TDZ

Bezares Group

VANE PUMP DESCRIPTION
FACTORS AFFECTING PUMP LIFE

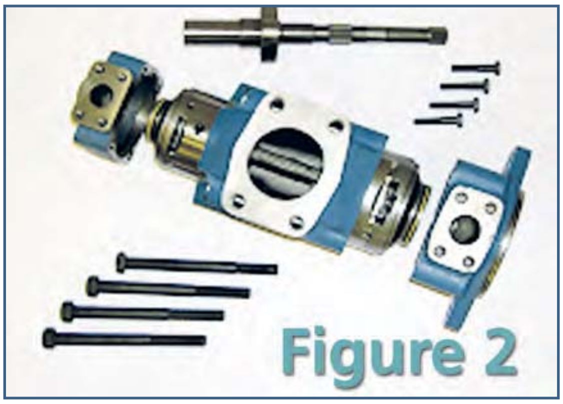
USE, MAINTENACE AND REPAIR GUIDE

PUMP CONSTRUCTION AND PARTS IDENTIFICATION

PUMP PARTS

The components of a typical vane-type pump are shown in Figure 1. This single-section pump has one cartridge assembly.

Double-section pumps (Figure 2) are similar, but have a longer shaft and housing, and use two cartridge assemblies. The housing sections include the body and covers, which have the openings for line connections. Also shown are the shaft with drive end bearing and seal, and the O-ring seals necessary to isolate the inlet and outlet compartments when the cartridge is assembled in the housing sections.



CARTRIDGE PARTS

Figure 3 shows the individual parts of a cartridge assembly. These high-precision parts comprise the actual pumping unit. The vanes (and vane inserts in most pumps) fit in the slots of the rotor, which is splined to, and driven by, the pump shaft. The rotor is installed on the shaft in the centre of the oval shaped cavity inside the cam ring. The cam ring is a liner for the housing, hardened for high resistance to wear. It is machined to provide the correct side clearance for the rotor and vanes, and the correct internal contour for the vanes to follow. The end plates fit against both sides of the cam ring, enclosing the rotor and vanes. Two pins hold all the parts in alignment, and two screws retain the assembly. Both plates have grooves and passages to control oil flow. The larger of the two end plates has the outlet ports and is usually called the pressure plate. The other plate, used on the inlet side is called the wear plate. Oil pressure behind the pressure plate holds the pump components together.

PRINCIPLE OF OPERATION AND OIL FLOW

During operation, the vanes are held outward against the cam ring by internal hydraulic pressure. Pressure oil enters the cavity between the vane and vane insert through the groove in one side of the rotor slot, causing the insert to act as a small piston. With the insert against the bottom of the rotor slot, the pressure oil between the top of the insert and the vane gives a uniform, controlled force to hold the vane outward. Any oil in the slot under the vane on each side of the insert can flow out through the drilled holes to the outside diameter of the rotor.

As the shaft turns the rotor, the vanes follow the internal contour of the cam ring. There are two points of minimum clearance between the rotor and cam ring, and two points of maximum clearance. These four points are located alternately each 90° of rotation. As the rotor turns, the vanes move outward during 90° of rotation, then inward during the next 90° of rotation. This completes a pumping cycle each 180° or one-half turn, giving two complete pumping cycles per revolution. With this design, the pressure loads and rotation resistance are equal on both sides of the rotor, so the internal forces are in balance. This keeps bearing loads and other stresses low for longer pump service life.

PUMPING ACTION

Each pair of vanes forms a pumping chamber which increases in volume as the vanes move outward, and decreases in volume as the vanes move inward. This change in volume, or displacement, produces the pumping action. During the rotation quadrant (90°) where the volume increases, oil is drawn into the chamber through the inlet port. As the chamber moves through the next quadrant, the volume decreases and the oil is forced out through the outlet port. Pressure develops only in direct relation to any restriction downstream from the pump outlet. If there is no restriction, the oil flows without pressure.

For the two pumping cycles per revolution, two inlet and two outlet ports are used. These are located alternately in each quadrant to permit oil flow in and out of the pumping chambers. Since the chambers are closed, and displace a specific volume per revolution, the pump is a positive displacement type.

PUMP ROTATION

When installing a replacement pump or pump cartridge, be sure to check the direction of rotation. The cartridge assembly is directional in rotation, but most cartridges can be reversed if necessary. Changing the direction of rotation changes the part number of the cartridge. To do this, it is only necessary to exchange the end plates. The cam ring, rotor, and vanes are the directional parts, and these must be correctly aligned with each other. Vane direction can be identified by the bevelled outer edge: The side in contact with the cam ring is the front, or leading side; the bevel is toward the back of the vane. The cam ring and rotor are marked with arrows showing the direction of rotation, and these arrows must be aligned to point in the same direction. A number is stamped beside the arrow on the cam ring. This number is a standard gallons-per-minute rating of the manufacturer under consistent, specific conditions, and can be used for comparative purposes; i.e., the cam ring of a new cartridge should have the same number as the cam ring of the cartridge that was removed. Normally, the manufacturer's rating is established at 1200 RPM and 100 PSI (7.03 kg/cm2), with oil at 150°F (66°C).

Today, TDZ machines use hydraulics almost exclusively to power implement and steering systems. Increased machine productivity has resulted in the design and use of greater capacity pumps and higher pressure systems. The new pumps and higher pressures impose greater stress on system components.

The vane-type hydraulic pump will normally provide good service when it is operated with a good grade of oil in a system that is clean and functioning properly. However, improper maintenance of the hydraulic system can cause early pump failure. Determining and correcting the cause of pump failure will insure adequate service life for the replacement pump.

This information is to assist in making a correct analysis of wear patterns or damage to pump parts. A correct analysis is very important in finding the basic cause of failure so it can be corrected. Unless the basic cause is corrected, a repeat failure is inevitable. Any time a pump or cartridge must be replaced, especially after early failure, inspect all the parts very carefully. The damage may not be as well defined as the examples shown, and/or the parts may have more than one type of damage. Also, the most obvious damage may not be the basic cause of failure. For example, a rotor seizure can be the result of gradual deterioration due to abrasive dirt or metal particles in the oil. If so, the contamination is the basic cause of failure, not the rotor seizure. This can be determined only by a careful, thoughtful study of the pump parts. A correct analysis and identification of the basic cause of failure is essential to prevent repeat failures.

The TDZ vane pump is the heart of the hydraulic system, which is a major component of the machine. When making an analysis of a pump failure, it is essential to consider all the factors affecting machine operation, including machine equipment, operator proficiency, job conditions and machine application. Be sure to check each of the following items:

1. Condition of each part of the pump and cartridge.
2. Type, grade and condition of hydraulic oil and filters.
3. Operating conditions and symptoms before and at the time of failure.
4. Condition of other components of the hydraulic system.
5. Severity of conditions in the job application.
6. Length of pump service life before failure.
7. Previous failures and repairs to the hydraulic system.

The factors affecting operation of the pump and hydraulic system are closely related and must be considered in conjunction with each other. Recognition of the various conditions and possibilities will aid in understanding the relation of pump damage characteristics to the hydraulic system.

HYDRAULIC OIL

The oil used in the system must have the correct additives and film strength sufficient to maintain a lubricating film, especially between the vanes and cam ring. Always use a high quality oil of the correct type and grade containing additives to control oxidation, foam, rust and wear. The anti-wear additive is very important and the present recommendation is to use oil containing zinc dithiophosphate or a comparable additive.

HIGH OIL TEMPERATURE

Excessive heat in the hydraulic system is a primary cause of seal failure. Oil temperatures in the tank must not exceed 200° - 210°F (93° -99°C), or damage can result. To keep the oil below critical temperatures, the hydraulic system must be well maintained, in efficient operating condition, and must not be abused or overloaded. Where there is evidence of high oil temperature, inspect the oil cooler to be sure it is clean and

functioning correctly, then check the system for bypassing of oil at high pressure. Any bypass of high pressure oil causes a rapid rise in oil temperature. Some possible causes of bypassing are:
... A worn pump, permitting oil to bypass internally from the high pressure to the low pressure side of the pump.
... A worn or sticking control valve or relief valve.
... A low pressure setting of the relief valve, allowing it to open too frequently.
... Frequent relief valve operation caused by excessive pressure in the system.
... Loose, missing or damaged parts, such as a seal or gasket, in the tank.

OIL SEALS

Hydraulic system seals are very important, and must be inspected frequently and carefully. The most critical seals are those on the hydraulic cylinder rods. The cylinder rods are the only hydraulic system components which are exposed alternately to both external and internal conditions, and only the seals prevent dirt from being carried directly into the system. If the lip of the wiper seal has no visible damage, there is no oil leakage, and the rod has no visible damage, these parts can be considered in good condition. Any worn or damaged seals, especially the wiper seal, can permit dirt to enter the system.
Seal damage is frequently caused by hot oil. Depending upon its material content, the seal may become hard and brittle, causing cracks; soft and pliable, permitting extrusion; or it may erode away. Seal effectiveness also depends on the contact surface of the cylinder rod, which the seal must wipe clean with every stroke of the cylinder. If the rod surface is scored, peened, pitted, rusted or worn, the seal cannot function effectively. In conditions where the cylinder rods can be damaged by falling rocks or other material, guards should be installed to provide protection.

SYSTEM OVERLOADING

The hydraulic system can be overloaded either by overloading the machine, or by poor operating practices. The machine is designed for optimum performance under specific conditions of weight, loads and operation. Oversize buckets, blades or other implements, and/or ballast or counterweights heavier than recommended, cause overloading of the machine and hydraulic system. Working the machine against extreme loads and/or bottoming the hydraulic cylinders causes excessive pressures. These pressures are potentially damaging, and should be prevented whenever possible. With a machine in good operating condition, correctly equipped and matched to the job, the operator should be able to achieve optimum production without exceeding the maximum pressure setting of the relief valve in the system more than once per machine cycle.

PUMP LUBRICATION

The pump must have an adequate supply of oil at all times. Before installing a new pump or a pump having a new cartridge, fill it with the same oil recommended for the system, and turn the shaft to distribute the oil over all the internal surfaces. This procedure is very important to prevent damage or excessive wear to the pump during the priming period after the engine is started. Also, to maintain pump lubrication, correct procedures must be followed when filling a system that has been drained. Remember, you are filling the system, not just the oil supply tank. Pump failure due to lack of oil can result if filling is not done correctly. The tank contains only enough oil to take care of changes in volume when the hydraulic cylinder rods are extended or retracted during machine operation. Refilling the hydraulic cylinders, lines and accumulators after the system has been completely drained may require a volume of oil two or three times the capacity of the tank. Therefore, oil must be added to the tank several times to be sure the system has an adequate supply. If the oil level in the tank drops too low, the new pump can be severely damaged by a lack of oil or by aeration of the oil. If the return oil in the tank discharges above the oil level in the tank, aerated oil will result. During operation, pump damage due to poor lubrication can result from excessively high oil temperature, using the wrong type of oil, or a lack of adequate oil supply.

PUMP SHAFT LUBRICATION

Lubrication of the drive splines on the pump shaft is completely separate from the hydraulic system. These splines receive lubrication from the engine oil system or other drive compartment through the pump drive. Spline wear can be due either to a defective shaft, which is not hardened correctly, or to a lack of shaft lubrication. Where splines are worn, make a careful inspection of the pump drive. Check all oil passages, including openings in seals, gaskets and sleeve-type bearings. An oil passage can be closed by an incorrectly installed seal, a gasket installed with the oil hole in the wrong position, or a wrong gasket having no oil hole. Also, a sleeve-type bearing with no oil hole, or installed with the oil hole in the wrong position, can prevent oil flow.

AERATION AND CAVITATION

Aeration and cavitation are two completely different conditions, but have very similar damage characteristics. Aeration is a mixing of air with the oil, either by excessive agitation or air leakage into the system; cavitation is the result of a restricted oil supply to the pump. In either condition, small bubbles of air or oil vapour are mixed with the flow of oil. These bubbles displace some of the oil, causing poor lubrication, and they are compressible, causing unstable vane action. Where a quantity of air bubbles enters the lines and cylinder, the compressibility can cause spongy or jerky operation and loss of a positive feel. Since the bubbles are compressible and the oil is not, the sudden collapse of the bubbles under pressure in the pump causes a hammering or pounding as the oil closes the spaces. This results in a vibration which can be strong enough to crack or break the cam ring, pump body and/or body bolts. This is also the source of the characteristic sound, often described as “pumping marbles”. The forces produced by the collapsing bubbles cause erosion and pitting of pump parts.

Aeration can be caused by:

... A low oil level. This can cause agitation if the return line is exposed, or let air directly into the pump suction line if the inlet line is exposed.
... An air leak in the pump suction line.
... Air leakage at a cylinder rod seal or line connection. When the implement is lowered, especially with the control valve in the float position, there is a vacuum in the rod end of the cylinder, and damaged rod seals or rods will permit air entry in the system.
... Tank agitation caused by damaged parts, such as: loose or broken hose, loose or missing baffles, or a return tube bent in a wrong direction.
... Agitation caused by excessive flow through the relief valve. This can be due to a low pressure valve setting, or excessive system pressure caused by machine overloading or poor operating practices.
... Water contaminated hydraulic oil. Although not aeration, it will have the same effect on pumps.

Cavitation can be caused by:

... Any restriction limiting the flow of oil through the pump inlet line. If the line is too small, a tube is bent, a hose collapsed, or the suction screen clogged; the flow of oil to the pump will be limited.
... A high vacuum in the tank, which retards the flow of oil.
... Hydraulic oil too viscous or thick to flow easily through the lines, especially in cold temperatures.

Since aeration and cavitation cause similar damage to the pump, further tests may be necessary to determine which condition is the cause of failure. Where damage characteristics indicate aeration or cavitation, first look for obvious problems, such as: A bent suction tube, collapsed suction hose, or thick, heavy oil which could cause cavitation; or a cracked suction tube, loose suction hose, or low oil level which could cause aeration. If none of these are evident, and the machine is in service, a “bottle test” can be made as follows:

1. Oil in hydraulic tank should be at normal operating level. Run engine at high idle for five minutes with all control valves in "HOLD" position. Be sure the oil is at, or near, the temperature of 150°F (66°C).
2. Lower a small, clean, clear glass bottle into the oil through the tank filler tube, and remove a sample of oil.
3. Hold the bottle up to a strong light and look through the oil for foam and/or bubbles, indicating aeration.
4. If oil is aerated, cause is either a suction line leak or oil discharge in the tank above the oil level. Make necessary corrections so that test can be repeated and a clear oil sample obtained.

If the problem is cavitation and occurs only at the time of starting, and oil viscosity is correct, a high vacuum may exist in the tank. This can be corrected by loosening the filler cap before starting the machine.

OIL SAFEGUARDS

There are several maintenance procedures that are particularly helpful in assuring satisfactory pump and hydraulic motor life.
Two of the most important are:

- Oil sampling
- System flushing.

OIL SAMPLING

A Scheduled Oil Sampling (SOS) program can provide an early warning of some hydraulic system problems. Normally, the testing will not detect particles larger than 10 microns in size, but will detect material such as fine abrasive dirt (silicon) or metal (iron) which is not visible in the oil. Since these fine particles are not visible, the oil can look clean. In addition to causing pump wear or damage, the presence of these particles may indicate other problems in the system. When the test reading shows a high iron content, it may indicate excessive wear or dam which could result in a failure. The test reading of silicon, which shows the amount of dirt in the oil, is normally less than 10 PPM (Parts per Million). When this reading shows a sudden increase, or is as high as 35 PPM, excessive dirt is entering the system. Since cylinder rods and seals are the most common point of dirt entry, make a careful inspection of these parts (See the topic "Oil Seals"), then perform a "Tee Test" to check pump condition.

FLUSHING THE SYSTEM

Abrasive dirt, metal particles or any other contaminants must always be removed from the hydraulic system. Contamination is a frequent cause of pump failure, often due to incorrect flushing procedures after a previous failure. Correct flushing procedures are given in Special Instructions Forms FE040041-01 and GMG00234 for loaders and Form FM055145 for tractor-scrapers. These procedures can be adapted to the hydraulic systems on most other Caterpillar machines, since the basic principles of flushing are similar. Always be sure to flush the system thoroughly after any failure which can introduce metal particles, dirt or any other contaminants into the oil.
If desired, the drained oil can be filtered and reused. This will reduce the quantity of oil needed by as much as 50%. The filter must remove particles 10 microns or larger in size. With diminishing supplies, and the increasing cost of oil, filtering is a practical method of conservation and cost reduction.