



# Fluid Power (Part 2) - Hydraulic Power Units

An Online Continuing Education Course for Engineers

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# Fluid Power (Part 2) - Hydraulic Power Units

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## CHAPTER 1: PUMPS

Pumps are used for some essential services. Pumps supply water to the boilers, draw condensation from the condensers, supply sea water to the firemain, circulate cooling water for coolers and condensers, pump out bilges, transfer fuel, supply water to the distilling plants, and serve many other purposes. Although the pumps discussed in this chapter are used primarily in hydraulic systems, the principles of operation apply as well to the pumps used in other systems.

### PURPOSE

The purpose of a hydraulic pump is to supply a flow of fluid to a hydraulic system. The pump does not create system pressure, since pressure can be created only by a resistance to the flow. As the pump provides flow, it transmits a force to the fluid. As the fluid flow encounters resistance, this force is changed into a pressure. Resistance to flow is the result of a restriction or obstruction in the path of the flow. This restriction is normally the work accomplished by the hydraulic system, but can also be restrictions of lines, fittings, and valves within the system. Thus, the pressure is controlled by the load imposed on the system or the action of a pressure-regulating device.

### OPERATION

A pump must have a continuous supply of fluid available to the inlet port to supply fluid to the system. As the pump forces fluid through the outlet port, a partial vacuum or low-pressure area is created at the inlet port. When the pressure at the inlet port of the pump is lower than the local atmospheric pressure, atmospheric pressure acting on the fluid in the reservoir forces the fluid into the pump's inlet. If the pump is located at a level lower than the reservoir, the force of gravity supplements atmospheric pressure on the reservoir. Aircraft and missiles that operate at high altitudes are equipped with pressurized hydraulic reservoirs to compensate for low atmospheric pressure encountered at high altitudes.

### PERFORMANCE

Pumps are normally rated by their volumetric output and pressure. Volumetric output is the amount of fluid a pump can deliver to its outlet port in a certain period of time at a given speed. Volumetric output is usually expressed in gallons per minute (gpm). Since changes in pump speed affect volumetric output, some pumps are rated by their displacement. Pump displacement is the amount of fluid the pump can deliver per cycle. Since most pumps use a rotary drive, displacement is usually expressed in terms of cubic inches per revolution.

As we stated previously, a pump does not create pressure. However, the pressure developed by the restrictions in the system is a factor that affects the volumetric output of the pump. As the system pressure increases, the volumetric output decreases. This drop in volumetric output is the result of an increase in the amount of internal leakage from the outlet side to the inlet side of the pump. This leakage is referred to as pump slippage and is a factor that must be considered in all pumps. This explains why most pumps are rated in terms of volumetric output at a given pressure.

## **CLASSIFICATION OF PUMPS**

Many different methods are used to classify pumps. Terms such as nonpositive displacement, positive displacement, fixed displacement, variable displacement, fixed delivery, variable delivery, constant volume, and others are used to describe pumps. The first two of these terms describe the fundamental division of pumps; that is, all pumps are either nonpositive displacement or positive displacement.

Basically, pumps that discharge liquid in a continuous flow are referred to as nonpositive displacement, and those that discharge volumes separated by a period of no discharge are referred to as positive displacement.

Although the nonpositive-displacement pump normally produces a continuous flow, it does not provide a positive seal against slippage; therefore, the output of the pump varies as system pressure varies. In other words, the volume of fluid delivered for each cycle depends on the resistance to the flow. This type of pump produces a force on the fluid that is constant for each particular speed of the pump. Resistance in the discharge line produces a force in a direction opposite the direction of the force produced by the pump. When these forces are equal, the fluid is in a state of equilibrium and does not flow.

If the outlet of a nonpositive-displacement pump is completely closed, the discharge pressure will increase to the maximum for that particular pump at a specific speed. Nothing more will happen except that the pump will churn the fluid and produce heat.

In contrast to the nonpositive-displacement pump, the positive-displacement pump provides a positive internal seal against slippage. Therefore, this type of pump delivers a definite volume of fluid for each cycle of pump operation, regardless of the resistance offered, provided the capacity of the power unit driving the pump is not exceeded. If the outlet of a positive-displacement pump were completely closed, the pressure would instantaneously increase to the point at which the unit driving the pump would stall or something would break.

Positive-displacement pumps are further classified as fixed displacement or variable displacement. The fixed-displacement pump delivers the same amount of fluid on each cycle. The output volume can be changed only by changing the speed of the pump. When a pump of this type is used in a hydraulic system, a pressure regulator (unloading valve) must be incorporated in the system. A pressure regulator or unloading valve is used in a hydraulic system to control the amount of pressure in the system and to unload or relieve the pump when the desired pressure is reached. This action of a pressure regulator keeps the pump from working

against a load when the hydraulic system is at maximum pressure and not functioning. During this time the pressure regulator bypasses the fluid from the pump back to the reservoir. The pump continues to deliver a fixed volume of fluid during each cycle. Such terms as fixed delivery, constant delivery, and constant volume are all used to identify the fixed-displacement pump.

The variable-displacement pump is constructed so that the displacement per cycle can be varied. The displacement is varied through the use of an internal controlling device. Some of these controlling devices are described later in this chapter.

Pumps may also be classified according to the specific design used to create the flow of fluid. Practically all hydraulic pumps fall within three design classifications: centrifugal, rotary, and reciprocating. The use of centrifugal pumps in hydraulics is limited and will not be discussed in this text.

## **ROTARY PUMPS**

All rotary pumps have rotating parts which trap the fluid at the inlet (suction) port and force it through the discharge port into the system. Gears, screws, lobes, and vanes are commonly used to move the fluid. Rotary pumps are positive displacement of the fixed displacement type.

Rotary pumps are designed with very small clearances between rotating parts and stationary parts to minimize slippage from the discharge side back to the suction side. They are designed to operate at relatively moderate speeds. Operating at high speeds causes erosion and excessive wear which results in increased clearances.

There are numerous types of rotary pumps and various methods of classification. They may be classified by the shaft position—either vertically or horizontally mounted; the type of drive—electric motor, gasoline engine, and so forth; their manufacturer's name; or their service application. However, classification of rotary pumps is generally made according to the type of rotating element. A few of the most common types of rotary pumps are discussed in the following paragraphs.

## **GEAR PUMPS**

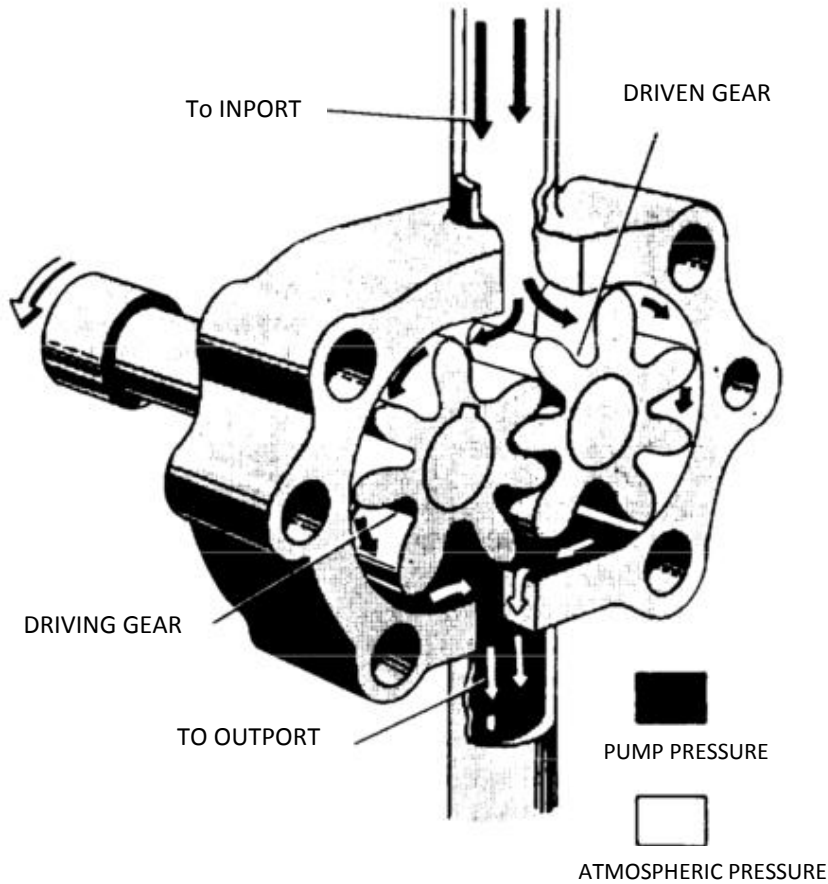
Gear pumps are classified as either external or internal gear pumps. In external gear pumps the teeth of both gears project outward from their centers (fig 1-1). External pumps may use spur gears, herringbone gears, or helical gears to move the fluid. In an internal gear pump, the teeth of one gear project outward, but the teeth of the other gear project inward toward the center of the pump (fig. 1-2, view A). Internal gear pumps may be either centered or off-centered.

## **SPUR GEAR PUMP**

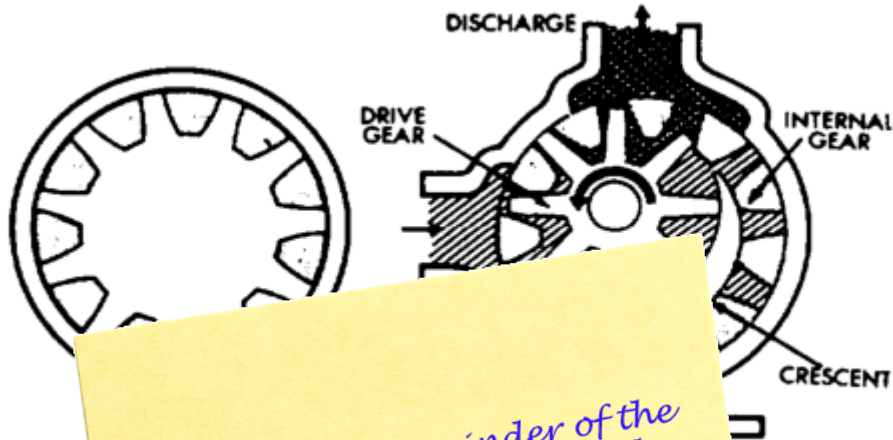
The spur gear pump (fig. 1-1) consists of two meshed gears which revolve in a housing. The drive gear in the illustration is turned by a drive shaft which is attached to the power source. The

clearances between the gear teeth as they mesh and between the teeth and the pump housing are very small.

The inlet port is connected to the fluid supply line, and the outlet port is connected to the pressure line. In figure 1-1 the drive gear is turning in a counterclockwise direction, and the driven (idle) gear is turning in a clockwise direction. As the teeth pass the inlet port, liquid is trapped between the teeth and the housing.



*Figure 1-1.—Gear-type rotary pump.*



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This liquid is carried a between the teeth is pu into the system. A shea the power source or rec parts.

mesh again, the liquid positive flow of liquid shaft. This is to protect the load or jamming of

### **HERRINGBONE GE**

The herringbone gear pu pumped in the same mar set of teeth begins its flu discharge phase. This overlapping and the relatively larger space at the center of the gears tend to minimize pulsations and give a steadier flow than the spur gear pump.

up. The liquid is in the herringbone pump, each set of teeth has completed its discharge phase. This overlapping and the relatively larger space at the center of the gears tend to minimize pulsations and give a steadier flow than the spur gear pump.