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Design And Analysis Of A Large Transportable Vacuum Insulated Cryogenic Vessel

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ABSTRACT

The CAD software Pro/Engineer (creo-2.0) is employed to see the models for the chosen designs. Additionally, the finite part module ANSYS WORK BENCH 14.5 is employed to get results of mechanical analyses so as to see if the stresses are among limits. During this thesis, 2 models of cyrogenic pressure vessels are modelled and analyzed for his or her strength and fatigue behaviour. One model of pressure vessel is with just one vessel and therefore the alternative pressure vessel with insulation that is created from inner vessel, outer vessel and surge plates. Static Analysis and Fatigue Analysis are performed on original pressure vessel, on insulated pressure vessel considering same material for inner and outer vessels & on insulated pressure vessel by considering different materials for inner and outer vessels and compared. The materials considered are Aluminum grade 5083, Stainless Steel and Steel grade 310 for inner vessel & Glass Carbon and S-Glass for outer vessel.

Keywords: CAD, Stainless Steel, Austenitic stainless steel grade 310, Aluminum grade 5083 Glass Carbon And S-Glass.

INTRODUCTION

CRYOGENICS

Cryogenics is that the science that addresses the assembly and effects of terribly low temperatures. The word originates from the Greek words 'kryos' that means "frost" and 'genic' that means "to manufacture."

Cryogenic Pressure vessel

Cyrogenic pressure vessel may be a specialised vaccum flask used for storing cryogens (such as cryogen or liquid helium), whose boiling points are a lot of under room temperature. Cyrogenic storage dewars could take many completely different forms together with open buckets, flasks with loose stoppers and self-pressurising tanks. All dewars have walls made from 2 or a lot of layers, with a high vacuum maintained between the layers.

LITERATURE REVIEW

The paper by Mummala Suresh, Alagala Harikrishan [1], presents analysis results of stress distributions during a horizontal pressure vessel and therefore the saddle supports. The results are obtained from a 3D finite part analysis. He showed the strain distribution within the pressure vessel, the results give details of stress distribution in several components of the saddle one by one, i.e. wear, web, projection and base plates. A value of 0.25 for the quantitative relation A/L is favored for minimum stresses within the pressure vessel and therefore the saddle. The

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Volume 04 Issue 10
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slenderness ratio (L/R) of but sixteen is found to come up with minimum stresses within the pressure vessel and therefore the saddle. The extremely stressed space, beside the pressure vessel at the pommel, is that the projection plate of the saddle. The paper by B.Venkanna,G.Naresh adult male, B.Venkatesh[2], Technical gases turns into liquid in tremendously cold go -200°C and very high strain what makes that transportation instruments have gotten to perform terribly strict demand. Cyrogenic vessel is effectively saying insulated strain vessel that is employed to store Cyrogenic liquid at refrigerant temperature that is –162C. Conferred paper suggests coming up with facet of the convenient Cyrogenic vessel for storing and transporting the refrigerant beverages like LNG for Indian rail conditions. Mobile vessel that is that the object of design may be a 2 shell tank with vacuum and layer insulation between shells instrumentality.

Reference journal for present project work

The base for the present project is taken from the journal "Implementation of a Large Transportable Vacuum Insulated Cryogenic Vessel by B.Venkanna, G.Naresh Babu, B.Venkatesh, International Journal of Research, https://edupediapublications.org/journals, p-ISSN: 2348-6848, e-ISSN: 2348-795X, Volume 03 Issue 14, October 2016", specified as [2] in References chapter.

The chosen truck is the TATA 4x2 Truck, which belongs to the TATA FM13 range. Its Main dimensions are shown in figure 1 and some other specifications of the truck are listed below.

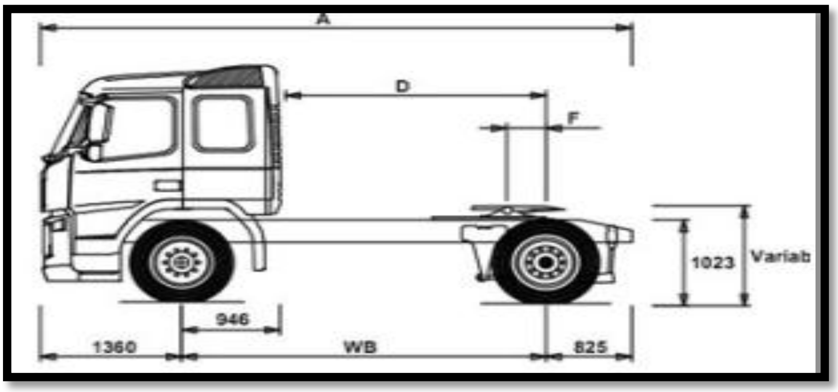

Fig: Dimensions of the TATA4x2

Chassis dimensions

- Wheelbase (WB): 3600 mm
- Overall chassis length (A): 7137 mm
- Centre of rear axle to back of cab (D): 2604 mm
- Theoretical wheelbase (T): 4285 mm

Plated weights

- Gross vehicle weight: 34000 kg
- Gross combination weight: 44000 kg

• Maximum payload: 10000 kg

Cyrogenic Pressure Vessel Specifications

Distance between inner and outer vessel - 150mm
Inner vessel length - 3320mm
Inner vessel ellipse major radius - 1900mm
Inner vessel ellipse minor radius - 1100mm
Inner vessel thickness - 18mm
Surge plate thickness - 4mm
Distance between surge plates - 550mm

3-D MODELING AND ANALYSIS OF PREESURE VESSEL

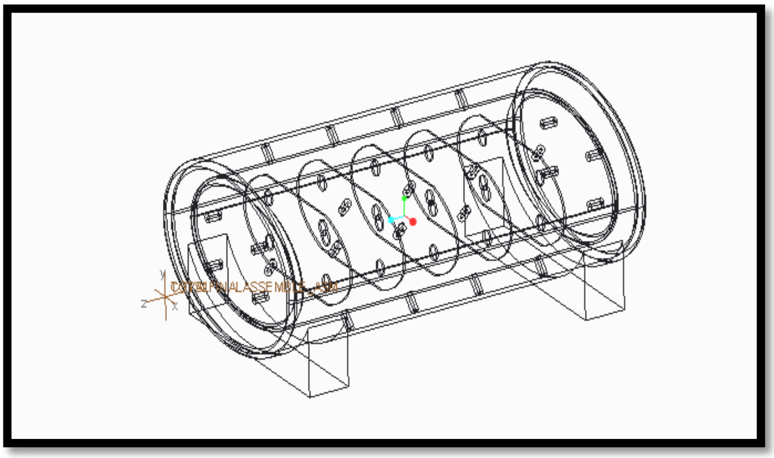

Fig – Wireframe model of pressure vessel

The pressure applied inside the vessel is taken from Design and analysis of large transportable vacuum insulated cryogenic vessel by Tejaswini N, Poorna Sai R, Reddy Babu Naik B and Naveen G, International Journal of Mechanical Engineering and Technology (IJMET), Volume 7, Issue 6, November–December 2016, pp.45–57, Article ID: IJMET_07_06

Analysis Of Insulated Cyrogenic Pressure Vessel Using Different Materials For Inner And Outer Vessels

Inner Material – Aluminium 5083 & Outer Material – Glass Carbon

Static Analysis

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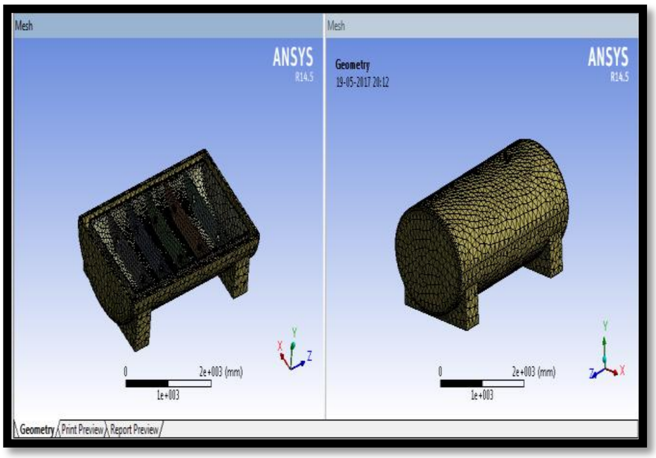

Fig - Meshed model of Pressure vessel using same material for inner and outer vessels

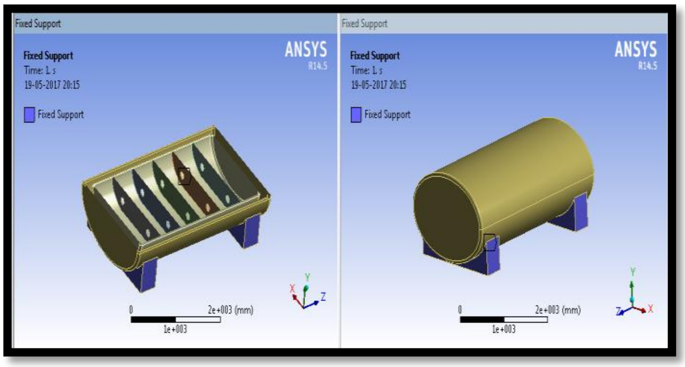

Fig - Fixed support on the ribs

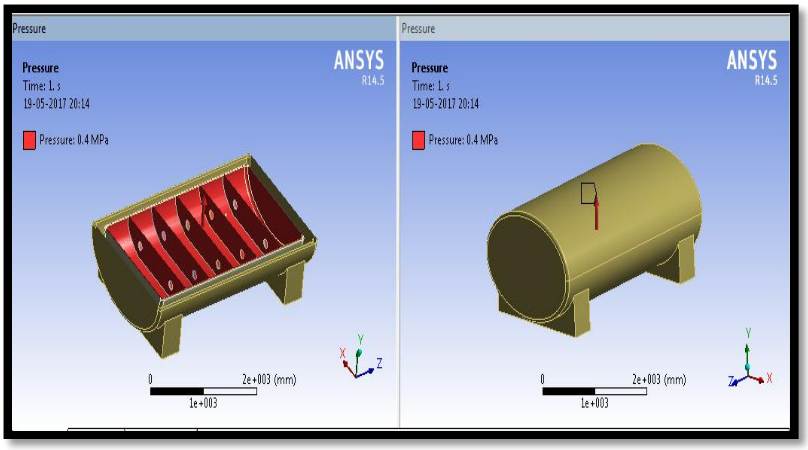

Fig – Pressure is applied inside the vessel

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Volume 04 Issue 10
September 2017

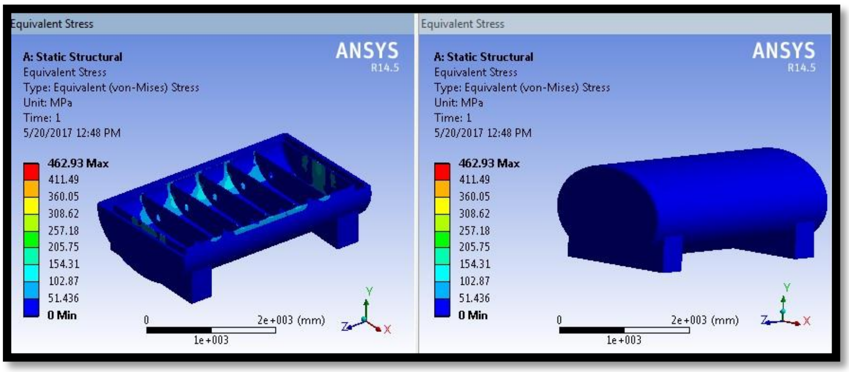

Fig: Stress of Pressure vessel using Al5083 for inner and Glass Carbon for outer vessel

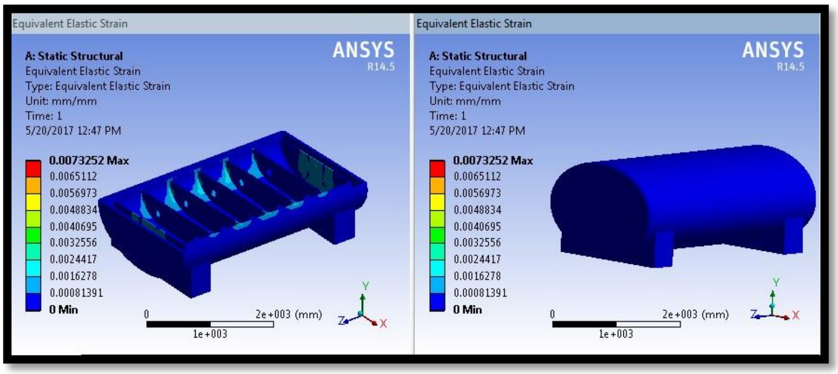

Fig: Strain of Pressure vessel using Al5083 for inner and Glass Carbon for outer vessel

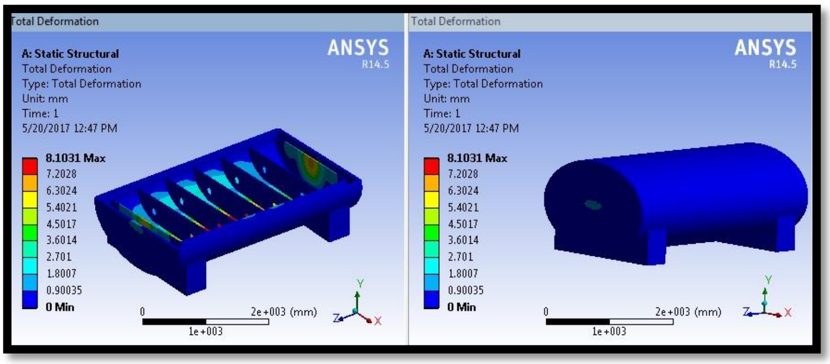

Fig: Deformation of Pressure vessel using Al5083 for inner and Glass Carbon for outer vessel

FATIGUE ANALYSIS

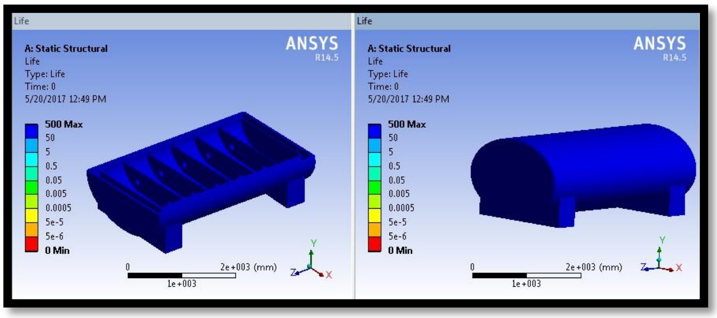

Fig: Life of Pressure vessel using Al5083 for inner and Glass Carbon for outer vessel

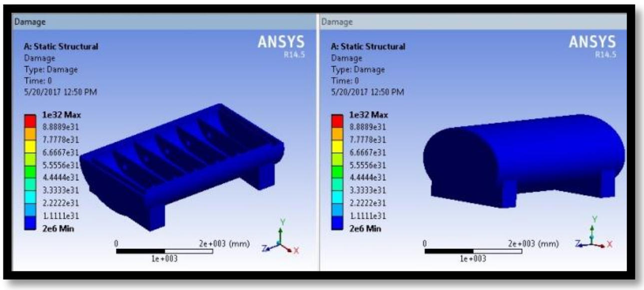

Fig: Damage of Pressure vessel using Al5083 for inner and Glass Carbon for outer vessel

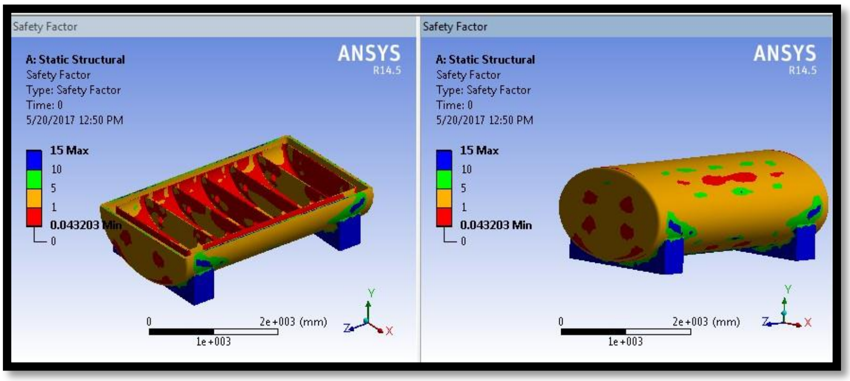

Fig: Safety factor of Pressure vessel using Al5083 for inner and Carbon Fiber for outer vessel

RESULTS & DISCUSSIONS

Static analysis

Original Model

	Deformation (mm)	Stress (MPa)	Strain
Aluminum 5083	21.084	277.43	0.0041012
Steel 310	7.6185	280.47	0.0014703
Stainless steel	7.8948	280.47	0.0015237

Inside & outside same material

	Deformation (mm)	Stress (MPa)	Strain

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Aluminum 5083	6.2566	286.93	0.00412
Steel 310	2.258	295.19	0.0015019
Stainless steel	2.3999	295.19	0.001556

Inside & Outside different material (Glass Carbon)

	Deformation (mm)	**Stress (MPa)**	**Strain**
Aluminum 5083	8.1031	462.93	0.0073752
Steel 310	3.2534	424.4	0.0021394
Stainless steel	3.5372	397.26	0.0020761

Inside & Outside different material (S- Glass)

	Deformation (mm)	**Stress (MPa)**	**Strain**
Aluminum 5083	8.4632	449.37	0.0065407
Steel 310	3.0813	406.14	0.002282
Stainless steel	3.53722	367.26	0.0020761

Fatigue analysis

Original Model

	Life	**Damage**	**Safety factor**
Aluminum 5083	500	1×e32	0.072091
Steel 310	600	2.383×10^{6}	0.35655
Stainless steel	350	3.2269×10^{6}	0.35655

Inside & outside same material

	Life	**Damage**	**Safety factor**
Aluminum 5083	500	1×e32	0.069703
Steel 310	600	2.4703×10^{6}	0.33876
Stainless steel	350	3.2613×10^{6}	0.33876

Inside & Outside different material (Glass Carbon)

	Life	**Damage**	**Safety factor**
Aluminum 5083	500	1×e32	0.043203
Steel 310	600	5.6947×10^{6}	0.023563
Stainless steel	700	3.2518×10^{6}	0.25172

Inside & Outside different material (S- Glass)

	Life	**Damage**	**Safety factor**
Aluminum 5083	500	1×e32	0.044506
Steel 310	600	6.4996×10^{6}	0.02414
Stainless steel	750	3.521×10^{6}	0.25177

CONCLUSION

From static analysis results, by observing deformation results, the values are less when the inner and outer vessels are made up of same material. The value is less when Steel 310 is used. By observing stress results, the values are less when the inner and outer vessels are made up of same material. The value is less when Aluminum 5083 is used. From fatigue analysis results, by observing life values, the life is more when the inner and outer vessels are made up of different materials. The value is more when S – Glass is used for outer vessel. By observing damage values, the damage value is more when the inner and outer vessels are made up of different materials. The value is more when S – Glass is used for outer vessel. When the damage value is more, the load required to fail the vessel will also be more, so life of the vessel will increase. By observing safety factor values, the value is more for original model of pressure vessel with Stainless Steel as material.

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