DESIGN AND STRESS ANALYSIS OF HIGH PRESSURE ACCUMULATOR

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***Abstract* -** The Main Objective of the project is to reduce to use of the pump for the descaling purposes thus the accumulator is used instead of pumps the main purpose of the accumulator is to store the 250 bar water with pressurized air, whenever we required high volume and high pressure water it will deliver from accumulator to descaling system. From this reason the designing of the high pressure accumulator as to be done. By this we can save the buying high volume & high pressure pumps, so that we can save the 160KW power 3 times and also cost can be reduce by using this mechanism.

Keywords: *Designing of accumulator, stress finding for different thickness (20mm, 30mm, 35mm, and 55mm), strain and displacement.*

I. INTRODUCTION

A hydraulic accumulator is a device in which potential energy is stored in the form of a compressed gas or spring, or by a raised weight to be used to exert a force against a relatively incompressible fluid[2].

They are used in fluid power systems to accumulate energy and to smooth out pulsations. A hydraulic system utilizing an accumulator can use a smaller fluid pump since the accumulator stores energy from the pump during low demand periods. This energy is available for instantaneous use, released upon demand at a rate many times greater than could be supplied by the pump alone.

Accumulators can also act as surge or pulsation absorbers, much as an air dome is used on pulsating piston or rotary pumps. They will cushion hydraulic hammer, reducing shocks caused by rapid operation or sudden starting and stopping of power cylinders in a hydraulic circuit.

A. Background & Motivation

Before thought of designing an accumulator, As they was using direct descaling in which they didn't get that much of flow i.e.330lpm.I thought of storing that in a we vessel so that we can get a desired pressure as well as flow. Even though we were facing the same problem. Finally we thought of designing the hydraulic accumulator in which will get a flow of 330lpm with a pressure of 250-300bar without using additional pump which might reduce the additional pump setup cost ,operating cost as well as maintenance cost[1]. In addition to this they have to spend man power and money for maintenance of separate pumping system in operation, this found them for laborious job.

As per the study we had gone with the descaling process which will be required in most of the steel plant so as to remove the layer of iron-oxide from the billets/slab. The oxidation of slabs in the reheating furnace is the first and determining process of the scaling of hot rolled flat products. The structure of the scale formed during reheating and the width of the internal oxidation zone are not only influenced by the heating parameters, but also by the chemical composition of the steel.

The prime scale formed on the slab has to be efficiently removed by hydraulic descaling. Previous studies showed that, under mechanical descaling conditions, the entanglement that arose at the steel-scale interface was in fact effective to maintain steel-scale adhesion. Descaling proceeds by fracture along chromite layers, which formed on the austenite grain boundaries; for this steel, the extend of descaling depended most strongly on austenite grain structure and the presence of un oxidized metal tendrils at the interface and not primarily on the conditions in the reheating furnace.

II. METHODOLOGY

Considering the specification for the accumulator design

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Calculating the total volume of the accumulator

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Selecting the material for the accumulator

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Calculating equivalent hoop stress and longitudinal stress

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Modelling the accumulator using SOLIDWORKS software

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meshing of the accumulator for different thickness

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Analysis of the model using SOLIDWORKS software

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Result and discussion

The methodology in this work involves the calculation of accumulator parameters. The model, meshing and analysis is done by using SOLIDWORKS software.

A. High Pressure Descaling Using Pump

The costs which a steel plant can understand for its things on the planet marketplace depend on upon the strategy for the thing. The time of five star steel for steel pieces and billets asks for a completely persuading descaling process. In case the descaling framework is not did fittingly or is done not totally issues will rise over the extent of the get prepared since scale scraps are moved into the steel.

Starting late, there is a representation towards higher weights (above 200 bar) joined with a reduction in stream[3]. Constantly, transmitting pumps with high stream rates and low weights are used for this application regardless they have two essential obstructions:

1. The high weaken limit cools the steel too really.
2. High centrality costs for water supply, purification and in-plant pumping systems.

Figure1: High pressure pump unit

B. The High Pressure Descaling System With Accumulator

Descaling Systems can be proposed for Billet/Slab/Plate /Forging/Seamless Pipe etc. for Primary descaling (Immediately metal taking out from furnace) and discretionary descaling (Just before convincing pass).

Hot metal coming out from the furnace, hot metal the detector will sense the hot metal and will send to signal to PLC. Spray will start at high flow & pressure to remove the scales on the Billet.

The high pressure Descaling system with accumulator is meant for removing furnace scales from hot billet before 1st pass in rolling mill. This system consisting of Hp pump, valves & high pressure accumulator with shut off valve to control the system with an interlocks system. The pre filtered water from customer water system & feeds to descale header mounted on descale box in the exit side of furnace.

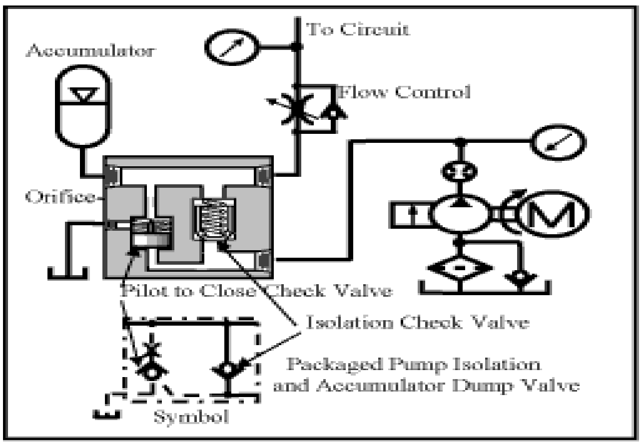

Figure 2: Piping & instrumentation diagram of accumulator

C. Tools Required

Design of accumulator is done by Solid works even Meshing, analysis of accumulator is also carried out within Solid Works Software.

III CALCULATION OF ACCUMULATOR

A. Total Volume Of Accumulator

Total volume of vessel = volume of cylinder + 2(volume of hemisphere)
D=1200mm
h=2550mm
Volume of Cylinder $=\pi r^2 h$
$= \pi\,(600mm)^2\,(2550)$
$=2883982056mm^3$
Volume of cylinder $=2883982.056cm^3$
Volume of Hemisphere$=\frac{2\pi r^3}{3}$
$=\frac{2*\pi(600)^3}{3}$
$=452389342.1mm^3$
Volume of hemisphere $=452389.342cm^3$
The total volume of vessel=
$[2883982.056cm^3+2(452389.342cm^3)]$
The total volume of vessel $=3788760.74\ cm^3$

Figure3: Isometric view of Accumulator

B. Calculation Of Longitudinal Stress

Longitudinal stress: That is when the vessel has closed ends the internal pressure acts on the vessel and then develop the force along the axis of the cylinder. This force acing is known as the longitudinal stress.

(σ_L) Longitudinal stress= Pd/4t

Where
P=internal pressure
d=mean diameter (outside diameter-thickness)
t=wall thickness
σ_L=hoop stress

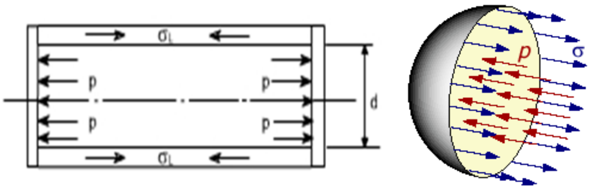

Figure 4: Longitudinal stress

Case - I (wall thickness=20mm)
Pressure =250 bar, Wall thickness= 20mm
"1 bar =1.019kgf/ cm²"
σ_L = Pd/4t
$= (254.929kgf/cm^2 \times 118cm)/ (4 \times 2cm)$
$\sigma_L = 3.760 \times 103\ kgf/cm^2$

Case – II (Wall thickness= 30mm)
Pressure =250 bar, Wall thickness= 30mm
σ_L = Pd/4t
$= (254.929kgf/cm^2 \times 117cm)/ (4 \times 3cm)$
$\sigma_L = 2.485 \times 103\ kgf/cm^2$
Case - III (Wall thickness= 35mm)
Pressure =250 bar, Wall thickness= 35mm
σ_L = Pd/4t
$= (254.929kgf/cm^2 \times 116.5cm)/ (4 \times 3.5cm)$
$\sigma_L = 2.121 \times 103\ kgf/cm^2$
Case - IV (Wall thickness= 55mm)
Pressure =250 bar, Wall thickness= 55mm
σ_L = Pd/4t
$= (254.929kgf/cm^2 \times 114.5cm)/ (4 \times 5.5cm)$
$\sigma_L = 1.326 \times 103\ kgf/cm2$

C. Calculations Of Hoop Stress

Hoop stress: This acts in a tangential direction to the circumference of the shell. This is the stress which is set up in resisting the bursting effect of the applied pressure by considering the equilibrium of the cylinder.

(σ_h) Hoop stress= Pd/2t

Where
P=internal pressure
d or Dm=mean diameter (outside diameter-thickness)
t=wall thickness
σ_h=hoop stress

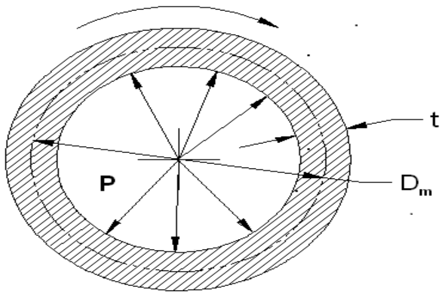

Figure 5: hoop stress

Case - I (wall thickness=20mm)
Pressure =250 bar, Wall thickness= 20mm
"1 bar =1.019kgf/ cm^2"
σ_h = Pd/2t
= (254.929kgf/cm^2 X 118cm)/ (2 X 2cm)
σ_h =7.520 X 103 kgf/ cm^2
Case – II (Wall thickness= 30mm)
Pressure =250 bar, Wall thickness= 30mm
σ_h = Pd/2t
= (254.929kgf/cm^2 X 117cm)/ (2X 3cm)
σh =4.971 X 103 kgf/ cm^2
Case - III (Wall thickness= 35mm)
Pressure =250 bar, Wall thickness= 35mm
σ_h = Pd/2t
= (254.929kgf/cm^2 X 116.5cm)/ (2 X 3.5cm)
σ_h = 4.242X 103 kgf/ cm2
Case - IV (Wall thickness= 55mm)
Pressure =250 bar, Wall thickness= 55mm
σ_h = Pd/2t
= (254.929kgf/cm^2 X 114.5cm)/ (2 X 5.5cm)
σ_h = 2.653 X 103 kgf/ cm^2

D. Material Selection

The material of the Accumulator body was specified as Carbon Steel Sheet (SS). Carbon steel sheet has a carbon content of 0.19-0.25% and is grouped under Carbon Steels. Its low in price (compared to other carbon steels) and multipurpose application in many engineering construction makes it a very economic engineering material. It is relatively ductile and malleable. It has a density of 7858kg/m3 and Young's modulus of 210GPa. Due to these properties and its availability, machinability and good strength quality, it was convenient to use in the construction of accumulator.

IV. RESULT ANALYSIS OF ACCUMULATOR

A. Meshing Of Accumulator

Figure 6: Meshing of Accumulator

B. Analysis Model And Result Diagram

The Pressure accumulator is analysed for the pressure of 250bar. The analysis is done by considering the different wall thickness of 20mm, 30mm, 35mm and 55mm respectively. The different results are obtained for different thickness, the results are as followed.

1. Three different types of studies namely Stress, Strain and Displacement are considered in analysis part, when the operating pressure of 250bars (20mm) is applied the effect on body is studied[6].

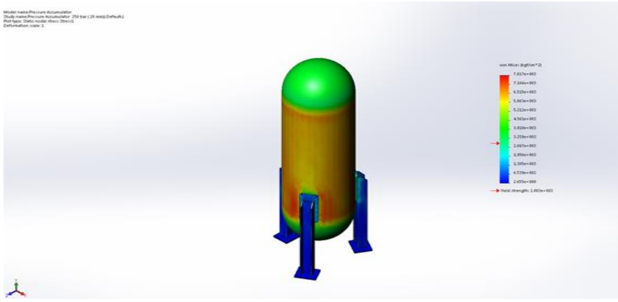

Figure 7: 250-bar (20mm) Hoop Stress Analysis

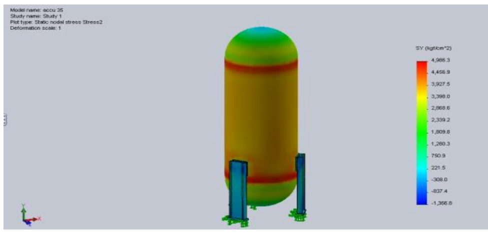

Figure 8: 250-bar (20mm) longitudinal Stress Analysis

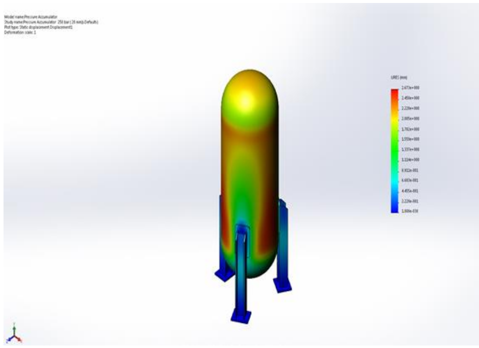

Figure 9: 250-bar (20mm) Displacement Analysis

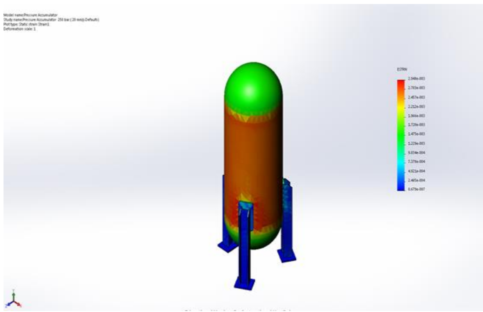

Figure 10: 250-bar (20mm) Strain Analysis

2. Three different types of studies namely Stress, Strain and Displacement are considered in analysis part, when the operating pressure of 250bars (30mm) is applied the effect on body is studied.

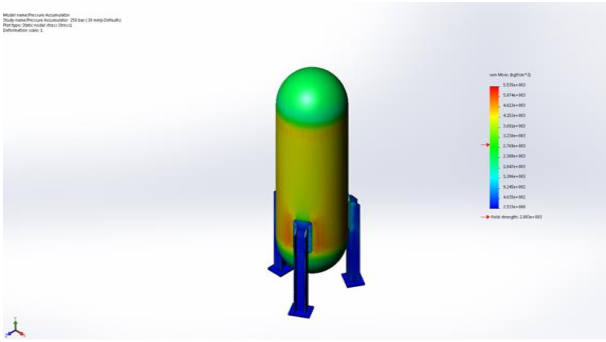

Figure 11: 250-bar (30mm) Hoop Stress Analysis

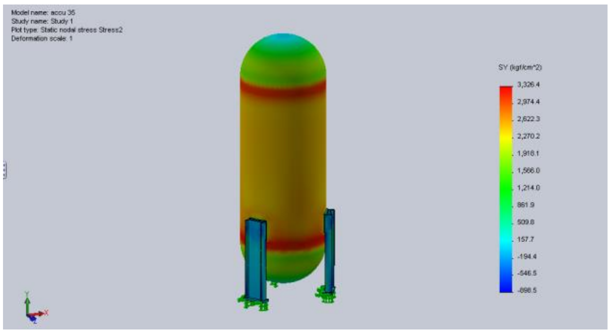

Figure 12: 250-bar (30mm) longitudinal Stress Analysis

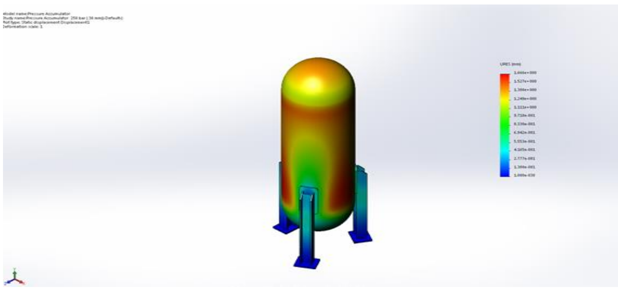

Figure 13: 250-bar (30mm) Displacement Analysis

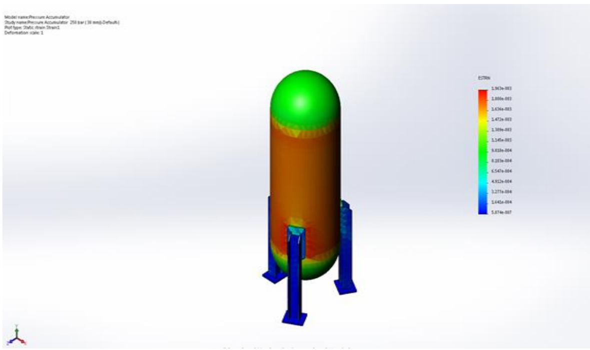

Figure 14: 250-bar (30mm) Strain Analysis

3. Three different types of studies namely Stress, Strain and Displacement are considered in analysis part, when the operating pressure of 250bars (35mm) is applied the effect on body is studied.

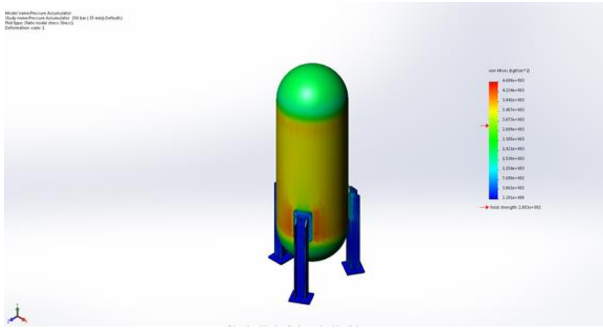

Figure 15: 250-bar (35mm) Hoop Stress Analysis

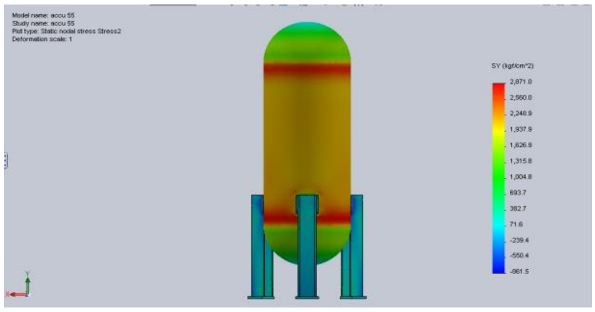

Figure 16: 250-bar (35mm) longitudinal Stress Analysis

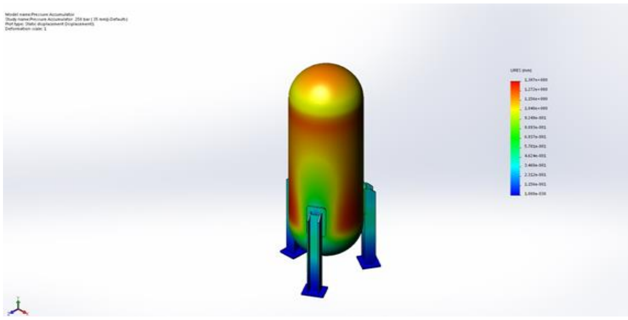

Figure 17: 250-bar (35mm) Displacement Analysis

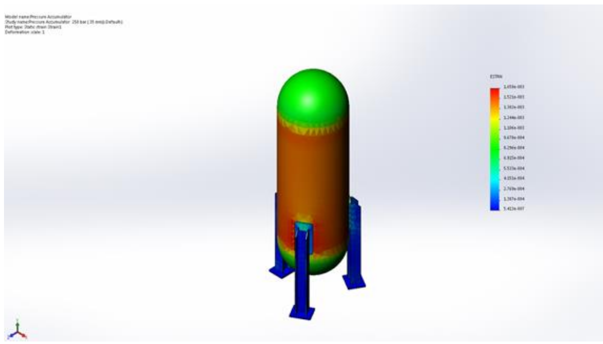

Figure 18: 250-bar (35mm) Strain Analysis

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4. Three different types of studies namely Stress, Strain and Displacement are considered in analysis part, when the operating pressure of 250bars (55mm) is applied the effect on body is studied.

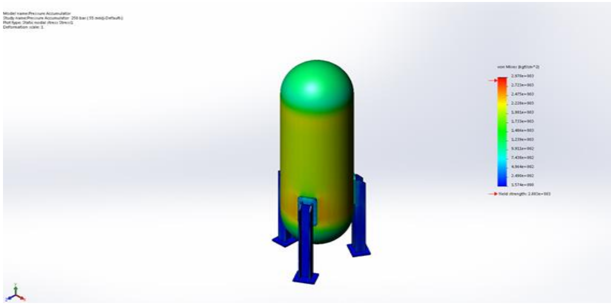

Figure 19: 250-bar (55mm) Hoop Stress Analysis

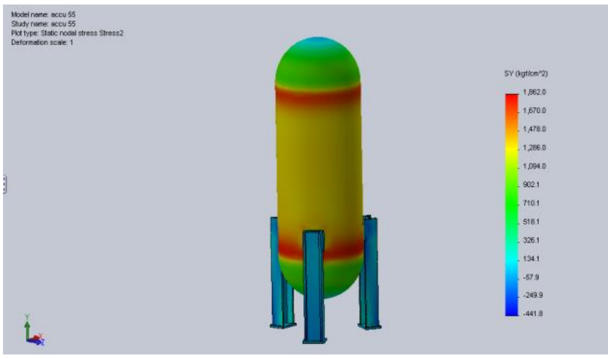

Figure 20: 250-bar (55mm) Longitudinal Stress Analysis

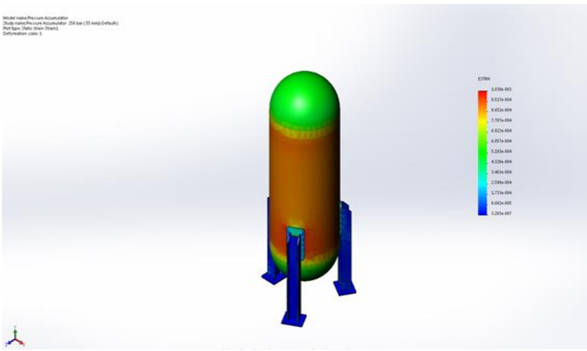

Figure 21: 250-bar (55mm) Strain Analysis

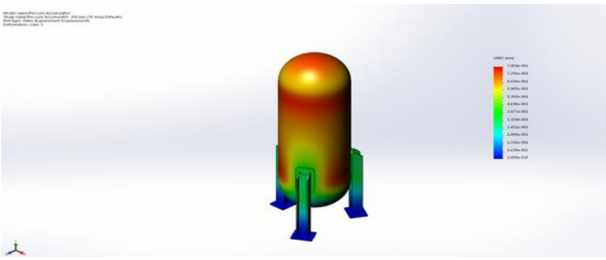

Figure 22: 250-bar (55mm) Displacement Analysis

V. RESULTS

The comparison for the theoretical and analytical work is shown below with the help of table consists of various parameters. Meshing and analysis is done in Solid Works and then results which are obtained as shown above.

Comparison Table

Table 1: Hoop stress comparis

Sl no	Pressure (bar)	Thickness (mm)	Material	Hoop Stress	
				Theoretical	Analytical
1.	250bar	20mm	Carbon Steel	$7.520e^{+3}$ kgf/cm^2	$7.817e^{+3}$ kgf/cm^2
2.	250bar	30mm	Carbon Steel	$4.971e^{+3}$ kgf/cm^2	$5.53e^{+3}$ kgf/cm^2
3.	250bar	35mm	Carbon Steel	$4.242e^{+3}$ kgf/cm^2	$4.60e^{+3}$ kgf/cm^2
4.	250bar	55mm	Carbon Steel	$2.653e^{+3}$ kgf/cm^2	$2.97e^{+3}$ kgf/cm^2

Table 2: Longitudinal stress comparison

Longitudinal-Stress	
Theoretical	**Analytical**
$3.76e^{+3}$ kgf/cm^2	$4.82e^{+3}$ kgf/cm^2
$2.485e^{+3}$ kgf/cm^2	$3.18e^{+3}$ kgf/cm^2
$2.212e^{+3}$ kgf/cm^2	$2.70e^{+3}$ kgf/cm^2
$1.326e^{+3}$ kgf/cm^2	$1.66e^{+3}$ kgf/cm^2

Table 3: Displacement and strain results

Displacement		**Strain**	
Max	**Min**	**Max**	**Min**
$2.67e^{+0}$mm	$1.0e^{-3}$mm	$2.948e^{-3}$	$8.67e^{-5}$
$1.66e^{+0}$mm	$1.0e^{-3}$mm	$1.96e^{-3}$	$5.87e^{-7}$
$1.38e^{+0}$mm	$1.0e^{-3}$mm	$1.65e^{-3}$	$5.41e^{-7}$
$7.95e^{-1}$mm	$1.0e^{-3}$mm	$1.03e^{-3}$	$3.28e^{-7}$

VI CONCLUSION

From the above table we can conclude that the pressure with 250bar and the thickness of 55mm will be safe. The stress obtained when the pressure of 250bar is applied on the accumulator is 2.97e+3kg/cm2 but the yield strength of the material is 3.670e+3kgf/cm2. Also displacement and strain obtained is also minimum at the 55mm thickness. As we go on reducing the thickness deformation/displacement is more which can be clearly seen in the displacement column along with that the stress is also increasing with the decrease in thickness.

A. Future Work

Future we can eliminate the series of pumps setup and can add the higher capacity accumulator from which we can supply the required pressure and flow for multiple descaling setups. We can take it further investigation and further study so that we can reduce setup cost, operating cost and maintenance cost.

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