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# LINEAR AND STATIC ANALYSIS USING FEA VARIOUS NOZZLE TO SHELL JUNCTION OF PRESSURE VESSEL

**Santosh Hiremath[1], Naresh Kumar[2], Nagareddy G[3]**
*[1,2,3] Mechanical Engineering Department,*
*G H Raisoni College of Engineering and Management, Pune, (India)*

**ABSTRACT**

*This research paper deals with the modeling and analysis pressure vessel by FEA. Pressure vessel is made with different geometrical shapes and with several nozzle joints this affects the pressure vessel profile and nozzle. The change in stress concentration may also lead to affect the joints near inlet and outlet connections. So that the system needs to carefully analyze with the FEA analysis software to study on stress level in the nozzle & pressure vessel. The main purpose of this study is to determine the value of stresses in the nozzle.*

***Key Words— FEA, Modeling, Nozzles, Pressure, Stress, Vessel***

## I INTRODUCTION

Pressure vessels are widely applied in many branches of industry such as chemical and petroleum machine-building, nuclear and power engineering, gas, oil and oil-refining industries, aerospace techniques, etc. As the name implies these are important components of processing equipment. Nozzles or opening are necessary in the pressure vessels to satisfy certain requirements such as inlet or outlet connection, manholes, vents & drains etc. Welded nozzles connecting a pressure vessel to piping can be placed both on the cylindrical shell and the heads of the vessel.

A pressure vessel is defined as container with internal pressure, higher than atmospheric pressure. The fluid inside the pressure vessel may undergo state of change like in case of boilers. Pressure vessel has combination of high pressure together with high temperature and may be with flammable radioactive material. Because of these hazards it is important to design the pressure vessel such that no leakage can take place as well as the pressure vessel is to be designed carefully to cope with high pressure and temperature. Plant safety and integrity are one of the fundamental concerns in pressure vessel design and these depend on adequacy of design codes.

In general the cylindrical shell is made of a uniform thickness which is determined by the maximum circumferential stress due to the internal pressure. Since the longitudinal stress is only one-half of this circumferential stress. The structure is to be designed fabricated and checked as per American Society of Mechanical Engineers standards .Pressure vessels are used in number of industries like power generation industry for fossil and nuclear power generation, In petrochemical industry for storage of petroleum oil in tank as well as for storage of gasoline in service stations and in the chemical industry. The size and geometric form of pressure vessel is varying from large cylindrical vessel for high pressure application to small size used as hydraulic unit of aircraft. In pressure vessel whenever expansion or contraction occurs normally as result of heating or cooling, thermal stresses are developed. There are many types of stresses developed in the vessel. Stresses are categorized into primary stresses and secondary stresses. Primary stresses are generally due to internal or external pressure or produced by moments and these are not self-limiting. Thermal stresses are secondary stresses because they are self-limiting. That is yielding or deformation of the part relaxes the stress (except thermal stress ratcheting).Thermal stresses will not cause failure by rupture in ductile materials except by fatigue over repeated loading applications.

## II.OBJECTIVES

Pressure Vessel deals with highly pressurized liquids and gases so this causes various types of loads and stresses acting on pressure vessel so this may lead to failure of pressure vessel.

As per the ASME design codes across the thickness three elements are kept but when it comes to complex structure three elements cannot fulfill the condition so in this project work is done for four elements across thickness. In some cases thickness is too small to divide it for three elements so in this project work is done for two elements in such cases for meshing purpose. Project analyses the changes in the result when meshing is done with two three or four elements across the thickness of shell and nozzle junction. To find the difference between 2-element, 3-element meshing method and its analysis. Analysis of Pressure vessel nozzle and finding its weak spot. Gain control over some software's. Using specific software for particular requirement like using Catia for modeling of vessel, Hyper mesh for meshing & Ansys for analysis

## III MODELING AND ANALYSIS

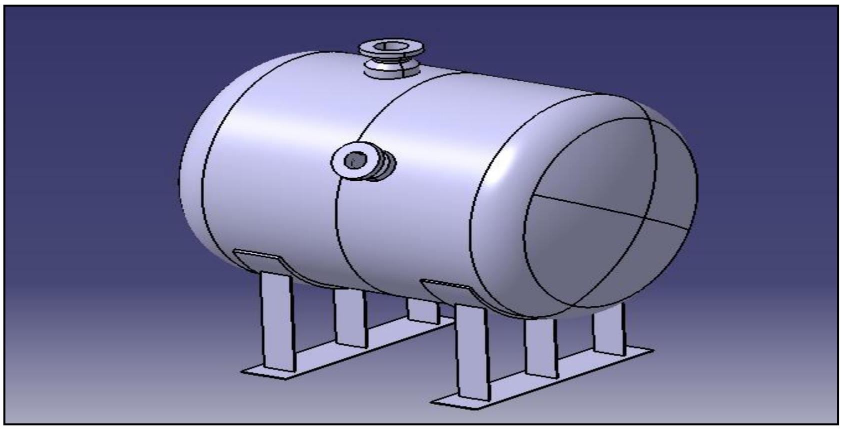

**Fig 3.1 CATIA Model of Pressure Vessel**

SOLID185 is used for 3-D modeling of solid structures. It is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, hyper elasticity, stress stiffening, creep, large deflection, and large strain capabilities. It also has mixed formulation capability for

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simulating deformations of nearly incompressible elasto-plastic materials, and fully incompressible hyper elastic materials. Fig 3.8 shows a detailed meshed model.

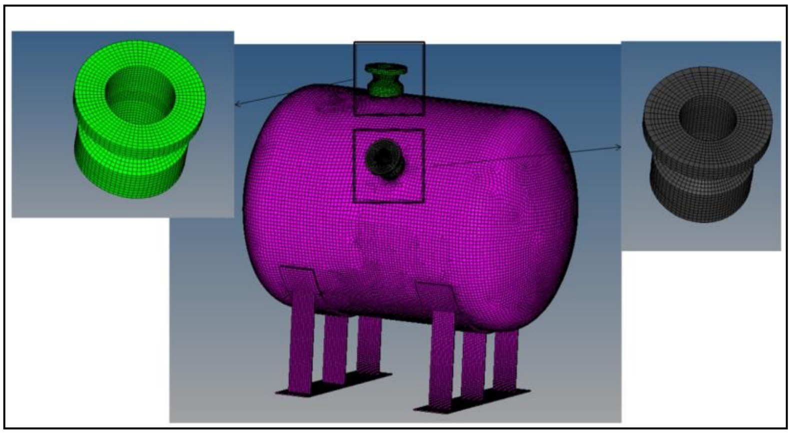

**Fig 3.2 Meshed Model**

**TABLE 3.1 SHAPE TESTING FOR ALL SELECTED ELEMENTS**

SUMMARIZE SHAPE TESTING FOR ALL SELECTED ELEMENTS

<<<<<< SHAPE TESTING SUMMARY >>>>>>
<<<<<< FOR ALL SELECTED ELEMENTS >>>>>>

: Element count 229044 SOLID185 :

| Test | Number tested | Warning count | Error count | Warn+Err % |
|---|---|---|---|---|
| Aspect Ratio | 229044 | 0 | 0 | 0.00 % |
| Parallel Deviation | 229044 | 4 | 0 | 0.00 % |
| Maximum Angle | 229044 | 0 | 0 | 0.00 % |
| Jacobian Ratio | 229044 | 0 | 0 | 0.00 % |
| Warping Factor | 229044 | 0 | 0 | 0.00 % |
| Any | 229044 | 4 | 0 | 0.00 % |

Meshing quality should be checked after meshing. Mesh aspects mainly influencing the analysis should be restricted to following values, 1. Max angle < 140°.2. Min angle < 30° .3. Jacobean > 0.64.Aspect ratio < 10.Always optimize the mesh count without failing to capture the critical areas with fine & good quality mesh.

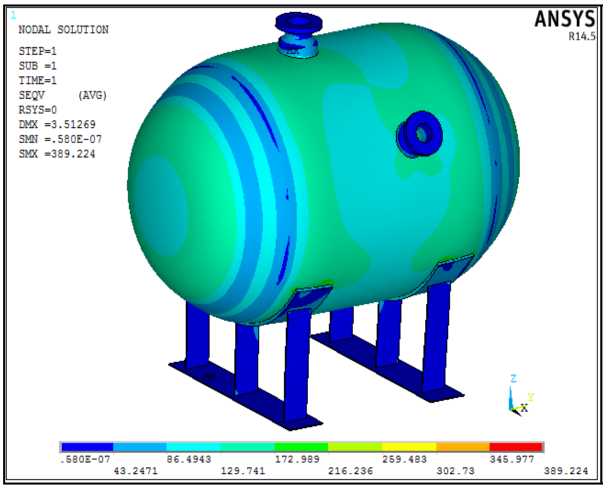


**Fig 3.3 (a) Von-Mises Stress, 2-Elemental**

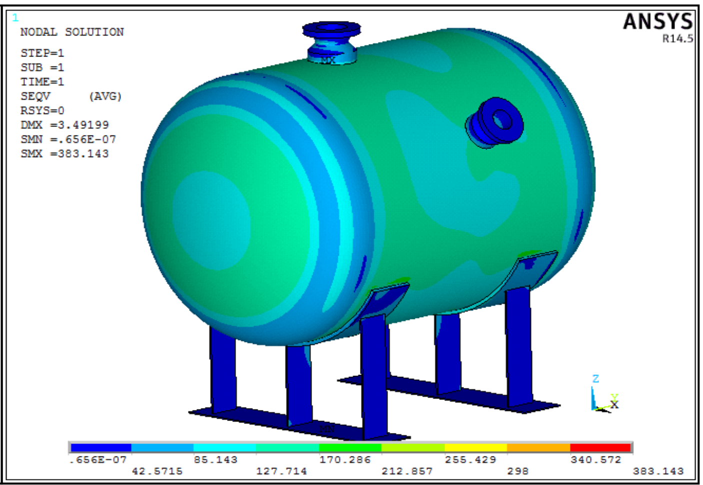


**Fig 3.3 (b) Von-Mises Stress, 3-Elemental**

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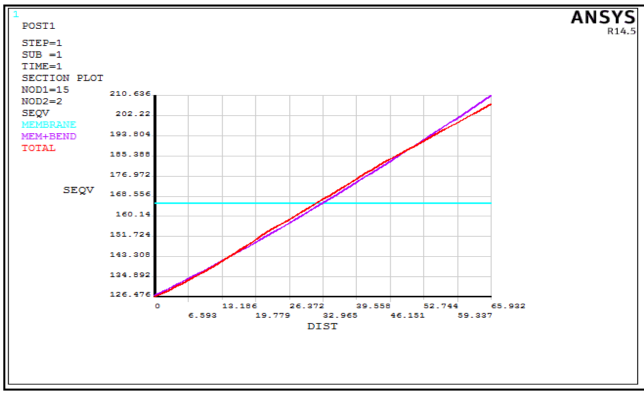
### III RESULT AND DISCUSSIONS



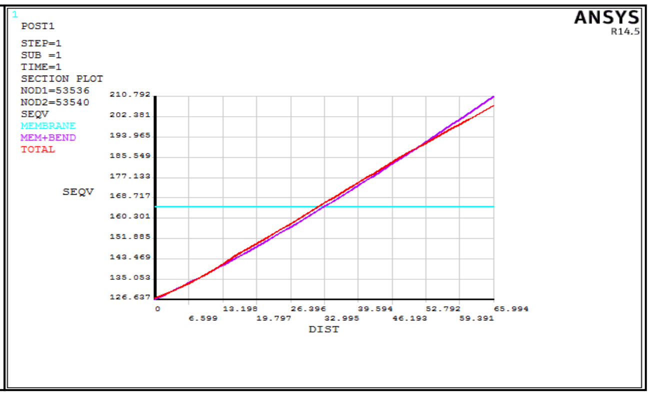




**Fig 3.4 (a) SCL-1 Result For 3-Elemental**

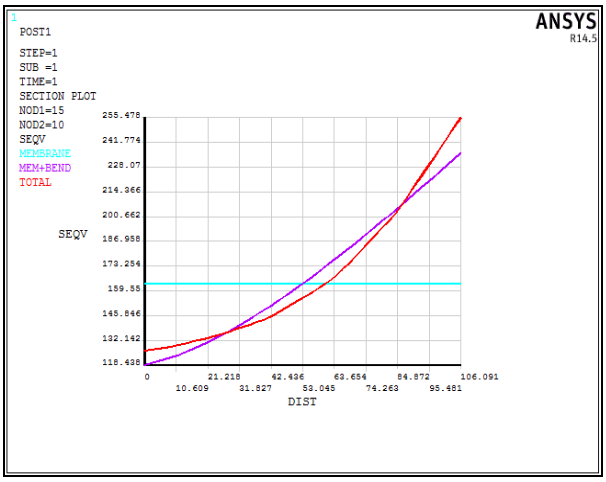
**Fig 3.4 (b) SCL-8 Result For 2-Elemental**

**Table 3.2 (a) SCL-1 Result For 3-Elemental**

| Scl no. | Description | Category | Stress (mpa) | Allowable stress limit (mpa) |
|---|---|---|---|---|
| Scl-1 | At discontinuity | PL | 165.7 | 1.5*S = 226.5 |
| | | PL+Pb+Q | 210.6 | Sps = 453 |

**Table 3.2 (b) SCL-1 Result For 3-Elemental**

| Scl no. | Description | Category | Stress (mpa) | Allowable stress limit (mpa) |
|---|---|---|---|---|
| Scl-8 | At discontinuity | Pl | 165.1 | 1.5*s = 226.5 |
| | | PL+Pb+Q | 210.8 | Sps = 453 |



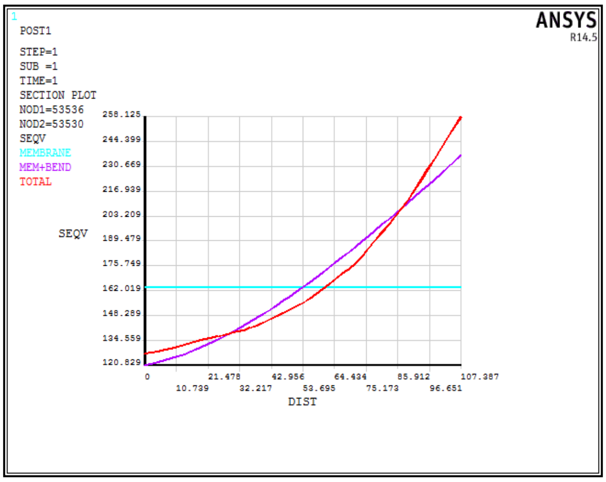




**Fig 3.5 (a) SCL-2 Result, 3-Elemental**

**Fig 3.5 (b) SCL-9 Result, 2-Elemental**

**Table 3.3 (a) SCL-2 Result, 3-Elemental**

| Scl no. | Description | Category | Stress (mpa) | Allowable stress limit (mpa) |
|---|---|---|---|---|
| Scl-2 | At discontinuity | Pl | 163.7 | 1.5*s = 226.5 |
| | | PL+Pb+Q | 235.8 | Sps = 453 |

**Table 3.3 (b) SCL-2 Result, 3-Elemental**

| Scl no. | Description | Category | Stress (mpa) | Allowable stress limit (mpa) |
|---|---|---|---|---|
| SCL-9 | At discontinuity | Pl | 164.0 | 1.5*s = 226.5 |
| | | PL+Pb+Q | 236.7 | Sps = 453 |

**Table 3.4 Overall Elemental Results by ANSYS**

| Scl no. | | 2-element | 3-element | Allowable stress (mpa) |
|---|---|---|---|---|
| 1 | $P_m$ | 165.1 | 165.7 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 210.8 | 210.6 | 453 |
| 2 | $P_m$ | 164.0 | 163.7 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 236.7 | 235.8 | 453 |
| 3 | $P_m$ | 221.3 | 222.7 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 355.5 | 359.3 | 453 |
| 4 | $P_m$ | 149.1 | 149.2 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 190.9 | 189.9 | 453 |
| 5 | $P_m$ | 145.2 | 144.3 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 215.6 | 212.9 | 453 |
| 6 | $P_m$ | 198.3 | 197.6 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 325.2 | 323.9 | 453 |
| 7 | $P_m$ | 129.2 | 128.2 | 226.5 |
| | $P_{m+}P_{b+}P_l$ | 134.3 | 132.7 | 453 |

**Table 3.5 Finalized Results**

| SR NO | Meshed Element | SCL 3 | Result | Allowable Value |
|---|---|---|---|---|
| 1 | 2-Elemental | PL | 221.3 | 1.5*S = 226.5 |
| 2 | | PL+Pb+q | 355.5 | Sps = 453 |
| 3 | 3-Elemental | PL | 222.7 | 1.5*S = 226.5 |
| 4 | | PL+Pb+q | 359.3 | Sps = 453 |

## III. CONCLUSION

From the result comparison we are getting in 3 meshed element the result value is nearer to allowable value from above result we conclude that 3 meshed element is proper for all above meshed. The accuracy of the FE model is highly dependent on the mesh employed, especially if higher order (cubic, quadratic etc.) elements are not used. In general, a finer mesh will produce more accurate results than a coarser mesh.The efficiency and reliability of the fixture design has enhanced by the system and the result of the fixture design has made more reasonable. To reduce cycle time required for loading and unloading of part, this approach is useful.If modern CAM, CAD, ANSYS are used in designing the systems then significant improvement can be assured.

To fulfil the multi- functional and high performance fixture requirements optimum design approach can be used to provide comprehensive analyses and determine an overall optimal design.

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