Design And Analysis of Pressure Disc Type Filter

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Abstract— Presently used Filters for Beverages making industries are very bulky in shape and gives low outlet discharge. Hence they are less efficient .Therefore there is a need to design compact, automated unit that produces completely clear liquor and which have large outlet discharge. This concept highlights the design of new filter which fulfill the requirements of beverages making industries for filteration.For making filteration more feasible, unit is to be design in which multiple disc comprising of blades is to be mounted on a shaft for filteration. Multiple discs will get patterned throughout the shaft and number of disc decides the capacity of filter. The special arrangement of Two cake discharge blades (scrapper remover) suspended from a frame mounted on the tank and serve to deflect and guide the cake to the discharge tube. On large diameter filters, the blades are of the swing type that float to maintain the cake to disc clearance and so allow for the wobble of the turning discs.

Keywords - Outlet Discharge, Filter**,** Filtration ,Scrapper Remover, Multiple Disc, Discharge tube.

Introduction

The Disc Filters are used in heavy duty applications such as the filtration of beverages and dewatering of aluminum hydrate, pyrite flotation concentrates, copper concentrate and other beneficiation processes. The filter consists of several rotary discs, each made up from sectors which are clamped together will form the disc. when compared to other vacuum filters, the floor space required for the disc filter is minimal and the cost per m^2 of filtration area is the lowest.

During operation the pure liquor collect into the hallow tank and a cake (pulp) is formed on the surface of the discs. It then come forward to the drying zone, the liquid draw off to a central barrel and from there passing through a regulator to the vacuum receiver. The regulator with its bridge setting controls the timing so that once the sector leaves the drying zone it moves over a separating bridge and a snap or low pressure blow is applied to discharge the cake. Scraper remover on each side of disc removes the pulp. Scrapper removers are positioned between adjacent discs and are wide enough to avoid their clogging by the falling cake.

A paddle type agitator is designed which is located at the bottom of the tank maintains the slurry in suspension which in most of the metallurgical applications contains solids with high specific gravity which are fast settling and abrasive avoid their jamming by the falling cake.

1.1 Paper Bag: paper bags are available in two forms. The standard bags are made up by two ply material. The inner lining arrest particles while air passes through the outer cellulose layer. The paper bag collects the bulk particles with a filtration efficiency of 99.7% at 3 microns. Particles smaller than 3 microns move through this paper bag headed for the next filter. For dustless disposal, the container can be lined with a disposable polyliner.The electrostatic paper bag offers finer filtration capabilities. This paper bag has an electrostatically charged inner lining consist of melt down polypropylene. The inner lining magnetize even the finest particles, enabling the bag to be used to receive materials like toner. The paper bag collects the particles with an efficiency of 97.8% at 1.5 microns.

1.2 Main Filter: Nilfisk and CFM filters are massive by design to provide maximum surface area for filteration. The extra large filtering surface attached with the vacuum's powerful suction maintains a steady airflow, prolonging filter life and ensuring optimum vacuum performance.

1.3 Cartridge Filter: These filters are available in large, continuous duty CFM vacuums, the cartridge filter retains 99.7% particles down to 0.3 microns. It is best for the collection of ultra-fine dusts, this "non-stick" filter collects the dust on the surface and eradicating clogging. Dust is easily cleaned from this filter media which is available for dry collection only. The filter is features Teflon coating for sticky dusts.

2. Literature Reviews

The following journal papers helps in understanding the topic clearly and to frame a strategy for solving the given problem. The following are the terminologies referred from journal papers.

To produce good-quality clarified juice, the enzyme liquefaction treatment carried out before membrane filtration has the advantage of not only lowering the juice viscosity but also of reducing the SS content. Insoluble solids can then be re-concentrated by microfiltration until the concentration is the same as the original juice. The clarified juice can thus be extracted without lowering the retentate's economic value. This methodology, if it were applied in a plant producing pulpy juice, would not generate waste or byproducts and would diversify the range of products being offered. The costs of producing clarified juice would also be highly competitive, compared with other established processes and would have a higher production yield. For tropical fruit juice industries, it represents a real alternative method to diversify production and increase market share. This methodology also allows fully continuous processing that can be easily integrated into the normal processing line and can also be automated. Indeed, in the trials, permeate flows seem to remain almost constant, not showing the classical decrease observed during microfiltration done in concentration mode.[1]

Flavored coffee Filters which can be impregnated with an essential oil and placed inside a conventional coffee maker to which coffee is then added to the filter. The filter permits the brewing water to filter through the coffee and the filter without obstruction while imparting the desired flavor of the essential oil to the brewing water. [3]

Hollow fiber ultrafiltration was successfully applied to obain a clear,amber-colored pear juice.the flux reached a maximum at an average pressure of 157 kpa with an average feed stream velocity of 0.15 m/sec at 50 degree temp.High flux obtained at high temp.within temperature limitation of the membrane.[4]

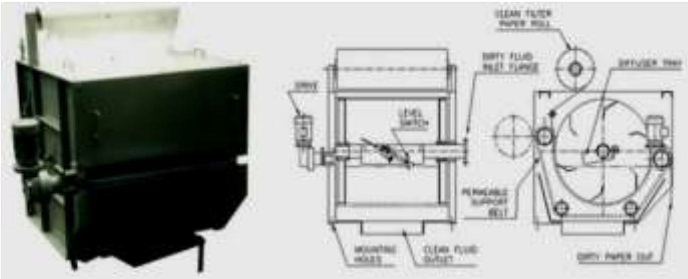
A method of filtering beverages and other liquids. To avoid the considerable ecoproblems encountered with the filter aids of known procedures, which must be thrown away, the filtering active structure of the inventive filter aids is maintained so that they may be reused as often as required. A mixture of filter aids of varying morphological and physical components is used, and constitutes a minimum of two components, namely one component of specifically heavy, chemically stable metal and/or metal oxide and/or carbon particles of fibrous and/or granular structure, and a further component, for building up the filter cake and increasing its volume, of synthetic and/or cellulose fibers having a fiber length of 1 to 5000 um and a fiber thickness of 0.5 to 100 pm. To increase the filtering efficiency of the filter cake of the aforementioned components, a further component may be added that comprises fibrillated or fanned out synthetic and/or cellulose fibers, preferably having a fiber length of 500 to 5000 um and a fiber thickness of 0.5 to 20 pm. The components are intensively mixed to form a homogeneous mixture, and are dosed to the liquid that is to be filtered. [7]

Kiwifruit is nutritionally rich fruit with high ascorbic acid content (193mg/100g) but the extraction of its juice is difficult due to slimy pulp.To overcome this problem a combination of enzymes + amylase + mash enzyme were used and thus, facilitating the extraction of juice. Though kiwifruit juice extraction is difficult, it can be extracted by pressing through hydraulic press. Yield is substantially increased by enzymes combinations treatment to pulp before pressing and extracted juice can be clarified to reduce total phenols (may be responsible for astringency) by passing the juice through filter press.[5]

The production of guava juice fortified with soluble dietary fiber as pectin extracted from guava cake (peel, pulp, seeds) was conducted. The waste guava cake from juice processing plant was used for pectin extraction using sodium hexametaphosphate method followed by pectin precipitation using acidified ethanol method. A yield of 30.50±0.34% crude pectin was achieved.[6]

3. Existing Filtration System

A compact Band Type filter "Figure.1" Majorly work with the use of filter paper bundle which can't be reuse. It gives very low output discharge i.e.upto13500 litre/ Day. The space required for the complete filtration system is more i.e.8 x 8 x 7 (M). Due to low output discharge the production rate is low. The pulp generated after the filtration process needs to be removed manually which is time consuming.



Figureure.1 Compact Band Type Filter

4.Objectives

- Design of an automated filter system which gives high Outlet Discharge.
- Design of scrap remover for removing pulp.
- To improve the production rate i.e.upto 100 LPM
- To reduce floor space area.

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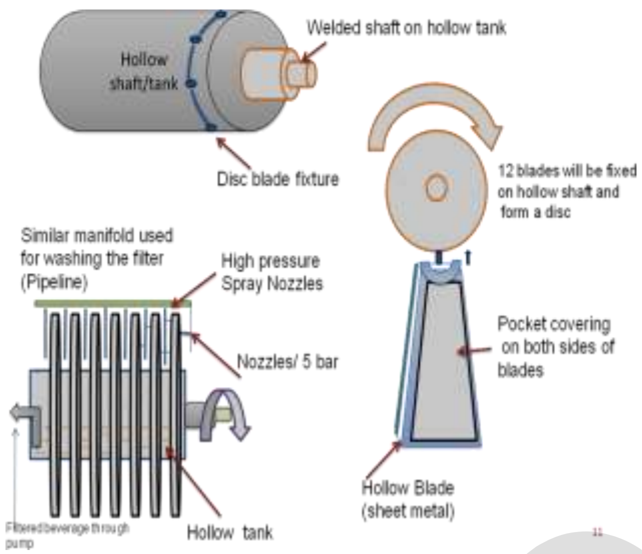
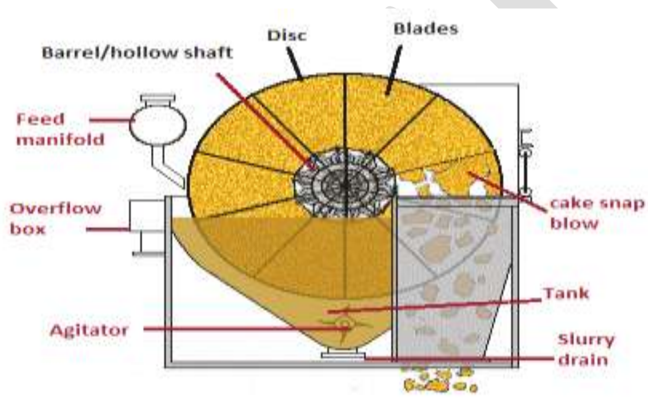
5.Proposed Design



Figureure. 2 Disc Type Filter



Figureure.3 Cross Sectional View

The filter consists of the following subassemblies

- Discs and sectors which may be made in injection molded polypropylene, metal or special redwood/ sheet metal.
- A center barrel supported by the main bearings and consisting of piped or trapezoidal filtrate passages. The sectors are attached to the barrel through "o" ring sealed connections in a number equal to the number of disc sectors.
- An agitator with paddles that are positioned between the discs and far enough not to interfere with the forming cake.
- A tank which, on its discharge side, has separated slurry compartments for the discs and discharge chutes for the blown-off cake. When the solids are of an abrasive nature it is advisable to line the bottom portion of the tank that cradles the agitator with rubber.
- Two cake discharge blades on both sides of each disc are suspended from a frame mounted on the tank and serve to deflect and guide the cake to the discharge chutes. On large diameter filters the blades are of the swing type that float to maintain the cake to disc clearance and so allow for the wobble of the turning discs.

- An overflow trough that spans across the entire tank length and ensures full submergence of the sectors in the cake formation zone since an exposed sector in the 6 o'clock position will cause immediate loss of vacuum.

6. Material Selection

6.1 Shaft and Blade

SS-310 (Stainless steel)

CHEMICAL COMPOSITION

Carbon - 0.25% max
Chromium - 24-26%
Iron - Balanced
Manganese - 2% max
Nickel - 19-22%
Phosphorus - 0.45% max
Silicon - 1.5% max
Sulphur - 0.3% max

6.2 Filter cloth

Polypropylene (E= 1.5 – 2 GPa and Sut = 28 – 36 MPa)

[1] Light in weight.
[2] High strength.
[3] High resistance to most acids and alkalis.
[4] Heat resistance is about 190^0 F.

7. Design Calculation

M = mass of cylinder (m1) + mass of pulp (m2) + mass of fluid in cylinder (m3)+ mass of Disc (m4).

Ri = inner radius of cylinder.
m1 = 980 kg.

(i) (Previous Cylinder Volume =400 litres. For volume > 1000 litres
By trial and error method: Ri = 0.4 m & L=2.480 m)

(ii) Mass of fluid(m2):
Since operating fluid (mixture of fruit & fruit pulp) with pulp of 200 gm per liter.

Mass of pulp on the cylinder
m2 = 1250 x 0.2 kg = 250 kg

(iii) Mass of fluid in cylinder
m3 = volume x density
= 1.250 x 1150 = 1437.5 kg.

(iv) Mass of disc
m4 = 1.9 x12 x 12 = 273.6 kg

Hence,
M = m1 + m2 + m3 + m4 = 980 + 250 + 1437.5 + 273.6
M = 2941.1 kg

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Volume of cylinder ($V= \pi Ri^2 L$) = 1.25 m^3 = 1250 lit.

7.1 Loading conditions on central hollow tank :

ID : 800mm
Length: 2480 mm

Mass inside the cylinder
M = density x volume
Density of liquid used : 1150 kg/m^3
M = 1150 x 1.25
M = 1437.5 Kg
Since tank will filled partially (50%),before going above 50% transfer pump get activates.
Therefore mass to be considered 1437.5/2 =718.7 Kg

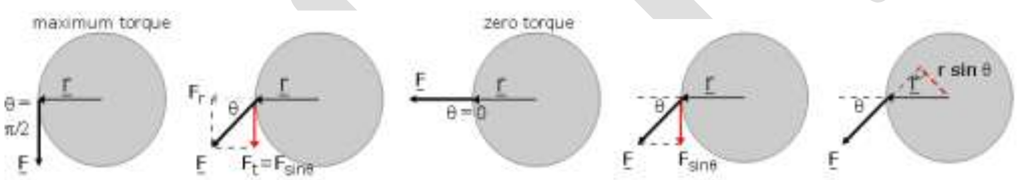
* Mass is the load inside the tank
Force = mass x g = 718.7 kg x 9.81 m/ s^2
=7050.9 kgm/s^2
= 7050.9 N

* Area of cylindrical surface
Area (A) = π * Do * Length of cylinder
A = 3.14* 0.84* 2.480= 6.54 m^2

* Pressure = F / A
= 7050.9 /6.54 = 1078.12 N/m2 or Pa.

Internal Pressure is also stresses which developed due to liquid inside the tank (Circumferential Stresses)

7.2 Rotating effect on hollow tank



The above diagrams shows the dependence of torque on the angle θ. Maximum torque will occur when the component of **F** at right angles to **r** is maximum, i.e. when θ = 90°.
The central figureure shows the tangential component of **F**, which is nothing but the F sin θ. The equation **τ = r F sin θ.**
It can be taken to mean in two different ways, as shown in these diagrams:
τ = r (F sin θ) or τ = F (r sin θ).
We can think of it as r times the tangential component of **F** (left sketch and equation) or as F times the shortest distance (r sin θ) between the axis and the line along which **F** acts (right sketch and equation).

Total weight : M = m1 + m2 + m3 + m4
= 980 + 250 + 1437.5 + 273.6 = 2941.1 kg

Total load of rotating components:
2941.1 x9.81 = 28852 N.
r =879 mm =0.879 M(value taken from blade geometry)

initial torque: 0; θ=0

* Torque (T); when ; θ= 45 °
Ft =Fsinθ = 28852 x sin 45
Ft = 20401.4 N
Torque (T) = Ft x r
T=17932.83 Nm
* Torque (T); when ; θ= P/2
Ft = F sinθ = 28852 x sin P/2
= 28852 N
T = Ft x r
T= 25360 Nm

7.3 Stress Calculations:

For cylinder shaft material: SS 310
Yield tensile strength (бyt) = 292 Mpa; Yield shear strength (бys) = 146 Mpa.
Selecting factor of safety = 4 (1.25 to 4 for ductile material)
σs permissible = 146/4 = 36.4 Mpa.

Ƭ = T r / J
$T_{max} = \tau_{max} J/R$
Where,

T_{max} = maximum twisting moment (Nm)
τ_{max} = maximum shear stress (Mpa,psi)
R = radius of shaft (m)
J = Polar moment of inertia (m^4)

Polar moment of inertia of a circular hollow shaft can be expressed as :
$J = \pi (Do^4 - Di^4) / 32$
where Di = shaft inside diameter.(m)

$T_{max} = (\pi / 16) \tau_{max} Do^3 (1 - K^4)$
Where, K= Di/Do <1
τ_{max} = 0.00122 Mpa
Since, $\tau_{max} <$ σs permissible.
Hence, design is safe.

7.4 Torsional deflection of shaft

The angular deflection of a torsion shaft can be expressed as
$\theta = L T / (J G)$
where,
θ *= angular shaft deflection (radians)*
L = length of shaft (m)
G = modulus of rigidity (MPa)

The angular deflection of a torsion hollow shaft can be expressed as
$\theta = 32 L T / (G \pi (Do^4 - Di^4))$
Where,
G = 79 GPa = 79000 MPa (Modulus of rigidity of steel)
We get,
Angular deflection
(θ) = 0.003 x 10^{-3} radians < 0.015 10^{-3} radians.

8. Modeling of Pressure Disc Filter

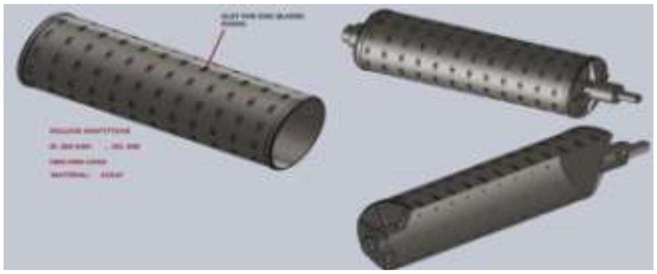


Figure 4.(a) cut section of cylinder (Hallow Shaft)

Figure 4.(b) Cylinder (Hallow Shaft)

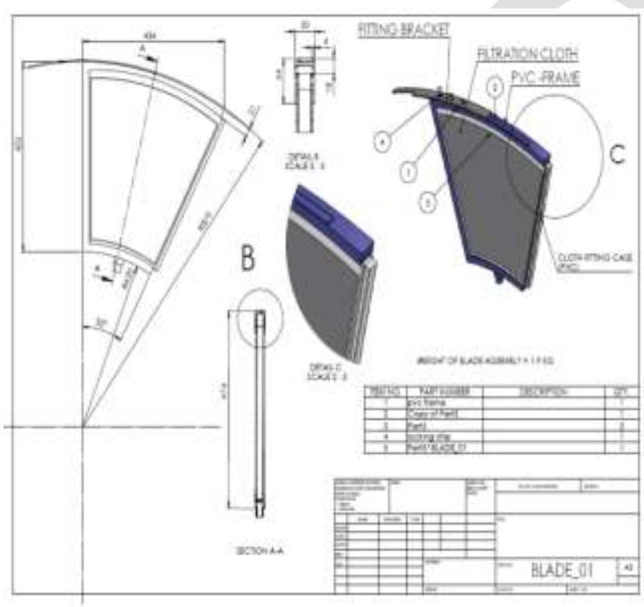


Figure 5 (a) Blade Fitting

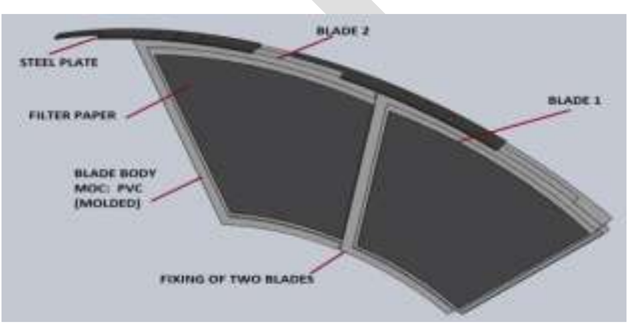


Figure 5 (b) Blade Fitting

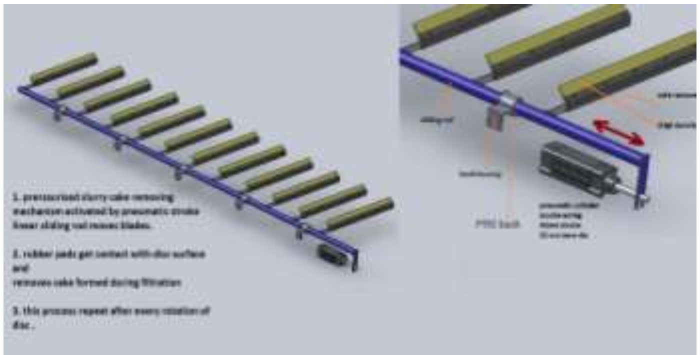


Figure 6. Scraper (Cake) Remover

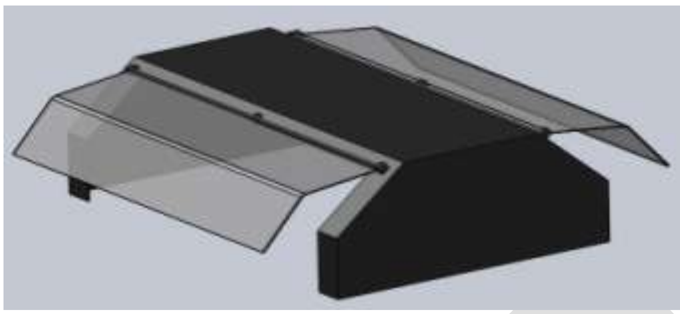


Figure 7. Glass Panel

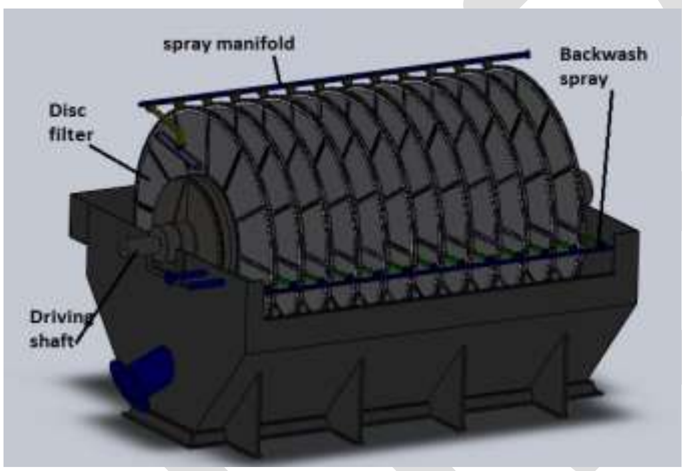


Figure 7. (a) Assembly

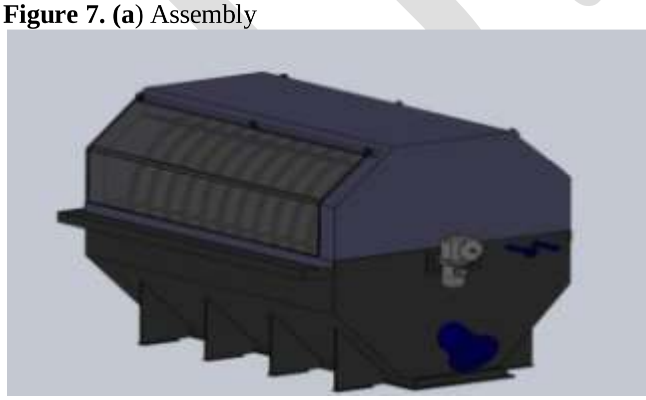


Figure.7.(b) Assembly

9. Analysis

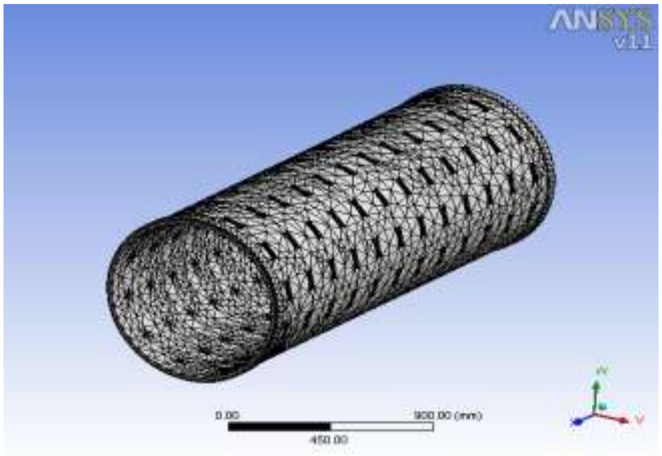


Figure.8 Meshing

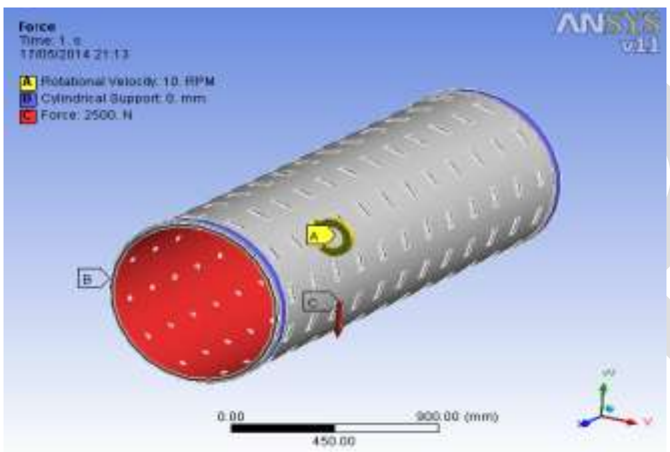


Figure. 9 Loading condition

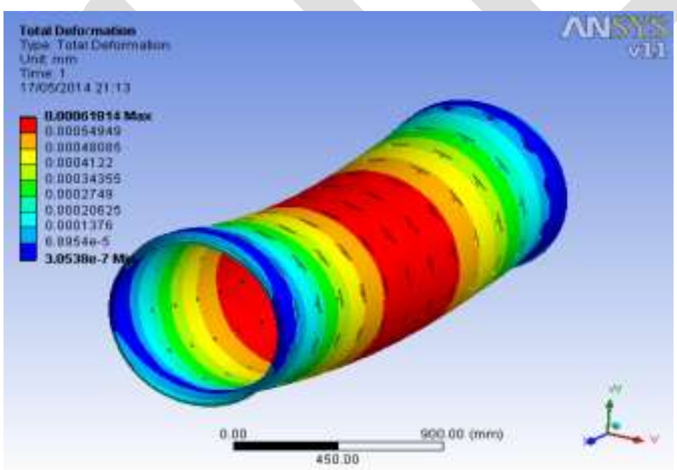


Figure.10 Deformation

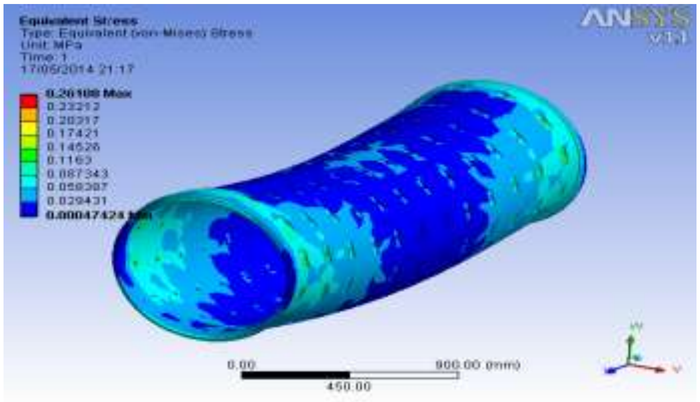


Figure.11 Stress

10. Conclusion

It has been seen that the Disc type concept for Filtration is possible and can be use majorly due to its bigger filtration medium surface than existing filtration medium surface which oriented horizontally in the system. The special arrangement of cake discharge blades (scrapper remover) on both sides of each disc guide the cake to the discharge chutes and reduces the human effort and helps to improves production and efficiency of the system.

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