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Design and Analysis of Multilayer Pressure Vessel

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Abstract: Pressure vessels are closed containers used for handling and storing of fluids, chemicals and gaseous things at more than 20psi Used in fertilizer industries, petroleum and petro-chemical industries for performing various unit operations. Our project deals with the design and stress analysis of multilayer pressure vessel (LAR buffer vessel) with its inspection techniques. These types of pressure vessels plays a vital role in any industry, hence a lot of care should be taken in design and fabrication procedure to withstand greater extent of pressures Our project design is made as per the statutory regulation by the ASME VIII division I & II (American Codes) and IS 2825 (Indian Codes) and other approaches and the vessel modeling and stress analysis is made by using PRO-ENGINEER & ANSYS software's.
Keywords: (FEM, FEA, THERMAL, ANYSIS, PROE, -CATIA)

I. INTRODUCTION

The word cryogenics literally means "the production of icy cold"; however the term is used today as a synonym for the low-temperature state. It is not well defined at what point on the temp scale refrigeration ends and cryogenics begins. The national institutes of standards and technology at boulder, Colorado have chosen to consider the field of cryogenics as those involving temperature below -150oC (123K). This is a logical dividing line, since the normal boiling points of the so-called permanent gases (such as helium, hydrogen, neon, oxygen, nitrogen and air) lie below -150oC while the Freon refrigerants, hydrogen sulphide and other common refrigerants have boiling points above -150oC.Cryogenics engineering is concerned with developing and improving low temperature process and equipment. It determines the physical properties of structural and other materials used in producing, maintaining and using low temperatures and applications of low temperature techniques and process. Cryogenics has ever increasing applications in various industrial sectors such as in steel production, fertilizer, factories, petro-chemical complexes, in metal working industries, in food and fish preservations, in space research, in education etc.Priority has been suggested for the development of the cryogenic components, materials, and instruments. The necessary reasons for developing cryogenics are as follows: quick freezing of food has several advantages so technology should be introduced in the country without loss of time. This will help on pushing our marine products export. Metals and alloys become softer on heating resulting in decrease in tensile strength. On the other hand at the temperature below the atmosphere there is an increase in the tensile strength and hardness and decrease in the plasticity. All metals and alloys in the solid state possess lower coefficient of expansion at sub-ambient temperature than at elevated temperature while there is an increase in strength and thermal conductivity. Loss of ductility occurs due to which the stresses encountered are not likely to be static or constant.

II. SCOPE OF THE PROJECT

The material is selected in such a manner that it will provide a foundation for the engineer who intends to enter the field of cryogenic engineering or who uses cryogenics in conjunction with other areas. The generalized design of the components has been provided. The dimensions of the components for any desired design pressure can be obtained easily. Theoretical discussions are presented where they are necessary to the understanding of the particular process or technique. Knowledge of the property of the materials at low temperatures is necessary in the design of any cryogenic system; therefore our starting point is discussion of the properties of the cryogenic materials.

The next after successful design is the manufacturing process. After determining the methods of manufacturing individual components, CAM packages like MASTERCAM, GIBB'S CAM etc., are used to generate CNC codes, which can be used to produce the components on CNC machines

III. DESIGN CODES

The design and manufacture of pressure vessels is always governed by the statutory regulation or codes. The codes and regulation are primarily intended to assure safety in operations and they cover aspect of products for manufacture methods to quality control and assurance. The codes generally adopted by pressure vessels manufacture are…

A. ASME Section Viii Division I & Ii (American Codes)
B. PD 5500 (British Codes)
C. AD merkblatter (German Code) and
D. IS 2825 (Indian Codes)

While the basic aims of the codes are the same, these are different in approach arising out of historical background, experience, raw material availability and design philosophy adopted in various countries of origin.

1) List Of Materials :

DESCRIPTION	SPECIFICATION
Inner shell, inner dished end, stiffeners	SA 240 TP 304
Outer shell, outer dished end, stiffeners	SA 516 GR 60
Pipes/sleeves	SA 312 TP 304
Bolts (ss)	SA 320 B 8
Nuts	SA 194 B 8
Supports, skirt	IS : 2062 GR A/B
Gaskets	Teflon/klingeroinet
Valves	s.s
Flanges	SA 182 F 304
Insulation	Perlite
Absorbent	Mobilsorbead's

2) Design Data:

	INNER VESSEL	OUTER VESSEL
Fluid Handled	LAR	-
Working Pressure kgf/cm2 (g)	2.9	Vacuum
Working temperature 0c	-189	Ambient
Design pressure kgf/cm2 (g)	3.9	1.003
Design temperature 0c in/out	-196 to 40	50
Pneumatic test pressure kgf/cm2 (g)	7.15	1.5
Weld joint efficiency	0.9	0.85
Radiography	Full	Spot
Corrosion allowance mm	Nil	Nil
Heat treatment	Nil	Nil
Designed to: ASME SEC VIII DIV I		

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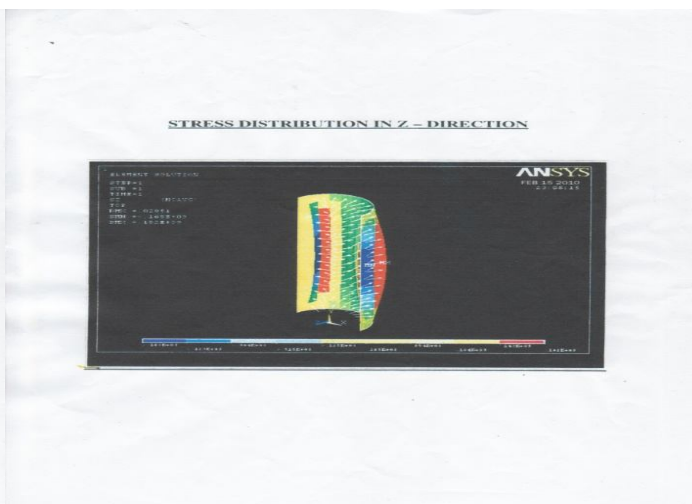
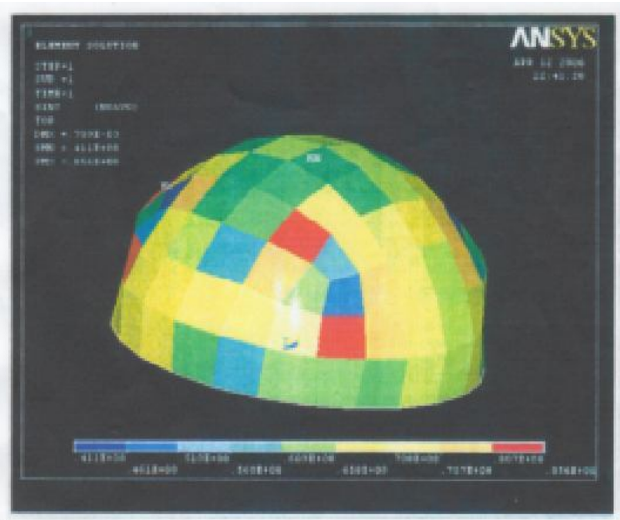
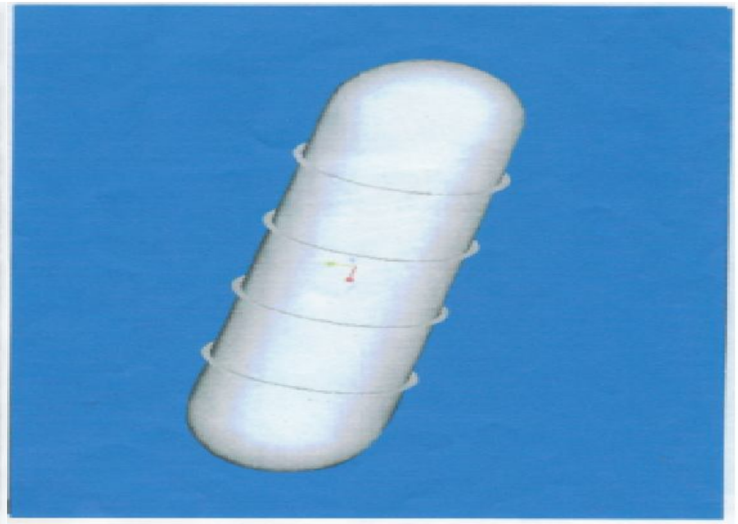
3) *Features of ANSYS*: ANSYS is a large – scale multipurpose computer program useful to solve finite element problems that maybe used for several class of engineering analysis. The analysis capabilities of ANSYS include the ability to solve static and dynamic structural problems, steady state, transient and heat transfer problems, mode frequency and buckling eigen value problems, static or time – varying magnetic analysis, and various types of field and couple – field applications. The program contains many special features, which allow non – linearity's or secondary effects to be included in the solution, such as plasticity, large strain, hyper elasticity, creep, swelling, large deflection, contact, stress stiffening, temperature dependency, material anisotropy and radiation. Other special features viz., sub structuring, random vibration, free convection field analysis and design optimizations have been added to the program. These features contribute further making ANSYS a multipurpose analysis tool for varied engineering disciplines
4) *Analysis of Hemispherical Dished End using ANSYS:*
a) *Element Type:* Shell 63
b) *Real Constants (Thickness):* 8 mm
c) *Material Properties:*
i) *Youngs Modulus:* 28*106 psi
ii) *Poissons Ratio:* 0.3
d) *Pressure Applied:* 7.15 kg/cm2
e) *Allowable Stress At Test Pressure:* 1898.3 kg/cm2
f) *Induced Stress At Test Pressure:*
i) *Theoritical:* 875.82 kg/cm2
ii) *Using Ansys:* 856.00 Kg/Cm2
5) *Analysis of Inner Cylindrical Shell:*
a) *Element Type:* Shell 63
b) *Real Constants (Thickness):* 10 Mm
c) *Material Properties*
i) *Youngs Modulus* : 28*106 Psi
ii) *Poissons Ratio:* 0.3
d) *Pressure Applied:* 7.15 Kg/Cm2
e) *Allowable Stress At Test Pressure:* 1898.3 Kg/Cm2
f) *Induced Stress At Test Pressure:*
i) *Theoritical:* 1196.3 Kg/Cm2
ii) *Using Ansys:* 1820.00 Kg/Cm2







6) *Testing Of Equipment :* Testing is of two types:
   a) Destructive testing
   b) Non – destructive testing

Destructive testing is one in which the vessel is tested to bursting. During this test the vessel is filled with air to the bursting pressure. As this test is very costly, this test will be conducted on a small prototype vessel. Next comes the non – destructive testing, in which there are several type of tests, like pickling and degreasing, black light control test, pneumatic testing, helium testing, etc.

RADIOGRAPHY: Radiography tests shall be carried out in accordance with ASME and design specification applicable.

7) *Full Radiography:* Butt welds shall be fully graphed to the extent specified in the drawings. All butt welds of nozzles and pipes within the vacuum space shall be fully radiography.Butt joints of pipes inside the inner vessel and the outer vessel shall be radio graphed if penetration cannot be ensured by visual examination. Acceptance criteria shall be as per UW – 51 of ASME SECTION – VIII DIVISION 1.
8) *Spot Radiography:* Butt welds intended for spot radiography shall confirm to the following limitations:

Joint efficiency	Design pressure	Extent of spot radiographic examination
0.8 and less	All	Minimum 10% of each welds at least

Acceptance criteria as per UW 52 of ASME SECTION VIII – DIV (latest)The following welds shall be subjected to die penetrate examination:
   a) The first and final layer of all pressure welds, which cannot be radio graphed.
   b) The final layer of all fillet welds.

9) *Pickling and Degreasing:* All stainless steel parts and assembles shell be pickled except outside surfaces, which shall be treated after pneumatic test. Complete inner vessel, loose components and inside surface of outer vessel shall be degreased.
10) *Pneumatic Test (Air Test):* Inner vessel shall be tested pneumatically at a pressure equal to at least 1.1 times maximum allowable working pressure. Outer vessel shall be tested at 1.2 kg/cm2 pressure where they are not designed to withstand external pressure. The pressure in the vessel shall be gradually increased to not more than one half of the test pressure and there after the test pressure shall be increased in steps of approximately 1/10th of the test pressure until the requited test pressure has been reached. There after the test pressure shall be reduced to 4/5th of the test pressure and held for sufficient time to permit inspection of the vessel. All the welds are subjected to die penetrate test after air test.
11) *Helium Leak Test:* For inner vessel to with stand over pressure, helium leak test shall be conducted by vacuum method. Long welds and circumferential welds shall be covered with polythene strip having an opening at each end. Each strip shall be scavenged by helium for a few seconds. Close the outlet, inflate helium to a positive pressure and close the inlet. Other welds shall be covered with empty bags into which helium shall be fed. Temporary welds shall be excluded from this leak detection

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test. Strips shall not overlap inside vacuum shall be in the range of 5*10-3 to 1*10-3 torr (1 torr = 1 mm of Hg). Minimum waiting time shall be ½ hr.For inner vessel not withstand an over pressure of 1.033 kg/cm2, inside evacuation is not permitted.

IV. RESULT

The safe minimum thickness of various components of the liquid argon storage tank has been calculated. A slightly higher dimension has been adopted. This has been done to ensure that standard dimensions are chosen. Only those components which have stress less than maximum safe allowable stress are adopted and the others are redesigned for increased thickness. The pressure vessel involved has uniform diameter and so there are no appreciable discontinuity stress. The joints have no appreciable stress. On the whole, design is fit to be adopted for fabrication.

The storage tank has been modeled using Pro/ENGINEER software and analysis of the components have been done using finite element package ANSYS.

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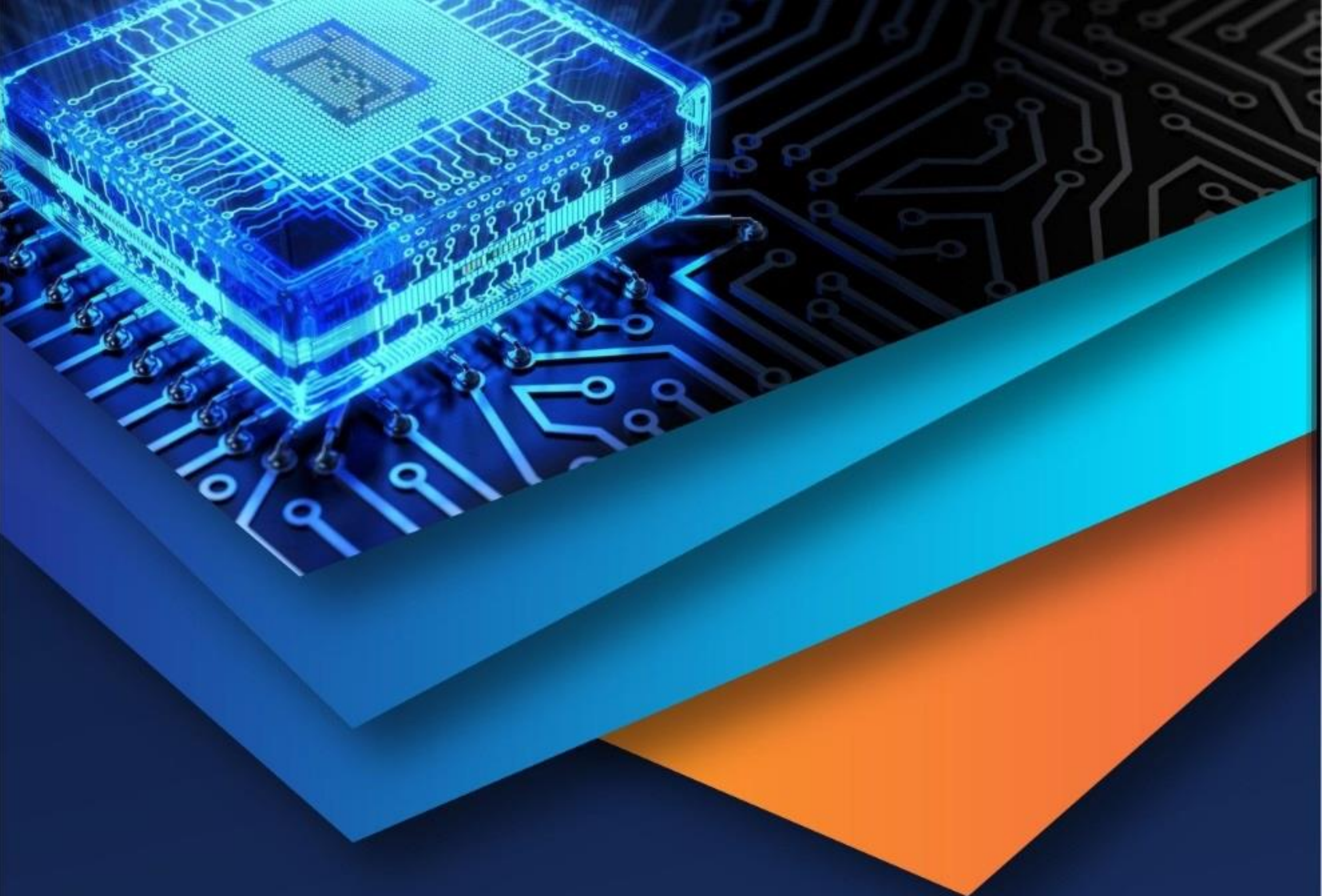

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