DESIGN AND THERMAL ANALYSIS ON CRYOGENIC PRESSURE VESSEL

PRASANNA KUMAR VV[1], RAVITEJA SURAKASI[2], RAMAKRISHNA R[3], VISHNUPRASAD MAHANTI[4]

1, 2, 3 – DEPARTMENT OF MECHANICAL ENGINEERING, LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY, JONNADA, VIZIANAGARAM

4 - DEPARTMENT OF MECHANICAL ENGINEERING, SRINIVASA INSTITUTE OF ENGINEERING AND TECHNOLOGY, AMALAPURAM

Abstract

After it has been liquefied and purified to a certain amount, a cryogenic fluid can be deposited and shipped. The increasing use of cryogenic liquids has increased the evolution of cryogenic storage vessels and transmission lines in numerous fields of engineering and research. The Dewar vessel was such an important development in cryogenic storage vessels that it was a "breakthrough" in the construction of containers.

Cryogenic pressure vessels are weight vessels used for capacities of cryogenic fluids with the lowest available warmth from the outside into the tube. The configuration test is to use materials which at certain low temperatures do not lose their appealing properties. Here a vessel that satisfies both mechanical and thermal specifications is designed with considerable consideration. The findings are contrasted with the most recent commercial vessel. Glass epoxy can be used to lower the heat exchange from the piping of boards that bolster from the external vessel to the inner vessel. The epoxy of glass can resist high temperatures.

In these industries, the air receivers and household hot water storage tanks are commercial compressed air. Examples include dive cylinders, recompressors, distilling platforms, pressure reactors and other pressure vessels. Catia V5R20 is used for modelling, and Ansys 15.0 workbench is used for thermal analysis.

Keywords:-Cryogenictank,modeling, Ansys, Cryogenics.

I.INTRODUCTION

The word "cryogenics" means study of liquefied gas under 150°C and the working of products at temperatures like these. Both gases are liquefied at cryogenic temperatures. For example, at a temperature of -162 degrees Celsius. The volume of methane that is liquefied is 580 fold at room temperature. As a result, a substantial amount of methane can be transported in a small tank.

A closed container containing gases or liquids which are under considerable pressure separate from that of the atmosphere is said to be a vessel. It can also be found in domestic hot water store tanks and in industrial compressed air recepteurs. Other examples include: tube rollers, compression chambers, destilling platforms, reactors, autoclaves, and a variety of other mining vessels, oil refineries, aircraft environments, pneumatic reservoirs, airbroke tanks, air freight tanks for ground truck freight airfreaks, etc.

MaterialSelection:

Appropriate mechanical and physical properties, compatible with fluid nitrogen, fabric capacity, soldability, cost and compliance with regulatory codes are important considerations for the selection of construction materials for fluid nitrogen vessels from cryogenic point of view. For liquid nitrogen storage applications, the following are required:

- Shear modules and tensile
- Thermal conductivity
- Emissive surface
- Properties of vacuum
- Low coefficient thermal contraction
- Manufacturing method
- Hot and cold tensile power and efficacy;
- Basic form and size availability
- Economic.

Earlier and Current Tests:

1. Cycling pressure and heat
2. Echoes.
3. Explosion test.
4. Analysis of Finite Elements
5. Pressure testing and shock conditioning of the cryogenic temperature
6. The liquid and gaseous hydrogen pressure vessel

II.LITERATUREREVIEW

E. Lisowski[1] explained in his paper that the present study is aimed at developing a Cryogenic Vessel concept that allows transportation equipment subject to very strict requirements with the incentive of technological gases liquor at anvery low and at very high pressures, temperatures below minus 200° C. The paper presented demonstrates a certain feature of liquefied gas simulation sloshing with regard to the needs of mobile vessels.

K. J. Jaya Kumar, [2] discussed the use of lightweight materials for spherical tank structures for cryogenic tanks was explored in his article. There are two cryogenic concepts for the construction of hydrogen tanks. Matlab and Abacus 6.10.1 compile this article and includes thermal and structural tank geometry analysis as well as hydrogen diffusion analysis for specifying the conditions for material permeability. Heat simulation and cryogenic tank configuration study subjected to intense heating profiles, Comparison of thermal efficiency for hydrogen storage tanks systems.

SM. Aceves, [3] explained that the applicability of isolated pressure vessels for light-duty hydrogen powered vehicles is analytically and experimentally evaluated in his article. Cryogenic pressurized vessels may be powered by liquid hydrogen (LH1) or compressed hydrogen ambient-temperature (CH2). The benefits of hydrogen tanks and liquid insulation vacuum vessels (low weight and volume). Design and safety assurance.

Craig A. Stephens[4] in his thesis, Generic Research Cryogenic Tank was used for cryogenic test article was scheduled for simulation quality thermal reaction of the trans-atmospheric vehicle fuel tanks which were subjected to hypersonic flight conditions in the environment. Thermal finite differential models in one dimension and two dimensions were designed to simulate the thermal reaction and help to refine the Cryogenic Tank Generic Research.

S. M. Aceves[5] In their analysis, insulated pressure vessels were explored in order to produce cryogenic vessels which can be fed liquid hydrogen or compressed hydrogen ambient temperature. The benefits of fluid hydrogen vessels with low weight and volume of insulated pressure vessels give decreased drawbacks

A.HimaBindu[6] In its article, the design process is defined as relevant to the whole area of design engineering. The design challenge is to use certain fabrics, which at such a low temperature do not lose their desired features. It is intended that cryogenic liquid (liquid-nitrogen) vaporization be determined with a range of combinations of internal, external and insulated substances. 3-D - 3-D the storage vessel simulation is carried out using the programme Pro-E 2001 and research is carried out using ansys software for 2-D modelling.

III. MODELINGOF CRYOGENICVESSEL

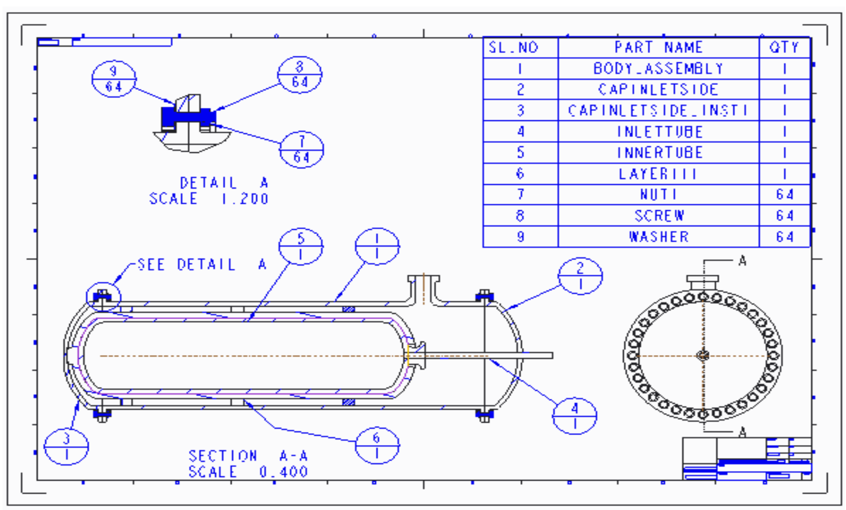


Fig1: FinalAssembly

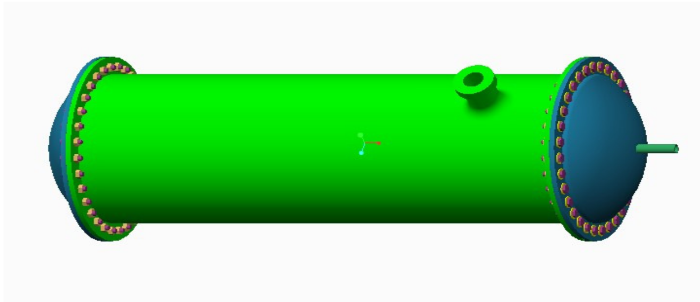


Fig2: Design of Body cover SurgePlate Assembly

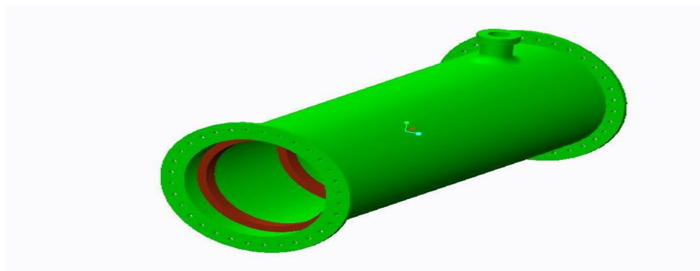


Fig3: TotalAssemblyBodyCoverandSurgePlates Assembly

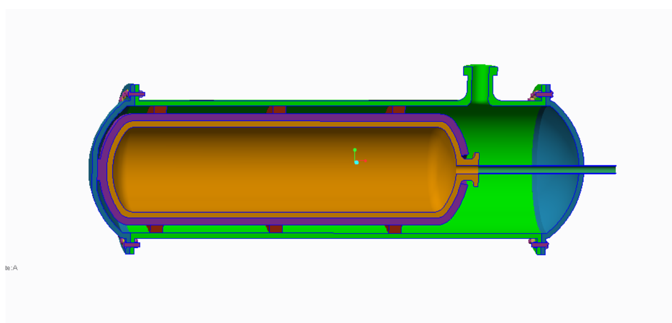


Fig4: CrossSectionalView

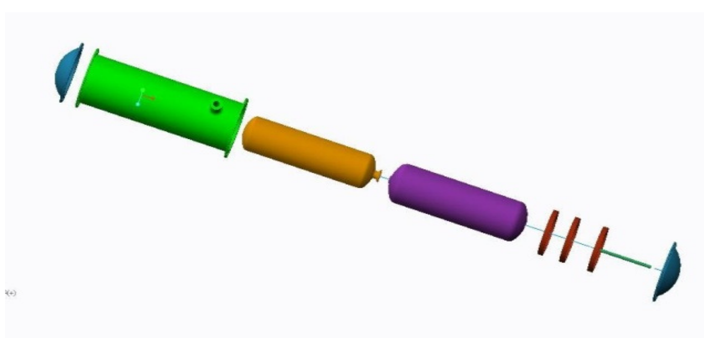


Fig5: ExplodedView

IV ANALYSISOFCRYOGENICVESSEL

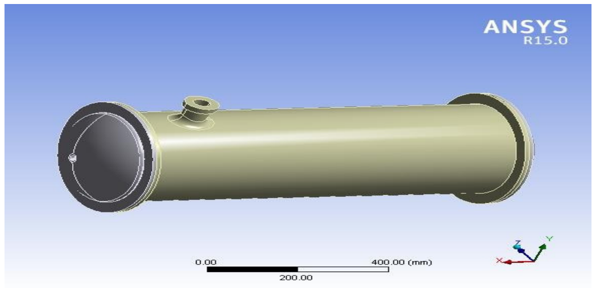


Fig 6.Geometryofthe CryogenicvesselStructuralsteelwith Aluminumposition

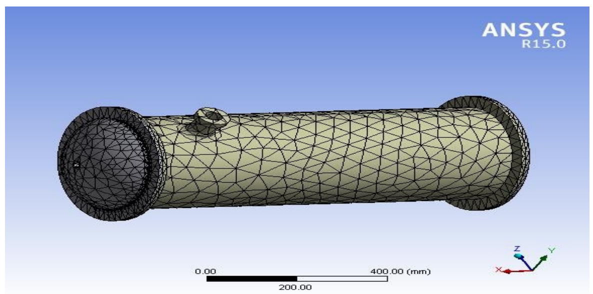


Fig. 7MeshedmodeloftheCryogenic vesselStructuralsteelwith Aluminumposition

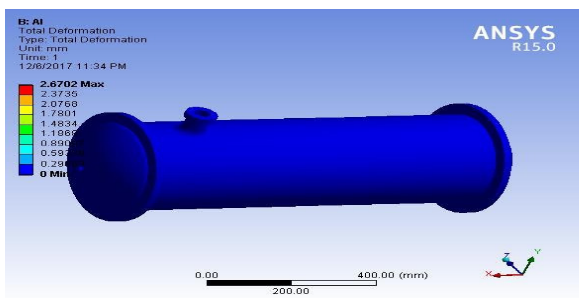


Fig.8Deformation ofthe CryogenicvesselStructuralsteelwithAluminumposition

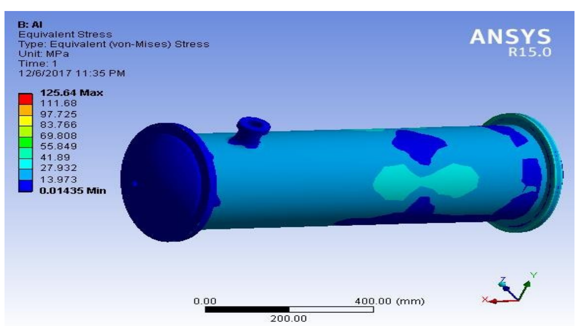


Fig.9Equivalent StressfortheCryogenicvesselStructuralsteelwithAluminumposition

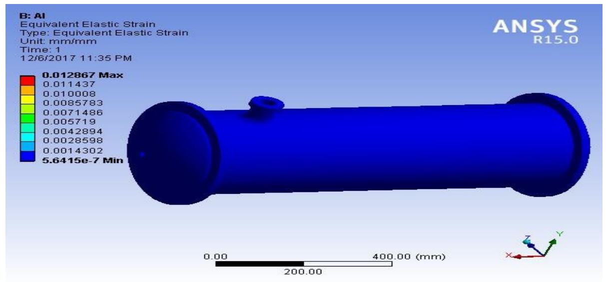


Fig.10Equivalent StrainfortheCryogenicvesselStructuralsteelwithAluminumposition

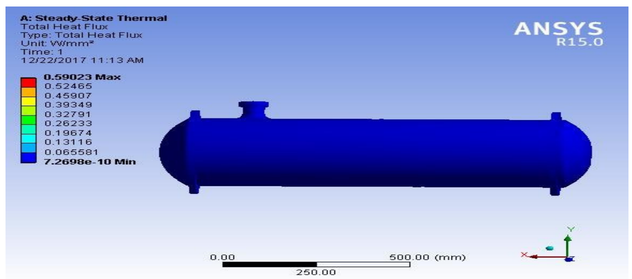


Fig. 11Temperatureforthe CryogenicvesselStructuralsteelwithAluminumposition

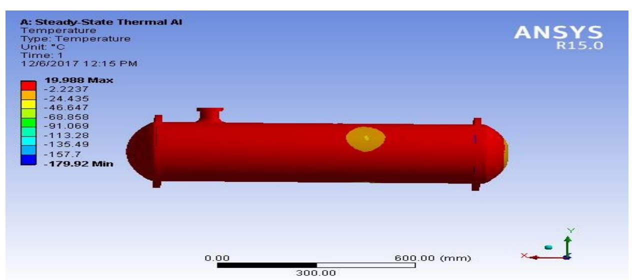


Fig.12TotalHeatfluxforthe CryogenicvesselStructuralsteelwithAluminumposition

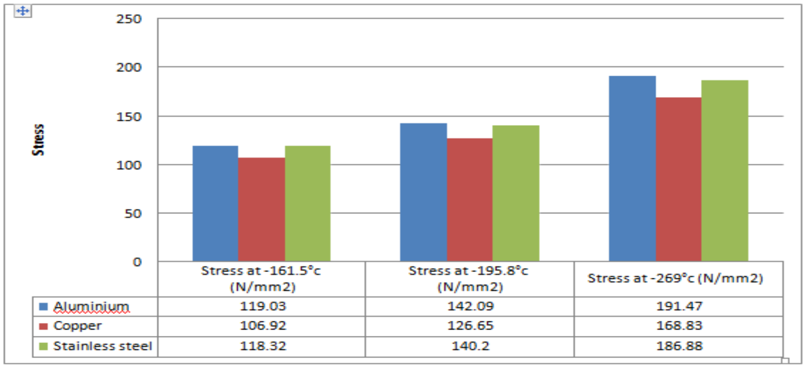
V RESULTS

Outer Vessel	Inner Vessel	Stress	Strain	Deformation	Heat Flux	Weight
Structural Steel	Aluminum	125.65	0.01284	2.6702	0.59023	176.84
Structural Steel	Copper	113.54	0.01066	2.2999	0.60242	222.4
Structural Steel	Stainless Steel	131.8	0.0104	2.3306	0.5363	217.93

Table1:Analyticalreport ofaluminuminnervessel, Copper Inner Vessel and Stainless Steel as Inner Vessel

Outer Vessel	Inner Vessel	Stress at -61.5°C	Stress at -95.8°C	Stress at -269°C
Structural Steel	Aluminum	119.03	142.09	191.47
Structural Steel	Copper	106.92	126.65	168.83
Structural Steel	Stainless Steel	118.32	140.2	186.88

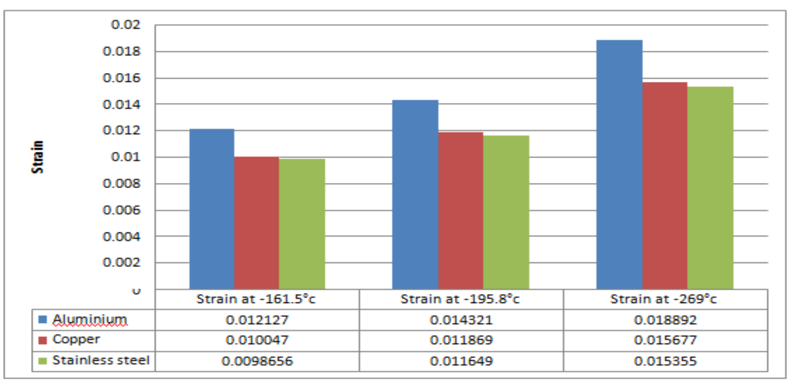
Table2:TablefordifferentstrainVariationsatdifferentliquids



Graph 1: Graph forStress Variations at different liquids

Outer Vessel	Inner Vessel	Strain at -61.5°c	Strain at -95.8°c	Strain at -269°c
Structural Steel	Aluminum	0.012127	0.014321	0.018892
Structural Steel	Copper	0.010047	0.011869	0.015677
Structural Steel	Stainless Steel	0.0098656	0.011649	0.015355

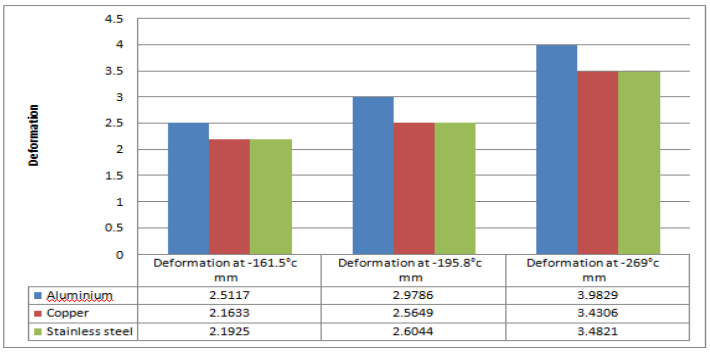
Table3:Tablefordifferentdeformation Variationsatdifferentliquids



Graph 2: TablefordifferentStrain Variationsatdifferentliquids

Outer Vessel	Inner Vessel	Deformation at - 61.5°c(mm)	Deformation at - 95.8°c(mm)	Deformation at - 269°c(mm)
Structural Steel	Aluminum	2.5117	2.9786	3.9829
Structural Steel	Copper	2.1633	2.5649	3.4306
Structural Steel	Stainless Steel	2.1925	2.6044	3.4821

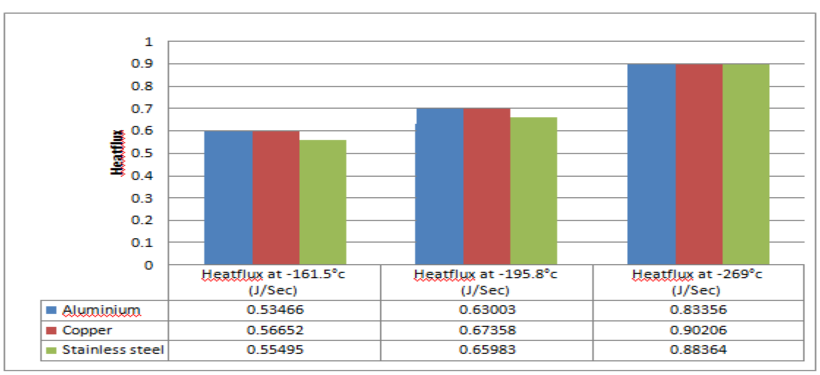
Table4:Tablefordifferentdeformation Variationsatdifferentliquids



Graph 3: Graphsfordeformation Variationsatdifferentliquids

Outer Vessel	Inner Vessel	Heatflux at - 161.5°c (J/Sec)	Heatflux at - 195.8°c (J/Sec)	Heatflux at - 269°c (J/Sec)
Structural Steel	Aluminium	0.53466	0.63003	0.83356
Structural Steel	Copper	0.56652	0.67358	0.90206
Structural Steel	Stailness Steel	0.55495	0.65983	0.88364

Table 5: TablefordifferentheatfluxVariationsatdifferentliquid



Graph 3: Graphsfordeformation Variationsatdifferentliquids

Outer Vessel	Inner Vessel	Weight at -161.5°c	Weight at -195.8°c	Weight at -269°c
Structural Steel	Aluminium	176.99	176.99	176.99
Structural Steel	Copper	222.16	222.16	222.16
Structural Steel	Stailness Steel	217.67	217.67	217.67

Table 6: TablefordifferentheatfluxVariationsatdifferentliquid

IV. CONCLUTION

- This study entails comparing material optimization of the vessel under static load conditions with cryogenic pressure vessel.
- Static loading conditions and thermal base conditions shall be analyzed.
- Structural steel and S-glass epoxy with external frame for the interior structure with aluminium, copper and steel are analyzed for various conditions and materials. Static Thermal Analysis done at Pressure vessel by storing Cryogenic Fluids like Methane, Liquid Nitrogenand Heliumon basisofTemperature attheir PhaseChange.
- Taking different temperatures of respective liquids into consideration, as the temperature is letting down by Kelvin scale, heat flux values seem to be tremendously increasing. So cryogenicvesselisable to withstandatdifferent temperatures.
- S-glass epoxy for external construction of aluminium is comparably superior than most materials when considering weight and stress.
- Taking into account weight and stress.

References

1. E. Lisowski, M. Domagała, “Simulation of liquid dynamics in a cryogenic mobile vessels”, IAI,CracowUniversityof Technology,al.JanaPawła37,31-864.

2. K. J. Jaya Kumar, “Heat Transfer Analysis of Light Weight Cryogenic Tank for Space Vehicles”,IndianJournalofScience andTechnology,Vol8(4),314-319,February2015.

3. SM. Aceves, J. Martinez-Frias, Garcia-Villazana, “Evaluation of Insulated Pressure Vessels for Cryogenic Hydrogen Storage”, ASME International MechanicalEngineering Congressand Exposition Nashville,TNNovember 14-19,1999.

4. Craig A. Stephens and Gregory J. Hanna, “Thermal Modeling and Analysis of a Cryogenic Tank DesignExposedtoExtreme Heating Profiles”,NASAContractorReport186012.

5. S. M. Aceves, J. Martinez-Frias, “Low Temperature and High Pressure Evaluation of InsulatedPressureVesselsforCryogenic Hydrogen Storage”,O.Garcia-Villazana

6. FIMEE, UniversidaddeGuanajuatoSalamanca, Gto. Mexico, Jan2000.

7. A.HimaBindu, “Design and thermal analysis of cryogenic Fluid storage vessel”, IJRASET,SpecialIssue-3,November2014

8. Patel PratikKumarBaldevBhai, Prof. Ronak Shah, “Design and Optimization of Cryogenic Storage Vessel”,IJEDR|Volume 3,Issue 1,2014.