Selecting the Right Motor for Your Hydraulic Application

In designing your hydraulic system, you want to match the overall efficiency of the system to performance you expect to receive. In order to do this, you must first match the motor to your specific system performance, then the pump. The design of the of an entire system will change depending on the motor you select.

A hydraulic motor is a hydraulic actuator that when connected adequately into a hydraulic system it will yield rotary actuation. The motor can be unidirectional or bidirectional depending on the design of the system. Motors are similar to the design of pumps, with the difference being that a motor takes flow into itself and puts out a rotary actuation, whereas a pump takes a rotary actuation to move hydraulic fluid out of the unit.

Load Requirement

Motor selection is first in the process because application design best practices require that you start with the load requirement, then work back to the prime mover-the pump that will put the fluid power into the motor to deliver the performance you expect/need.

Motor Types

Each motor type has its own set of applications where they are the better choice. As an example, if you chose a small gear motor that is designed to operate at a max of 3,000 psi and 2,000 rpm, and you put it into an application where you require it to run consistently at 3,000 psi and 1,0000 rpm, the motor will running in a overstressed condition which in turn will reduce its life cycle, even when it is technically within its ratings. The better choice would be to select a motor with higher ratings that will live long in this application. Sure, a higher rated motor will cost you more, but the this could be outweighed by its performance and life cycle.

How Motors Are Rated

Motors are rated by displacement which is the volume of fluid that it takes to rotate the shaft of the motor once. Common rating units are cubic inches per revolution (cir), or cubic centimeters per revolution (ccr).

Motors are also rated by their torque which is the amount of twisting force that the motor can deliver. The common measurements of torque are inch-pounds (in-lb), and Newton-meters (Nm). The torque of a motor is a function of motor displacement and system pressure.

The starting torque is the torque that the motor can generate to turn the load when starting from a stopped position. In general, starting torque is the lowest torque rating of a hydraulic motor due to inefficiencies.

Stall torque is the maximum torque the motor will generate before it stops rotating. This is sometimes referred to as running torque.

Rotational speed of the motor shaft is measured in units of rotations per minute (rpm). Motor speed is a function of the hydraulic input flow, and the motor displacement.

Pressure is generated by resistance to the hydraulic flow. The more resistance there is, the higher the pressure is. Common measurement units are pounds per square inch (psi), kilos Pascal's (kPa), or bar.

Common Motor Classes and Types

Generally, hydraulic motors are placed into one of two classifications; high-speed, low-torque (HSLT) or low-speed, high torque (LSHT).

Gear Motors, Vane Motors, Piston Motor Types

Gear motors come in two variations, the gerotor/geroller also known as (aka) orbital and external spur gear designs. The orbital style motors are classified as LSHT motors; however, there are some that exist with the HSLT classification. They consist of a matched gear set that is enclosed in a housing. When hydraulic fluid is moved into the motor, it causes the gears to rotate. One of these gears is connected to the output shaft, which then produces the motor's rotary motions. The biggest drawback to gear motors is the higher level of noise.

Key features of a gear motor include:

- Low weight and size
- Medium pressures
- Low cost
- Wide range of speeds
- Wide temperature range
- Simple design
- Wide viscosity range

Applications include:

- Mobile hydraulics
- Agriculture machinery (to drive conveyor belts)
- Dispersion plates
- Screw conveyors
- Fans

Vane motors are typically classified as HSLT; however, larger displacements will fall into the LSHT range. Hydraulic fluids enter the motors and are applied to a rectangular vane, which then slides into and out of the center rotor. This center rotor is connected to the main output shaft of the motor. The fluid that is being applied to the vane causes the output shaft to rotate.

Key features include:

- Low noise level
- Low flow pulsation
- Medium pressure
- High-torque at low-speeds
- Simple design
- Easy versatility
- Friendly vertical installation

Applications include:

- Industrial
- Screw-drive
- Injection molding
- Mobile
- Agricultural machinery

Piston motors come in a variety of designs with both the LSHT and HSLT classifications. In-line piston motors are classified as HSLT. Hydraulic fluids enter the motors and are applied to a series of pistons inside a cylinder barrel. The pistons are pressed against a swash-plate, which is at an angle. The pistons push against the angle, which then causes the rotation of the swash-plate, which is mechanically connected to the output shaft of the motor. The swash-plate can be a fixed or variable angle. Variable angle motors can have their displacements adjusted between a maximum and minimum setting. Common signals to change the displacement can be electrical, hydraulic or a combination of both.

Bent-axis piston motors are classified as HSLT. They are similar to inline motors except that the piston barrel is at an angle in relation to the swash-plate. The hydraulic fluid enters the motor and is applied to the piston, which are contained in a cylinder barrel. The pistons are at an angle to the drive shaft, meaning that the piston will rotate the shaft as the fluid enters the motor.

Bent-axis piston motors can be both fixed and variable displacement. In a variable displacement bent-axis motor, the cylinder barrel is rotated between maximum and minimum displacements. The most command signals to change the displacement can be electrical, hydraulic or a combination of both.

Bent-axis motors are known for their high-performance, high-pressures, high-speeds, and volumetric mechanical efficiencies in the 97% to 98% range. They offer a quick reaction time and precise control.

Key features in-line bent-axis include:

- Higher speeds
- Higher efficiency
- Can be fixed or variable displacement
- Multiple controls to adjust displacement
- Wide range of speeds
- High power density

Applications include:

- Drive Mobile and Construction Equipment
- Winches
- Ship-Cranes
- Heavy-Duty Hydraulic Equipment
- Offshore and Onshore Operations

Radial piston motors are LSHT classified. These motors are designed with pistons arranged perpendicular to the output shaft. Typically, the pistons ride against a cam, which is mechanically connected to the output shaft. The pistons force the cam to rotate as hydraulic fluid enters the motor. In general, these motors are a fixed displacement. However, some versions will allow for a variable displacement. They are able to do this by limiting the number of pistons that can receive hydraulic fluid. Other versions change the geometry of the cam the pistons are acting against.

Key feature radial piston motors include:

- Higher output torques
- Lower output speeds
- Smoother output speed at low-speeds (no “cogging”)
- Simplification of system design by reducing or eliminating gearboxes or other mechanical ratios that would need to be used in the system

Motor Selection Considerations

There are many things to consider when selecting a motor for your application. Below is a list of what we feel is important when selecting your hydraulic motor.

- What are the performance needs of the application?
- What is the load and amount of break-away and running torque needed?
- What is the shaft speed and horsepower?
- What is the operating pressure and flow?
- Is displacement fixed or variable?
- What is the operating temperature?
- Is there any leakage potential?
- What noise level can the application handle?
- How reliable is the motor design?
- What type of controls will be used—mechanical or electronic?
- Is ease of installation critical?
- Is ease of maintenance necessary?
- What is the bearing type and expected life?
- What is the expected motor life?
- Is it open or closed loop?
- What kind of contamination potential is there?
- What certifications and approvals are needed?

In Summary:

Remember that proper hydraulic motor selection starts with the expected performance required by the application, then works back to the prime mover – the pump. It is then necessary to evaluate the cost of your motor options with the degree of complexity you want for your overall system. Follow the basic formulas as provided on the following page.

GS Global Resources can assist you in sizing the most efficient accumulator for your application. Download the sizing form from our website and e-mail it back to us sales@gsgr.com

References:
Parker

Retrieved from:
Motor Hydraulic Tips, Mary Gannon https://www.mobilehydraulictips.com/select-the-right-motor-for-your-hydraulic-applications/


Article contributed by Jeanette Cutberth, marketing coordinator for GS Global Resources.

Size Your Motor to It's Given Load

Basic formulas for hydraulic motors

Flow (q)

$$q = \frac{D \times n}{1000 \times \eta_v} \text{ [l/min]}$$

Torque (M)

$$M = \frac{D \times \Delta p \times \eta_{hm}}{63} \text{ [Nm]}$$

Power (P)

$$P = \frac{q \times \Delta p \times \eta_t}{600} \text{ [kW]}$$

D - displacement [cm³/rev]
n - shaft speed [rpm]
η_v - volumetric efficiency
Δp - differential pressure [bar]
(between inlet and outlet)
η_{hm} - mechanical efficiency
η_t - overall efficiency
($\eta_t = \eta_v \times \eta_{hm}$)

Basic formulas for hydraulic pumps

Flow (q)

$$q = \frac{D \times n \times \eta_v}{1000} \text{ [l/min]}$$

Torque (M)

$$M = \frac{D \times \Delta p}{63 \times \eta_{hm}} \text{ [Nm]}$$

Power (P)

$$P = \frac{q \times \Delta p}{600 \times \eta_t} \text{ [kW]}$$

D - displacement [cm³/rev]
n - shaft speed [rpm]
η_v - volumetric efficiency
Δp - differential pressure [bar]
(between inlet and outlet)
η_{hm} - mechanical efficiency
η_t - overall efficiency
($\eta_t = \eta_v \times \eta_{hm}$)

Conversion factors

1 kg	2.20 lb
1 N	0.225 lbf
1 Nm	0.738 lbf ft
1 bar	psi
1 l	0.264 US gallon
1 cm^3	0.061 cu in
1 mm	0.039 in
1°C	$^5/_9$(°F-32)
1 kW	1.34 hp

Conversion factors

1 lb	0.454 kg
1 lbf	4.448 N
1 lbf ft	1.356 Nm
1 psi	0.068948 bar
1 US gallon	3.785 l
1 cu in	16.387 cm^3
1 in	25.4 mm
1°F	$^9/_5$ °C +32
1 hp.	0.7457 kW

To size a hydraulic motor or pump to the design of the machine or application for which it will be used, it is necessary to estimate the required speed, torque, and horsepower. This can require greater knowledge and experience than what is required in selecting an electric motor. If you need assistance GS Global Resources is here to help you.