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## Determining safety and Stability of Overhang Pressure Vessel using Finite Element Analysis

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**Abstract:** A Pressure vessel which is typically used in chemical company for large production of Nitrous Oxide. Due to operating conditions of pyrolysis process the required vessel is to be mounted on another inclined vessel. The vessel for pyrolysis process is supported by leg support but structure stability of vessel due to leg support is poor, because the inclined vessel will be constantly moving to control the rate of reaction, the support will not be stable. Design stress is accepted as the lower value. Design is associated with the calculation of dimensions of an overhang pressure vessel to withstand the applied loads and perform the desired function. Analysis is associated with the estimation of displacements or stresses in a component of assumed dimensions so that adequacy of assumed dimensions is validated. The concept is to create a support structure around the vessel which will give lateral supports and the vessel will be free from the bottom. The objective is to provide stability of overhang pressure vessel. This pressure vessel are typically susceptible to wind loads the supports will have to be design keeping the following factors in mind i.e. wind loads, internal pressure and self weight. Stability of vessel is observed by mounting strain gauge sensors to measure displacement. The stability of vessel is observed by FEA.

**Keywords:** FEA, pressure vessels, structural analysis.

### I. Introduction

The structural stability depends mainly on support of pressure vessels. Cylindrical and other type of vessels are to be supported by different methods. For structural stability of pressure vessel it is important to determine the various loads subjected to supports. Generally the pressure vessels are design according to operating conditions of pressure and temperatures. Now pressure vessels are designed according to ASME standards, in some countries they have developed their own national standards. Also after designing pressure vessel many piping system are attached to pressure vessels. Therefore vessel is subjected to different load conditions and it is also essential to determine this load. Generally, failures of pressure vessels can be traced to one of the following areas organic materials. Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen.

The pressure vessels and support to be design for current work is for production of Pyrolysis Reaction: Specifically Nitrous Oxide is obtained by "ammonium nitrate pyrolysis synthesis".

$\text{NH}_4\text{NO}_3 \text{ (S)} \longrightarrow 2\text{H}_2\text{O (g)} + \text{N}_2\text{O (g)}$ . It is an exothermic reaction occurring at around 200 deg C.

### II. Objective

**FEA analysis:**-The whole objective is to use theoretical approach and FEA based simulation, and determine which the best design solution to establish safety and stability of the structure. The concept is to create a support structure from the top of vessel which will give lateral supports and the vessel will be free from the bottom.

### III. Therotical Approach

**Wind load:**-The wind load in any region mainly depends on intensity of pressure of wind or wind velocity in that area. Pressure vessels are subjected to wind load, which must be considered while designing the legs of pressure vessels. The direction of wind changes as the environmental conditions changes therefore the velocity of wind or intensity of pressure of wind changes; hence it is necessary to determine the maximum value of wind load which will act on pressure vessel.

$F_w = \text{Projected area of vessel} \times \text{design wind pressure}$

$F_w = \text{Diameter of vessel} \times \text{Height of cylindrical portion} \times \text{design wind pressure}$

$F_w = 1.524 \times 3.048 \times 2239.80$

$F_w = 10404.21 \text{ N}$

For analysis, wind load as 11000 N.

**Dimension of support:-**The dimensions of support are found out by considering the pressure vessel as Subjected to axial loading subjected to bending load of wind. .For loading condition considered I section W 8 × 31 is considered.

**Forces:-** the maximum load which can be transmitted to one leg support is calculated as

$$W = \frac{\text{total weight of vessel}}{4} = 21336.75\text{N}$$

**Stresses:** the stress calculated for on leg support is

$$\text{Stress} = \frac{P}{A} + \frac{M}{Z} = 116.1183 \text{ N/mm}^2$$

**Deformation of support:** - The deformation for that support is under permissible limits

$$\delta_{\text{Total}} = \frac{P \times L}{A \times E} = 1.9025 \text{ mm}$$

#### IV. Software Analysis

In any kind of structural simulation, a modal analysis will help the Engineer to understand the global behaviour of the system. By performing a modal analysis first. The modelling and analysis of pressure vessel and required over hang support is done in Ansys workbench 12.

Figure 1 Model of Overhang Pressure Vessel

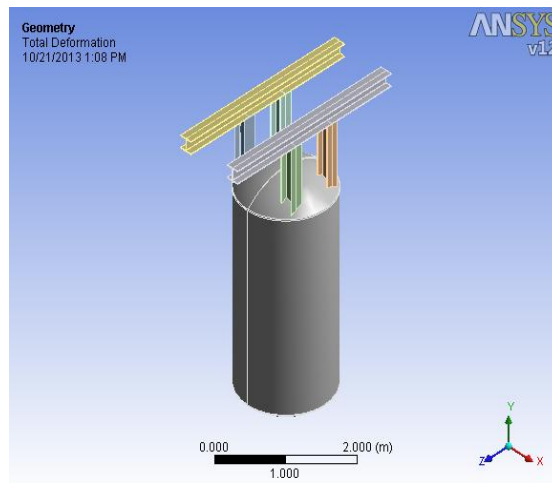


Figure 2 Boundary Conditions of Overhang Pressure Vessel

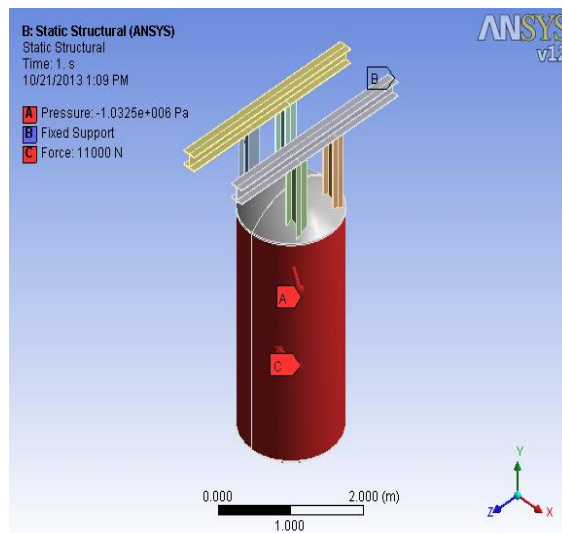


**Figure 3 Total Deformation of Overhang Pressure Vessel**

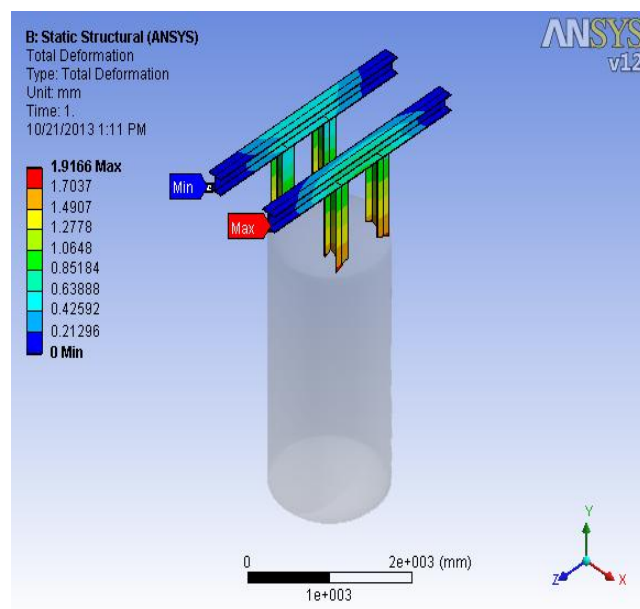
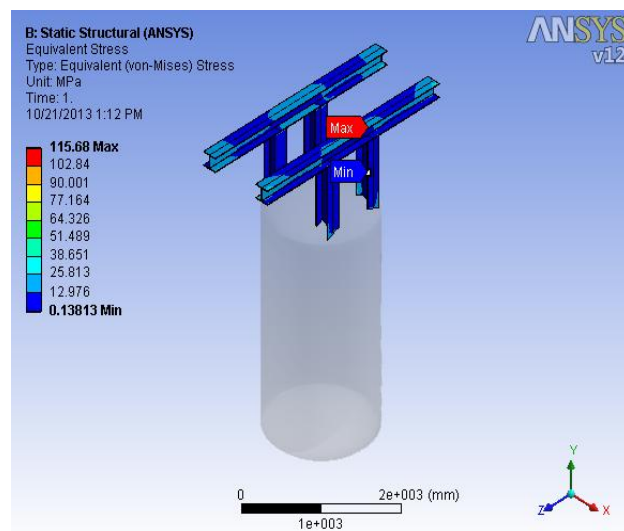


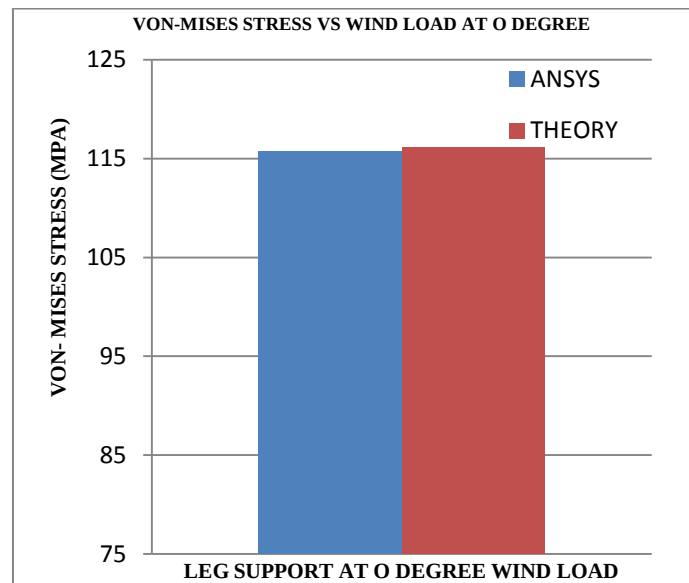
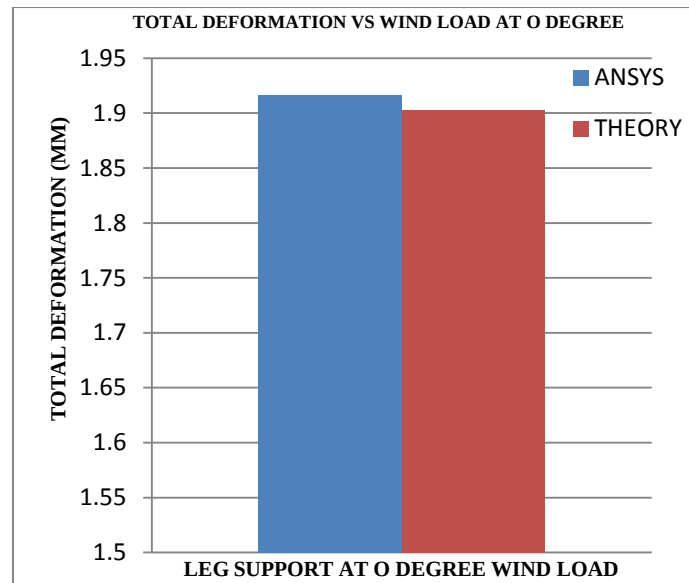
**Figure 4 Equivalent (Von- Mises) Stress of Overhang Pressure Vessel**



## V. Result

After analysis the value of total deformation and equivalent stresses of overhang support for wind load direction at 0 degree as shown in table and graph the Total deformation and equivalent stresses are within the permissible limits. Therefore we can mount the pressure vessel according to the support structure which is safe.

| Sr.no              | Total deformation(mm) | von-mises stress (Mpa) |
|--------------------|-----------------------|------------------------|
| <b>Theoretical</b> | 1.9025                | 116.11                 |
| <b>ansys</b>       | 1.9166                | 115.68                 |



## VI. Conclusion

As the vessel which is vertical which take support from top, so vessel will be overhang with the overhang support and support is analyzed with theoretical and software for total deformation respectively which are negligible and equivalent stress [vion messes stress] is below than yield stress so mounting of this overhang support is possible and structure is safe.

## VII. References

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