Optimization of Reciever Tank Thickness used in Reciprocating Air Compressor

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***Abstract*—This technical paper presents design, and analysis of pressure vessel. High pressure rise is developed in the pressure vessel and pressure vessel has to withstand severe forces. In the design of pressure vessel safety is the primary consideration, due the potential impact of possible accident. There is real problem of industry which using 14 mm thickness plate for designing air receiver in two stage reciprocating air compressor. Thickness is optimized by using analytical method and Ansys software.**

***Keywords*— Pressure vessel, ANSYS.**

I. INTRODUCTION

Tanks, vessel and pipelines that carry, store or receive flu-ids are called pressure vessel. A pressure vessel is defined as a container with a pressure differential between inside and outside. The inside pressure is usually higher than the out-side. The fluid inside the vessel may undergo a change in state as in the case of steam boiler or may combine with oth-er reagent as in the case of chemical reactor. Pressure vessel often has a combination of high pressure together with high temperature and in some cases flammable fluids or highly radioactive material. Because of such hazards it is impera-tive that the design be such that no leakage can occur. In addition vessel has to be design carefully to cope with the operating temperature and pressure[1]

An air compressor is a device that converts power (usually from an electric mo-tor, a diesel engine or a gasoline engine) into potential energy by forcing air into a smaller volume and thus increasing its pressure. The energy in the compressed air can be stored while the air remains pressurized. The energy can be used for a variety of applications, usually by utilizing the kinetic energy of the air as it is depressurized.

Double stage or two stage reciprocating air compressors consists of two cylinders. One is called low pressure cylinder and another is called high pressure cylinder.

Suction valves of high pressure cylinder opens when air pressure in high pressure side is below to the receiver pressure & air from low pressure cylinder drawn into high pressure cylinder.

II. RECEIVER TANK

A pressure vessel is a closed container designed to hold gases or liquids at a pressure substantially different from the ambient pressure. Maintaining the Integrity of the Specifications.

Based on wall thickness pressure vessels can be classified as:

- Thin Walled Pressure Vessels
- Thick Walled Pressure Vessels

Design of receiver tank is based on thick walled pressure vessel, so in a Thick Walled Pressure Vessel:

- Yield strength is a continuous function of radius.
- Radial stress is present, in addition to hoop stress and longitudinal stress.
- The thick walled pressure vessel requires very high tensile strength.
- No Buckling effects which arise in thin walled pressure vessels are countered with pressure vessels having thick walls.
- Failure points can be foreseen in thick pressure vessels. Nevertheless, the fail-ure would be along the longitudinal direction.

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III. SRESSES IN THICK WALLED CYLINDERD.

Thick-wall theory is developed from the theory of elasticity which yields the state of stress as a continuous function of radius over the pressure vessel wall. The state of stress is defined relative to a convenient cylindrical coordinate system.

σt - Tangential Stress

σr - Radial Stress

σl - Longitudinal Stress

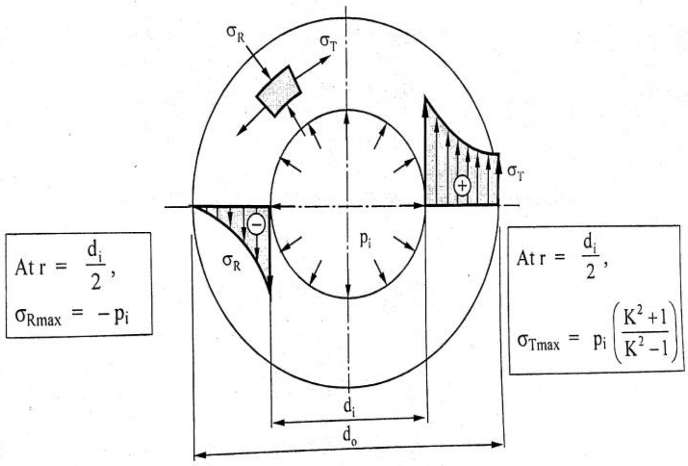

Fig.1 Tangential Stress and Radial Stress Stress Equations:

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$$\sigma_T = \frac{p_i}{(K^2-1)}\left(1+\frac{d_0^2}{4r^2}\right)$$

$$\sigma_R = \frac{-p_i}{(K^2-1)}\left(\frac{d_0^2}{4r^2}-1\right)$$

[2]

Specification of Air Compressor:

Air Compressor	Reciprocating Type
Motor	20 HP
No. of Cylinders	2
No. of Stages	2
FAD(cfm)	32
Minimum Pressure	35 Bar
Maximum Pressure	50 Bar
Air Receiver Capacity	500 Ltr.

Air Reservoir Tank Specifications:

Material	Mild Steel
Capacity	500 ltr
Overall Length	1625 mm
Tank Diameter	610 mm
No. of Ports	6

IV MODELING

The design of receiver tank was done. So after designing, modeling of parts has been done in Pro-Engineering software.

Following Fig.1 is assembly of Air receiver.

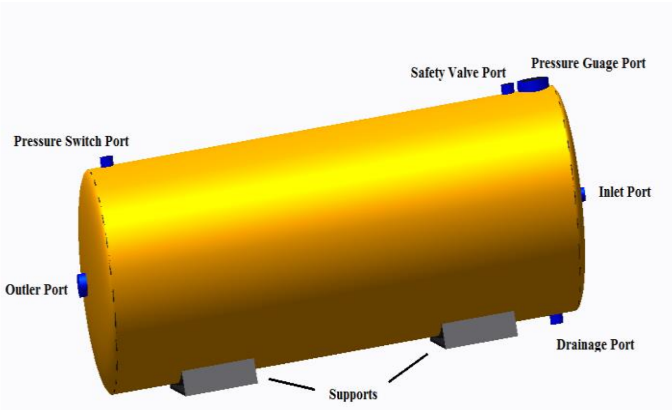

Fig.2 Modeling of Air Receiver:

V. FEM ANALYSIS:

The finite element method is a numerical method that can be used for the accurate solution of complex engineering problems. The basic idea in the finite element method is to find the solution of a complicated problem by replacing it by a simpler one. Since the actual problem is replaced by a simpler one in finding the solution, we will be able to find only an approximate solution rather than the exact solution.

Finite Element Analysis was done in ANSYS software.

Fig.2 shows boundary condition of vessel, it is fourth part of total vessel for that symmetric condition has been used to analysis so it can be saved computation time.

For mashing quadratic plane element is used. Arrow indicated pressure distribution on entire surface.

In 2D analysis, plain strain condition is use, based on that strain along longitudinal direction remain constant, so instead of taking 3D vessel it can be analyzed based on 2D, so computational time can be saved.

Fig.3,4 and 5 shows Maximum Principal stress result of different thickness of 12 mm, 10mm and 14 mm.

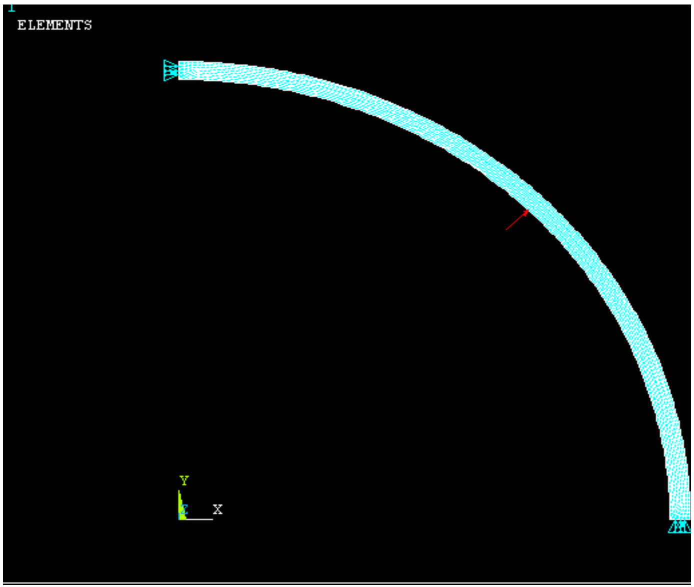

Fig.3 Mesh Model and Boundary condition [5]

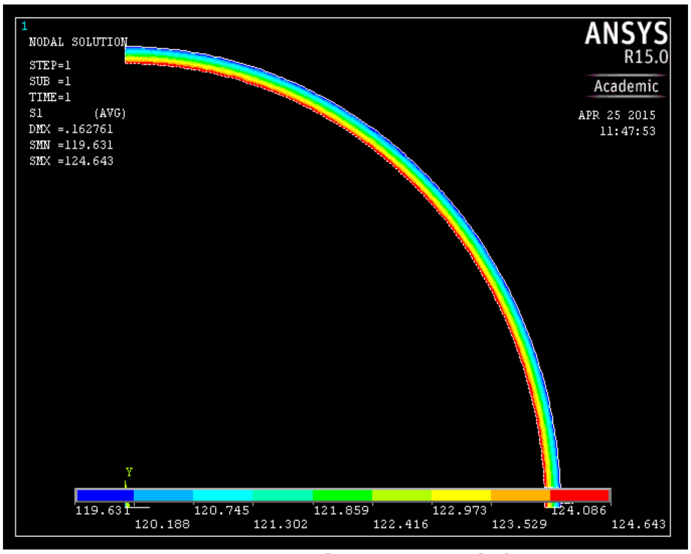

Fig.4 Maximum Principal Stress (12 mm Thickness)

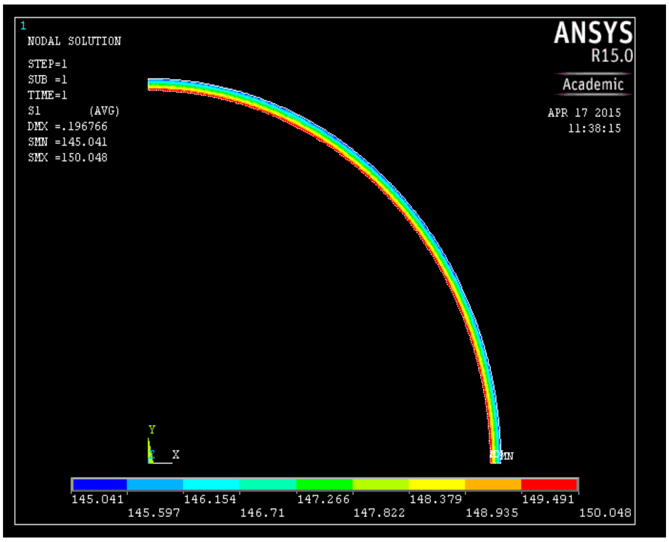

Fig.5 Maximum Principal Stress (10 mm Thickness)

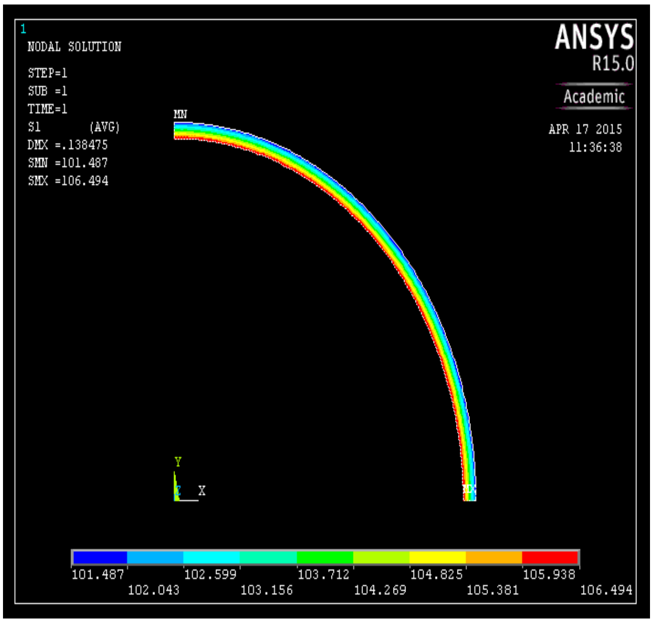

Fig.6 Maximum Principal Stress (14 mm Thickness)

ANSYS software calculations TABLE1*:*

Cylinder Thickness (mm)	**Stresses**		
	Max.Principal stress (MPa)	***Yield Strength (MPa)***	***Factor of safety***
10	150.48	250	1.66
12	124.64	250	2.01
14	106.6	250	2.31

Theoretical Calculation:

Maximum Principal Stress is given by the following equation:

$$\sigma_T = \frac{p_i}{(K^2-1)}\left(1+\frac{d_0^2}{4r^2}\right)$$

$$\sigma_{T\max} = p_i\left(\frac{K^2+1}{K^2-1}\right), \qquad K = \frac{d_0}{d_i}$$

d_0 = outer diameter of vessel

1) thickness =10 mm, K=1.033,

$$\sigma_{T\max} = 149.92MPa$$

2) thickness =12 mm, K=1.040,

$$\sigma_{T\max} = 127.54MPa$$

3) thickness =12 mm, K=1.048

$$\sigma_{T\max} = 107.06MPa$$

Theoretical Calculation TABLE 2:

Cylinder Thickness (mm)	**Stresses**		
	Max.Principal stress (MPa)	***Yield Strength (MPa)***	***Factor of safety***
10	149.92	250	1.66
12	127.54	250	1.96
14	107.06	250	2.33

CONCLUSION:

Comparison TABLE 3

Cylinder Thickness (mm)	**Stresses**		
	Max.Principal stress (MPa)	***Max.Principal stress (MPa)***	***Yield Strength (MPa)***
10	150.48	149.92	250
12	124.64	127.54	250
14	106.6	107.06	250

From table we can conclude that software and theoretical result match with each other and it is below yield strength of material.

By taking factor of safety 2 we can select 12 mm thickness plate for making of receiver tank of air compressor, so that we can reduce thickness from 14 mm to 12 mm.

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[5] ANSYS 15.