Design and Development of High-Pressure Reciprocating Plunger Pump.

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***Abstract*— Pump is device which is used for industrial purposes. For most of the purposes we require constant discharge at variable head. This constant discharge at various heads can be achieved by reciprocating plunger pumps.The paper presents the design of a reciprocating pump which provides input to the boiler, and is such designed that it helps in increasing the efficiency of the system. Pump characteristics clearly show the advantages of both the pumps. It is also designed considering the high temperature and high pressure.**

***Keywords*— Plunger, reciprocating, High pressure, High temperature.**

I. Introduction

A pump is a device which helps us for easy transfer of fluid with the help of a mechanical action. A pump is defined as mechanical that adds energy to a liquid to increase its rate of flow and pressure. A reciprocating pump traps a fixed volume of liquid at near suctions conditions, compresses it to discharge pressure, and pushes it out of the discharge nozzle. There are two basic types of pumps reciprocating and centrifugal pumps. A reciprocating pump is a positive plunger pump.
The recent innovations in fluid power technology has resulted in an effective alternative for all the conventional power sources and thus has resulted in varied applications of fluid power technologies in industry. For any hydraulic system, high pressure liquid is the major requirement. A pump is also called as the heart of the hydraulic system which transfers liquid from low pressure to high pressure for proper functioning of the hydraulic system. As per the requirement of the application of hydraulic system, a suitable type of pump is to be selected. Factors such as required discharge, pressure, head, and efficiency are considered for selection of pump from various types. For applications requiring pressure above 10 bar, positive displacement pumps are to be used. Partial vacuum is created at the pump inlet due to the mechanical energy supplied to the pump. Thus, the atmospheric pressure forces the fluid to the pump inlet port. This is the basic working principle of any pump. The fluid in the pump is thenmoved to the discharge line by use of mechanical energy supplied to the pump. The source of energy to pump is the prime mover used in the application which converts its input energy into mechanical energy and supplies it to the pump. The input energy to the prime mover depends on the type of prime mover used that is for electric motor input energy is electricity, for IC engine fuels like petrol, diesel is used as input, etc. In this study, the prime mover used is electric motor.

Pumps are classified according to their applications and working principle. The classification is as follows: -

1)Dynamic Pump:

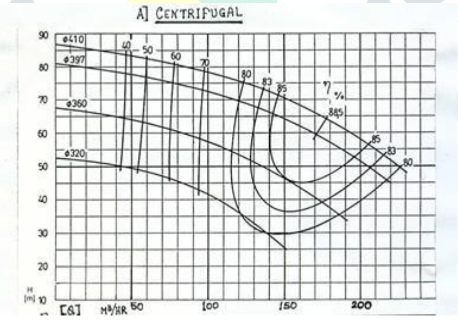


Fig 1: Performance Curve of Centrifugal Pump

The performance curve of a dynamic pump (centrifugal pump) is shown in the figure above. As the head increases the discharge decreases. As we increase the diameter and the discharge the efficiency also increases up to certain point after which the efficiency again starts decreasing.

2)Reciprocating Pump:

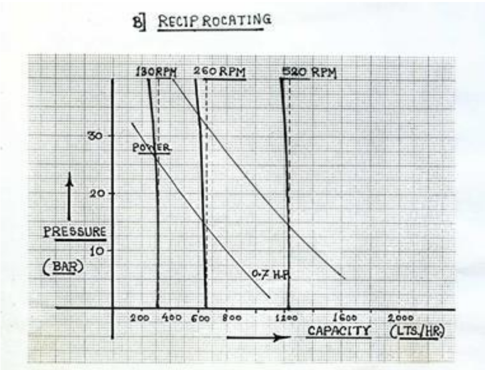


Fig 2: Performance Curve of Reciprocating Pump

In the case of a reciprocating pump the discharge of the pump remains constant in spite of the head being increased, after certain increase in head there is slight variation in capacity.

II. SPECIFICATION

SR. NO.	PARAMETER	VALUE
1	Discharge	750 lts/hr
2	Pressure	50
3	Temperature	85°C

III. PRIME MOVER

Squirrel cage induction motor is the most commonly used prime mover for pumps which consists of conventional stator with a specific number of poles and phases, and a rotor which has either cast bars or brazed bars imbedded in it. The operating speed of squirrel cage motor is usually below synchronous speed by specific slip or revolutions per minute. Synchronous speed of any motor is the speed of operation of ideal motor that is when motor is working at ideal conditions and is specified by manufacturer on the catalogue. The actual speed of the motor is normally slight less than the synchronous speed.

The synchronous speed is calculated as,

$$N = (f \times 60 \times 2)/p$$

A three-phase motor is generally used to drive the pumps. The motor selection is done from the preferred HP and speed ratings specified on the nameplate of motor. The types of mountings used are flange mounted, foot mounted, face mounted, foot cum flange mounted, foot cum face mounted. Depending upon location of motor application for the required site, the type of mountings for motor are selected.

When the motor is working at no load condition, the speed of operation of any motor is slightly more than the full load operating speed. As there is increase in load acting on the motor, the demand for voltage and frequency is constant hence only current supply must be increased so that the loading condition is worked upon, only up to the specified maximum current drawn capacity for the motor.

The input to motor is constant frequency current & voltage which gives speed and torque at output which is required as input for pump.

BkW=(H*Q)/(3.6*102*Eff)

= (500*0.75)/(3.6*102*0.8)

= 1.27 kW

Considering 10% FOS,

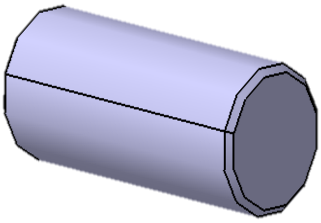
BkW = 1.39 kW = 1.77 HP

From manufacturers catalogue, for 6 pole, 2 HP, corresponding values of speed and torque are obtained.

IV. Design

Further the design calculations for certain parts of the pump are being shown as below:

A. Gudgeon Pin



Function of the gudgeon pin is to connect with the connecting rod.

Force on Piston = $(\pi D * D/4)p_{max}$ (a)
Resisting Force = $p_b*d_g*l_1$ (b)

$l_1 = 0.45D$
$= 0.45*22$
$= 9.9$ mm
$= 10$ mm

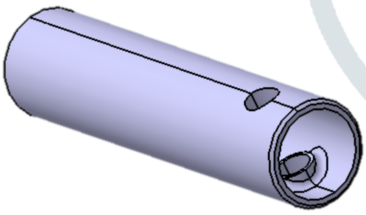
By equating (a) and (b) we get,

$(\pi D * D/4)p_{max} = p_b*d_g*l_1$

$\pi*22^2*5/4 = 25*d_g*10$

$d_g = 7.6$ mm
$d_g = 8$ mm
considering 20% factor of safety,
d_g=10mm.

B. Piston-



Discharge = Displacement*number of piston*speed

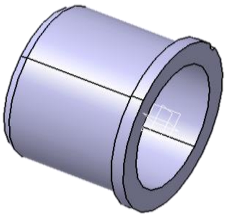
$Q = (\pi*d^2*s/4)*N*n$ (c)

Q- discharge / Capacity, cm^3/min
d- diameter of piston, cm
s-stroke, cm
N- no. of piston
n- speed, rpm
Assuming a stroke length of 12mm & substituting other known variables in equation(c), we get

$$\frac{750*1000}{60} = \frac{\pi}{4} d^2 * 1.2 * 3 * 950$$

d = 22mm

C. Piston Guide



According to the study of previous design consideration, it is observed that if ratio of areas of crosshead diameter 'd' is equal to 1, then pressure developed is around 30 bar.

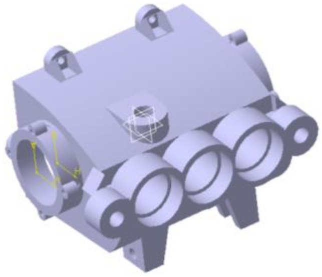
For required pressure of 50 bar, the ratio is 1.66

$$\frac{\pi/_4 D^2}{\pi/_4 d^2} = 1.66$$

$$\frac{D^2}{(22)^2} = 1.66$$

D = 29mm

D. crank case-



V. CONCLUSION

This project helped us understand the design procedures for the vital components of a reciprocating pump. We have learnt important engineering concepts related to design, development and production.

The pump we have designed acheives the goal of conformance with the API standards due to the use of the integrated hydraulic end. Further, this model is easier to assemble and maintenance due to the lesser number of parts compared to the conventional hydraulic end. The pump is used to handle water at high temperature and pressure which helps in energy saving of the boiler feed.

This model can be further developed so that it can be used with wide variety of fluids.

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