International Journal of Engineering Research and Development
ISSN: 2278-067X, Volume 1, Issue 4 (June 2012), PP.26-33
www.ijerd.com

Aesthetics & Ergonomics Design Of Hyperbaric Oxygen Chamber- A Case Study

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Abstract—with an aim of developing Hyperbaric Chamber for conducting studies on naval divers, is a collective and interesting approach of present project work. While working in underwater environment person has to face that pressurised state, at different depth he has to face different pressures and remain in that pressurised condition for certain period of time so as to carry out his work. Thus, divers have to be treated with Hyperbaric Oxygen therapy unit . Thus, a diver brought up hurriedly from deep water and in consequence suffering from decompression sickness can be recompressed to alleviate any bend pains and other more serious symptoms. It is a therapy in which the patients breathe pure oxygen at higher than atmospheric pressure. In this present work it deals with overall design of Hyperbaric chamber and increasing the capacity of chamber so as to accommodate more number according to company requirement from 2-beds and 2-seat to 2-beds and 5-seats. The calculations involved here are carried out according to ASME standards. Apart from this Aesthetic and Ergonomics features of chamber is being studied. The static analysis is carried out using FEA of the entire chamber which traces the stresses on the flat end side of chamber (entrance) and along with it deformation results of the chamber also calculated.

Keywords— Hyperbaric chamber, diving schedule, Decompression sickness, design, aesthetics, ergonomics, FEA etc

I. PROBLEM DEFINITION

Presently there is lack of data on naval divers in India, therefore there is a need to design and develop hyperbaric chamber i.e. Clinical chamber.
First task is the basic design of Human Occupancy Pressure Vessel as per ASME SEC VIII Div-1, ASME PVHO 1 Code, and NFPA 99 (Chapter-19)
The pressure to be maintained inside the chamber is 6Atm.
The various control systems being used in present hyperbaric chamber is to be modified and made compact.
Finite Element Analysis of hyperbaric oxygen chamber is done.

II. SUGGESTED SOLUTION

1. Now in response to the defined problem, the chamber is designed as per ASME Sec VIII Div 1, ASME PVHO-1 Code.
2. Increasing the capacity of the hyperbaric chamber.
3. The static analysis is carried of the entire chamber using FEA which traces the stresses on the flat end of chamber (entrance) and along with it deformation results of the chamber also calculated.

III. What is Hyperbaric Oxygen Therapy(HBOT) ?

Hyperbaric oxygen is a mode of therapy in which the patient breathes 100% oxygen at pressure greater than atmospheric pressure. Oxygen is necessary for the function of cell tissues and organs in the body. Many forms of illness and injury cause inadequate oxygen delivery, with resulting damage.

For years, hyperbaric oxygen therapy has been recognized as the definitive treatment for decompression sickness, air embolism and carbon monoxide poisoning. Today, hyperbaric oxygen is used successfully as an adjunctive therapy for such indications as deep-seated acute and chronic bone and soft tissue infections, hypoxic non-healing wounds, preservation of compromised soft tissue flap and grafts, and management of wounds in radiated tissue. In hyperbaric oxygen therapy, patients are treated with 100% oxygen at elevated atmospheric pressure.

IV. How Does HBO Therapy Work?

It works by:

- Saturating the plasma with oxygen, resulting in increased oxygen delivery to the tissues.
- Dissolving sufficient oxygen in the plasma to support cellular function without utilizing haemoglobin.
- Increasing the oxygen tension in hypoxic areas such as chronically infected, irradiated or compromised tissues.
- Enhancing the white blood cells capacity to kill bacteria.

- Reducing edams through vasoconstriction.
- Blocking cytoxic effects of carbon monoxide and its reperfusion injury.
- Counteracting the hypoxia of methemoglobinemia generated with the treatment of cyanide poisoning.

V. AUTOCAD PICTURES OF OLD & MODIFIED DESIGN(TOPVIEW)

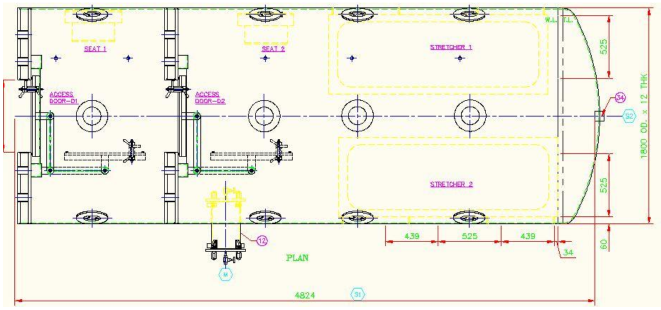

Fig : 1 OLD DESIGN OF HBOT
Dia: 1800mm, total length: 4500 mm
Seats: 2nos, stretcher: 2nos

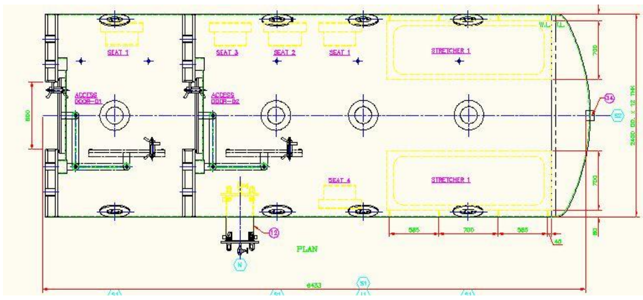

Fig : 2 **NEW DESIGN OF HBOT**
Dia : 2400mm, total length:6500mm
Seat: 5nos, stretcher: 2nos

Design of clinical chamber:-
These chamber are designed as per ASME section VIII DIV-I in conjunction with ANSI/ASME PVHO-I . The safety aspects in design & operators as well as the safety of personal & equipment are taken care of as per NFPA 99 (chap. 99)

Material selection:-
Based on the service condition requirements SA-516 grade 70 is selected as the material for shell dished ends & saddle plates.

Mechanical properties :-

Ultimate tensile strength	:	483-586 MPa
Yield point	:	262 MPa
Elongation	:	21%

Chemical Composition :

Carbon	:	0.27% (max)
Manganese	:	0.85 - 1.2%
Phosphorus	:	0.035% (max)
Sulphur	:	0.04%(max)
Silicon	:	0.13 - 0.33%

VI. DESIGN OF COMPONENTS

1. Torisphrical head : Thickness of outside torispherical heads as per **ASME SEC VIII, Div I**

$$t=\frac{0.885\times P_i\times L}{S\times E-0.1\times P_i}$$

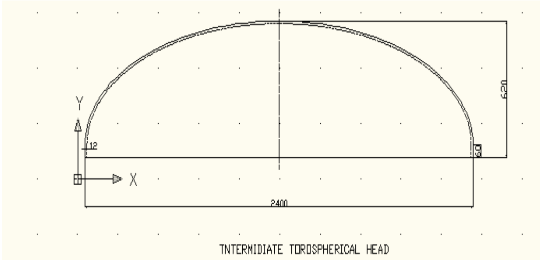

Fig : 3

2 .Weld Design

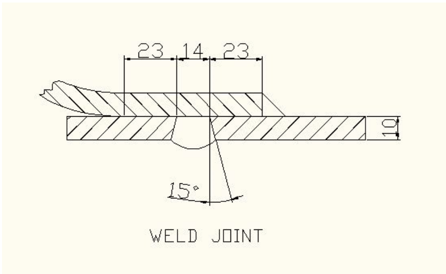

Fig : 4

3. Saddle Plate

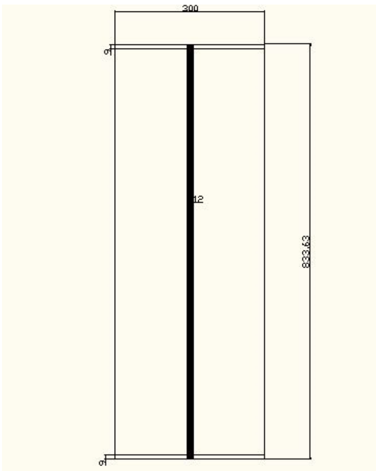

Fig : 5

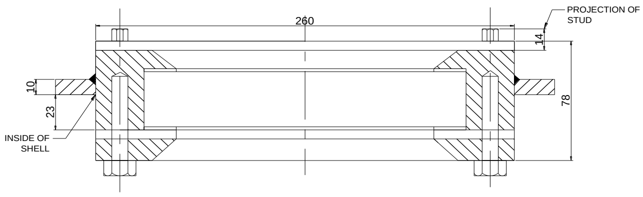

Fig.6 view port assembly

VII. ASSEMBLY OF ENTIRE PARTS

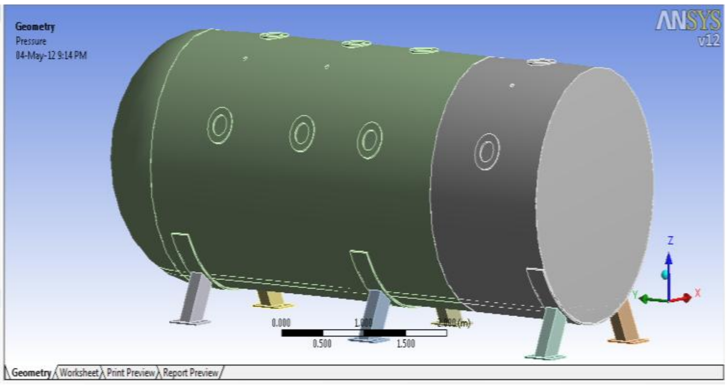

Fig : 7: 3-D MODEL OF HBOT

VIII. COMPARISON BETWEEN OLD AND NEW DESIGN

PARAMETER	**OLD DIMENSIONS**	**MODIFIED DIMENSIONS**
Length	4460 mm	6500 mm
Inside diameter	2200 mm	2400 mm
Beds	2	2
Seats	1	4
Thickness	9	12

IX. FABRICATION OF HBOT:

Fig : 8 Saddle support and Entire chamber

X. ASPECTS OF AESTHETIC DESIGN

The various aspects of the aesthetic design, which are discussed below, are also related to : functional requirements, ergonomic considerations, manufacturing considerations, assembly considerations and cost, in addition to the aesthetic considerations. These aspects are not very rigid.

1. Form(shape)
2. Symmetry and Balance
3. Colour
4. Continuity
5. Variety
6. Proportion
7. Contrast
8. Impression and Purpose
9. Style
10. Material and Surface Finish
11. Tolerance
12. Noise
13. Ergonomic considerations in design

In a machine design the machine is considered as an entity in itself. However, in reality, the man (operator), machine and working environment form the system and this system needs to be considered as a single unit.

Ergonomics is defined as the scientific study of the man-machine-working environment relationship and the application of anatomical, physiological and psychological principles to solve the problems arising from this relationship.

The word ergonomics is formed from two Greek words: ergo(work) and Nomo's (natural laws)

The final objective of the ergonomics is to make the machine fit for user rather than to make the user adapt himself or herself to the machine. It aims at decreasing the physical and mental stresses to the use

Ergonomic Aspects in Design of Controls

The ergonomic considerations in the design of the controls are as follows:

1. The control devices should be logically positioned and easily accessible.
2. The control operation should involve minimum and smooth moments.
3. The control operation should consume minimum energy.
4. The portion of the control device which comes in contact with user's hand should be in conformity with the anatomy of human hands.
5. The proper colours should be used for control devices and backgrounds so as to give the required psychological effect.
6. The shape and size of the control device should be such that the user is encouraged to handle it in such a way as to exert the required force, but not excessive force, damaging the control or the machine.

XI. AESTHETIC AND ERGONOMICS FEATURES OF HYPERBARIC CHAMBER

1. Control Console
2. Compresses air filtering system
3. Fire fighting system.
4. Breathing oxygen supply system.
5. Medical Lock.
6. Climate control system.
7. High and low pressure supply system

XII. ACTUAL VIEW OF HYPERBARIC CHAMBER SHOWING AESTHETICS AND ERGONOMICS FEATURES

Fig 9: Typical installation of HBOT

Fig 10: Internal view (Aesthetic look)

Fig 11: Control console

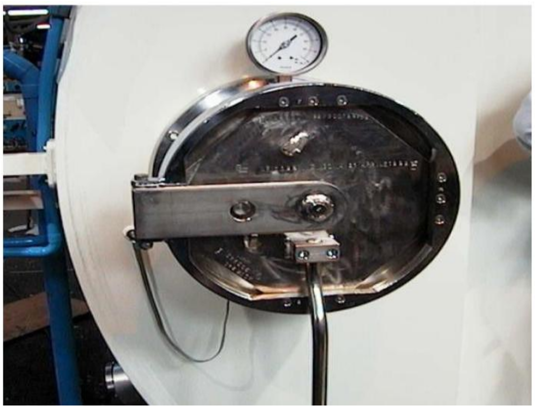

Fig 11: Medical Lock

XIII. FINITE ELEMENT ANALYSIS OF HYPERBARIC CHAMBER

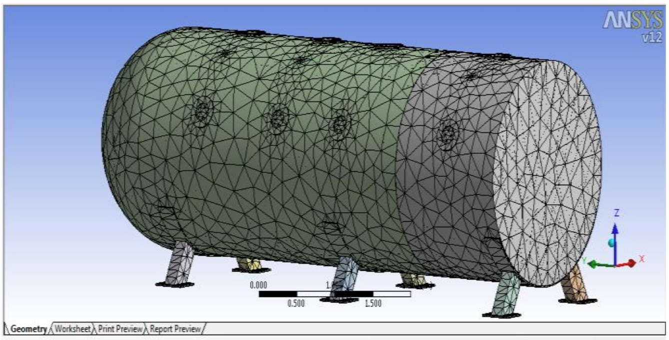

Fig 12: Meshed Model

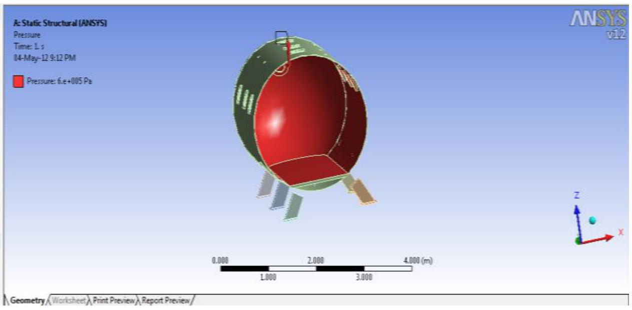

Fig 13: Application of 6 bar pressure on inner surface

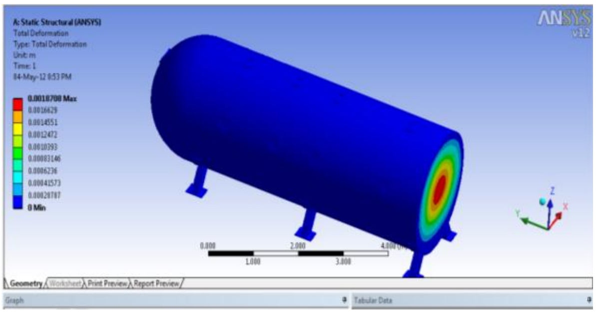

Fig 14: Deformation of chamber

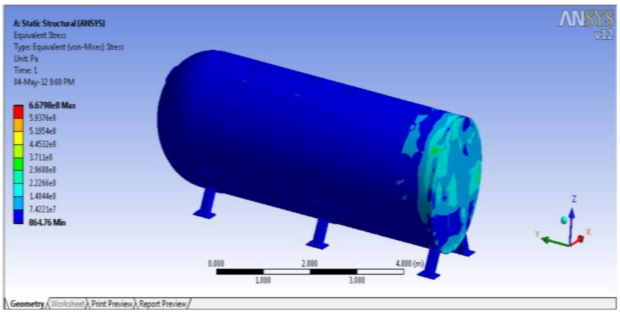

Fig 15 Von-mises stress

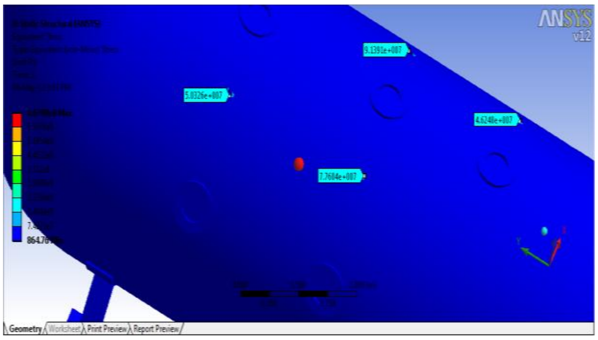

Fig 16: Stress concentration on the nozzle

XIV. CONCLUSION

1) Re-design of entire Hyperbaric chamber has been done, so as to increase the capacity as per the company requirement.
2) The safety of designed chamber has been done using Finite Element Analysis using Ansys 12.0.
3) Aesthetic and Ergonomics aspect of the chamber has been studied in detail.

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