Pumps - Types and Selection

An Online Continuing Education Course for Engineers

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Pumps – Centrifugal vs. Positive Displacement

Two Categories – Kinetic (Centrifugal) and Positive Displacement

There are two main categories of pumps - kinetic and positive displacement. Almost all pumps fall into one of these two categories. The main difference between kinetic and positive displacement pumps lies in the method of fluid transfer. A kinetic pump imparts velocity energy to the fluid, which is converted to pressure energy upon exiting the pump casing. A positive displacement pump moves a fixed volume of fluid within the pump casing by applying a force to moveable boundaries containing the fluid volume.

Kinetic pumps can be further divided into two categories of pumps – centrifugal and special effect. Special effect pumps include jet pumps, reversible centrifugal, gas lift, electromagnetic and hydraulic ram. Special effect pumps are not commonly used relative to centrifugal pumps, so they will not be covered in this course.

Positive displacement pumps are also divided into two major pump categories – reciprocating and rotary. Reciprocating pumps transfer a volume of fluid by a crankshaft, eccentric cam or an alternating fluid pressure acting on a piston, plunger or a diaphragm in a reciprocating motion. Rotary pumps operate by transferring a volume of fluid in cavities located between rotating and stationary components inside the pump casing. The relative features of reciprocating and rotary pumps, as well as centrifugal pumps, will be covered in this course.

Figure 1 below shows the major pump categories and the types of pumps within each category.

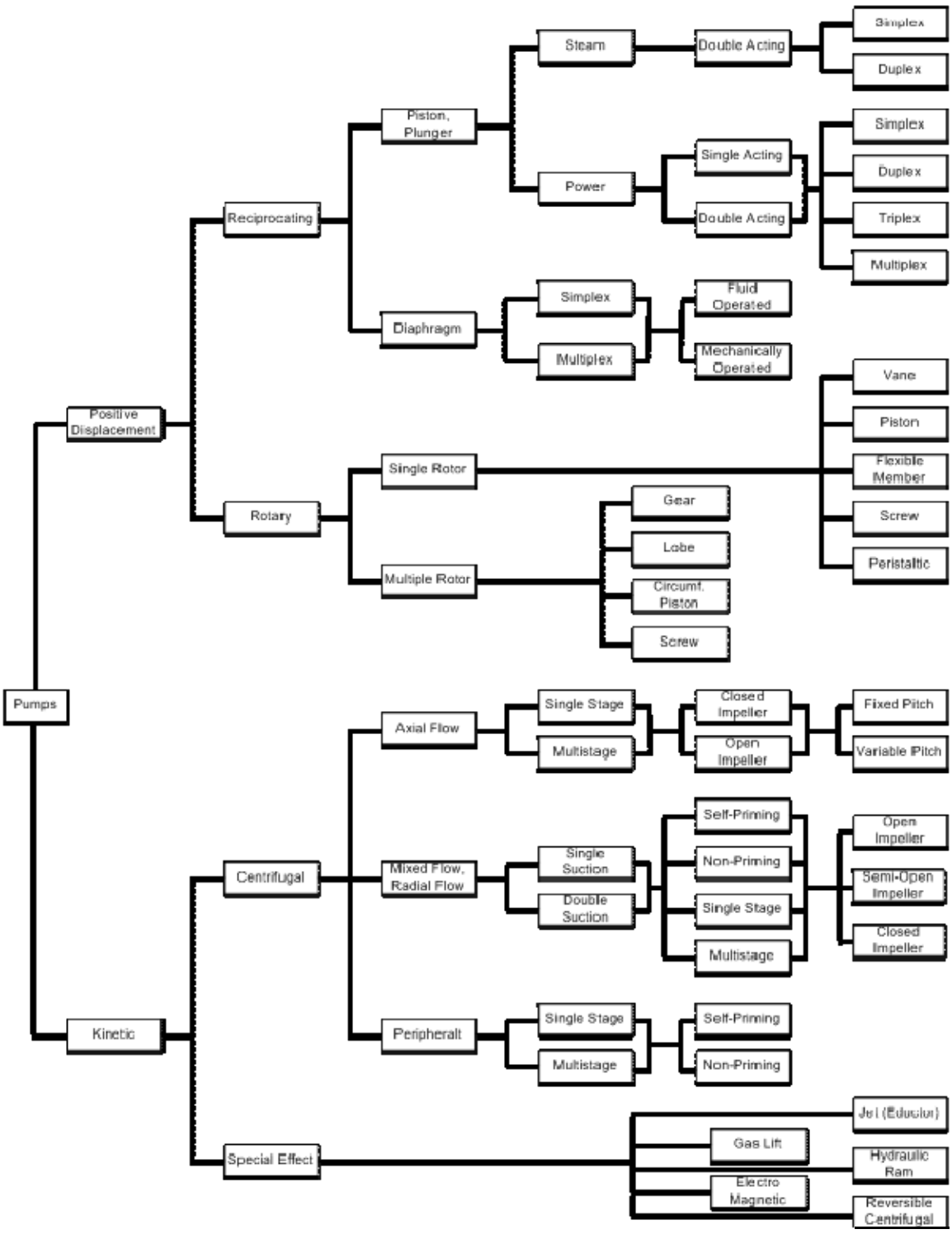

Figure 1 – Major Pump Categories

Comparison Table – Centrifugal vs. Positive Displacement Pumps

Table 1 below outlines some of the main differences between centrifugal pumps, reciprocating pumps and rotary pumps. Note that "centrifugal", "reciprocating" and "rotary" pumps are all relatively broad categories. The table below provides a comparison of features between these pump categories that generally holds true. However, there are exceptions. For example, reciprocating pumps generally require more space than centrifugal pumps for a given flow rate. But, there may be specific applications where a positive displacement pump requires less space relative to a centrifugal pump. Also, note that Table 1 lists typical maximum flow rates and heads. It is possible to build special pumps outside the upper bounds of the pressures and flow rates listed, but such pumps would be prohibitively expensive for most applications.

Parameter	Centrifugal Pumps	Reciprocating Pumps	Rotary Pumps
Optimum Flow and Pressure Applications	Medium/High Capacity, Low/Medium Pressure	Low Capacity, High Pressure	Low/Medium Capacity, Low/Medium Pressure
Maximum Flow Rate	100,000+ GPM	10,000+ GPM	10,000+ GPM
Low Flow Rate Capability	No	Yes	Yes
Maximum Pressure	6,000+ PSI	100,000+ PSI	4,000+ PSI
Requires Relief Valve	No	Yes	Yes
Smooth or Pulsating Flow	Smooth	Pulsating	Smooth
Variable or Constant Flow	Variable	Constant	Constant
Self-priming	No	Yes	Yes
Space Considerations	Requires Less Space	Requires More Space	Requires Less Space
Costs	Lower Initial Lower Maintenance Higher Power	Higher Initial Higher Maintenance Lower Power	Lower Initial Lower Maintenance Lower Power
Fluid Handling	Suitable for a wide range including clean, clear, non-abrasive fluids to fluids with abrasive, high-solid content.	Suitable for clean, clear, non-abrasive fluids. Specially-fitted pumps suitable for abrasive-slurry service.	Requires clean, clear, non-abrasive fluid due to close tolerances

	Not suitable for high viscosity fluids	Suitable for high viscosity fluids	Optimum performance with high viscosity fluids
	Lower tolerance for entrained gases	Higher tolerance for entrained gases	Higher tolerance for entrained gases

Table 1 – Comparison Table

Capacity

The wide variety of centrifugal pumps manufactured offer a relatively large range of available capacities. Radial-flow and mixed flow pumps are used for low to medium capacity applications. For high capacity applications, axial-flow pumps are capable of delivering flow rates in excess of 100,000 gpm. Centrifugal pumps are not stable at low flow rates, although there are special low-flow centrifugal pumps available that can deliver flow rates less than 10 gpm. However, for extreme low-flow applications (< 1 gpm), positive displacement pumps are a better selection.

Reciprocating and rotary pumps are capable of capacities ranging from low to medium, with flow rates peaking at 10,000+ gpm. In theory, reciprocating pumps can be manufactured to deliver more capacity, but they become prohibitively large and expensive at high flow rates. Both reciprocating and rotary pumps are capable of delivering product at extremely low flow rates (fractions of a gpm), making them particularly suitable for many chemical injection applications.

Pressure

Centrifugal pumps and rotary pumps are best suited for low to medium pressure applications. Reciprocating pumps are usually specified for high pressure service, with

capabilities exceeding 100,000 psi. Multi-stage centrifugal pumps can deliver at pressures of 6,000+ psi and may be the most economical choice at this pressure in high capacity applications. But, in most applications exceeding 1,000 psig, reciprocating pumps are more suitable, particularly in low to medium capacity service. Both reciprocating and rotary pumps will continually increase pressure when pumping against a closed discharge to the extent allowed by the driver's horsepower. This can result in overpressure of the pump or piping components, so it is necessary to install a relief valve on the discharge of the pump capable of discharging the full capacity of the pump. A centrifugal pump's pressure rise is limited to the shut-off p ump curve, which is always less than the design pres ystem if properly designed). A di rovided to detect h e relief valve r e flow and p

Sm

Cen while recip ecial desig action sourc y requi be instal ting flow.

Variab

Centrifu rge pressure given speed, reciproc ant flow rate regardless of the discharge pressure. pplications that require either constant flow or variable flow. Metering pumps rely on a constant flow at varying pressures, which makes reciprocating pumps and rotary pumps suitable for this application. Piston pumps used for metering will often use an adjustable stroke length to allow the operator to vary the flow rate to meet the system requirements. Centrifugal pumps are favored where process conditions often require varying flow rates. For example, a level control valve must throttle the flow rate from a vessel to maintain a constant level in the vessel. A centrifugal pump is well suited to handle this process condition, whereas a positive