Hydrostatic Transmissions (HSTs)

In modern industrial and mobile systems, power has to be transmitted from the prime-movers to the machines in a controlled way. Power can be conveyed mechanically, electrically, or hydrostatically. In the hydrostatic transmission (HST) a hydraulic pump drives a hydraulic motor. If the displacements of the pump and the motor are fixed, the HST just acts like a gearbox for transmitting power from the prime mover to the connected load. Let us now run through the subject matter …

Characteristics of HSTs

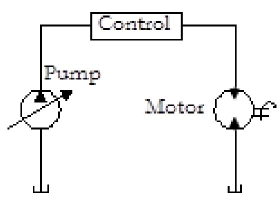
The overwhelming majority of today's HSTs use variable-displacement pumps and/or variable-displacement motors so that their speed, torque, and/or power can be regulated hydrostatically. Depending on its design, an HST can drive a load from its maximum speed in one direction to the maximum speed in the opposite direction, with the fine variation of the speed between the two maximums - all with the prime mover operating at a constant speed. The relative spatial position between the pump and the motor is arbitrary, but it should not be enormous (<50m) to avoid potentially significant transmission line losses.

Classifications of HSTs

The hydrostatic transmissions (HSTs) are classified as (1) open-circuit drives and (2) closed-circuit drives. They can also be configured as (1) close-coupled configuration or (2) split configuration. Also, the energy transmission in an HST can be under (1) variable-power, variable-torque, (2) variable-power, constant-torque, or constant-power, variable-torque mode.

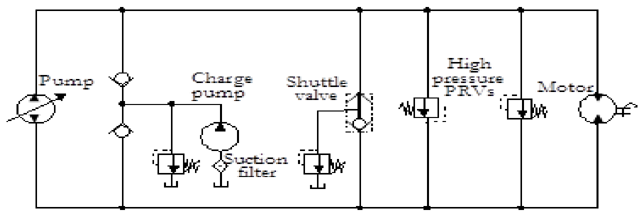
Open-circuit HST

A typical open-circuit HST consists of a prime-mover-driven pump, a hydraulic motor that is coupled to a load, and all the required controls in one simple package. All the elements of the HST are then interconnected through the metal tubing and/or hose assemblies. The pump draws the fluid from the system reservoir, generates the flow, and drives the motor. The fluid is then discharged back into the reservoir. This arrangement can provide infinitely variable speed, torque, and/or power ranging from zero to their maximums in both the directions of motion of the drive.



Closed-circuit HST

A typical closed-circuit HST consists of a bi-directional variable-displacement pump, a fixed-displacement motor (uni/bi-directional), pressure relief valves, a charge pump, check valves and a shuttle valve, all in one package. The fluid discharged from the motor's outlet flows directly to the pump's inlet, without the need for the fluid to return to the reservoir.



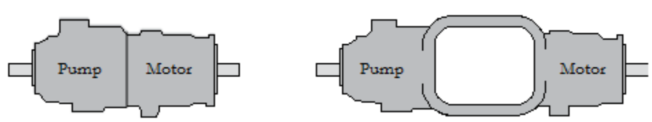
Pump
A prime-mover-coupled axial piston variable-displacement pump of the swash-plate construction can be used as the power source. The swash-plate angle can be infinitely adjustable to obtain displacements from zero to a maximum and hence to achieve infinitely variable speeds.

Motor Unit
A fixed-displacement axial-piston hydraulic motor of the swash-plate construction with preset displacement can be used as the driven unit. The motor's speed is proportional to the flow rate of the input fluid. The output torque is proportional to the pressure differential across the motor.

Charge Pump
While the HST system is in operation, there is a constant loss of fluid within the pump and the motor. Therefore, a charge pump is used to continuously replenish the lost fluid in the transmission loop. A simple circuit for the charge pump comprised of a gear/gerotor pump, a relief valve, and two check valves. Once the loop is charged to the relief valve's pressure setting, the flow from the charge pump passes over the relief valve on its way back to the reservoir.

Pressure Relief Valves
The high-pressure PRVs prevent any inadvertent overload on the pump and the motor. If the feed pressure rises above the relief valve setting, the fluid bypasses the motor through the respective relief valve.

HST Configurations
In the close-coupled configuration, the pump and hydraulic motor share a common valving surface. This arrangement provides an extremely short fluid flow path, thus eliminating the high-pressure fluid leaks. The close-coupled transmissions are, usually, found in light-duty applications, where tight space constraints require compact units.



(a) Close-coupled configuration (b) Split configuration

In the split configuration, the power unit with a hydraulic pump, heat exchanger, filters, valves, and controls is mounted on the reservoir, and a remotely mounted hydraulic motor is connected to the power unit through hoses or steel lines. The split configuration is typically used in heavy-duty applications because it offers full flexibility in configuring the system.

Advantages
Typically outperforming the mechanical and electrical variable-speed drives, the hydrostatic transmissions offer quick response, precise speed control under varying loads, step-less adjustment of speed, torque, and power, fast reverse, smooth and controllable acceleration/deceleration, and stalling without damage. Using proper pumps and hydraulic motors, almost limitless control of any possible movement is possible.

Applications

Initially, HSTs were employed for low-cost systems, such as farm equipment and garden tractors. However, with improved designs, they are found suitable for a broad range of applications. Light-duty HST units (< 20 hp) are used on equipment, such as lawn tractors and small machine tools. Medium-duty HST units (25 to 50 hp) are used on skid-steer loaders, trenchers, and harvesters. Heavy-duty HST units (> 60 hp) are used on agricultural and large construction equipment.

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Reference: JOJI PARAMBATH, Industrial Hydraulic Systems – Theory and Practice, Universal Publishers, Boca Raton, USA, 2016. Please visit: http://www.universal-publishers.com/book.php?method=ISBN&book=1627340580

Note: A comprehensive account of the topic is given in the textbook on 'Industrial Hydraulic Systems-Theory and Practice' by Joji Parambath.
