Design and Development of Centrifugal Pump

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ABSTRACT

The Paper described, The Design and Development of Single Stage Centrifugal Pump in this paper, a high flow and high pressure pump which lift liquid at high level or for delivering liquid from a region of low pressure to high pressure. This design and Development carried out many factor during development and difficulties like Special Testing Setup, High Rated Motor. From the Energy point of view, Pumps are the reverse of hydraulic Motors, Which Convert the energy of the liquid into mechanical work. The design of Centrifugal pump is based on the assumption "Shock less Entry" into the impeller.

Keyword - *Design of hydraulics parts, Design of Mechanical parts, Validation.*

1. INTRODUCTION

Pump is defined as a machine which increase the pressure energy of a fluid with the help of centrifugal Pump. Whirling motion is imparted to the fluid by means of blade mounted on the disc known as impeller. The principal of operation depends on the fact that rotation of an impeller with appropriately shaped blades, sets the particles of liquid in the impeller passage (bounded by two adjacent blades and two shrouds, in the case of centrifugal pump), in motion, from the suction side towards the delivery side. This motion produces a reduction in pressure on the inlet side at the back of the impeller blades and cause liquid to be down through the suction pipe into the pump casing.

As the liquid flows through the impeller through passages, its particles are accelerated, thus causing an increase in the kinetic energy of the liquid. This energy is partially transformed into pressure energy in the impeller and volute casing.

The Centrifugal pump Performance Standard for testing is ISO 9906 Ed 2012 Grade 1U Positive Tolerance. And Sponsor for Testing is "Indo Entity Hydro pump Pvt. Ltd, Pune".

1.1 Historical Development of Centrifugal Pump

The first centrifugal pump known in the history of engineering was discovered in July, 31st, 1772, in a copper mine in san Dolmingos, being in operation in the fifth century. The wooden impeller of that provided with vanes of double curvature is still an evidence of the ingenuity of the ancient craftsman who 15 century ago invented an impeller with double curvature vanes applied to centrifugal pumps.

2. Problem Statement

Design a water pump for the Flow 1050 m3/hr. and head 75 m and for the Speed 1450 rpm?

3. Design

3.1 Hydraulic Design

Let, Q=flow in m3/hr., n=Speed in rpm, H=head in meter, =inlet and outlet angle, z=number of blade b1 and b2 = inlet width and outlet width of blade.

1. Specific Speed

$$n_s Q = \frac{n\sqrt{Q}}{H^{3/4}} = \frac{1450\sqrt{0.2917}}{75^{3/4}} = 30.73 \text{ metric unit}$$

Shape No. Range	Shape of the Impeller
$10<n_s<50$	Radial Type
$50<n_s<150$	Mixed Type
$150<N_s<400$	Axial Type

Table no.1: Type of Pump

After finding Specific speed the shape of impeller can be decided Radial type pump range.

2. The shaft Power

$$P = \frac{\rho QgH}{\eta_o}$$

$$P = \frac{10^3 \times 0.2916 \times 9.81 \times 75}{0.85} = 252\,kW \approx 275\,kW$$

3. Shaft Diameter:

$$d_s = \sqrt[3]{\frac{360000}{N}\frac{P(hp)}{\tau_t}}$$

$$d_s = \sqrt[3]{\frac{360000}{1450}\frac{369(hp)}{450}}$$

ds= 58.60 mm, ds=60mm

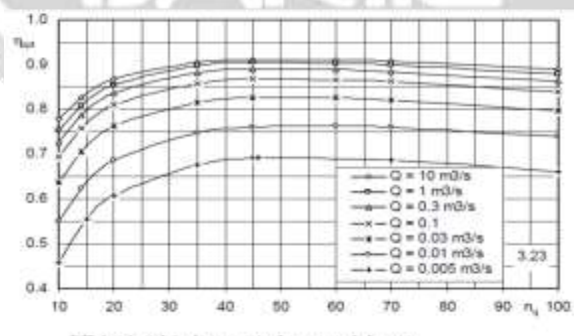

Fig 1: Efficiencies (Source Johann Friedrich Gulich, 2nd Ed)

4. Velocity at inlet :

From Stepanoff A.J

Km1 = 0.13

Cm1 = 5.99 m/s

We will make double curvature blade so construction factor assume say Qm=1.25

C0=Cm1/Qm = 4.78m/s

5. Eye Diameter D1: D1=305 mm
6. Outlet Diameter D2 : 529 mm
7. Width of blades: b1=56 mm

   b2=44mm
8. Blade angle :

$$\beta_1 = \tan^{-1}\left(\frac{C_{m1}}{U_1}\right) = \tan^{-1}\left(\frac{C_{1m}}{\pi D_1 n}\right)$$

$$= \tan^{-1}\left(\frac{5.99}{\pi \times 0.305 \times 1450 / 60}\right) = 16^o$$

β_2 assuming 23°

9. $Z \approx \frac{\beta_2}{3} \approx 7.45, Stepanoffapproach$
10. Casing Design

a) Average Velocity in casing:

=11.51 m/s

b) Base Circle =604 mm

c) Volute angle = 9°

d) Throat area = 25350 mm2

e) Thickness of Casing = 20 mm

Note: As the size is exceeding 200x150x400 as per ISO 2845 the pump for Dimensions standard we have to conclude the dimension by itself.

3.1 3D Design for Casing and Impeller

Fig no.2: 3D Model of Impeller

Fig no.3: 3D model for Casing

4. RADIAL AND AXIAL THRUST

4.1 Radial Thrust

$$T_R = \frac{K\,H\,D_2\,B_2{*}}{2.31}$$

=2308.36 kg

Where,

K= Radial Coefficient for 0.21 for n_sQ :- 30,

H= Head in m,

D2=52.9, Outlet Diameter in cm,

B2*=6.4, Breadth of outlet Vane with shroud in cm

Let,

Radial thrust is high so we have to balance radial thrust by double volute so after making double volute radial thrust is balance upto 80-90%, accordingly bearing calculation for thrust.

4.2 Axial Thrust

$T_A = (A_1 - A_s)(P_b)$

=8100 kg

Where,

A_1=Area for inlet including Shroud in Cm^2

A_s=Area of shaft including shaft sleeve in Cm^2

Balancing axial thrust

In order to balance the axial thrust in single-stage pumps with closed impellers. Axial thrust is balanced by providing balancing holes on impeller back shroud.

Which is balance up to 70 to 90 %.

T_A=810 kg

4.3 Bearing Calculation

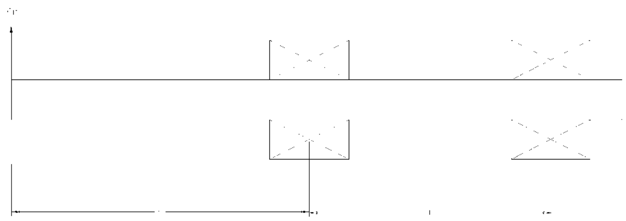

Fig No3: Bearing Connection on shaft

Let us consider the case of as shaft with an overhung impeller as shown in fig no. 3
Such the direction of the radial thrust Fr is usually in a direction from the direction of action of action of the weight of the impeller Wi, it is necessary to find resultant force.

The load on outer bearing
R2=(a/l)F
= 2600 kg

The load on outer bearing
R1=(L/l)F
= 4400kg

Bearing Selection: Angular Contact Ball Bearing and Angular roller Bearing (7315 and NU 415)
Life for Outer Bearing (7315x2) = 16000 Hrs.
Life for inner Bearing NU 415= 23000 Hrs.

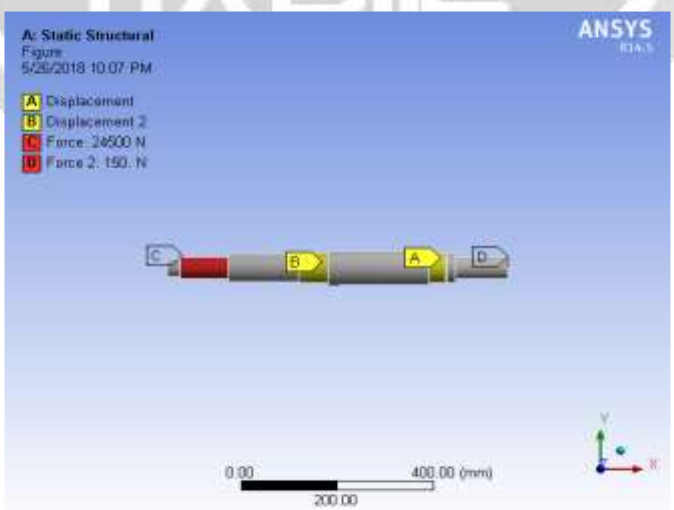

Fig no.:4 Shaft structural

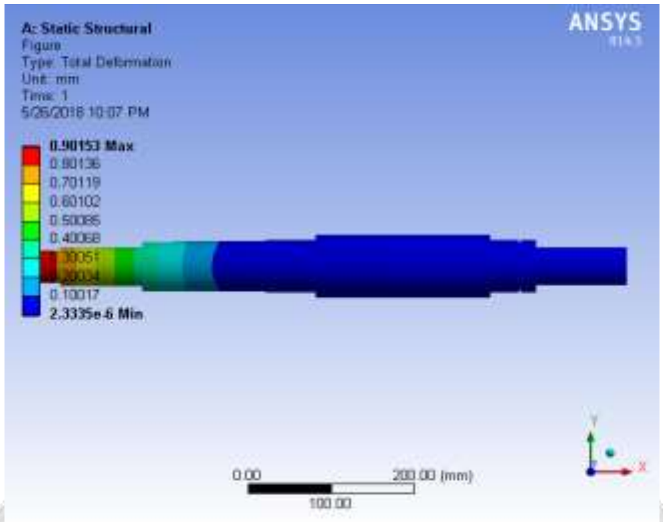

Fig no.5:Deformation of shaft

4. PUMP DETAIL AND MATERIAL

4.1 Shaft and sleeve:

The determination of the shaft diameter has been discussed above. The shaft is stepped with its greatest diameter near Centre. The diameter at coupling and the diameter at the impeller is still greater.

4.2 Bearings:

Both sleeve or journal bearing and ant frictional are used for bearing.

4.3 Impeller:

The impeller is usually cast in one piece and made of cast iron or bronze, for special liquid it may be made of stainless steel, Lead, Glass or other. The impeller be “Open” with no shroud, “Semi open” with a shroud only one side away from the inlet

4.4 Casing

Practically all pumps having their impellers between the bearings, are split horizontally on the shaft centerline so the upper half or cover can be easily removed for inspection or repair.

4.5 Material Selection

To aid in the selection of the proper material to be used when pumping various liquids, the standard of the hydraulic Institute list over 200 liquids and give the material suitable for the parts which come into contact with liquid.

pH Range	Material
Under 3.5	Corrosion-resistant steels
3.5 to 6.0	All Bronze
6.0to 8.0	Bronze iron or a combination of the two
Over 8.0	All iron or steel

Table no:2 Material Selection

5. PUMP TEST

It is impractical to illustrate all the possible testing arrangement and types of instrument which might be used.

Pump will test as per ISO 9906 2012 Edition.

6. CONCLUSIONS

In pump Designing and development it is desirable to be able to predict the performance of a pump when operating at speeds other than that at which it is tested. The usual design is based upon a certain desired head capacity at which pump will operate.

- The outlet angle is important part for Designing Impeller.
- Number of blade also important for performance of pump.
- Casing Sections area are important for reducing losses.

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[7].International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 8, August 2014 DOI: 10.15680/IJIRSET.2014.0308066 Copyright to IJIRSET www.ijirset.com 15553 CFD Simulation of Centrifugal Pump Impeller Using ANSYS-CFX, Raghavendra S Muttalli 1 , Shweta Agrawal 2 , Harshla Warudkar 3 P.G. Student, Department of Mechanical Engineering, MVJ College of Engineering, Bangalore, Karnataka,