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CASE STUDY OF MATERIAL SELECTION OF CRYOGENIC PRESSURE VESSELS

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ABSTRACT:

This paper presents the detailed study about material selection of cryogenic pressure vessels which is closed containers used to store cryogen at desirable condition of pressure and temperature. These liquids with minimum heat in-leak into the vessel from the outside as far as possible. The challenge of design is to use such materials that do not lose their desirable properties at such a low temperature. This project aims to determine the alternate material for the inner layer's cladding from the case study.

KEYWORDS: *Storage, Compress, Cryogenic liquids, Material selection, Stainless steel, carbon steel, Inconel 625, alloy steel.*

INTRODUCTION:

A Pressure vessels are leak proof containers which are used for storage, in industrial processing and power generation under unusual condition of pressure and temperature. When pressure vessels are considered to be formed of plate in which thickness is very small in comparison to other dimensions, they are called thin vessels and stresses developed are called average stresses or membrane stresses, but when the ratio of inner diameter to outer diameter is relatively large, as in case of gun barrels. High pressure hydraulic rams cylinders, etc. It is called as thick walled cylinder.

The development of Dewar vessel represents such an improvement in cryogenic fluid storage vessels that it could be classed as a "break-through" in container design. The high performance storage vessels in use today are based on the concept of the Dewar design principle a double walled the space between the two vessels filled with an insulation and container with the evacuated from the space. Improvements have been made in the insulation used between the two walls,

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but the Dewar vessel is steel the starting point for the performance cryogenic fluid vessel design.

The storage vessel consists of an inner vessel called the product container, which encloses the cryogenic fluid to be stored. The inner vessel is enclosed by an outer vessel or vacuum jacket, which contains the high vacuum necessary for the effectiveness of the insulation and serves as a vapor barrier to prevent migration of water vapor.

The space between the two vessels is filled with an insulation, and the gas this space may be evacuated. In small laboratory Dewar's, the "insulation" consists of the silvered walls and high vacuum alone; however, insulations such as powders, fibrous materials, or multilayer insulations are used in larger vessels. Since the performance of the vessel depends to a great extent upon the effectiveness of the insulation. When large storage vessels first came into use, most were custom-tailored for the specific use.

CRYOGENICS:

The branches of physics and engineering that study very low temperatures, how to produce them, and how materials behave at those temperatures. Besides the familiar temperature scales of Fahrenheit and Celsius, cryogen cists use the Kelvin and Rankine scales.

CRYOBIOLOGY:

The branch of biology that studies the effects of low temperatures on organisms (most often for the purpose of achieving cryopreservation).

CRYOGENIC FUEL:

The word cryogenic*s* 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 temperature scale refrigeration ends and cryogenics begins. The workers at the National Institute of Standards and Technology at Boulder, Colorado have chosen to consider the field of cryogenics as that involving temperatures below –180 °C (93.15 K).

This is a logical dividing line, since the normal boiling points of the so-called permanent gases (such as helium, hydrogen, neon, nitrogen, oxygen, and normal air) lie below -180 °C while the Freon refrigerants, hydrogen sulfide, and other common refrigerants have boiling points above -180 °C.

Liquefied fuels, such as liquid nitrogen, liquid hydrogen, liquid oxygen, and liquid helium, are used in many cryogenic applications. Liquid nitrogen is the most commonly used element in cryogenics and is legally purchasable around the world.

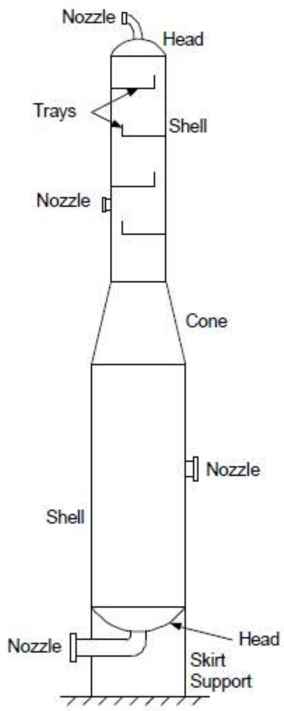
CRYOGENIC LIQUID HYDROGEN:

Any substance in liquid form is called as cryogenic. This pressure vessel is used to hold the liquid hydrogen. Liquid hydrogen is a hazardous substance, which makes suffocation and endangerious to environment. The temperature of cryogenic hydrogen is -190 C. This pressure vessel is used to hold the liquid hydrogen in such a pressure (4119.2 p.s.i) and temperature (-190 C).

COMPONENTS OF PRESSURE VESSEL:

1) Shell
2) Flange and Nozzle
3) Dished head
4) Skirt Support
5) Cone
6) Tray and Ladder

CONSTRUCTION OF THE PRESSURE VESSEL



Tall Vertical Tower

CODE SELECTION:

1. Section I: Power Boilers
2. Section II: Material Specification:
3. Section III Subsection NCA: General Requirements for Division 1 and Division 2
4. Section IV: Rules for Construction of Heating Boilers
5. Section V: Nondestructive Examinations
6. Section VI: Recommended Rules for the Care and
Operation of Heating Boilers
7. Section VII: Recommended Guidelines for Care of
Power Boilers
8. Section VIII
9. Section IX: Welding and Brazing Qualifications
10.Section X: Fiberglass-Reinforced Plastic Pressure Vessels

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DESIGN & CONSTRUCTION CODES FOR PRESSURE VESSELS

Material	Material grade	Allowable Stress (Mpa)
Carbon steel (outer shell only)	SA-285 Grade C SA-442 Grade 55 SA-299 SA-516 Grade 60	94.8 94.8 129.2 103.4
Low alloy steel	SA-202 Grade B SA-353-B(9%Ni) SA-203 Grade-E SA-410	146.5 163.7 120.6 103.4
Stainless steel	SA-240(304) SA- 240(304L) SA-240(316) SA-240(410)	129.2 120.6 129.2 112.0
Aluminum	SB-209(1100-0) SB-209(5083-0) SB-209(6061-T4) SB-209(3004-0)	16.2 68.9 41.4 37.9

Country	Code	Issuing authority
U.S.	ASMEBoiler&Pressure Vessel Code	ASME
U.K.	BS1515Fusion Welded Pressure Vessels BS5500Unfired Fusion WeldedPressureVessels	British Standard Institute
Germany	AD Merblatter	ArbeitsgemeinschaftDruckbehalter
Italy	ANCC	AssociazioneNationalePerIlControllo Peula Combustione
Netherlands	Regeis Voor Toestellen	Dienst voor het Stoomvezen
Sweden	Tryckkarlskommissionen	SwedishPressure Vessel Commission
Australia	AS1200:SAABoilerCode AS1210Unfired Pressure Vessels	Standards Association of Australia
Belgium	IBNConstructionCode for Pressure Vessels	Belgian Standards Institute
Japan	MITI Code	Ministry of International Trade and Industry
France	SNCTConstruction Code for Unfired Pressure	Syndicat National de la Chaudronnerie et de la Tuyauterie Industrielle

MATERIAL SELECTION:

Several of materials have been use in pressure vessel fabrication. The selection of material is based on the appropriateness of the design requirement. AU the materials used in the manufacture of the receivers shall comply with the requirements of the relevant design code, and be identifiable with mill sheets. The selection of materials of the shell shall take into account the suitability of the material with the maximum working pressure and fabrication process.

NEW SUGGESTION FOR CLADDING MATERIAL INCONEL 625:

Inconel Alloy 625 (UNS designation N06625) is a nickel-based super alloy that possesses high strength properties and resistance to elevated temperatures. It also demonstrates remarkable protection against corrosion and oxidation. Its ability to withstand high stress and a wide range of temperatures, both in and out of water, as well as being able to resist corrosion while being exposed to highly acidic environments makes it a fitting choice for nuclear and marine applications.

Cladding Material suggestion	
Nickel-alloys (annealed)	SB-127(Monel) SB-168
Copper	SB-11 SB- 169(annealed)
Inconel	Garde 600,601,625,718

MARKETS FOR INCONEL ALLOYS:

- Marine
- Nuclear
- Chemical Processing
- Aerospace

Product and technology applications of Inconel 625 include:

- Pollution control equipment
- Jet engine parts
- Heat exchangers
- Pressure valves

Mechanical Data

ALLOY 600 - Tensile Data

Temperature (°F)	Ultimate Tensile (ksi)	Yield Strength at 0.2% Offset (ksi)	Elongation %
Room Temp.	93.0	37.0	-
1000	84.0	28.5	-
1200	65.0	26.5	-
1400	27.5	17.0	-
1600	15.0	9.0	-
1800	7.5	4.0	-

ALLOY 625 - Tensile Data

Temperature (°F)	Ultimate Tensile (ksi)	Yield Strength at 0.2% Offset (ksi)	Elongation %
Room Temp.	144.0	84.0	44.0
400	134.0	66.0	45.0
600	132.0	63.0	42.5
800	132.0	61.0	45.0
1000	130.0	61.0	48.0
1200	119.0	60.0	34.0
1400	78.0	59.0	59.0
1600	40.0	39.0	117.0

ALLOY 601 - Tensile Data

Temperature (°F)	Ultimate Tensile (ksi)	Yield Strength at 0.2% Offset (ksi)	Elongation %
Room Temp.	100.0	54.0	45.0
1000	90.0	48.0	44.0
1200	60.0	41.0	45.0
1400	34.0	26.0	70.0
1600	18.0	15.0	120.0

ALLOY 718 - Tensile Data
ANNEALED 1800°F, AGED 1325/1150°F

Temperature (°F)	Ultimate Tensile (ksi)	Yield Strength at 0.2% Offset (ksi)	Elongation %
Room Temp.	210.0	175.0	22.0
400	198.0	163.0	20.0
800	191.0	156.0	19.0
1000	185.0	155.0	18.0
1200	168.0	149.0	19.0
1400	111.0	110.0	27.0

FUTURE SCOPE:

Design a cryogenic pressure vessel model and choose the cladding material selection will be refer this this case study material.

Analysis with FEA for further verification of this cladding material life and fatigue details.

CONCULSION :

From this case study understand the cryogenic pressure vessel and the material selection. From the new suggestion need to vertify with the FEA material analysis to applied in the sour service application. As the Inconel and Nickel materials are costly it can be use to the required application.

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