Middle-East Journal of Scientific Research 20 (5): 580-585, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.20.05.11338

Analysis of Stress in Welded Joint in Bending And in Torsion Using 'Ansys'

A. Thirugnanam, Manish kumar and Lenin Rakesh

Department of Mechanical Engineering, Bharath Institute of Science and Technology, P.O 600073 Chennai, India

Abstract: In this project the analysis of stress in welded joint in bending and in torsion has been carried out by using ANSYS version 12.1 and then the value of stresses and deflection obtained are compared with the values obtained by analytical solution. It is a type of eccentric loaded member on which load is applied at an eccentric distance on an asymmetric shaped member. For creating the diagram of the member, PRO-E is used and then imported into ANSYS where the analysis part is carried out.

Key words: ANSYS version 12.1 · Applied at an eccentric · Analytical solution

INTRODUCTION

Welding is the most commonly used process for permanent joining machine parts. Welding is the process in which fusion of metallic parts with heat and with or without pressure [1]. Welding is a fabrication process which joins materials (metals) or thermoplastics, by causing union.It is the process of melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint.

Gas flame, an electric arc, a laser, an electron beam, friction and ultrasound are used for welding [2].

MATERIALS AND METHODS

Forge Welding: Parts are heated to plastic state at the regions where connections are to be made an impact is given be a hammer or press. This method is employed in the manufacture of wrought iron pipes.

Electric Resistance Welding: Parts to be joined are pressed together an electric current is passed through the joint. At the joint the parts are heated to plastic state and welding takes place [3].

Fusion Welding: Weld metal is melted and deposited between the parent metal which hase been heated to plastic state. The molten metal solidified to form the solidified [4].

Thermit Welding: A mould is build around the joints. Then the thermit which is the mixture iron oxide and aluminium is placed in the mould. Thermit welding is used mainly to weld heavy section, such as rails.

Gas Welding: Oxygen- hydrogen or oxygen-acetylene gas flame is used to heat the parts to be welded and melts the weld metal (filler rod) which on cooling forms the joint. Gas welding is mainly used for joining the elements made of low carbon steels, cast iron, non-ferrous metal and alloys [5].

Arc Welding: Coated electrodes are preferred to bare electrodes, because electrodes coated with flux material gives off inert gas that completely shields the arc from the surroundings atmosphere. Thus the weld is protected from oxygen and nitrogen. Also, slag is formed on the top of the weld preventing oxidization while the weld is cooling. Welding electrodes of 0.15% carbon are used usually on mild steel with 0.3% carbon or less. Welds of steel with higher carbon content are likely to become brittle because of quenching action.

Corresponding Author: A. Thirugnanam, Department of Mechanical Engineering, Bharath Institute of Science & Technology, P.O 600073 Chennai, India.

Advantages:

- Economy of material and lighter weight of the structure.
- Less labour is required since there is no need for marketing out, drilling or punching holes
- Cost is less.
- Possibilities of joining curvilinear parts.
- Tightness of joints.
- Noiseless process.
- Greater strength – efficiency of the joint is 100%.

Disadvantages:

- Since there is non-uniform heating and cooling during welding, the members become warp end and residual stress developed.
- Skilled workers are required.
- Welding reduces fatigue strength.

Stresses in Welded Joints in Bending: Stress is a measure of the internal forces which after beyond certain limits will make permanent shape change or structural failure.For calculation of stress in weld joint in bending we use the following formula to finding bending stress, shear stress and maximum shear stress.

Bending Stress:

$$\sigma_b = \frac{pl}{z}$$

Stresses in Welded Joints in Torsion: For calculation of stress in weld joint in torsion we use the following formula to finding maximum stress induced.

Shear Stress in Torsion:

$$\tau = \frac{T(\frac{d}{2})}{J}$$

where

P = Applied Load
l = Length of bar
b = Length Of Weld
d = Throat Depth Of Weld
h = Size of weld
J = Polar Moment Of Inertia
T = Applied Load
τ = Shear Stress In Weld Due To Shear Force

Introduction to PRO/ENGINEER

Creo Elements/Pro, a product formerly known as **Pro/ENGINEER** is a parametric, integrated 3D CAD/CAM/CAE solution created by Parametric Technology Corporation (PTC). It was the first to marketwith parametric, feature-based, associative solid modelingsoftware. The application runs on Microsoft Windows platform and provides solid modeling, assembly modelling and drafting, finite element analysis and NC and tooling functionality for mechanical engineers. The Pro/ENGINEER name was changed to Creo Elements/Pro on October 28, 2010, coinciding with PTC's announcement of Creo, a new design software application suite.

PRO/ENGINEER is very powerful solid modelling software. It develops models as solids, allowing us to work in a three-dimensional environment. The design procedure is to create a model, view it, assemble parts as required, then generate any drawings which are required. It should be noted that for many uses of Pro/E, complete drawings are never created. To truly appreciate the power of PRO/ENGINEER as a solid modelling tool, we must acquire an understanding of the following concepts. Creo Elements/Pro (formerly Pro/ENGINEER), PTC's parametric, integrated 3D CAD/CAM/CAE solution, is used by discrete manufacturers for mechanical engineering, design and manufacturing.

Created by Dr. Samuel P. Ginsberg in the mid-1980s, Pro/ENGINEER was the industry's first successful rule-based constraint (sometimes called "parametric" or "variational") CAD modeling system. The parametric modeling approach uses parameters, dimensions, features and relationships to capture intended product behavior and create a recipe which enables design automation and the optimization of design and product development processes. Creo Elements/Pro provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform. These required capabilities include Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis and NC and Tooling Design.

FEA: The finite element method (FEM), its practical application often known as finite element analysis (FEA). It is a numerical technique for finding approximate solutions of partial differential equations (PDE) as well as integral equations. The solution approach is based either on eliminating the differential equation completely (steady state problems), or rendering the PDE into an approximating system of ordinary differential equations.

In solving partial differential equations, the primary challenge is to create an equation that approximates the equation to be studied, but is numerically stable, meaning that errors in the input and intermediate calculations do not accumulate and cause the resulting output to be meaningless. There are many ways of doing this, all with advantages and disadvantages. The finite element method is a good choice for solving partial differential equations over complicated domains (like cars and oil pipelines), when the domain changes (as during a solid state reaction with a moving boundary), when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear (thus reducing cost of the simulation).

Comparison to the Finite Difference Method: The finite difference method (FDM) is an alternative way of approximating solutions of PDEs. The differences between FEM and FDM are:

- The most attractive feature of the FEM is its ability to handle complicated geometries (and boundaries) with relative ease. While FDM in its basic form is restricted to handle rectangular shapes and simple alterations thereof, the handling of geometries in FEM is theoretically straightforward.
- The most attractive feature of finite differences is that it can be very easy to implement. There are several ways one could consider the FDM a special case of the FEM approach. E.g., first order FEM is identical to FDM for Poisson's equation, if the problem is discredited by a regular rectangular mesh with each rectangle divided into two triangles.
- There are reasons to consider the mathematical foundation of the finite element approximation more sound, for instance, because the quality of the approximation between grid points is poor in FDM.
- The quality of a FEM approximation is often higher than in the corresponding FDM approach, but this is extremely problem-dependent and several examples to the contrary can be provided.

Application: A variety of specializations under the umbrella of the mechanical engineering discipline (such as aeronautical, biomechanical and automotive industries) commonly use integrated FEM in design and development of their products. Several modern FEM packages include specific components such as thermal, electromagnetic, fluid and structural working environments. In a structural simulation, FEM helps tremendously in producing stiffness and strength visualizations and also in minimizing weight, materials and costs.

ANSYS: “ANSYS” is used for the structural analysis of welded joint in bending and in torsion to evaluate the stress pattern occurring in it at the time of loading. ANSYS is an engineering simulation software (computer-aided engineering, or CAE) developer that is headquartered south of Pittsburgh in Canonsburg, Pennsylvania, United States. ANSYS offers a comprehensive range of engineering simulation solution sets providing access to virtually any field of engineering simulation that a design process requires. Companies in a wide variety of industries use ANSYS software.

Design Calculation

Problem on Weld Joints in Bending: Given data

- Load applied (P) = 10KN
- Length (*l*) = 200mm
- Width (b) = 50mm
- Depth (d) = 70mm
- Size of weld (h) = 3mm

To Find

- Bending stress
- Shear stress
- Maximum shear stress

Bending Stress:

$$\sigma_b = \frac{Pl}{z}$$

We know, treating weld as line

$$Z_u = bd + \frac{d^2}{3}$$

$$Z_u = 50 \times 70 + \frac{70^2}{3}$$

Z_u = 5133.3 mm^2

Now,

$Z = Z_u \times h$
Z = 5133.3× 3
Z = 15399.9 mm^3

Now, Bending Stress is

$$\sigma_b = \frac{10000 \times 200}{15399.9}$$

σ_b=129.87 N/mm^2

Shear Stress:

$$\tau = \frac{P}{total\ weld\ area}$$

total weld area = (b+d) 2× h

total weld area = (50+70) 2× 3

total weld area = 720mm^2
now,

$$\tau = \frac{10000}{720}$$

τ = 13.89N/min^2

Maximum Shear Stress:

At base

$$\tau_{\max} = \sqrt{\left(\frac{\sigma b}{2}\right) + \tau^2}$$

$$\tau_{\max} = \sqrt{\left(\frac{129.87}{2}\right) + (13.89)^2}$$

τ_{max} = 66.4N/mm^2

On throat replace h by 0.707h

where:

P = Applied Load
l = Length of bar
b = Length Of Weld
d = Throat Depth Of Weld
h = Size of weld
τ = Shear Stress In Weld Due To Shear Force
J = Polar Moment Of Inertia
τ_{max} = Maximum Shear Stress in Weld

Problem on Weld Joints in Bending

Torsional Stress:

$$\tau = \frac{T(d/2)}{J}$$

As we know treating weld as line for torsion

$$J_u = \frac{\pi d^2}{4} \times h$$

$$J_u = \frac{\pi^{4}_{40^3}}{4} \times 3$$

J_u = 50285.7mm^2
$J = J_u \times h$
J = 50285.7 × 3
J = 150857.1

Now, $\tau = \frac{T(d/2)}{J}$

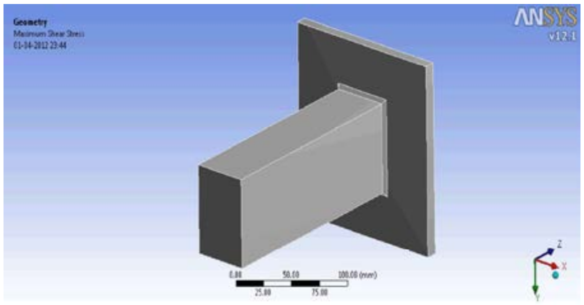
$$\tau = \frac{10000\left(\frac{40}{2}\right)}{150857.1}$$

τ =14.N/mm^2

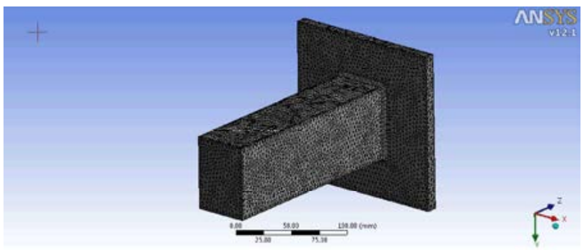
where:

T = Applied Load
d = Diameter
h = Size of weld
τ = Shear Stress in Weld Due To torsional Force
J = Polar Moment Of Inertia
τ_{max} = Maximum Shear Stress in Weld

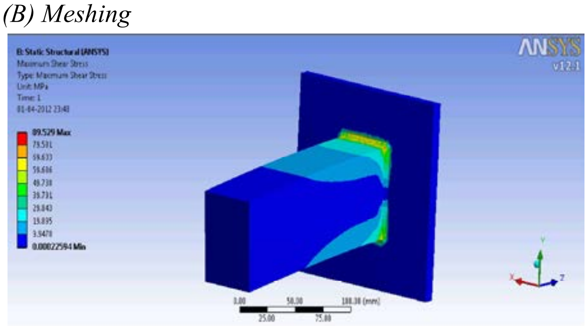
Analysis of Bending stress in welded joint in ANSYS



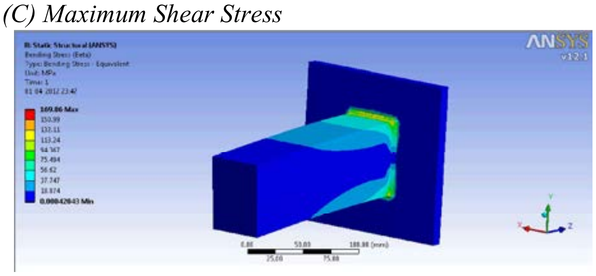
(A)Basic Model



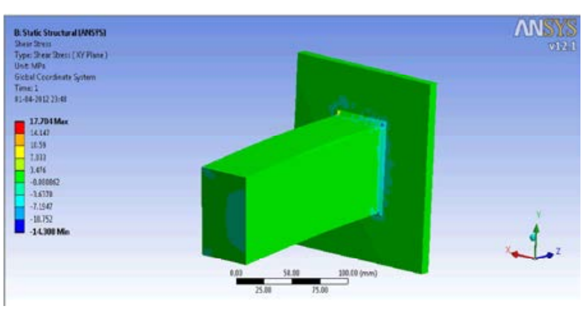
(B) Meshing



(C) Maximum Shear Stress

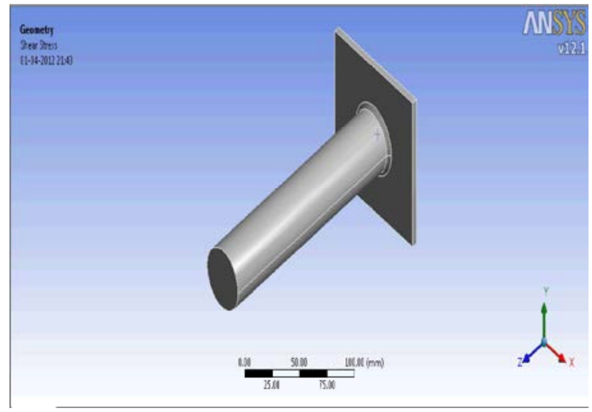


(D) Bending Stress

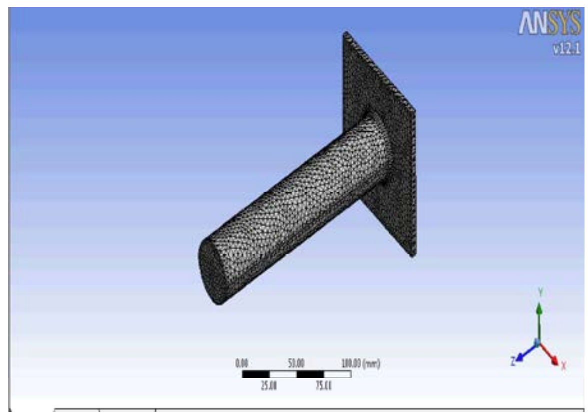


(E) Shear Stress

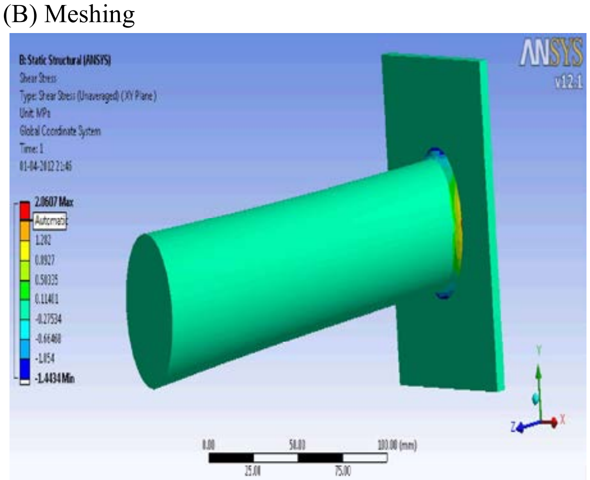
Analaysis of Torsional Stress in Welded Joint in ANSYS:



(A) Basic Model



(B) Meshing



(C) Shear Stress

Objective of the Present Research Work: The following research objective is to analyse and study the results from both theoretical and analytical values obtained from ANSYS. They are as follows:

- It helps to determine the life of an object under certain load conditions.
- It help to study the various stress acting upon model and prevent it from getting failure.
- It highlights the stress concentration area.

Effect of Stress Concentrations: Stress concentration may occur due to abrupt changes of cross section of the member due to the presence of discontinuities like holes, notches, grooves or shoulders. It may also be due to the presence of internal cracks or air holes in the material. If stress concentration area increases, it results in development of cracks and failure of the model.

CONCLUSION

In this project, we worked and studied upon the various stresses i.e. Bending and Torsion which occurs in weld joint on applied load. ANSYS being the integral part, basics framework of this stress analysis, has really come up with minute as well as the detail view and distribution of the stresses on the weld joints. Stress concentration areas, the maximum stress bearing area around weld region are easily determined. The differences between theoretical and analytical values has been compared and found approximately equal.

List of Symbols:

Symbol	Units	Designation
B		Length of Weld
d		Throat Depth of Weld
H		Size of weld
h		Size of weld
J		Polar Moment Of Inertia
l		Length of bar
P		Applied Load
T		Applied Torsional Load
τ		Shear Stress inWeld
τ_{max}		Maximum Shear Stress

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