LOAD CONTROLS INCORPORATED

USING POWER SENSING TO **MONITOR AND PROTECT PUMPS**

BY MICHAEL MCCLURG,
LOAD CONTROLS, INCORPORATED

TAKE ACTION TODAY
TO IMPROVE YOUR PUMP SYSTEM

Are you properly tracking infeeds, flows, pressure and viscosity, process efficiency and changes to the pumping subsystem over time? Early detection and proper intervention can protect your motors and pumps, improve efficiency, and extend their longevity even in the most dangerous and harmful conditions.

LEARN MORE ABOUT THE BENEFITS OF POWER SENSING.
www.loadcontrols.com/industries-and-applications/monitoring-and-protecting-pumps/

Pumps play an increasingly important role in today's manufacturing. The global market for pumps is over $60B and is expected to continue growing at a rate of 6% into the future. This investment is surpassed by the budget for running and maintaining these pumps over time. Pumps used for industrial applications represent one of the world's largest electrical power consumers. According to the Hydraulic Institute, pumping systems account for nearly 20% of the world's electrical energy demand and from 20% to 25% of the energy usage in certain industrial plant operations.

Well-managed and maintained pumps can enjoy a long productive life, playing an important role in an efficient manufacturing process. But events can happen! Proactive monitoring and maintenance are important to avoid costly downtime, cleanup, repairs, and replacement.

An additional factor for critical and environmentally sensitive pumping applications is magnetically coupled, "sealless" or "canned" pumps that are increasingly being specified. These pumps offer a number of clear advantages, but since the bearings are now inside the pump a presence of fluid is needed to remove heat buildup. This requires new thinking about how to protect and monitor them.

A monitoring system that alerts to dry running and provides valuable feedback on process status, flow, and viscosity change is needed. It should also offer important insight into maintenance needs that deliver short-term payback, ongoing cost savings, and process optimization benefits. Pump power measurement can play a fundamental role in all these key elements and should be considered an important factor in pump subsystem design.

HOW DOES POWER MONITORING WORK?

At the heart of nearly all industrial pumps are three-phase induction motors. The three-phase power creates a rotating field in the stator which 'induces' the rotor to rotate. To measure three-phase power we use this formula:

P = (E)(I)(Cosø)(1.73)

P = Power (Watts)

E = Voltage Phase to Phase (Volts)

I = Current in each phase (Amps)

Cosø = Power Factor (Ranges from 0 to 1)

1.73 = Multiplication Factor for three phases = √3
For single-phase use 1.0

1 Horsepower = 746 Watts

WHAT IS POWER FACTOR?

Here is how the Power Factor plays a role in the above equation. In an induction motor, the current always lags the voltage. Power Factor is the cosine of this angular lag. For a lightly loaded pump motor, the Power Factor can be as low as 0.1. You can think of this low Power Factor as electrical inefficiency: current is flowing to the motor to charge the magnetic portion of the circuit, but it is not doing useful work (Power). As the load increases the Power Factor improves and is typically 0.9 for a fully loaded motor.

Fun fact: the power utility has to produce and deliver the full amount of Amps on the motor nameplate, but only bill for the 'real', 'work', or 'power' part. When Power Factor remains low across a plant, a 'low Power Factor' surcharge is applied to the bill to enable the utility to recoup this difference.

WHY MONITOR POWER INSTEAD OF AMPS?

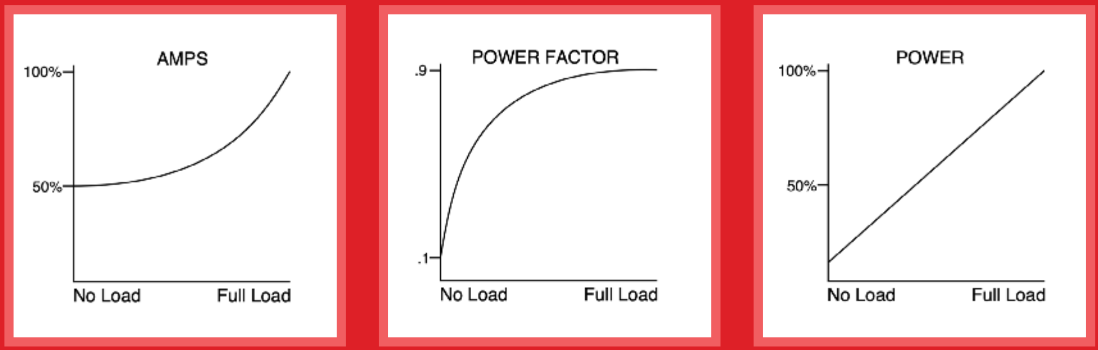
As you start to load a motor the power factor improves rapidly. The current (Amps) doesn't change significantly until the motor reaches 50% of capacity.

Power, on the other hand, is linear. A change in load is a change in power (HP or kW).

This gives us a signal to monitor and control pumps:

- When the flow rate is low, Power is low
- When the flow rate is high, Power is high
- During light load conditions, caused by cavitation or dry running, change in Power is 10X more sensitive than Current (Amps)

Figure 1.1, 1.2, 1.3 Changes in Power Factor, Current (Amps), and Power with increasing Motor Load



APPLICATION AND SETUP FOR CENTRIFUGAL AND POSITIVE DISPLACEMENT PUMPS

Power monitoring can be applied to both Centrifugal and Positive Displacement Pumps.

CENTRIFUGAL PUMPS

Pump Power (horsepower [HP]) requirements will increase with an increasing delivered flow rate. Figure 2 shows how pump Power HP changes with the flow.

With the inlet valve closed (dry running), HP will drop to near zero, enabling relays to be tripped so the pumps stop before it overheats (this can be a matter of seconds) and expensive damage occurs. With the discharge valve fully closed (deadhead condition) some fluid still remains in the pump (churning) and HP will not drop as low as compared to when the inlet valve is fully closed (dry running). Note that many pump users are hesitant to close the inlet valve, this is not a prerequisite to setting appropriate trip points when monitoring Power.

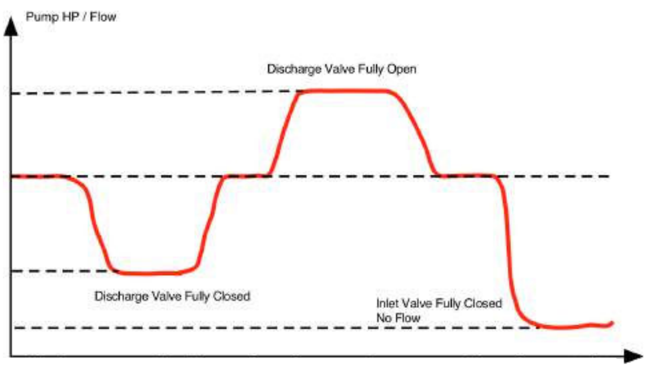


Figure 2 Changes in Power from Steady State with Valve movement

To set up a power monitoring and control system for a Centrifugal pump, users can set a minimum HP Low Trip point over the dead head condition. This will protect against both dry running and deadhead conditions. On the upper end, a High Trip above the maximum flow condition can catch motor bearing problems and protect the pump.

PROCESS CHANGES

Process changes, such as increases in the viscosity of the material being pumped, affects the pump HP level proportionally. The more viscous the material, the more power the pump will pull for an equal flow level. The closed/open discharge valve conditions will behave as previously illustrated, but the entire curve will be offset by the change in Power measured due to increased viscosity as shown below in blue. Setting trip points can catch NO FLOW conditions and protect the pump. The HIGH trip point can be set to protect pumps against motor shaft bearing failure or potentially harmful conditions including temperature decline in feeds or contaminants in the line.

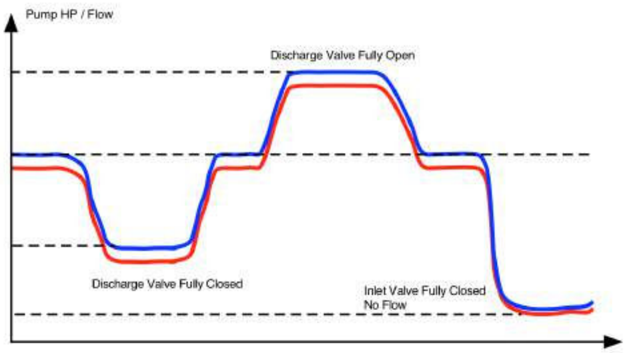
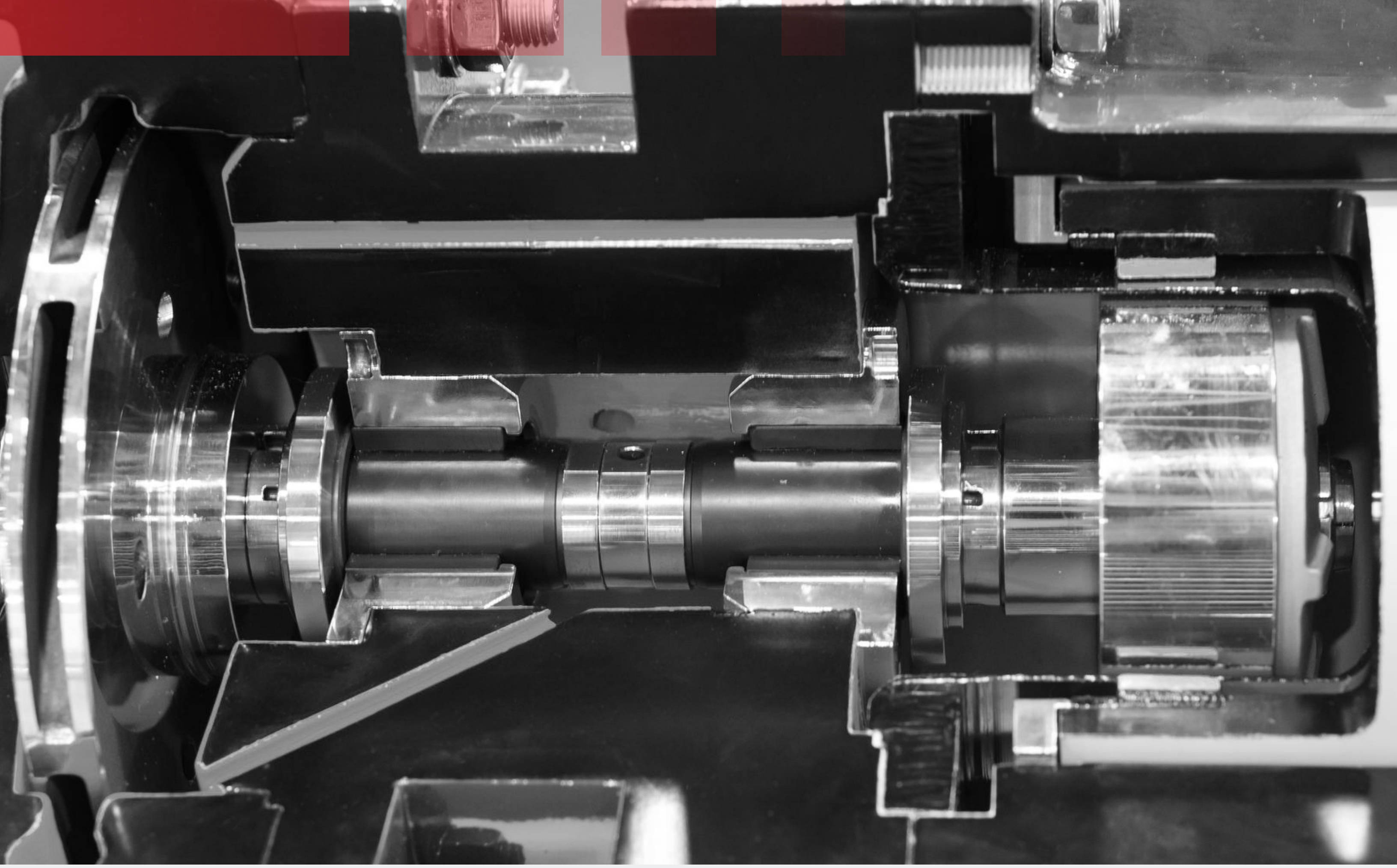


Figure 2 Changes in Power from Steady State with Valve movement

Additional data gathered over time showing the increase in HP can provide insight into process efficiency and quality of a produced product. This curve may shift up over time due to wear, misalignment, and inefficiency in the pump subsystem design. All these factors indicate the potential need for proactive maintenance.

SCHEDULE A CALL TODAY to find out more ways power sensoring can strengthen your industrial pump system.
www.loadcontrols.com/contact/



POSITIVE DISPLACEMENT PUMPS

With a Positive Displacement pump, a blocked outlet will increase pressure in the pump and the HP will increase. The diagram below shows a discharge valve starting to close and the HP starting to increase with pressure in the pump. When the valve opens again, the HP will drop back down to the normal pumping power. When the flow is lost, the pump motor will go unloaded. The HP will drop to almost an idle condition on the pump motor until the pump overheats and trouble occurs.

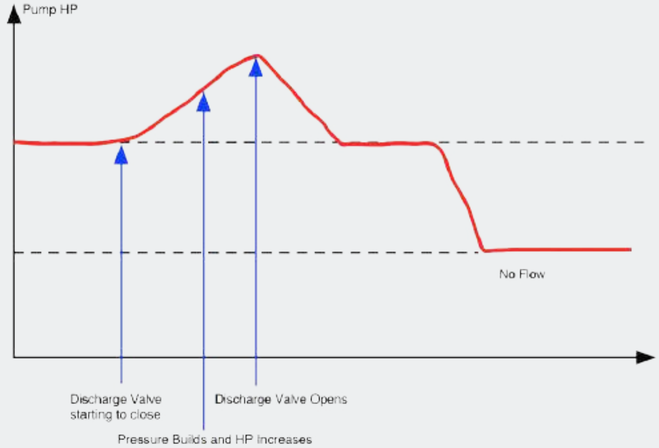
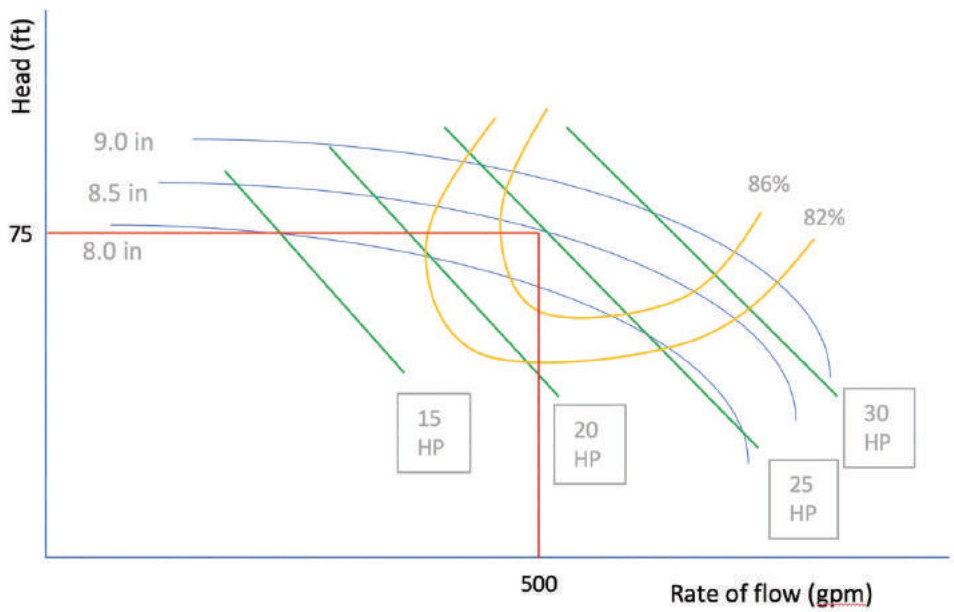


Figure 4 Changes in Power from Steady State with Discharge Valve Closed for a Positive Displacement Pump

ADDING IN THE PUMP CURVE

A conversation about pump efficiency would not be complete without addressing the impact on the pump curve. A typical pump curve, displayed in Figure 5, shows that the corresponding recommended motor HP can be determined when arriving at a Best Efficiency Point (BEP). For this example the BEP would dictate a 25HP motor.



By using a motor power sensor, the actual HP requirements of the current process can be captured over time. By comparing the average and peak HP requirements with the installed HP motor and the pump curve we can draw important insights.

Is the motor potentially oversized (actual HP measured much less than stated HP on the motor)?

CAUSES FOR THIS MIGHT INCLUDE:

- Process changes and improvements that reduce operating Head or Flow
- Addition of new pumps in parallel functions
- Lower throughput requirements based on lower demand from the business
- Overly conservative sizing during the initial installation
- Replacement impeller sizing that places lower demand on the pump's motorbusiness

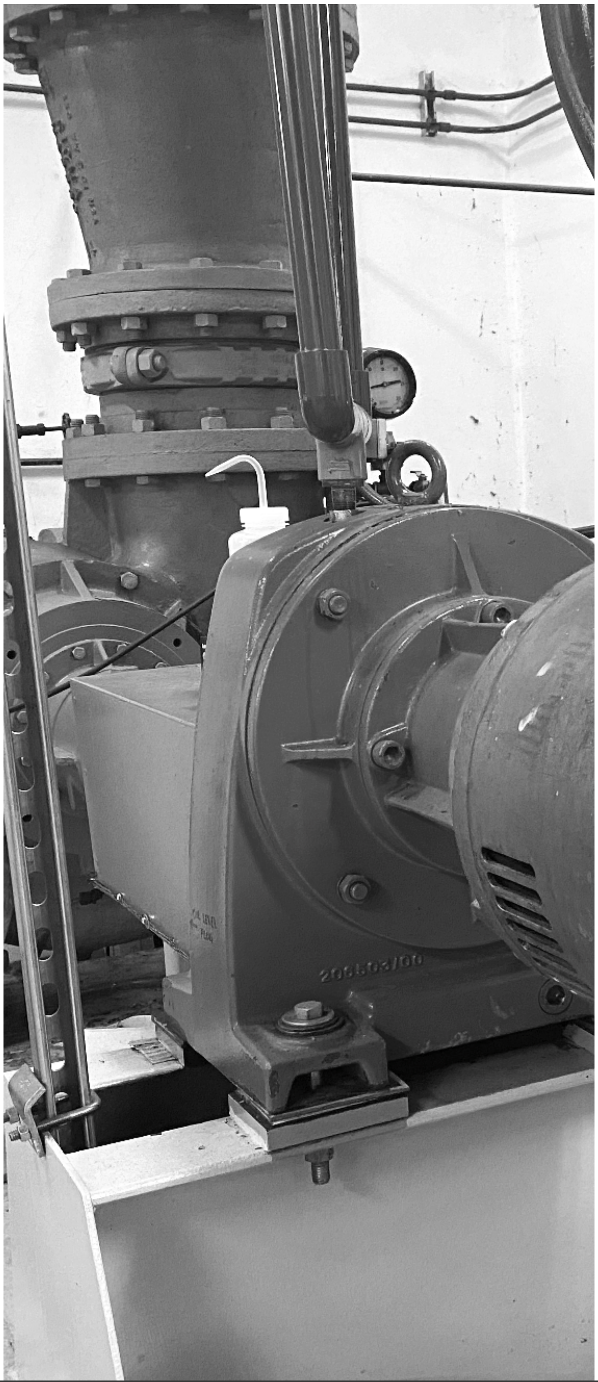
Has the process moved further out (down and to the right) the pump curve? This indicates the pump motor is potentially undersized.

CAUSES FOR THIS MIGHT INCLUDE:

- Increased Flow requirements from the process or business
- Process changes over time that increased Head or Flow
- Aggressive cost savings approach when initially sizing the pump motor
- Wear or maintenance needs
- Spikes from seasonally high demand that were not originally forecasted

THE IMPLICATIONS

In the case of oversizing there can be significant expense implications. Some industry analysts estimate that up to 75% of installed pumps are oversized, many by as much as 20%. Identifying a 30HP pump motor that is oversized by 20% could save over $25,000 per pump per year. This would yield a payback period for a newer, more correctly sized motor, of just a few months.



COMPARISONS TO ALTERNATIVE MONITORING TECHNIQUES

Power measurement can be used alone or as part of a multi-mode measurement program. Other techniques for measuring pump status include:

FLOW METERS

Measuring flow can provide throughput and viscosity data, which is critical to understanding the subsystem status. A potential downside is that the most effective measurements are taken in the flow, leading to reliability and maintenance concerns. Flow Meters can also be costly to install. Leveraging flow sensors in addition to power measurement can be important to pump efficiency when viscosity changes. Both can provide rapid feedback on flow loss and impeller damage.

VIBRATION SENSING

Measuring vibration provides feedback on pump balance. Since vibration will increase with ongoing wear and misalignment, vibration sensing is commonly used in preventative maintenance programs. Ultrasonic vibration measurement can provide some insight into the process state. Vibration sensing is typically easy to install, however it can be more expensive than power measurement alternatives and may not be possible in scenarios where the motor cannot be easily reached or is installed in a hazardous environment. The combination of vibration and Power sensing over time can provide valuable insight into ongoing pumping costs and maintenance efficiencies.

TEMPERATURE MONITORING

When implementing temperature sensing in pumping applications a decision needs to be made to measure temperature in flow or pump/motor housing. Measuring temperature inflow is the most accurate but will require ongoing maintenance. Housing-based solutions are simplest to install but may suffer from accuracy and latency challenges, particularly in canned pumps. You may also require an ambient temperature sensor to ensure measurements reflect the process, not external factors. Leveraging temperature alone is unlikely to diagnose impeller failure in a timely fashion. When used with Power sensing, temperature monitoring can provide accurate centipoise readings, enabling viscosity-based process decision-making.

CONCLUSION

Power monitoring can be an important element of a well-managed pump subsystem. Pump motor power status and consumption provides valuable input about infeeds, flows, pressure and viscosity, process efficiency, and the changes to the pumping subsystem over time. This can all be vital data for optimizing processes, protecting pumps from dangerous and harmful conditions, and maintaining an efficient pumping process into the future.

VISIT WWW.LOADCONTROLS.COM FOR MORE APPLICATION USE CASES AND PRODUCT INFORMATION, OR TO REQUEST A 30-DAY TRIAL.

ABOUT LOADCONTROLS

Since 1984 Load Controls has been providing Power monitoring solutions for Chemical Processing, Pharmaceutical, Food Processing, Paper, Waste Treatment, Machine Tool, and other process manufacturing applications. Our sensors and controls are in use by 9 of the 10 world's largest chemical processing firms, and 9 of the 10 largest Pharmaceutical companies globally. All of our products are manufactured in the USA and our company is ISO 9001:2015 Certified.

CONTACT US

Load Controls Incorporated
53 Technology Park Road
Sturbridge, MA 01566

Toll-Free: 888-600-3247
Phone: 508-347-2606
Fax: 508-347-2064
Email: sales@loadcontrols.com