Centrifugal Pump Selection
Part 1: Total Head

Centrifugal pumps are the most common type of pumps used to move fluids through a system. Centrifugal pumps are used for high flow, low pressure systems. Positive displacement pumps are required for high pressure, low flow systems. In this 2-part GATEKEEPER series, we will discuss how centrifugal pumps work and what information is needed to determine the pump needed for a particular application.

Mechanism

A centrifugal pumps consists of an impeller attached and rotating with a shaft. The casing encloses the impeller. The liquid is forced into the inlet side of the pump casing by atmospheric pressure or some upstream pressure. As the impeller rotates, the liquid moves towards the discharge side of the pump. This creates a void or reduced pressure area at the impeller inlet. The pressure at the pump inlet is greater than the pressure at the impeller inlet. The pressure at the impeller inlet forces additional liquid into the impeller in order to fill the void.

The liquid entering the impeller, moves along the impeller vanes, thereby increasing the liquids velocity as it progresses down the vane. The vanes are usually curved backward to the direction of rotation. See Figure 1.

As the liquid leaves the impeller vane, the liquid is at its maximum velocity. Once the liquid leaves the vane, it enters the casing. The casing cross sectional area increases as the flow path increases. This enlargement causes the liquid to lose velocity. The decrease in velocity causes a decrease in kinetic energy and an increase in potential energy (pressure). See Figure 2.

Centrifugal Pump Selection Criteria

In order to select a centrifugal pump, certain factors must be determined:

- Pump Capacity Needed
- Total Head of the System
- Horsepower
- Efficiency
- Net Positive Suction Head (NPSH)

Calculating Total Head of the System

There are four components that must be combined to determine the total head (TH) of the system:

Static Head

Static head is the total elevation change that a liquid must undergo. Static head is normally measured from the surface of the liquid in the supply vessel to the surface of the liquid in the delivery vessel or location.

- If the pump is located above the liquid level in the supply vessel, the head is known as suction lift.
- If the pump is located below the liquid level in the supply vessel, the head is known as suction head.
Friction Head

Friction head is the head required to overcome the friction losses in the piping, valves, and fittings in the system prior to delivery. Pipe friction head loss will be calculated separately from the valve and fitting head loss.

The smaller the size piping the greater the friction head loss. To determine pipe friction loss and a preliminary line size for the system, tables have been composed based on the type of liquid, temperature of the liquid, and the type of material used in the system shown in Figure 3. In order to use the table the pump capacity needs to be known.

The velocity is usually used to determine a preliminary line size. When establishing the recommended velocity range for a particular application, factors to consider include abrasiveness of the liquid, pipe material, and settling properties of any suspended solids. Common velocity guidelines are 4 to 6 ft/sec for suction piping and 6 to 10 ft/sec for discharge piping. Suction and discharge connection sizes of the pump will not necessarily be the same as the suction and discharge lines. Reducers/Expanders may need to be used. Once a pipe size has been determined that will give a velocity within the recommended ranges at the required pump capacity, the head loss in feet per 100 linear feet of pipe (h_f) and Equation 1, can be used to find the pipe friction head.

In order to find the friction loss in valves and fittings, Equation 2 must be used. The second term, V^2/2g, can be found in the friction tables used to determine the pipe friction loss. K is the resistance coefficient for the particular valve or fitting and is determined to the TH. Pressure can be converted to feet using Equation 3.

Pressure Head

Pressure head is the head required to overcome a pressure or vacuum in the system upstream or downstream of the pump. This is normally measured at the liquid surface in the supply and delivery vessels. If the pressure in the supply tank is equal to the pressure in the delivery tank, then there is no required pressure head adjustment to the TH. If it is a closed loop system, there is no pressure head adjustment. If the supply vessel is under a different pressure than the delivery vessel, a pressure head adjustment needs to be added to the TH. Pressure can be converted to feet using Equation 3.

Velocity Head

The velocity head is energy of a liquid as a result of its motion at some velocity. The velocity at the suction of the pump is different from the velocity at the discharge of the pump because the sizing of the suction and discharge piping is different.

Putting It All Together

Once the static head, friction head (pipe, valve and fitting friction head loss), pressure head and velocity head are known, the TH can be found by adding them together. Part 2 will cover pump speed, horsepower, efficiency, NPSH and final selection of the pump.