Glossary

Open-center System/Closed-center System

Refer to Development of Control Valve KVSX-12C for Small Size Excavators (page 46)

FUKUSHIMA Ryo
Valve Design Sect., Ueda Engineering Dept., Hydraulic Components Operations

1 Open-center System

1.1 What is the Open-center System?

The open-center system consists of a bleed-off circuit, a meter-in circuit, and a meter-out circuit (Fig. 1). The bleed-off circuit controls the flow of oil from the pump to the tank. The meter-in circuit controls the flow of oil from the pump to the actuator. The meter-out circuit controls the flow of oil from the actuator to the tank.

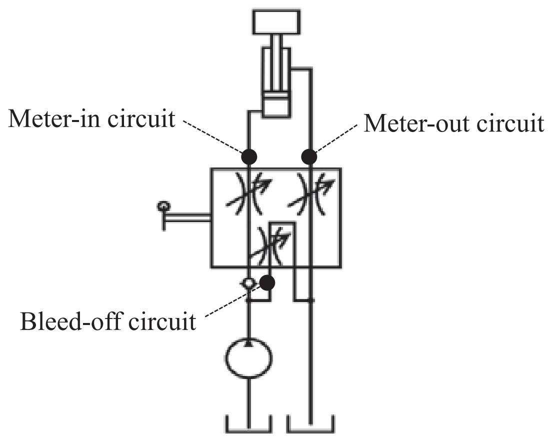

Fig. 1 Open-center system circuits

When the spool is in the neutral position, the bleed-off circuit is open while the meter-in and meter-out circuits are closed. The actuator is disabled in this condition.

Switching the spool position with a control lever closes the bleed-off circuit and opens the meter-in and meter-out circuits, operating the actuator.

1.2 Features of Open-center System

With a constant discharge from the pump, when the actuator load has any pressure variation, the distribution ratio between the bleed-off and meter-in circuits changes, affecting the supply flow to the actuator. In other words, if the actuator load has pressure variation even with the control lever held in a fixed position, the actuator speed changes (Fig. 2).

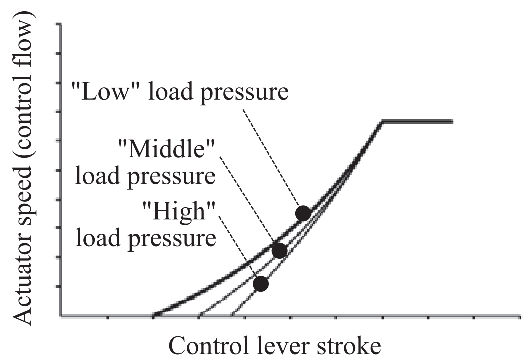

Fig. 2 Relationship between control lever stroke and actuator speed

This can be expressed by the orifice flow equation $Q = C\ A\ \sqrt{\Delta P}$ (Q: Flow rate, C: Capacity coefficient, A: Orifice area, ΔP: ¬Pressure difference). ΔP indicates the pressure difference over the meter-in orifice. To follow the pressure variation of the actuator load, the flow rate to the actuator Q changes.

If you were to compare this system to driving a car, your car slows down on a slope even if you keep pressing the accelerator to a certain depth.

1.3 Types of Open-center System

Small excavators are usually used in combination with a fixed displacement pump that discharges fluid at a fixed flow rate all the time. Medium-sized excavators in turn are generally combined with a variable displacement pump that discharges a given flow of fluid according to input signals. For the open-center system combined with a variable displacement pump, the system can be controlled in two different ways. One is negative control for which an orifice is provided downstream from the bleed-off circuit to feedback the downstream pressure to the pump in order to control the discharge flow. The other is positive control for which a signal (pressure or current value) corresponding to the spool actuating variable is fed back to the pump to control the discharge pressure.

The both systems are of energy-saving type that can minimize the pump discharge according to the actuating variable.

2 Closed-center System

2.1 What is the Closed-center System?

A typical circuit of closed-center system is a load-sensing system.

Unlike the open-center system, the load-sensing system has no bleed-off circuit. It mainly consists of a meter-in circuit and a meter-out circuit and is combined with a variable displacement pump (Fig. 3).

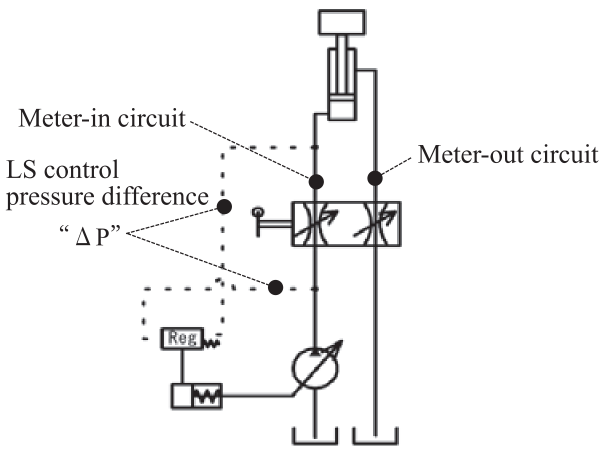

Fig. 3 Load-sensing system circuits

When the spool is in the neutral position, the meter-in and meter-out circuits are closed, disabling the actuator. In this case, the pump discharges fluid at a stand-by flow rate to the tank via an unload valve and other devices.

Switching the spool position with a control lever will close the unload valve and open the meter-in and meter-out circuits, operating the actuator. Thus, the pressure of the actuator load is fed back to the pump so that the pressure difference over the meter-in orifice ΔP is constant, controlling the discharge flow. This ΔP is defined as the LS control pressure difference.

2.2 Features of Load-sensing System

The flow rate of fluid supply to the actuator does not change even if the actuator load has pressure variation. In other words, if the actuator load has pressure variation even with the control lever held in a fixed position, the actuator speed does not change (Fig. 4).

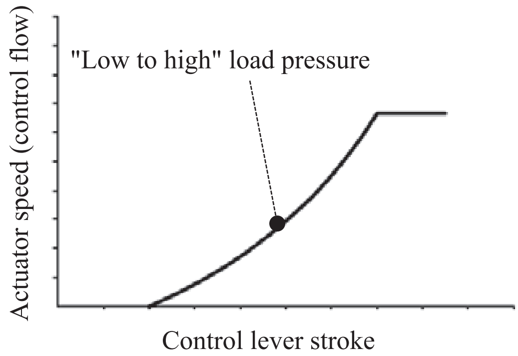

Fig. 4 Relationship between control lever stroke and actuator speed

This can be expressed by the orifice flow equation $Q = C A\sqrt{\Delta P}$. ΔP indicates the pressure difference over the meter-in orifice. Since the load-sensing system has a constant ΔP, the flow rate Q does not change.

2.3 Trend of Load-sensing System

The load-sensing system is of energy-saving type that can minimize the pump discharge according to the actuating variable and is in increasing demand mainly for small excavators.

With its features of being independent of any pressure variation of the actuator load and having a reliable flow control according to the actuating variable, the demand for the load-sensing system has recently grown not only for excavators but also for hydraulic systems for automation.