

Design and Analysis of Double Walled Vacuum Vessel

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Abstract— Present study is aimed towards design and study of cryogenic double wall vacuum vessels. A liquid nitrogen storage vessel has been considered for present study. Thermal loading due to temperature difference between low temperature liquid nitrogen and atmospheric temperature is considered as a major factor for designing the vessel in addition to this, fatigue due to thermal cycling of vessel is considered. Moreover vessel will be subjected to structural loads, e.g. dead weight of the vessel, transportation accelerations and seismic actions. All these structural boundary conditions are applied for present study and accordingly design and optimization of vessel is carried out.

Key words: Inner & Outer vessel design, ANSIS Analysis, thermalAnalysis, Heat flux, Structural Analysis.

I. INTRODUCTION

Cryogenics is defined as that branch of physics which deals with the production of very low temperatures and their effect on matter, a formulation which addresses both aspects of attaining low temperatures which do not naturally occur on earth, and of using them for the study of nature of human industry in a more operational way, it is also defined as the science and technology of temperatures below 123 K. The reason for this latter definition can be understood by examining characteristic temperatures of cryogenic fluids (Table 1). The limit temperature of 123 K comprehensively includes the normal boiling points of the main atmospheric gases, as well as of methane which constitutes the principle component of natural gas.

Cryogenics	Cryogenic temperature
O ₂	90.19 K
Air	78.6 K
N ₂	77.36 K
H ₂	20.39 K
He	4.2 K

Table 1

The cryogenic temperatures are transition points between liquid and gaseous phase of these cryogens, hence for storage of these cryogens the most important factor is to keep them below their transition temperature. Hence an effective solution is required to implement to serve this purpose.

One of the solution to above problem is to use double wall vacuum vessel where these two walls are isolated by vacuum vessel is essentially a double walled cylindrical tank.

Annular space between inner and outer vessel is filled with an insulating material and evacuated to a high vacuum to achieve minimum evaporation losses. As vacuum is a bad thermal conductor, it can be use as an efficient barrier for temperature transfer between cryogens and atmosphere.

II. PROBLEM DEFINITION

During study of "AIR LIQUID" located at Germany. They used Alluminium lined Multi layer around at inner, outer and supports. They frequently face the problem of heat loss during application of the Double wall vacuum vessel. Heat loads produced during this arrangement like 7.37 W.

The application for the system arrangement is as under. In this design of double walled vacuum vessel used Mylar material around at support for insulation and improve design of support. Heat load reduced by this arrangement and value of heat load is 2.26 W.

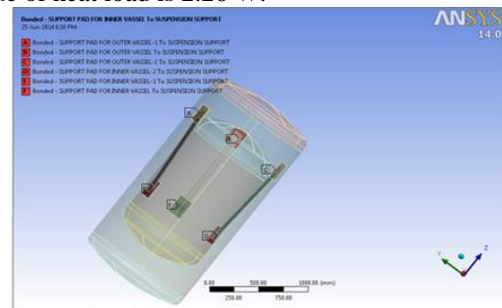


Fig. 1: connection of parts

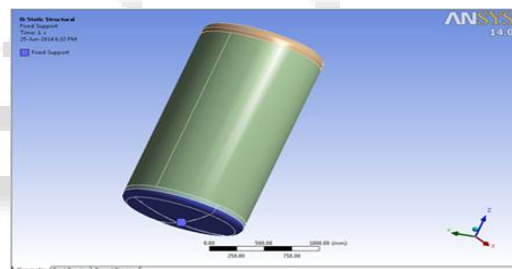


Fig. 2: Static structural analysis

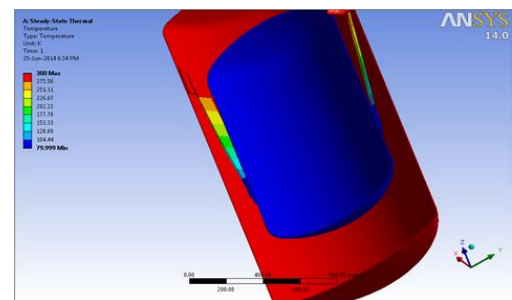


Fig. 3: Static structural analysis

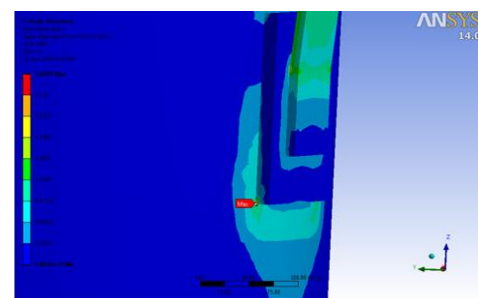


Fig. 4: Equivalent stress of support due to self weight

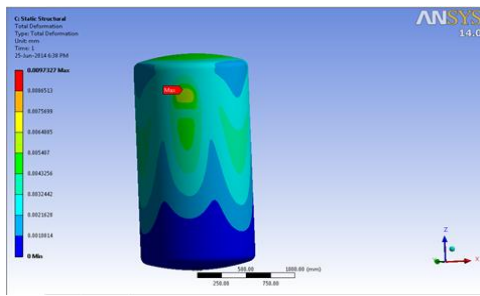


Fig. 5: Total deformation of outer vessel due to self weight and 2g acceleration

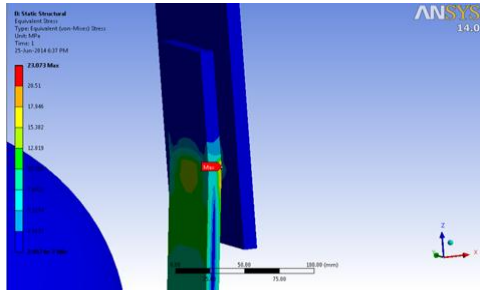


Fig. 6: Equivalent stress due to thermal effect

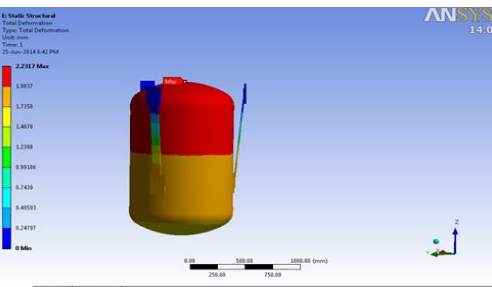


Fig. 7: Total deformation of inner vessel due to self weight and 1.5g acceleration

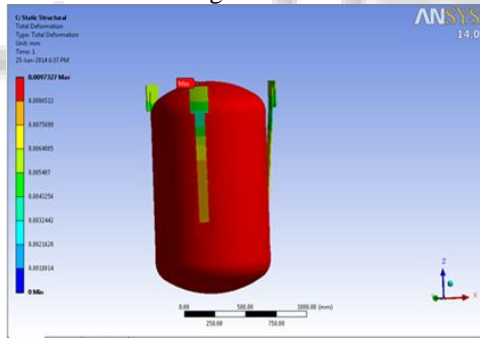
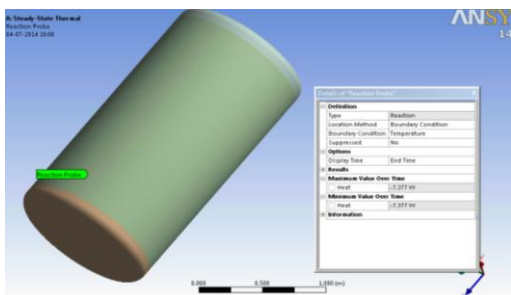
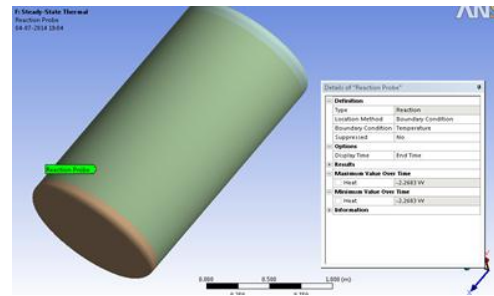


Fig. 8: Equivalent stress of support due to self weight

III. RESULT & DISCUSSION



Without Multi-layer Insulation
Heat Load =7.37 W.



With Multi-layer Insulation
Heat Load =2.26 W.

By Wrapping the Insulation on the Inner Vessel, the Radiation Heat Load will be reduced. The Heat Flux Value for Multi-layer Insulation is taken as 1 W/m^2

Sr. No.	Load Case	Total Deformation (mm)	Equivalent Stress (Mpa)
1	Thermal	3.05	23.07
2	Self weight	0.009	2.62
3	Transportation (In gravity direction 2g)	0.02	7.86
4	Transportation (Lateral direction 1.5g)	2.23	158.27

From the above result of analysis for the different load cases, the stress value is less than the allowable value. So the design is safe.

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