OPTIMIZING BURSTING EFFECT OF SUBMARINE PRESSURE HULL UNDER RADIAL STRESSES

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Abstract. Pressure hulls are the main load bearing structures of naval submarines, and autonomous underwater vehicles (AUVs). A pressure hull is a structure that is designed to withstand the compressive forces associated with hydrostatic pressure. The most efficient geometries for resisting these compressive forces are circular cross-sections, and thus, pressure hulls are typically composed of a combination of ring-stiffened cylinders and cones, with spherical or torispherical domes at either end. The design and manufacturing process of a pressure hull is a cumbersome engineering challenge because of the extre me pressure conditions and extre mely low tolerances required. Now a days Burst effect in cylindrical components form a worst loss in manufacturing sector. Burst effect is a failure condition which occurs a cylindrical components subjected to huge amount of internal pressure (Radial stresses). Reduction of Burst effect is a best solution for making safe pressure hull under huge amount of radial pressure condition. Burst effect depends on hoop and longitudinal stress formed. Theses stresses can optimized by variation of thickness of pressure hull and types of materials used for pressure hull.

1. INTRODUCTION

1.1 PRESSURE HULL

The term light hull (casing) is used to describe the outer hull of a submarine, which houses the pressure hull, providing hydro dynamically efficient shape, but not holding pressure difference . The term pressure hull is used to describe the inner hull of a submarine, which holds the difference between outside and inside pressure.

All small modern submarines and submersibles, as well as the oldest ones, have a single hull. However, for large submarines, the approaches have separated. All Soviet heavy submarines are built with a double hull structure.

The double hull of a submarine is different from a ship's double hull. The external hull, which actually forms the shape of submarine, is called the outer hull, casing or light hull. This term is especially appropriate for Russian submarine construction, where the light hull is usually made of steel that is only 2 to 4 millimeters thick, as it has the same pressure on both sides. The light hull can be used to mount equipment, which if attached directly to the pressure hull could cause unnecessary stress. The double hull approach also saves space inside the pressure hull, as the ring stiffeners and longitudinal can be located between the hulls. These measures help minimize the size of the pressure hull, which is much heavier than the light hull. Also, in case the submarine is damaged, the light hull takes some of the damage and does not compromise the boat's integrity, as long as the pressure hull is intact.

Inside the outer hull there is a strong hull, or pressure hull, which actually withstands the outside pressure and has normal atmospheric pressure inside. The pressure hull is generally constructed of thick high-strength steel with a complex structure and high strength reserve, and is separated with watertight bulkheads into several compartments. The pressure and light hulls aren't separated, and form a three-dimensional structure with increased strength. The interhull space is used for some of the equipment which doesn't require constant pressure to operate. The list significantly differs between submarines, and generally includes different water/air tanks. In case of a single-hull submarine, the light hull and the pressure hull are the same except for the bow and stern.

The term pressure hull can be defined as the inner hull of a submarine, in which approximately normal pressure is maintained when the vessel is submerged.

The task of building a pressure hull is very difficult. No matter how large the submarine is, its hull must be constructed with high precision. Inevitable minor deviations are resisted by the stiffener rings, but even a one inch (25 mm) deviation from roundness results in over 30 percent decrease of hydrostatic load.

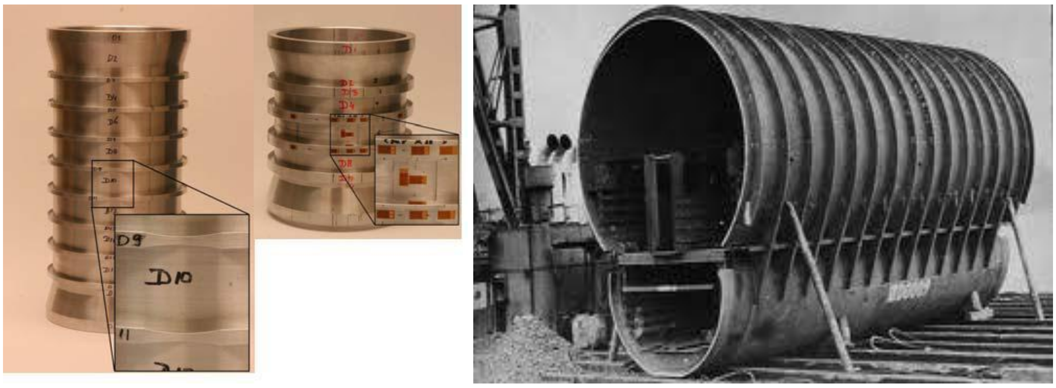

Figure1 : Figure showing the pressure hull

2. PROBLEM DEFINITION AND METHODOLOGY

2.1 PROBLEM DEFINITION

Burst effect in cylindrical components form a worst loss in manufacturing sector. Burst effect is a failure condition which occurs a cylindrical components subjected to huge amount of internal pressure (Radial stresses). Reduction of Burst effect is a best solution for making safe pressure hull under huge amount of radial pressure condition. Burst effect depends on hoop and longitudinal stress formed. Theses stresses can optimize by variation of thickness of pressure hull and types of materials used for pressure hull.

2.2 METHODOLOGY

- Design of pressure hull done using Unigraphics CAD software. Design of pressure hull completed based on ISO standard drawing sheet.
- After that theoretical hoop and longitudinal stresses are calculated at radial pressure condition (input condition) of pressure hull.
- These stresses are calculated for three different thickness of pressure hull .
- Pressure hull design imported in Ansys software for analysis purpose.
- Structural analysis of hull done for different thickness and different material types (steel, Aluminium).
- Ansys software is produces hoop and longitudinal stresses.
- Compare theoretical and analytical hoop and longitudinal stresses.
- From these results, suitable pressure hull proposed under radial pressure conditions which have low hoop and longitudinal stresses.

3. Design specifications of Pressure Hull:

- Length overall = 520 mm.
- Pressure hull diameter = 0.1 m.
- Layout = Single diameter ring stiffened cylinder with domed ends.
- Submerged displacement = 12.5 MPa.

3.1 3D modeling of pressure hull with 2.5mm

The 3d model of the pressure hull assembly is generated using UNIGRAPHICS software.

Below figure 2 shows the assembly of the pressure hull.

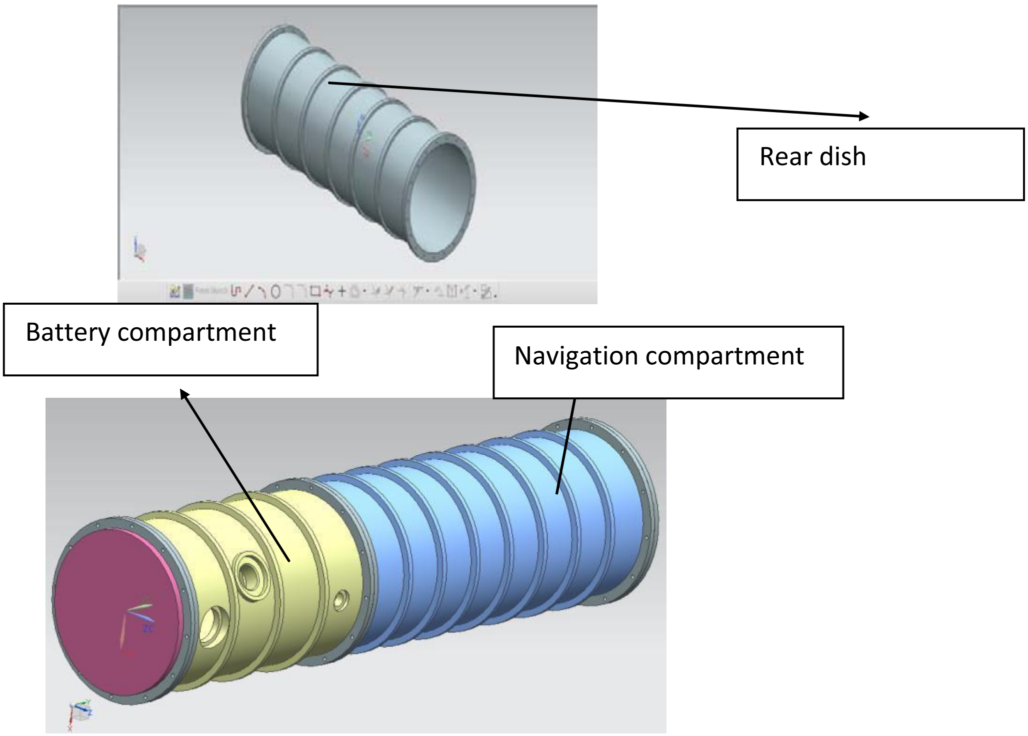

Figure.2 The assembly of the pressure hull

4. THEORETICAL CALCULATION OF STRESSES IN PRESSURE HULL

4.1 STRESSES IN 2.5 MM THICK PRESSURE HULL

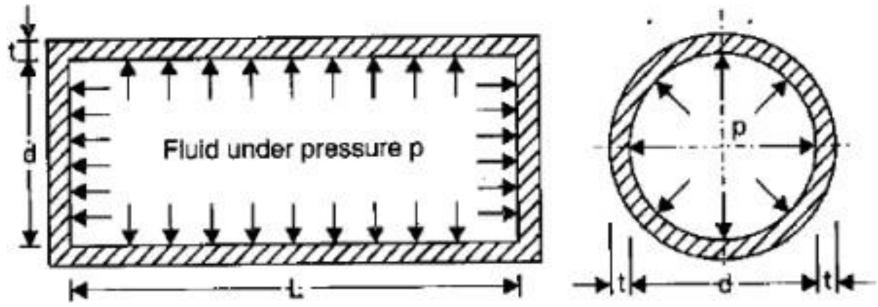

Figure 3 Stresses in Pressure Hull

Let d = internal diameter of the thin cylinder

t = thickness of the wall of the cylinder = 2.5mm

p = Internal pressure of the fluid, L = Length of the cylinder

Hoop stress (σ_1) = pd/2t = $12.5*10^6*0.096/2*0.0025$= 240MPa

4.2 STRCTURAL ANALYSIS OF PRESSRE HULL WITH 2.5 mm THICKNESS USING STEEL MATERIAL

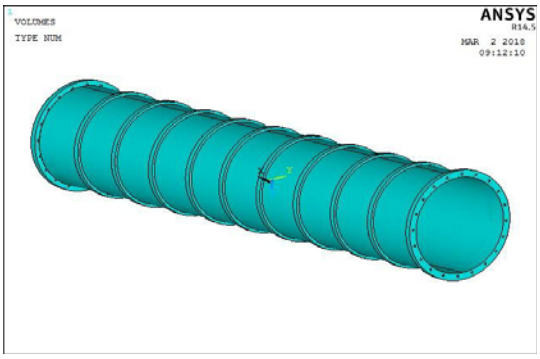

Figure 4. Pressure Hull With 2.5 Mm Thickness

4.3 Resultant Deformation

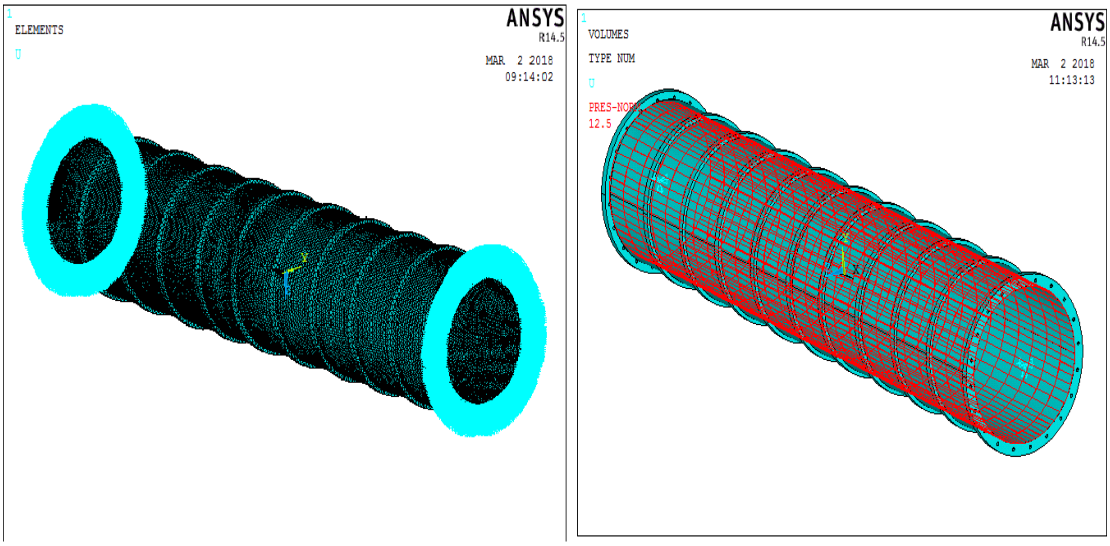

Figure 5. Applied fixed constraints at ends of hull and applied pressure 12.5 MPa

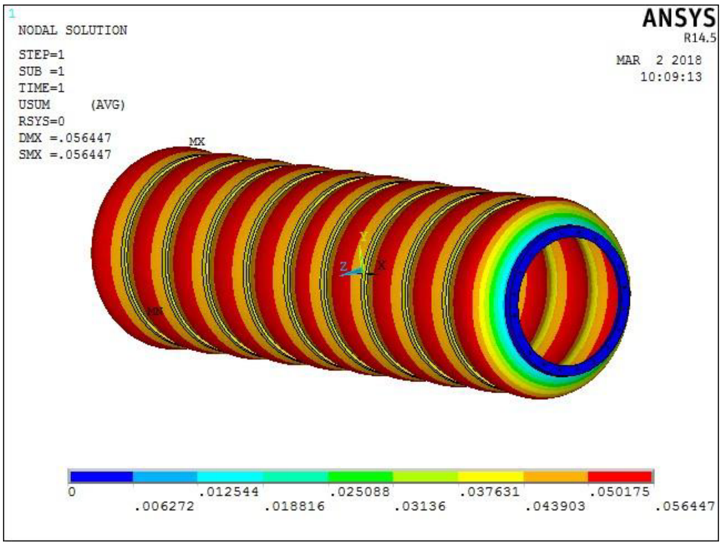

Fig.6. Resultant Deformation

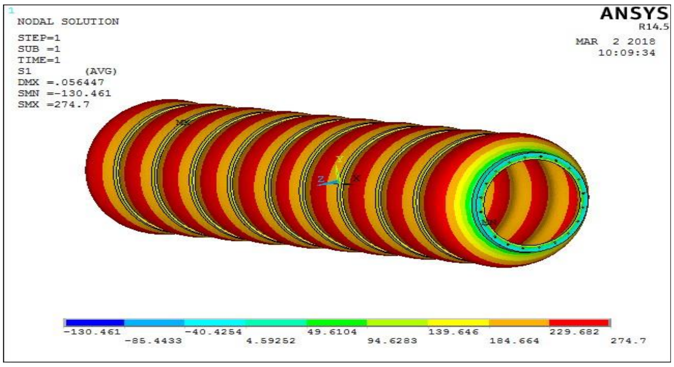

Fig 7 (a)

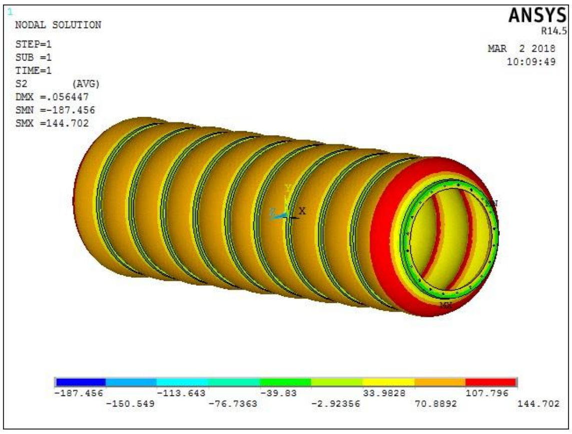

Fig 7 (b)

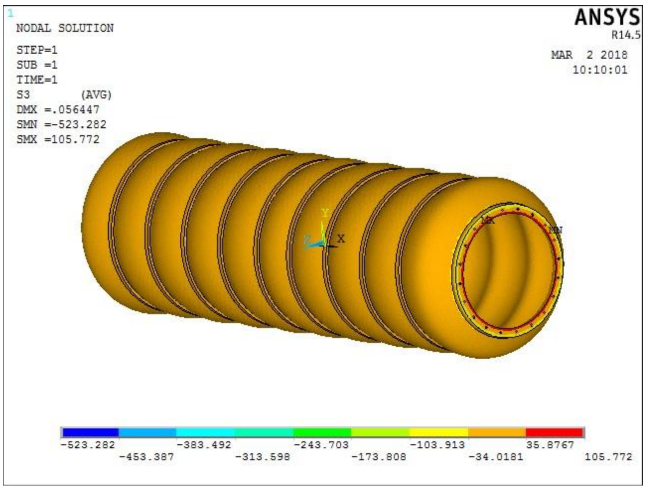

Fig 7 (c)

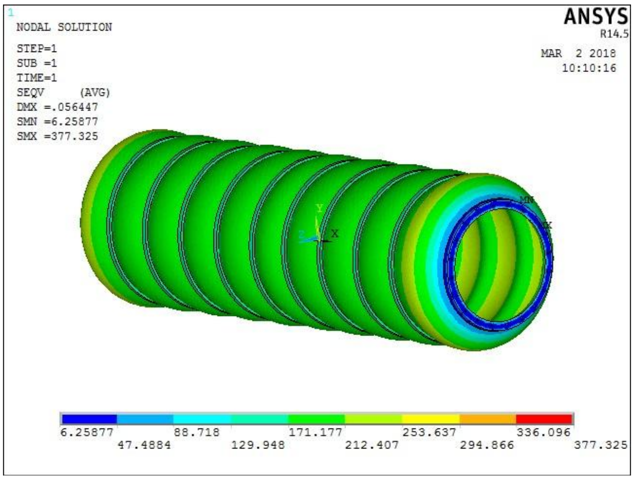

Fig 7 (d)

Figure 7 (a), (b), (c), (d) Von-mises Principal Stress

USING ALUMINIUM MATERIAL

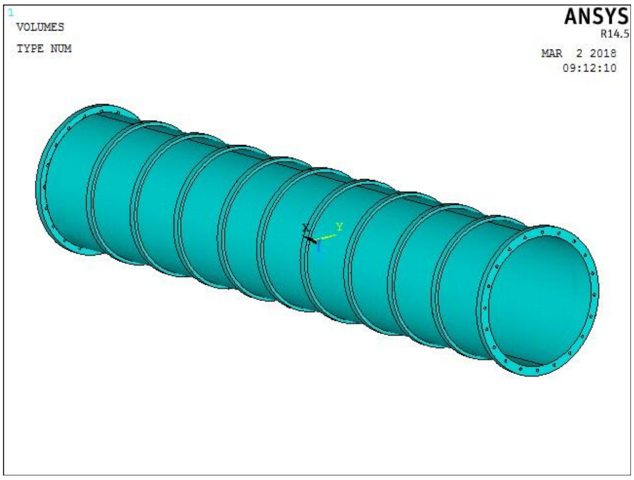

Figure.8 Imported pressure hull in ANSYS

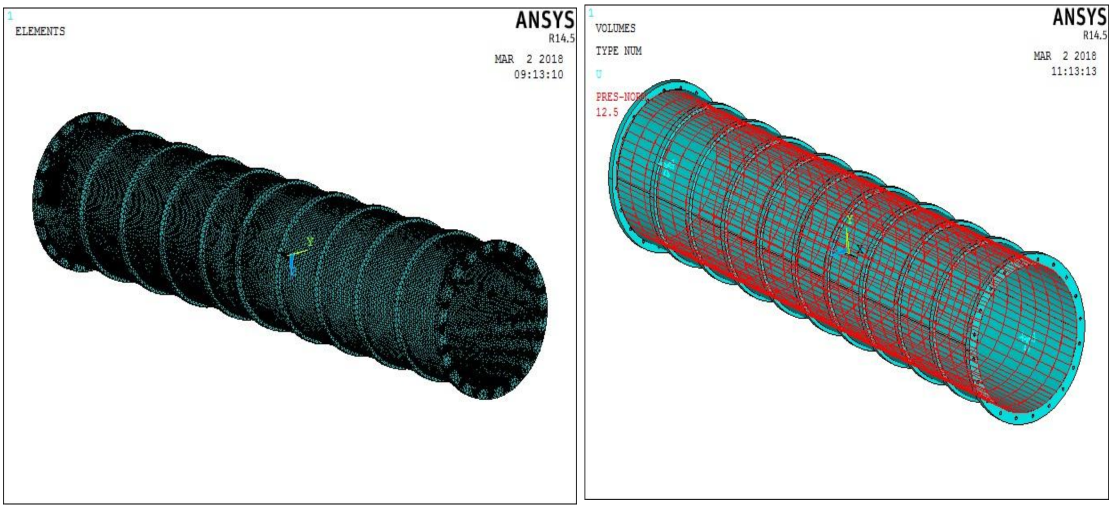

Figure 9. Created Mesh on pressure hull

Applied fixed constraints at ends of hull and applied pressure 12.5 MPa

5. RESULTS

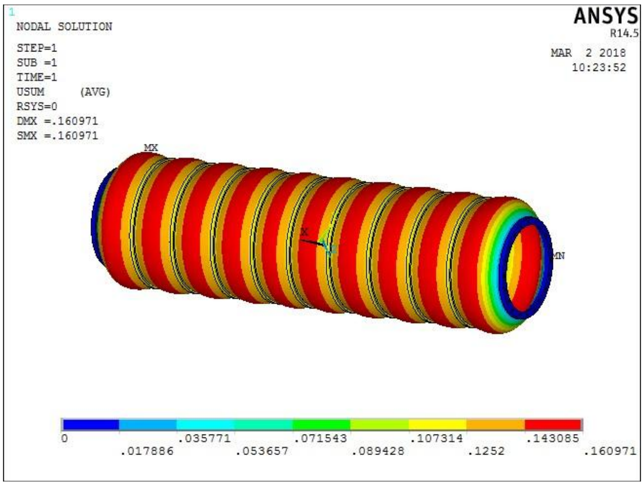

Figure.10 Resultant Deformation

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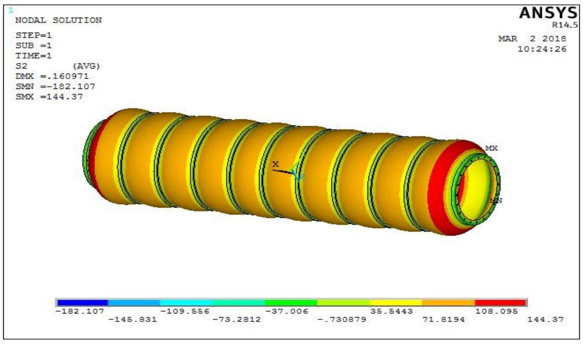

Fig 11 (a)

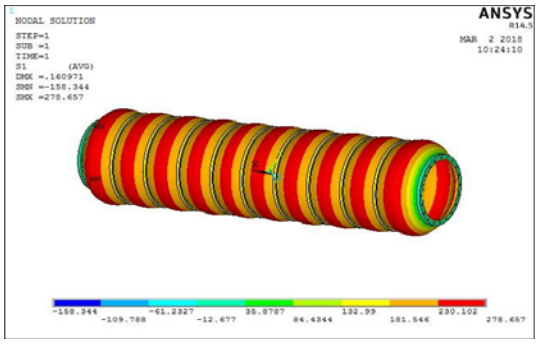

Fig 11 (b)

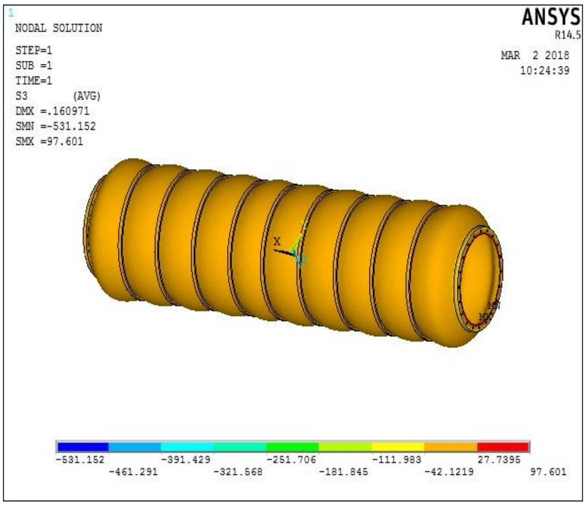

Fig 11 (C)

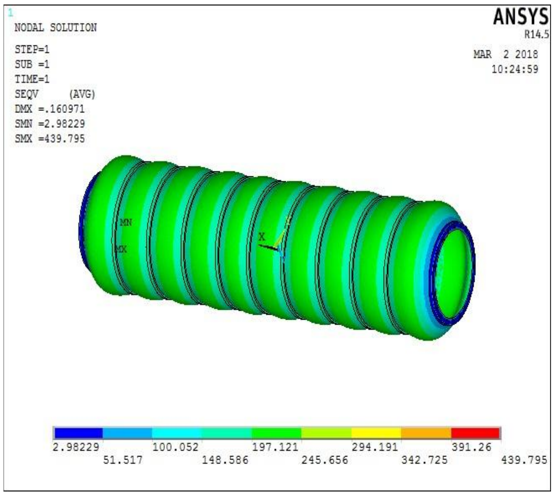

Fig 11 (d)

Figure 11 (a), (b), (c), (d). Von-misses Principal stress

Table.1 Deformation Results

Results type	**Hull with 2mm thick**		**Hull with 2.5mm thick**		**Hull with 3mm thick**	
	Steel	Aluminium	Steel	Aluminium	Steel	Aluminium
Deformation (mm)	0.0712	0.20	0.0564	0.160	0.130	0.130
Von-mises stress(MPa)	531.38	531.38	377.325	439.710	413.317	298.59

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6. Discussion

In this project, Pressure hull with three different thicknesses are analyzed by using ANSYS software. From analysis results observed that,

Pressure hull with 2.5 mm thickness forms von misses stress 377.325MPa using steel material. But yield strength of steel is 300MPa. Von misses stress is more than yield strength of steel So it is not safe at maximum pressure conditions. **pressure hull with 2.5 mm thickness** forms the von misses stress 439.71MPa using Aluminium 7075-T6 material. But yield strength of Aluminium 7075-T6 is 450 MPa. Von misses stress is less than yield strength of Aluminium 7075-T6 So it is safe at maximum pressure conditions. Factor of safety is 450/ 439.71 =1.02.

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