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Comparative Study of Alloy Steel & Kevlar Made Pressure Vessel using Stiffeners

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Abstract— A pressure vessel is a closed container designed to hold gases or liquids at a pressure different from the ambient pressure. The end caps fitted to the cylindrical body are called heads. Pressure vessels are used to store fluids under pressure. Stiffeners are secondary plates or sections which are attached to beam webs or flanges to stiffen them against out of plane deformations. Stiffeners provide stiffness to vessel. After analysis it was found that the Kevlar material is better than the alloy steel for design of pressure vessel when providing outer stiffeners.

Key words: Inner & Outer Pressure Vessel, Solid Works, Alloy Steel, Kevlar, Stress, Strain, Displacement, Mass Reduction

I. Introduction

A pressure vessel is a closed container designed to hold gases or liquids at a pressure different from the ambient pressure. The material of pressure vessels may be brittle such that cast iron or ductile such as mild steel. Stability of pressure vessel is observed by placing various measuring instruments such as pressure gauge, temperature sensor, strain etc.

In our study the rectangular ribs type stiffeners are using. This is easy to design and wear the maximum pressure than other type.

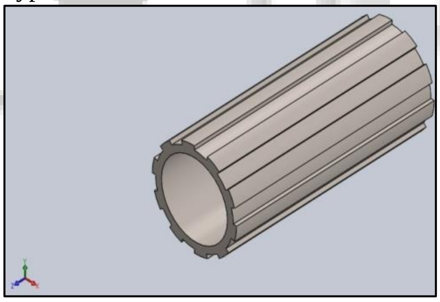

Fig. 1: Rectangular Ribs Type Stiffeners

II. Literature survey

Eswara Kumar.A et.al (2018)[2] "Static and Dynamic Analysis of Pressure Vessels With Various Stiffeners" in this wok helical type stiffners design carrid out With comparing to the basic cylinder, the helical stiffener design having a weight reduction of 28% and 0.5% more specific structural stiffness. In strength point of view, helical stiffener design having 23% less von mises stress than basic cylinder.

Rashmi Khobragade el.al(2017)[5] "Design, And Analysis of Pressure Vessel with Hemispherical and Flat Circular End" in this work Horizontal pressure vessels are analysis for three different curved saddle supports and vertical pressure vessels for three different lengths of legs and modifications are done for better functioning of pressure vessels.

Vipul J. Solanki et.al(2016)[7] "Static and Dynamic Analysis of Pressure Vessel with Vertical orientation using PVElite" From the analysis, Load case 18 for internal design pressure, operating weight, axial stress in the vertical direction due to seismic force and lateral force for seismic load is govern the whole analysis as maximum of all the stress ratio as 0.8282. Tensile stress value is less than the allowable tensile stress value and design is safe for the structure. i.e. 97.65 N/mm2 < 117.90 N/mm2

A. DEVARAJU et.al (2015)[10] "A Study On Stress Analysis For Design Of Pressure Vessel" in this work It was found that the values are found to be within the limits. The ANSYS results are compared with allowable stresses and found that the values are also within the limits.

Sandeep Gond et.al (2014) [13] "Design and Analysis of the Pressure Vessel" in this paper study has been done for safe design of vessel and result taken out that the Factor of safety that we consider is permissible and by which the design are considered safe. The bursting pressure is under the allowable stress so that the design does not fail.

III. Problems identification

The Strength to weight ratio is very low for steel and if we can increase this strength to weight ratio, then we could either reduce the weight of the vessel for same strength or we could increase the pressure inside the vessel by increasing the mass.

IV. Objectives

- To compare the maximum stress to weight ratio of pressure vessels made up of steel and Kevlar.
- To compare the variation in stress level that the vessel is undergoing by creating inner and outer stiffeners (ribs) over the cylindrical surface of the vessel.

V. Methodology

A. Boundary Conditions

- The cylindrical pressure vessel is not allowed to have any deformation or movement in axial direction, so as to allow it to have only radial deformation.
- The vessel is subjected to radial outward pressure of 500 Mpa from the inside cylindrical surface.

B. Properties of Material

Name:	Alloy Steel
Model type:	Linear Elastic Isotropic
Default failure criterion:	Max von Mises Stress
Yield strength:	6.20422e+008 N/m^2
Tensile strength:	7.23826e+008 N/m^2
Elastic modulus:	2.1e+011 N/m^2
Poisson's ratio:	0.28
Mass density:	7700 kg/m^3

Shear modulus:	7.9e+010 N/m^2
Thermal expansion coefficient:	1.3e-005 /Kelvin

Table 1:

Name:	K29
Model type:	Linear Elastic Isotropic
Default failure criterion:	Max von Mises Stress
Yield strength:	3.62e+009 N/m^2
Tensile strength:	3.62e+009 N/m^2
Elastic modulus:	2e+009 N/m^2
Poisson's ratio:	0.394
Mass density:	1440 kg/m^3
Shear modulus:	3.189e+008 N/m^2

Table 2:

C. Creation of Solid Modal

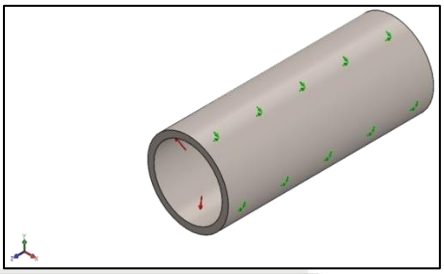

Fig. 2:

VI. RESULTS & DISCUSSION

A. Static Analysis of Stress, Strain & Displacement for the Simple Pressure Vessel of Alloy Steel

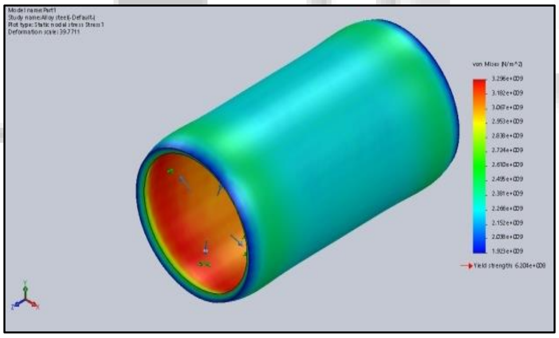

Fig. 3:

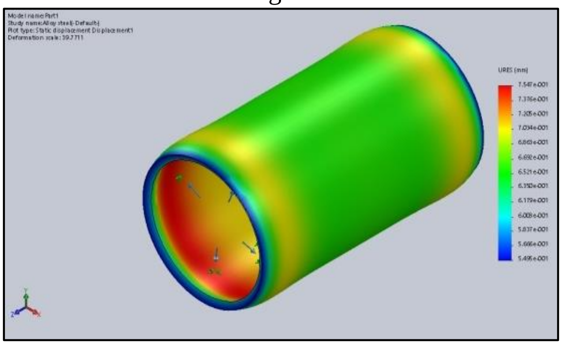

Fig. 4:

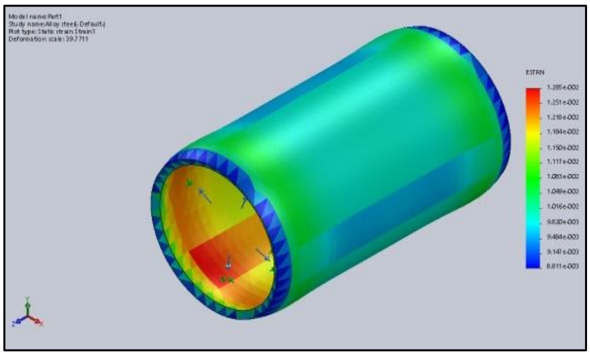

Fig. 5:

B. Static Analysis of Stress, Strain & Displacement for the outer Stiffeners Pressure Vessel of Alloy Steel

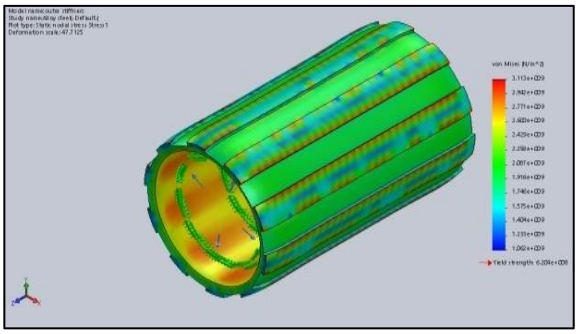

Fig. 6:

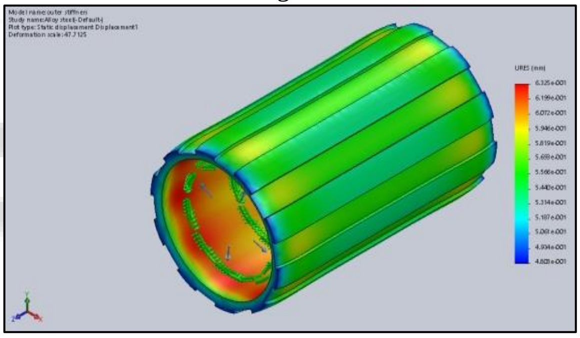

Fig. 7:

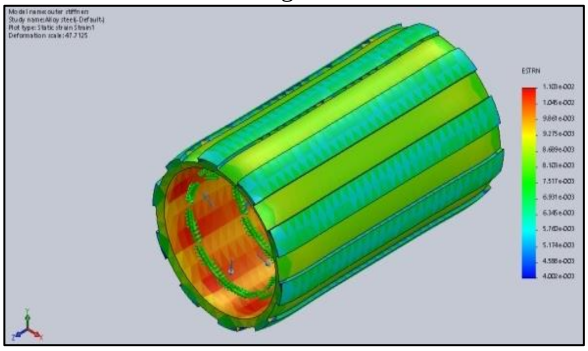

Fig. 8:

C. Static Analysis of Stress, Strain & Displacement for the Simple Pressure Vessel of Kevlar

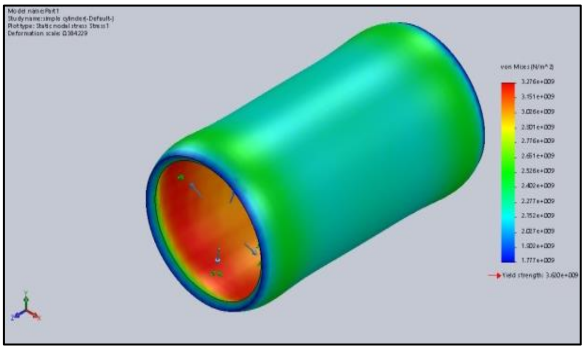

Fig. 9:

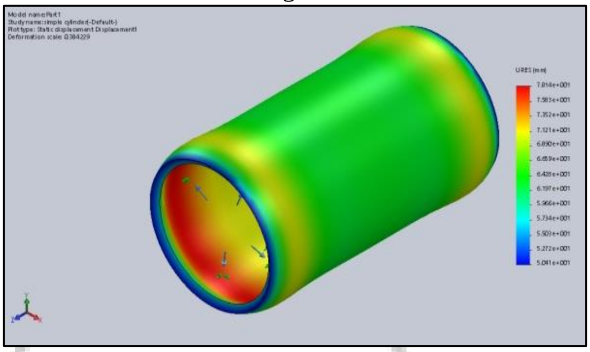

Fig. 10:

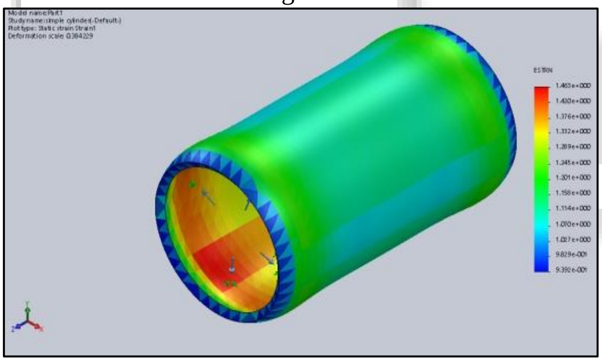

Fig. 11:

D. Static Analysis of Stress, Strain and Displacement for the Outer Stiffeners Pressure Vessel of Kevlar

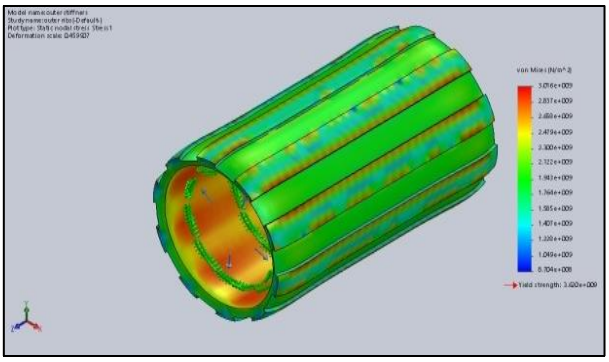

Fig. 12:

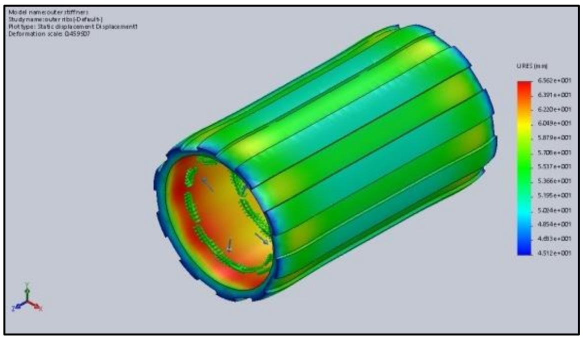

Fig. 13:

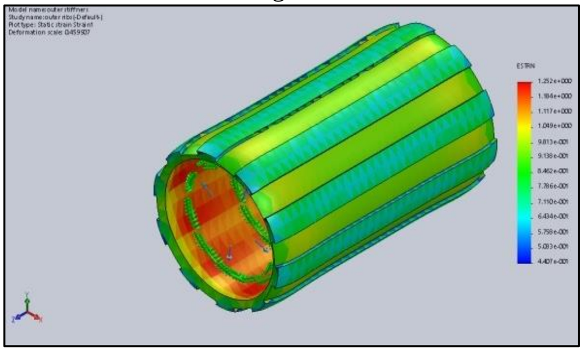

Fig. 14:

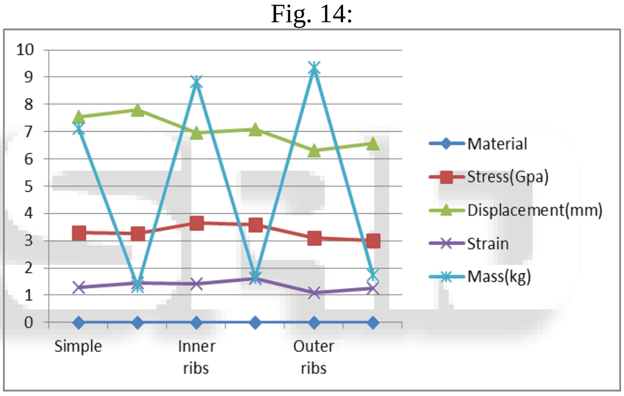

Fig. 15:

VII. CONCLUSIONS

- It has been observed that a huge amount of reduction in weight is obtained while keeping the stress levels same in case of Kevlar material which is 81.30% less than steel.
- It has also been observed that creating ribs on the outer surface of the cylinder tends to reduce the stress that the vessel is undergoing.
- Whereas the value of stress increases after providing inner ribs in all the cases.

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