International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

Design Of A Fixture For T-Joint Weld In Friction Stir Welding

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Abstract: Abstract —Friction Stir Welding being a solid-state process is free from defects generally occurs in fusion welding process. T-welded joints are commonly seen in various industrial assemblies and in automobile chassis manufacturing. A fixture for such a welding operation is made using materials that are suitable for the fixture manufacture. Designing and fabrication of the fixture should accommodate high magnitude forces and withstand high temperature during melding process. Experimentations have been carried and with ANSYS problems have been solved. On basis of practical and ANSYS data design has been presented. In this paper, designing of fixture is done using Creo drawing and designing. mechanical characteristics such as total deformation, equivalent stress and strain were measured and material selection has been made.

Keywords: Friction Stir Welding, T-welded joints, automobile chassis manufacturing, forces and high temperature, Creo drawing, Material Selection, total deformation, equivalent stress and strain

1. INTRODUCTION

In 1991, Friction stir welding was invented by the Welding Institute and it is a process of solid state joining. In Friction stir welding heat is generated between the tool and the work piece due to friction leading to softening of the region near the tool and so the welding is done. This process uses a non-consumable tool to accomplish the welding without melting of the work piece. It was initially used for welding structures which requires high weld strength and done on materials such as wrought or extruded aluminium. For friction stir welding process suitable alloys of aluminium, titanium, stainless steel and magnesium are some ot the suitable materials preferred. Recent technologies made it possible to use the technology for the welding of polymers.

A. *Principle of operation:*

A rotating cylindrical tool with a structured extrusion is fed into a butt joint in the middle of two fixed work pieces, until the shoulder, which has a larger surface area than the pin, touches the top side of the work pieces. The extrusion is a bit shorter than the depth of weld required, with the tool shoulder travelling a top the surface of the work piece.

After short resting time, the tool is moved in the direction along the joint line at a specific predetermined welding speed. Between the tool and the work piece heat is generated due to friction. The frictional heat, the mechanical heat and the adiabatic heat causes the material to soften without melting. when the tool is moved towards the desired direction, the designed probe on the tool plasticized material from the leading face to the rear. Then, the high forces assist in a forged consolidation of the weld. In a plasticized tubular shaft, this process of the tool traversing along the weld line metal results in severe solid-state deformation involving dynamic recrystallization of the base material.

B. The objective of work:

The major objectives of the work involving the design of the fixture are listed below:

- To come up with a fixture design that is suitable to perform most of the T-Welding processes in Friction Stir Welding.
- The fixture material chosen should be capable of withstanding the huge amount of stress developed during welding operation with negligible deformation.
- The Fixture material choosen should be easy to manufacture and suitable to withstand high forces and temperature in the Friction stir welding operation.The thermal defects should also be low.
- The overall weight of the fixture should be minimal and suitable for the easy mobility of the fixture.

THE DESIGN OF FIXTURE

A. Fixture Design:

The proposed design is given in the figure that follows. The design contains two main elements namely, the base plate and the main fixture element. The main fixture contains two blocks of metal in the passage among which one is fixed and the other is moveable. The top of the fixture contains six plate stoppers on either side of the main fixture plate, which is used to stop or contain the work piece within the weldable region

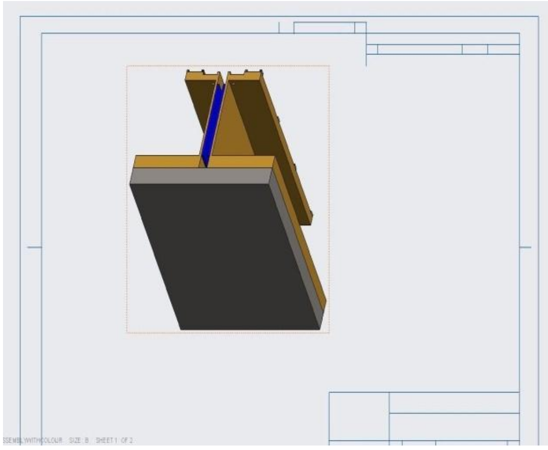

Figure 1: Fixture design

The Fixture Cad Design:

The initial design of the fixture was done in Creo design software .The dimesnsions of the fixture was mainly based on the requirement of the plated to be welded and we choose 6mm plated to be welded in the fixture.

The material used for the fixture design are as follows:

Table 1: 1 Type of Materials Used

Component number	**Components**	**Materisl Used**
1	Channel plate	EN 24 steel
2	Backing plate	EN 24 steel
3	Pressure plate	EN 8 steel
4	Plates to be welded	EN 24 steel

(i). The Fixture Drawing

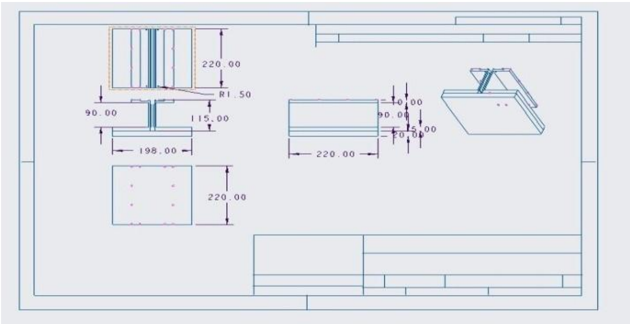

Figure 2: Fixture Drawing

The detailed fixture design was drawn usijng the Creosofteaware with required dimensions and is given below.Front view , top view combined with isometric view were also generated by using the same software.

B. Material Composition of the Fixture:

The materials used in for the fixture design are EN 24 and En 8 steel.

(i). Study ofEN24 Steel material

The EN24 steel is a very high strength steel alloy which can be purchased as hardened and tempered condition. The US SAE for the material is AISI 4340 with tensile strength ranging from 850 to 1000 N/mm^2.The yield strength of the material is 650 N/mm^2. The density of the material is 7840 kg/m^3. The Brinell Hardness number ranges from 248 to 302.The chemical Composition of the material is given in the below table.

Table 2: Material Composition of EN24

Element number	**Element name**	**Content**
1	Carbon	0.36-0.44%
2	Silicon	0.10-0.35%
3	Manganese	0.45-0.70%
4	Sulphur	0.040 Max
5	Phosphorous	0.035 Max
6	Chromium	1.00-1.40%
7	Nickel	1.30-1.70%

The EN24 steel is specifically chosen because it is a very high strength steel and offers good combination if strength, ductility and wear resistance. Overall it is a very high strength alloy engineering steel.

(ii). Study of EN8 Steel material

The EN8 steel is an unalloyed medium carbon steel and it is used where we need overall better properties than mild steel yet the cost of the material is lower than alloy steel. The US SAE standards for the material are AISI 1039,1042,1043,1045 with tensile strength ranging from 700 to 850 N/mm^2.The yield strength of the material is 450 N/mm^2.The density of the material is 7840 kg/m^3.The Brinell Hardness number ranges from 201 to 255.The chemical Composition of the material is given in the below table.

Table 3: Material Composition of EN8

Element number	**Element name**	**Content**
1	Carbon	0.36 to 0.44%
2	Silicon	0.10 to 0.40%
3	Manganese	0.60 to 1.00%
4	Sulphur	0.050 Max
5	Phosphorous	0.050 Max

The EN8 offer good wear resistance and hence chosen as material for pressure plate.

C. Design in CAD Software:

The design of the fixture assembly was carried out in Creosoftware.Basiccreo tools such as extrude , pattern , mirror were used in design of the model.Finally the individual components are assembled by using the assembly option to constrain the geometry .The creo workspace with the model is shown below:

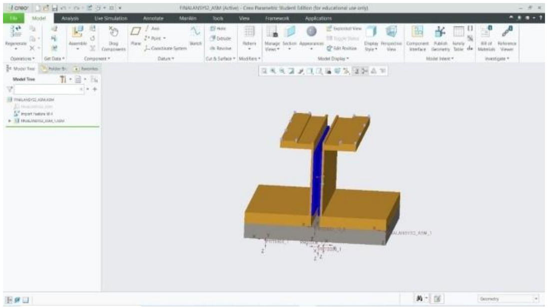

Figure 3: Fixture Designing

ANALYSIS IN ANSYS

ANSYS structural analysis software enables us to solve complex structural engineering problems and make better, faster design decisions. With the finite element analysis (FEA) solvers available in the suite, we can customize and automate solutions for your structural mechanics problems and parameterize them to analyze multiple design scenarios. We can also connect easily to other physics analysis tools for even greater fidelity. ANSYS structural analysis software is used across industries to help engineers optimize their product designs

International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

and reduce the costs of physical testing.

A. Static Structural analysis:

The static structural analysis is used for determining the total stresses and deformation in the component due to the application of a force. We can also able to predict the failure of a component and optimize the design accordingly.

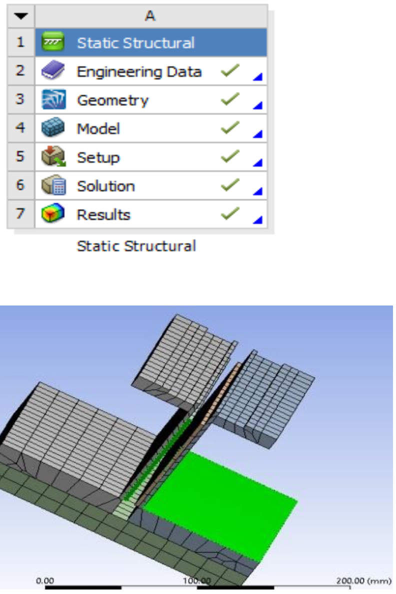

Figure 4: Static Structural analysis

B. Engineering data:

Engineering Data is used to specify the material type and material properties to be used for the corresponding product for analysis. Choosing Static structural>Engineering data>Engineering data sources, will reveal a number of preset materials to choose our choice of materials.

Outline of Schematic A2: Engineering Data

	A	B	C	D	E
1	Contents of Engineering Data			Source	Description
2	Material				
3	Aluminum Alloy			General_Materials.xml	General aluminum alloy. Fatigue properties come from MIL -HDBK-5H, page 3-277.
4	Structural Steel			General_Materials.xml	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
5	Structural Steel 2			General_Materials.xml	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
*	Click here to add a new material				

Figure 5: Input of Engineering Data

The tensile strength, the compressive strength and ultimate tensile strength of these materials are modified based on the properties of the materials being used in the fixture.

C. Geometry:

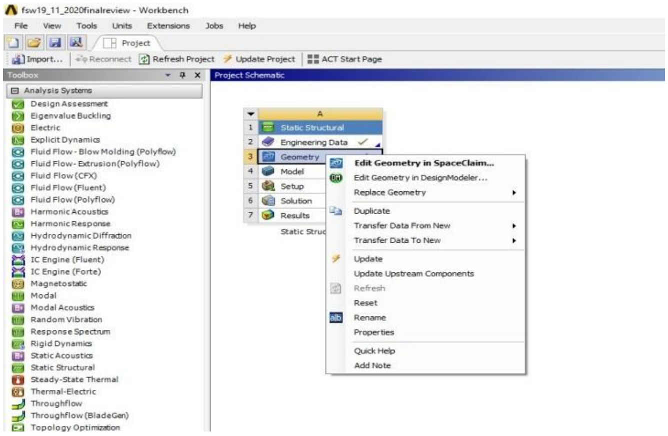

Figure 6: Importing of CAD Geometry

D. *Applying Mesh:*

The Mesh is applied to the imported geometry. Meshing is an integral part of the engineering simulation process where complex geometries are divided into simple elements that can be used as discrete local approximations of the larger domain. The mesh influences the accuracy, convergence and speed of the simulation.

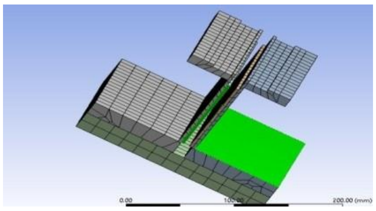

Figure 7: Component after Meshing

E. Applying Forces and adding support for analysis:

The fixed support is added by selecting the static structural and in the drop down menu select the insert option, then fixed support and selecting the lower side of the fixture makes that plane as the fixed support.

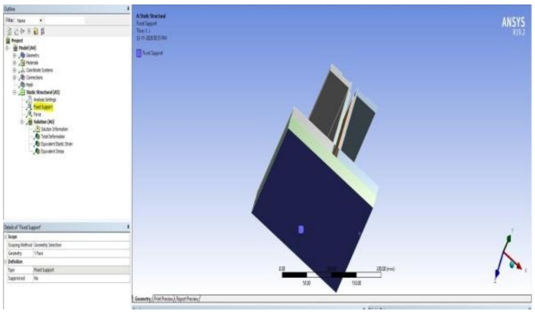

Figure 8: Adding forces and support

A force of 30000N is added on the top side for a default duration of 1 second on the fixture where the load is acting and the vector direction in the drop down menu is given as the +z direction , since that is the direction in which the force is acting.

SOLUTION AND RESULTS FROM ANSYS ANALYSIS

A. Solution Parameter:

The output solution is solved for three main parameters namely total deformation, equivalent stress and equivalent strain. This is done by selecting the solution in the dropdown menu and clicking on solve, which solves for the output parameters.

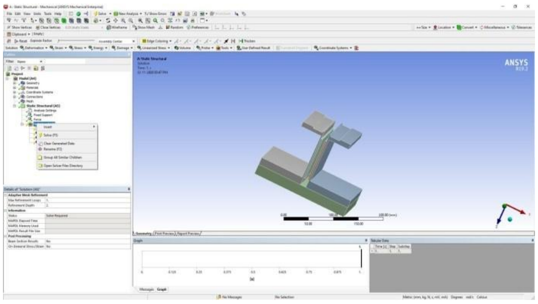

Figure 9: Solution in ANSYS

B. Total Maximum Deformation:

Deformation analysis is the determination of geometrical changes of an object. Geometrical changes are movements and distortions in the geometry of the object. The deformation has to be as low as possible to ensure the longevity of the fixture.

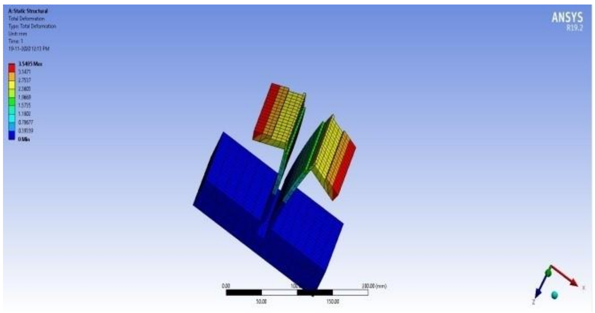

Figure 10: Total Deformation of the Component

The total deformation of the component under a high load of 3 ton or 30000N is found to be 3.5mm.

C. Total Equivalent Stress:

An equivalent tensile stress or equivalent von Mises stress, is used to predict yielding of materials under multiaxial loading conditions using results from simple uni-axial tensile tests.

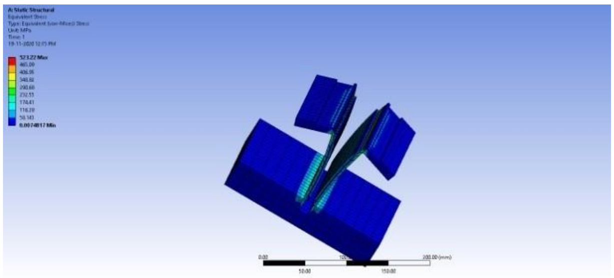

Figure 11: Total Equivalent Stress of the Component

The Maximum Equivalent stress of the component under a high load of 3 ton or 30000N is found to be 523.2*10^6 pascals

D. Equivalent Elastic Strain

A scalar quantity called the equivalent strain, or the von Mises equivalent strain, is often used to describe the state of strain in solids. The equivalent elastic strain is defined as the limit for the values of strain up to which the object will come back to the initial shape even after the removal of the load.

If values for velocity is given less than the calculated minimum velocity from table – 4 then the sample values lie stable region but we cannot make the fluid come out of the nozzle because the velocity will not meet the threshold

The Maximum Equivalent Elastic Strain of the component under a high load of 3 ton or 30000N is found to be 0.0026 mm/mm.

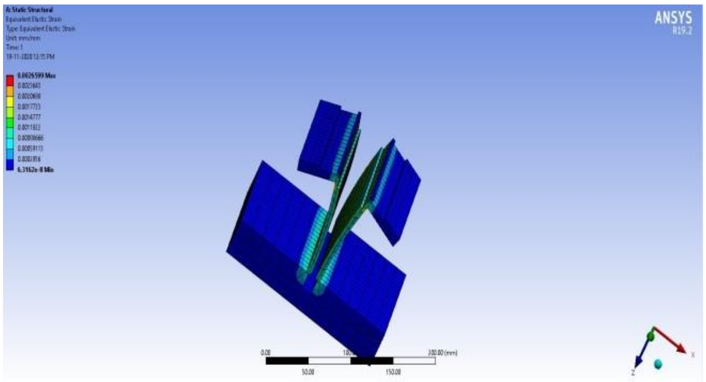

Figure 12: Equivalent Strain of the Component

2. RESULTS

For our testing of the fixture we use a load of 3 ton on top of fixture acting in the direction of the welding, which is sufficient enough for a T-Welding operation on Friction Stir Welding. Our study and design of the fixture is for a safe operation under ideal operating conditions.

Table 4: Results

Parameters	**Values**
Total load	3 ton or 30000N
Maximum Deformation	3.5mm.
Maximum Equivalent stress	523.2*10^6 pascals Maximum
Equivalent Elastic Strain	0.0026 mm/mm.
Total load	3 ton or 30000N

These values are found to be ideal for the manufacture of the component using EN 24 and EN 8 steel

3. CONCLUSION

Our work is to provide a permanent solution for T-welding fixture. We believe that this fixture design will be more useful when it comes to T-Weld in FSW welding and fulfill the need of manufacturing sectors using the above said process.Moveover there is scope for further improvement by adapting to Al 6061 in certain parts of the fixture material or to some subassemblies of the fixture in order to achieve weight reduction and increase portability of the fixture. Our major focus in this project were,

- Provide a design for better fabrication of the component.
- Provide a safe design of welding fixture with necessary load carrying capacity.

- Choose suitable material for the manufacture of the fixture.
  - Make necessary arrangements such as Bill of material, design parameters such as dimensions, tolerances and material requirement that would be useful to minimize the manufacturing cost.
  - Research necessary manufacturing methods and solutions for manufacturing the components for fabricating the fixture.
  - Research necessary testing methods to be carried out after the manufacture of the components and achieve the most optimized fixture design.

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