DESIGN AND FABRICATION OF SWEEP PUMP

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ABSTRACT

This paper deals with “Design and Fabrication of sweep Pump” which is a distinctive type of pump with a few salient features. This is a novel pump in which the components prone for wear in a conventional pump are eradicated by our innovative design. It is noteworthy to mention here that searches and literature survey related to the foresaid pump reveals that no such type of pump has been invented earlier. The pump was successfully fabricated using unconventional machining techniques with high degree of accuracy. Tests results evinced out a satisfactory performance. We hope that this type of pump can excel the conventional pumps owing to its unique features and expected to have a large potential in the pump industry.

Keywords: Four Bar Mechanism, Oscillation, Rotor

1. INTRODUCTION

The proposed sweep pump is a novel design in the pump technology. This is a double acting semi-positive displacement pump with unique construction & working. The conventional pump are either rotary type or reciprocating type. This proposed pump is oscillating type pump in which the motion to the pump shaft is oscillating which is transferred from rotary motion obtained from motor which works on four bar mechanism. In conventional type the friction between the parts is inevitable and causes wear and tear. Hence, gradually the efficiency of the pump decreases due to the frictional loss / due to wear and tear of parts. Say in case of a gear pump which is mostly used in hydraulics uses a set of gears. The rubbing of the mating gears causes wear in the gears and the locating pins which eventually reduces the pumping efficiency. This requires more maintenance and the down time also increases. In centrifugal type pump when head requirement is high, more number of stages is required. The centrifugal pumps has to work with a reasonably higher RPM so that the fluid leaving the tip of the impeller sufficiently posses a high kinetic energy which is then transformed into pressure energy. The running of pump in high RPM causes many problems like vibration, noisy running and fast wear of Bearings. In order to avoid the inherent problem as mentioned for the gear pump and a centrifugal pump, we have launched a new type of pump compromising both the drawbacks as cited in case of a positive a gear pump and centrifugal pump.
II CONSTRUCTION DETAILS

2.1 Cylinder
The cylinder is a stationary part of the pump. Both the ends of the cylinder are threaded and cylinder nuts are tightened to it. The valve body is housed inside the cylinder. The cylinder is made up of low carbon steel. The inner surface of the cylinder is accurately machined so that clearance between inner diameter of cylinder and lobe shaft is <10μm.

2.2 Valve Body
It is sector shaped body which is fitted inside the cylinder with interference fit. Holes are drilled in the valve body to form a passage for fluid flow for inlet and exit of the fluid from cylinder.

2.3 Cylinder Nut
Cylinder nut which are tightened at both the ends of cylinder houses the ball bearings. Circlip groove is taken inside the nut for retaining the bearings inside the nuts. The lobe shaft is mounted to this bearing.

2.4 Shaft and Lobe
The lobe en bloc with the shaft is manufactured by wire cut EDM process and is made of EN8 steel. The drive end of the shaft is assembled with a disc or a link plate. The shaft passes through the sector shaped hole cut inside the valve body. The clearance between shaft and hole of valve body shall be < 10μm in order to prevent oil seepage in between the clearance. Similarly the outside diameter of the lobe shaft is precisely machined so that the clearance between cylinder and lobe shall be < 10μm in order to prevent oil seepage in between the clearance. The lobe is the main pumping component in the pump.

2.5 Bearing
The bearing used is 6206–zz bearing of size: Bore 30mm, OD 62mm & width 16mm the bearing is sealed on both the sides.

2.6 Check Valves
The check valves are provided at the inlet and outlet. The purpose of check valve is to admit fluid flow in one direction only. Swing type check Valve is provided at the inlet and the spring type check valve is provided at the outlet. The inlet check valves (SV1 & SV2) are connected to the sump and the outlet check valve (DV1 & DV2) are connected to the discharge tank. Fig.5 shows the piping and tank connection for chamber#1. Similar connections are replicated for the chamber#2.

2.7 Drive Arrangement
The drive end of the pump shaft is fastened to a pump link. The drive from motor is connected through ‘V’ belt to the counter shaft pulley. The counter shaft is supported by ball bearings. The front end of the counter shaft is fastened to a motor link. The motor link and pump link is connected by a Connecting Rod. When motor is
switched on, it rotates at a high RPM. The counter shaft pulley size is larger than the motor pulley. Hence velocity ratio of counter shaft is reduced. The motor link also rotates at the reduced RPM. The above link arrangement can be assumed as a Four Bar Mechanism. Hence when the motor rotates, counter shaft also rotates which results in oscillatory motion of the pump crank or lobe shaft. Or otherwise the rotary motion from motor is transformed into oscillatory motion of the lobe shaft in the pump. Fig.1a shows a Four Bar Mechanism. Fig.1b shows that the rotary motion is converted into oscillatory motion. Detailed description and conditions of working of a Four Bar Mechanism is given below.

III ASSEMBLY OF PUMP

After finishing the machining the parts should be assembled in a right manner and assembly should be carried out significantly. Firstly the valve body should be assembled to the cylinder block very tightly and there should be minimum clearance between the cylinder and the valve body i.e. micron level should be given. The shaft and lobe should be inserted to the valve body and the shaft is supported by the bearing in the bearing house. Then the bearing housing should be fitted into the cylinder and lock nut is provided to lock the cylinder and the bearing housing and the o ring provided at the cylinder end should seat properly in the groove. The check valves are connected to the inlet and outlet holes. The swing type check valve is used for the inlet and spring type check valve is used for the outlet.

![Cylinder and Lobe Assembly](image)

Fig : Cylinder and Lobe Assembly of the Pump

IV FOUR BAR MECHANISM OF THE PROPOSED PUMP

The sweep pump works by converting the rotary motion of the motor into oscillating motion. This is done by the four bar linkage mechanism. A four bar linkage also called four bar, is the simplest movable closed chain linkage. It consists of four bodies called links connected in a loop by four joints.
4.1. Grashof Condition

The Grashof condition for four bar linkage states: If the sum of the shortest and longest link of a planar quadrilateral linkage is less than or equal to the sum of the remaining two links, then the shortest link can rotate fully with respect to a neighboring link. In other words, the condition is satisfied if \( S+L \leq P+Q \) where \( S \) is the shortest link, \( L \) is the longest and \( P \) and \( Q \) are the other links.

Fig 1a Exploded View

Fig. 1b Exploded View of Sweep Pump
**V WORKING PRINCIPLE**

SV1, SV2 are suction valves whereas DV1, DV2 are discharge valves and all of them are unidirectional valves (NRV). Pos.1 shows the lobe before it starts to turn. When lobe has moved from P1 to P2, partial vacuum is created inside the chamber and oil flows from suction tank to the pump opening the suction valve SV1 as indicated by the arrow. (The ball of check valve lifts from ‘V’ shape seat forming passage for the oil flow.) When lobe has moved to extreme Pos.3, it sucks the maximum oil from tank and the oil is shown by less dense hatch pattern. When the lobe reverses, the oil is pumped out from the chamber by opening the discharge valve DV1 and closing the suction valve SV1. The compressed oil is shown by thick dense hatch pattern. Simultaneously a partial vacuum is created on the other chamber and SV2 opens and oil flows into the other chamber. When lobe reaches the extreme position pos.5, the oil is fully pumped out. The cycle is repeated by the oscillatory motion of the lobe which was transformed from the rotary motion of the motor pulley. Suitable Mechanical Seal shall be assembled at the front/rear end of the lobe shaft to prevent oil leak. The probable radial and axial leak paths are denoted by L1, L2, L3 and L4 as shown in Fig.4. However the internal leaks may be reduced by maintaining a close machining clearance. The clearance shall be 5 – 10 μm is preferable. The maximum pressure produced in the pump depends upon the kinematic viscosity of oil to be pumped and the clearance maintained between pumping element. When compared to other conventional pumps like gear pump, vane pump etc. the proposed lobe pump does not have physical contact with stationary components and hence wear and tear can be minimized.
VI PERFORMANCE OF THE PUMP

The theoretical discharge of the pump is given by the formulae,

\[ Q_{th} = \frac{2ALN}{\theta} \]

Where

\( A = \text{area of the sector} \)

\[ A = \pi r^2 \cdot \frac{\theta}{360} \]

\( L = \text{Length of the Cylinder} \)

\( r = \text{Radius of the Cylinder} \)

\( \theta = \text{Angle of Sector} \)

The slip of the pump is calculated by the difference between theoretical and actual discharge

\[ \text{Slip} = Q_{th} - Q_{act} \]

\[ \% \text{Slip} = \frac{Q_{th} - Q_{act}}{Q_{th}} \]

This pump gives the lesser value of the slip and so it gives stupendous performance.

VII SALIENT FEATURES OF OSCILLATING PUMP

The salient features in oscillating pump are:

Since the oscillating part is supported at two end by ball bearing:

1. The pumping element have no contact with the cylinder or other elements in the pump.
2. Wear and tear of the pump is reduced.
3. This is friction less pump.
4. Less maintenance cost & down time.
5. Simplest construction with less components.
VII CONCLUSION

In this paper proposed new type of pump which has few salient features. It can satisfy the problem of centrifugal pump and some other positive displacement. This pump may alternative for the above mentioned pump. It will have large potential in the pump industries.

REFERENCES