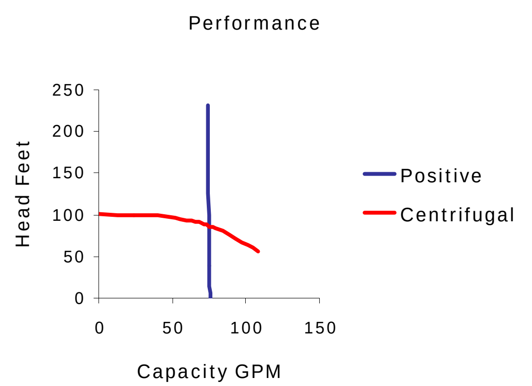
When to use a
Positive Displacement Pump

When to use a centrifugal or a Positive Displacement pump ("PD Pump") is not always a clear choice. To make a good choice between these pump types it is important to understand that these two types of pumps behave very differently.

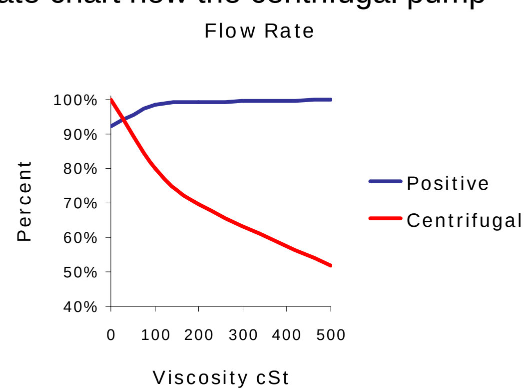
Flow rate versus pressure

By looking at the performance chart to the right you can see just how different these pumps are. The centrifugal has varying flow depending on pressure or head, whereas the PD pump has more or less constant flow regardless of pressure.



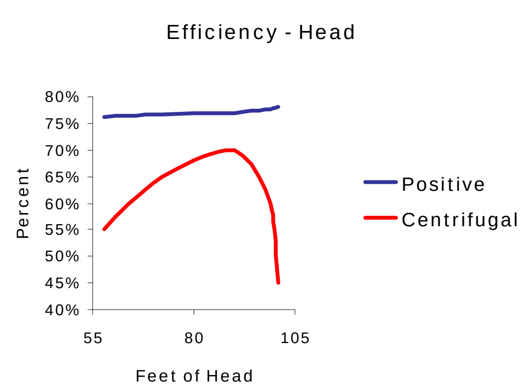
Flow rate versus viscosity

Another major difference between the pump types is the effect viscosity has on the capacity of the pump. You will notice in the flow rate chart how the centrifugal pump loses flow as the viscosity goes up but the PD pump's flow actually increases. This is because the higher viscosity liquids fill the clearances of the pump causing a higher volumetric efficiency. Remember, this chart shows only the effect of viscosity on the pump flow; when there is a viscosity change there is also greater line loss in the system. This means you will also have to calculate the change in pump flow from the first chart for this pressure change.



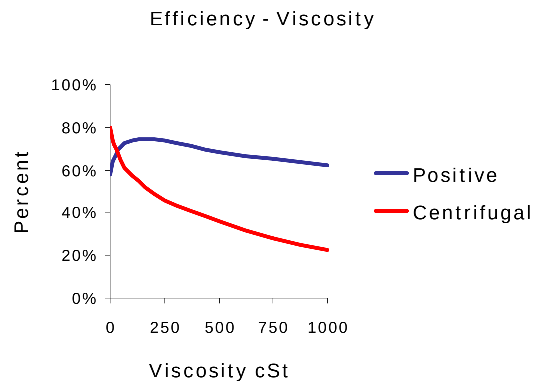
Efficiency versus pressure

The pumps behave very differently when considering mechanical efficiency as well. By looking at the efficiency chart to the right you can see the impact of pressure changes on the pump's efficiency. Changes in pressure have little effect on the PD pump but a dramatic one on the centrifugal.



Efficiency versus viscosity

Viscosity also plays an important role in pump mechanical efficiency. Because the centrifugal pump operates at motor speed, efficiency goes down as viscosity increases due to increased frictional losses within the pump. Efficiency often increases in a PD pump with increasing viscosity. Note how rapidly efficiency drops off for the centrifugal pump as viscosity increases.



Net Positive Suction Head Requirements

Another consideration is $NPSH_R$. In a centrifugal the $NPSH_R$ varies as a function of flow, which is determined by pressure and viscosity as discussed above. In a PD pump, $NPSH_R$ varies as a function of flow which is determined by speed. The lower the speed of a PD pump, the lower the $NPSH_R$.

Operating at different points on the curve

Another thing to keep in mind when comparing the two types of pumps is that a centrifugal pump does best in the center of the curve. As you move either to the left or right, additional considerations come into play. If you move far enough to the left or right, pump life is reduced due to either shaft deflection or increased cavitation. With a PD pump you can operate the pump on any point of the curve. In fact the volumetric efficiency as a percent actually improves at the high speed part of the curve. This is due to the fact that the volumetric efficiency is affected by slip, which is essentially constant. At low speed the percentage of slip is higher than at high speed.

The data presented in these charts is the actual data for a specific application. The centrifugal was picked at its Best Efficiency Point (BEP) and the PD pump (Internal Gear) was selected to match the flow, viscosity, and pressure. Different applications will have different curves and efficiencies. These curves are presented as an example of the performance behavior differences of the two pump principles.

Pump Selection Scenarios

Now that you have a clearer understanding of the performance differences between these two pump principles, when would you choose to use a PD pump? The following chart lists several such scenarios.

High Viscosity	As illustrated by the graphs above, even modest viscosities dramatically affect the flow rate and efficiency of a centrifugal pump. While many centrifugals are cataloged to 1,000 cSt and higher, PD pumps are clearly the better choice when considering the high energy costs resulting from this lost efficiency.
Operating Away from the Middle of the Curve	Centrifugals do not operate well when being run too far off the middle of the curve. At best, this results in reduced efficiency which would require larger motors and higher energy costs. At worst, this can result in cavitation damage, shaft deflection, and premature pump failure. PD pumps on the other hand can be run at any point on their curve without damaging the pump or greatly affecting the efficiency.
Variations in Pressure	The first graph above clearly illustrates the effect that even modest changes in pressure can have on the flow rate of a centrifugal pump. Additional restrictions such as debris in a filter, corroded / rough piping, or a valve left too far closed (or too far open) can have a dramatic effect on a centrifugal pump's flow rate and efficiency. PD pumps maintain their flow rate and efficiency even with significant changes in pressure.
Variations in Viscosity	Many liquids vary in viscosity depending on temperature or due to chemical reaction. A rise in viscosity will independently alter the flow rate and efficiency. Add to that the rise in pressure due to the increase in frictional line losses and PD pumps become the clear choice for variable viscosity applications.
High Pressures	While some centrifugals can be run in series to boost their pressures, none can compete with PD pumps for high pressure applications. Pressure limits will depend on the design of each pump, but pressures of 250 PSI (580 feet) are not unusual for a PD pump, with some models going over 3,000 PSI (7,000 feet). The capability for a PD pump to produce pressure is so great that some type of system overpressure protection is required.
Shear Sensitive Liquids	Generally speaking, pumps tend to shear liquids more as speed is increased and centrifugals are high speed pumps. This makes PD pumps better able to handle shear sensitive liquids.
Suction Lift Applications	By their nature, PD pumps create a vacuum on the inlet side, making them capable of creating a suction lift. Standard ANSI centrifugals do not create a vacuum and cannot create a suction lift. There are self-priming centrifugal designs that can lift liquid an average of 15 feet when partially filled (13" hg vacuum). Many dry PD pumps can pull that or better and wetted PD pumps (a pump that is not full of liquid but with some liquid in it) can often reach vacuums of 25 to 28" hg. PD pumps are the logical choice when a suction lift is required.