DESIGN AND ANALYSIS OF MULTI LAYER PRESSURE VESSEL

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ABSTRACT

In Process Industries, like chemical and petroleum industries designers have recognized the limitations involved for confining large volumes of high internal pressures in single wall cylindrical metallic vessels. In process engineering as the pressure of the operating fluid increases, increment in the thickness of the vessel intended to hold that fluid is an automatic choice. The increment in the thickness beyond a certain value not only possesses fabrication difficulties but also demands stronger material for the vessel construction.

Multilayer Pressure Vessels have enlarged the art of pressure vessel construction and presented the process designer with a reliable piece of equipment useful in a wide range of operating conditions for the problems generated by the storage of hydrogen and hydrogenation processes.

*In this Project "**DESIGN AND ANALYSIS OF MULTILAYER HIGH PRESSURE VESSELS**" features of multilayered high pressure vessels, their advantages over uni block vessel are discussed.*

The stresses occured in Solid wall pressure vessel and Multilayer pressure vessel are analyzed by using ANSYS software, a versatile Finite Element Package. The theoretical values and ANSYS values are compared for both solid wall and multilayer pressure vessels and conclusions are drawn.

I. INTRODUCTION TO PRESSURE VESSELS

The word pressure vessel refers to those reservoirs or containers, which are subjected to internal or external pressures.

The pressure vessels are used to store fluids under pressure. The fluid which are stored may undergos a change of state inside the pressure vessels as in case of steam boilers or it may combine with other reagents as in chemical industries. Pressure vessels are used in wide applications in thermal and nuclear power plants, process and chemical industries, in space and ocean depths, in water, steam, gas and air supply system in industries.

The material of a pressure vessel may be brittle such as ductile or cast iron such as mild steel.

1.1 High Pressure Vessels

High Pressure vessels are used in industries as reactors, separators, heat exchangers. This are vessel with an integral bottom and a removable top head, and which are generally provided with an inlet,for heating and cooling system and also for agitator of system. High Pressurized vessels are used for a pressure range of 15 N/mm^2 to a maximum range of 300 N/mm^2. These vessels are essentially thick walled cylindrical in shape, ranging in size of small tubes to several meters of diameter. Both the size of the pressure vessel and the pressure involved will dictate the type of construction used.

II. DESIGN DATA OF THE VESSEL

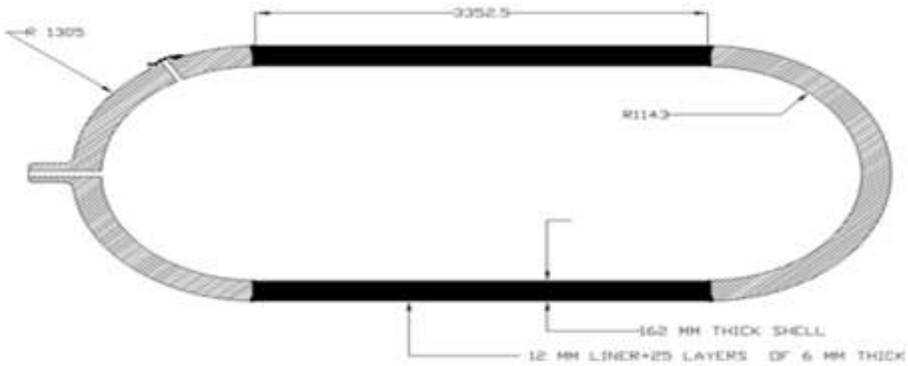


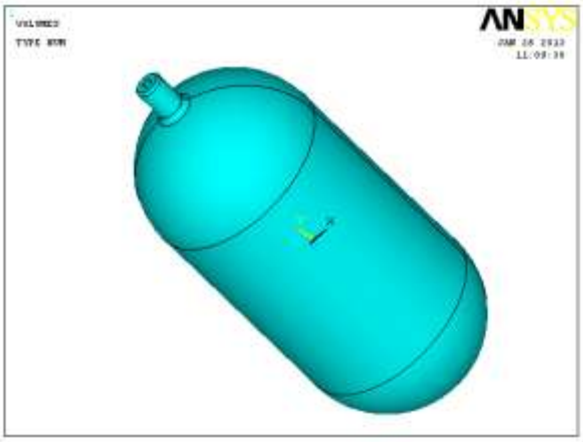
Fig 4.2 Drawing of Multilayer Pressure Vessel

Design Pressure P - 21 N/mm^2, Hydrogen.

Design Temperature, T - 20^{0}C

Hydrostatic Pressure P_H - 27.3 N/mm^2

III. ANALYSIS OF SOLID WALL PRESSURE VESSEL STEEL



Material Properties

Young's Modulus – 209000Mpa

Poisson's ratio – 0.3

Density – 0.00000785Kg/mm^3

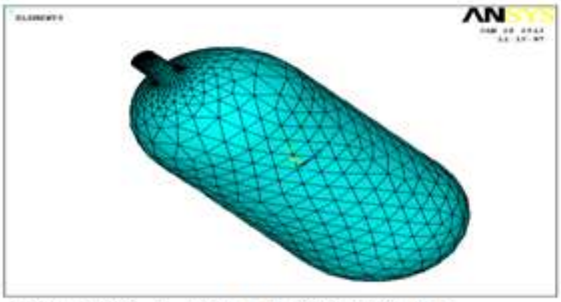


Fig 6.2 Meshed Model of Solid Wall Pressure Vessel in ANSYS 11.0

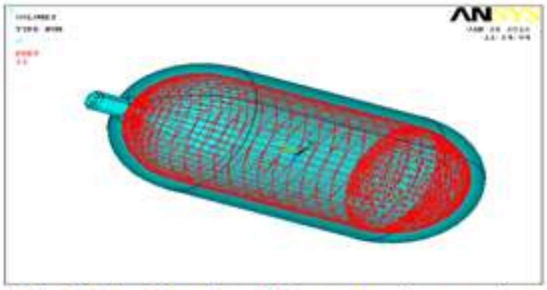


Fig 6.3 Application of Pressure - Symmetric Boundary Conditions.

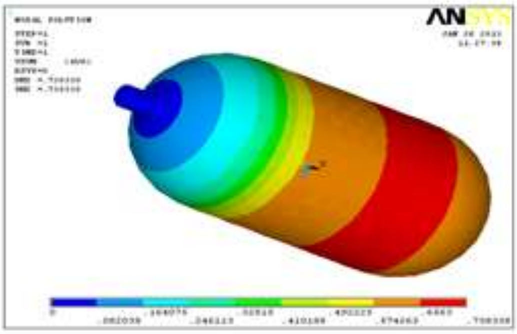


Fig 6.4 Displacement

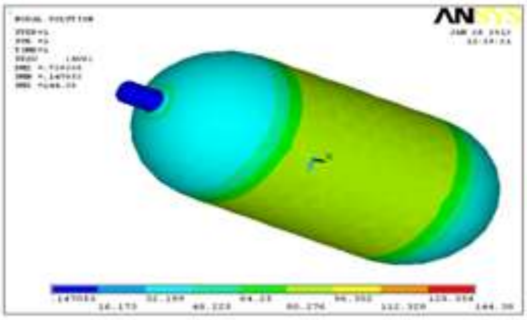


Fig 6.5 Stresses

IV. ANALYSIS OF MULTI LAYER PRESSURE VESSEL STEEL

Material Properties

Young’s Modulus – 209000Mpa

Poisson’s ratio – 0.3

Density – 0.00000785Kg/mm^3

Liner Material – SA515 GR70

Young’s Modulus – 205000Mpa

Poisson’s ratio – 0.29

Density – 0.00000785Kg/mm^3

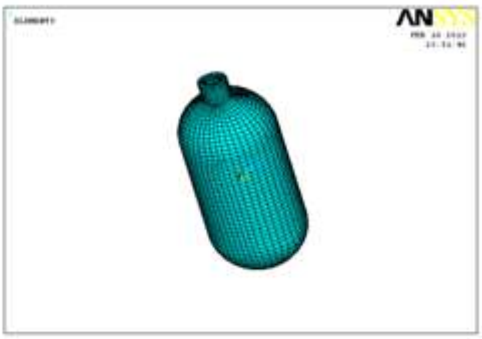
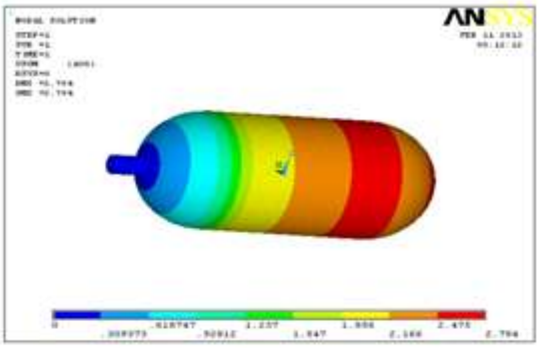
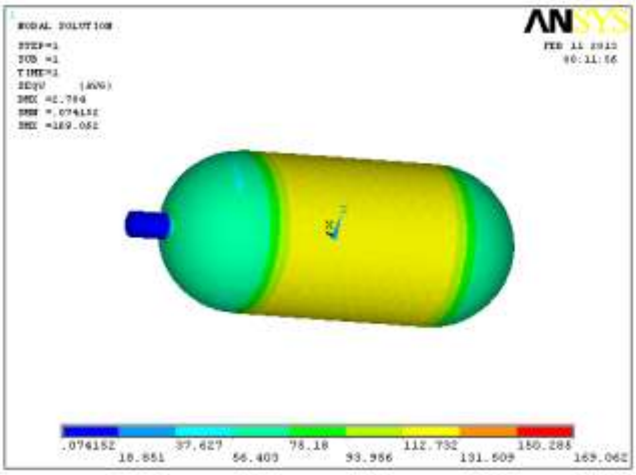


Fig 6.12 Meshed Model of Solid Wall Pressure Vessel in ANSYS 11.0



a. Displacement



6.14 Von-Mises Stresses

V. S2 GLASS EPOXY

Material Properties

Young's Modulus – 86900Mpa

Poisson's ratio – 0.23

Density – 0.00000246Kg/mm^3

Liner Material – SA515 GR70

Young's Modulus – 205000Mpa

Poisson's ratio – 0.29

Density – 0.00000785Kg/mm^3

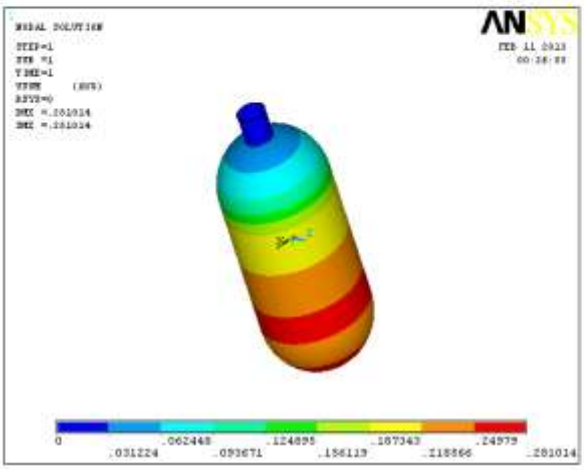


Fig 6.9 Displacement

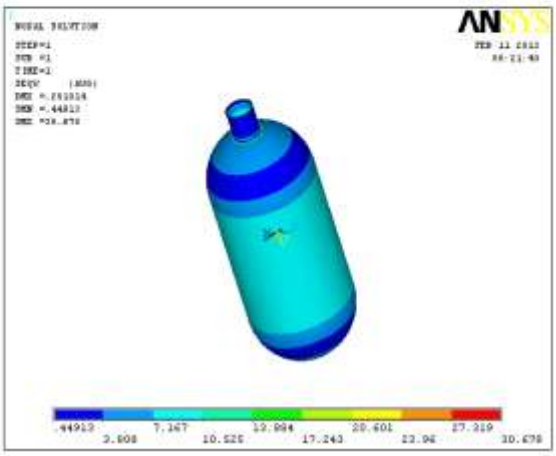


Fig 6.10 Von-Mises Stesses

VI. RESULTS TABLE

SINGLE LAYER			MULTI LAYER		
	DISP (mm)	**STRESS (N/mm^2)**		**DISP (mm)**	**STRESS (N/mm^2)**
STEEL	0.738338	144.38	**STEEL**	2.784	169.062
			S2 GLASS	0.28	30.678

WEIGHT COMPARISION (Kg)

SINGLE LAYER		MULTI LAYER	
STEEL	79439.265	**STEEL**	60943.7427
		S2 GLASS	4999.9044

VII. CONCLUSION

At present solid wall pressure vessels are used extensively. But by using multilayered vessels, there is a huge difference in weight. The weight is almost decreased by 18495Kg when multilayered vessels are used in place of solid vessels.

This decreases not only the overall weight of the component but also the cost of the material required to manufacture the pressure vessel. This is one of the main aspects of designer to keep the weight and cost as low as possible.

The stresses developed in the multilayered vessels are more when compared with solid vessels. Minimization of stress concentration is another most important aspect of the designer. It also shows that the material is utilized most effectively in the fabrication of shell.

Owing to the advantages of the multi layered pressure vessels over the conventional single walls pressure vessels, it is concluded that multi layered pressure vessels are superior for high pressures and high temperature operating conditions.

By using composite material S2 Glass epoxy in place of steel, decreases the overall weight of multilayered vessels almost by 50000kg. And also by analysis it is proved that using S2 glass epoxy is also safe since the analyzed stress value is less than yield stress value 4920Mpa and also less than that by using S2 Glass epoxy.

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