EXPERIMENTAL ANALYSIS OF CENTRIFUGAL PUMP

Gavit Bhaveshkumar R[1], More Ketankumar v[2], Mishra Adarshkumar[3], Mr. Vishal Naik[4]

[1]STUDENT OF B.E DEPARTMENT OF MECHANICAL, LIT (SARIGAM)
[2]STUDENT OF B.E DEPARTMENT OF MECHANICAL, LIT (SARIGAM)
[3]STUDENT OF B.E DEPARTMENT OF MECHANICAL, LIT (SARIGAM)
[4]ASSISTANT PROFESSOR, DEPARTMENT OF MECHANICAL ENGEERING, LAXMI INSTITUTE OF TECHNOLOGY (SARIGAM), Gujarat, India

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Abstract - *the report insert and represent the principal and its execution of centrifugal pump. centrifugal pump are consumed to transmit fluid by the regeneration or modification of rotational Kinetic strength to the hydrodynamic strength of the liquid to transfer on its common uses as a discharge petroleum and acting actinic throbbing a centrifugal .rooter is commonly used to apply as vacuum cleaner. If the mechanical vitality is reformed into pressure vitality by mean on the liquid the pneumatic machine is called "centrifugal pump". It Act on the leading of vortex flow the centrifugal pump act as contradiction of an inner radial run on reaction turbine. That means and the part of pump are impeller case absorption .pipe with a foot valve and a cylinder.*

Key Words: *Centrifugal Pump, Mechanical Seal, Type of Failure*

1. INTRODUCTION

The hydraulic machines which convert the mechanical energy into hydraulic energy are called pumps. The pressure energy is increased by creating a region of low pressure (usually lower than the atmospheric pressure) near the inlet of the pump and the higher pressure at the outlet of the pump and a higher pressure at the outlet of the pump. Due to low inlet pressure, the liquid rise to the pump from low level reservoir (sump) and high pressure created inside the pump, forces the liquid out of the pump which is delivered to the high level reservoir.

It increases pressure energy or kinetic energy or both by using mechanical energy. The energy level of the fluid can be increased by either roto dynamic action or by positive displacement of the fluid. "If the mechanical energy is converted into pressure energy or kinetic energy by means of centrifugal force acting on the fluid the hydraulic machine is called Centrifugal pump." Centrifugal Pumps are the most popular and commonly used type of pump for the transfer of fluids. In simple words, it is a pump that uses a rotating impeller to move water or other fluids by using centrifugal force. These are the undisputed pump choice especially for delivering liquid from one location to another in numerous industries including agriculture, municipal (water and wastewater plants), industrial, power generation plants, petroleum, mining, chemical, pharmaceutical, and many others. Centrifugal Pumps are useful since they can generally handle large quantities of fluids, provide very high flow rates (which may vary with the changes in the Total Dynamic Head (TDH) of the particular piping system) and have the ability to adjust their flow rates over a wide range. Centrifugal pumps are generally designed and suitable for liquids with a relatively low viscosity that pours like water or light oil. More viscous liquids such as 10 or 20 wt. oils at 68-70 deg F will require additional horsepower for centrifugal pumps to work. For viscous liquids of more than 30 wt. oils, positive displacement pumps are preferred over centrifugal pumps to help lower energy costs.

1.1 LITRATURE OVERVIEW

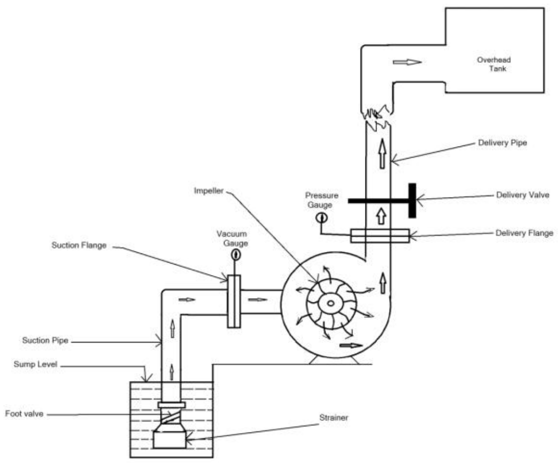
1. Deeptesh Singh studies of failure analysis of centrifugal pump from the perspective of life its components and frequency of occurrence of failure in it has done.2. N. R. Sakthivel., V. Sugumaran. And S. Babudevasenapati. Shows the experimental analysis on the "Vibration based fault diagnosis of mono block centrifugal pump using decision tree" by which they shows the different condition of failure and its causes easily explain by the decision tree and its Expert Systems with Applications.

2. WORKING PRINCIPLE OF CENTRIFUGAL PUMP

As mentioned earlier, Centrifugal pump relies on the centrifugal force. When you swing a bucket of water around over your head, you will find that as you increase the speed, the bucket is pulled harder against your arm. This pull on your arm is the. Centrifugal force. It makes no difference if you swing the bucket horizontal or vertical. If the speed is fast enough, then the water will remain on the bucket.

If you punch a small hole on the bottom of bucket, the water throws a stream and the distance the water travels is proportional to the centrifugal force. The same force that kept water in the bucket, is how the simple Centrifugal pump works. Centrifugal Pump consists of a rotating impeller inside a stationary volute (casing). Liquid enters the pump through the suction inlet into the eye of the impeller. The speed of the rotating impeller then forces the liquid out through the discharge nozzle. The liquid enters the inlet of the centrifugal pump under atmospheric pressure, and flows into the eye of the impeller.

The Centrifugal force exerted on the liquid by the rotating impeller, moves the liquid away from the impeller eye and out along the impeller vanes to their extreme tip where the liquid is then forced against the inside walls of the volute and out through the discharge of the pump. Due to the reduction of pressure occurring at pump inlet and impeller eye, liquid is drawn into the pump in continuous flow as it moves through the pump. The shape of the volute casing is such that it is wider at the discharge point than where the liquid is first forced by the impeller against the volute.When the water from the impeller strikes the side of the volute, the velocity is increased. This accelerated motion is called "Kinetic Energy", which is the energy in motion.



2.1 DIFFERENT TYPES OF FAILURES MODES IN CENTRIFUGAL PUMP

Pump failures result in operational changes that reduce efficiency or result in a breakdown of the pump. There are 13 main problems that afflict centrifugal pumps when in use. These problems, which include both mechanical and hydraulic problems, have been discussed in the literature over a number of years in a wide variety of industries.

 The problems that will be addressed here will be hydraulic failures:-

1.Cavitation 2.Fauling effect 3. Pressure pulsations, 4. Pump Recirculation. 5. Radial thrust, axial thrust, 6. Suction and discharge recirculation.

 Mechanical failures:-

1. Bearing failure, 2. Seal failure, 3.Lubrication 4.Excessive vibrations, 5. Fatigue 6.vibrations

 And other types of failure:-

1. Erosion, 2. Corrosion,

3. Excessive Power Consumption).

Each problem will be outlined including its cause and effect, symptoms, and pertinent

Mechanical Corrective Procedures.

In this project we major focuses on the problems like

1. Seal failures, 2. Cavitations

1. Seal failure:-

1. Mechanical seals are the essentials part of the centrifugal pumps to prevent the fluids leakages, the life of the mechanical seal is very less due to numbers of factors affects its. 2. Mechanical seal may fail due to the pump running dry. Many applications are best protected by using dual pressurized mechanical seals, which remain lubricated even through periods of complete dry running. 3. In non-hazardous applications, a pump sealed with packing that is lubricated from an external source will survive dry running better, given that the source is compatible with the fluid being pumped 4. Mechanical seals, in general, fail for two reasons: the lapped faces open up, or one of the seal components becomes damaged. When a seal face opens, it allows solids to penetrate between the lapped surfaces. The solids embed themselves into the softer carbon /graphite face causing it to act like a grinding wheel, which then causes severe wear on the hard face. This type of failure accounts for the majority of mechanical seal failures.

2.2 Gland Packing Elastomers

Elastomers take their denomination from the excellent elastic memory they have. This is the reason why Elastomers are the primary choice as secondary seals.

Their Properties Are:

1. Capacity to operate in a satisfactory way even when the mating surface is not accurately finished. 2. Capacity to tolerate small misalignments between the shaft and the rotary ring 3. Capacity to absorb shaft vibrations. 4. Easy installation in any kind of seat or shaft, even with key or sharp 5. Corners. 6. The cost is generally low, with the exception of perfluoroelastomers (Kalrez or equivalent)

❖ **Main Composites Are**:

Nitrilic Rubber

- Composed of acrylonitrile polymer and butadiene
- **Temperature range:** -40 a 100°C (120° max for a short time).

Availability: easy in all sizes

Chemical compatibility:

- Very good with mineral oils.
- Good with water, greases and aliphatic hydrocarbons.
- Poor with concentrated acids, aromatic hydrocarbons , ketones.

Fluoroelastomer

- ELASTOMER is a braided, rope like material that is packed around the shaft - physically stuffing the gap between the shaft and the pump housing.
- ELASTOMER materials can be used in normal NITRILE butadiene rubber (NBR) More appropriate material INCLUIDE Hydrogenated NITRILE butadiene rubber (HNBR)
- Composed by copolymer of hexa fluoropropylene (HFP) and vinylidene fluoride (VDF or VF2).

Temperature range: -20 a 200°C

Availability: easy in all sizes

Chemical compatibility:

- Very good with mineral oils and hydrocarbons
- Good with most acids
- Poor with hot water and steam
- Very poor with concentrated alkaline solutions and ketones.

ADVANTAGE OF FLUORO ELASTOMER

- Material can be Easy to available in market
- Leakage can be reduced
- Cost can be lower than mechanical seal
- Exhibit high strength and good oil resistance

DISADVANTAGE

- Poor chemical and heat resistance
- Low impact resistance
- Low thermal stability

Selection Of Mechanical Seals

- The API 682 standard is a powerful tool to carry out mechanical seal selection for intended use in refinery plants.
- In chemical plants the variety of applications and process fluids makes the selection of the seal a challenging job.
- Many parameters should be considered as characteristics of the fluids , configuration of the machinery on which the seal have to be installed , specific requirements in terms of compatibility with some restrictive standards (i.e. FDA rules for food industry).
- In the next sections the most diffuse products and relevant recommended configurations are grouped into families and defined with the intent of explaining the logic of the API plans.

Cooling System And API Plans:

- The great importance of efficient lubrication of the seal rings for good importance has been previously underlined. It follows that a suitable cooling system should be implemented to limit the operating temperature of the seal. Many different lay-outs can be used, depending on the configuration and the required service.
- A good seal selection must include criteria for a safe and durable installation. API standard has supplied an exhaustive collection of flushing and pressurization lay-outs, each intended for a specific service. The various connection lay-outs are identified by a specific number which gives the possibility to simply define all possible configurations

Clean, Not Harmful, Neutral, Not Flammable Products

Example: Water, Vegetal oil, Glycol

- API Plan 11 or 01 is the recommended lay-out, in order to dissipate the heating produced by the seal rings and to carry out a proper venting of the stuffing box.
- In the case of a conical stuffing box. also API Plan 02 can be used.

Fluids crystallizing when in contact with atmosphere

Example: Sulphates, phosphates, saline solutions, alkaline solutions

- A single configuration is recommended, combined with API Plan 11 or 01 in order to dissipate the heating produced by the seal rings and to carry out a proper venting of the stuffing box.
- Implementing an additional API Plan 62 with water or steam at low pressure (max 0.3 barg), an efficient

removal of crystallization deposits can be insured, preventing locking of the rotary ring.

Acid products

- A single internal seal is recommended, API Plan 11/61 or 01/61 is in theory the proper connection. In case of conical stuffing box use API Plan 02/61.
- With these products an external seal is suitable too; in this case protection should be provided to prevent possible spraying of product.

Hot liquids

Example : Heavy hydrocarbons, diathermic oils

- Temperatures over 200°C up to 400°C are typical applications in refinery plants or pumps for diathermic oil.
- It is important to evaluate the effective operating temperature in the stuffing box.
- Many pumps come with a cooling system which reduces the temperature in the stuffing box, in order to avoid very expensive configurations of the mechanical seals.
- The selection of the materials and the configuration will mainly depend on the operating temperature.
- The recommended configuration is a single internal seal, with API Plan 02. A complete venting of the stuffing box is required and then the installation of a suitable system has to be verified.
- Implementing an additional API Plan 62 with water or steam at low pressure (max 0.3 barg), an efficient removal of crystallization deposits can be insured, preventing locking of the rotary ring. For a more accurate analysis, make reference to API 682 specifications

Mechanical seal balance component cell style196

- DEPAC component Seal type 196 is a pressure balance stationary single seal which has been developed Especially to fit installation chamber according to DIN 24960/EN 12756 the seal stationery seal design completely rules out seal fretting and guarantees smooth Running. Balanced mechanical seal work with lower face pressure. in lower face fiction and therefore less wear on the face pair. the mechanical seal lasts longer
- style 196 can be combined with all common adaptors and sale glands stage

Advantage

- stationery design
- L1KU dimension and larger dimension available
- pressure balanced
- direction of rotation independent multiples spring design and spring made of Hast alloy C
- no fretting of Shaft
- no clogging of spring

3. METHODOLOGY

SPECIFICATIONS : -

1. Centrifugal pump - 25 x 25 mm. size

2. Motor:- D .C. , 1 H.P.

3. Sump Tank = 1200X500X1500 mm

4. Measuring tank = 400x400x400 mm fitted with gauge tube and drain valve.

4. Gate valve to control the head

5. Pressure gauge to measure discharge pressure.

6. Vacuum gauge to measure suction vacuum.

7. Energy meter to measure input the motor.

EXPERIMENTAL PROCEDURE :-

1. Fill up sufficient water in the sump tank. 2. Open the priming nipple plug (At the top of pump) and fill up water up to the nipple.

Replace the plug and tighten it properly. 3. Start the pump. As discharge valve is closed, no discharge will be observed, but discharge pressure will be indicated. This is called ' Shut off head' of the pump. 4. Slowly open the discharge valve, so that small discharge is observed. 5. Note down discharge head (pressure), suction vacuum, time required for 10 cm. water collection in measuring tank and 10 imp of energy meter. 6. Note down the observations at different valve openings. 7. Repeat the steps 3 to 7 for different speeds.

MECHANICAL SEAL

Sr. No.	Pump speed rpm	Discharge Pr. (Kg/cm2)	Suction Vacuum mm of Hg	Time for 10 cm water collection, sec. 't w'	Time for 10 Imp. Of Energy meter sec ' t e'
1	1800	0.35	200	18	24.3
2	2000	0.70	200	14.42	20.2
3	2500	0.87	400	12.38	19.0

FLURO ELASTOMER(GLAND PACKING)

Sr. No.	Pump speed rpm	Discharge Pr. (Kg/cm2)	Suction Vacuum mm of Hg	Time for 10 cm water collection, sec. 't w'	Time for 10 Imp. Of Energy meter sec ' t e'
1	1800	0.5	400	20	25.7
2	2000	0.72	400	16.64	22.6
3	2500	0.91	600	14.67	21.2

CALCULATIONS 2nd TABLE:

1) Discharge Pressure Pd= 0.91 kg/cm2

For water, 10 m height corresponds to 1 kg/cm2

So Discharge head h d = Pd x 10 = 0.91 X 10 = **9.1 m of water.**

2) Suction Head – $hs = \frac{Ps}{1000} X \frac{13.6}{1}$ $= \frac{600}{1000} X \frac{13.6}{1} = \mathbf{8.16}$ **m of water.**

Sp, gravity of mercury = 13.6 and Sp, gravity of water = 1

3) Total Head, ht = h d + h s + h f=9.1+ 8.16 +2 =**19.26 m**

Where, h f = 2 meter is the assumed head loss due to friction.

4) Discharge - $Q = \frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} = \mathbf{1.09\ X\ 10^{-3}}$ **m³/sec**

Let time for 10 cm water collection be t w sec. Then,

5) Output power of pump

$$Pw = \frac{w\ x\ Qa\ x\ ht}{1000} = \frac{9810\ X\ 1.09X\ 10^{-3} X\ 19.26}{1000} = \mathbf{0.2060Kw}$$

where, W = Specific weight of water = 9810 N/m3

Q a = Discharge m3/sec.

Ht = Total head m

6) Input power to pump-Let time required for 10 indication mean pulse of energy meter be t e sec. then,

$$IP = \frac{10\ x\ 3600}{te\ x\ 3200} = \frac{10\ x\ 3600}{21.2\ x\ 3200} = \mathbf{0.530kw}$$

energy meter constant is 3200 imp/K wh.

Taking motor efficiency 80 %, we have input shaft power

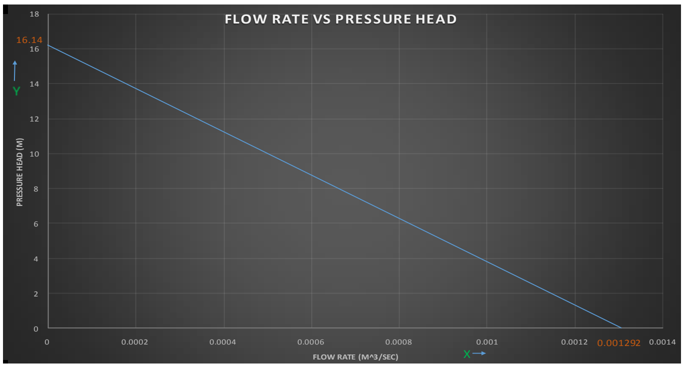
S.P.= I.P. x 0.80 =0.530 X 0.80 =0.424

7) Overall efficiency of pump –

$$\eta = \frac{PW}{SP} X\ 100\% = \frac{0.2060}{0.424} X\ 100\% = \mathbf{48.58\%}$$

First Table Graphs

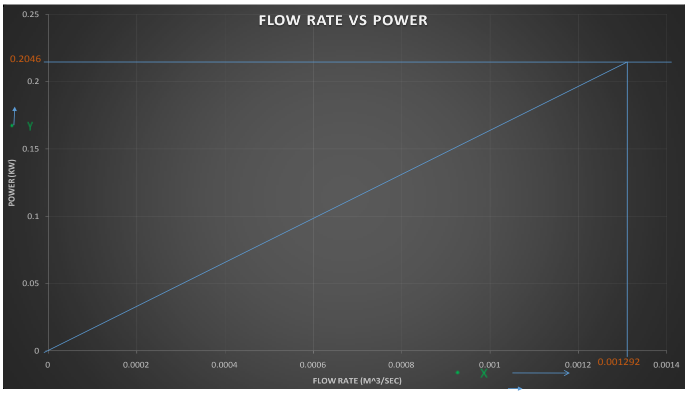
Flow Rate & Pressure Head



- Discharge $(Q) = \frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} = \mathbf{1.292\ X\ 10^{-3}}$ **m³/sec**

  Total Head, ht = h d + h s + h f=8.7+ 5.44 +2 =**16.14 m**

Flow Rate & Power

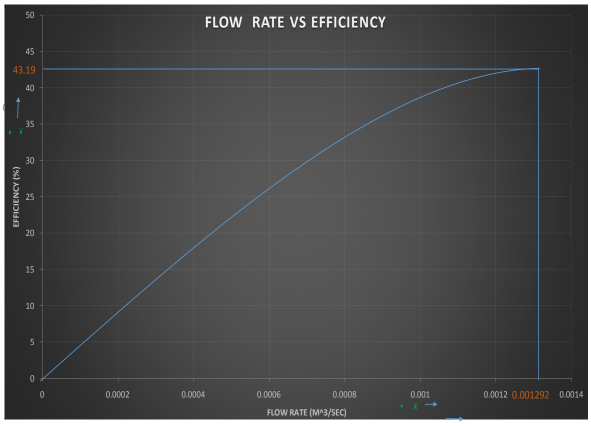


- Discharge $(Q) = \frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} =$ $\mathbf{1.292\ X\ 10^{-3}}$ **m^3/sec**
-) Output power of pump

$$(Pw) = \frac{w\ x\ Qa\ x\ ht}{1000} = \frac{9810\ X\ 1.292X\ 10^{-3}X\ 16.14}{1000} =$$

0.2046Kw

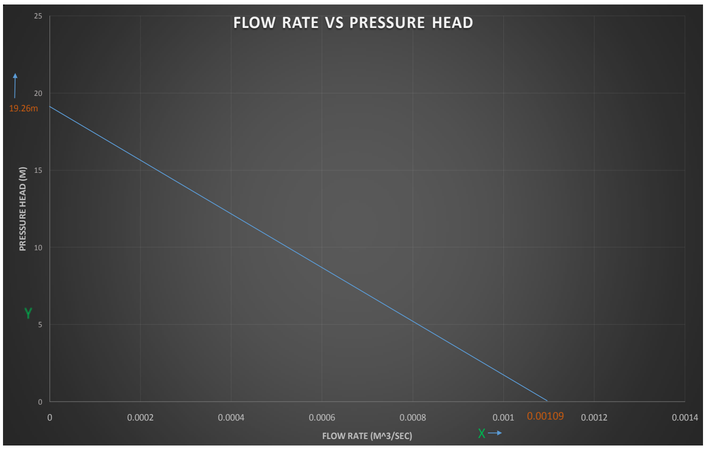
Flow Rate & Efficiency



- Discharge $(Q) = \frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} =$ $\mathbf{1.292\ X\ 10^{-3}}$ **m^3/sec**
- Overall efficiency of pump (η) $= \frac{PW}{SP}\ X\ 100\% = \frac{0.2046}{0.4736}\ X\ 100\% =$ $\mathbf{43.19\%}$

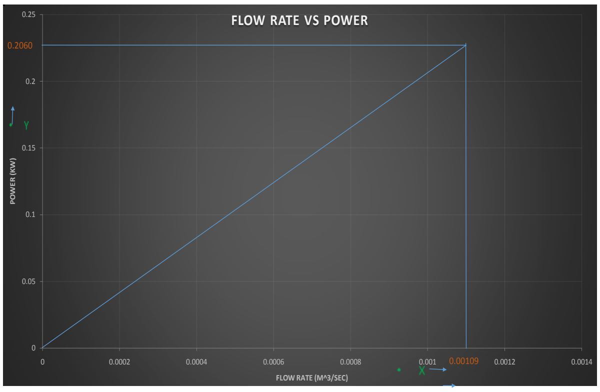
Second Table Graph

Flow Rate & Pressure Head



- Discharge $(Q) = \frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} =$ $\mathbf{1.09\ X\ 10^{-3}}$ **m^3/sec**
- Total Head, ht = h d + h s + h f=9.1+ 8.16 +2 =**19.26 m**

Flow Rate & Power

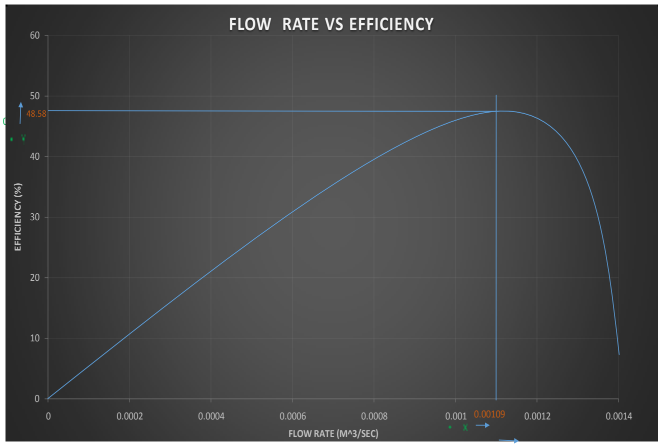


- Discharge $(Q) = \frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} =$ $\mathbf{1.09\ X\ 10^{-3}}$ **m^3/sec**
- Output power of pump

$$(Pw) = \frac{w\ x\ Qa\ x\ ht}{1000} = \frac{9810\ X\ 1.09X\ 10^{-3}X\ 19.26}{1000} =$$

0.2060Kw

Flow Rate & Efficiency



- Discharge (Q)= $\frac{0.4x0.4x0.1}{t} = \frac{0.4x0.4x0.1}{20} = \mathbf{1.09\ X\ 10^{-3} m^3/sec}$
- Overall efficiency of pump (η) $= \frac{PW}{SP}\ X\ 100\% = \frac{0.2060}{0.424}\ X\ 100\% = \mathbf{48.58\%}$

4. CONCLUSION

- In the experiment , we could observed the behavior of the pump .after doing various test with the pump, we understood the operational behavior and its reaction as we opened and closed the valve. We can conclude that when pump are working configuration the have a higher volumetric flow with the most Hz and the high RPM's increases water flow. As a conclusion, we had obtained a performance curve at 3 different speed of pump by variable characteristic. the efficiency of pump have related to the losses mean energy during the process this efficiency will be increase if less loss occur.
- In this experimental analysis we concluded the various test on the centrifugal pump by replacing the gland packing by the mechanical seal to archive the maximum efficiency and economical solution and long lasting operation to get maximum output by solving and determining hydraulic failure like corrosion , cavitations and falling effect which affects the pump operation and reduce pump life and increasing to maintenance and repairing cost By solving these hydraulic failures enhances pump operation and increasing pump efficiency. In these experimental analysis we are mainly focuses on the centrifugal pump sealing methods. We are conducted various test on centrifugal pump to determine that mechanical seal gives maximum output and efficiency by these sealing method. We are replacing gland packing (elastomer) by the mechanical seal because elastomer is not long lasting and gives temporary sealing solution and wear and tear occurs at high speed and does not capable to carry high temperature fluids and failure occurs at higher RPM so by looking this limitations we replacing elastomer by the mechanical seal. mechanical seal having capability to carry high temperature freed working on high RPM speed and wear and tear rates are very less compared to elastomer by looking this property replacing elastomer by mechanical seal . By conducting experiment on both the sealing method at different RPM and different discharge rate and head find efficiency of pump. Efficiency of pump. By elastomer we achieved 48.58% efficiency and by mechanical seal 43.19 % efficiency. And by graphically shows on pump performance curve illustrate that elastomer gives more efficiency compare to mechanical seal . From this experimental study and sealing method Android preventing hydraulic failure where to maximum efficiency and enhances pump operation.

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