Understanding hydraulic load sensing control

Load sensing is a term used to describe a type of pump control employed in open circuits. It is so called because the load-induced pressure downstream of an orifice is sensed and pump flow adjusted to maintain a constant pressure drop (and therefore flow) across the orifice. The 'orifice' is usually a directional control valve with proportional flow characteristics, but a needle valve or even a fixed orifice can be used, depending on the application.

A load sensing circuit typically comprises a variable displacement pump, usually axial-piston design, fitted with a load sensing controller, and a directional control valve with an integral load-signal gallery (Exhibit 1). The load-signal gallery (LS, shown in red) is connected to the load-signal port (X) on the pump controller. The load-signal gallery in the directional control valve connects the A and B ports of each of the control valve sections through a series of shuttle valves. This ensures that the actuator with the highest load pressure is sensed and fed back to the pump.



Exhibit 1. Typical load sensing circuit.

To understand how the load-sensing pump and directional control valve function together in operation, consider a winch being driven through a manually actuated valve. The operator summons the winch by moving the spool in the directional valve 20% of its stroke. The winch drum turns at five rpm. For clarity, imagine that the directional valve is now a fixed orifice. Flow across an orifice decreases as the pressure drop across it decreases. As load on the winch increases, the load-induced pressure downstream of the orifice (directional valve) increases. This decreases the pressure drop across the orifice, which means flow across the orifice decreases and the winch slows down.

In a load sensing circuit, the load-induced pressure downstream of the orifice (directional valve) is fed back to the pump via the load-signal gallery in the directional control valve. The load-sensing controller responds to the increase in load pressure by increasing pump displacement (flow) slightly so that pressure upstream of the orifice increases by a corresponding amount. This keeps the pressure drop across the orifice (directional valve) constant, which keeps flow constant and in this case, winch speed constant. The value of the pressure drop or delta P maintained across the orifice (directional valve) is typically 10 to 30 Bar (145 to 435 PSI). When all spools are in the

center position the load-signal port is vented to tank and the pump maintains 'standby' pressure equal to or slightly higher than the load sensing controller's delta P setting.

Because the pump always receives the load signal from the function operating at the highest pressure, high-end load sensing directional control valves feature a pressure compensator (not shown) at the pressure inlet to each section. The section pressure compensator works with the spool-selected orifice opening to maintain a constant flow, independent of the pressure variations caused by the operation of multiple functions at the same time. This is sometimes referred to as 'sensitive load sensing'.

A load sensing pump only produces the flow demanded by the actuators - this makes it energy efficient (fewer losses to heat) and as demonstrated in the above example, provides more precise control. Load-sensing control also provides constant flow independent of pump shaft speed variations. If pump drive speed decreases, the load-sensing controller will increase displacement (flow) to maintain the set delta P across the directional control valve (orifice), until maximum displacement is reached.

Load sensing pump controls usually incorporate a pressure limiting control, also referred to as a pressure cut-off or pressure compensator. The pressure compensator limits maximum operating pressure by reducing pump displacement to zero when the set pressure is reached.