POWER Engineering®

# 5.5 Things Power Plant Engineers Need to Know About Pumps

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Pumps in Power Plants 1

Product Technology

| Application/System | Centrifugal Pumps | Three Screw Pumps | Two Screw Pumps | Progressing Cavity Pumps | Peristaltic Pumps | Gear Pumps |
|---|---|---|---|---|---|---|
| Lube Oil | ■ | ■ | | | | |
| Control Oil | | ■ | | | | |
| Turbine Shaft Jacking | | ■ | | | | ■ |
| Water Injection (low NOx) | | ■ | | | | |
| Purge Water for Gas Turbines | | ■ | | | | |
| Secondary Cooling Water | ■ | | | | | |
| Sealing Oil for Turbo Generators | ■ | ■ | | | | |
| Compressor Washing | ■ | | | | | |
| Fuel Injection for Gas Turbines | | ■ | | | | ■ |
| Fuel Unloading | | ■ | ■ | | | |
| Fuel Transfer | ■ | ■ | ■ | | | |
| Fuel Feed | ■ | ■ | | | | |
| Burner Operations | | ■ | | | | |
| Feed Water Conditioning | | | | | ■ | |
| DeNOx | ■ | | | | ■ | |
| FGD Waste Water Cleaning | ■ | | | ■ | ■ | |
| Service Water Purifying | ■ | | | ■ | ■ | |
| Ash Water and Sump Pumps | | | | ■ | ■ | |

Pumps and pumping systems are used in power plants for primary applications such as fuel oil handling and for auxiliary systems such as lubrication and cooling (Figure 1). On average, a 300 MW combined cycle power plant will have more than 100 pumps.

When looking for opportunities to improve the performance metrics of a plant, these pumps and fluid handling systems should be primary targets for evaluation, optimization and maintenance due to their sheer number and their influence on overall performance.

However, because pumps and pumping systems are located in so many diverse applications and locations throughout the plant, their collective impact may be easily overlooked.

Both centrifugal and positive displacement pumps are utilized in power generation applications. Of the two, engineers are generally more familiar with centrifugal pumps, which use an impeller to move fluid through the application process. The velocity of the rotating impeller imparts energy on the liquid and causes a rise in pressure (or head) that is proportional to the fluid's velocity.

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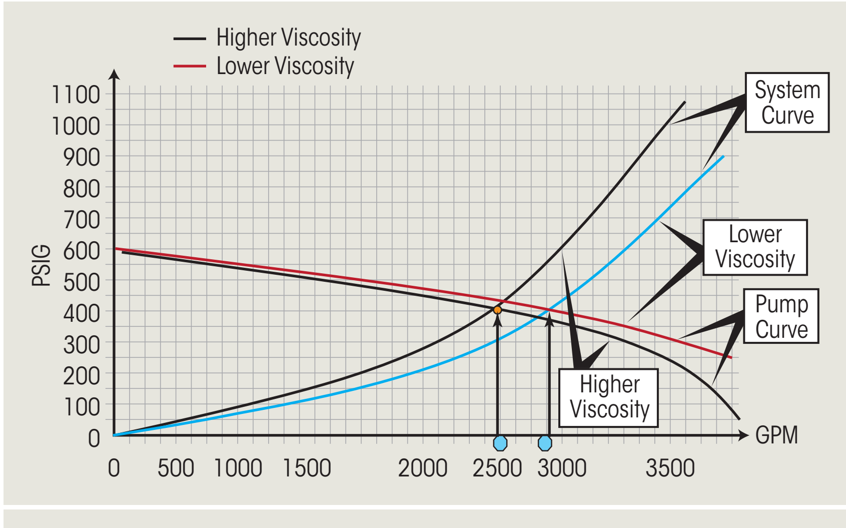
Positive displacement pumps – and, in particular, rotary variants – are less common, but can prove to be more cost effective and offer more efficient fluid handling in many applications. Instead of creating pressure, positive displacement pumps simply move liquid. Pressure is generated due to resistance to movement of the liquid downstream of the pump.

## THINGS TO CONSIDER

Whether you are an original equipment manufacturer (OEM), an engineering, procurement and construction (EPC) firm designing a new system, or a power plant operator looking to improve the performance and reliability of an existing system, here are 5.5 things to consider regarding pumps and pumping systems.

**Centrifugal Pump Performance** **2**




## 1 LIQUID

The type and nature of the liquid being handled is a primary consideration when determining which pump technology to use. When handling viscous liquids such as heavy crude oil, bunker or residual fuel oils, low sulfur fuels and distillate fuels, multiple screw pumps – a variant of positive displacement pumps – provide remarkably good operating efficiencies as opposed to centrifugal pumps. The high efficiency performance of multiple screw pumps provides a clear advantage over centrifugal pumps where liquid viscosity exceeds 100 SSU (20 centistokes). Progressing cavity pumps are an excellent choice for wastewater and fuel sludge, as they can handle fluids that are contaminated or contain abrasive materials.

## 2 SUPPLY

The specific hydraulic characteristics of positive displacement and centrifugal pumps lead to clear recommendations to keep total cost of ownership (TCO) as low as possible. When the system pressure is subject to change, a positive displacement pump is recommended, as it will remain efficient even when operating at varying pressures. While centrifugal pumps provide good efficiency within a relatively limited range of heads (pressures), this efficiency deteriorates rapidly if the head is too low. It suffers even more when the head exceeds the ideal range. Positive displacement pumps are the most economical choice when liquid viscosity changes, but flow volume remains constant. The efficiency of centrifugal pumps drops rapidly when viscosity is outside the optimal range (also known as the Best Efficiency Point, or BEP), whereas positive displacement pumps are less susceptible to these fluctuations (Figure 2).

## 3 DISCHARGE

Whether pressure is constant or not is another key factor in the determination of which pump technology is better suited to the application. When the system has varying pressure requirements, centrifugal pumps will be forced to operate outside of their Best Efficiency Point, increasing the stress and wear on the pump. In these conditions, positive displacement pumps are the better choice to ensure high reliability. Today's high performance three screw pumps can operate with system pressures up to 4500 psi (310 bar) and flows to 3300 gpm (750 m3/h) with long term reliability and excellent efficiency. Power levels to 1,000 hp (745 kW) and higher are available. Two screw pumps are available for flow rates to 18,000 gpm (4000 m3/h), pressures to 1450 psi (100 bar) and can handle corrosive or easily stained materials, again at good efficiencies. Power ranges to 1,500 hp (1,100 kW) are available on critical applications.

## 4 OPERATIONS

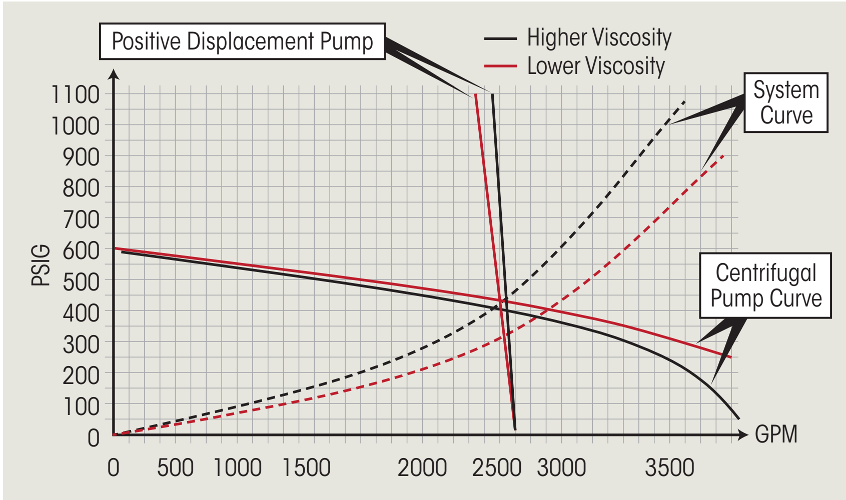
When specifying pumps, consideration should be given to the mode of operation as well as to the operating conditions; will either change significantly? If flow volume remains constant, but pressure or delivery head varies, positive displacement pumps are the right choice due to their fixed displacement design (Figure 3). In contrast, centrifugal pumps are particularly efficient when operating on water-thin liquids at fixed operating conditions where it is possible to select the pump based on exact requirements. Centrifugal pumps will incur noticeably higher costs for spare parts, maintenance and downtime if viscosity and pressure are not constant. In either case, costs can be significantly reduced by operating a pump close to its most efficient range.

## 5 SIZING & SELECTION

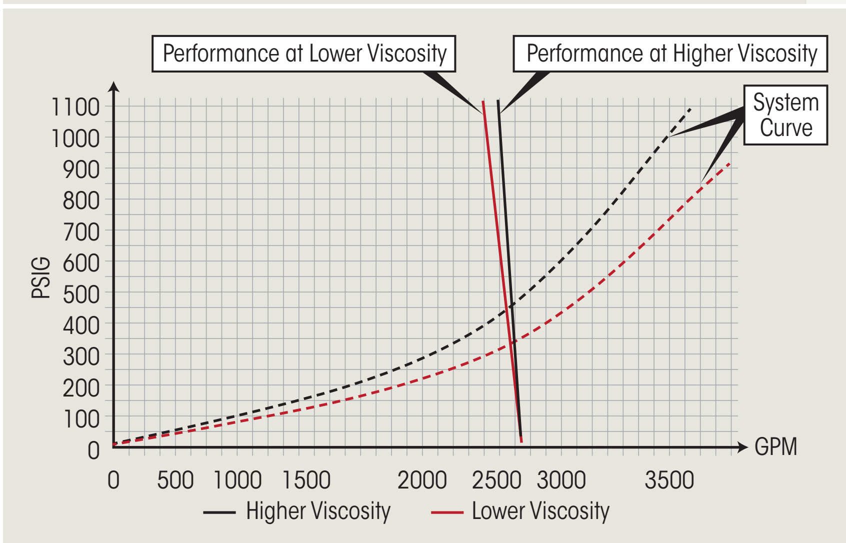
Selecting the right type of pump – centrifugal or positive displacement

## Centrifugal pumps offer good potential for optimization efforts, simply because there are more of them.

## Centrifugal vs. Rotary Positive Displacement Pump Performance 3




## Rotary Positive Displacement Pump Performance 4




– is important, but it is also critical to ensure that the pump and fluid handling system is properly sized. Figure 4 is a performance curve typical of multiple screw pumps. It shows excellent efficiency over a broad range of discharge pressures. When properly sized, multiple screw pumps also can handle various grades of liquid fuels, such as distillate or residual oil, using the same pumps and driver. This can provide a utility with some diversification of available oil supplies. For example, combustion gas turbines can be started and stopped using light distillate fuel while running on less costly (and higher heat value) heavy fuels.

If each piece of equipment is over-engineered, the power plant will have a system that is too large, performs at less than optimum efficiency, consumes excessive energy and adds higher maintenance and service costs. Conversely, a pump that is undersized may cost less at the outset, but the cost to rework or replace the system to meet performance expectations will outweigh the initial savings.

The best rule of thumb is to size for worst-case flow and power requirements. In order to ensure the system is delivering adequate flow – especially in applications where fuel is being delivered to a turbine – size the pump for the highest temperature and lowest viscosity conditions. In contrast, during startup (cold) conditions, the fluid will have a higher viscosity, resulting in a higher power requirement. In this case, motor sizing is also important, making sure it can deliver the required power.

Screw pumps offer excellent suction lift capability, which provides an operation margin for "upset" conditions, such as during startup when the liquid may be cold and more viscous or when there is an extended distance to the supply reservoir. This operation margin allows the use of smaller supply piping, reducing component costs and a simpler design.

Centrifugal pumps offer good potential for optimization efforts simply because there are more of them. Centrifugal pumps should be selected for, and normally operated at, the manufacturer's design rated conditions of head and flow. This is usually at the best efficiency point, which is where pump impeller vane angles and the size and shape of the internal liquid flow passages provide the optimum combination of pressure and flow. As you move away from a centrifugal pump's BEP, the shaft will deflect and the pump will experience vibration.

## Pumps used in auxiliary systems for lubrication will require less preventive maintenance.

This causes reduced performance and accelerated wear.

### 5.5 MAINTENANCE

Power plant operators tasked with improving efficiency and reliability should initiate a scheduled preventive maintenance program as part of the operational plan. Pumps used in auxiliary systems for lubrication will, by nature of their clean working conditions and application, require less preventive maintenance than pumps used for primary applications such as fuel injection and fuel forwarding.

In both positive displacement and centrifugal pumps, the following components should be inspected, serviced and replaced when necessary to ensure optimum efficiency and reliability:

- Radial Bearings: if not sealed, these will need periodic lubrication and may need to be replaced if vibration or excessive heat is being generated
- Mechanical Seals: check for leakage and replace if necessary; it should be noted that a mechanical shaft seal is not a zero leak device
- O-rings and Gaskets: check for deterioration and replace if necessary

As a service to their end users, many pump manufacturers provide these parts in what is sometimes called a "minor kit," allowing the customer to easily identify and order the parts they need for ~~a~~ scheduled maintenance program on the pump.

In addition to the items mentioned above, centrifugal pumps also require inspection of the impeller, which can be replaced if worn or damaged. For positive displacement pumps, virtually every wearing part of the pump – screws, gears (in the case of two-screw pumps), and housing – can often be replaced in the form of what some manufacturers refer to as a "major kit." When repairing a pump with a major kit, the user essentially has a new pump, at a cost that is somewhat lower than replacing the entire pump.

When servicing pumps and fluid handling systems, it is recommended to only use replacement parts manufactured or certified by the pump manufacturer. Knock-offs, or "pirated parts," may work initially, but are typically not manufactured to the same standards as OEM parts and could result in early failure, leading to system downtime, damage to other components or even injury. In most cases, use of non-OEM parts will void any original equipment warranties. Using parts approved by the manufacturer will result in a longer service life, extended intervals between maintenance, a more predictable process and an increased system efficiency – not to mention peace of mind. pe