

## GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES STRUCTURAL AND THERMAL ANALYSIS OF PRESSURE VESSEL

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### ABSTRACT

A pressure vessel is an instrumentation to contain things at higher pressure this implies that it will withstand greater pressure than traditional amounts of pressure while not exploding. pressure vessels are used to contain a large number of things, as well as air, water, chemicals, nitrogen, and fuel. they're employed in paper and pulp, energy, food and potable and chemical industries. since the pressure within the vessel is high, it's too with stand each thermal also as structural. the aim of this project is to try to analysis on the pressure vessel whose sole purpose is to resist the pressure of the substance keep in it. modeling has been designed in creo 3.0 and analysis is been done using ansys15.0.

**Keywords:** Pressure vessel, High pressure, Analysis, Ansys15.0.

### I. INTRODUCTION

A pressure vessel is a closed vessel designed to carry gases or liquids at a pressure well totally different from the ambient pressure. The pressure differential is dangerous and fatal accidents have occurred within the history of pressure vessel development and operation. Consequently, pressure vessel design, manufacture, and operation are regulated by engineering authorities backed by legislation. For these reasons, the definition of a pressure vessel varies from country to country, however involves parameters like most safe operative pressure and temperature. Vessels often have a combination of high pressure together with high temperature and in few of the cases flammable fluids or highly radioactive material. Due to such hazards it is imperative that the design should be leakage proof. Pressure vessel and tank are generally very essential in the industries like chemical, petroleum, petrochemical and nuclear industry. It is in the class of equipment that the reaction, separation and storage of raw material occur. The pressure vessels, when empty are subjected to atmospheric pressure internally as well as externally. So the resultant pressure on the walls of vessel is nil. The component placed in the pressure vessel may fail in service when subjected to an excessively high internal fluid pressure. Pressure vessels are used in a variety of applications in both industry and the private sector. They are generally used in these sectors as industrial pressurized air receivers and domestic storage tanks for hot water. Similarly other cases of pressure vessels are diving cylinders, recompression vessels, distillation towers, pressure reactors, autoclaves, and many other vessels in mining operations, oil refineries and petrochemical plants, nuclear reactor vessels, submarine and space ship habitats, pneumatic reservoirs, hydraulic reservoirs under pressure, rail vehicle airbrake reservoirs, road vehicle air brake reservoirs, and storage vessels for liquefied gases such as ammonia, chlorine, propane, butane, and LPG. Pressure vessels can theoretically be almost any shape, but shapes made of sections of spheres, cylinders, and cones are usually employed. A common design is a cylinder with end caps called heads. Head shapes are frequently either hemispherical or dished (torispherical). More complicated shapes have historically been much harder to analyze for safe operation and are usually far more difficult to construct. The need of extremely high pressure and temperature vessels for petroleum refineries and chemical plants gave rise to vessels joined with welding rather than rivets (which were unsuitable for the pressures and temperatures required) and in 1920s and 1930s the BPVC included welding as a suitable means of construction, and welding is the main means of joining metal vessels today.

### II. METHOD & MATERIAL

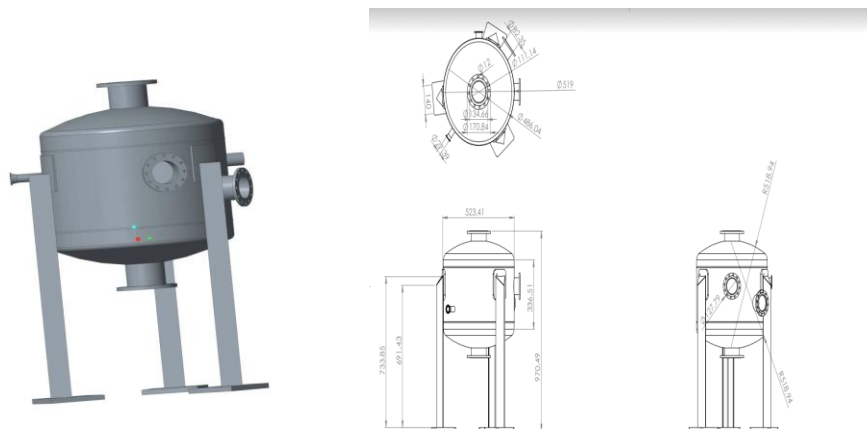
Nitin Deshmukh et al carried-out analysis on pressure vessel. Material used in this carbon steel according to ASTM standards. The design of pressure vessel is initialized with the specification requirements in terms of standard

technical specifications along with numerous requirements that lay hidden from the market. The design of a pressure vessel is more of a selection procedure, selection of its components to be more precise rather designing each and every component. The pressure vessel components are merely selected, but the selection is very critical, a slight change in selection will lead to a different pressure vessel altogether from what is aimed to be designed. Somnath Chattopadhyay discussed about material selection for pressure vessel that carbon steels and stainless steel are the materials used for pressure vessels. In addition, they are designed to safety to leak before break (LBB). LBB describes the situation in which a leak occurs before a complete double-ended break of a component. Ductile and tough materials are widely used in nuclear pressure vessels, because of their high resistance to catastrophic rupture. The design process involves fatigue analysis to demonstrate that there is insignificant crack growth a postulated surface crack during the entire design life. However, in terms of LBB the significant parameter is the elastic-plastic fracture toughness, and the material strength. However, based on assessment based on linear elastic fracture mechanics, the candidate materials are carbon steels, low alloy steels and stainless steels, which interestingly are the materials that are used for pressure vessels. In terms of the fatigue crack initiation, the appropriate parameters are the threshold stress intensity factor range and the endurance limit, and the material selection is based on these parameters.

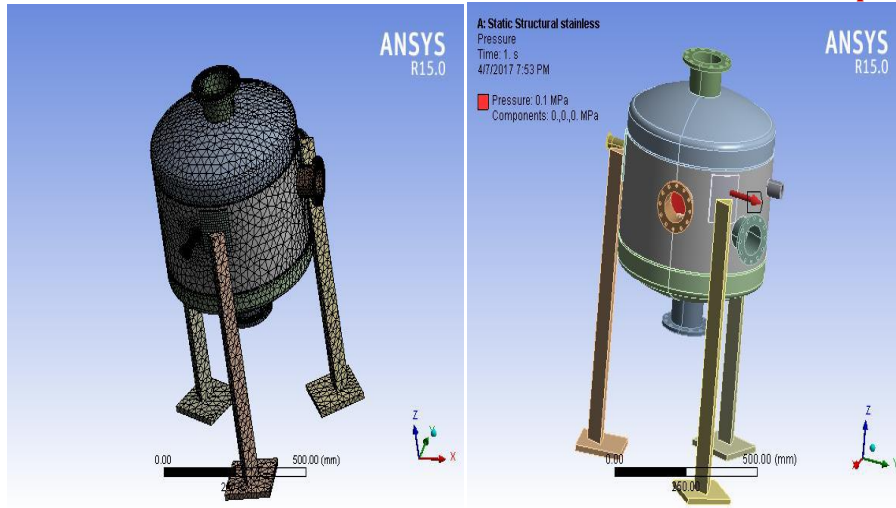
B.S. Thakkur et al carried out designing of pressure vessel and material used is carbon steel. In this high pressure rise is developed in the pressure vessel and pressure vessel has to withstand severe forces. So, the selection of pressure vessel is most critical. That's why we can say that pressure vessel is the heart for storage of fluid. Pressure vessel must pass series of Hydrostatic tests. These tests examine the ability of the structure to withstand various pressures to see if protective zone around the operator station remains intact in an overturn. The structure is to be designed, fabricated, fitted and checked as per ASME standard. Plant safety and integrity are of fundamental concern in pressure vessel design and these of course depend on the adequacy of design codes. The performance of a pressure vessel under pressure can be determined by conducting a series of tests to the relevant ASME standard.

### III. MATERIALS USED AND THEIR PROPERTIES

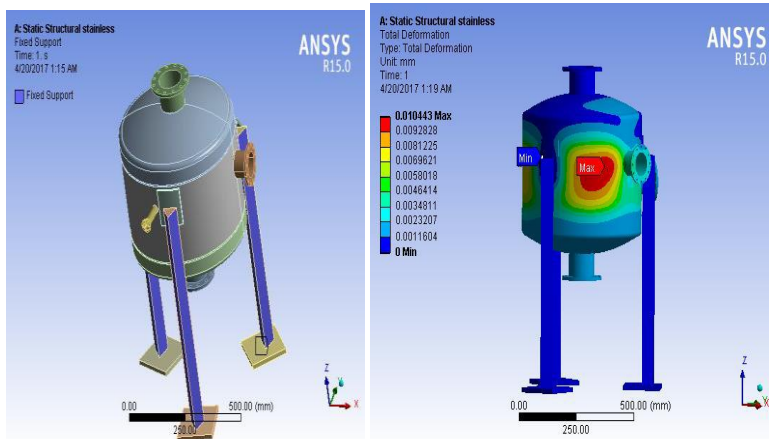
1. Carbon steel (0.14-0.20% C, 0.60-0.9% Mn, 98.81-99.26% Fe)
2. Stainless steel (0.12% C, 1% Mn, 16-18% Cr)
3. Gray Cast iron (1.4-4.3% C, 0.3-5% of Si, Mn, S and P)



*Assembly of pressure vessel Dimensions of blow down vessel*

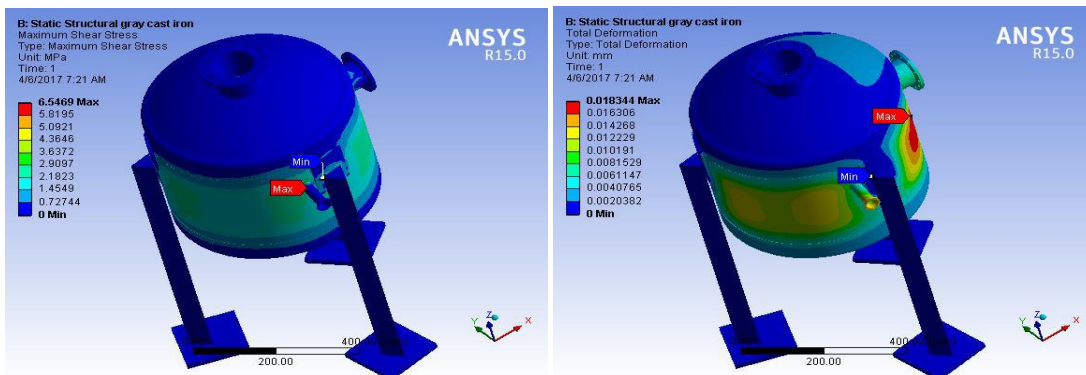


*Boundary condition of pressure*



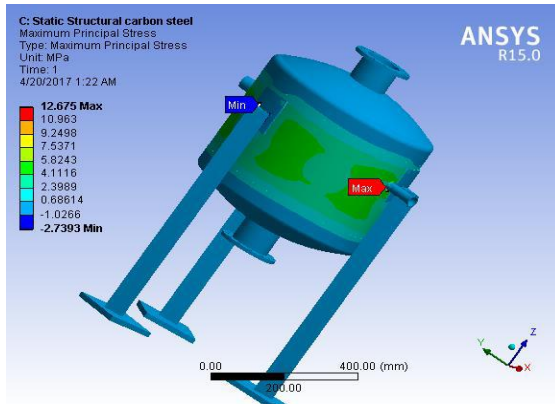
*Boundary condition or fixed support*

*Deformation for stainless steel*

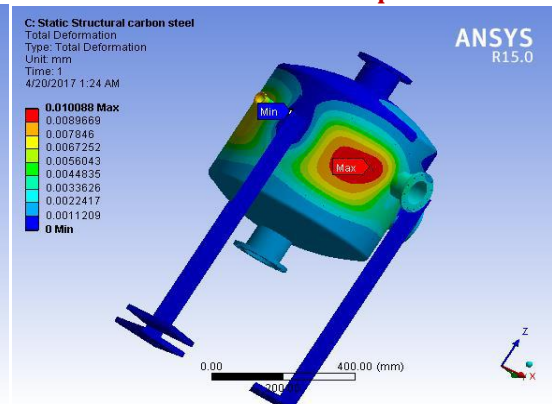


*Stress for gray cast iron*

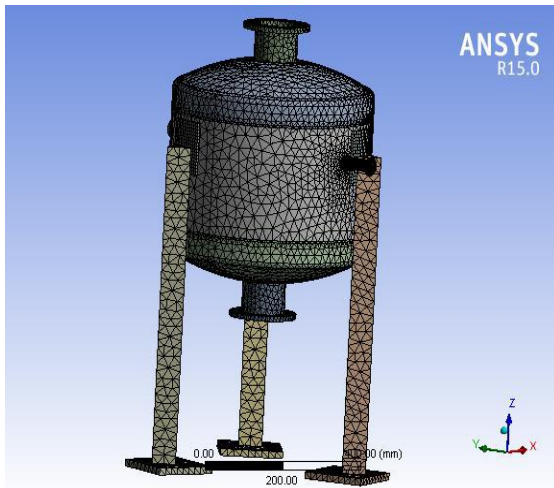
*Deformation for gray cast iron*



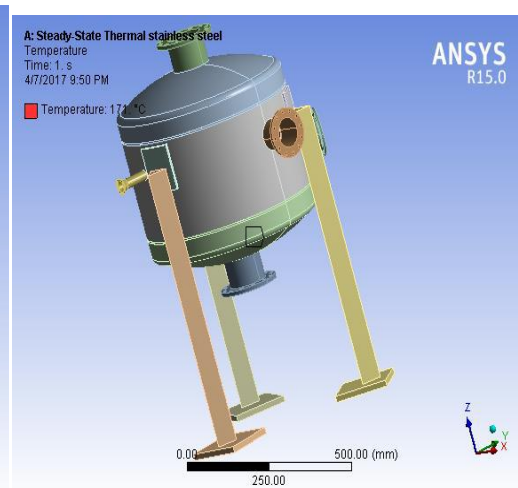
*stress for carbon steel*



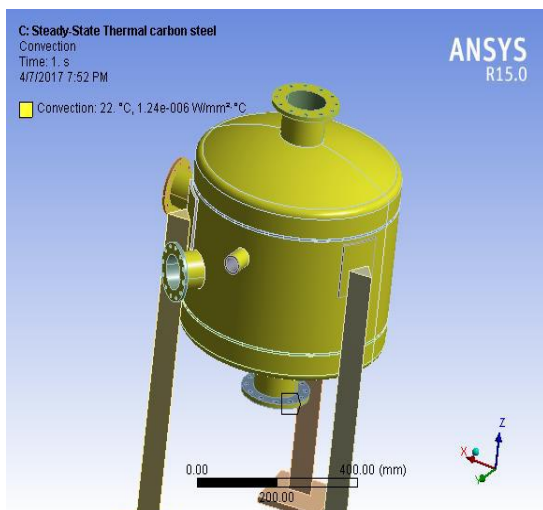
*Deformation for carbon steel*



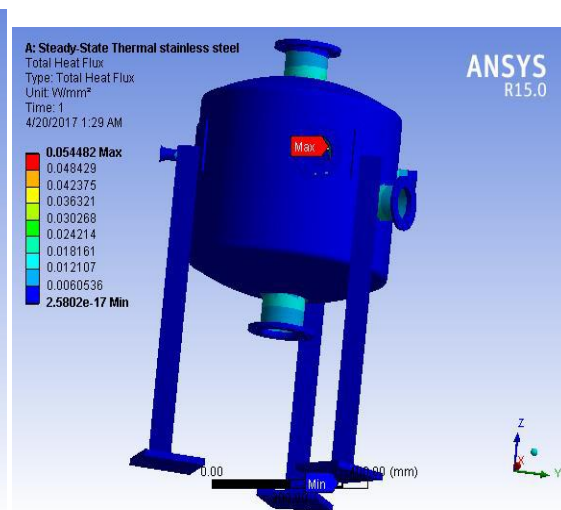
*Meshing in thermal analysis*



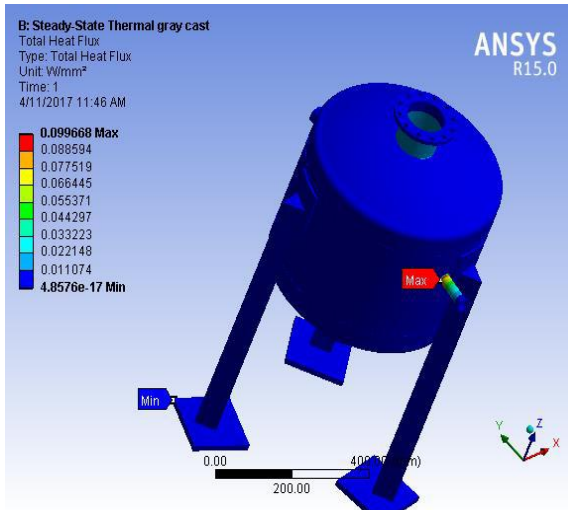
*Boundary condition of temperature*



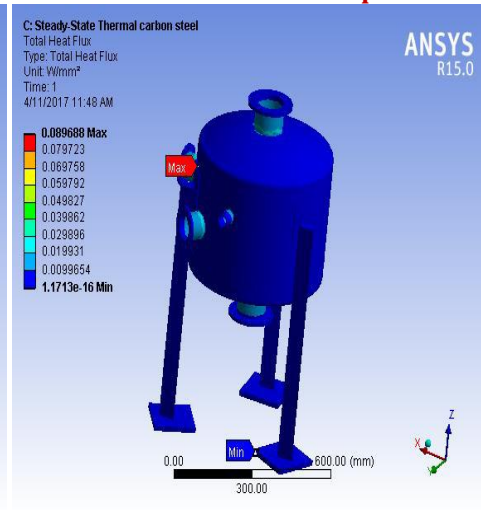
*Boundary condition of convection*



*Heat flux for stainless steel*



Heat flux for gray cast iron



Heat flux for carbon steel

#### IV. OTHER SECTIONS

##### Pressure vessels importance and accidents

Lethal result may occur if the design or conditions for the pressure vessels are not the correct ones, which is why a regulating committee of engineers was created to avoid such cases. They make sure that legislation for the specific country is being followed. It is being known from past that many pressure vessel lethal cases have happened, among them the most important issues for the design is safety, the pressure release system, the installment, etc. Those pressure vessels have botched without any word of warning, creating fatal project-outs. They are known as high energy storage containers.

The majority of accidents have happened for the reason that of a mistake of the engineers in the pressure release system, that couldn't handle a high amount of pressure, or the usage of an improper container as a pressure vessel, without being certified or inspected. Also, the inappropriate welding of a vessel in 2004 of a 50.000lb resulted in a fierce blast in a chemical plant, since it was modified by the company illegally, by highly decreasing the strength, due to which projected pieces of the vessel flew up to 1000ft away.

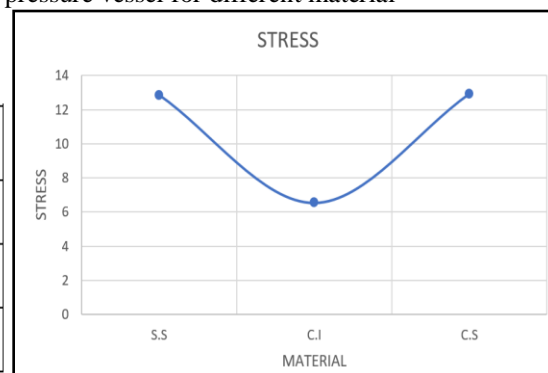
#### V. RESULT & DISCUSSION

##### Stresses in pressure vessel

At Pressure 0.1MPa Stress in the pressure vessel for different material

MATERIAL	STRESS(MPa)
Stainless steel(S.S)	12.844
Cast iron(C.I)	6.5469
Carbon steel(C.S)	12.905

Heat flux for carbon steel



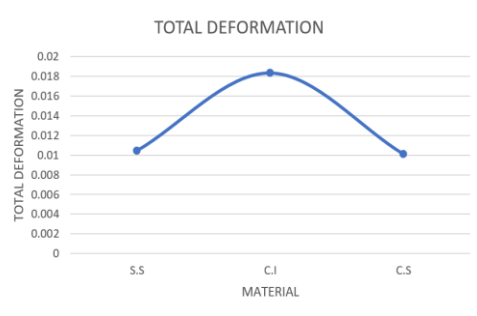
Stress vs materials

From the above graph , it is known that carbon steel has maximum stress and gray cast iron has minimum because carbon steel is more ductile where gray cast iron is brittle.

**Total deformation in pressure vessel**

At Pressure 0.1MPa Deformation in the pressure vessel for different material

MATERIAL	TOTAL DEFORMATION(mm)
Stainless steel(S.S)	0.010443
Cast iron(C.I)	0.018344
Carbon steel(C.S)	0.010088



*Graph of total deformation & material*

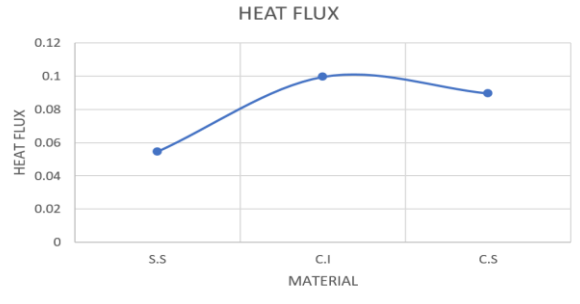
From the above graph , it is known that gray cast iron has more deformation whereas carbon steel having lowest deformation because carbon steel is ductile whereas gray cast iron is brittle.

**Heat Flux in Pressure Vessel**

At temperature 171°C Heat flux in pressure vessel of different materials

Table: values of heat flux

MATERIAL	HEAT FLUX(W/ mm <sup>2</sup> )
Stainless steel(S.S)	0.054482
Cast iron(C.I)	0.099668
Carbon steel(C.S)	0.08968



*Variation Heat flux with material*

From the above graph 6.3, it is known that stainless steel has less heat flux whereas gray cast iron has more heat flux because thermal conductivity of stainless steel has less thermal conductivity whereas gray cast iron has high thermal conductivity.

**Comparing the values of the materials:**

*Table: Comparison of values*

MATERIAL	STRESS(MPa)	TOTAL DEFORMATION(MM)	HEAT FLUX(W/ mm <sup>2</sup> )
Stainless steel(S.S)	12.844	0.010443	0.054482
Cast iron(C.I)	6.5469	0.018344	0.099668
Carbon steel(C.S)	12.905	0.010088	0.08968

## VI. CONCLUSION

- The stress of stainless steel, gray cast iron and carbon steel of pressure vessel are 12.844, 6.546, and 12.90 M Pa respectively.
- The total deformation of stainless steel, gray cast iron and carbon steel of pressure vessel are 0.010443, 0.018344 and 0.010088 mm respectively.
- The heat flux of stainless steel, gray cast iron and carbon steel of pressure vessel are 0.054482, 0.099668, and 0.089080 w/mm<sup>2</sup> respectively.
- By comparing three materials gray cast iron and carbon steel has less stress and deformation respectively
- By comparing the heat flux of three materials stainless steel has less heat flux.
- When considering high pressure vessel gray cast iron and carbon steel are good compared with stainless steel.
- When considering high temperature in the pressure vessel stainless steel is good when compared with gray cast iron and carbon steel.

## VII. ACKNOWLEDGEMENTS

With great pleasure we want to take this opportunity to express our heartfelt gratitude to all the people who helped in making this project work a grand success.

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