Evaluating Hydrostatic Transmission System Pumps

For High Horsepower, Heavy-Duty Closed Circuit Applications
Hydrostatic transmission drives have long been recognized for superior power transmission when variable output speed is required because they provide fast response, maintain precise speed under varying loads, and allow infinitely variable speed control from zero to maximum. Most important, they feature a continuous power curve without peaks and valleys and can increase available torque without having to shift gears as is necessary with mechanical gear transmissions.

A hydrostatic transmission is an entire hydraulic system in a single package—pump, motor, and all required controls. These systems provide all of the advantages of a conventional hydraulic system:

- Step-less adjustment of speed, torque, and power
- Smooth and controllable acceleration
- Ability to be stalled without damage
- Easy controllability

There are two general hydrostatic transmission configurations: split or closed coupled. Integrated (or closed coupled) transmissions are designed to have the hydraulic pump and motor share a common valving surface and are typically used in light-duty applications.

Split hydrostatic transmission systems (Fig. 1) consist of a power unit with the hydraulic pump, heat exchangers, filters, valves, and controls mounted on a reservoir. The hydraulic motor is remotely mounted and connected to the power unit through hose or tubing. Split transmissions are widely used in heavy- and severe-duty closed circuit applications such as shredding, logging, and oil drilling as well as land and sea military equipment because they provide wide flexibility in configuring the system for the most efficient use of space or best weight distribution.

Closed hydraulic circuits typically utilize a variable displacement pump and fixed motor. This combination provides a constant torque output at a fixed maximum pressure over the pump’s full speed range. Speed and direction are controlled with a variable displacement over-center pump. Power from overhauling loads is regenerated back into the pump prime mover. Motor speed is limited to the maximum speed permitted by full pump displacement.

The decision as to which and what type of power unit design to use in a split hydrostatic transmission configuration depends in large part on how severe the demands will be for the intended application. Example: shredding anything from cars to tires, scrap steel, wood, and hot water heaters is an extremely harsh operating environment for a hydraulic pump. Here, a very fast compensator is important that can handle the rapid pressure spikes and rapid pressure decay of these operations. Some pumps can handle massive pressure spikes with ease, while others have difficulty.

For high-horsepower, heavy-duty applications, it is important to carefully evaluate five pump design approach areas, specifically, the pump’s shaft and bearing design, valving and valve packages, controls and control options, oil replenishment pump, and the hot oil shuttle option for closed circuit applications.

Fig. 1: A typical split closed-circuit hydrostatic transmission configuration for high horsepower, heavy-duty applications.
SHAFT AND BEARING DESIGN

The majority of pump designs utilize conventional bearings at each end of a heavy, large-diameter shaft to support the loading. An alternative approach utilizes a bearing centered around the barrel. The position of the bearing was determined relative to the summation of the internal rotating group forces at one point in the barrel. With the bearing centered at that point, the barrel bearing takes the radial loading, eliminating the need for conventional large pump shafts and support bearings.

Because the radial loads generated from the rotating group are supported by the large barrel bearing, a smaller diameter main shaft can be employed. This design permits use of a smaller main shaft with the pistons grouped tighter to the center. With a smaller diameter piston bore circle, the piston and fluid velocity is reduced, allowing the pump to run at higher speeds without risk of losing the oil film.

**SELECTION KEY:** Overall, the pump’s design can play a key role in how well it can handle higher operating speeds and shaft/bearing loading.

OIL REPLENISHMENT

When pressure in the pump’s main line drops below the required replenishing pressure, an auxiliary pump is used to provide for the makeup oil. In some pump designs, this auxiliary pump is externally mounted. Other designs incorporate the auxiliary pump inside the main pump body (Fig. 4) along with the necessary check valves for bi-directional operating. This design approach reduces the overall pump envelope and simplifies component and circuit complexity.

The built-in check valves are ideally suited for proper replenishment in applications such as shredding and drilling. The replenishment of fluid into the system is especially critical during high dynamic loading conditions where main line pressures can switch from one extreme to the other in a matter of milliseconds.

**SELECTION KEY:** Some pump or system designs utilize conventional check valve configurations for oil replenishment, which are slow to operate and have higher-pressure drops. Others use a ring check approach that permit high flows and react very fast due to their low mass.

FIGURE 2: Parker’s GOLD CUP® modular valve block provides complete closed circuit valve function including servo and replenish (charge) pressure control. It is removable and replaceable for ease of service.

VALVING

Most closed-circuit pumps will operate in conjunction with multiple valves, providing relief functions along with pressure compensation. How those valves are arranged and positioned in or on the pump will vary depending on the pump design. One approach incorporates all valving into a single block (Fig. 2) that can be quickly changed out and replaced with a new one should there be a problem—such as system contamination causing blocked orifices and/or sticking poppets. Other designs, depending on the location of the problem, could require an extended system shut down to troubleshoot and fix the problem.

**SELECTION KEY:** Carefully check the pump’s valving arrangement in light of the intended application and what time and cost considerations would be to deal with a downtime problem area.

FIGURE 3: Electrohydraulic control mounted on the “B” side of a Parker GOLD CUP® pump. The same control can be mounted to the “A” side to quickly and easily change the pump’s configuration.

HOT OIL SHUTTLE OPTION

Recommended for closed-loop applications, hot oil shuttles can be mounted on the pump or motor to remove hot oil and allow the transfer of cool filtered oil into the loop. This prevents the same oil from continuously circulating the loop. For example, if the oil-replenishing pump is capable of providing 12 gpm, and 4 gpm is lost to leakage, there is an 8-gpm excess of replenish oil. Without the hot oil shuttle, the excess 8 gpm of replenishing oil will spill across the replenishing relief valve and generate heat.

With the shuttle, anytime a pre-set pressure differential is created from one main line side of the system to the other, the valve shifts so that the excess replenishing oil mixes with the low pressure side of the circuit and goes back into the reservoir through the filters and heat exchangers that are part of the system.

**SELECTION KEY:** Built-on shuttle options are ideal to eliminate unnecessary hoses, leak point connections, and simplify the overall hydraulic circuit.

CONCLUSION

There are many hydrostatic piston pump differences that must be carefully considered along with their features, performance capabilities, control options and certifications. For high horsepower, heavy-duty applications, pump and system failures are not an option. Long-term success starts with an in-depth cost/benefit analysis.

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