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Modeling and Analysis of Metal and Fiber Reinforced Polymer LPG Cylinder

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ABSTRACT:

In recent years there has been an increasing demand from the core industries for the materials possessing high strength to weight ratio[1]. So, for this purpose a material known as MFRP[1] (METAL AND FIBER REINFORCED POLYMER) has been introduced. This material possess both the properties of metal and fiber composites[4].

An LPG cylinder[2] is designed and analysis is done by using the properties of Steel, MFRP and FRP[3] materials. Finally the comparison is made on the basis of displacement and Stress produced due to the application of internal pressure to the cylinder.

Key words: ***MFRP, FRP, Von-Mises stress, Displacement.***

1.INTRODUCTION:

Now - a - days there is a huge demand for conventional materials like Steel, Iron, etc.. For manufacturing of various components. As these materials are not exhibiting required properties in some cases. So, there is need to shift towards other materials like composites.

An LPG cylinder is taken into consideration as it is made of steel which are heavy to carry. So this steel material is replaced with a composite material[5] called MFRP which has the similar strength and having less weight compared to steel cylinder and MFRP possess high strength compared to FRP. The properties of these materials are taken for the analysis of the cylinder and comparison is done.

2.LITERATURE REVIEW:

LPG cylinder has been developed over time and their heritage can be seen in various generations[2].

The first generation cylinders were introduced between 1870 - 1880 to store liquid co_2 for industrial gas business. They were long steel tubes without handles and very hard to handle. Later on, the second generation was introduced to bridge some gaps in the first one. They were also made from steel, but with a handle shorter .But wider and the shape have been refined. This generation cylinder is the most populous and known as "Traditional Cylinders".

Third generation cylinders improved up on type II using plastic for coating the metal exterior allowing the exterior to be customized. However, the cylinders continue o have the some drawbacks as Gen I and Generation II.

Generation IV Cylinders are the latest on the market. They were developed with aerospace technology and represent a real advance in technology, that otherwise has effectively remained unchanged over 75 years.There are couple of companies which have started to work on LPG composites cylinders including Aburi composites, London based and Hexagon Ragosco in Norway. Hyundai has also started in Asia and in India. There are some new factories.

From the literature cylinder thickness is the critical factor in designing. If the thickness is increased the cylinder safety increases in conventional design. However the weight of the cylinder increases

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proportional to thickness.

The cylinder specification states, the thickness is based on yield strength and test pressure and the diameter of cylinder, while analysis stresses and deformation studies on cylinders, critical factors are indentified such as yield strength, percentage elongation, tensile strength, volumetric expansion.

Software's like solid works, Ansys, Pro –E, FEA can be used for estimation of stress in cylinder.

However this software's cannot be used for routine laboratory tests as these are expensive, cannot be operative in shop floor and are not possible to integrates with online field equipment, where instantaneous response is solicited.

3.PURPOSE OF RESEARCH:

The main purpose of research is to replace the conventional material used for cylinder with the new material MFRP which shows the similar properties to conventional material and weight can also be reduced for the cylinder with the similar strength.It may not show the similar properties as steel cylinder. But if we slightly increase the thickness of the MFRP Cylinder, it can with stand same as conventional cylinder with less weight compared to it.

As the MFRP cylinders is made of fiber composite, the thermal shock resistance and corrosion resistance of cylinder increases.

4. PROPERTIES OF MATERIALS:

Material/ properties	ELASTIC MODULUS N/m²	POISSIONS RATIO	MASS DENSITY KG/m³	YIELD STRENGTH N/m²
METAL	2×10^{11}	0.3	7800	2.4×10^{8}
MFRP	1.9×10^{10}	0.29	3400	1.315×10^{8}
FRP	8.47×10^{8}	0.28	1800	1.5×10^{8}

5. DESIGN OF LPG CYLINDER:

The design of LPG cylinder is done in solid works[1] software. In this software a small elemental profile of a cylinder is drawn by giving the dimensions.

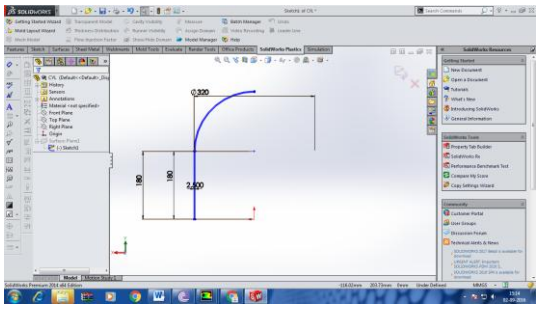

Fig.1 Design of cylinder profile

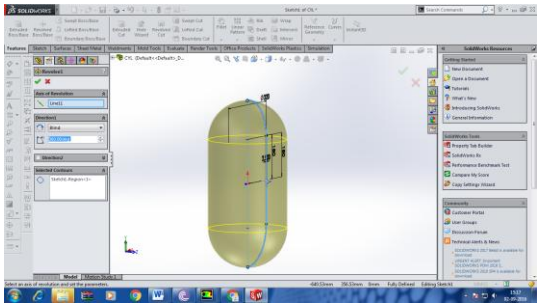

Fig.2 Design of full cylinder

Then this profile is rotated through 90 ^{0} about vertical axis to get the section of cylinder.

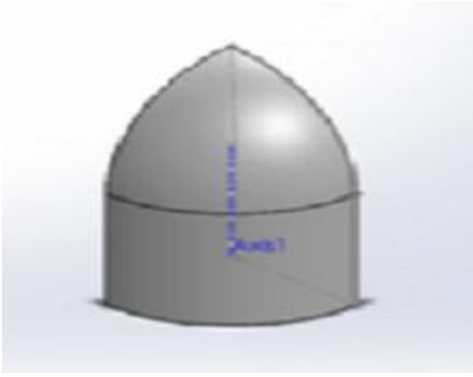

Fig.3 Cylinder profile rotated to 90^{0}

6. ANALYSIS OF LPG CYLINDER:

The analysis of LPG Cylinder is also done in solid works software. Simulation is done on designed part by selecting static study from the list. Then the material properties are added to the design and meshing is done by clicking on create mesh.

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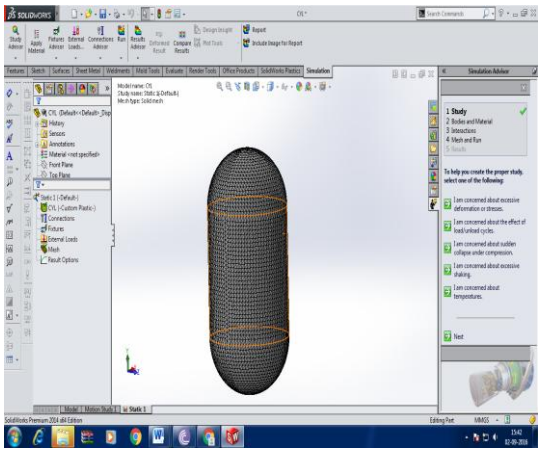

Fig.4 meshing of full cylinder

Fig.5 meshing of cylinder part

Constraints are created by clicking on advanced fixtures and select the top portion of the cylinders.Pressure of 1.2MPa is applied on faces by going into load options and then selects the faces on which pressure is to be applied.

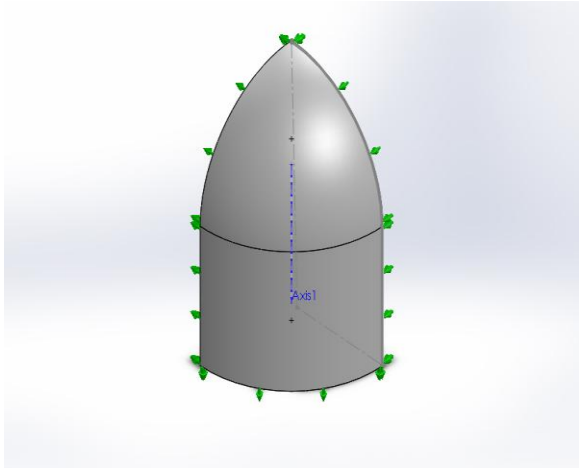

Fig.6 Pressure applied on the surface

Then select symmetry and then select down symmetrical face to create a closed cylinder.

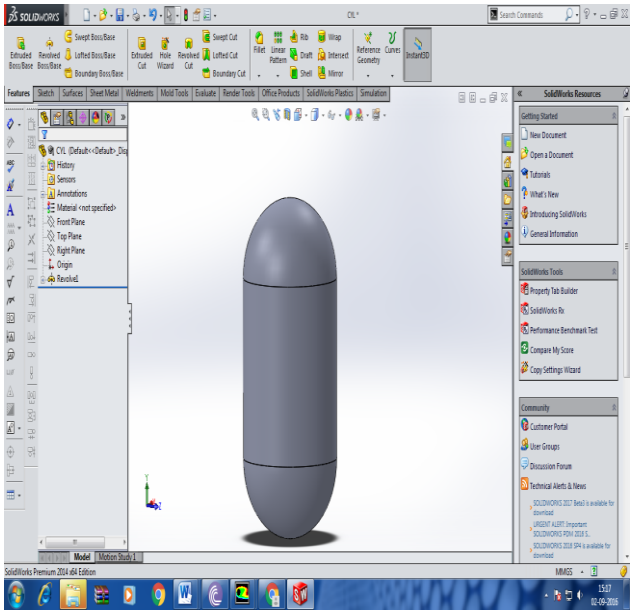

Fig.7 cylinder with internal pressure

Run option is selected to solve. The same procedure is done for the different materials like MFRP, STEEL and FRP with properties as young's modulus, yield strength, poisson's ratio, mass density.

7.1 Results for metal cylinder:

Name	Type	Min	Max
Stress	von Mises Stress	3.24607 e+007 N/m²	8.62385e +007 N/m²

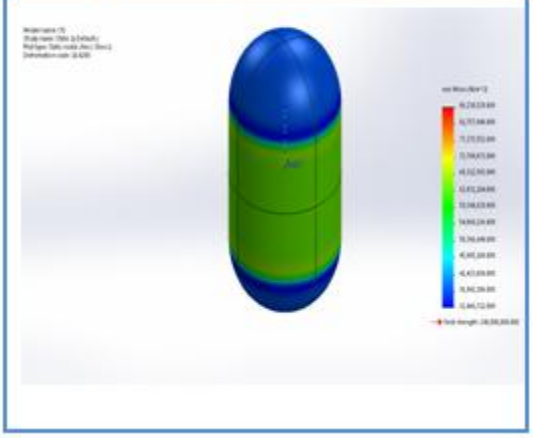

Fig.8 stress in steel cylinders

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Name	Type	Min	Max
Displacement	URES: Resultant Displacement	0.0332934 mm	1.84622 mm

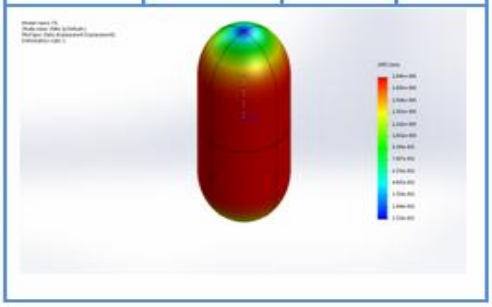

Fig.9displacement in steel cylinder

7.2 Results for MFRP cylinder:

Name	Type	Min	Max
Stress	von Mises Stress	3.32384e+007 N/m²	6.86e7 N/m²

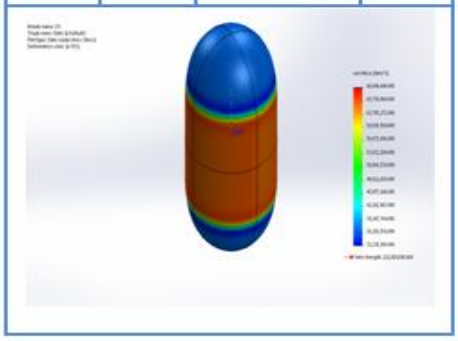

Fig.10von-mises stress in MFRP cylinder

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.359757 mm	2.03727 mm

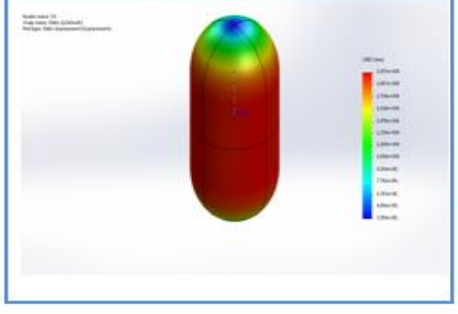

Fig.11 displacement in MFRP cylinder

7.3 Results for FRP cylinder:

Name	Type	Min	Max
Stress	von Mises Stress	3.6789e+007 N/m²	6.82368e+007 N/m²

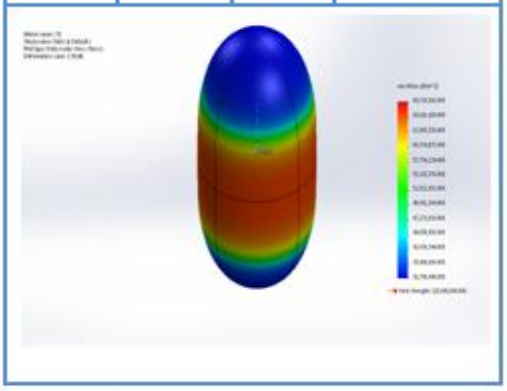

Fig.12 von-mises stress in FRP cylinder

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	6.78302 mm	13.1201 mm

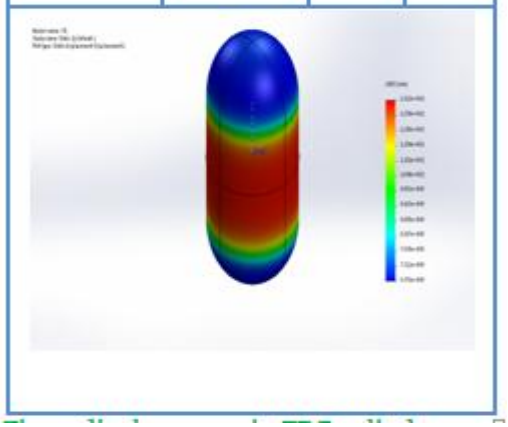

Fig.13 displacement in FRP cylinder

8. CONCLUSION:

From the above analysis the following results are obtained. The displacement and stress of cylinders with diff material properties are obtained as shown in figure.

From the above table the displacement in MFRP cylinder is nearly equal to the displacement in steel cylinder and less than FRP cylinder. The stress of

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MFRP lies between steel and FRP cylinder which shows the better property than the FRP cylinder and low weight compared to steel cylinder.

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