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Piping Stress Analysis

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Abstract - *Pipe is a critical component in any process industry. The pipe is used for transfer such liquid or chemical from one tank to another tank with a specific quantity under pressure. The design of the pipe depends on the type of liquid that should be transferred concerning their fluid properties like viscosity, the pressure required to transfer from one place to another place. This research paper base on stress analysis in pipe assembly and checking the strength of the connector which is used for plant industries as required operation. By using Solid work software to make a CAD model of components of pipe assembly and one of the modules used for analysis. By using a simulation module to check factor safety as a bolt and joint level in pipe assembly. In the static analysis module to get the value of von mises stress, deformation, and strain so according to result, we looking factor of safety at bolt fitting.*

Key Words: Pipet; Static Analysis; Factor of Safety; Design; Von mises Stress, Deformation, Strain.

1. INTRODUCTION

There are different thumb rules for pipe analysis in plant and process industries because there were different plant-like food process plants, thermal power stations, chemical process industries, pharmaceutical plants, and agricultural plants. The process of different materials should be transferred concerning specific pressure conditions to be justified according to the transfer ratio of fluid which may be critical or non-critical as discussed in the upcoming analysis.

2. SIMULATION

2.1 Problem Statement

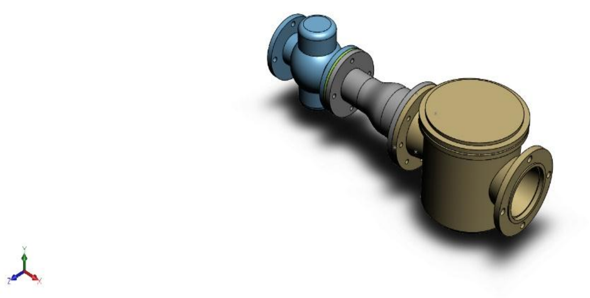

Fig -1: Pipe Assembly

The components of a piping assembly are subjected to a high internal pressure load. You define two sets of bolt connectors and check which bolts can safely carry the load, and which will fail.

Define bolt connectors in a hole series.

Run a pass/no pass check for connectors.

There are three major components are in Figure 1 which are connected through number bolt. The major problem is the joining process in the plant because during assembly required standard process to link or connection between pipeline and valve. The design of the plant depends on the process and type of liquid or chemical to be transfer form on components to other components concerning quality and state of material or chemical it may be a hot or cold condition as the process required.

2.2 Study Properties

Table -1: Study Properties Information

Study name	ready
Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	Include temperature loads
Zero strain temperature of	298 Kelvin
Include fluid pressure effects from SOLIDWORKS Flow Simulation	Off
Solver type	FFE Plus
In-plane Effect:	Off
Soft Spring:	Off
Inertial Relief:	Off
Incompatible bonding options	Automatic
Large displacement	Off
Compute free body forces	On
Friction Off	
Use Adaptive Method:	Off

Table- 1 having information containing information about simulation which indicated static analysis. The solver required different parameters that should be on or off as per the resulting requirement. Concerning the fluid movement in pipe assembly which created friction between the fluid and internal area of the pipe. During the flow of fluid which created friction regarding pressure and velocity data. Pressure and Velocity are the main parameters for the selection of pipes, valves, and other accessories that depended on technical data fluid qualities and justified plant cycle which is run maybe 24 hr or 48 hr depend on producing electricity to run a specific power plant or chemical plant.

2.3 Material Properties

Name: Cast Stainless Steel
Model type: Linear Elastic Isotropic
Default failure criterion: Unknown
Elastic modulus: 1.9e+11 N/m^2
Poisson's ratio: 0.26
Mass density: 7,700 kg/m^3
Shear modulus: 7.9e+10 N/m^2
Thermal expansion coefficient: 1.5e-05 /Kelvin

Name: AISI 1020
Model type: Linear Elastic Isotropic
Default failure criterion: Unknown
Yield strength: 3.51571e+08 N/m^2
Tensile strength: 4.20507e+08 N/m^2
Elastic modulus: 2e+11 N/m^2
Poisson's ratio: 0.29
Mass density: 7,900 kg/m^3
Shear modulus: 7.7e+10 N/m^2
Thermal expansion coefficient: 1.5e-05 /Kelvin

Name: Cast Alloy Steel
Model type: Linear Elastic Isotropic
Default failure criterion: Unknown
Yield strength: 2.41275e+08 N/m^2
Tensile strength: 4.48082e+08 N/m^2
Elastic modulus: 1.9e+11 N/m^2
Poisson's ratio: 0.26
Mass density: 7,300 kg/m^3
Shear modulus: 7.8e+10 N/m^2
Thermal expansion coefficient: 1.5e-05 /Kelvin

The above detail used different materials in pipe assembly like a pipe, connector, and valve so here used cast stainless steel, AISI 1020, and cast alloy steel which most popular for sustaining in high pressure and temperature condition.

The material is the main parameter for pipe industries because of the hot extrusion process used for the manufacturing pipe and other valves. The major material is cast alloy steel due to its density, it is lightweight and easily handle from one place to another place and satisfied with reference thermal effect and static effect.

As shown above details of three different components material characteristic.

2.4 Boundary Condition

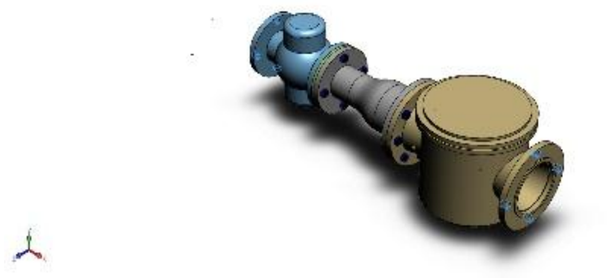

Fig -2: Fixed at Fitting area

8 faces must be fixed as per practical condition because the fitting of number blots are 8 which are connector different components as per requirement. As shown Figure II is one fixed boundary condition for justified simulation in Solid Works.

As shown in Figure 2 which indicated boundary conditions taken as per practical data detailed studied.

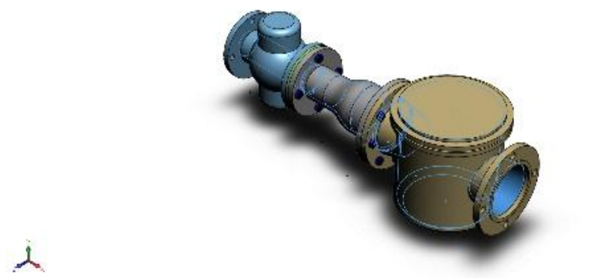

Fig -3: Applying Pressure at Inside Pipe Assembly

As per practical data here we should apply pressure up to the maximum limit of 1000 psi and check the static analysis of pipe assembly.

Entities: 12 face(s)
Type: Normal to selected face
Value: 1,000
Units: psi
Phase Angle: 0
Units: deg

2.5 Connector Definition

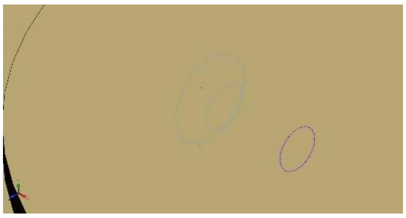

Fig -4: Countersink with Nut-1

Table -2: Detail of Countersink with Nut-1

Bolt Check:	Needs attention
Calculated FOS:	1.31815
Desired FOS:	2

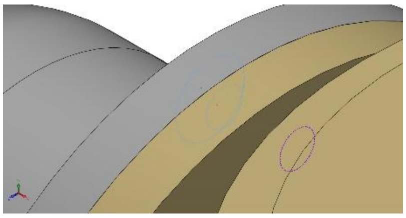

Fig -5: Countersink with Nut-2

Table -3: Detail of Countersink with Nut-2

Bolt Check:	Needs attention
Calculated FOS:	0.163759
Desired FOS:	2

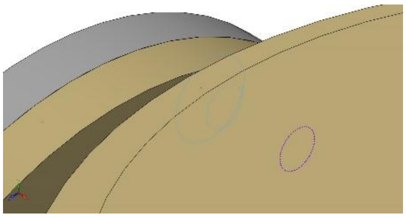

Fig -6: Countersink with Nut-3

Table -4: Detail of Countersink with Nut-3

Bolt Check:	Needs attention
Calculated FOS:	0.260768
Desired FOS:	2

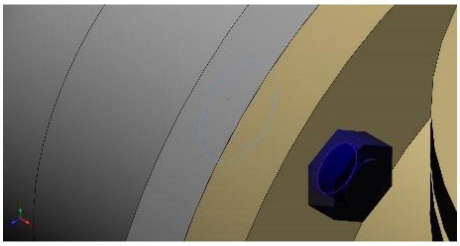

Fig -7: Countersink with Nut-4

Table -5: Detail of Countersink with Nut-3

Bolt Check:	Needs attention
Calculated FOS:	0.26187
Desired FOS:	2

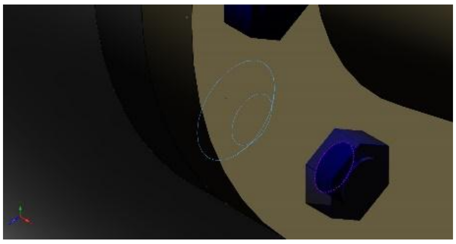

Fig -8: Countersink with Nut-6

Table -6: Detail of Countersink with Nut-6

Bolt Check:	Needs attention
Calculated FOS:	1.27177
Desired FOS:	2

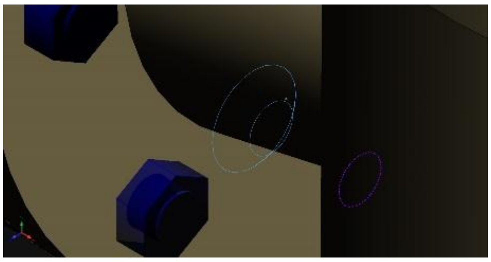

Fig -9: Countersink with Nut-7

Table -7: Detail of Countersink with Nut-7

Bolt Check:	Needs attention
Calculated FOS:	0.267452
Desired FOS:	2

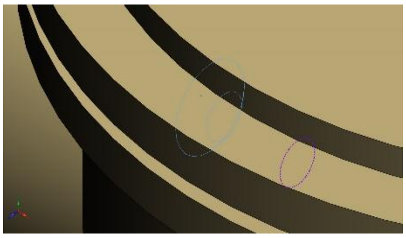

Fig -10: Countersink with Nut-8

Table -8: Detail of Countersink with Nut-8

Bolt Check:	Needs attention
Calculated FOS:	0.164902
Desired FOS:	2

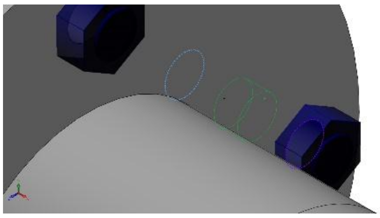

Fig -11: Counterbore with Nut-1

Table -9: Detail of Countersink with Nut-1

Bolt Check:	OK
Calculated FOS:	10.6145
Desired FOS:	2

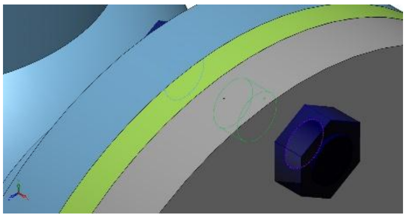

Fig -12: Counterbore with Nut-2

Table -10: Detail of Countersink with Nut-2

Bolt Check:	OK
Calculated FOS:	7.59158
Desired FOS:	2

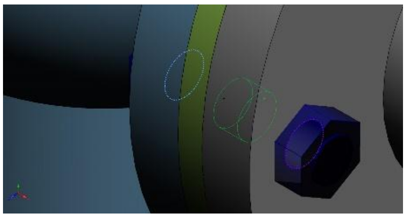

Fig -13: Counterbore with Nut-3

Table -11: Detail of Countersink with Nut-3

Bolt Check:	OK
Calculated FOS:	10.5846
Desired FOS:	2

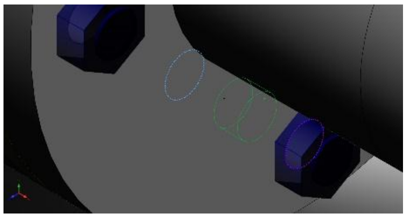

Fig -14: Counterbore with Nut-4

Table -12: Detail of Countersink with Nut-1

Bolt Check:	OK
Calculated FOS:	6.30083
Desired FOS:	2

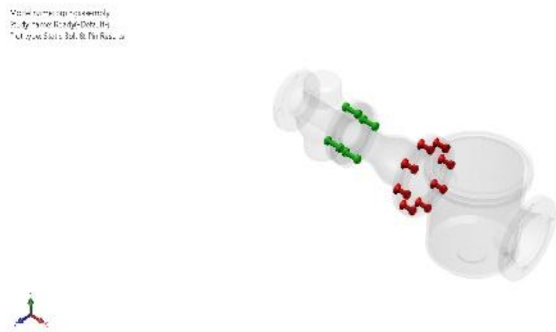

Fig -15: Connector Forces

Table -13: Detail of Connection of Bolts

Entities:	1 edge(s), 1 face(s)
Type:	Bolt(Head/Nut diameter)(Countersink with nut)
Connection Type:	Rigid
Head diameter:	28.5496 mm
Nominal shank diameter:	15.875 mm
Material Name:	Alloy Steel
Young's modulus:	2.1e+11 N/m^2
Poisson's ratio:	0.28
Thread Count:	11 threads/mm
Bolt Strength:	5e+07 N/m^2
Safety Factor:	2
Preload (Torque):	0 lbf.in
Friction Factor (K):	0.2
Tight Fit:	No

2.6 Mesh Information

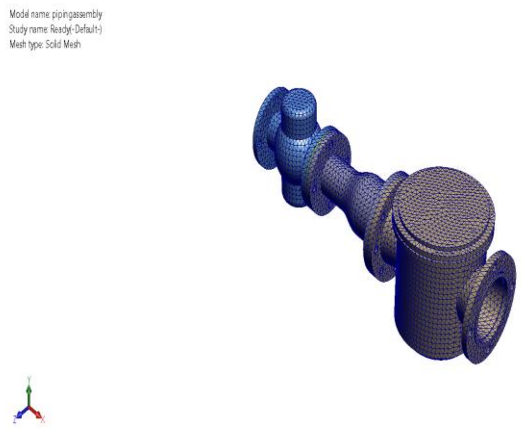

Fig -16: Meshing Process

Total Nodes 84608

Total Elements 46121

Maximum Aspect Ratio 7.8817

% of elements with Aspect Ratio < 3 96.6

% of elements with Aspect Ratio > 10 0

% of distorted elements (Jacobian) 0

Time to complete mesh (hh;mm;ss): 00:00:09

Mesh type	Solid Mesh
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points for High-quality mesh	4 Points
Element Size	0.59537 in
Tolerance	0.0297685 in
Mesh Quality	High
Remesh failed parts with incompatible mesh	Off

3. RESULTS

As per practical data and applied standard boundary condition we should get the result mention in the figure which seem to safe as per 1000 psi pressure and selection bolt and pipe material are appropriate as per justified design.

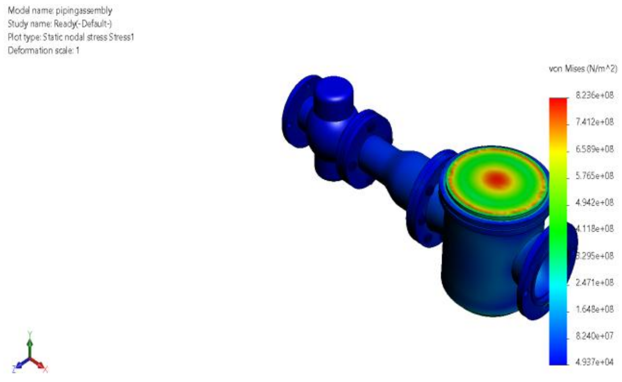

Fig -17: Von mises Stress

Table -14: Von mises Stress

Name	Type	Min	Max
Stress1	VON: von Mises Stress	4.937e+04N/m^2 Node: 82142	8.236e+08N/m^2 Node: 35716

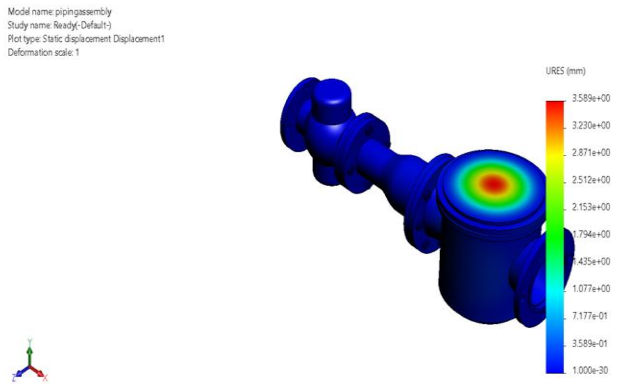

Fig -18: Displacement in pipe assembly

Table -15: Displacement

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 470	3.589e+00mm Node: 17600

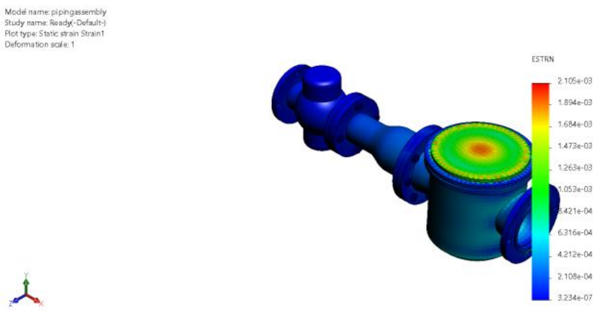

Fig -19: Strain in pipe assembly

Table -16: Strain

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	3.234e-07 Element: 44594	2.105e-03 Element: 19551

4. CONCLUSIONS

As per l result, as per standard practical which applied which gives result defected high passed through pipes and there alue in von mis stress, deflection and strain value are 8.236e+08N/m^2, 3.889, and 2.150e-03.

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