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Vane Pump Test Rig

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Abstract: *The face of modern industries has change by leaps and bounds in recent times. This calls for a need to develop a simple and intelligent solution for every problem. Many types of vane pumps are being developed and manufactured. Thus it becomes necessary to ensure the customers satisfaction that these pumps are meeting the performance conditions for which they are purchased. This paper aims at making a working test rig for testing of such pumps. It aims for testing the discharge head, flow and power between maximum and minimum point of operation.*
Keywords – *Performance test, Vane Pumps.*

I. Introduction

Performance testing can help reduce energy costs by identifying poor efficiency and decrease maintenance costs by diagnosing chronic pump problems. How often do pumps operate away from their design point? How much power is being wasted? How do these conditions impact pump reliability and repair costs.

Performance testing can also be used to solve pump problems and reduce maintenance costs. Pumps are designed to operate near a specific flow rate—the BEP (Best Efficiency Point). Flow values significantly below or above BEP often result in poor reliability, cavitation, impeller and case damage and high maintenance costs, and wasted energy. Water, specifically, does extensive damage to pump components when the pump operates at off-design flow rates. No matter what the systems is pumping, performance testing can identify the hydraulic issues that are causing repeat failures.

II. Hydraulic Pumps

The hydraulic pump is a device that transfers mechanical energy into hydraulic energy.

2.1. Principle and Classification of Pumps

Principle

Newton’s First law states that “Energy can neither be created nor be destroyed, but can be transformed from one form of energy to another form.”

All pumps work on the same basic principle

A vacuum is created at the pump inlet. The higher atmospheric pressure present in the tank pushes oil through the inlet passage and into the inlet chamber. The pump gears then push the oil out the pump outlet.

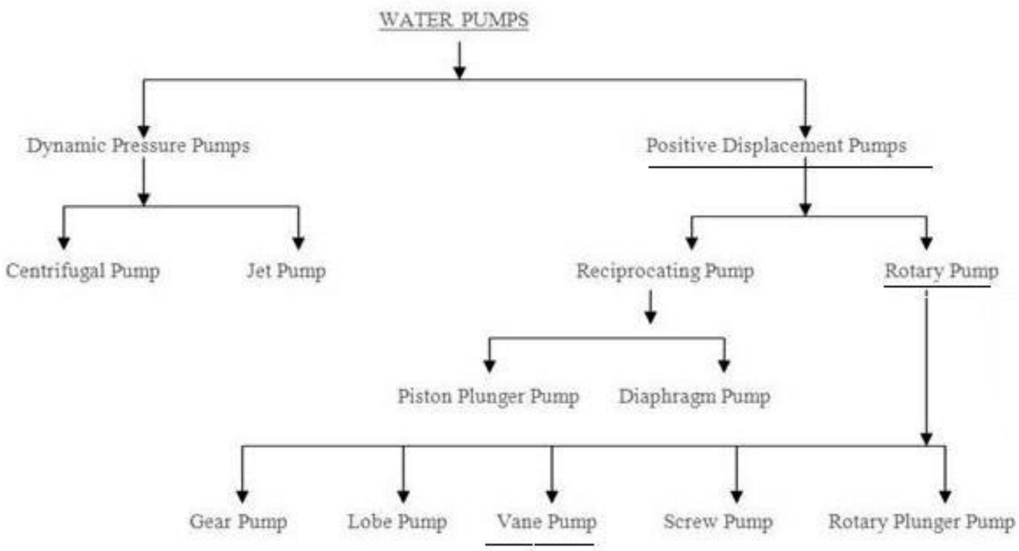

Fig. 1 Classification of pumps

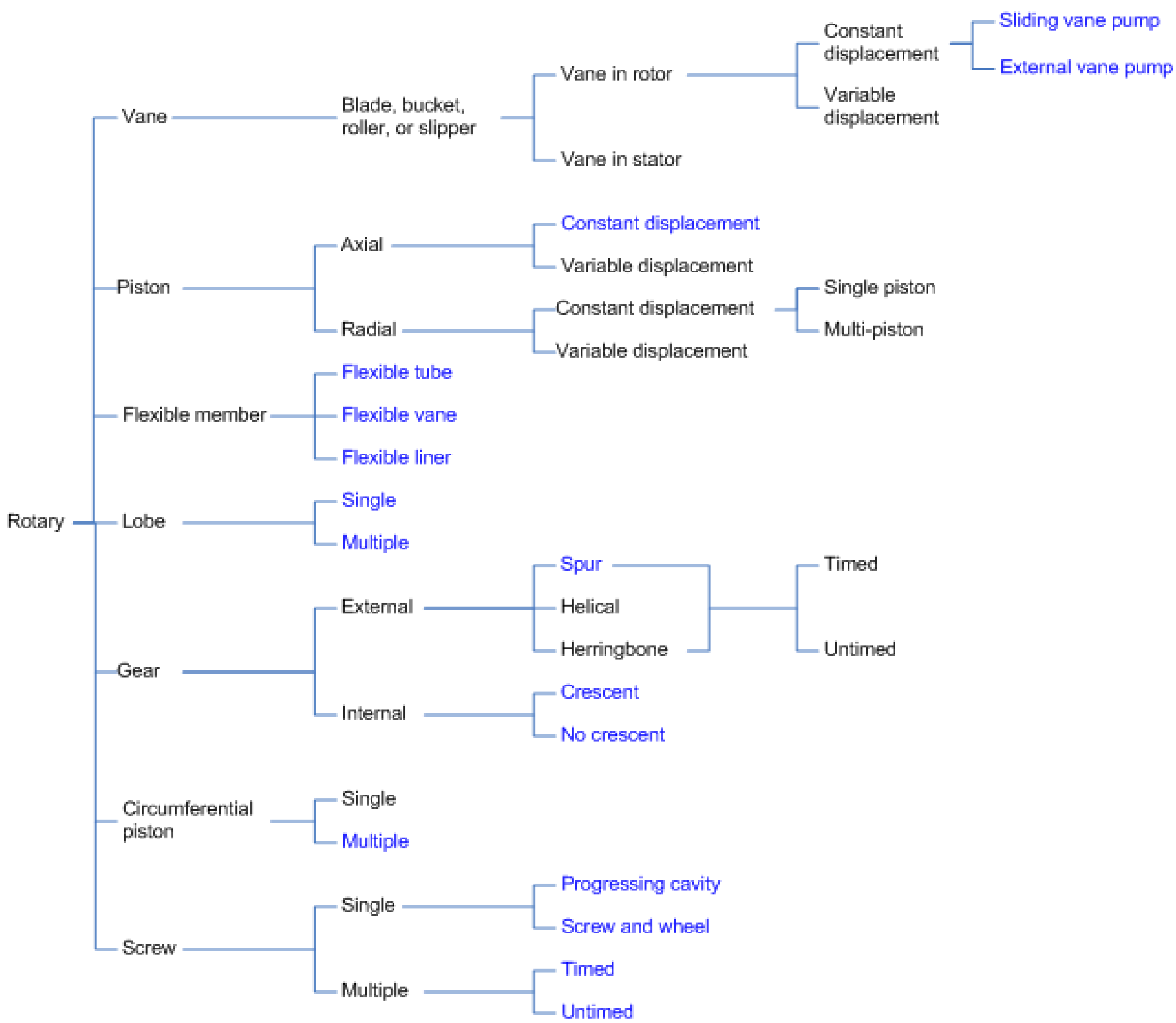

Fig. 2 Classification of rotary pumps

2.2. Details of Vane Pumps

Vane pumps are positive displacement rotary type pumps. The output can be either fixed or variable.

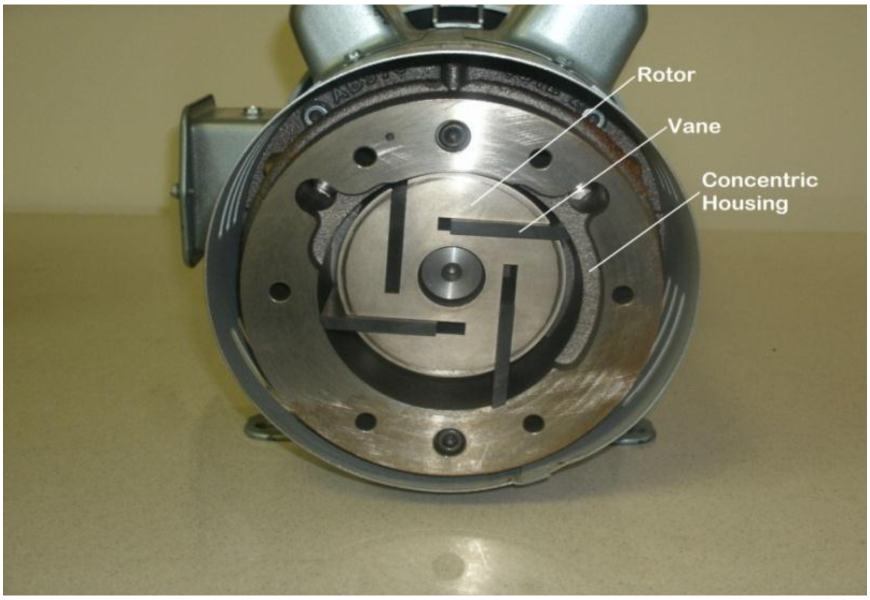

Fig. 3 Vane pump

2.3. Principle of Vane pump

Fig 4 Principle of vane pump

The vane pump is a device that works on the principle of positive displacement. Consisting of a series of vanes that are mounted to a rotor that provides circulation with the main cavity, the vane pump makes it possible to force liquid through a pipe or duct system at the rate desired by the operator. In most examples of the vane pump, the vanes slide in and out of the rotor during the operation of the device. This combination of actions creates a seal on the interior of the cavity, and effectively forms a series of small chambers within the larger chamber. Liquid is captured in each of these chambers and is forced through the system by the resulting pressure of the rotation. Essentially, there is atmospheric pressure on the intake side of the pump that helps to suck in the liquid, while the pressure created by the rotating action help to move and discharge the collected liquid from the outtake or discharge side of the pump. The rotor helps to keep the flow of the liquid uniform throughout the process. Vane pumps can handle moderate viscosity liquids; they excel at handling low viscosity liquids such as LP gas (propane), ammonia, solvents, alcohol, fuel oils, gasoline, and refrigerants. Vane pumps have no internal metal-to-metal contact and self-compensate for wear, enabling them to maintain peak performance on these non-lubricating liquids. Though efficiency drops quickly, they can be used up to 500 cPs / 2,300 SSU. Vane pumps are available in a number of vane configurations including sliding vane (left), flexible vane, swinging vane, rolling vane, and external vane. Vane pumps are noted for their dry priming, ease of maintenance, and good suction characteristics over the life of the pump. Moreover, vanes can usually handle fluid temperatures from -32°C / -25°F to 260°C / 500°F and differential pressures to 15 BAR / 200 PSI (higher for hydraulic vane pumps).

2.4. Working

Despite the different configurations, most vane pumps operate under the same general principle described below.

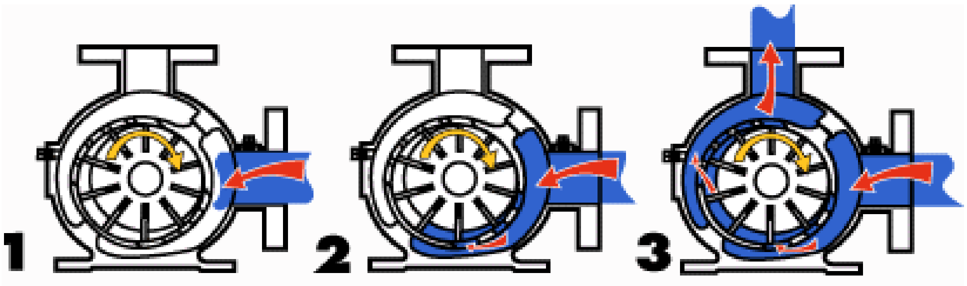

Fig. 5 Working of vane pump

1. A slotted rotor is eccentrically supported in a cycloidal cam. The rotor is located close to the wall of the cam so a crescent-shaped cavity is formed. The rotor is sealed into the cam by two side plates. Vanes or blades fit within the slots of the impeller. As the rotor rotates (yellow arrow) and fluid enters the pump, centrifugal force, hydraulic pressure, and/or pushrods push the vanes to the walls of the housing. The tight seal among the vanes, rotor, cam, and side plate is the key to the good suction characteristics common to the vane pumping principle.
2. The housing and cam force fluid into the pumping chamber through holes in the cam (small red arrow on the bottom of the pump). Fluid enters the pockets created by the vanes, rotor, cam, and side plate.
3. As the rotor continues around, the vanes sweep the fluid to the opposite side of the crescent where it is squeezed through discharge holes of the cam as the vane approaches the point of the crescent (small red arrow on the side of the pump). Fluid then exits the discharge port.

2.5. Classification

1. Fixed displacement unbalanced pump
2. Fixed displacement balanced pump
3. Variable displacement unbalanced pump
4. Variable Displacement pressure compensated balanced vane pump.

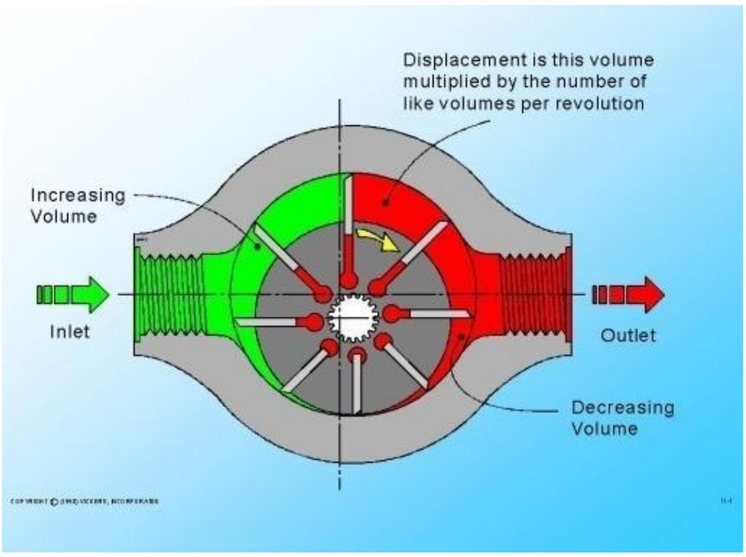

Fig. 6 Fixed displacement Unbalanced pump

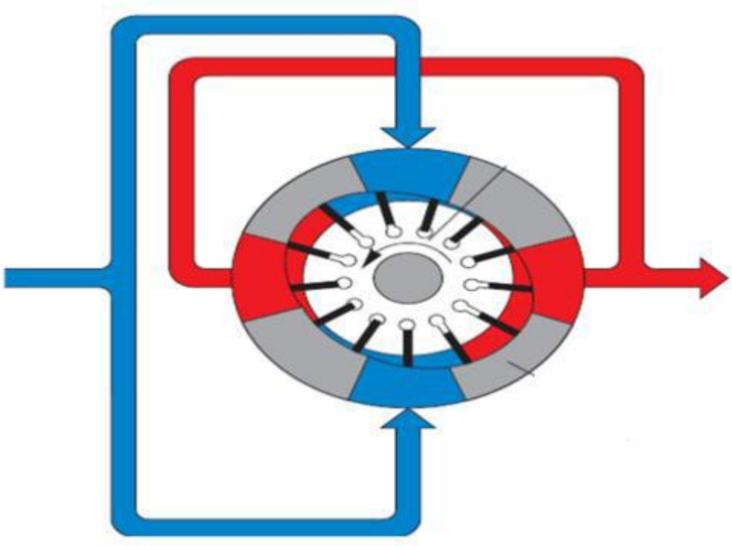

Fig. 7 Fixed displacement Balanced pump

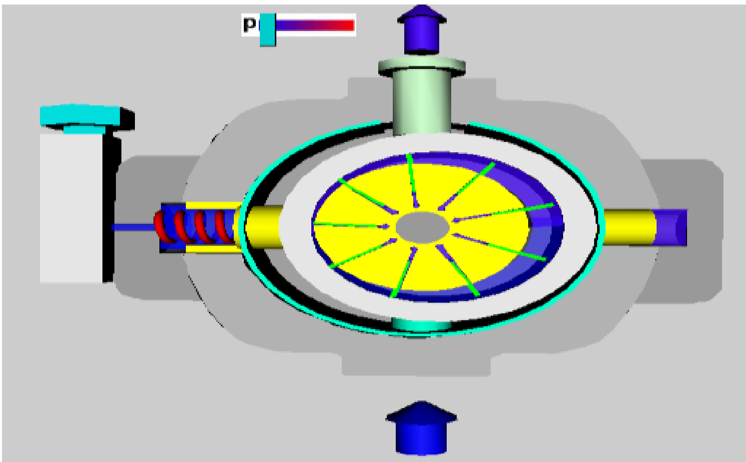

Fig. 8 Variable displacement Unbalanced pump

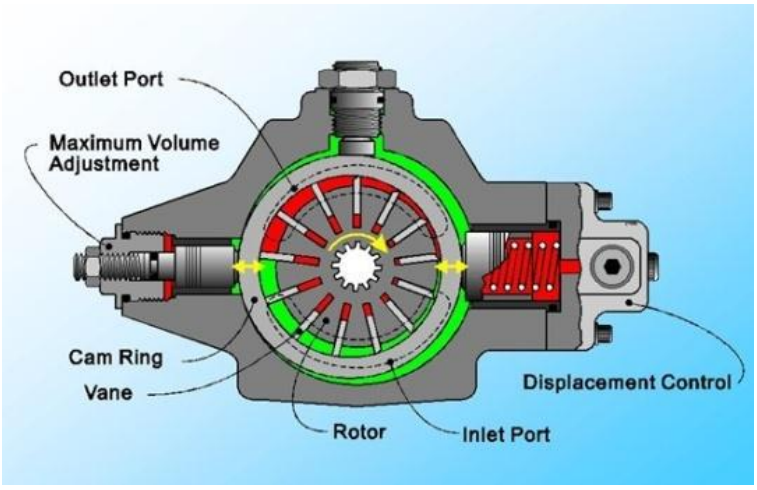

Fig. 9 Variable displacement Balanced pump

2.6. Manufacturers of vane pump

1. Viking Pump, Inc.
2. Corken, Inc.

2.7. Advantages of vane pump

1. Handles thin liquids at relatively higher pressures.
2. Compensates for wear through vane extension.
3. Sometimes preferred for solvents, LPG.
4. Can run dry for short periods.
5. Can have one seal or stuffing box.
6. Develops good vacuum.

2.8. Disadvantages of vane pumps

1. Can have two stuffing boxes.
2. Complex housing and many parts.
3. Not suitable for high pressures.
4. Not suitable for high viscosity.
5. Not good with abrasives.

2.9. Applications

1. Aerosol and Propellants
2. Aviation Service - Fuel Transfer, De-icing
3. Auto Industry - Fuels, Lubes, Refrigeration Coolants
4. Bulk Transfer of LPG and NH3
5. LPG Cylinder Filling
6. Alcohols
7. Refrigeration - Freon, Ammonia
8. Solvents
9. Aqueous solutions

2.10. Care to be taken for the best performance of the pump

Some general considerations should be made on hydraulic system in which the pump must be fitted. Special attention should be given to hydraulic system design and assembly, especially to intake, delivery & return pipes and positions of system parts. (Valves, filters, tanks, heat exchangers and accumulators) proper safety devices and reliable instruments to avoid fluid turbulence, especially in return pipe to tank, and prevent air; water or foreign bodies from entering into the system are of major importance. It is also important to equip the hydraulic system with a proper filtering unit.

III. Experimental Procedure

3.1. System Resources

1. Vane pump
2. Electric motor with coupling
3. Sump tank & delivery tank
4. Flow measurement unit
5. Pressure gauge & vacuum gauge
6. Energy meter
7. Piping
8. Pressure relief valve

3.2. Procedure

1. After completion of installation system will be ready for experiments.
2. Switch on the mains supply. Let the system run for 2-3 minutes for stabilizing.
3. Put OFF the return line cock, so the oil level in measuring tank will start rising.
4. Note the reading as per reading table.
5. Put ON the return line cock for draining the oil in measuring tank.
6. Adjust the delivery pressure to 0 Kg/cm2.
7. Put OFF the return line cock. So the oil level in measuring tank will start rising.
8. Note the readings as per observation table.

9. Put ON the return line cock for draining the oil in measuring tank.
10. Subsequently note down readings for further pressure range in the interval of 5 bars.

IV. Results and Discussions

4.1. Observations

1. Dimension of measuring tank = L X W = 365mm x 262mm
2. Energy Meter Constant =200

4.2. Observation Table

Table 1 Observation Table

Sr. No.	Suction Pressure(mm of Hg)	Delivery Pressure (kg/cm^2)	Initial Level 'A' (cm)	Final Level 'B' (cm)	Time 't' (sec)	Energy meter Reading(Time for 10 pulses) 'tm' sec
1.	100	0	10	10	20	18
2.	100	10	10	10	23.5	17.2
3.	100	20	10	10	28.6	16
4.	100	30	10	10	50	14.2
5.	100	40	10	10	72.1	12.3

4.3. Calculations

For second reading,

1) Delivery Flow Rate

Initial reading of measuring tank = A
Final level of measuring tank = B
Time taken= t

Height; h = A - B
 Height; h = 10 - 7
 Height; h = 7 cm = 0 .07 m

Volume of rise of fluid is,
Volume; v = L * W * h
 Volume; v = 0 .365 * 0 .262 * 0 .07
 Volume; v = 6 .6941 * 10^{-3} m^3

Delivery Flow Rate;
Delivery Flow Rate = Volume/t
 Delivery Flow Rate = 6 .6941 * 10^{-3}/23.5
 Delivery Flow Rate = 2.84 * 10^{-4} m^3/sec

2) For Pump Input Power

P_i = 3600/ (200 * t)
t - Time for 10 pulses
 P_i = 3600/ (200 * 17.2)
 P_i = 0.64 Kw

3) Pump Output Power

P_o = Delivery Pressure * Flow rate
 P_o = 10 * 10^4 * 9.81 * 2.84 * 10^{-4}
 P_o = 0.278 Kw

4) Efficiency

Efficiency;
η = (Output Power) / (Input Power)
 η = (0.278) / (0.64)
 η = 0.434 * 100
 η = 43.4 %

4.4. Results

Table 2 Experimental Results

Sr. No.	Delivery Pressure (kg/cm^2)	Discharge (m^3/s) (X 10^{-4})	Pump Input (Kw)	Pump Output (Kw)	Pump Efficiency (%)
1.	0	3.094	1.00	0	0
2.	10	2.4	0.64	0.278	43.4
3.	20	2.318	1.125	0.454	44.2
4.	30	1.338	1.26	0.393	31.19
5.	40	0.927	1.46	0.364	24.93

4.5. Graph for Delivery Pressure vs. Efficiency

Table 3 Experimental results of Delivery pressure and Pump efficiency

Delivery Pressure (kg/cm^2)	Pump Efficiency (%)
0	0
10	43.4
20	44.2
30	31.19
40	24.93

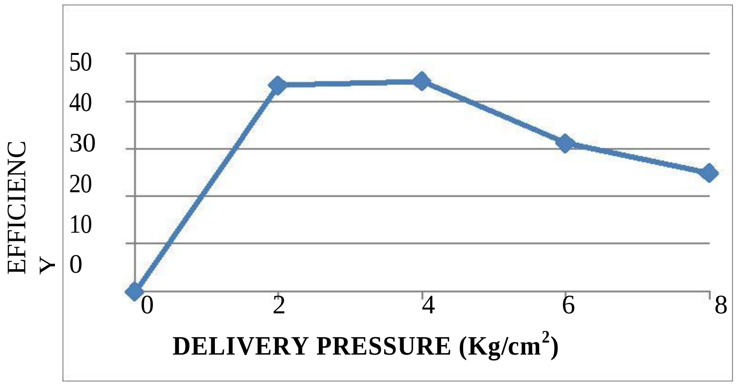

Fig. 10 Plot of Efficiency vs. Discharge Pressure

4.6. Graph for Delivery Pressure vs. Discharge

Table 4 Experimental results of Delivery pressure and Discharge

Discharge (m^3/s) (X 10^{-4})	Delivery Pressure (kg/cm^2)
3.094	0
2.4	10
2.318	20
1.338	30
0.927	40

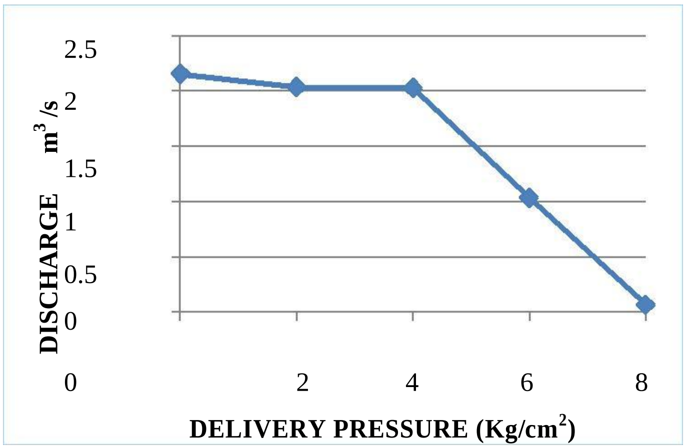

Fig. 11 Plot of Discharge vs. Delivery pressure

4.7. Graph for Delivery Pressure vs. Pump Input Power

Table 5 Experimental results of Delivery pressure and Pump Input Power

Delivery Pressure (kg/cm^2)	Pump Input (Kw)
0	1.00
10	0.64
20	1.125
30	1.26
40	1.46

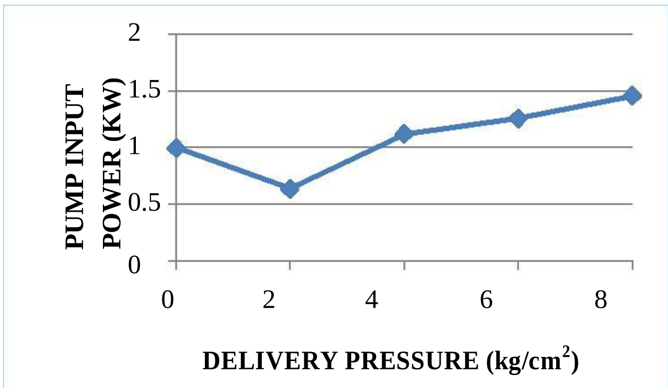

Fig. 12 Plot of Pump Input Power vs. Delivery pressure

4.8. Graph for Delivery Pressure vs. Pump Output Power

Table 6 Experimental results of Delivery pressure and Pump Output Power

Delivery Pressure (kg/cm^2)	Pump Output (Kw)
0	0
10	0.278
20	0.454
30	0.393
40	0.364

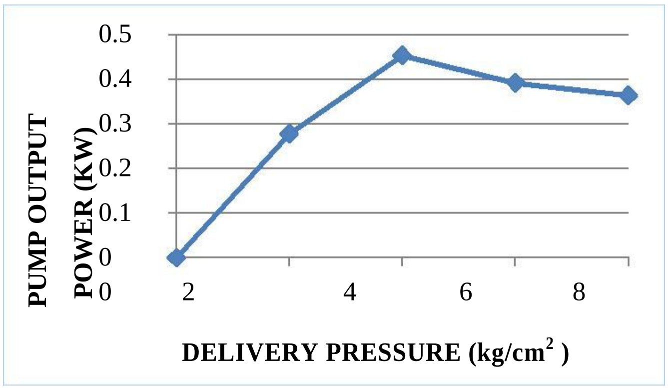

Fig. 13 Plot of Pump Output Power vs. Delivery pressure

V. Conclusions

In this work, relation of delivery pressure with discharge flow rate, efficiency and input power were plotted from which following conclusions were drawn as follows:

1. Discharge of a vane pump fairly remains constant. Though increase in pressure causes reduction in discharge.
2. Efficiency of pump goes on increasing with increase in pressure to certain point then it will decrease.
3. Power required to drive the pump is linearly proportional to the pressure.

References

[1] Machine Design, R. S. Khurmi, year 2005.
[2] Design of machine elements, V. B. Bhandari, second edition-2008.
[3] PSG Design data, year 2008.
[4] www.pumpschool.com/principles/external.htm
[5] http://www.rheinchemie.com/"
[6] Research paper I00-9.7 Evaluation of Hydraulic Fluid Lubrication by Vickers Vane.
[7] Pump Testing: Effect of Testing Conditions.
[8] Research paper on Studies on several key problems of water hydraulic vane pump 10.1108/00368791111112243
[9] Fluid power design handbook- Franklin Yeaple.
[10] Tribology of hydraulic pump testing- George E. Totten.
[11] Fluid power- Espisito.
[12] Vickers- vane pump and motor design guide.