Closed Loop Hydrostatic Transmissions

Information in this section is extracted in part from the Womack textbook “Industrial Fluid Power – Volume 3”. Please refer to that book for a complete description of this subject. The book may be purchased at www.womack-machine.com or by phone at 214-631-7983.

What is a Closed Loop Hydrostatic Transmission?
It is a marriage between a hydraulic pump and a similar hydraulic motor for the purpose of delivering a variable speed, variable HP mechanical output from the motor while driving the pump at a constant speed from an electric motor or an engine.

What are the Advantages of Closed Loop?
As compared to an open loop hydraulic system, an operator, by using a small control lever on the pump can produce reversible rotation, variable speed, constant or variable HP to a load at a higher efficiency than many open loop systems.

Description of a Closed Loop System.
In a closed loop system, return oil from the hydraulic motor, instead of being discharged to tank, is ported back to the pump inlet and recirculated. A low volume, low pressure charge pump is part of the system for replacing a small percentage of the oil in the loop with fresh oil on a continuous basis. Valves are added to the system for pressure relief and for directing replacement oil into the loop.

Components Used in Closed Loop Systems.
In most systems piston pumps and motors must be used because the slippage loss in piston components is less than in gear or vane pumps and motors. Low slippage is vital if the system is to operate over a wide range of speeds. Gear and vane units cannot operate smoothly at low speeds and their higher slippage loss usually will cause the system to overheat.

Variable displacement pumps in this manual which are suitable for hydrostatic transmissions include the Rexroth AA4V and Rexroth Hydromatik. Motors suitable for transmissions include the Rexroth AA2F, Rexroth AA6VM and Rineer. Please refer to the Manufacturers Index at the back of this manual for page numbers for these products.

In most systems the displacement of the pump and motor should be the same or have a difference of no more than about 20% if the maximum power, torque, and speed range is to be realized.

Typical Circuit of a Closed Loop Hydrostatic Transmission.
Most systems use a variable displacement piston pump driving a fixed displacement hydraulic motor. In the above circuit diagram the pump is shown as Item ① and the motor as Item ⑩. A charge pump (Item ②) is required for all systems. This will usually be a gear-type pump of about 15% of the displacement of the main pump and operating at 250 to 500 PSI. This pump can be external but is usually built into the rear cover of the main.
A low pressure relief valve (Item 6) is required for the charge pump and is usually in the main pump. Sometimes another relief valve (Item 3) is in the motor cover. Two high pressure relief valves (Item 8) are required on a reversible system connected back-to-back across the loop lines. These valves are usually in the motor cover.

The shuttle valve (Item 4) serves to discharge the excess loop oil, which is replaced by fresh oil from the charge pump, into the low pressure side of the loop as the direction of oil flow in the loop is reversed. It is usually in the motor rear cover.

Two check valves feed the charge pump oil into the side of the loop which happens at that moment to be the lower pressure side. They are usually contained in the main pump cover.

Additional items which are not contained within the pump or motor covers include filters (Item 6), strainers (Item 7), heat exchanger, and a reservoir sized for about two times the flow rate of the charge pump.

Variations in Closed Loop Systems.

The circuit shown is used in the majority of applications. Variations for special applications may include a variable, instead of a fixed displacement motor. This will extend the high speed end of the speed range when, after the pump has been placed at full displacement, the displacement of the motor is decreased. Variation of motor displacement will give constant HP operation. As the speed is increased, the torque is decreased by the same amount. Another variation, but seldom used, is to use a fixed displacement instead of a variable displacement pump where speed variation is not required or can be accomplished by varying engine drive speed.

Operator Controls for Closed Loop Transmissions.

Several types of controls are available for pump and/or motor control depending on the manufacturer. Some act automatically, others are under the control of an operator. The control is mounted on the unit (pump or motor) which it controls. The more popular controls and those available on all brands of equipment are the following:

Pressure Compensator. This control must be adjusted for the maximum rated system pressure. If the operator control lever is moved to maximum displacement, the compensator will keep pump displacement at maximum until, due to build-up of load, system pressure reaches maximum. The control will then override the operator to reduce displacement sufficiently to keep pressure from exceeding compensator setting. This control, by itself, does not limit HP, and to prevent stalling of the hydraulic motor the power source must have sufficient HP to satisfy maximum PSI and GPM parameters of the system.

HP Limiter. This control has a pressure compensator. It also has a device for detecting the rate of oil flow (or speed of the motor). By combining information from the compensator with flow information it can prevent a HP overload by reducing pump displacement when HP output reaches the maximum.

Other Controls. Most transmissions have one of the above controls. Other controls for special applications may include a winch control, pressure compensator for motor, constant speed control, proportional torque control, and electric remote adjustment.

Hydraulic Oil for Transmissions.

It is highly important to use only an oil which is approved by the manufacturer. This would be similar to an automatic transmission oil for motor vehicles. Oil temperature on industrial applications should not exceed 160°F. On mobile applications the temperature should be kept as low as possible but oil should be changed when it has deteriorated from heat.

Oil Filtering.

Because of the piston pumps and motors used, transmissions are very sensitive to microscopic dirt. Oil entering the closed loop should be filtered to 10µM or better. Oil going into the charge pump should be filtered to 74µM or finer. The filler and breather holes on the reservoir should be protected with 10µM breathers.

Heat Exchanger.

Transmission of 40 or more HP nearly always require a heat exchanger. Drain lines from pump and motor plus charge pump relief oil should be routed through the heat exchanger. On mobile equipment the best cooling is usually by a cooling radiator mounted in front of the engine radiator.

Cylinders in Closed Loop Circuits.

Although cylinders can be mated to a variable displacement pump to operate in a closed loop, there are special problems. Please read the information in the Womack book “Industrial Fluid Power – Volume 3”.

521