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DESIGN AND MANUFACTURING OF HYDRO PULPER

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***Abstract* - The paper industries are growing their values because of their recycle nature.Also the comprehensive nature of this industry is helped us in centuries. Also the parts or machineries used in paper industries are not well known pulper is used to mix the hemp with water and to make the slurry form which can be used to make the papers. Thus the modification in design and fabrication can help us to extend its life and process with ease.**

I. INTRODUCTION

Hydro pulper is used in paper and pulp industry for breaking waste paper and wet strength paper. Hydropulper is the capital machine using for pulp thick liquid board, decreased paper and wasted paper in paper-making industry. This machine adopts the Model D structure, it has changed the inflow type of the traditional pulp machine, shorten the circular flow direction of stock. The rotor contacts with the pulp more quickly, more frequently. It can shorten the pulping time, save energy and increase the specific production in volume.

II. SCOPE

In our recycled paper making Industries the paper and boards are produced from waste papers, fabric wastes and cellulosed agro waste. In this paper making process the waste paper or cellulosic materials are pulping initially using Side drive or Top drive hydro pulpers.In this paper pulp making process the pulper needs 1 hour time using 5hp motor drive to convert 50kgs waste paper. In this time it maintain only 15deg SR(Sofas Reclux) and then the pulp is sending to another equipment for refining to maintain 20deg SR.Our design gives more strength, high efficiency,low maintenance and superperformance.

III. OBJECTIVE

The design process of this hydro pulper is iterative and based on several engineering and reverse engineering processes. Following are the major points which were considered for designing the hydro pulper.

1. Endurance
2. Safety and Ergonomics
3. Market availability
4. Cost of the components
5. Standardization and Serviceability
6. Maneuverability
7. Safe engineering practices.

IV. PARTS OF HYDRO PULPER

In a Hydro Pulper, there are mainly nine parts. They are

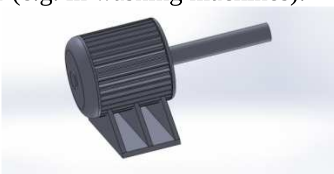
1. Motor
2. Shaft
3. Impeller
4. Ss-Strainer
5. Gun metal bush
6. Belt
7. Pulley
8. Bearings
9. Tank
10. Trapezium sheets

Motor

Rotation Reversal

The method of changing the direction of rotation of an induction motor depends on whether it is a three-phase or single-phase machine. In the case of three phase, reversal is carried out by swapping connection of any two phase conductors.

In the case of a single-phase motor it is usually achieved by changing the connection of a starting capacitor from one section of a motor winding to the other. In this latter case both motor windings are similar (e.g. in washing machines).



Motor Specifications:

1. 7.5hp AC motor
2. Motor speed =960rpm
3. Capacity = 440volts
4. Current = 12amps

Drive Shaft

A driveshaft, driveshaft, driving shaft, propeller shaft (prop shaft), or Cardan shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Drive shafts are carriers of torque: they are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia. To allow for variations in the alignment and distance between the driving and driven components, drive shafts frequently incorporate one or more universal joints, jaw couplings, or rag joints, and sometimes a splined joint or prismatic joint

Shaft design

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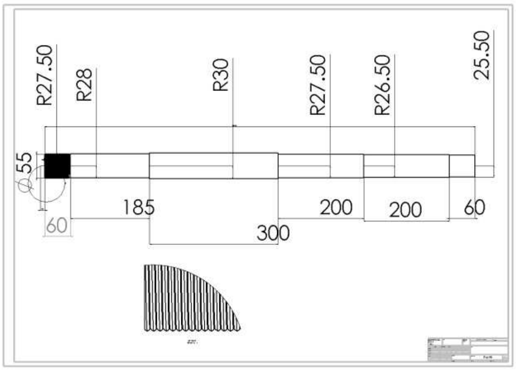
Shaft

Shaft Layout



Hydraulic forces

The calculation of hydraulic forces is a part of a package containing an extensive set of computer programs used in the design and calculation of the hydraulic components.

Radial pumps

The axial force from an impeller is normally directed towards the inlet as the pressure is lower there than on the back of the impeller, especially for open impellers. Sometimes large flows may create axial forces that shift direction, a situation that shall be avoided since it may have a harmful influence on the bearings. Radial forces caused by the impeller and volute are at their minimum at nominal flow since the pressure distribution and internal flow are most favourablethere. Since, (in many cases) these forces are the dominating ones, it is very important to ensure that the duty point is favourable. The frequency of the dynamic force is determined by the number of vanes. Single vane impellers create large dynamic forces.

Shear Stress in the Shaft

When a shaft is subjected to a torque or twisting, a shearing stress is produced in the shaft. The shear stress varies from zero in the axis to a maximum at the outside surface of the shaft.

The shear stress in a solid circular shaft in a given position can be expressed as:

$$\tau = T\, r / J \quad (1)$$

where

τ = shear stress (MPa, psi)

T = twisting moment (Nmm, in lb)

r = distance from center to stressed surface in the given position (mm, in)

J = second moment of area (mm^4, in^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 (mm, in)
G = modulus of rigidity (Mpa, psi)

The angular deflection of a torsion solid shaft can be expressed as

$\theta = 32\ L\ T / (G\ \pi\ D^4)$

The angular deflection of a torsion hollow shaft can be expressed as

$\theta = 32\ L\ T / (G\ \pi\ (D^4 - d^4))$

The angle in degrees can be achieved by multiplying the angle θ in radians with $180 / \pi$

Solid shaft (π replaced)

$\theta_{degrees} \approx 584\ L\ T / (G\ D^4)$

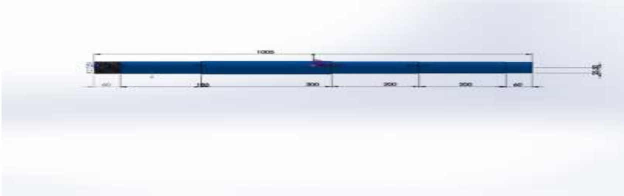
Hollow shaft (π replaced)

$\theta_{degrees} \approx 584\ L\ T / (G\ (D^4 - d^4))$

Torsion Resisting Moments of Shafts of Various Cross Sections

Shaft Cross Section Area	***Maximum Torsional Resisting Moment - T_{max} - (Nm, in lb)***	***Nomenclature***
Solid Cylinder Shaft	$(\pi / 16)\ \sigma_{max}\ D^3$	
Hollow Cylinder Shaft	$(\pi / 16)\ \sigma_{max}\ (D^4 - d^4) / D$	
Ellipse Shaft	$(\pi / 16)\ \sigma_{max}\ b^2\ h$	*h = "height" of shaft b = "width" of shaft h > b*
Rectangle Shaft	$(2 / 9)\ \sigma_{max}\ b^2\ h$	*h > b*
Square Shaft	$(2 / 9)\ \sigma_{max}\ b^3$	
Triangle Shaft	$(1 / 20)\ \sigma_{max}\ b^3$	*b = length of triangle side*
Hexagon Shaft	$1.09\ \sigma_{max}\ b^3$	*b = length of hexagon side*

Shaft design



Impeller

An impeller (also written as impellor or impellar) is a rotor used to increase (or decrease in case of turbines) the pressure and flow of a fluid. An impeller is a rotating component of a centrifugal pump, usually made of iron, steel, bronze, brass, aluminum or plastic, which transfers energy from the motor that drives the pump to the fluid being pumped by accelerating the fluid outwards from the center of rotation. The velocity achieved by the impeller transfers into pressure when the outward movement of the fluid is confined by the pump casing. Impellers are usually short cylinders with an open inlet (called an eye) to accept incoming fluid, vanes to push the fluid radially, and a splined, keyed or threaded bore to accept a drive-shaft. The impeller made out of cast material in many cases may be called rotor, also. It is cheaper to cast the radial impeller right in the support it is fitted on, which is put in motion by the gearbox from an electric motor, combustion engine or by steam driven turbine. The rotor usually names both the spindle and the impeller when they are mounted by bolts.

Impeller types

- Open
- Semi Open
- Closed

Impellers in agitated tanks

Impellers in agitated tanks are used to mix fluids or slurry in the tank. This can be used to combine materials in the form of solids, liquids and gas. Mixing the fluids in a tank is very important if there are gradients in conditions such as temperature or concentration. There are two types of impellers, depending on the flow regime created (see figure):

- Axial flow impeller
- Radial flow impeller

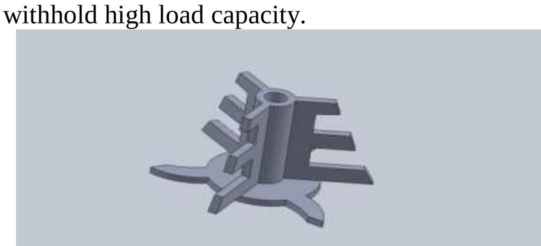
Radial flow impellers impose essentially shear stress to the fluid, and are used, for example, to mix immiscible liquids or in general when there is a deformable interface to break. Another application of radial flow impellers are the mixing of very viscous fluids. Axial flow impellers impose essentially bulk motion, and are used on homogenization processes, in which increased fluid volumetric flow rate is important.

Impellers can be further classified principally into three sub-types

- Propellers
- Paddles
- Turbines

Impeller design

In this impeller the angle set between the blades is around 60° equally. For this design it will give more efficiency. The impeller materials are made up of mild steel. Mild steel has been chosen because it can avoid rust and corrosion, and it has more life time than many other properties. The blades are welded by using arc welding where it can withstand for high performance and which can withhold high load capacity.



Part Dimensions

Bush height = 180mm
Bush outer diameter = 75mm
Bush inner diameter = 53mm
Base plate = 200mm
Angle between blades = 60°
The impeller blades are very well designed where it can rotat ıe power consump

Blades

It can be pulp the raw materials to the required range easily. And this model is the best and very suitable design for this project. This blades are attached to the bush. It is joined by using arc welding which increases the life time.

Blade Design

Part dimensions

Height = 160mm
Thickness of blade = 12mm
Teeth length 1 = 65mm
Teeth length 2 = 95mm
Teeth length 3 = 130mm

SS-Strainer

A device through which a liquid is passed for purification, filtering or separation from solid matter; anything (including a screen or a cloth) used to strain a liquid; any device functioning as a sieve or filter – in special, a perforated screen or openwork (usually at the end of a suction pipe of a pump), used to prevent solid bodies from mixing in a liquid stream or flowline.In plumbing, a stainless steel strainer is a type of perforated metal sieve used to strain or filter out solid debris in the water system. Different varieties are used in residential premises and for industrial or commercial applications. Such strainer elements are generally made from stainless steel for corrosion resistance.

For example the bearing fixed in our shaft is placed as

One more bearing is used at the bottom of the shaft which is used to avoid the bending moment at any type of loads applied.

Chain / Belt Shaft Load:

The tangential loads on sprockets or pulleys when power (load) is transmitted by means of chains or belts can be calculated by formula

Kt＝19.1 ×106
・H N Dp・n
＝1.95×106
・H ｛kgf｝ Dp・n

where, Kt : Sprocket/pulley tangential load, N {kgf}

H : Transmitted force, kW

Dp : Sprocket/pulley pitch diameter, mm

For belt drives, an initial tension is applied to give sufficient constant operating tension on the belt and pulley. Taking this tension into account, the radial loads acting on the pulley are expressed by formula. For chain drives, the same formula can also be used if vibrations and shock loads are taken into consideration.

Kr＝fb・Kt

where, Kr : Sprocket or pulley radial load, N {kgf}

fb : Chain or belt factor

Bearing load distribution

For shafting, the static tension is considered to be supported by the bearings, and any loads acting on the shafts are distributed to the bearings.This example is a simple case, but in reality, many of the calculations are quite complicated.

FrA＝a+b F1＋ d

bc+d F2

FrB＝－ a F1＋ c

bc+d F2

where,FrA : Radial load on bearing A, N {kgf}

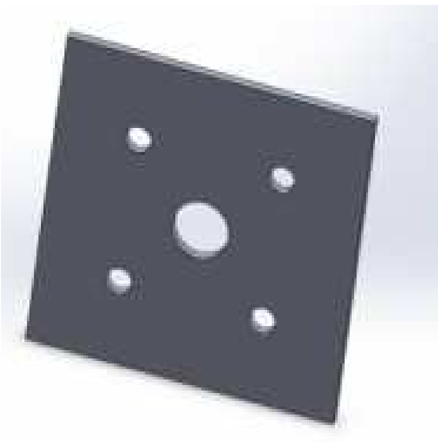
FrB : Radial load on bearing B, N {kgf}

F1, F2 : Radial load on shaft, N {kgf}

If directions of radial load differ, the vector sum of eachrespective load must be determined.

Square Plate

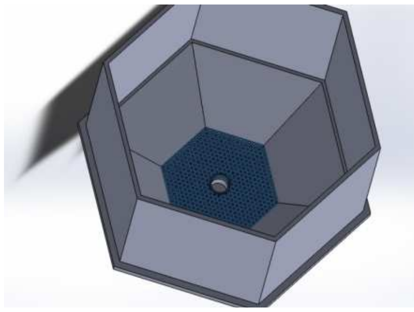
The square plate has been used at the middle to fix the bearings at the top and bottom. It helps to avoid the bending moment



Tank

A pulper tank is a container for storing water& raw materials. The need for a pulper tank is as old as civilization, providing storage for maximum level. We have used civil work at the top of the tank which can be used for long life time. It helps to avoid rust where it forms on the sheet metal.

The tank is made up of hexagon shape in which it can be easily pulp simultaneously. At any stage at any speed of the blade.



Part dimensions

Tank Capacity – 1000 liters

It works at ratio of 1:10 ,

For example when we apply 50 kgs of wastes then

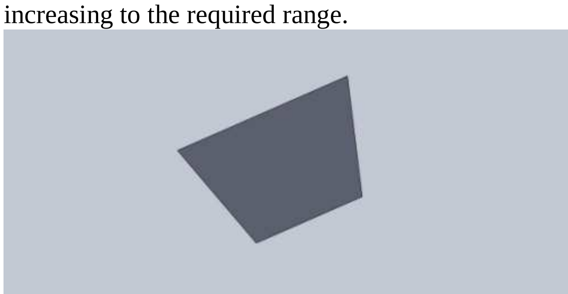
500 liters water should be added.

Height = 800mm

Length = 610mm

Trapezium Sheets

The trapezium sheets are used at the bottom of the tank at a conical shape in which where the impeller is placed. When raw material is added it will automatically placed at the bottom of the tank. It helps to pulp the raw material at less number of time. This will decrease the time consumption and efficiency of the pulp will be increasing to the required range.



Part dimensions

- Thickness = 4mm
- Height = 380mm
- Bottom length = 380
- Top length = 610

This trapezium sheets fixed at the bottom of the tank is to seemed as,,

Bearing Selection

To calculate the bearing selection which is fixed at the middle of the shaft.
Diameter of shaft = 55mm
Speed = 480rpm
Radial load, Fr = 750N
Thrust load, Fa =1000N
For this diameter and for our application we selected "SELF ALIGHNING BEARING".
From PSGDB 4.16 "SKF 2211" is selected.
Static load capacity Co = 12700N
Dynamic load capacity C = 20800N
From PSGDB 4.4
e= 0.28
X = 0.65 Y = 3.5
S = 1 for any rotary machine
P = (XFr+YFa)S
= (0.65 * 750+3.5 * 1000)
= 3987.5N
From PSGDB 4.6
C/P = 4.56
C = 4.56 * 3987.5
C = 18183N
Since the dynamic load rating of the SKF 2211 is more than the required dynamic load capacity, the selected bearing is suitable.
For fixing bearing at bottom:
Diameter of shaft = 50mm
Speed = 480rpm
Radial load, Fr = 300N
Thrust load, Fa = 1000N
For this diameter and for our application we selected "SELF ALIGHNING BEARING".
From PSGDB 4.16 "SKF 2210" is selected.
Static load capacity Co = 10800N
Dynamic load capacity C = 18000N
From PSGDB 4.4
e= 0.28
X = 0.65 Y = 3.5
S = 1 for any rotary machine
P = (XFr + YFa) S
= (0.65 * 300+3.5 * 1000)
= 3695N
From PSGDB 4.6
C/P = 4.56
C = 4.56 * 3695
C = 16,849.2N
Since the dynamic load rating of the SKF 2210 is more than the required dynamic load capacity, the selected bearing is suitable.

Torque For Shaft

Power = 7.5hp
1hp = 746watts
7.5hp = 746 × 7.5
= 5595watts
Shaft speed = 480rpm
To calculate torque
P = 2πNT/60
T = {60×5595}/{2×π×480}
= 111.36 N-m
Motor torque:
T = 55.68 N-m

Shaft Pulley Design

1. Diameter:
Standard pulley diameter,
D = 350 mm
From PSGDB 7.54
D = 355mm
2. Width of pulley:
From PSGDB 7.54
Belt width = 125 to 250 mm
Standard belt width = 250mm
Standard pulley = 25mm
Manufactured pulley = 23mm
3. Thickness of pulley:
From PSGDB 7.57
t = {D/200} + 6
= {350/200} + 6
= 7.75mm
4. Dimensions of arms:
From PSGDB 7.56
Number of arms = 4 for diameter up to 450mm
5. Cross section of arms:
From PSGDB 7.56
b = 2.94 ×{aD/2n}^1/3
= 2.94× {250 ×350/2×4}^1/3
= 65mm
6. Radius of cross section of arms:
R = {3/4}×b
= {3/4} × 65
= 48.75mm

Belt

Length of the belt:
Diameter of driving wheel N1= 960rpm
Diameter of driven wheel N2 = 420rpm
Diameter of driving shaft d = 160mm
Diameter of driven shaft D = 355mm
Centre distance = 820mm
Speed Ratio = N1/N2
= 960/420
= 2.3
Power consumed = 3.75 kw
To find length of the belt
L = 2C+(3.14/2) (D-d) + (D-d)^2/4C

= 2 * 820 + (3.14/2) (160+355) (160-355)^2/4820

= 2459.84mm

From PSGDB 7.58

L = 2474mm

V. CONCLUSION

Our Hydro Pulper which is designed and analysed gives better performance we designed the hydro pulper by bottom drive, hexagon shape tank, ss strainer and triple flighted rotor impeller it will give four times better than sydropulper.If we use with large amount of pulp and highly specified equipments better result will be obtained.In our recycled paper making Industries the paper and boards are produced from waste papers fabric wastes and cellulosed agro waste. In this paper making process the waste paper or cellulosic materials are pulping initially using Side drive or Top drive hydro pulpers.In this paper pulp making process the pulper needs 1 hour time using 5hp motor drive to convert 50kgs waste paper.

In this time it maintain only 15deg SR(Sofas Reclux) and then the pulp is sending to another equipment for refining to maintain 20deg SR.Our design gives more strength , high efficiency ,low maintenance and super performance.For reduction of time and better performance we designed the hydro pulper by bottom drive , hexagon shape tank, ss-strainer and triple flighted rotor impeller it will give four times better result co-paring with side drive hydro pulper.In our bottom centre hydro pulper drive with 5hp will give a result of 100kgs pulp production by 40 minutes time and it will maintain 20deg SR on that time.

Advantages of using our hydro-pulper will reduce of time taken for pulping. It breaking the waste paper in high consistency and it process intense fibre to fibre friction. So it can speed the de-fibering the waste paper. So the paper production will be increased and reduce the production cost.

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