Troubleshooting of Hydraulic External Gear Pumps

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AN external gear pump is a tough and very long lasting moving component of a mechanical system. It is suitable for indoor and outdoor hydraulic applications. Due to its simple design and construction, this type of hydraulic pump is produced at a very competitive price compared to other types of pump in their family. Then it is the most popular hydraulic pump to be used when the system pressure is limited up to about 200 bar and when the noise generated by this pump is acceptable and not the major concerned in the case of indoor application. The various industrial applications and several unpredicted working conditions however, may lead to the pump malfunction or failure. Life of an external gear pump may be reduced drastically if the working condition is not maintained as required by the pump manufacturer. Poor circuit design and inadequate filtration are among the common failures of any hydraulic pump, and should be avoided. This article explores and highlights some causes of pump malfunction and failure. This information is relevant as a guide in the troubleshooting and identification of the likely causes of repeated failures of an external gear pump and any pump of a similar working principle. In general, a typical installation and components of an external gear pump with lobe (bearing set) and without lobe are shown in Figures 1 and 2, respectively.

EXTERNAL CHECK AND VISUAL OBSERVATION

The two factors related to system performance are pressure and flow rate produced by the pump. Reduced flow rate will result in slower actuator velocity. Meanwhile, lack of pressure will exhibit an inability to move or lift heavy loads. Therefore the most effective method of testing the pump operation in situ is the use of a flow meter and pressure gauge to measure and monitor the pump operation. A separate loading valve will indicate the actual pump capability rather than the system pressure which may be affected by a faulty component such as a pressure relief valve or worn out piston and rod seals.

HYDRAULIC FLUID

By taking the (OBE) concept, one should at all times conduct Visual observation of the hydraulic fluid which is useful to determine faults such as:

1) *Aeration* – if air is present, hydraulic fluid will appear bubbling or frothy in the tank. Check for loose hoses and fittings.
2) *Water content* – hydraulic fluid tends to have a 'milky' appearance or in the form of emulsion. System needs to be drained or flushed especially through the tank.
3) *Contamination* – Take a sample of hydraulic fluid from the tank during operation and pour it through a filter paper to determine the presence of contaminants in the hydraulic fluids.
4) *Oil degradation* – mineral hydraulic fluids are bio-degradeable. After a certain period of service, it will lose some of its lubrication properties. The normal symptoms are change in colour, odour and viscosity. Periodical replacement of hydraulic fluid is required to secure an appropriate level of lubrication to the pump.

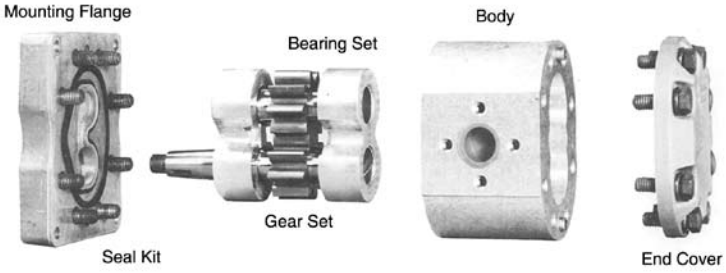

Figure 1: Typical installation and components of an external gear pump with lobe

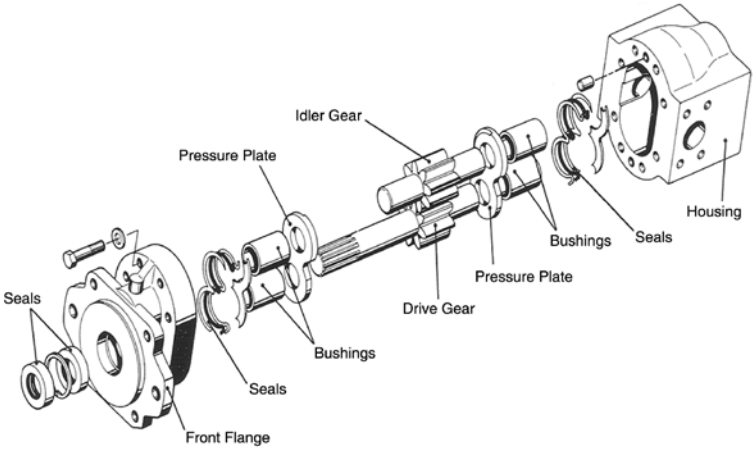

Figure 2: Typical installation and components of an external gear pump without lobe

INTERNAL INSPECTION

Inspection of internal parts of an external gear pump is suggested as follows:

1) Ensure work space and external pump casing are clean before dismantling the entire of the pump.
2) Inspect the pump components prior to internal cleaning to look for evidence and cause of failure.
3) Use appropriate identification marks on each component to enable correct reassemble sequence.
4) Remove all packings and seals. Prepare a new seal kit.
5) Avoid dropping, hammering or mishandling of components since they may damage and unable to be reassembled or reused.
6) Always test the pump performance at a pump test rig upon reassembley, before it is installed to machineries.

PUMP CAVITATION

The majority of industrial hydraulic mineral oils contain up to 10% dissolved air by volume. Under very low suction or local pressure, cavitation may occur in which air is released in form of bubbles and flow together with hydraulic fluid. At high pressure region, the bubbles may collapse or explode due to compression effect. If this phenomenon occurs at or very close to the solid surface, such gear teeth and pump body, the energy released by the explosion will cause pitting damage to the internal surfaces of the pump components. Repeated sharp knocking sound (or vibration) during pump operation is due to the pump cavitation.

Figure 3 shows a typical pitting failure due to cavitation on the internal surface of a pump casing. Possible causes of pump cavitation and its remedy may be explained as follows:

a) Diameter of the suction (inlet) hoses/pipes or fittings are too small.
b) Flow restriction (pressure loss) in inlet line is too high – remove hose (pipe) and inspect for any blockage in the hose/pipe and suction strainer.
c) Suction hose is collapsing – examine hose for tight bends and rectify the problem by using correct hose length or reroute. Check hose for suitable quality and still in good working condition, such as no sign of cracks of fraying and bulging.
d) Location of pump or tank – longer pipe/hose may cause high pressure loss which is very critical for suction line since it may create vacuum and cavitation. If the hose/pipe can be shortened, then the pressure loss may be compensated by rising up the tank above the pump and upgrade the hose/pipe to a larger diameter.
e) Incorrect oil viscosity – too viscous (difficult to flow) hydraulic fluid may introduce high pressure loss due to fluid internal friction or restriction to flow.

Figure 3: A typical pitting on the pump casing

AERATION

Aeration is due to the present of too much entrained air. In extreme cases, aeration may produce similar characteristics as cavitation. If the present of entrained air is too much in the system, then the oil in the tank will become frothy and cloudy. Possible causes of pump aeration and its remedy may be explained as follows:

1) Restriction in inlet circuit – high suction head will cause heavy contact between shaft seal and shaft. This action causes premature failure of seal and allowing air ingress.
2) Hardening of shaft seal – hardened seal is a result of high oil temperature or prolonged exposure to heat or direct sunlight duty storage.
3) External side loading – excess unbalanced radial side loading will cause the shaft to be offset and out of contact with the seal. Leakage passage is introduced as the annular clearance around the drive shaft, bearing and bushing are not consistent.
4) Leakage at suction (inlet) - entrained air is introduced into the pump suction due to the leak suction line especially at joints, unsecured shaft seals and damaged on port faces such as deep scratches in the proximity of seals.
5) Leaking and damaged suction hose – Inspect for any sign of leak and damage of hoses such as fraying, cracking and bulging. Replace if necessary.
6) Incorrect volume of hydraulic fluid in tank – always ensure the correct oil level in the tank to ensure the ends of suction and return lines are totally immersed in the fluid. In this case, there is no possible of partly exposed end of pipes.
7) Tank design and maintenance – end of suction line is located as far as possible from the end of return line to avoid turbulence and by-passed of high temperature fluid. Contaminated fluid must be drained periodically.

EXTERNAL LOADING

Unbalanced external radial loading of the pump drive shaft occurs when the external gear or belt and pulley types of pump driving is not properly installed. The unbalanced loading will cause excess bearing and seal wear. This condition may reduce the pump volumetric efficiency and shorten the pump life due to premature failure such as severe internal wear and fracture of the pump drive shaft. Examine the body cut-in track where the gear runs. Scour marks or any shining spot on the internal surface of the pump body will indicate the

location and the direction of unbalance force. The drive gear teeth will contact the body away from its normal track. The normal condition of the gear pump assembly is shown in Figure 4. Possible causes of pump unbalanced radial loading and its remedy may be explained as follows:

1) Excess tension of belt drives may pull the shaft to one side – inspect for correct belt tension as recommended by the manufacturers. Ensure belt is correct length. Check for belt and pulley alignment. The unbalanced loading condition is shown in Figure 5.
2) Eccentricity of drive unit – ensure all pulley, shaft and coupling are centered and balanced to avoid distortion, wobbling and vibration due to mass imbalance. Any bushing or damping element in the coupling unit must be in good working condition.
3) Lack of backlash in gear drive or coupling – check and reset gear centre distance and backlash. Check for alignment and balancing. Gear bore diameter must always closely fit to the pump shaft diameter.
4) Pump mounting – ensure all mounting bolts are secured tightly, and all flange spigot or union type of mountings are in good tolerance with mating holes.

CONTAMINATION

If the hydraulic fluid becomes contaminated by abrasive particles, internal wear will take place. Once the sealing faces become eroded, internal leakage will result. Pump performance will drop as the result of poor volumetric efficiency and pump may be subjected to higher operating temperature due to too much circulation of internal leakage. Scoring around the body cut in track, bearing lobes and faces will indicate the location of contaminants abrasive action under pressure. Contamination in hydraulic system may be controlled and explained as follows:

1) During toping up activity, make sure filler caps are kept clean and top up fluid is filtered.
2) Ensure hoses and pipes are deburred and flushed before they are installed into the circuit.
3) Inspect filter condition – replace filter periodically as recommended by the manufacturers.
4) Carry out proper tank flushing process during system commissioning to remove loose weld scale, wax and coating materials, sealant and residual of sealing tape and other debris.

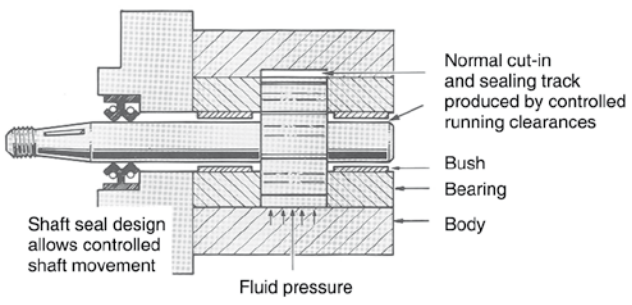

Figure 4: Normal loading condition of an external gear pump

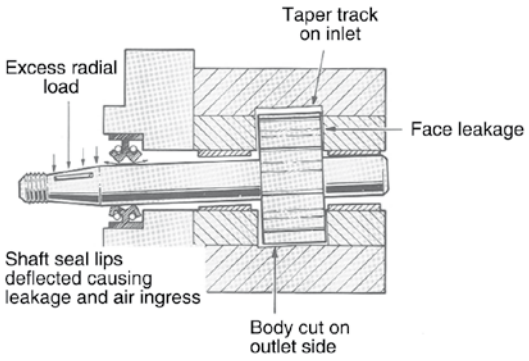

Figure 5: Typical unbalance loading condition of an external gear pump

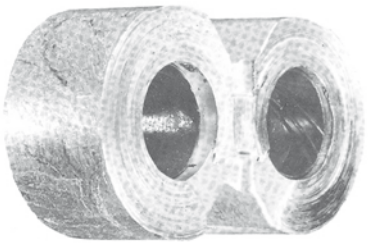

Figure 6: Scoring marks on the bearing lobe

Scoring marks on the surface of internal bore of bearing lobe due to the fluid contamination is shown in Figure 6.

CONCLUSION

An external gear pump is a tough and very long lasting. In order to obtain its optimum performance and ensure reliable working life, however, the full understanding of the pump construction, operation and maintenance are essential. The pump malfunction and failure could be derived from the operator's negligence during installation and operation, poor working condition and improper maintenance procedures.

Contamination of hydraulic fluid also adversely affected the pump performance. In the case of repeatable pump failure, the troubleshooting must be conducted fully. The pump must be dismantled and inspection of every pump components must be carried out thoroughly to establish the possible cause of problem. ■

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