Learn and Lunch

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SEMINAR

ON

HYDRAULIC THRUSTS IN CENTRIFUGAL PUMP

CONTENTS

- **Introduction**

- **Construction and Working of Centrifugal pump.**

- **Bearing life.**

- **Hydraulic thrusts in centrifugal pumps.**
  - **Radial thrust**
  - **Axial thrust**

- **Need for optimization of axial thrust.**

- **Methods of balancing axial thrust.**

- **Theoretical analysis**

- **Experimental Analysis**

- **Conclusion**

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 upon hydraulic forces acting on the impeller.

BEARING LIFE

- Bearing life is determined by the number of hours it will take for the metal to "fatigue"

- *The basic rating life of bearing in millions of revolution according to ISO281-1990 is*

  L10=(C/P)^p

- *The basic rating life of bearing in operating hours according to ISO281-1990 is*

  L10h=[(10^6)/(60*n)]*L10

  C= Basic dynamic load rating in,kN

  P= Equivalent dynamic load rating in,kN

 *p=exponent (3- for ball bearing & 10/3 for roller bearing)*

  n= revolution per minute

- Bearing life of centrifugal pump depends on many parameters. But the major contribution for predicting bearing life of any pump is on account of hydraulic thrusts generated during operation of pumps.

WORKING PRINCIPAL

The two main components of a centrifugal pump are the Impeller and the volute.

•Impeller produces liquid kinetic energy

•Volute forces the liquid to discharge from the pump converting kinetic energy to pressure energy.

To discharge piping

Cut-Water

Impeller

Volute
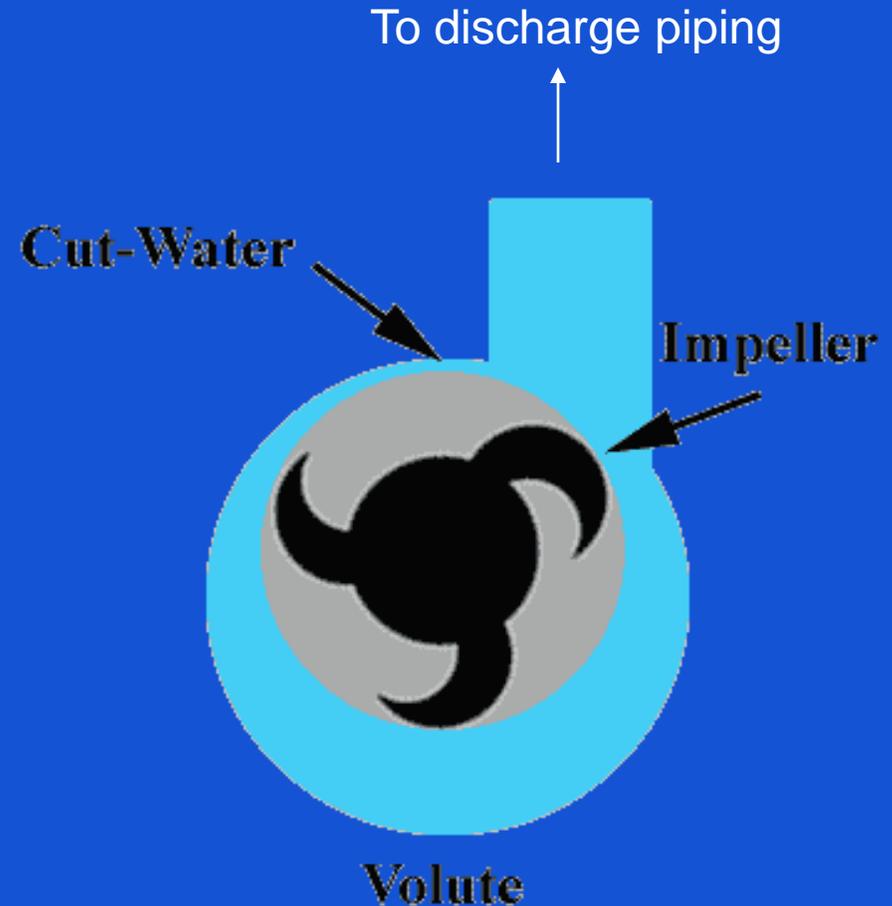
HYDRAULIC THRUSTS

- During operation and working of centrifugal pump the high pressured liquid trapped between impeller and casing exerts pressure on the outlet passages and shrouds of the impeller resulting in generation of two forces. These thrusts are –
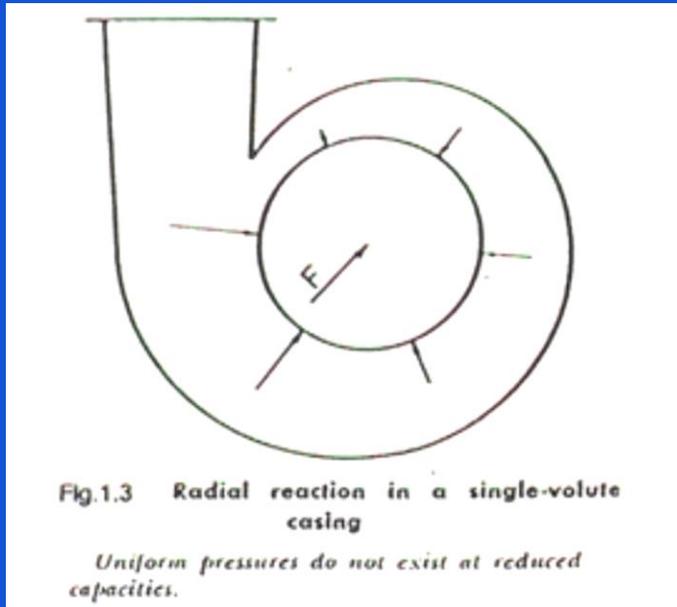
1. Radial Thrust –

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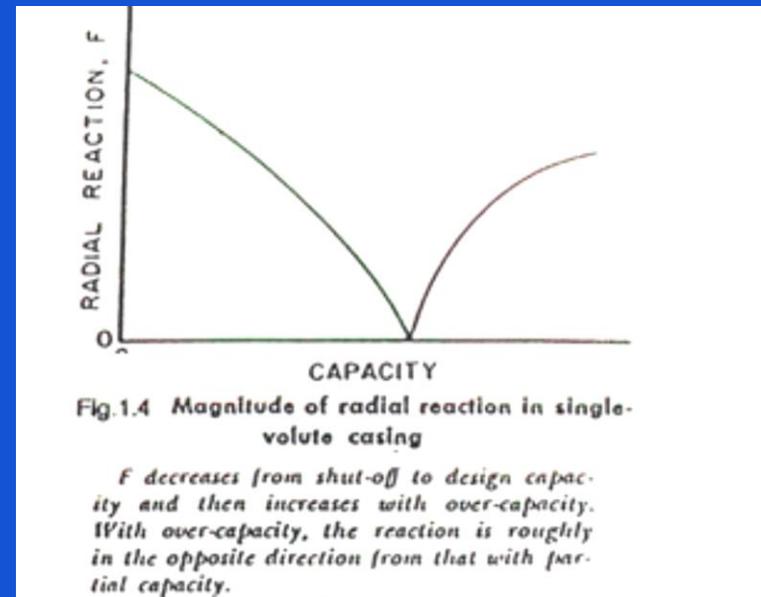
2. Axial thrust –

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

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RADIAL THRUST - DEFINITION

Fig.1.3   Radial reaction in a single-volute casing

Uniform pressures do not exist at reduced capacities.

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

- A graphical representation of the typical change in this force with pump capacity .

Fig.1.4   Magnitude of radial reaction in single-volute casing

F decreases from shut-off to design capacity and then increases with over-capacity. With over-capacity, the reaction is roughly in the opposite direction from that with partial capacity.

RADIAL THRUST - DEFINITION

Radial Thrust Rt = (0.1*K*(B/(2*10))*(D/10)*H*γ)/V

K : is a Radial Thrust factor (values are taken from Agostinelli D Mobles & C R Mockridge curve)
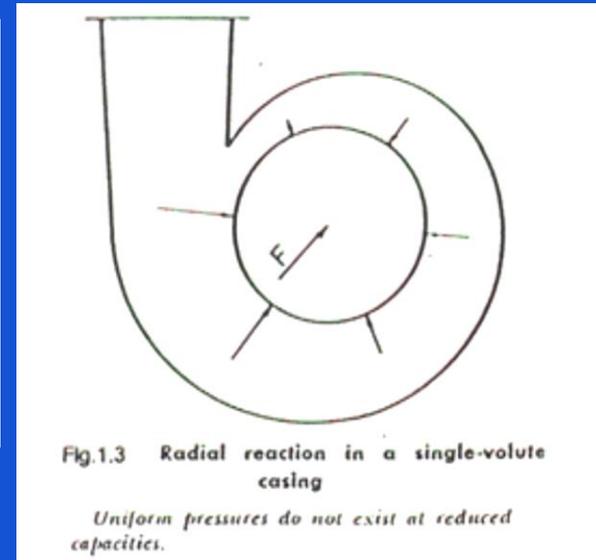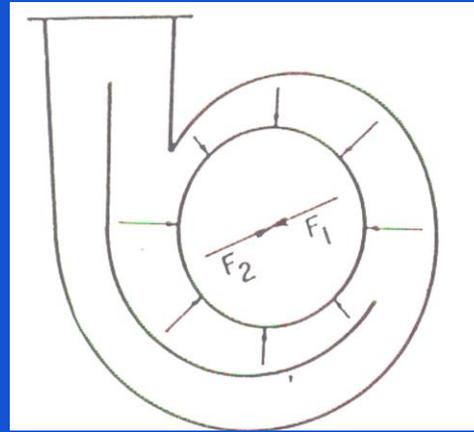
B: Impeller Outlet width in mm

D : Imperller dia in mm

H : Head in meters

γ *: Sp.gravity of liquid*
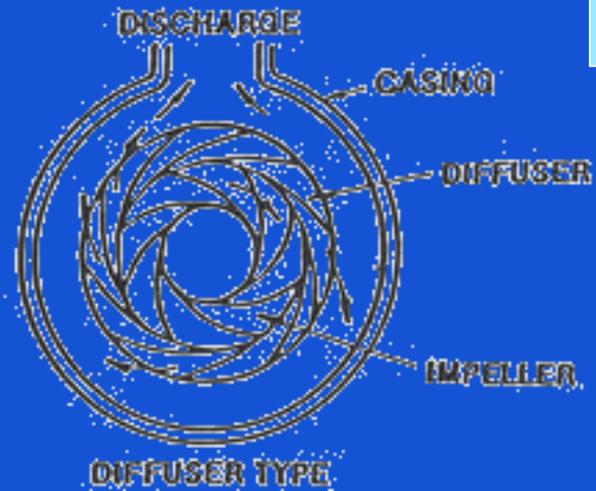
V : Volute type (1- for single,2- for double)

RADIAL THRUST - BALANCING

- Radial thrust can be balanced by using double volute casing.

Fig.1.3 Radial reaction in a single-volute casing

Uniform pressures do not exist at reduced capacities.

DOUBLE VOLUTE

**SINGLE VOLUTE**

DISCHARGE

CASING

DIFFUSER

IMPELLER

DIFFUSER TYPE

- Radial thrust can also be balanced by using diffuser type casings.

AXIAL THRUST - DEFINITION

- Axial hydraulic thrust is the summation of unbalanced impeller forces acting in the axial direction.
- Elements of axial thrust –
  - Force acting on front 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**)
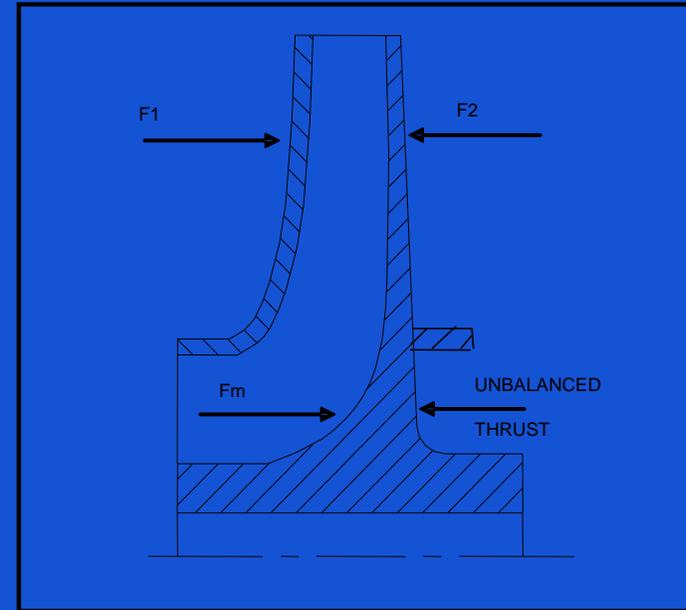
AXIAL THRUST

AXIAL THRUST

- SUMMATION OF UNBALANCED HYDRAULIC FORCES ACTING AXIALLY ON THE IMPELLER.

SEVERITY OF AXIAL THURST DEPENDS ON THE TOTAL HEAD, SUCTION PRESSURE & MECHANICAL CONFIGURATION OF IMPELLER.

AXIAL PRESSURE ACTING ON THE IMPELLER SHROUDS TO PRODUCE AXIAL THRUST

DOUBLE SUCTION IMPELLER

SINGLE SUCTION IMPELLER
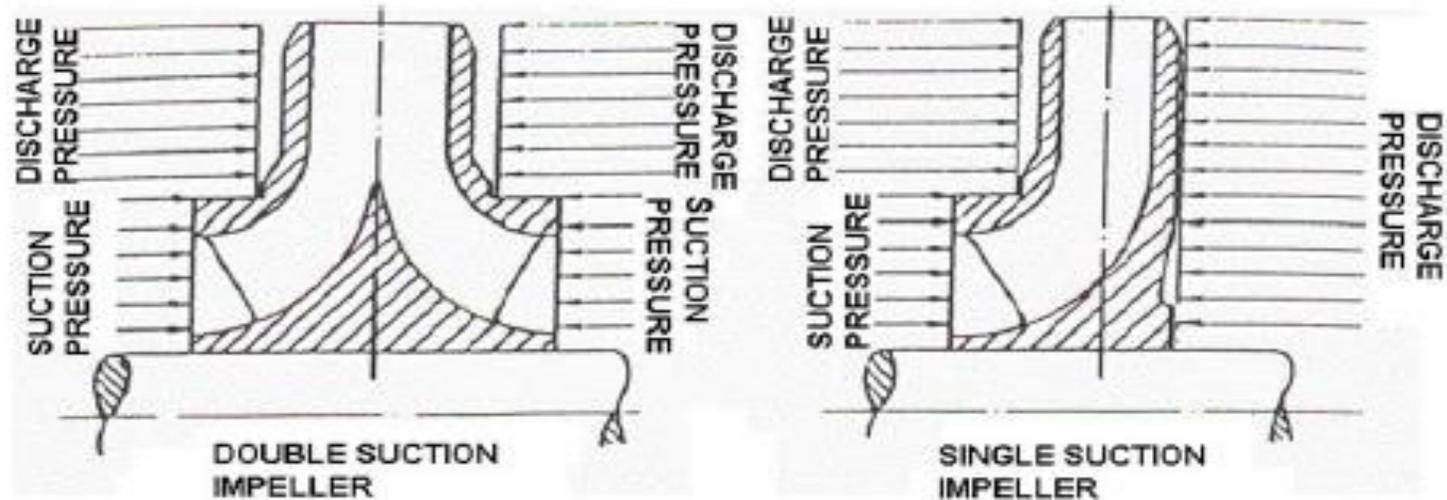
AXIAL THRUST – INFLUENCING PARAMETERS

- Asymmetry of impeller shrouds.

- Clearances between casing cover and impeller back shroud.

- Clearances between casing and impeller front shroud

- Radius of back vanes.

- Suction pressure.

AXIAL THRUST – NEED FOR OPTIMIZATION

- The life and size of the bearings is greatly influenced by the axial thrust developed.

- High axial thrust loads can cause rapid thrust bearing wear and either subsequent pump failure or frequent overhauls

- No recognized and proven methods are available for theoretical analysis of axial thrust.

- The available literature on measurements of axial thrust in pumps indicates the lack of adequate and accurate experimental results data.

- Axial thrust data and improved analytical methods are critical to the proper selection of thrust bearings.

AXIAL THRUST – BALANCING METHODS

- [Providing wear rings on both sides and balancing holes](#) in back shroud

- [Balancing with radial back vanes](#)

- [Use of Bearings](#)

EXPERIMENTAL ANALYSIS

Pump type : End Suction Centrifugal Process Pump

**Impeller type** : enclosed impeller with back vanes

- The actual thrust induced on the impeller will be measured by virtue of an experimental test rig.

- The methods of measuring the unbalanced hydraulic axial thrust experimentally are –

  1. Providing tapping in pump casing and casing cover for obtaining the pressure values between the clearances of impeller and casing.

  2. By making a provision for load cell at the end of the shaft, this will directly give the axial end thrust in Kg.

  3. Finally the results obtained experimentally and those obtained by theoretical analysis will be compared.

EXPERIMENTAL SET UP
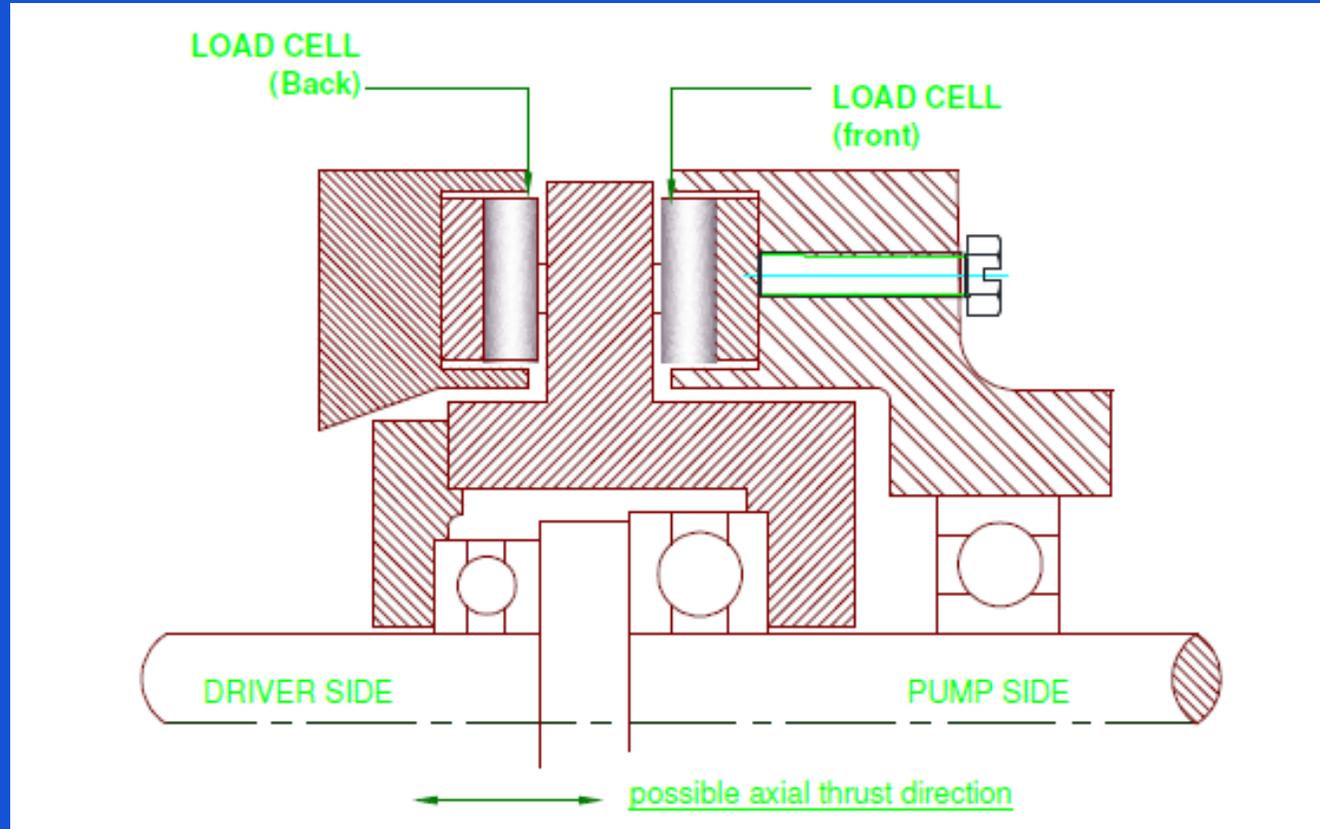
OBSERVATIONS

- It is observed that the parameter controlling axial thrust are as follows in order of importance:
  - Back vane radius
  - Back vane height
  - No. of back vane
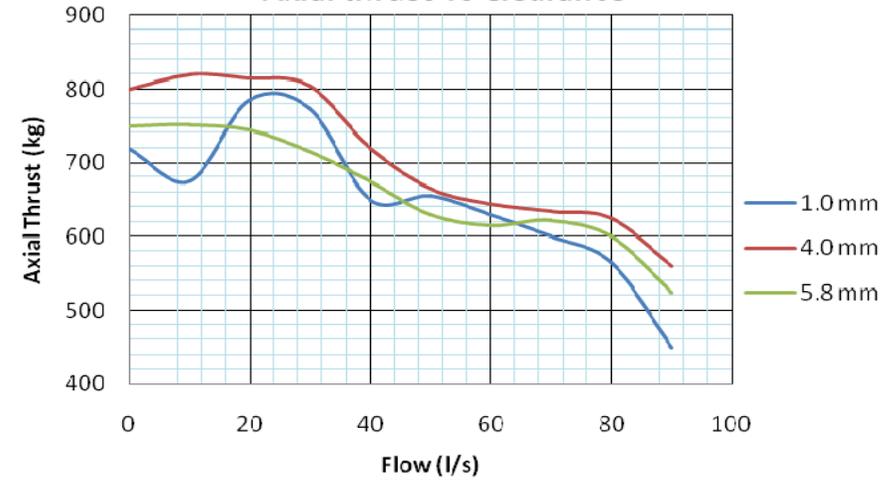 - Clearance between casing cover and Impeller back Vane.

Variation of Back vane force with No of back vane

Variation of Back vane force with Backvane radius
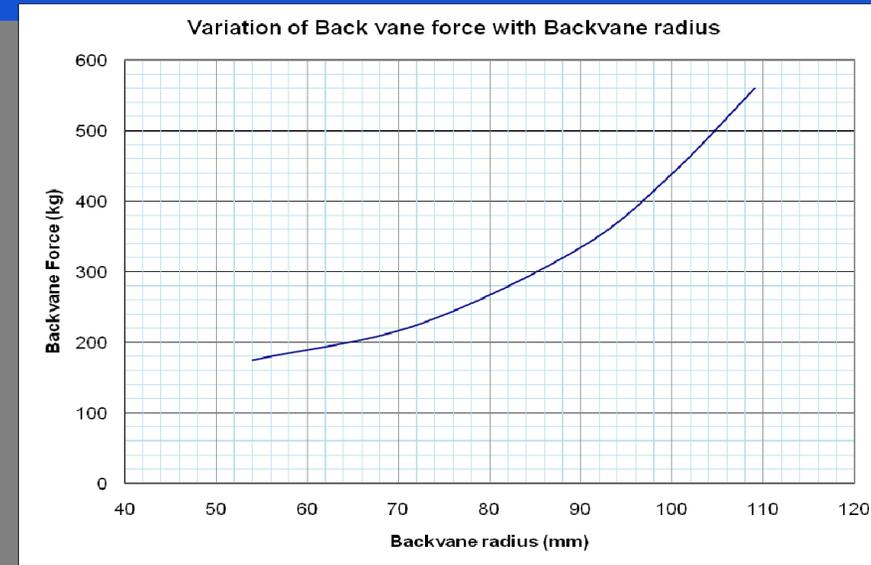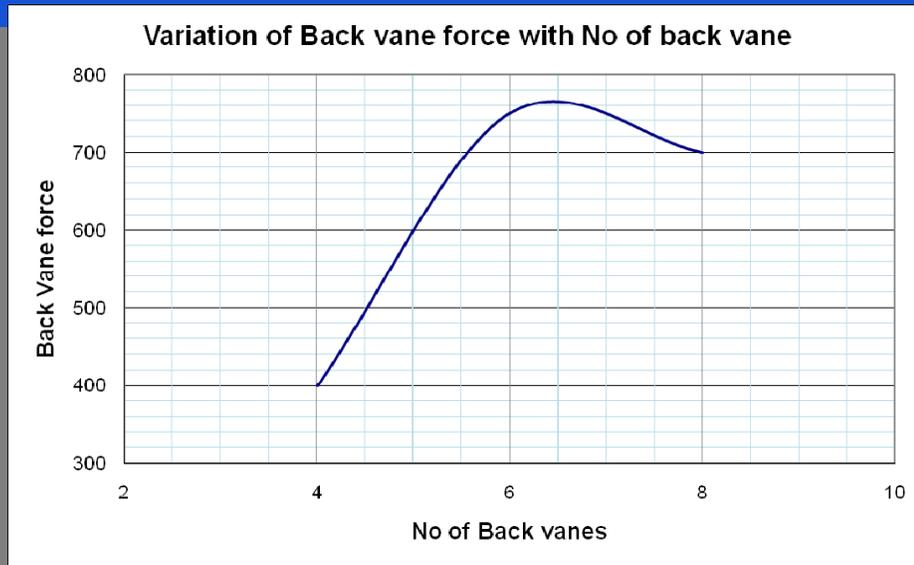
OBSERVATIONS

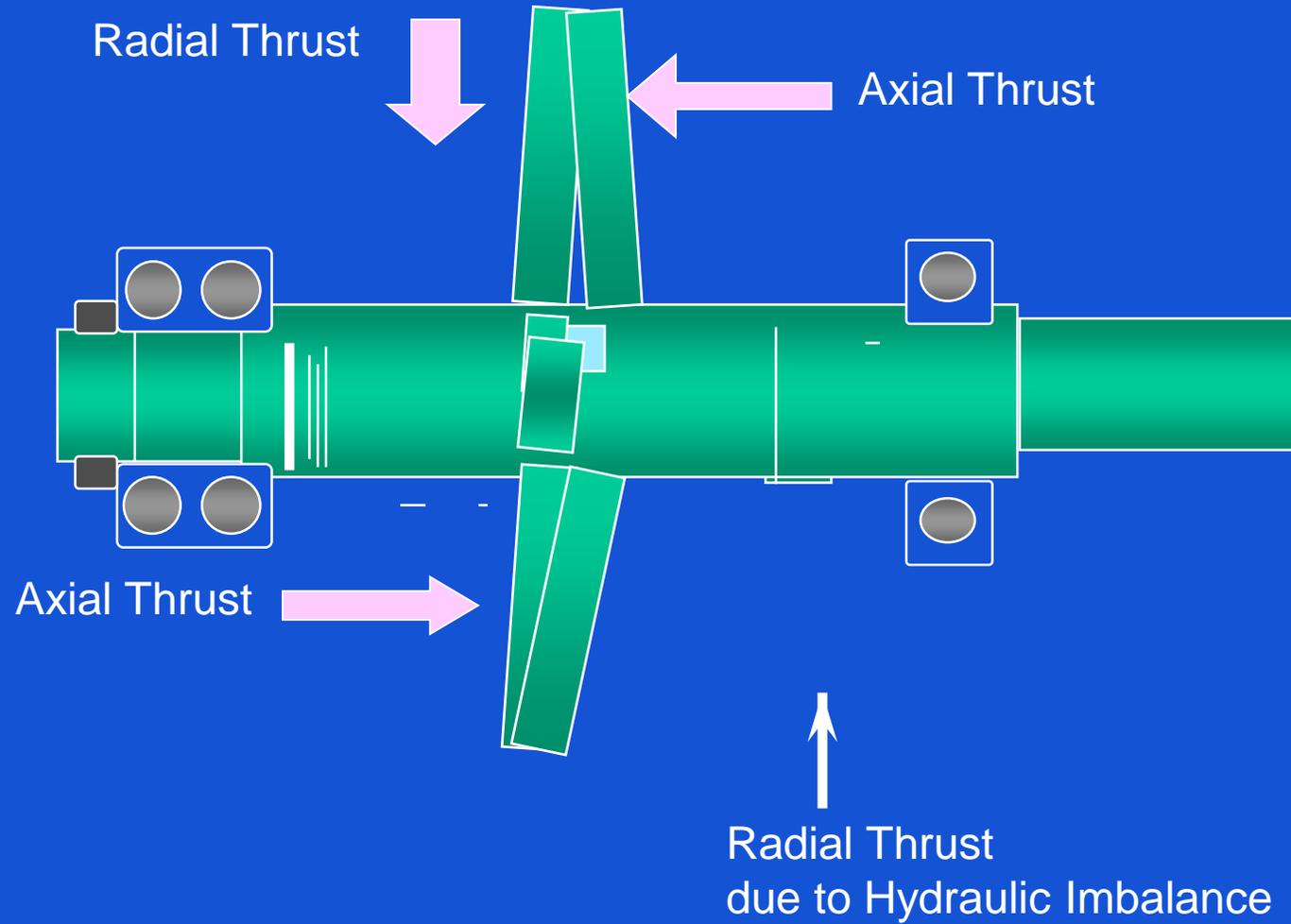Variation of back vane force with back vane height
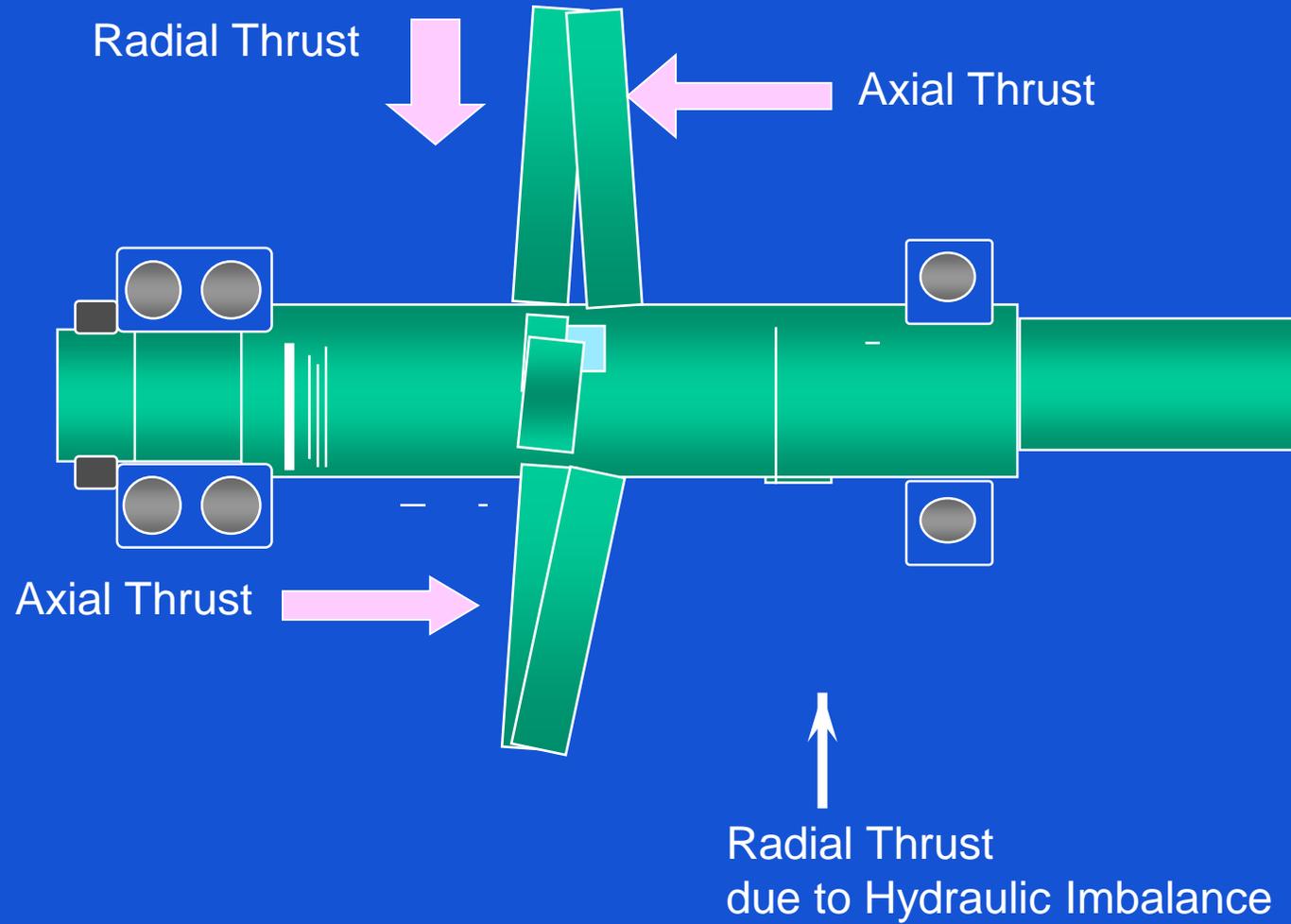

Axial thrust Vs Clearance

CONCLUSION

- 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.

- It is observed that the parameter controlling axial thrust are as follows in order of importance:

  - Back vane radius
  - Back vane height
  - No. of back vane
  - Clearance between casing cover and Impeller back Vane.

  - Back vane radius contributes to the maximum extent to the variation of axial thrust.

HYDRAULIC THRUSTS

Radial Thrust

Axial Thrust

Axial Thrust

Radial Thrust
due to Hydraulic Imbalance

HYDRAULIC THRUSTS

Radial Thrust

Axial Thrust

Axial Thrust
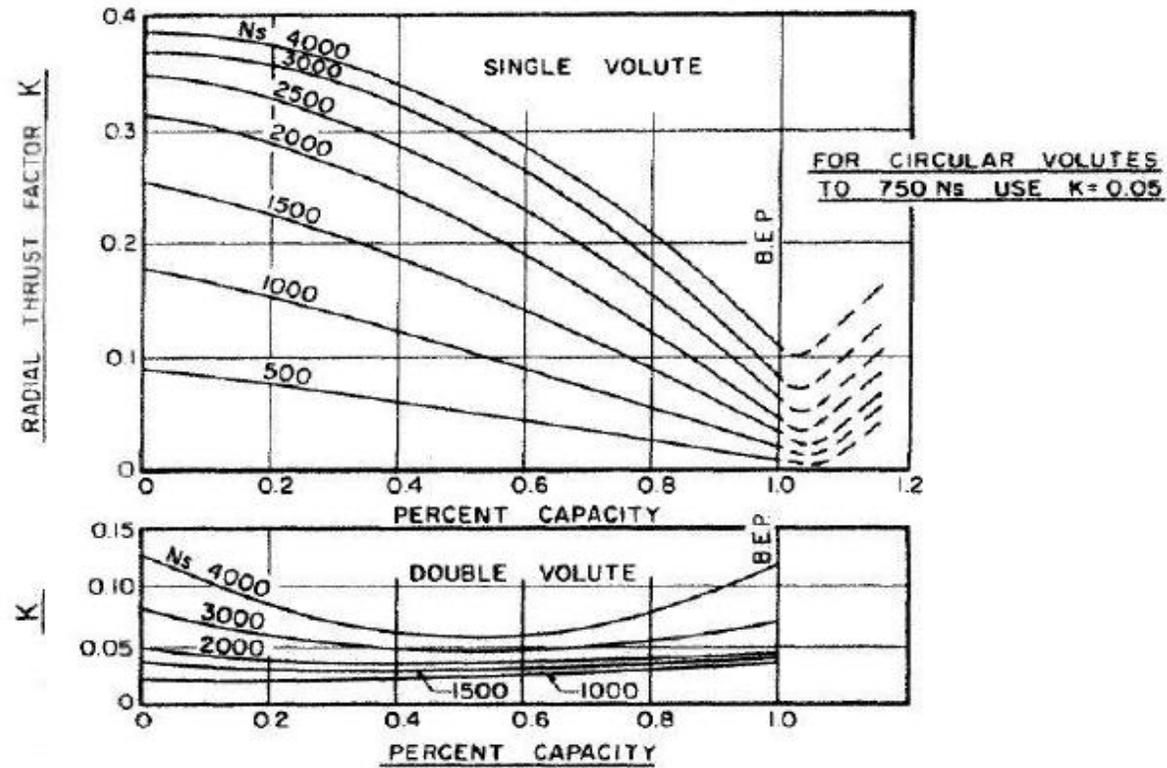
Radial Thrust
due to Hydraulic Imbalance

RADIAL THRUST FACTOR

Figure 5-2. Radial thrust factor.

Thank You