# Analysis of Hydraulic Thrusts in Centrifugal Pump to Increase te Bearing Life

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Abstract-Centrifugal hydraulic pump is я machine which converts the mechanical energy into the hydraulic energy .It is one of the mechanical devices which play the important role in the water sector as well as the industrial sector. Also it is very useful in human life. Water is life so pump plays vital role in bringing the water from deep area up to the needy lives door. So it is necessary, the pump should be reliable and durable over the many years from installation. But there are many factors which are responsible for the damage to the pumps and end its life before it completes his life. Thus in this paper some points are highlighted which are responsible for the damage to the bearings and thus to pump. While working of pump there are two types of forces are acting on the pump which are radial and axial thrust. The force generated in lateral direction is due to dissimilar pressure generated in volute is called as Radial thrust. The force generated in longitudinal direction is on account of different areas of impeller exposed to trapped pressurized liquid called as axial thrust.

*Index Terms-* Centrifugal pump, Axial thrust, Radial thrust, Bearing life.

## I. INTRODUCTION

Reliability of rotating machineries, especially centrifugal pumps is defined on account of wear rate of components and bearing durability. One of the important performance parameter for any centrifugal pump is its bearing life. Bearing life

of centrifugal pump depends up on two hydraulic forces acting on the impeller of pump which are radial thrust and axial thrust. Amongst the two forces, radial thrust is dependant solely on pressure generated by pump. Whereas, axial thrust is dependent on the many aspects viz. shroud and casing clearances, peripheral shroud speeds, head developed by the pump, impeller geometry etc.

## II. BEARING LIFE

Bearings are used to reduce the friction between the rotating parts. Bearing life is determined by the number of hours it will takes for the metal to "fatigue" and that is a function of the load on the bearing, the number of rotations and the amount of lubrication that the bearing receives.

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To have the minimum maintenance and repairs cost, the bearing life for any centrifugal pump must be as high as possible. Bearing life of centrifugal pump depends on many parameters such as inter-cage clearances, bearings location, method of locating bearings, application of pump. But the major contribution for predicting bearing life of any pump is on account of hydraulic thrusts generated during operation of pumps i.e. Radial thrust and Axial thrust.

Types of bearings used in centrifugal pumps

- 1. Ball bearings
- 2. Roller bearing



Fig. 1 Ball and Roller Bearing

## III. HYDRAULIC THRUSTS

The high pressured liquid trapped between impeller and casing which exerts pressure on the outlet wide passages and shrouds of the impeller resulting in generation of two thrusts. These thrusts are -

1. Radial Thrust – The force generated in lateral direction is due to dissimilar pressure generation in volute is called as *Radial thrust* 

2. Axial thrust – The force generated in longitudinal direction is on account of different areas of impeller exposed to trapped pressurized liquid called as *axial thrust*.

## 1. RADIAL THRUST – DEFINITION

Radial thrust is a resultant of the pressure exerted by fluid at high pressure towards the end of the volute.



Fig.2 Radial reaction in a single volute casing

In the radial thrust uniform pressures do not exist at reduced capacities. In this thrust, due to the unbalance forces the radial unbalance forces are occurs on the bearings resulting in reducing bearing life.



Fig. 3 A graphical representation of the typical change in radial force with pump capacity

Radial reaction (F) decreases from shut-off to design capacity and then increases with over capacity. The reduction is roughly in the opposite direction from that with partial capacity.

## 1.1 RADIAL THRUST - BALANCING

1.1.1-By using double volute casing



Fig.4 Radial thrust balancing using double volute casing

Radial thrust is balanced by using double volute casing. In this method the volute is divided into two parts with the centrally provided partition. 1.1.2 By providing diffuser type casing



Fig.5 Balancing by using diffuser type casings

Radial thrust is also balanced by using diffuser type casings. In this method the diffuser is provided in between the impeller and casing. After excursion of the liquid from impeller outlet it passes through the diffuser so due to that the liquid is not directly collapsed on the casing so there is not back jerk taking place and thus the radial forces are balanced.

## 2. AXIAL THRUST – DEFINITION

Axial hydraulic thrust is the summation of unbalanced impeller forces acting in the axial direction.

This thrust is excessively affecting on the bearings. This thrust is generally high at the starting and shut-off of the pump. During starting of pump there is sudden jerk of whole impeller and shaft towards driving end, as the liquid suddenly enters at impeller eye. Thus the force is exerted on the bearings which lead to the damage of bearings resulting in reducing bearing life.



Fig.6 Axial thrust

## Elements of axial thrust -

Force acting on front the shroud due to liquid of delivery pressure entrapped between pump casing and front shroud. (**F1**)

Force acting on back shroud due to liquid of delivery pressure entrapped between casing cover and back shroud. **(F2)** 

Force acting in the direction of the liquid flow due to its momentum change. (**Fm**)

## 2.1 AXIAL THRUST – INFLUENCING PARAMETERS

1. Asymmetry of impeller shrouds.

2. Clearances between casing cover and impeller back shroud.

3. Clearances between casing and impeller front shroud

4. Radius of back vanes.

5. Suction pressure.

## 2.2 AXIAL THRUST – NEED FOR OPTIMIZATION

1. The life and size of the bearings is greatly influenced by the axial thrust developed. 2. High axial thrust loads can cause rapid thrust bearing wear and either subsequent pump failure or frequent overhauls.

3. No any recognized and proven methods are available for theoretical analysis of axial thrust. 4. The available literature on measurements of axial thrust in pumps indicates the lack of adequate and accurate experimental results data. 5. Axial thrust data and improved analytical methods are critical to

the selection of proper thrust bearings. 2.3 AXIAL THRUST – BALANCING METHODS

- 1. Providing wear rings and balancing holes
- 2. Balancing with radial back vane
- 3. Balancing drum.
- 4. Balancing Disks.
- 5. Combination of Balancing Disk and Drum
- 2.3.1 Providing wear rings and balancing holes

In this method the balancing holes are made in the impeller in-between the vanes. Generally when pump starts, due to change in momentum of the liquid the impeller creates pressure from suction side and generates axial jerk on the bearing. But due to balance hole the water rushes from the holes and creates the back pressure on the impeller to oppose the jerk and thus balances the axial thrust

Balancing Holes



Fig.7 Balancing holes in impellers

#### 2.3.2 Balancing with Radial back vanes Back vanes



Fig.8 Back vanes on impellers

By providing back vanes at the back sides of the impeller the clearance between the impeller back side and casing cover is reduced which prevent incoming water flow so due to that the axial thrust is gets balanced. 2.3.4 Balancing drum



Fig.9 Axial thrust balancing by using balancing drum In this method the drum is provided to balance the Axial thrust.

2.3.5 Balancing Disks



Fig.10 Axial thrust balancing using balancing drum

In this method balancing disks are provided to balance the Axial thrust.

#### 3. THEROTICAL ANALYSIS

In this phase, the unbalanced axial thrust is calculated on the basis of the following theories.

- 1. Val S. Lobanoff
- 2. A. J. Stepanoff
- 3. K. J. Zanker- BHRA paper

#### 4. EXPERIMENTAL ANALYSIS

- 1. The actual thrust induced on the impeller will be measured by virtue of an experimental test rig.
- 2. The methods of measuring the unbalanced hydraulic axial thrust experimentally are
- a. Providing tapping in pump casing and casing cover for obtaining the pressure values between the clearances of impeller and casing.
- b. By making a provision for load cell at the end of the shaft, this will directly give the axial end thrust in Kg.
- c. Finally the results obtained experimentally and those obtained by theoretical analysis will be compared and conclusions will be drawn.

#### CONCLUSION

- 1. The bearing life is highly influenced by radial and axial thrusts developed during running of the pump.
- 2. There are deviations in the answers obtained by methods stated by different researchers; hence it is very difficult to predict the correct value of axial thrust.
- 3. If we can predict the axial thrust correctly, then we can easily predict the bearing life. This in turn will improve the reliability of the centrifugal pumps

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