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Study on the Effected of Weld Joint Behaviour using Finite Element Analysis

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ABSTRACT

Frame assembly in fabrication field contain hundreds of welds joint end. Most of all time, failure joint weld occurs at the end of frame structure especially at joint. Thus, welds joint has an impact on a structure's overall structural integrity. So, from a design perspective, modelling of welded joints is crucial. The main goal of this study is to create a weld model to evaluate the strength of welded connections based on stress analysis using the finite element method (FEM) and experimental validation. The stress distribution in welds joint depends on geometry, loading case and materials properties. Hence, it is very difficult to create a weld model that accurately forecast how stress distribution and weld stiffness will behave in joints. There are various FEM modelling techniques for welded structures. In this research, a finite element analysis was used to investigate the value of strength and residual stresses on the two joints with different materials by using method Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG). The different values included several types of basic joint which are mostly in industrial manufacturing fabrication. Thus, it's considered while the other parameters were kept constant (e.g., thickness, heat input, types of welding, root gap and root face). Therefore, the problem was modelled and examined using Finite Element Analysis by Solid works software, which has been shown to be a useful tool for examining trends impacted by changing welding parameters. Several type of joint will choose this research which are butt joint and T-joint. However, take 45 degrees as bevel angle as it had the smallest distortion and less required less volume of filler metal for butt joint. In contrast, it had the highest level of residual stresses, which may have been brought on by the fact that less of the deposited weld was exposed to the environment, slowing the rate at which the metal cooled during the weld. Expectantly, the successful result of this research will be great helping guidance for industrial fabrication manufacturing towards quality of welded.

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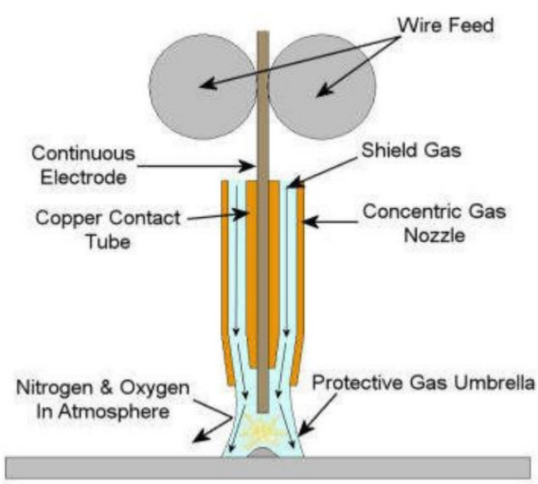
1. Introduction

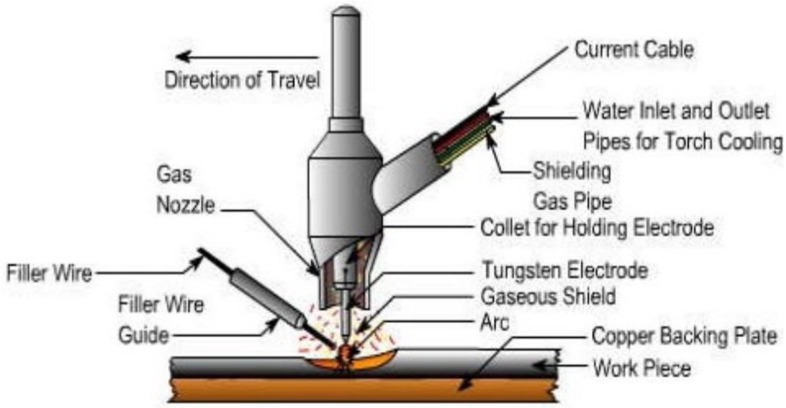
In Malaysia, metal is formed through a variety of industrial processes, including shape, drilling, and moulding of raw metal into completed, usable items. Steel is without a doubt the most often used metal type for customized metal fabrication in Malaysia. Stainless steel and aluminium alloy are widely used in manufacturing operations, infrastructure, and construction components, including as a building material, industrial equipment, structural support, and loose metal accessories. To fulfil the growing demand for metal products, Malaysia's metal fabrication industry is crucial, and its supply base is expanding every year. Besides, stainless steel and aluminium alloy are many types and there are most important materials for the mass in production nowadays. It is widely known that due to the inherent differences in the electrical, thermal, and mechanical properties of the two materials, metallurgical connections between steel and aluminium are challenging to produce with fusion welding. Ismail *et al.,* [1] investigate that it is widely known that due to the inherent differences in the electrical, thermal, and mechanical properties of the two materials, metallurgical connections between steel and aluminum are challenging to produce with fusion welding. The mutual solubility of aluminum and steel in fusion welding procedures like direct resistance spot welding (RSW) is minimal to nonexistent.

1.1 Principle MIG and TIG Welding

Argon is used as a shielding gas for both TIG and MIG welding procedures. S. Kanemaru *et al.,* [2] studied about Compared to TIG welding, MIG welding is a high-efficiency procedure. Spatter reduction and welding metal toughness need to be improved, nevertheless. The two most common gas-shielded arc welding methods applied in many kinds of industries are tungsten inert gas (TIG) and metal inert gas (MIG). Based on N. Jayaprakash *et al.,* [3] investigated TIG welding involves maintaining an arc in an inert environment (Ar, He, or an Ar-He mixture) between a tungsten electrode and the work piece. It is possible to work with or without filler depending on the weld preparation and the thickness of the work piece. Depending on the method, the filler might be introduced manually or automatically. Besides, S. Sharma *et al.,* [4] investigated one of the common and traditional methods to combine materials is gas metal arc welding. Similar metals, different metals, alloys, and nonmetals can all be joined by gas metal arc welding. Due to their benefits, which can result in high yield strength, deeper penetration, continuous welding at greater speed, and tiny welding defects, the demand for connecting similar materials is continuously rising in the current situation. R. Pradhan *et al.,* [5] illustrates in Figure 1 the principle of MIG welding and TIG welding.



(a)



(b)

Fig. 1. (a) Principle of MIG welding (b) Principle of TIG welding

1.2 Finite Element Analysis

The finite element method has become a useful tool for the numerical solution of a wide range of engineering problems. Numerical analysis and modelling of the welding process are challenging due to its complexity. SG Jadhav *et al.,* [6] stated Complexity factors include temperature-dependent material and thermal properties, transient heat transfer with difficult boundary conditions, moving heat sources, phase changes and transformations, complicated residual stress states, and the challenges of performing experiments at high temperatures. There are many ways to simulate welded connection in the commercial Finite Element (FE) codes. P. Griskevicius *et al.,* [7] studied that FE package The SolidWorks Simulation software was used to gauge the welded joints' strength. Using 3D solid or shell models, the software enables the simulation of welded joints. The sort of model you choose relies on the complexity of the structure. Use of the shell model is advised for more complicated structures to prevent convergence issues. Three-dimensional solid and shell models were used to simulate the geometry of the tested specimens. The central surfaces of the solids have been used to construct shell models. The butt-welded joining process of two steel plates is simulated in the study by Wu *et al.,* [8] Finite Element Analysis (FEA) is carried out in two stages. The temperature distribution throughout the welding operation is first determined using a non-linear transient thermal analysis. The stress developed from the thermal analysis is used to build the stress analysis. In their study of the mechanical characteristics of multi-pass welding, Jang *et al.,* [9] used finite element analysis to simulate welding deformations and residue stresses. Utilizing finite element simulation, Zu and Chao *et al.,* [10] performed a thorough three-dimensional non-linear thermal and thermomechanical analysis.

1.3 Application Materials

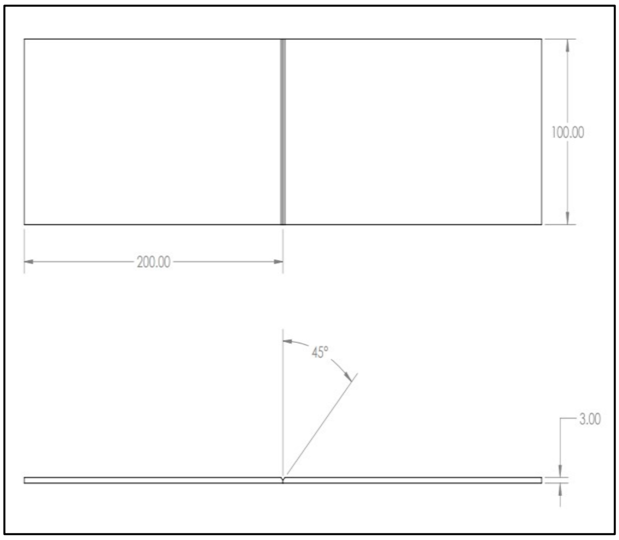
The Stainless Steel 304 (SS304) is one of stainless-steel group which is widely used in manufacturing industries for various purposes. According to Marqus F *et al.,* [11] investigated Due to their high strength and great formability, austenitic stainless steels represent remarkable corrosion resistance in a variety of conditions. However, N. Mubarak *et al.,* [12] investigated in actual use, SS304 has several parts that fail. The SS304 regularly experiences severe metallic wear as a result of the pipes' degradation (erosion) caused by fine materials (clays), bitumen, and sands.

Aluminium 5xxx series alloys are the strongest non-heat treatable aluminium alloy. S. Shanavas *et al.,* [13] studied with its superior formability and weldability compared to other aluminium alloys, AA 5052 H32 is a cold-rolled aluminium alloy that has been employed for structural purposes in both the automotive and maritime industries. Based on AK. Gupta *et al.,* [13] Aluminum alloy 5052 H32 has very good corrosion resistance, weldability, high fatigue strength and moderate strength.

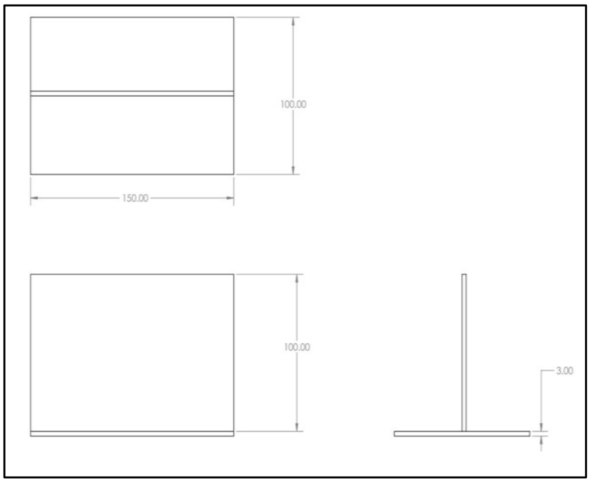
2. Methodology

2.1 Background

The methodology of this project was organized to systematically arrange all the activities and plans involved regarding this project to be conducting smoothly and on time as well as to prevent any mistakes from occur during the activities especially on the analysis procedures based on M. Duan *et al.,* [14]. This research was focused mainly on the working of designing the butt joint welding and T-joint welding by TIG and MIG technique and the analysis of the strength in terms of its mechanical properties on the welding joint of 5052-H32 aluminum alloy and 304 stainless steels in SolidWorks software. There were several parameters involved in the analysis of the welding joint structure design which were obtained from the literature review. For butt joint as shown in Figure 2, it shows that butt joint will design with dimension 100 mm x 200 mm with thickness 3 mm. for this research this butt joint will add bevel angle for 45 degrees. This is because beveling both workpieces to make a Vshaped opening between them. The most typical joint design for butt welds is one that allows for good penetration. Meanwhile, for T-joint model with dimension 100mm x 150mm as Figure 2 shown.



(a)



(b)

Fig. 2. (a) 2D modelling for Butt joint (b) 2D modelling for T-joint

2.1 Mechanical and Mesh Analysis

The thermal analysis's nodal temperatures were used as the mechanical analysis's predetermined temperature fields. The mechanical analysis used the same finite element meshes used for the stress element and the thermo-mechanical characteristics. The mechanical boundary conditions were taken into consideration to stop the specimen's rigid body movement. Dean *et al.,* [15] was performed that phase transformation induced strain increment in low carbon steel contributes minimally to the overall strain. Based on D. Deng *et al.,* [16] investigated that the welding process involved a quick heating process. Table 1 and 2 stated the mechanical properties for material in this research.

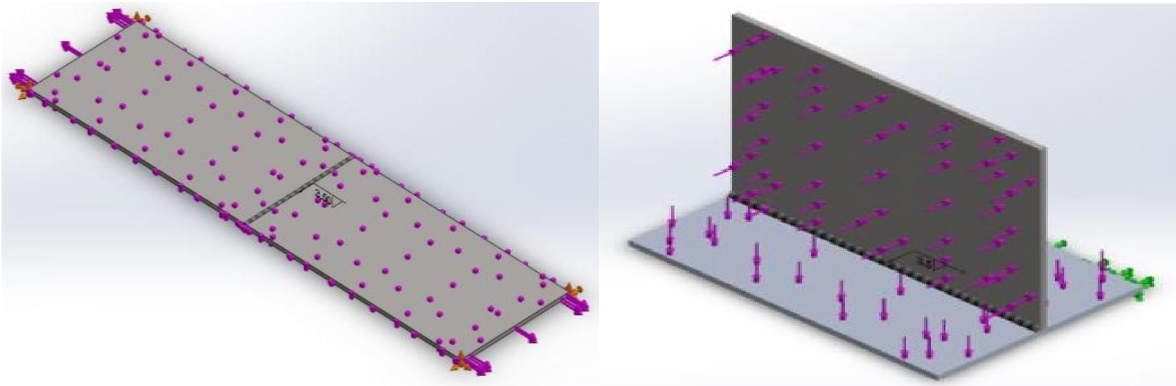
Table 1
Mechanical properties 5052-h32 aluminium alloy

Properties	Value
Elastic Modulus	7000 N/mm^2
Tensile strength	230 N/mm^2
Poisson’s ratio	0.33
Shear modulus	25900 N/mm^2

Table 2
Mechanical properties SST 304

Properties	Value
Elastic Modulus	190000 N/mm^2
Tensile strength	517.017 N/mm^2
Poisson’s ratio	0.29
Shear modulus	75000 N/mm^2

The meshing of the geometry, that ensues after finite element modelling and is necessary for FEAs, is the following phase. There were subdomains for the entire geometry model. Every subdomain is referred to as an element. The manner in which the mesh is created, and the quality of the elements determine the sensitivity of the output results. The modelling used a variety of element sizes. In locations with large stress gradients, it is crucial to have a fine mesh density, while areas with moderate stress gradients or places where the magnitude of the stresses is unimportant should have a coarser mesh density. M Nuruzzaman *et al.,* [17] investigate the transition from a coarse mesh to a fine mesh should be gradual. Figure 3 shown meshing boundary of butt joint and T joint for this research.



(a) (b)

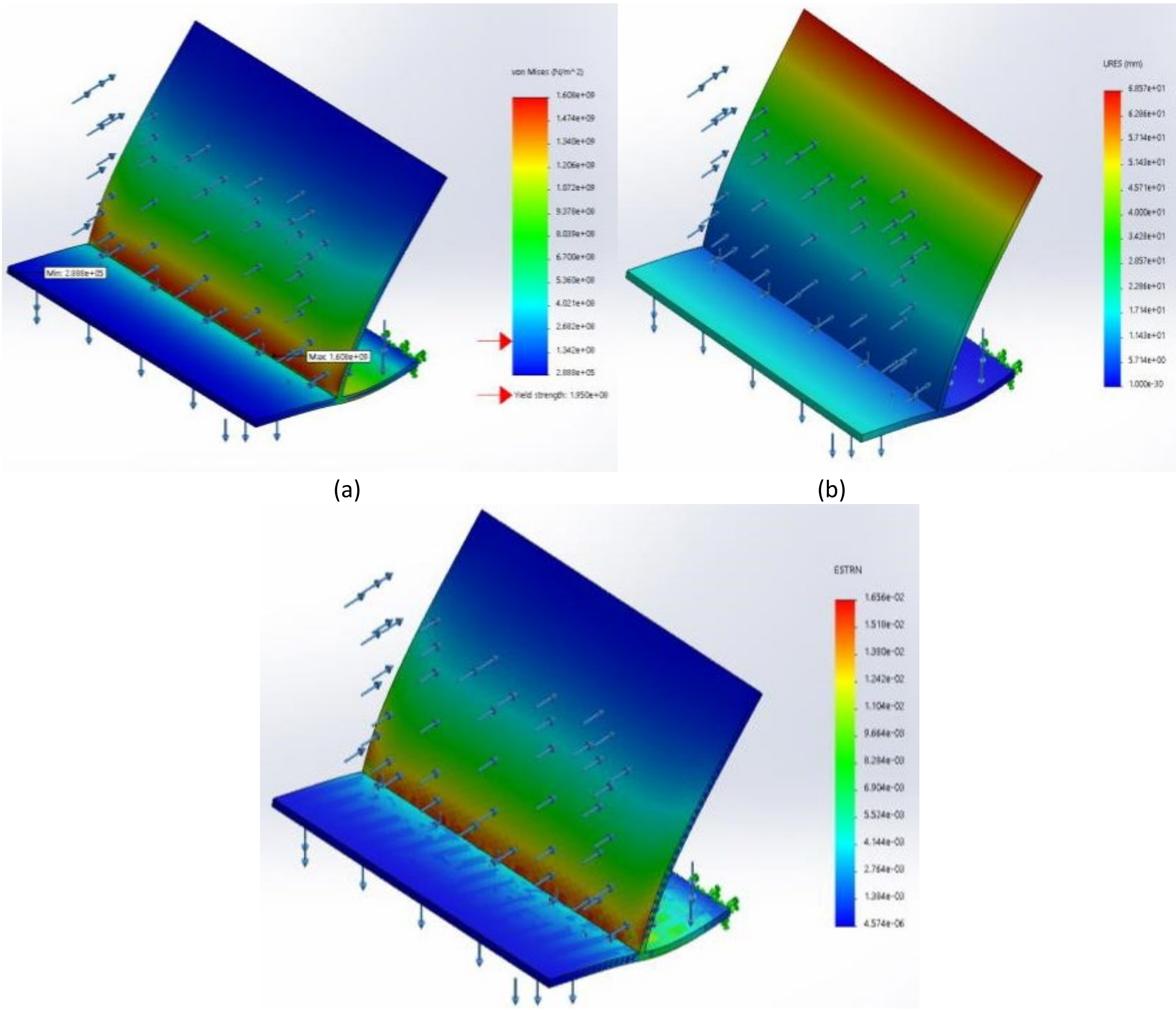
Fig. 3. (a) Mesh boundary for Butt joint (b) Mesh boundary for T-joint

3. Results and Discussion

FE package The SolidWorks Simulation program was used to evaluate the welded joints strength. Using 3D solid or shell models, the software enables the simulation of welded connections. The sort of model you choose relies on the intricacy of the structure. Use of the shell model is advised for more complicated structures to prevent convergence issues. The 3D solid and shell models have been used to simulate the geometry of the tested specimens. The central surfaces of the solids have been used to construct shell models.

The welded faces must belong to several bodies in order to represent the welded connections in a 3D solid model. SolidWorks Simulation 2018 only allows modelling of fillet weld beads (full length, intermittent, and staggered) using 3D solids. Then, in SolidWorks, we need to add the fillet weld bead feature between two disjunct bodies using the Weldments command Fillet Bead. After that, the fillet bead body in SolidWorks Simulation can be developed using solid or beam elements. Using standard strength parameters, such as, it is possible to assess the design resistance of a weld in the case of solid elements. For solid elements, conventional strength metrics, such as the Von Mises yield criterion, can be used to assess the design resistance of the weld. If we choose to simulate a fillet weld using a beam element, the program will automatically compute the section properties of the beam based on the fillet bead geometry and convert the fillet bead into the beam components.

In this situation, the strength of the weld can be assessed using the same common strength criteria for beam elements (Figure 4), or by manually calculating the strength of the welded connection in accordance with Euro Code 3 part 8 standards using the beam force from simulation results. According experiment M. Urbas *et al.,* [18] the applied force for these two joints was taken from experiment F = 10 KN.

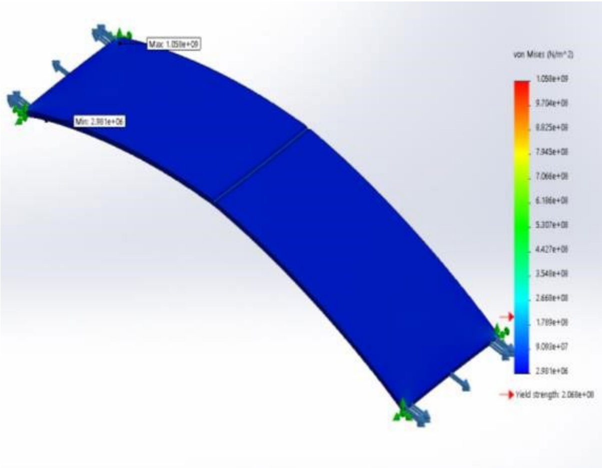


(a) (b) (c)

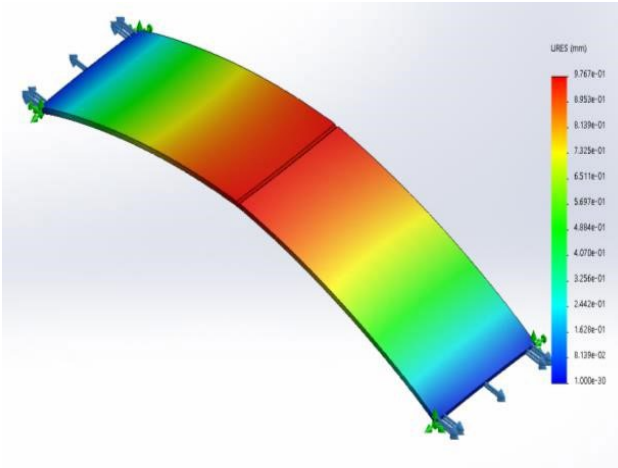
Fig. 4. Simulation T-joint model using SolidWorks simulation (a) stress (b) displacement (c) strain

Table 3
Result from SolidWorks of min and max of stress, displacement and strain T-joint

Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.888e+05 N/m^2 Node: 9982	1.608e+09 N/m^2 Node: 54270
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 5	6.857e+01 mm Node: 35176
Strain1	ESTRN: Equivalent Strain	4.574e-06 Element: 14751	1.656e-02 Element: 25612



(a)



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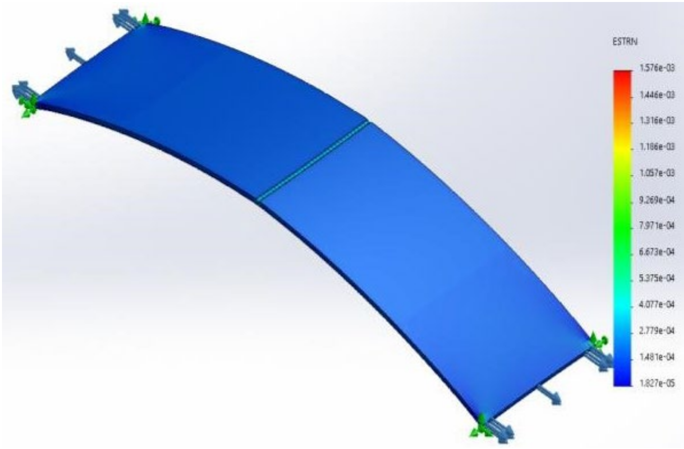

(c)

Fig. 5. Simulation butt joint model using SolidWorks simulation (a) stress (b) displacement (c) strain

Table 4
Result from SolidWorks of min and max of stress, displacement and strain butt joint

Name	Type	Min	Max
Stress1	VON: von Mises Stress	2.981e+06 N/m^2 Node: 151	1.058e+09 N/m^2 Node: 1
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 1	9.767e-01 mm Node: 214
Strain1	ESTRN: Equivalent Strain	1.827e-05 Element: 37499	1.576e-03 Element: 29013

4. Conclusions

In conclusion, the SolidWorks simulation package demonstrates its value for assessing the strength of welded joints through accurate computation of weld loads and quick estimation of weld throat requirements or stress levels. Since the model was loaded symmetrically, the effective weld throat thickness 3 mm determined using 3D Solid models with beam elements is very variable. Additionally, the simulation process was not carried out particularly fluidly. Due to improper operation of the no penetration contact in 3D Solid models, the global bonded contact has been engaged. This has led to a difference between the FE model of 3D Solid and the experimental one.

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