FLUID POWER
Design Data Sheet

Revised Sheet 52 - Womack Design Data File

SPEED REGULATION OF HYDRAULIC MOTORS- PART 2

In this issue we will continue our study of how speed regulation of a hydraulic motor circuit is a direct measure of the range over which its speed can be varied with acceptable performance. Internal slippage of the motor itself is a very important factor, and was the topic for the preceding issue. The circuit used for speed control is also quite important, and is the topic for this issue.

Remember, that to get as wide an adjustable range of speed as possible for a hydraulic motor, the motor itself must have low internal slippage, the speed control valve (if a pressure compensated type is used), must have low internal slippage, and the best speed control circuit should be selected which is compatible with the components.

Before going into this study, be sure you understand the foundation laid in the previous issue, **Design Data Sheet 51**, on the subject of speed regulation in general.

BY-PASS SPEED CONTROL

Figure 1. The flow control valve is placed to divert the unwanted oil to tank. While this is usually the simplest method of speed control, and tends to produce less heating in the oil than the other methods described, the speed regulation of the total circuit is very poor because slippage in both the pump and the motor contribute to poor regulation. This method should be used only on applications where a very limited range of speed is needed, no greater than a 2:1 range.

A further disadvantage is that only one branch motor circuit can be used on the pump line.

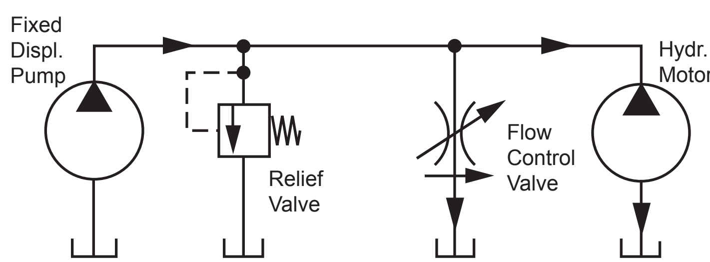

Figure 1. *By-pass method of motor speed control.*

SERIES METER-IN METHOD

Figure 2. When the flow control valve is placed in series between pump and motor, the effect of slippage in the pump is eliminated, leaving motor slippage as the main factor which limits the range of adjustable speed. Overall speed regulation is approximately equal to the regulation of the motor itself. Twice the speed range can be covered successfully as with the by-pass method of **Figure 1**, or roughly about a 4:1 speed range for most applications.

Although oil heating tends to be somewhat greater than in **Figure 1**, several branch motor circuits can be operated from one pump.

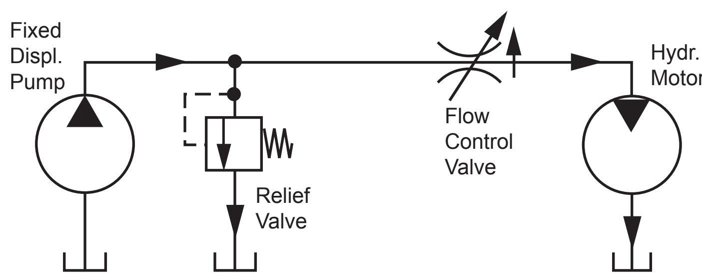

Figure 2. *Series meter-in method of motor speed control.*

THREE-PORT FLOW CONTROL

Figure 3. This circuit uses a special "3-port" flow control valve, and is a combination of the by-pass and series methods.

Speed regulation is about equal to the series circuit of **Figure 2**, and the oil heating is no more than the by-pass circuit of **Figure 1**, since surplus oil, not needed by the motor, is allowed to discharge to tank through the 3rd port of the flow control valve at a pressure only slightly greater than actual load pressure, instead of at relief valve pressure.

Like the by-pass method of **Figure 1**, only one branch motor circuit can be operated from the pump.

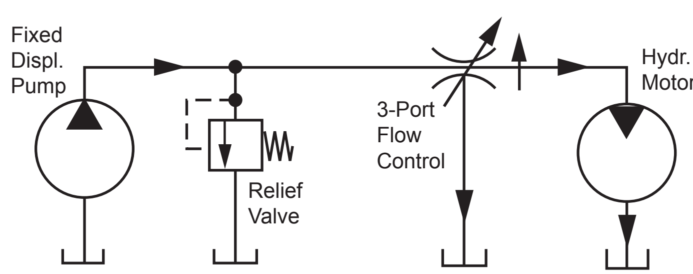

Figure 3. *Three-port flow control method.*

SERIES METER-OUT METHOD

Figure 4. This is the only method which permits a full range of adjustment of motor speed from near zero RPM up to maximum rated motor speed, and which holds speed constant at the selected RPM from zero load up to full load. But this circuit can only be used with selected components.

The motor must be one of the piston types because this is the only type in which the internal slippage can be drained out without coming out of the motor outlet port. Motor speed is in direct proportion to the oil coming from the outlet (not the flow entering the inlet). If, then, the flow control valve is placed in the motor outlet, speed will not vary from no load to full load. Inlet flow and slippage will increase with loading, but outlet flow will remain constant and can be accurately metered regardless of load.

The pump can be any type but the best results, with minimum oil heating are obtained with a variable displacement piston pump with pressure compensator. It must produce more than enough flow to take care of working oil plus slippage oil in the motor under all conditions of loading and speed.

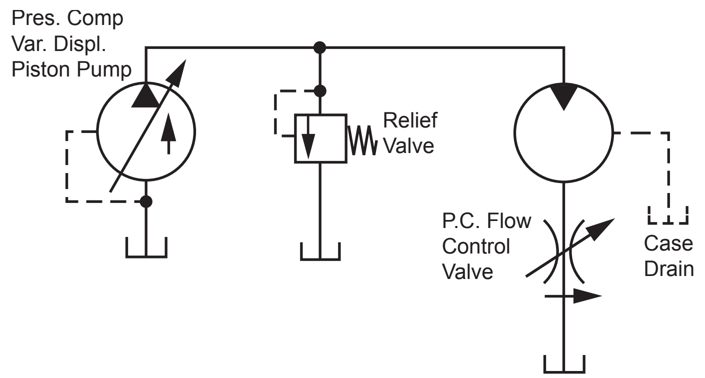

Figure 4. *Series meter-out speed control gives best speed regulation.*

RECOMMENDATIONS FOR INCREASING SPEED RANGE BY IMPROVING SPEED REGULATION

1. Select a motor which has a maximum continuous speed rating no higher than the top speed in the range you wish to cover. Do not use a motor which has extra displacement, more than needed to get your top speed. The use of an over-capacity motor will cause speed regulation and performance to be poor at the low end of your speed range.
2. After estimating the lowest motor speed at which motor performance is acceptable, if the speed range is not wide enough for the application, it can be extended on the upper end, by going into the intermittent speed range as shown in **Figure 5**.

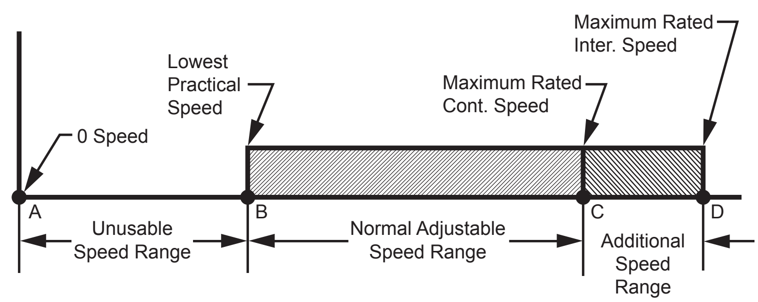

Figure 5. *The adjustable speed range of a hydraulic motor can be extended by operating it into its rated intermittent speed range.*

Figure 5. Speeds between Point A (zero RPM) and Point B are unusable because motor performance is unacceptable. So the speed range cannot be extended downward. In the speed range between Points B and C motor performance is acceptable. For a wider speed range, the motor can be operated up in the intermittent speed range, up to Point D. However, prolonged operation in this area will reduce life expectancy. Efficiency will be poor because of increased porting losses, and these losses may overheat the system.

3. Since internal slippage is greater when operating at high pressure, better speed regulation and a wider range of speed can sometimes be achieved by selecting a different motor model one which will produce the same horsepower but at a lower pressure with a higher oil flow.
4. Place the speed control valve in series between the pump and the motor, as in **Figures 2** or **3**, or in series with the motor outlet as in **Figure 4** if a piston motor is used.
5. In a given frame size, particularly with gear-type or vane-type motors, the model with highest displacement will usually cover the widest speed range. For example: if a certain motor is offered in a number of displacements from 0.5 to 2.0 C.I.R. (cubic inches per revolution), it is likely that the 2.0 C.I.R. model will have better speed regulation and will therefore cover a wider speed range. Although the larger displacement model will have a larger slippage volume, the percentage of slippage in relation to total displacement will be less, and it will produce the same horsepower while operating at a lower pressure.

MORE INFORMATION

This matter of motor speed regulation and speed range is covered in much greater detail in the book “***Industrial Fluid Power - Volume 3***” available from **Womack Educational Publications**.

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