PERFORMANCE EVALUATION OF EXTERNAL GEAR PUMP WITH THE USED OF BURNT OIL

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ABSTRACT

The external gear pump is external rotary positive displacement pump. Gear pump provides smooth pumping action & high volumetric efficiency. It is used in industrial machine for a fluid delivery and for a cooling purpose. It is used with a wide range of fluid viscosity. In this present work with the help of external helical gear type gear pump test rig generate experimental data with the used of contaminated burnt oil as fluid medium. Setup runs at a different rpm with adjusted speed of motor through vari-o-state, which measure with the help of the tachometer. At a different rpm of gear rotor check the performance of external gear pump.This data validate with the theoretical estimation & good agreement found.

Keywords : Contaminated Burnt Oil,Helical Gear, External Gear Pumptest Rig, Suction Pressure, Discharge Pressure, Discharge Flow Rate, Varies rpm

1. INTRODUCTION

The pump is the heart of the hydraulic system. Like a heart in a human body, a hydraulic pump generates a flow by moving the fluid in an environment with an adverse pressure gradient. The pumps are generally categorized in two distinct groups, positive-displacement pumps and kinetic pumps.The gear pump is gaining widespread application and acceptance for automotive oil and fuel delivery purposes due to its simplicity and versatility in design and manufacture. It is basically an internal gear type rotary positive displacement pump. It is driven by engine crankshaft. Gear pump pumps provide high volumetric efficiency and smooth pumping action. Further, they work well with a wide range of fluid viscosities.

1.1 External Gear Pump Operation

All pumps used in fluid power systems are of the positive displacement type that includes gear, vane, and piston pumps. The gear pump is made of two or more gears rotating inside a closed casing. The driving gear motion is produced by a motor, while the driven gear motion occurs through the meshing of the teeth of the two gears. As the gears start to rotate, the teeth are in and out of contact with each other. As a tooth leaves the contact region, a vacuum is created. The liquid that runs into this space to fill this vacuum has to be supplied through the pump's inlet port. Once filled with the fluid, the fluid follows in pockets between the teeth, trapped in place because of the sealed housing, until it reaches the pump's outlet port. In other words, the gear pump works like a rotating conveyor belt that moves pockets of liquid between the teeth of the gears.

1.2 Previous Work

James R. McBurnett, William D. McMillan (2000) [1]positive displacement gear pump useful for pumping hydraulic fluid includes a drive gear and an idler gear. In a first embodiment, the drive gear has symmetrical teeth, whereas the idler gear has asymmetrical teeth. The asymmetrical teeth of the idler gear include working surfaces which have a profile corresponding to the profile of the working and non-working surfaces of the drive gear, but have a non-working surface which has been relieved so as to be substantially flat. Consequently, in the zone of the pump where the gears mesh, a large backlash is created which substantially prevents bubble formation. In a second embodiment, the drive gear, as well as the idler gear, has non-contact surfaces which are substantially flat to create even a larger backlash for relieving cavitations when the teeth are made wider in the axial direction. By preventing bubble formation, cavitation which occurs at high pump speeds is substantially eliminated, thus avoiding pump damage which results from cavitations.NiranjanHimatlalDeliwala(2009) [2] presented invention relates to the external type of rotary gear pump for carrying high volume of the liquid. This rotary gear pump consists of impeller assembly, timing gears and reduction gears which ensure the handling of high volume of liquid by the gear pump. Because of inbuilt speed reduction the pump can directly be coupled with the prime mover there by reducing the overall cost and space, the timing gears reduces the noise level and enhances the working life of the pump. These pumps are used for loading, un-loading and transfer high volumes for wagon decanting, cargo un-loading of various viscous liquids such as edible oils, fuel oils, viscous chemicals etc.M Suresh Kumar and K Manonmani(2010) [3] CFD integrated development process for the gear rotor pump inlet components such as the suction pipe, strainer, and ports has been executed using a three-dimensional transient mathematical model. The effects of the rotor speed, strainer porosity, and number of ports on the pump performance have been investigated. The results showed that the inlet pipe size, the free area ratio of the strainer, and the sizing of the ports have vital roles in the suction capacity, flow velocity, and volumetric efficiency of the gear rotor pump.M. Suresh Kumar, K. Manonmani(2010) [4] Gear rotor pumps are widely used in automotive industry for engine oil lubrication. Often, dust particles mix with the oil flowing through the pump and affect the engine life ultimately. This phenomenon was studied by a CFD investigation at different conditions in three phases. In first phase, the effect of fluid viscosity, rotor speed and port cover grooves were studied with non-contaminated oil and validated experimentally. Suction pipe, strainer and ports were added in the second phase to predict the flow behavior around the inlet region. These factors have vital role on suction capacity, flow velocity and volumetric efficiency. In third phase, different solid concentrations were simulated and found that wear rate, dilatancyandshear layer movement of oil-solid particle mixtures influence the oil pumping mechanism.JhaManeesh, PoojariAmbika(2013) [5] According to the invention, there is provided a pump performance analyzer for a centrifugal pump. The pump performance analyzer comprises pressure transducers disposed at pre-determined locations of the centrifugal pump for measuring suction and discharge pressures thereof, a flow rate indicator for indicating a flow rate corresponding to a pump operating head computed based on a specific gravity of an operating fluid of the centrifugal pump and a difference of the suction and discharge pressures, a cavitations indicator for computing a Net Positive Suction Head available (NPSHA) based on a difference of a fluid vapor pressure and the suction pressure and generating a cavitations alert when the NPSHA is less than a Net Positive Suction Head required (NPSHR) at the indicated flow rate, and a pump wear-out indicator for computing a pump operating head and a power at closed discharge valve operation and generating an alert when the head and power deviate from pre-determined head and power at a zero flow rate condition.

II EXPERIMENTAL TESTING

2.1 Experimental Set-Up

Fig.1Experimental set-up

The experimental set-up consist of gear pump, in which suction side a vacuum gauge is attached while on the discharge side a pressure gauge is fitted for measurement of the delivery head.. Schematic arrangement of test rig of External Gear type oil pump is shown in Fig.1.1 test rig consists of a motor, oil sump, voltmeter, ammeter, tachometer and vari-o-stat for varies motor speed. In external gear type oil pump test rig 25.4 mm pipe is used in both side suction as well as delivery side.The main parameters that were observed from the test rig are speed of the gear pump, vacuum Pressure of the oil at inlet, discharged pressure of oil at outlet, measure discharge flow.

2.1.1 Testing methodology

First of all the vari-o-stat is connected to the main current supply line. Through variac connection attached with ammeter and motor of single phase. After that work done the power switch is on and varies variac voltage to set required rpm of motor with the help of tachometer. Certain rpm range (850- 1200) set with the help of tachometer and measure the value of inlet pressure and outlet pressure through pressure gauge for each rpm. At the time of set each rpm also measure ampere to know about actual load on the motor required for each rpm.

At the time of experiment observed that the motor is not run speed below 800 rpm and above1250 rpm. Because motor running with the overload condition so ampere is increase and chance to damage the motor. So we collect data of motor speed between 850 rpm to 1200 rpm. Collected data shown in observation table 1.2.At the each rpm measure the discharge flow rate with the help of delivery tank capacity of 64liter. Start the set up and continue to remain in running condition. After five minutes to set each rpm with the help of vari-o-stat measure the discharge flow rate. Measure the flow rate for time interval of 10 second. Delivery tank volume capacity is 64 liter, so first at 850 rpm run the pump and for 10 second time period collect oil in to discharge tank. The depth of oil quantity in delivery tank is measure with the help of scale. Take three consecutive reading at same rpm and select average value.

2.1.2 Observation

Table.1 Experimental Observation Table

SR NO.	Pump Speed (RPM)	Vacuum gauge Pressure (Pascal)	Discharge Pressure (Pascal)	Discharge Q_{actual} m^3/sec
1	850	-11990.07	13789.5	0.00053
2	920	-13332.3	27579.0	0.000576
3	1032	-13998.9	34473.8	0.00065
4	1060	-14665.5	34473.8	0.00067
5	1200	-18665.2	34473.8	0.00076

III THEORETICAL ANALYSIS

3.1 Gear Specification

The teeth on helical gears are cut at an angle to the face of the gear. When two teeth on a helical gear system engage, the contact starts at one end of the tooth and gradually spreads as the gears rotate, until the two teeth are in full engagement.

Gear pump which is used in experiment is helical gear type pump as shown in Fig 2. Helical gear side view and front view is also shown in figure respectively.

Fig2 Gear Pump Assembly/Helical Gear Side View/Gear Front View

The dimensional specification of helical gear which is used in experimental set up of gear pump is shown in table 2.

Table.2 Gear Specification

Gear type	Helical gear
Gear diameter	43cm
Gear width	43cm
Gear teeth tapper(HELIX ANGLE)	15°(degree)
Number of tooth on gear	8
Gear tooth height	0.09cm
Flank	0.02cm
Clearance between gear tooth and pump body	.00025 to.00075 cm
Distance between two gear centre axis	3.6cm

3.2 Theoretical Discharge Calculation

Now for theoretical discharge of pump (all dimension are in meter),

$$Q_{theoretical} = \frac{2alZN}{60} \quad (1)$$

Where, a = area enclosed between two teeth

l = axial length of teeth

Z = number of teeth in each gear

N = rotational speed in r.p.m.

To find out area enclosed between two teeth applying the equation of area for trapezium section because are enclosed between two teeth is trapezoidal. Figure shows the trapezoidal section and their equation for find out area.

Here a = area enclosed between two teeth = (a + b) h/2 (2)

= (4+14) 9/2

= 81mm2 = 8.1 x 10-5m2

l = axial length of teeth = 0.043m

Z = number of teeth in each gear = 8

Put all this value in equation for find out theoretical discharge in m3/ sec.

3.3 Volumetric Efficiency Of Gear Pump

Volumetric efficiency calculated by ratio of actual discharge versus theoretical discharge.

$$\eta_v = \frac{Q_{act}}{Q_{th}} \quad \textbf{(3)}$$

Table.3Volumetric efficiency of gear pump at different rpm.

Sr no.	RPM	Q_{actual} m^3/ sec	Q $_{theoretical}$ m^3/ sec	$\eta_v = \frac{Q_{act}}{Q_{th}}$
1	850	0.00053	7.89×10^{-4}	67.17
2	950	0.000576	8.49852×10^{-4}	67.77
3	1032	0.00065	9.585216×10^{-4}	67.80
4	1060	0.00067	9.84528×10^{-4}	68.02
5	1200	0.00076	1.11456×10^{-3}	68.18

IV RESULTS AND DISCUSSION

Figure 3 shown line graph at various rpm theoretical and actual discharge of oil at various rpm. From graph it is clearly seen that there are difference between actual and theoretical discharge of external gear pump, which affect the volumetric efficiency of pump. The difference is occurs due to the contaminated burnt oil is used as fluid medium. The viscosity of burnt oil is less which affect the overall discharge of flow rate.

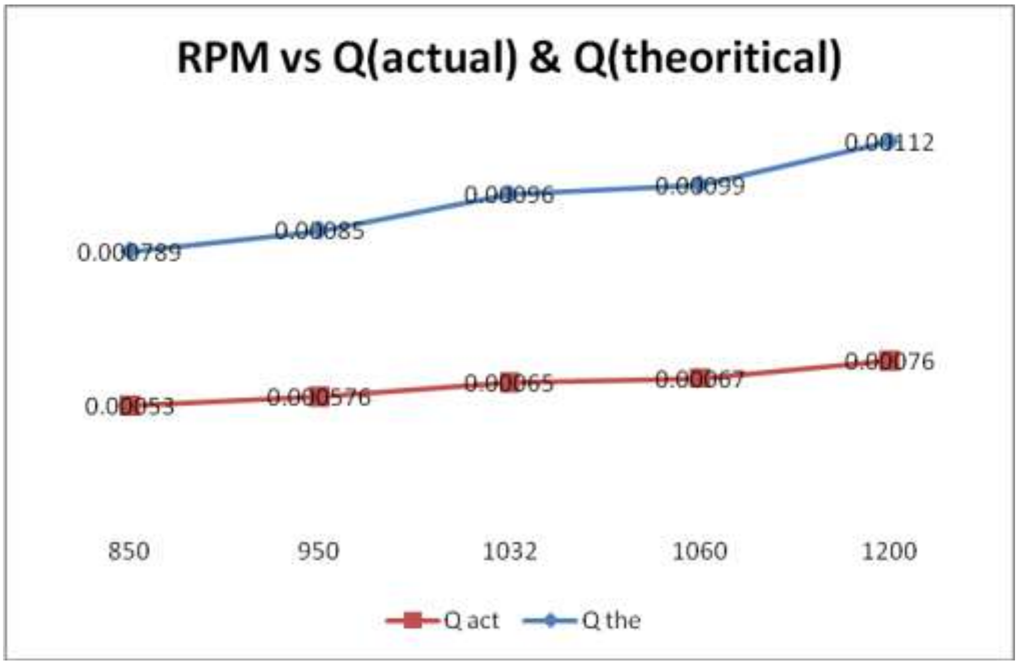

Fig.3 Line Graph of Rpm Vs Discharge Flow Rate

From Fig.4 it is clearly seen that as the rpm increase the volumetric efficiency of external gear pump is also increase. The volumetric efficiency is low due to the contaminant burnt oil is used and vibration of shaft, which connect the motor to the pump.

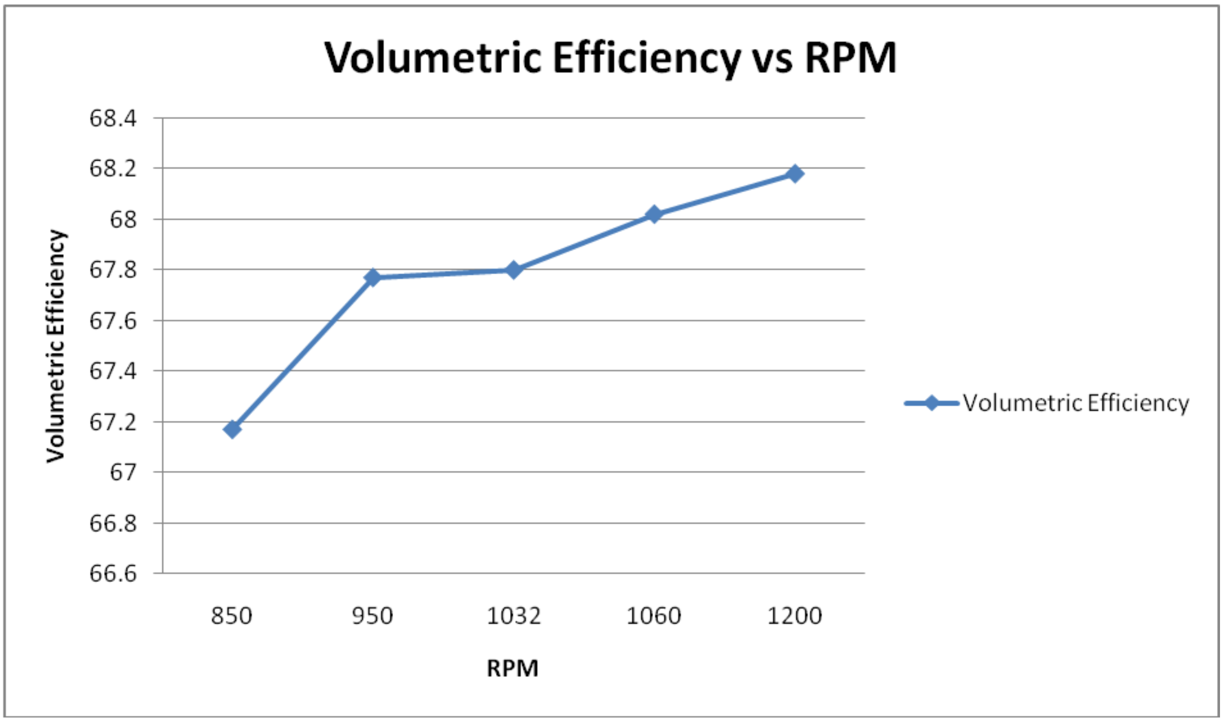

Fig.4Line Graph of Volumetric Efficiency Vs Pump Rotor Rpm

V CONCLUSION

This study focused only on the oil flow in the suction pipe to delivery pipe and did not consider phenomena such as cavitations, air entrainment and bubble formation. From research conclude that as the rpm of gear rotor increase discharge flow rate is increase. Due to the use of burnt oil the pump efficiency decrease because of burnt oil contain less viscosity and many rust and carbon particles contamination in burnt oil.

Future research will be extended to investigatethe possibilities of cavitations, noise generation, andair entrainment in the suction line, inlet ports, andchambers, and their effects on the pump performance.It is imperative that the amount of turbulenceand entrained air is kept to a minimum. Entrained aircan cause a reduced efficiency as well as vibration,noise, and/or accelerated corrosion.The challenge was to ensure that as much oil aspossible would be fed evenly into the pump, evenwhen operating at high speeds. By performing a seriesof CFD simulations, the design of the intake channelwas optimized. In this way, it is now possible to pre-evaluatedesigns more accurately at lower costs andshorter times using CFD, which will considerablyreduce the turnaround time of a physical model testand provide moreinformation about the innerbehavior of fluids.

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