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HYDROSTATIC TRANSMISSIONS

Hydrostatic transmissions use oil (hydraulic fluid medium) to transmit power from the power source to the driven mechanism. The hydrostatic transmission depends upon high pressure, rather than just moving oil, to transmit power.

On the other hand, there is also a hydrodynamic transmission (called a torque converter- or a hydraulic torque converter) which also uses oil. But the fact that both use oil is the only similarity. A hydrodynamic transmission uses a high-speed stream of oil from an impeller to impinge on the blades of a turbine to transmit power.

Hydrostatic transmissions, used in agricultural tractors, on and off highway mobile equipment and various self-propelled equipment generally use a hydraulic pump and a hydraulic motor to propel the driven source through piping, and various control systems. The hydraulic motor is much like an electric motor except that it uses fluid instead of electricity.

Hydrostatic transmissions can replace the clutch, gear transmissions, rear end differentials and rear axles. As an illustration, let's consider a simple piece of mobile equipment which can be powered by a hydrostatic transmission, an agricultural or industrial tractor. The operator only has to move a lever forward to go forward, and backward to reverse. The further the lever is moved, the faster the vehicle will go because more oil is being pumped.

The hydrostatic transmission uses a variable displacement pump attached directly to the driving source (the engine in this case). Such a pump can force the hydraulic fluid full speed in one direction and then, by a simple change, the output of the pump can be at zero and the vehicle stops. Further movement reverses the flow and the vehicle will then go in reverse.

The driving source can run at constant speeds or varying speeds and power can be diverted to varying driven sources by the hydraulic fluid which can be pumped to drive wheels, rotating mechanisms, lift mechanisms, etc. The hydraulic motor can also act as a brake, when the control lever goes from fast to slow.

There are both advantages and disadvantages to hydrostatic transmissions, when compared to the conventional sliding gear transmission. Some are as follows:

Advantages

1. Infinite number of speeds forward and backward.
2. Transmission is also a positive brake.
3. Various slow speeds are possible.
4. Control is with one lever.
5. Can have drive wheels "locked" together.

6. Wheels, tracks or other driven mechanisms can be easily spaced.
7. Four-wheel traction vehicles turn in smaller circles when they are hydrostaticly driven.
8. Can have built in overload protection.
9. Easily shifted to keep power matched most efficiently to various fluctuating loads.

Disadvantages

1. Lower efficiency than sliding gear transmissions - about 75%-80% for hydrostatic and about 95% for sliding gear transmission.
2. Higher cost than other transmissions.

Hydrostatic adjustable speed drives fall into five standard drive categories:

- PF-MF (fixed displacement pump and motor with various speed prime mover)
- PF-MF (with flow control valves)
- PF-MV (fixed pump, variable motor)
- PV-MF (variable pump, fixed motor)
- PV-MV (variable pump, variable motor)

PF-MF (variable speed prime mover) - Prime mover speed determines pump delivery and output (hydraulic motor) speed. Output torque is constant for any given hydraulic system pressure. Output torque and speed can be greater or lesser than prime mover speed, depending upon the relationship between the displacements of pump and motor. There is essentially a trade-off between torque and speed; to increase one, the other must be proportionately decreased. Rotation is reversible only if the prime mover rotation can be reversed.

PF- (with valving) -This drive is similartpAhe above, but does not require a variable speed prime mover. Pump output volume and motor torque are constant, and output speed and horsepower are variable. The flow control valve limits the amount of fluid available to the motor and thus controls output speed. Efficiency of this system is relatively low compared with other hydrostatic drives, because of the throttling action of the valve. However, this kind of drive is low in cost. It is used in a wide variety of industrial applications, usually where only small speed changes are required.

PF-MV (pump output is constant with constant input speed, for example with an electric drive motor) - Hydraulic motor displacement is varied to change output speed. Reducing motor displacement increases output speed. However, if this displacement was reduced to a point approaching zero, the drive speed would attempt to reach an infinite value.

Therefore, output speeds are usually kept within design limits by limiting displacement extremes with mechanical stops. The displacement range of a variable displacement motor is commonly 4:1. Output torque varies proportionately, but inversely, with output speed. This pattern of variation is particularly useful in rewind drives that require constant web speeds. When reel diameter is small, drive speed must be relatively high to maintain constant line speed, but the torque requirement is relatively low. As the reel builds up, motor output speed must decrease and torque increases proportionally matching the characteristics of a PF-MV drive. This combination has a relatively constant power versus speed characteristic.

PV-MF - This is the most common combination. Output speed is adjusted by the varying pump displacement control the amount of fluid delivered to the hydraulic motor. Output speed can be varied or held at any spot across the complete speed range. Because the pump can be stroked "across center" to reverse the direction of oil flow, output speed of the drive is fully reversible without change in prime mover speed or direction of rotation. Because motor displacement is constant, output torque is constant if pressure is constant. Horsepower is variable and a direct function of the output shaft speed at a given pressure setting. Applications of this drive include machine tools, printing and processing machinery, foundry and continuous casting equipment, textile machinery, elevators, hoists and winches.

"Closed system" drives of this type (where fluid from the motor outlet returns to the pump inlet directly instead of to a reservoir) generally incorporate a small supercharge pump to provide the main pump inlet with positive pressure at all times. This prevents pump cavitation, and permits rapid speed changes.

PV-MV - Variable pump-variable motor hydrostatic drive provides the greatest flexibility and versatility. Output speed can be varied by adjusting the displacement of the pump, the motor, or both. Output torque and power are infinitely variable across the complete range in both directions of rotation. This combination provides the widest operating range of any hydrostatic drive.

As pump displacement is increased with the hydraulic motor maintained in its maximum displacement position, essentially constant torque output at a constant pressure is obtained while output speed and horse-power increase. With pump displacement and system pressure held constant, the drive delivers essentially constant horsepower; if motor displacement is increased, speed will drop and torque increases proportion-ally, and vice versa. In some installations, pump and motor displacement are controlled simultaneously to provide constant horsepower through the speed range.

The PV-MV circuit controls the peripheral speed of the rewind rolls on a multi-spindle slitting machine. Close control of preset linear velocity and tension is required. During slitting, the machine pulls the web from the mill roll at a constant linear speed. As the rewind roll builds up, the displacement controls on both pump and motor are varied proportionately, through mechanical linkages. The main drive pump is driven off the machine drive, and a small auxiliary pump is included for supercharging and replenishing. Auxiliary valving maintains constant tension on the web from standstill through its entire buildup range, eliminating slack when the main machine drive is stopped. Other valving allows the rolls to freewheel when unloading and loading the mandrels.

Pump-drive speed is considered to be constant, and torque is measured at a constant pressure. Due to design changes, improvements in components and an increase in operating pressures, more efficient hydrostatic transmissions are now becoming available at lower costs. As a result, their use is expanding in a variety of equipment, both for the "sheltered type" application in industrial machinery, as well as for the "out-of-doors" equipment where the operating conditions are not always under the closest control.

To get the maximum benefit from such equipment, operators should be aware that hydraulic oil is a vital component in hydrostatic transmissions. Not only is it the power transfer medium, but it also serves as a coolant. At the same time it must protect the motor and pump against wear, rust and deposits, and be compatible with such other components as flexible lines and seals.

Ordinary hydraulic oils are usually not satisfactory because they lack some of the desired properties. The properties an operator should look for in a quality hydraulic fluid will depend on both the design of the transmission and the environment in which it is expected to operate. Properties particularly important are:

1. ANTI-WEAR - The need for enhanced anti-wear protection from hydraulic oils has been recognized all along, and recommendations for suitable types of oil have been made. Hydraulic fluids with proper anti-wear additives and the hydraulic transmission fluids (wet brake fluids) specified by major manufacturers provide adequate protection.

2. OXIDATION STABILITY - A measure of the effective life of an oil - a property imparted by additives plus the degree of refinement of the oil.

3. ANTI-RUST - Corrosion of equipment, especially during shutdown periods when moisture is present, can seriously damage a transmission. Protection against rusting of the parts covered by oil is not difficult to obtain and should be provided by the oil.

4. DEMULSIBILITY - This describes the ability of an oil to separate from water. When a hydrostatic transmission operates under conditions where large amount of condensation can contaminate the oil, rapid separation is desirable. This permits water draw-off and continued use of the oil.

5. CAVITATION AND AIR ENTRAINMENT - Cavitation of an oil in the pump or motor of a hydrostatic transmission can cause failure if it continues out of control. This problem is often traceable to the use (operation) of the equipment rather than to the oil properties. The use of oil without volatile components will be of help. The entrainment of tiny air bubbles in the oil can aggravate the problem because air can become focal points for cavitation. The formation of foam on top of the oil is a different type of air entrainment and can be controlled with anti-foam additives.

6. BULK MODULUS - This has become a popular term in hydraulics. It describes the oil's resistance to a decrease in volume when subjected to pressure. Compressibility can be used to describe this phenomenon in a simplified manner. The use of VI improvers, to improve lesser quality oils, will cause a slight increase in the compressibility as oil temperatures increase.

7. SEAL CONDITIONING - Most transmission seals are made of materials such as Buna N rubber. A desirable oil should not only protect the elasticity and softness of the seal, but also cause it to swell very slightly. A desirable seal swell can be maintained through proper choice of additives.

When compatible with the hydraulic oil being used, the seals will last for a long time.

8. VISCOSITY AND VISCOSITY INDEX - Both viscosity and viscosity index should be considered in the selection of a hydraulic oil. These oils must perform satisfactorily over a wide temperature range and a high VI oil is needed. Hydrostatic equipment makers usually recommend a 200 SUS oil at 100°F.(38°C.), for outdoor equipment. Hydraulic oils with a naturally high VI is preferred. High temperature operating ranges can be extended about 20°F(-7°C) higher when using naturally high VI oils over the low VI oils, or VI improved oils. Improved VI oils are desirable, only when no "shear down" can be assured.

All the listed properties are easily met by LE's 7500 MONOLEC Power Fluid. On rare occasions, some manufacturers under certain operating conditions, will require a top quality Dexron or Mercon type automatic transmission fluid, which is fully met by LE's 1107 Automatic Transmission Fluid.

On occasion, engine oils with anti-wear additives have also been shown as suitable for some users, provided they have been proven in service. However, the components of engine oils are changed frequently to meet changing crankcase requirements due to the widely varying engine designs of today. And all of the desirable properties may not be included in such engine oils. High quality, premium grade hydraulic transmission oils have shown to give better satisfaction and assurance of good performance. The advantages of shear stable, naturally high VI oils with anti-wear additives have been fully demonstrated. LE's 7500 MONOLEC Power Fluid is such a shear stable, high VI, anti-wear and anti-foam inhibited hydraulic transmission oil. LE's 7500 MONOLEC Power Fluid is the finest hydraulic transmission oil with high VI as well as all of the other highly beneficial proper6es resulting from the use of MONOLEC, LE's exclusive wear-reducing additive.

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