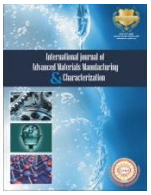

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Design of Centrifugal Pump for Palm Fruit Pulp Handling in Palm Oil Plant.

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ABSTRACT

For the design of pump the system resistance (total head) is calculated by considering head and capacity correction factor for 5% consistency of pulp. This factor is taken from data book. Power required and specific speed calculated by standard formulae. For pulp pumps above 3% consistency semi open impeller is preferable. Impeller vane angles, number of vanes, vane curvatures are designed as per standards. Casing is considered as volute type. While designing of volute casing volute angle, throat area and tongue distance are designed as per standards. The shaft is designed as per power required by the pump. Designing of stuffing box and flexible coupling are done based on the shaft diameter by standard proportions. The thrust load and radial loads on the bearings are calculated and deep groove ball bearings are selected for withstanding that loads. The results obtained are compared with the operating parameters of the existing pump in our Palm oil plant and observed that the design is matching with the exist one.

Introduction

A pump, in general may be defined as a machine, when driven from some external source, lifts water or some other liquid from a lower level to a higher level. Ex:-Lifting of water from a lower level to a higher level (Over head tank) or lifting water from a well to the surface for irrigation. The object of pumping is to raise the energy of a liquid in one of the three forms datum head, pressure head or velocity head. In the first type the liquid is raised from a low level to a high level liquid is stored at atmospheric pressure. The velocity in the pipe remains constant liquid available under high pressure can be made to flow under high velocity i.e., by converting pressure head to velocity head. [1,7]

The pump which raises water or a liquid from a lower level to a higher level by the action of centrifugal force, is known as centrifugal pump. In pump, the mechanical energy is fed into the shaft and water enters The centrifugal pumps has found applications in various fields such as water supply irrigation purposes, sewage pumping plants ,feeding water in boilers, circulation of cooling water through condensers in power houses, for driving hydraulic condensers in power houses, for driving hydraulic machinery such as cranes, lifts and elevators in fire fighting Vance's for sprinkling water to extinguish fire, for raising the pressure to lift chemical and pulp for mine drainage's, for refrigerators, ice plants and air-conditioning system etc.
the impeller (attached to rotating shaft) which increases the pressure energy of the out going fluid. The water enters the impeller radially and leaves axially along the vanes.

Role of pump in palm oil industry

Palm Oil is being produced from the Palm trees where we grow Palm fruit bunches. Various methods are being adopted to crush the Palm fruit into pulp. Various methods like cooking of fresh fruit bunches with steam, boiling of fruits in hot water and pressing in hydraulic presses, twin screw presses and pulp is being transported from underground tank to the clarifiers for clarifying the oil by density. Pumps are used to transport water, pulp, waste water generated from the process to ETP, hot water, treated water to different process, Oils etc. for various applications different type of pumps are being used. It is very much essential to select a suitable pump for the above purposes. Types of pump are determined by the application and their capacity, head etc. are chosen as per the requirement.
Normally in the palm oil industry centrifugal type pumps are used. Depending upon the material to be transported the pump is selected. E.g. for transporting water centrifugal pump of closed impeller, for transporting pulp of consistency of pulp 1 to 2.5% closed impeller, more than 2.5% to 5% open impeller is used.To transport high viscosity liquid screw type pumps are used. Reciprocating pumps are also used in case of high pressure

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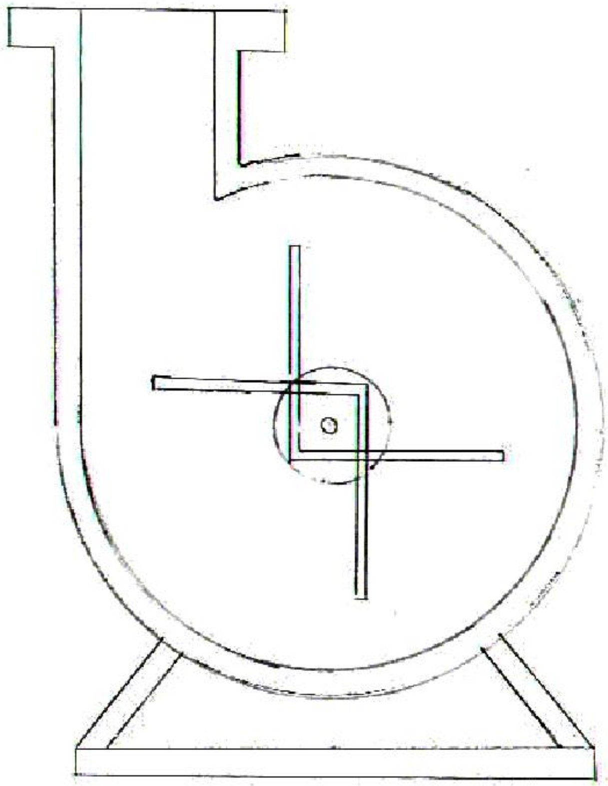

Massachusetts Pump

requirement such as cleaning the pre heater tube, wire & felt where high water pressure (40-60 kg/cm2) is required. To create high pressure multi stage centrifugal pumps are also used. Reciprocating pumps are used to transport high consistency pulp in some paper mills.

Rotary pumps are used for creating vacuum. While selecting the type of pump for transporting different types of liquids their material of construction plays a very important role. For e.g., for handling Hcl which is highly corrosive P.V.C material are used for pump body, impeller and shaft protective sleeve and the piping material is also selected as P.V.C and to give strength F.R.P is applied above the pipe. For Hypo transportation of rubber lined pump body and impeller is used. For transporting Alum SS316 impeller, body and shaft is used. For transporting water C.I body and Bronze impeller is used. For transporting black liquor and white liquor pump body of C.I and impeller SS 304 are selected

Operation of centrifugal pump:-

The first step in operation of a pump is priming that is, the suction pipe and the casing are filled with water up to delivery valve. This is done for the removal of air, with the pressure of air, it is not possible to create pressure because the pressure generated by the impeller is directly proportional to the density of the liquid to be handled. Thus, if impeller is run in air, negligible pressure will be produced because of very less density of air and hence no liquid will be lifted the pump.Thus it is very essential to prime the pump properly and it should be noted that during priming delivery valve is kept closed. After priming the delivery valve is kept still closed and prime mover (generally electrical motor) is started to rotate the impeller. The rotation of impeller in the casing full of liquid produces a forced vertex which is responsible for imparting a centrifugal head to the liquid. Rotation of impeller effects a reduction of pressure at the center. This causes liquid in the suction pipe to rush in to the eye. The speed of the pump should be high enough to produce centrifugal head sufficient to initiate discharge against the delivery head. When pump attains a constant speed, delivery valve Is gradually opened and thus liquid is allowed to flow in a radially outward direction through the impeller vanes and attains a higher velocity and pressure nat the outer periphery. With in the help of special shape of casing (volute, vortex or diffuser) this higher velocity energy is converted into pressure energy and reduce high velocity. Now this water at higher pressure rises through the delivery piper in to a desired height. At the same time centrifugal action creates partial vacuum at the center. The partial vacuum causes the water to rush through the suction pipe towards the impeller eye, to take the place of water which has left the impeller vanes, from the pump (where the pressure is atmospheric). Thus, in this way water reaches and leaves the impeller continuously and water is raised to a certain height at a constant rate .

Power required by pump:-

The work performed by the pump is equal to the Weight of the liquid in unit time * Total head in meters.

$$\text{Power} = \frac{Q*\text{Sp.gravity}*Hm}{102 * \eta_o}$$

Q= Discharge in Lps
Hm= Manometric head in meters
η_o= Overall efficiency of the pump
EFFICIENCIES:-
Hydraulic efficiency.
The ratio of actual head developed by an impeller (with finite number of vanes) to its virtual of theoretical head (i.e., the head with out accounting for various hydraulic losses like friction and turbulance) is called hydraulic efficiency.
η_{hid} = actual measured head / head imparted to fluid by impeller

Mechanical efficiency.

This is the ratio of the gross virtual power delivered to the fluid by the impeller (with finite number of vanes), to the brake horse power supplied to pump shaft.
η_m = gross horse power delivered to pump / BHP
gross horse power = BHP – HPdf - HPm
HPdf = disc friction HP
HPm = HP to over come mechanical losses in Brg, stuffing box etc.

Manometric efficiency
η_{mano} = manometric head / energy imparted to water by impeller

Overall efficiency.
The ratio of the actual fluid horse power out-put to the brake horse power input is known as overall efficiency.
o = actual fluif HP output / BHP input = FHP/BHP
FHP = Q H / 75
o = m Xmano

DESIGN OF CENTRIFUGAL PUMP:-
DESIGN OF CENTRIFUGAL PUMP BY TAKING THE FOLLOWING DESIGN CONSIDERATIONS:
3.DESIGN CONSIDERATIONS:-
Allow 2.5 to 7.5% for leakage back to suction side through the sealing rings and past clearances, of gland etc.
Allow the velocity of water in suction pipe at 1.5 to 4.5 meters per second, an average value being 3 meters per second. (same in delivery pipe). Loss of head due to friction in pipe fittings i.e., 90^0 long radius elbow, foot valve and strainer were taken from standard tables and graphs.
A single medium radial impeller will produce a practical total head of not more than 45 meters. If a large head is required other impellers are fitted in series (i.e., a multi stage pump).
A strainer should always be provided in suction pipe.
The actual vertical suction lift from the surface of water to center line of pump should be as small and direct as possible and should never exceed 6 meters for fresh water. The greater value of total suction lift theoretically would correspondent to the barometric pressure of out 10.37 meters. In any case precaution should be taken such that cavitation does not occur.
(LS 1520,1-10) The impeller must be machined and properly balanced (so as not to cause any vibration) against the end critical torsion speeds. The end thrust is due to
to the difference of pressure at a given radius on the two sides of vane shrouding due to the fact that while the water in impeller is rotating in a forced vortex,thatout side the shrouding is in the state of comparative rest. This is by far the most important factor in producing the end thrust.
Since the water is taken in axially and diverted radially it suffers a change of momentum in an axial direction and this change of momentum can only be produced by an axial force transmitted through the shaft to the impellers.
In calculating B.H.P of the electric motor, the following losses must be taken into consideration is addition to fluid B.H.P.
Bearings and gland friction i.e., mechanical losses.
Disc friction and friction due to end thrust on the impeller.
Hydraulic losses in the impeller and casing (friction and turbulence).
Leakage around the impellers, glands etc.
(I.S. 1520, 14.9) the casing should be of robust construction cast in close grained cast iron to grade 12 to I.S 210 of 1950. The casing should be belted together in the vertical or horizontal plane with a thin gasket between.
Impeller should be cast in phosphor Bronze, where ever the liquid to be pumped is not likely to attack or erode this material, otherwise a special grade of cast iron may be necessary.
The glands should be of ordinary packed type provided with a greaser to prevent drying of packing material.
A flexible flanged type of coupling should be provided between the pump and electric motor.
(I.S. 1520, 14-8) The base plate which accommodates the pump andthe motor, when provided, shall be rigid and stable so that alignment is not effected under normal working conditions.
(I.S. 1520, 14.11) The shaft should be finished to tolerance at the impeller, coupling and bearing diameters, characteristics of a typical shaft steel commonly used are as follows:

CARBON	0.35 TO 0.45%
SILICON	0.05 TO 0.35%
MANGANESE	0.6 TO 1%
SULPHER	0.06%
PHOSPHOURS	0.06%
TENACITY	55 TO 70 KG/mm2

(I.S. 1520, 14.11.2) The design of the shaft shall take into consideration the critical speed of the shaft which shall be revolved from the actual working speed by at least 10% on either side.
(I.S. 1520, 14.12) The bearing may be ball, or roller or sleeve bearings. The bearings shall be so designed as to make up the necessary radiaL load as well as the net hydraulic axial thrust bearings should be lubricated properly.
(I.S.1520, 5.2.4):-
standard fitted pumps :- pump-s in which the casing and the impeller are of C.I the casing ring, the impeller ring and the shaft sleeves are of bronze and the shaft is of steel.
Bronze fitted pumps:- pumps in which the casing is of C.I, the impeller and shaft sleeves are of bronze, and shaft is of steel.
All iron pumps in which except shaft all the other parts are made of C.I material shaft is steel.

Paper stock pumps:

Important consideration for suction piping:
1). It should be short as possible.
2). Pipe lay out must be horizontal (no air pockets)
3). Pipe size should be bigger than pump suction size.
Ordinary centrifugal pumps operate satisfactory up to 3% consistency of stock. Beyond this limits pumps require special design features for impeller. Two charts showing approximate head- capacity correction factors (Kp) for paper stock applied to water performance. Correction factors are available for given at various % of max capacity (Qp)
(I.S. 1520, 14.5) Air cock should be fitted near the highest point of the casing to assist the priming.
(I.S. 1520, 5.2.3) the type of casing of centrifugal pump will be :
a)Hydraulically:- 1)volute pumps
2)Diffuser pumps
b)Mechanically:- 1)Horizontally split casing pumps
2)End suction pumps (vertically split)
3)Diagonally split casing pumps
21.Impeller shaft:
The shaft should be strong enough to take care of the torque and bending moment and stiff enough for deflection. The shaft diameter (Ds) based upon torque alone is given by formulae.

$$T=\prod/16*Ds^3*fs$$

For taking care of bending moment, axial thrust, stiff ness etc. consider Te (Equivalent torque) is 1.5 of T. and find then dia of the shaft

Conclusions:-

In the design of the pump for given problem, the following points are considered.The head & capacity correction factor for 5% consistency pulp is taken as 0.87 from data book. The out let vane angle is kept slightly larger than the inlet angle to obtain the smooth continuous passage.

Deep grove ball bearing is selected to take axial and radial loads. Flexible coupling is selected to connect the shafts of motor and pump. This taken care of the motor & pump misalignment. In order to reduce the turbulence the total divergence in the volute divergent nozzle angle should not exceed 10^0 to 12^0

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