UNIT 3

Hydrostatic Systems

Introduction

Hydrostatic systems have been in use for many years. The water wheel on a mill takes the power created by the flow and the weight of water to create the mechanical energy to drive the mill. Hydrostatic systems are defined as using a hydraulic source of power (water) to rotate a source of output power (the waterwheel) converting that output into mechanical energy.

The modern hydrostatic systems take the mechanical rotary output power of an engine or electric motor and convert it to a hydraulic source of power using a pump. The hydraulic power is converted back to mechanical power using a motor. This mechanical power is used to drive a fan, a transmission, final drives, a differential or a pump.

Hydrostatic fan drive systems can either send pump flow directly to the motor or share the pump flow with other machine systems such as brakes. Additional valving is required to control the division of the pump flow when the pump output flow is shared.

Hydrostatic drive systems propel the machines using pumps and motors. Most hydrostatic drive systems are closed loop systems. Some hydrostatic drive systems are open loop systems that use spool type control valves to direct the pump flow and return the motor outlet oil to the tank.

Dual hydrostatic drive systems have separate pump and motor combinations for each side of the machine. The right and left side systems share the control systems for the pump and motor to regulate the speed and direction of machine movement. The right and left systems have separate controls to facilitate turning the machine.

Unit Objectives:

At the completion of this unit each student will be able to:

1. Identify the differences between open loop and closed loop hydrostatic drive systems.
2. Identify the differences between fixed and variable pumps and motors, the difference between mono-directional and bi-directional pumps and motors and the effects of various combinations of these.
3. Identify all components in a Hydrostatic Fan Drive and, using the procedures in the Service Manual, test and adjust the fan drive.
4. Identify all components in a single hydrostatic drive system and, using procedures in the Service Manual, test and adjust the hydrostatic drive system.
5. Identify all shared control components in a dual hydrostatic drive system.
6. Trace the oil flow through each of the various systems in each operation mode (Park, brakes off, full forward, right turn, low speed, high speed, etc.).

Lesson 1: Basic Hydrostatic Systems

Introduction

The basic hydrostatic systems described in this lesson will show how the various types of pumps, motors and systems are used to convert mechanical power to hydraulic power and then back to mechanical power. The information in this lesson will allow students to understand the basic hydrostatic systems used on a large variety of machines.

Objectives

Upon completion of this lesson, the student will be able to:

1. Identify the difference between open loop and closed loop hydrostatic systems.
2. Identify the various combinations of fixed and variable pumps, mono-directional and bi-directional pumps, fixed and variable motors, and mono-directional and bi-directional motors.
3. State the applications of the various systems.

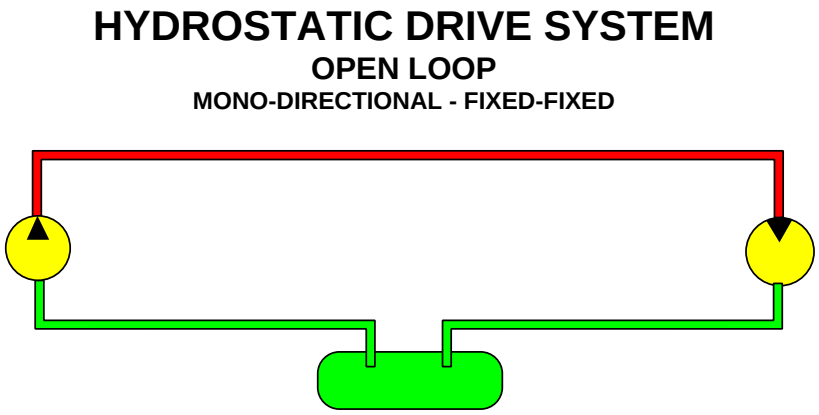

Fig. 3.1.1 Open Loop, Mono-directional, Fixed Pump and Fixed Motor Hydrostatic System

OPEN LOOP HYDROSTATIC SYSTEM

An open loop hydrostatic system is one in which the pump inlet oil is completely drawn from the hydraulic tank, the pump output oil is sent to drive the hydraulic motor, and the return oil from the motor flows to the tank. The return oil may be directed through a cooler and/or a filter before returning to the tank. The open loop, mono-directional, fixed pump and mono-directional, fixed motor combination shown in Fig. 3.1.1 is often used in hydrostatic fan drives.

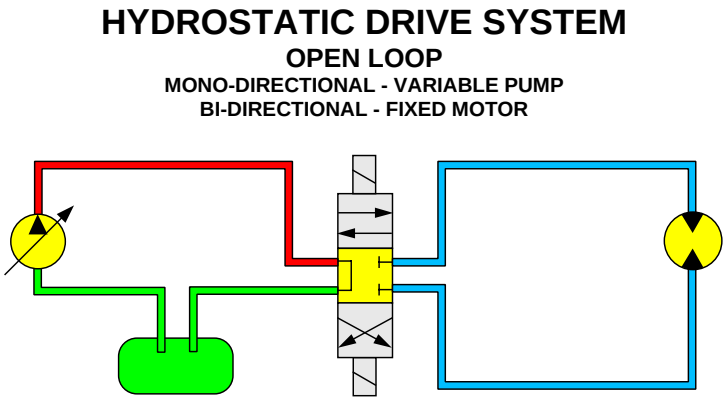

Fig. 3.1.2 Open Loop, Mono-directional, Variable Pump and Bi-directional, Fixed Motor Hydrostatic System

Open Loop Hydrostatic System with Directional Control Valve.

Another type of open loop hydrostatic system uses a directional control valve to direct mono-directional pump flow to a bi-directional motor. The directional control valve allows the motor to be propelled either clockwise or counterclockwise by a mono-directional pump. The open loop, mono-directional, variable pump and bi-directional, fixed motor hydrostatic system shown in Fig. 3.1.2 is used in the hydrostatic drive system of many excavators.

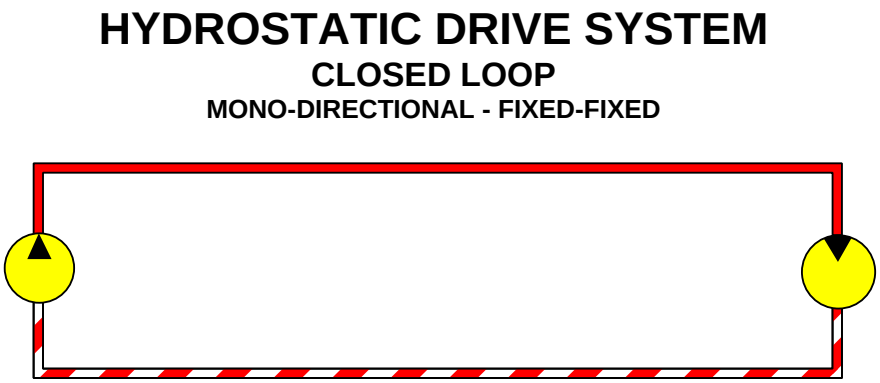

Fig. 3.1.3 Closed Loop, Mono-Directional, Fixed Pump and Fixed Motor Hydrostatic System

Closed Loop Hydrostatic System with Fixed Pump and Fixed Motor

A closed loop hydrostatic system is one in which the return oil from the motor is sent directly to the pump inlet. This system is used to drive a motor in one direction at a speed that is determined by the speed of rotation of the pump. The closed loop, mono-directional, fixed pump and fixed motor hydrostatic system in Fig. 3.1.3 is used primarily in industrial applications.

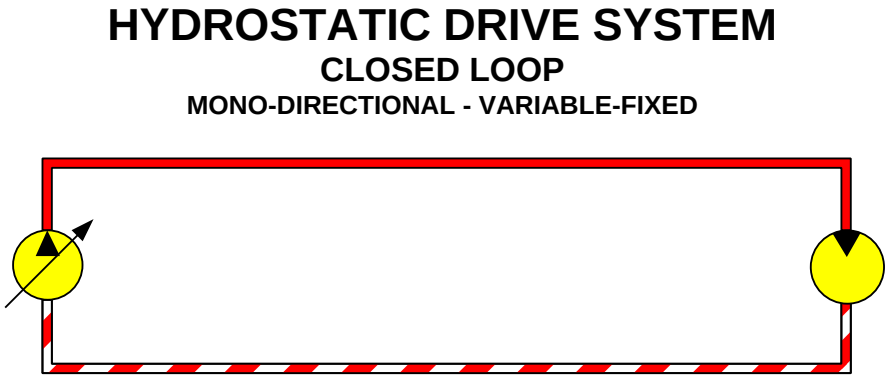

Fig. 3.1.4 Closed Loop, Mono-Directional, Variable Pump and Fixed Motor Hydrostatic System

Closed Loop Hydrostatic System Using Variable Pump and Fixed Motor

The closed loop, mono-directional, variable speed hydrostatic system is used when the pump is driven at a constant speed by a fixed rpm input but a variable motor output is desired. The speed of the motor output in this system is controlled by the swashplate angle of the pump upstroking or destroking. The closed loop, mono-directional, variable pump and fixed motor hydrostatic system in Fig. 3.1.4 can be used in applications where the motor output speed is controlled.

This hydrostatic system can be used on the fan drive system of earthmoving machines by controlling the swashplate angle with a thermostat. This reduces the fan speed when the oil is cool and increases the fan speed as the oil temperature increases.

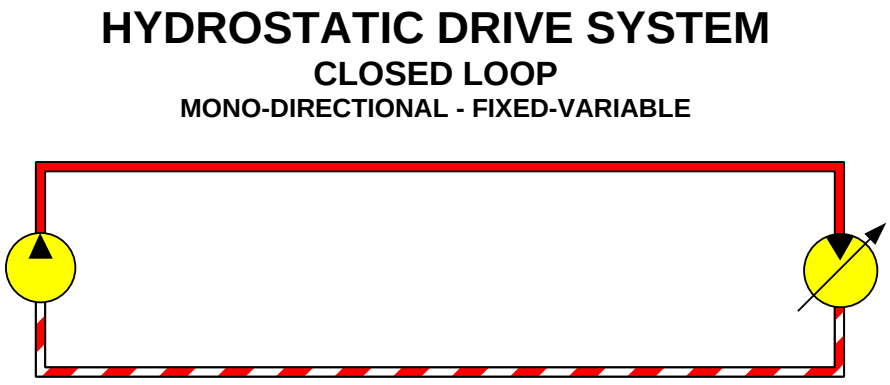

Fig. 3.1.5 Closed Loop, Mono-Directional, Fixed Pump and Variable Motor Hydrostatic System

Closed Loop Hydrostatic System using Fixed Pump and Variable Motor

A variation of the closed loop, mono-directional variable speed hydrostatic system would be to use a fixed pump with a variable motor. Where the system shown in Fig. 3.1.4 would require the pump to upstroke to increase the speed of the motor, the closed loop, mono-directional, fixed pump and variable motor hydrostatic system in Fig. 3.1.5 would require the motor to de-stroke to increase the speed of the motor.

HYDROSTATIC DRIVE SYSTEM

CLOSED LOOP

BI-DIRECTIONAL - VARIABLE-FIXED

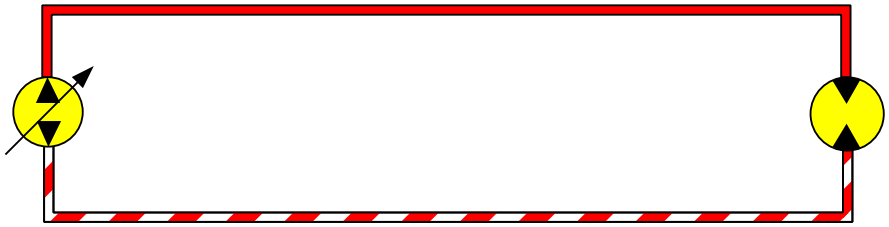

Fig. 3.1.6 Closed Loop Bi-directional, Variable Pump and Bi-directional, Fixed Motor Hydrostatic System

Closed Loop Hydrostatic System Using Bi-directional, Variable Pump and Bi-directional, Fixed Motor.

A closed loop, bi-directional variable pump and bi-directional fixed motor hydrostatic system requires the pump to allow the swashplate to go "over center."

Going "over center" means that the swashplate can tilt in either direction from zero angle. Zero angle means that the swashplate is parallel to the face of the barrel. Bi-directional pumps can tilt clockwise to a given angle (i.e. 17°), then travel through zero angle to tilt counterclockwise to a give angle (i.e. 17°).

The bi-directional, variable pump rotates in only one direction. The movement of the swashplate going "over center" changes the pump inlet port to the output port. At the same time, it changes the pump outlet port to an inlet port. These changes reverse the rotation direction of the motor in a closed loop hydrostatic system. This makes the system output bi-directional.

The closed loop, bi-directional, variable pump and bi-directional fixed motor combination in Fig. 3.1.6 is used in applications that propel machines at infinitely variable speeds in both forward and reverse directions.

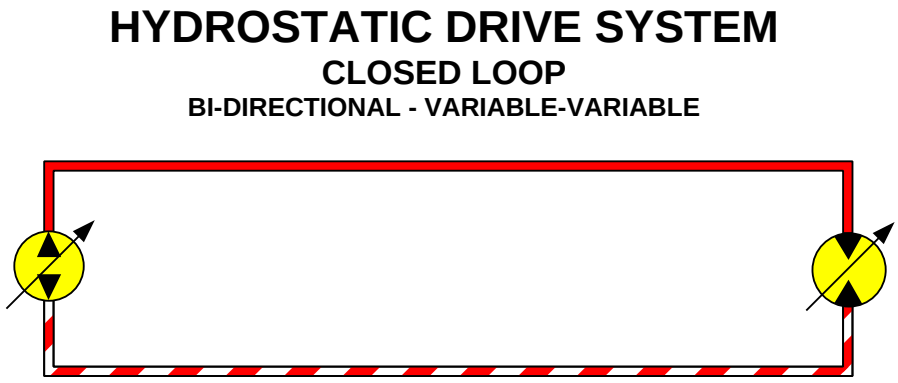

Fig. 3.1.7 Closed Loop, Bi-directional, Variable Pump and Bi-directional, Variable Motor Hydrostatic System

Closed Loop Hydrostatic System Using Bi-directional, Variable Pump and Bi-directional, Variable Motor.

A closed loop, bi-directional hydrostatic system with bi-directional, variable pump and bi-directional, variable motor allows the use of a smaller pump and a smaller motor to achieve the same motor maximum output speed as the system shown in Fig. 3.1.6. The system shown in Fig. 3.1.7 also has the advantage of being able to keep the motor at maximum angle in the work mode for maximum drive torque and then stroke the motor toward minimum angle for higher speed when traveling. Variable speed, bi-directional motors do not go "over center" to reverse the direction of rotation. The direction of rotation of a bi-directional motor is determined by the motor port that receives supply oil. The system shown in Fig. 3.1.7 is the hydrostatic drive systems that propel many of today's earthmoving machines.