TENNCO, INC

EXCELLENCE IN FLUID POWER

Fluid Power Formula

SIZING A HYDRAULIC CIRCUIT

THE FOLLOWING INFORMATION MUST BE KNOWN

1. Maximum force required	Usually in pounds or tons offorce
2. Total stroke required	Usually in inches
3. High pressure stroke required	Usually in inches
4. Total cylinder cycle time	Usually in seconds
5. Maximum pressure allowed	Arbitrarily decided by theengineer

SAMPLE PROBLEM

1. Maximum force required	50,000 pounds
2. Total stroke required	42 inches
3. High pressure stroke required	Total cylinder stroke
4. Total cylinder cycle time	10 seconds
5. Maximum pressure allowed	2,000 PSI

A. Minimum Cylinder Bore = $\sqrt{\frac{\text{Maximum Force Required x 1.1 / Maximum PSI Allowed}}{.7854}}$

$\sqrt{\frac{\text{50,000 Pounds x 1.1 / 2,000 PSI}}{.7854}}$ = 5.917" diameter or a 6" Bore

GPM = $\sqrt{\frac{\text{PistonArea (in.}^2\text{) x Stroke (Inches) x 60 Seconds GPM}}{\text{Cycle Time (Seconds) x 231 (Cubic Inches/Gal.)}}}$

GPM = $\sqrt{\frac{28.275 \times 84 \times 60}{10 \times 231}}$ = 61.7 GPM or a 65 GPM pump

84 is for cylinder extend and retract. Rod displacement is disregarded in this example.

C. Electric motor horse power = HP = GPM x PSI x .000583
HP = 65 x 2,000 x .000583 = 75.79 or a 75 HP motor

D. Tank size = 2-3 times pump GPM = 2 x 65 = 130 gallons = 150 gallon tank
3 x 65 = 195 gallons = 200 gallon tank

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On the facing page is an exercise sizing a simple single cylinder hydraulic circuit with straight forward parameters. The example gives basic requirements for sizing a hydraulic cylinder powered machine.

In the real world of circuit design, experience, knowing the process, the environment, the skill of the user, how long will the machine be in service, and other items affect cylinder and power unit choices. Before designing any circuit it is necessary to know several things.

First is force requirement. Usually, the force to do the work is figured with a formula. In instances where there is no known mathematical way to figure force, use a mock up part on a shop press or on a prototype machine for best results. If all else fails, an educated guess may suffice. The sample problem requires a force of 50,000 pounds.

Second, choose a total cylinder stroke. Stroke length is part of machine function and is necessary to figure pump size. Use a stroke of 42 inches in this problem.

Third, how much of the stroke requires full tonnage? If only a small portion of the stroke needs full force, a HI-LO pump circuit and/or a regeneration circuit could reduce first cost and operating cost. This cylinder requires full tonnage for all 42 inches.

Fourth, what is the total cylinder cycle time? Make sure the time used is for cycling the cylinder. Load, unload and dwell are part of the overall cycle time, but should not be included when figuring pump flow. Use a cylinder cycle time of 10 seconds for this problem.

Finally, choose maximum system pressure. This is often a matter of preference of the circuit designer. Standard hydraulic components operate at 3000 PSI maximum, so choose a system pressure at or below this pressure. If a company has operating and maximum pressure specifications, adhere to them. Remember, lower working pressures require larger pumps and valves at high flow to get the desired speed.

On the facing page part A, taking the square root of the maximum thrust, times 110%, for fast pressure buildup, divided by the maximum system PSI, divided by .7854. This gives a minimum cylinder bore of 5.244". Choose a standard 6" diameter cylinder for this system.

To figure pump capacity, take the cylinder piston area in square inches, times the cylinder stroke in inches, times 60 seconds, divided by the cycle time in seconds, times 231 cubic inches per gallon. This shows a minimum pump flow of 61.7 GPM. A 65 GPM pump is the closest flow available. Never undersize the pump since this formula figures the cylinder is going maximum speed the whole stroke. The cylinder must accelerate and decelerate for smooth operation, so travel speed after acceleration and before deceleration should actually be higher than this formula allows.

Figure horsepower by taking GPM times PSI times a constant of .000583. This comes out to 75.79 HP, and is close to a standard 75 HP motor. This should be sufficient horsepower since the system pressure does not have to go to 2000 PSI with the cylinder size used.

The tank size should be at least two to three times pump flow, which is three times sixty-five, or 195 gallons, so a 200 gallon tank is satisfactory. When using single acting cylinders or unusually large piston rods, size the tank for enough oil to satisfy cylinder volume without starving the pump.

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