iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1243

Pressure Vessel Material – Composite Material

Sagar Santu Shete[1], Prof. Hredeya Mishra[2]
[1, 2] Dept. Of Mechanical Engineering, University of Pune

Abstract*: The aim of this paper is to study and analyze the composite material used to design the pressure vessel for different aspect. A pressure vessel is a container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Pressure vessels are widely used for commercial, under water vehicles and in aerospace applications. At present the outer shells of the pressure vessels are made up of conventional metals like steels and aluminum alloys. For manufacturing the pressure vessel, different child parts need to be welded together. In these mechanical properties of steel, achieved by operation rolling or forging, could be adversely affected by welding, unless special precautions are to be taken. For adequate mechanical strength, current standards suggest to use of steel with a high impact resistance, especially for vessels used in low temperatures. In applications where carbon steel would suffer corrosion, special corrosion resistant material should also be used. Now a days some of the pressure vessels are made of different materials i.e. composite materials, such as filament wound composite using carbon fibre held in place with a polymer. Due to the very high tensile strength of carbon fibre these vessels can be very light, but are much more difficult to manufacture.
Keywords: Pressure vessel design, Shell Material, Composite Material,

I. INTRODUCTION

The study says the conventional materials like steels and alloy are not perform in various condition due to some drawbacks. Like weight, chemical reaction and corrosion issues, speed, operating range. The payload performance/ speed/ operating range depends upon the weight. The lower the weight the better the performance, one way of reducing the weight is by reducing the weight of the shell structure. The use of composite materials improves the performance of the vessel and offers a significant amount of material savings. In this stacking sequence is very crucial to the strength of the composite material. The design involves various objective functions such as stiffness, buckling load and Weight at each level of optimization. Usually composite material use for design the pressure vessels are designed for minimum mass under strength constraints.

Pressure vessels are important because many liquids and gases must be stored under high pressure. Special emphasis is placed upon the strength of the vessel to prevent explosions as a result of rupture. Codes for the safety of such vessels have been developed that specify the design of the container for specified conditions. In some applications pressure vessels are carry only low pressures and thus they are constructed of tubes or sheets rolled to form cylinders. The pressure vessels must carry high pressures, however, and the thickness of the vessel walls must increase in order to provide adequate strength. Interest in studying of the shell arises from the fifties of twentieth century. The assemblies, containing thin shells, find wide use in the modern engineering, especially in ships, aircraft and spacecraft industry. Shell vibrations and buckling modes are analyzed by different methods like numerical methods, this to clear qualitatively different buckling modes.

Fig 1.1.Cylindrical Pressure Vessel

Now a day's main concern for design and vessel industry is structural efficiency. Due to the requirement of their specific strength and light weight, fiber reinforced composites find a wide range of applications in this type of cases. The material of light weight composite material taken compression load carrying structures form part of all aircraft, and space vehicle fuel tanks, air cylinders are some of the many applications. For a latest work, analysis of composite shell minimum mass under strength constraints for a cylinder with or without stiffs and ribs under axial loading for static and buckling analysis on the pressure vessel has been studied.

The pressure vessels design are like thin walled laminated and composite vessels also it is unstiffened which is like as deep submarine exploration housings and autonomous underwater vehicles are subjected to any combination of in plane, Out of plane and shear loads due to the high external hydrostatic pressure during their application. Due to the geometry and structure of these, mainly buckling is one of the most important failure criteria. The buckling failure mode of a stiffened cylindrical shell can further be subdivided into different modes like global buckling, local skin buckling and stiffener crippling. In this case the global buckling is collapse of the whole structure, i.e. collapse of the stiffeners and the shell as one unit. But In the local buckling and stiffeners crippling on the other side and which are localized failure modes which are involving local failure.

On the other way Grid stiffened cylindrical shells are the shells having a certain kind of stiffening structures either on inner, outer or both sides of the shell and significantly increases the load resistance without much increase in weight. For some cases to further reduce the weight, both the shell and the stiffeners are made using fiber reinforced polymers. Now a days the promising future of stiffened composite cylinder has in turn led to an extensive research work in this area.

A. *Thin Composite Shells*

The shell whose wall thickness is small compared to the radius of curvature and the corresponding radius of twist is known as thin shell. Plate and shell structures are used in a lightweight load bearing structural parts for various modern aerospace, offshore, nuclear, automotive, and civil engineering structures. These shells are subjected to compressive loads. In the case of air crafts, they are subjected to fluctuating flight loads, which also produce compressive components. These compressive loads cause buckling of the shell structure. The analysis of pressure vessel of composite shell structures requires consideration of a different of failure modes. Often analysis programs cannot predict all failure modes using a single analysis model, and consequently structural designers must use a variety of analysis tools. It is also common that for a given failure mode, it is difficult to obtain the same result using different programs.

B. *Composite Materials*

Mainly composition are considered to be combinations of materials differing in composition or form on a macro scale. The constituents retain their identities in the composite i.e. they do not dissolve or otherwise merge completely into each other although they act in the idea of a composite material is not a new or recent one concert. In nature, one can find out many composite materials, for example wood is a fibrous natural composite (cellulose fibrous in lignin matrix). Bone is yet another example of natural composites. Our ancestors invented composite by mixing straw and clay to make bricks. Straw is fiber reinforcement and clay is the matrix. The first glass fiber reinforced polymer was developed in 1940. The origin of distinct discipline of composite materials started in 1960‟s.Extensive research has been done on composite material since 1965. One difference between laminated composites and traditional engineering materials is that a composite’s response to loads is direction dependent. Monolithic metals and their alloys can’t always meet the demands of today’s advanced technologies. The composite materials gives high specific strength and high specific modulus and its resulting in reduction of mass of the components, because of this improves efficiency, and results in energy savings. One of the main advantages of the composite materials is the flexibility which involved and gives the desired strength and stiffness in the direction required. Carbon fibers are very common in high-modulus and high-strength applications. It is well known that the measured strength of most materials is much smaller than their theoretical strength because of presence of imperfections or inherent flaws in the materials. Flaws in the form of cracks that lies perpendicular to the direction of load are particularly detrimental to the strength. It is found that non polymeric materials have higher strength along their lengths because of small cross sectional fibers, the flaws are minimized. In case of polymeric materials, orientation of the molecular structure is responsible for high strength and stiffness. Fibers because of their small-sectional dimensions are not directly usable in engineering applications. They are embedded in matrix materials to form fibrous composites. The shell is multi-layered fibrous composite shell. Each layer or lamina is a single-layer composite and thus orientation is varied according to design. Each layer is very thin (thickness 0.4 mm to 0.7mm) and cannot be directly used. Several identical or different layers are bonded together to form a multi-layered composite shell. Each layer may be vary from another layer in

1) Relative volumes of the constituent ‟s materials
2) Form of the reinforcement.
3) Orientation of fibers with respect to common reference axes. Thus the directional properties of the individual layers may be quite different from each other.

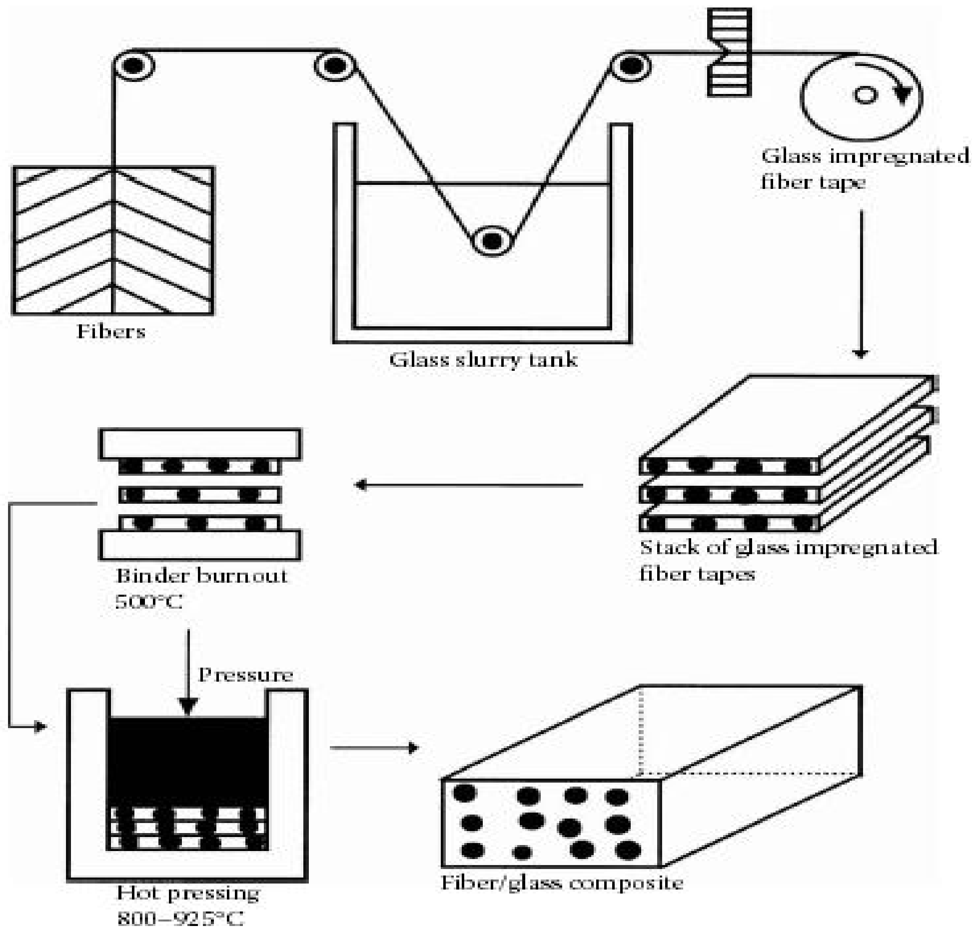

Fig. 1.2.Schematic Matrix Composite Laminates Manufacturing

One of the most common methods to manufacture matrix composites is called the hot pressing method. Glass fibers in continuous tow are passed through slurry consisting of powdered matrix material, Solvent such as alcohol, and an organic binder as shown in fig 1.2. The tow is then wound on a drum and dried to form prepare tapes. The prepare tapes can now be stacked to make a required laminate; heating at about 932°F (500°C) burns out the binder. Hot pressing at high temperatures of about 1832°F (1000°C) and pressures of 7 to 14Mpa. Design analysis of any composite structural element would require a complete knowledge of properties of individual layers. In this each layer is a continuous angle-ply composite laminate consists of parallel fibers embedded in a matrix. One of the most important factors for determining the properties of composites is relative proportions of the matrix and reinforced materials. The relative proportionate can be given as the weight fractions or by one of the experimental methods after fabrication. The volume fractions are exclusively used in the theoretical analysis of composite materials. Most manmade composite materials made from two materials, these are a reinforced material called fiber and a base material called matrix. For example in concrete columns the concrete is base material which is called matrix and the iron rods come under fibers for reinforcement. Their existing three types of composites.

4) *Fibrous Composites:* It consists of fibers of one material in a matrix material of another material.
5) *Particulate Composites*: These are composed of particles of one material in a matrix of another material.
6) *Laminate Composites:* These are made of layers in which fibers and matrix are made of different materials, including the composites.

The purpose of matrix is to transfer loads and protect them against environmental attack and damage due to handling. Based upon the properties required, the matrix and fiber materials are selected.

C. Fiber

Fibers are main constituents in fiber reinforced composite material. In this they will occupy the large volume fraction in a composite laminate and share major portion of load acting on a composite.

The most common fiber used is the Glass in polymer matrix composites. It is advantage including its high strength, low cost, high chemical resistance and good insulating properties.

Also a very common fibers are Carbon fibers in the high-modulus and high-strength applications. The advantages of these carbon fibers including high specific strength and modulus, low coefficient of thermal expansion and high fatigue strength.

Third one is Aramid fiber and it is an aromatic organic compound made of carbon, hydrogen, oxygen and nitrogen. Its advantages are low density, high tensile strength, low cost and high impact resistance.

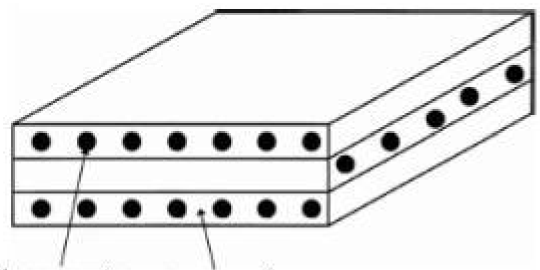

Fig1.3.Typical Laminate made of three laminate

D. Matrix

Use of fibers by themselves as matrix is limited, because of smaller dimensions. Therefore fibers are used as reinforcement to matrices. The role of matrix in a fiber – reinforced composite material is

To transfer stresses between the fiber.

To provide a barrier against an adverse environment.

To protect the surface of the fiber from mechanical abrasion.

The matrix plays a minor role in load carrying capacity. The matrix has a major influence on Inter laminar shear as well as in plane shear properties of the composite. Inter laminar shear strength is important in design under bending loads. In plane shear, strength is important in design under tensional loads. The matrix provides lateral support against the possibility of fiber buckling under compressive loads. Among the matrix materials epoxies are used because of commercial availability and ease of processing. The main reason why epoxy is the most used polymer matrix material is due to its Advantages over the other matrix:

Wide variety of properties available.

Absence of volatile maters during cure.

Low shrinkage during cure.

Excellent resistance to chemical and solvents.

Excellent adhesion to fibers.

The disadvantages are relatively high cost and long curing time.

E. Characteristics Of Composites Fiber Reinforced

Composite materials is given a combination of strength and elasticity that are better than conventional metallic materials. These are superior because properties like low specific gravities, high strength-weight ratios and high modulus-weight ratios. Conventional materials i.e. structural material such as mild steel and different alloys is considered isotropic since they exhibit nearly equal properties irrespective of the direction of measurement. In case of composite materials, mainly properties depend strongly on the direction of measurement. In composite material fiber reinforced composites have internal damping which leads to better vibration energy absorption within the material. Which results in reduced transmission of noise and vibrations to neighbouring structures? There are several characteristics that make composites different from many conventional materials.

F. Applications of Composite Materials

Mainly aircraft industry uses these composites to meet performance as per requirements beyond the capabilities of metals. Composites are also used in race cars, tennis rackets, golf clubs, and other sports and leisure products. Few more applications are given as below

1) Aircraft and military applications
2) Space applications
3) Automotive applications
4) Sporting goods applications
5) Marine applications Medical applications
6) Commercial goods an easy way to comply with IJRASET paper formatting requirements is to use this document as a template and simply type your text into it.

II. CONCLUSION

Undoubtedly, the use of composite material will be expanding as the demand for efficient storage of pressurized gases increases in a variety of commercial, aircraft, spacecraft, and transportation applications. Metal vessels have evolved from the time, well over a century ago, of exploding steam boilers to their mature and reliable technology today. Now composite material technology is continuing development to provide an increasing understanding of material characteristics and the resultant increasing composite material reliability. As this technology development continues, additional information will be available to aid in vessel material selection and design process to satisfy performance requirements for the intended application.

REFERENCES

[1] Alexis A. Krikanov., “Composite pressure vessels with higher stiffeness” 1999 Elsevier science Ltd. Composite structures, vol-48, pp 119-127 (2000).
[2] S.Adali, E.B. Summers & V.E. Verijenko., “Optimization of Laminated Cylindrical pressure vessels under strength criterion”, Composite structures, vol-25, pp 305-312 (1993), University of national Durban 4001, South Africa.
[3] Tae-Uk Kim.,Hvo-Chol Sin., “Optimal design of composite laminated plates with the discreteness in ply angles and uncertain in material properties considered”, Computers and Structures 79, pp 2501-2509, (2001).
[4] Levend Parnas., Nuran Katirei., “Design of Fiber-Reinforced Composite pressure vessels under various loading conditions”, Composite structures 58, pp 83-95 (2002).
[5] Graham J., “preliminary Analysis Techniques for Ring and Stringer Stiffened Cylindrical Shells,” NASA report TM-108399, March 1993.
[6] Phillips J.L., Gurdal Z.,“Structural Analysis and Optimum Design of Geodesically Stiffened Composite Panels,” NASA Report CCMS-90-05, July 1990.