# DESIGN AND FABRICATION OF HYDROSTATIC PRESSURE VESSEL

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**Abstract**

*For the strength of any material to be used in a certain machine the testing of particular is important. This governs the durability and robustness of the machine to be used for the prime requirement of the material. For many years different testing procedures have been adopted for the purpose using air pressure, ultrasonic method etc. but less is carried out using water pressure. This is because water when applied to high pressure does not change its volume hence, the output required is more accurate. So the idea of hydrostatic pressure vessel is bought out. The designing of the pressure vessel is made using a cylindrical vessel with a barometer connected to govern the pressure inside the cylinder. The vessel is made for the required dimensions for the purpose of testing. A composite material is used of the workpiece and its dimensional stability is to be governed.*

***Key words:*** *Pressure Vessel, Pressure gauge, water pipe, Control valve, Fatigue, Stress Concentration Factor, Fatigue Curve, Cumulative Usage Factor*.

## 1. INTRODUTION

Pressure vessel is reservoirs which have high pressurized fluid inside it. The pressure is variance between inside and outside of the container. The inside pressure is normally greater than the outside pressure .The fluid inside the vessel may undergoes change in state as in case of steam boiler ,or may combine with other substances as in the reservoir. The size and geometry from of pressure vessel are differs as per application. The large cylinder-shaped vessel used for high –pressure gas loading to the minor size used as hydraulic components for air craft

With increasing demands from industrial processes for higher operating pressures and higher temperature, new machineries have been industrialized to grip the present day specialized necessities. Multilayer Pressure Vessels have extended the art of pressure vessel structure and presented the process designer with a dependable portion of equipment useful in a wide range of operating circumstances for the problems generated by the storage of hydrogen and hydrogenation processes the term pressure vessel signified to those reservoirs or containers, which are subjected to internal or external pressures. The pressure vessels are used to store fluids under pressure.

## 2. OBJECTIVES

The process for producing a composite pressure vessel is termed filament winding. The techniques for filament-wound composite pressure vessel can be classified into two main types: geodesic winding and in-plane winding, which consist of three basic steps. First, the fibers are impregnated with a resin. To obtain good results, the impregnation must be done in a carefully controlled manner, by pulling the fibers through a basin filled with the resin. Then, by the use of a winding machine, the fibers are positioned onto a mandrel, which has the shape of the pressure vessel required. Finally, the wet fibers are removed from the winding machine and placed in an oven, where the resin is cured under well-defined conditions of temperature and time. Typical pressure vessels are generally designed with a central cylindrical section and two spherical end caps with optional polar openings. The relative dimensions of different sections of the vessel are designed according to the corresponding space and weight requirements and the pressure levels that the vessel is expected to withstand. Along with thickness and length dimensions, the shape of the end caps also plays a vital role in the design. This is due to the fact that the dome regions undergo the highest stress levels and are the most critical locations from the viewpoint of structure failure. The design concept requires that the pressure vessels provide extremely high efficiencies in meeting the overall yielding and buckling failure criteria. Moreover, the slippage tendency of the band at its edges must be taken into account, especially when utilizing the in-plane winding technique.

## 3. LITRATURE REVIEW

David Heckman [3] tested three dimensional, symmetric and axis symmetric models; the preliminary conclusion is that finite element analysis is an extremely powerful tool when employed correctly. Depending on the desired solutions, there are different methods that offers faster run times and less error. The two recommended methods included symmetric models using shell elements and axis symmetric models using solid elements. Contact elements were tested to determine their usefulness in modeling the interaction between pressure vessel cylinder walls and end caps. Yogesh Borse and Avadesh K. Sharma [4] present the finite element modeling and Analysis of Pressure vessels with different end connections i.e. Hemispherical, Ellipsoidal & Toro spherical. They describes its basic structure, stress characteristics and the engineering finite element modeling for analyzing, testing and validation of pressure vessels under high stress zones. Their results with the used loads and boundary conditions which remain same for all the analysis with different end connections shows that the end connection with hemispherical shape results in the least stresses when compared to other models not only at weld zone but also at the far end of the end-connection. A. J. Dureli (1973) presented work on the stresses concentration in a ribbed cylindrical shell with a reinforced circular hole subjected to internal pressure, by several experimental methods and the results obtained were compared with those corresponding to a non-reinforced hole in a ribbed and un-ribbed shell and also to a reinforced hole in an un-ribbed shell. From the result it was found that the maximum value of hoop stress, and longitudinal stress, in shells always occurred at the points $\theta = 0°$ and $\theta = 90°$, respectively, along the edge of the hole, $\theta$ being the angle measured clockwise from the longitudinal axis of the hole R. C. Gwaltney (1973) compared theoretical and experimental stresses for spherical shells having single non-radial nozzles. The stress distributions for radial and non-radial nozzle geometry are analyzed. Stress distributions for the non-radial and the radial nozzle attachments are quite similar but the non-radial nozzle configuration gave the maximum normalized stress, both theoretical and experimental, for internal pressure and for axial loads on the nozzles well as for pure bending moment loading in the plane of obliquity. M.A. Guerrer, C. Betego´n, J. Belzunce .

## 4. METHODOLOGY

**Fig.4.1 Vessel**

A hydrostatic test is a way in which pressure vessels such as pipelines, plumbing, gas cylinders, boilers and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurization of the vessel to the specified test pressure. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss. The location of a leak can be visually identified more easily if the water contains a colorant. strenght is usually tested by measuring permenant deformation of the container.

Hydrostatic testing is the most common method employed for testing pipes and pressure vessels. Using this test helps maintain safety standards and durability of a vessel over time. Newly manufactured pieces are initially qualified using the hydrostatic test. They are then re-qualified at regular intervals using the proof pressure test which is also called modified hydrostatic test. (citation needed) (clarification needed). Testing of pressure

**Fig.4.2 Pressure cylinder**

vessels for transport and storage of gases is very important because such containers an explode if they fail under pressure. This project is proposed to analyses and design a cylindrical pressure vessel made up of composite material. The new composite material considered is wispily.

In today's aviation brass is the major element used for construction of pressure vessels .It has high mingling properties which provide various properties. But Brass has many disadvantages like getting deformed, bursting, hydraulic failure and pneumatic failure. The design features focus on providing high fuel efficiency, reduction of bursting of pressure vessels in aircrafts. Pressure vessels have been manufactured by filament winding for a long time. Although they appear to be simple structures, pressure vessels are difficult to design. The advantages are superior specific strength and stiffness, resulting in a lighter design. This makes the use of fiber reinforced composites ideally suited for applications where a pressure vessel must withstand high internal pressure along with axial, bending, and shear loads. In certain applications, significant loads are imparted to composite pressure vessels due to accelerations caused by transportation and handling operations. This project will present the development, application and results of this new composite material which shows better performance.

# 5 COMPONENTS

## 1) Pressure vessel

Pressure vessels used in industry areleak-tight pressure containers, usually cylindrical or spherical in shape, with different head configurations. They are usually made from carbon or stainless steel and assembled by welding. Early operation of pressure vessels and boilers resulted in numerous explosions, causing loss of life and considerable property damage Some 80 years ago, the American Society of Mechanical Engineers formed a committee for the purpose of establishing minimum safety rules of construction for boilers. In 1925 the committee issued a set of rules for the design and construction of unfired pressure vessels. Most states have laws mandating that these Code rules be met. Enforcement of these rules is accomplished via a third party employed by the state or the insurance company. These Codes are living documents in that they are constantly being revised and updated by committees composed of individuals knowledgeable on the subject. Keeping current requires that the revised Codes be published every three years with addendas issued every year. This chapter covers a very generalized approach to pressure vessel design based on the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1: Pressure Vessels.

**Fig.5.1.1 .Pressure vessel**

**2) Control valve**

Control valves automatically regulate pressure and/or flow rate, and are available for any pressure. If different plant systems operate up to, and at pressure/temperature combinations that require Class 300 valves, sometimes (where the design permits), all control valves chosen will be Class 300 for interchange-ability. However, if none of the systems exceeds the ratings for Class 150 valves, this is not necessary. The most common final control element in the process control industries is the control valve. The control valve manipulates a flowing fluid, such as gas, steam, water, or chemical compounds, to compensate for the load disturbance and keep the regulated process variable as close as possible to the desired set point. Control valves may be the most important, but sometimes the most neglected, part of a control loop.

The reason is usually the instrument engineer's unfamiliarity with the many facets, terminologies, and areas of engineering disciplines such as fluid mechanics, metallurgy, noise control, and piping and vessel design that


**Fig.5.1.2 Control valve**

can be involved depending on the severity of service conditions. Any control loop usually consists of a sensor of the process condition, a transmitter and a controller that compares the "process variable" received from the transmitter with the "set point," i.e., the desired process condition. The controller, in turn, sends a corrective signal to the "final control element," the last part of the loop and the "muscle" of the process control system. While the *sensors* of the process variables are the eyes, the *controller* the brain, then the *final control element* is the hands of the control loop. This makes it the most important, alas sometimes the least understood, part of an automatic control system. This comes about, in part, due to our strong attachment to electronic systems and computers causing some neglect in the proper understanding and proper use of the all important hardware.

**3) Pressure gauge**

Pressure measurement is the analysis of an applied force by a fluid (liquid or gas) on a surface. Pressure is typically measured in units of force per unit of surface area. Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called pressure gauges or vacuum gauges. A manometer (not to be confused with nanometer) is a good example, as it uses a column of liquid to both measure and indicate pressure. Likewise the widely used Bourdon gauge is a mechanical device, which both measures and indicates and is probably the best known type of gauge. A vacuum gauge is a pressure gauge used to measure pressures lower than the ambient atmospheric pressure, which is set as the zero point, in negative values (e.g.: −15 psig or −760 mmHg equals total vacuum).


**Fig.5.3.1 Pressure gauge**

Most gauges measure pressure relative to atmospheric pressure as the zero point, so this form of reading is simply referred to as "gauge pressure". However, anything greater than total vacuum is technically a form of pressure. For very accurate readings, especially at very low pressures, a gauge that uses total vacuum as the zero point may be used, giving pressure readings in an absolute scale. Other methods of pressure measurement involve sensors that can transmit the pressure reading to a remote indicator or control system.

**4) Water pipe**

Plumbing is any system that conveys fluids for a wide range of applications. Plumbing uses pipes, valves, plumbing fixtures, tanks, and other apparatuses to convey fluids. Heating and cooling (HVAC), waste removal, and potable water delivery are among the most common uses for plumbing, but it is not limited to these applications. The word derives from the Latin for lead, *plumbum*, as the first effective pipes used in the Roman era were lead pipes. In the developed world, plumbing infrastructure is critical to public health and sanitation.

**Fig.5.4.1 Water pipe**

Boilermakers and pipefitters are not plumbers, although they work with piping as part of their trade, but their work can include some plumbing.

**5) Deflection gauge**

We supply a wide range of deflection gauge extensometers ideal for measuring deformation in three and four point bend tests and in compression testing applications. In various contexts of science, technology, and manufacturing an indicator is any of various instruments used to accurately measure small distances and angles, and amplify them to make them more obvious. The name comes concept of indicating to the user that which their naked eye cannot discern; such as the presence, or exact quantity, of some small distance. The internal works of a mechanical dial indicator are similar to the precision clockworks of a mechanical wristwatch, employing a rack and pinion gear to read the probe position, instead of a pendulum escapement to read time. Since the mechanisms are necessarily delicate, rugged framework

**Fig.5.5.1 Dial gauge**

construction is required to perform reliably in harsh applications such as machine tool metalworking operations, similar to how wristwatches are ruggedized.

**6) Plumping joints**

A fitting is used in pipe systems to connect the straight pipe or tubing sections, adapt to different sizes or shapes and for other purposes, such as regulating fluid flow. "Plumbing" is generally used to describe the conveyance of water, gas, or liquid waste in domestic or commercial environments; "piping" is often used to describe the high-performance conveyance of fluids in. Specialized applications."Tubing" is sometimes used for lighter-weight piping, especially that flexible enough to be supplied in coiled form. Fittings (especially uncommon types) require money, time, materials and tools to install, and are an

important part of piping and plumbing systems. [1] Valves are technically fittings, but are usually discussed separately. A coupling connects two pipes. If their sizes differ, the fitting is known as a reducing

coupling, reducer, or an adapter. There are two types of couplings: "regular" and "slip". A regular coupling has a small ridge or stop internally, to prevent over-insertion of a pipe, and thus under-insertion of the other pipe

**Fig.5.6.1 Plumping joint**

segment (which would result in an unreliable connection). A slip coupling (sometimes also called a repair coupling) is deliberately made without this internal stop, to allow it to be slipped into place in tight locations, such as the repair of a pipe that has a small leak due to corrosion or freeze bursting, or which had to be cut temporarily for some reason. Since the alignment stop is missing, it is up to the installer to carefully measure the final location of the slip coupling to ensure that it is located correctly.

**7)Solid plate**

Solid is one of the four fundamental states of matter (the others being liquid, gas, and plasma). In solids molecules are closely packed. It is characterized by structural rigidity and resistance to changes of shape or volume. Unlike liquid, a solid object does not flow to take on the shape of its container, nor does it expand to fill the entire volume available to it like a gas does. The atoms in a solid are tightly bound to each other, either in a regular geometric lattice (crystalline solids, which include metals and ordinary ice) or irregularly (an amorphous solid such as common window glass)

**Fig.5.6.1 Solid plate**

Solids cannot be compressed with little pressure whereas gases can be compressed with little pressure because in gases molecules are loosely packed. The branch of physics that deals with solids is called solid-state physics, and is the main branch of condensed matter physics (which also includes liquids). Materials science is primarily concerned with the physical and chemical properties of solids. Solid-state chemistry is especially concerned with the synthesis of novel materials, as well as the science of identification and chemical composition.

## 6. PROPERTIES

1. Due to the fundamental nature of fluids, a fluid cannot remain at rest under the presence of a shear stress.
2. If a point in the fluid is thought of as an infinitesimally small cube, then it follows from the principles of equilibrium that the pressure on every side of this unit of fluid must be equal.
3. If this were not the case, the fluid would move in the direction of the resulting force. Thus, the pressure on a fluid at rest is isotropic; i.e., it acts with equal magnitude in all directions.
4. A pressure vessel is a container designed to hold gases or liquids at a pressure substantially different from the ambient pressure.
5. As the pressure vessel is designed to a pressure, there is typically a safety valve or relief valve to ensure that this pressure is not exceeded in operation
6. Pressure vessel closures are pressure retaining structures designed to provide quick access to pipelines, pressure vessels, pig traps, filters and filtration systems. Typically pressure vessel closures allow maintenance personnel.

## 7. Results

- From the analyzed results it is clear that the new composite material has better performance results than brass.
- The displacement variation is much less in wispily than brass.
- Reaction force of brass and wispily is almost equal.
- Vanishes stress variation is lesser for wispily.

## CONCLUSION

Structural Composites Industries has developed, qualified, and delivered a number of high performance composite wrapped pressure vessels for use in military aircraft where low weight, low cost, high operating pressure and short lead time are the primary considerations. This paper describes product design, development, and qualification for a typical program. The vessel requirements included a munitions insensitivity criterion as evidenced by no fragmentation following impact by a .50 cal tumbling bullet. This was met by the development of a carbon-Spectra hybrid composite overwrap on a thin-walled seamless nickel liner. The same manufacturing, inspection, and test processes that are used to produce lightweight, thin walled seamless aluminum lined carbon/epoxy overwrapped pressure vessels for satellite and other space applications were used to fabricate this vessel.

This report focuses on the results of performance in the qualification testing. Thus the assumed results are got. When comparing wispily and brass; wispily shows better performance results. In future we have to study about analysis of the axial displacement of the pressure vessel, material collection with less cost and a real time model with the assumed dimensions and testing of the model.

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