph, it shows that, as the groove angle increases



Graph: 4 Groove angle Vs Impact strength of butt joint in FEA for V-groove

From FEA data, for groove angle Vs ultimate tensile strength graph, it shows that, as the groove angle increases and at 45^0 we have maximum Impact strength



Graph: 5 Groove angle Vs Impact strength of butt joint in FEA for V-groove

From FEA 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. Also it is observed that the strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry.

3.1 Discussion on computational analysis

First off all a model of tensile and impact specimen has been prepared in Solid Works-2013 parametric software with the help of analytical data which has been discussed previously. Later using ANSYS software tensile and impact stress analysis was performed and I was found that the Ultimate Tensile strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry. Also Ultimate Tensile strength of material AA7025 is more as compare to AA2025 at 45^0 U-groove geometry, hence 45^0 groove angle shows more strength. In Both Case (V & U) For AA 7025 Also, the Impact strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry. hence 45^0 groove angle shows more Impact strength.

So considering higher strength and less requirement of weld metal groove 45^0 angle was chosen for single V& U-groove butt weld joint.

3.2 Discussion on Experimental Results

Table 7: Tensile test results of all specimens for AA2025 Exp

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 8: Tensile test results of all specimens for AA7025 Exp

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

Table: 9 Impact test results of all specimens for AA2025 Exp

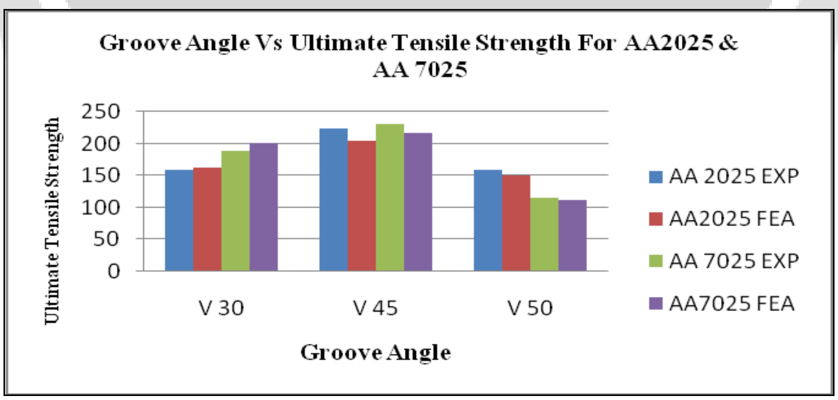
Sr. No.	Sample Name	Groove Angle (Degree)	Bevel Height (mm)	Materials	Impact Strength J
1	V1	30^0	1	AA2025	30
2	V2	45^0	1.5	AA2025	32
3	V3	50^0	2	AA2025	38
4	U1	30^0	1	AA2025	38
5	U2	45^0	1.5	AA2025	34
6	U3	50^0	2	AA2025	36

Table: 10 Impact test results of all specimens for AA7025 Exp

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

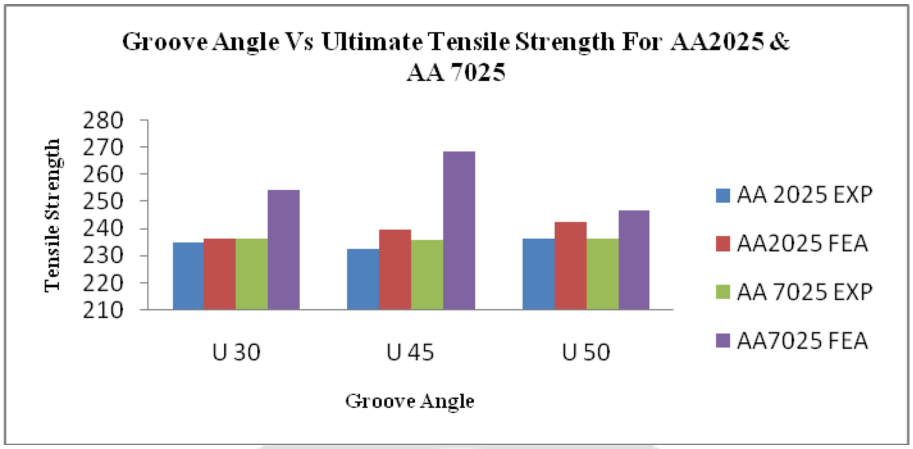
3.3 Comparision Between Experimental And FEA Results For AA 2025 & AA7025 For UTS.

From the above experimental and computational data, we are going to compare experimental results with computational results.



Graph .6 Groove angle Vs ultimate tensile strength for V groove weld butt joint For AA2025 & 7025 Exp &FEA Result.

From FEA & Exp data, for groove angle Vs ultimate tensile strength graph For AA 2025 & AA 7025, 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. Also it is observed that the UTS of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry in FEA & Exp data.



Graph .7 Groove angle Vs ultimate tensile strength for U groove weld butt joint For AA2025 & 7025 Exp &FEA Result.

From FEA & Exp 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 and at 45^0 we have maximum ultimate tensile strength. Also it is observed that the strength of material AA7025 is more as compare to AA2025 at 45^0 U-groove geometry in FEA & Exp

I. Conclusions

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

1) From FEA Result The Ultimate Tensile strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry.
2) From FEA Result Impact strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry.
3) Hence, From FEA Results it is conclude that V & U groove geometry with groove angle 45^0 is suitable for both the materials
4) From the above FEA Result it is conclude that AA7025 is good in tensile strength as compare to AA2025
5) The Impact strength of material AA7025 is more as compare to AA2025 at 45^0 V-groove geometry. hence 45^0 groove angle shows more Impact strength, So considering higher strength and less requirement of weld metal groove 45^0 angle was chosen for single V& U-groove butt weld joint.
6) From the above FEA & Exp Result it is conclude that AA7025 is good in tensile strength & Impact strength as compare to AA2025 at 45^0 V Groove Butt Weld Joint

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