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Maintenance and repair of Gear Pump Test Rig

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Abstract – *The aim of this project is to modify the Gear pump test rig available in the Hydraulic machinery laboratory. The pump system utilizes a 3-phase a.c. electric motor which is used to run the pump. The Gear pump is coupled to the motor. The system had faults which were to be identified and analyzed for modification. The fault-tree analysis is carried out on the available Gear pump test rig and attempts were made to overcome the identified faults. This enabled to make necessary modifications and the system was modified for improved and efficient operation.*

Key Words: **Gear pump, fault-tree analysis**

1. INTRODUCTION

Pump is hydraulic machinery which is operated by use of hydraulics where liquid is a powering medium. These hydraulic machines come across several problems during their operation if proper maintenance and repair is not carried out. Also the incorrect design of such machines may lead to unsuccessful operation. This is the reason why industries have a special maintenance department for smooth operation of the plant. Global market shows that customers want for new modifications and more flexible design in machine components, which makes the organization to concentrate more on research and development section. We came across such hydraulic machine which is gear pump test rig in our institute where we found that there was a need to work on this unit. And hence all the historical data related to this gear pump test rig was collected and analyses were carried out for its improved performance.

Especially pump setups have noticeable feature of the varying speed which enables us to find out the main performance characteristic of the pump. So we are trying to work out for this test rig by knowing actual principles of operation, factor affecting the performance. By taking the review of previous project report and under guidance, we did the experimental work.

With the help of observations, analysis of faults is done through fishbone diagram. So some major faults are being resolved by taking corrective measures.

If we are able to resolve the all faults of test rig, then it will be beneficial for us as well as upcoming students to work on it. Taking into consideration of future scope we decide to work on this project.

2. LITERATURE REVIEW

It was necessary to recollect all the historical data regarding the available gear pump test rig. This data was first recollected from BE student's Project on "Design, fabrication, analysis of gear pump test rig", 2002-2003. This enabled us to carry out the pre-test analysis by detail study of previous report. Other data related to gear pump and its concept were referred from

"Hydraulic machines, theory and design" by V.P. Vasandani and "Hydraulic machines" by S.C. Sharma.

3. PUMPS

Pump is a mechanical device to increase the pressure energy of liquid. In most of the cases pump is used for raising fluids from a lover to a higher level. This is achieved by creating a low pressure at the inlet or suction end and high pressure at the outlet or delivery end of the pump. Due to the low inlet pressure the fluid rise from a depth where it is available and the high outlet pressure forces it up to a height where it is required. Of course, work has to be done by a prime mover on the pump to enable it to import energy to the liquid.

4. PUMP CLASSIFICATION

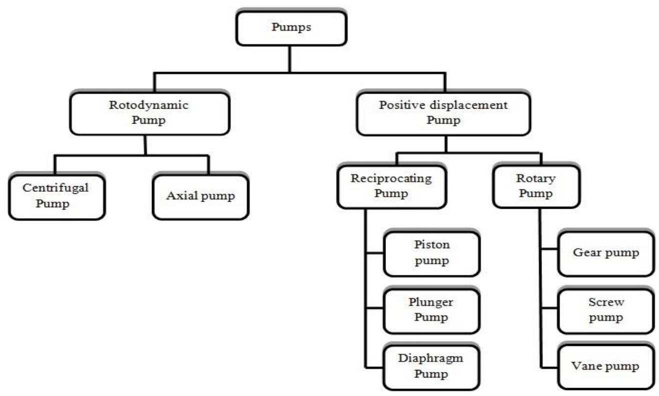

Fig.1 Classification of pumps

5. COMPONENTS OF GEAR PUMP

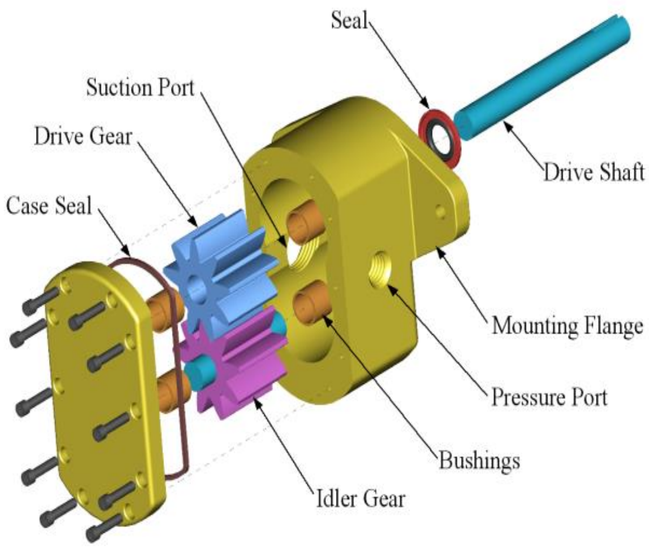

Fig.2 Components of gear pump

6. WORKING OF GEAR PUMP

External gear pumps are similar in pumping action to internal gear pumps in that two gears come into and out of mesh to produce flow. However, the external gear pump uses two identical gears rotating against each other, one gear is driven by a motor and it in turn drives the other gear. Each gear is supported by a shaft with bearings on both sides of the gear.

1. As the gears come out of mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the gear teeth as they rotate.

2. Liquid travels around the interior of the casing in the pockets between the teeth and the casing, it does not pass between the gears.

3. Finally, the meshing of the gears forces liquid through the outlet port under pressure.

Because the gears are supported on both sides, external gear pumps are quiet-running and are routinely used for high-pressure applications such as hydraulic applications. With no overhung bearing loads, the rotor shaft can't deflect and cause premature wear.

7. GEAR PUMP TEST RIG

The modified set up consist of the following

1. Sump tank
2. Discharge collecting tank
3. Pumping system
4. Driving system
5. Measuring system

7.1 Sump tank:

This tank is made up of M.S. plates 3 mm thick and dimensions are 0.3*0.3 sq. meter. Special care has been taken to make this tank leak proof. This tank is used to supply oil to the pump. If overall oil is send to the collecting discharge tank.

7.2 Discharge collecting tank:

This tank is mounted above the sump tank and has same dimensions as that of sump tank and made up of 3mm M.S. plates. This tank is supported by the framework which is also made up of M.S. material.

7.3 Pumping system:

This system consists of gear pump, foot valve, discharge gate, valve, suction pipe, delivery pump motor. A foot valve with strainer is provided at the bottom end of the suction pipe. A 1 h.p. gear pump is used for the equipment. This pump sucks the oil from the sump tank and delivers it to the discharge collecting tank. The discharge gate valve is used to regulate the flow rate of oil.

7.4 Driving system:

Driving system consist of single phase a.c. motor at 220 volts which rotates the gears in such a way that oil is discharged from sump tank to discharge collecting tank. To avoid the lifting of the motor at high speed due to vibrations, the motor frame is locked on the guide ways by M.S. square framework. The motor capacity is 1 h.p. at 1425 revolution per minute.

7.5 Measuring system:

The measuring system consist of

1. Vacuum gauge(0 to 760 mm of Hg)
2. Pressure gauge(0 to 14 kg/cm^2)
3. Energy meter
4. Glass tube with scale

The vacuum gauge tapping is on suction side just before the pump and pressure gauge tapping is on the delivery side just after the pump. Flexible hose pipes connect these tapping to the vacuum gauge and pressure gauge through a brass valve. The vacuum gauge and pressure gauge readings are use for calculating the manometric head. The energy meter gives the power consumed by the motor. The vacuum gauge, pressure gauge and energy meter are mounted on the wooden board made up of plywood (18 mm thick).

7.6 Alignment:

Correct alignment is absolutely essential for successful operation. A flexible coupling will not compensate alignment. Rotary pumping units should be aligns as if the coupling were solid. The flexible coupling will when serve its purpose i.e., to prevent the transmission of end thrust from one machine to other and to compensate for slight changes in alignment, which may occur during normal operation.

7.7 Suction piping:

Experience has proved that a faulty suction line is responsible for the trouble with rotary pumps. Suction piping should never be less in diameter than the full size of the pump suction opening. It should be as short and direct as possible and thoroughly clean. It should be uniformly grade up from the source of supply to the pump.

7.8 Discharge piping:

Always carry the discharge up through a riser approximately five times the Diameter. This prevents gas or air pockets in the pump and will act as a seal in high vacuum service. A valve on the top of the riser may be used as a vent when starting the pump.

8. FAULT DETECTION AND MAINTENANCE

This chapter gives the brief description about fault detection techniques which we have used like "Ishikava-Fish-bone diagram" and "Fault–tree analysis" and repair steps we performed.

8.1 Fault-Tree Analysis:

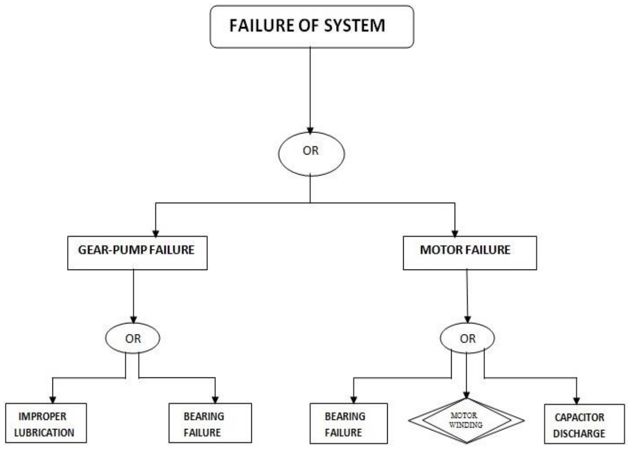

Fig.3 Fault-Tree diagram

The machine becomes non-operative when either gear pump or motor fails. Reasons of Gear pump failure can be improper lubrication OR bearing failure due to rusting. Motor failure can be occur due to bearing failure OR due to discharge of capacitor. The DOUBLE DIAMOND represents an event (motor winding) whose causes will be specified later

8.2 Fish-bone diagram:

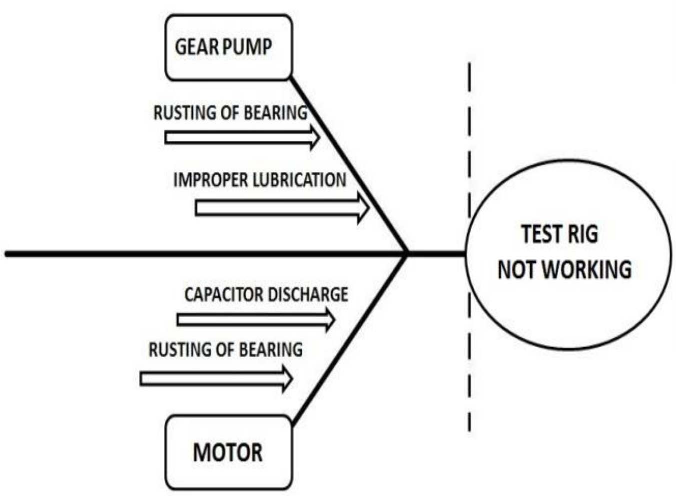

Fig.4 Fish-Bone diagram

9. MAINTENANCE STEPS PERFORMED

9.1 Cleaning of test rig setup:

The test rig set was not in working condition since long time. Hence there was rust formed on set up and pipes. We cleaned the set up using sand paper. The two oil tanks were filled with burnt oil sediments. We washed the oil tanks and cleaned them. We also cleaned the metallic pipes.

9.2 Checking of electrical system:

We checked the electrical power supply at the HM lab which was found to be 250V at 50 Hz frequency of current using digital multi-meter, which was fair for our requirement.

9.3 Checking of the motor:

We disassembled the motor from set-up. We checked the motor at "m/s Abhay Electricals", Ratnagiri. It was found that there was no problem with motor. The starting and running capacitors of motor gave reading as 120µF and 10µF resp. which was ok. Also motor winding was found to be in good condition.

9.4 Cleaning of the Gear pump:

We cleaned the gear pump in workshop. We removed all burr and dust particles from gear pump and new needle bearing of type SKF NA49/02 is replaced.

9.5 Re-coupling the pump and motor with proper alignment:

We coupled the motor and pump with proper alignment and checked the motor speed with digital tachometer. It was approximately 1488 rpm. We also replaced the damaged coupling with new one.

9.6 Getting ready for oil-circulation:

We filled oil tank with 40 liters of fresh refined oil.

9.7 Checking of Energy meter:

The energy-meter is checked after running of motor and pump and no fault detected with it.

9.8 Checking for leakage:

We replaced both taps with new one; the rubber pipe is replaced by metallic pipe for long durability. We re-joined all the pipes and started the system to check whether there is any leakage or not. We found that the system is leak proof.

9.9 Replacement of pressure gauge and vacuum gauge:

After starting the set-up, we found that pressure gauge and vacuum gauge were not working. So we replaced them with new one.

9.10 Painting of whole test rig:

We painted the whole set up and setup is ready for experimentation

10. EXPERIMENT ON GEAR PUMP

Experiment:

Aim: To study the characteristics of gear pump at constant speed.

Experimental Procedure:

1. Fill the supply tank with oil to the required height, say three fourth of the tank.
2. Open the gate valve in the delivery pipe fully.
3. Start the motor, oil flows in.
4. Throttle the gate valve to get the required head.
5. Note the following readings:
    a. Pressure gauge and vacuum gauge reading.
    b. Time for 10 revolutions of energy meter disc (T seconds).
    c. Time for 10 cm rise in collection tank (t seconds)
    d. Take 4-5 sets of readings by varying the delivery pressure.

Observation table:

Sr. No.	Pressure Gauge reading in Kg/cm²	Vacuum gauge Reading in mmHg	Time for 1cm rise in collⁿ tank (t) in sec	Time for 1rev. of energy meter disc (T) in sec
1	0	90	5.14	18.63
2	1	80	5.20	17.51
3	2	75	5.54	15.09
4	3	70	5.85	14.44
5	4	55	6.86	13.65

Calculations (for second reading):

Assuming motor efficiency=0.8

Discharge (Q):

Time for 1 cm rise (t) =5.20 seconds

Area of collecting tank (A) $=0.3*0.3=0.09m^2$

Rise in oil level (R) =0.01m

Discharge (Q) in m^3/s = (AR)/t

= (0.09*0.01)/5.20

$=1.730*10^{-4}$ m^3/s

Total delivery head (H):

Pressure=P kg/cm2 =1

Vacuum=V mmHg =80mmHg

Total head = [(p+ (v/760)*10]/sp. gravity of oil

=13.164 m of oil

Output Power of Pump:

O/P Power = (9.81*0.83)*Q*H

=0.01875 kW

Input Power of Pump:

Energy meter constant =900 rev/ kWh

Motor efficiency =80%=0.8

Time for 10 revolutions = T*10

I/P Power = (3600*0.8*10)/ (N*T)

=0.1827kW

Efficiency

= [(output power)/ (input power)]/*100

=10.26%

Theoretical characteristics of gear pump:

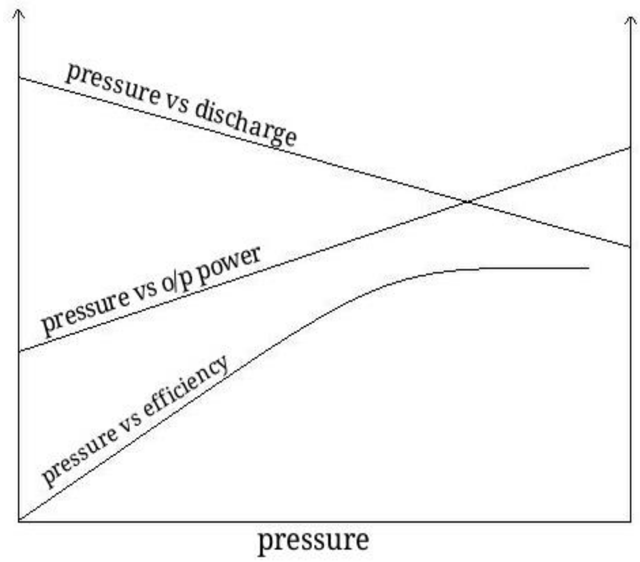

Fig.5 Theoretical characteristics of gear pump (ref. no.5)

Actual practical Graphs:

Following graphs were plotted from observation table:

1. For greater pressure, discharge is low.
2. As pressure is increased, the efficiency goes on increasing.
3. If pressure goes on increasing, the required energy input goes on increasing.
4. Total head is more for lower discharge.

Graph of Pressure Vs Discharge:

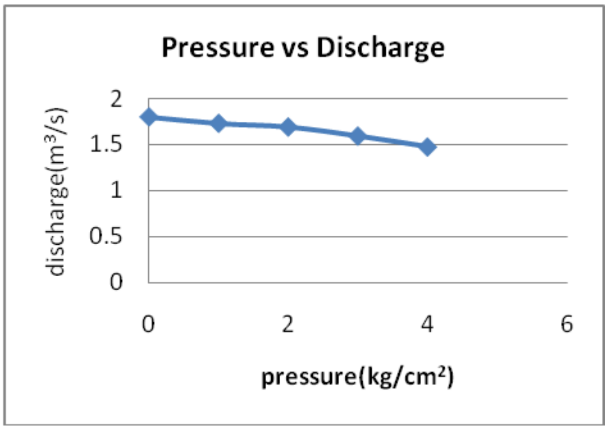

Chart -1: Graph of Pressure Vs Discharge

Graph of Pressure Vs Efficiency:

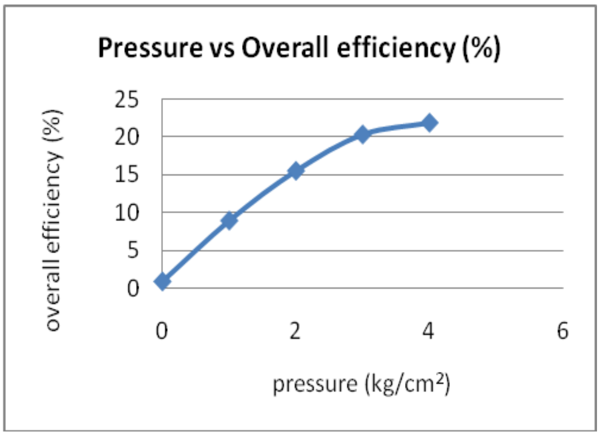

Chart -2: Graph of Pressure Vs Efficiency

Graph of Pressure Vs Output power:

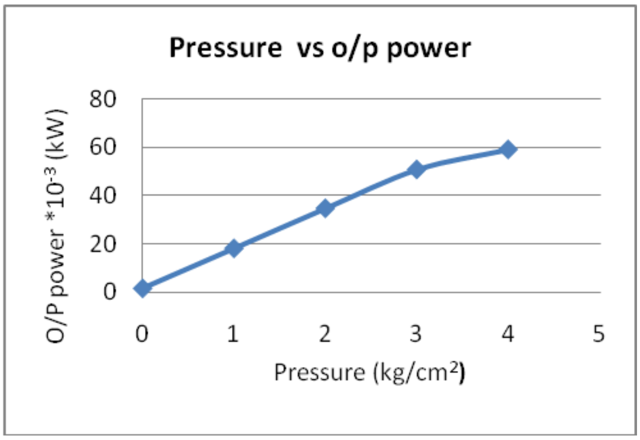

Chart -3: Graph of Pressure Vs Output power

Graph of Discharge Vs Total head:

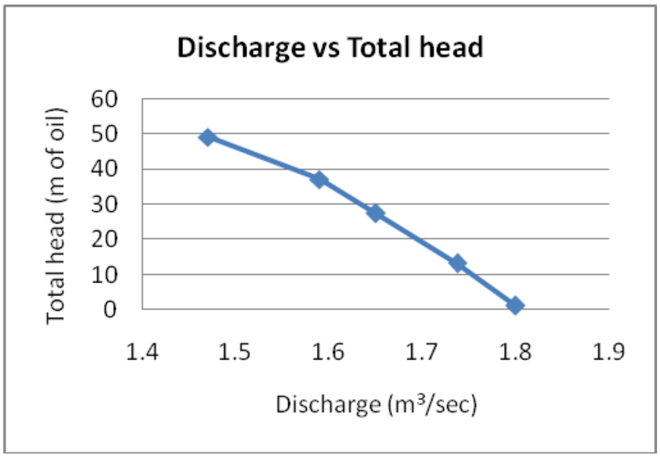

Chart -4: Graph of Discharge Vs Total head

Results:

Experiment performed on the gear pump gave the following results:

1. For greater pressure, discharge is low.
2. As pressure is increased, the efficiency goes on increasing.
3. If pressure goes on increasing, the required energy input goes on increasing.
4. Total head is more for lower discharge.

11. CONCLUSION

All the major as well as minor faults were detected with the help of fault-tree analysis techniques and necessary actions were taken on them. The modified setup is made leak proof and the motor shaft is aligned properly with the pump, and hence vibrations are reduced. Gauges, bearings, taps, coupling and hose are replaced with new one. The test rig is ready for experimentation. We carried out experiments on test rig and plotted the performance characteristic curves of gear pump, which are well accordance with theoretical graphs giving satisfactory performance.

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