Pump Monitoring with Electronic Differential Pressure Transmitters

An electronic differential pressure transmitter can monitor a pumping system, detecting problems and providing information needed to improve efficiency and save money.

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Companies incur thousands, if not millions of dollars in maintenance costs to keep their pumping systems in good health. Predictive maintenance is one of the best ways to cut pump operating costs. One effective predictive maintenance technique uses an electronic differential pressure transmitter to not only monitor instantaneous pump performance, but also to identify issues related to pump health and efficiency.

Monitoring Differential Pressure

All pumps perform best when they are at, or very close to, their Best Efficiency Point (BEP) on their pump curve (Figure 1). The BEP is defined by the manufacturer on its pump curve, and is typically 70-85% of the shut-off head or maximum differential pressure between the suction and discharge. Helping the pump operate at the BEP is the single most important aspect for prolonging pump life, and cutting maintenance time and costs.

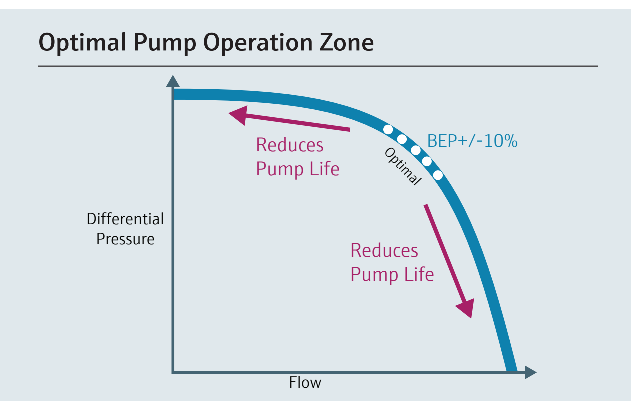

Figure 1: The Best Efficiency Point (BEP) is 70-85% of the maximum differential pressure between the suction and discharge pressure.

An electronic differential pressure (EdP) transmitter is well suited for monitoring the performance of a pump in applications such as cooling tower systems or aeration pumps in wastewater treatment where continuous pump operation is critical. An EdP transmitter is primarily used to measure level and differential pressure in tanks, distillation columns, cooling towers, etc., but it can also be used in pumping systems (Figure 2).

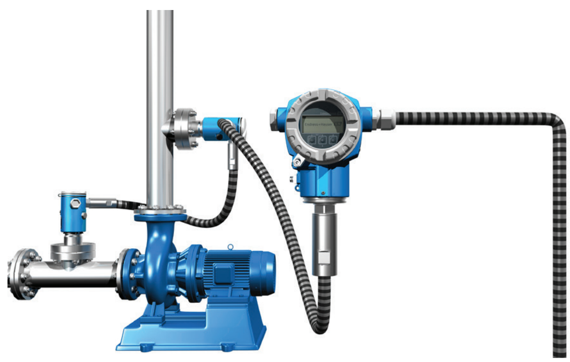

Figure 2: An EdP transmitter monitors a pump's suction and discharge pressure.

An EdP transmitter can monitor the suction and discharge pressure—i.e., the differential pressure—of a pump. Too high or too low suction and discharge pressures can cause various pump issues such as cavitation, loss of flow, mechanical failure, vibration issues, excessive noise, bearing and sealing wear, etc.

The EdP transmitter outputs values for suction, discharge and differential pressure and other useful values. An electronic DP (EdP) transmitter (Figure 3), for example, can also monitor absolute pressure at each of the two sensing points. High and low alarms can be set for any of the monitored values. The EdP has a 4-20mA HART output for connection to an automation system, such as a PLC or a DCS.

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Figure 3: Endress+Hauser FMD71 EdP differential pressure transmitter mounted across a pump.

The DP or gauge value from the EdP can be used to set alarms which in turn help monitor problems such as cavitation, etc.

For example, cavitation occurs if the pressure falls below a liquid's vapor pressure in the impeller or if air entrainment occurs. Monitoring the discharge pressure and comparing it to a table of correct pressures at the automation system will reveal when cavitation is occurring.

Monitoring pressure in the suction line can indicate problems such as leaks or a clogged valve or strainer. If suction pressure drops below preset limits, the EdP transmitter will send an alarm.

Setting the Right Flow Rate

Incorrect flow rate settings is one of the typical causes of inefficient pump operation. Following is an example of how to use the EdP to set the right flow rate. For a given pump curve, first note:

1. Impeller size
2. Rated horsepower
3. Impeller speed
4. Expected flow at BEP

The pump curve is typically provided by the manufacturer (Figure 4). Run the pump with media flowing through the system at an arbitrary flow. Let the flow stabilize. Note the reported differential pressure. This is the total head or differential pressure of the pump.

Assuming 120 feet of water is the total head generated by this 7 hp pump, point A is the intersection with the 70% performance curve. The corresponding value on the X axis (30 gpm) is the flow rate for the pump at an efficiency of

Pump curve for determining flow rate

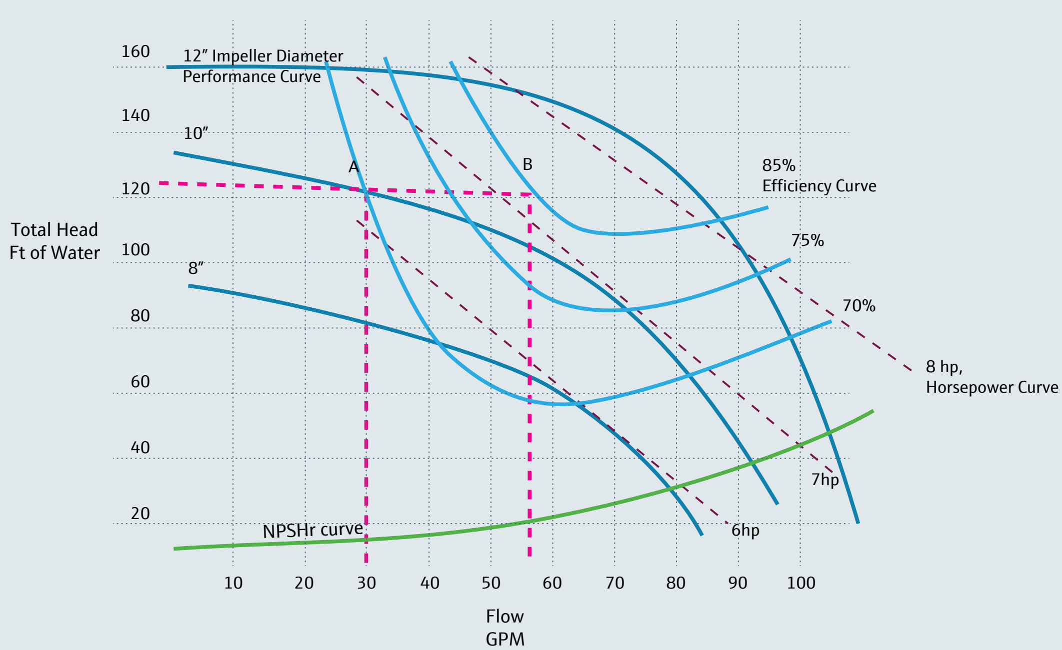

Figure 4: Pump curve for determining flow rate of a pump with a 10-inch impeller.

Pump curve for monitoring total head

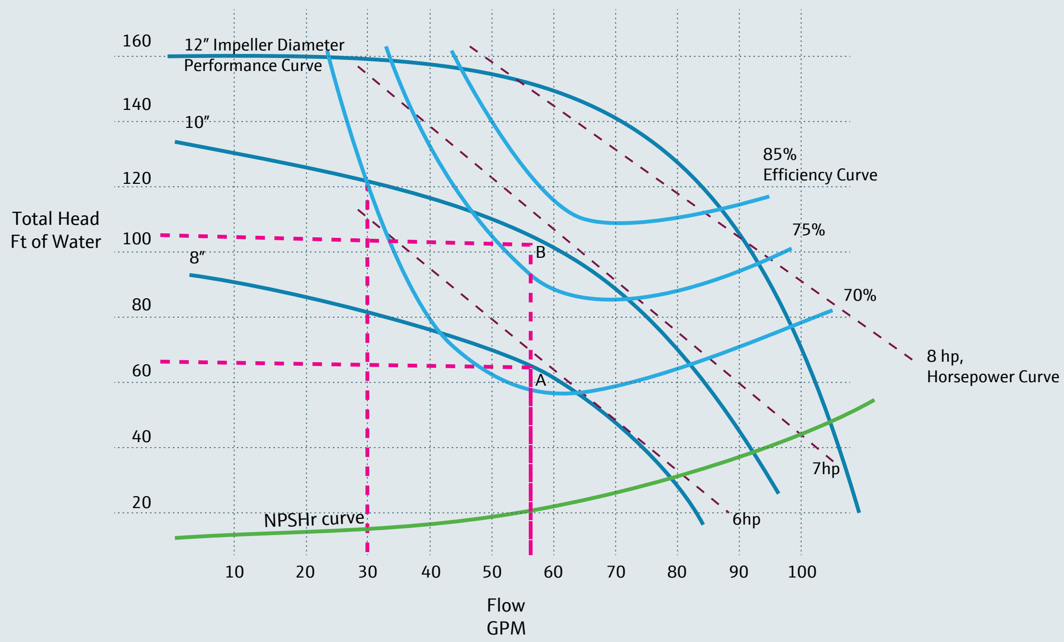

Figure 5: Pump curve for monitoring total head.

70%, corresponding to a Net Positive Suction Head (NPSHr) of 10 feet of water.

To increase efficiency and run this pump at the same total head, the flow rate needs to be increased to 55 gpm (rightmost red dotted line in Figure 4), so that the intersection with the 85% efficiency curve will be at point B. The users should set high and low alarms on the EdP output to keep the DP tightly controlled while increasing the flow rate.

If the pump doesn't generate 120 feet total head at the 55 gpm flow rate, this could be your first indication of an operational or mechanical issue. Check the suction pressure and ensure it is greater than NPSHr. Check the discharge pressure and calculate the HP generated and verify it matches the listed HP on the pump curve for the operating flow rate.

Monitoring Total Head

Assume 55 gpm is the operating flow rate for a 6 hp pump with an 8-inch impeller. The expected intersection on the performance curve for this pump (Figure 5) would be point A. The corresponding expected total head on the Y axis would be 65 feet of water.

The EdP transmitter sends its outputs to an automation system that has control logic and calculations to convert the transmitter data to total head. The automation system compares the EdP transmitter outputs to the expected total head—65 feet of water in this case—and adjusts pump speed accordingly. This alters the pump speed to maintain the pump at BEP, which is 70% according to the manufacturer's pump curve.

If higher pump efficiency is desired, the pump must be run at a higher speed, or a larger impeller diameter needs to be used.

With a known flow rate, different impeller sizes can be tried to arrive at a desired total head and corresponding efficiency. Referring to Figure 4, if 55 gpm is the known flow rate, then an 8-inch impeller can be used to achieve 70% efficiency. If a higher efficiency is desired, then a 10-inch impeller can be used to achieve an efficiency of 75%, and a 12-inch impeller would achieve 85%. The corresponding total head would then be 100 feet of water.

Return on Investment

An EdP transmitter can pay for itself in a matter of months. Let's use an example of a pump in a large industrial chemical company (Figure 6). The company spends approximately $1,000 per year for seal failure and replacement because it operates its pumps below the BEP.

Point A represents the BEP of a 7 hp pump with a 10-inch impeller operating at 75% efficiency. If the pump is in continuous operation, the energy consumption per year would be $1,310 at 10 cents per kWh. Point B represents the deviation from optimum, operating at only 70% efficiency.

The total cost of operating the pump at 70% efficiency is $2,151, where lost power output per year is $1,151 and repairs due to seal failure, vibration issues, other cavitation damages and associated downtime are $1,000. Total cost, considering a system of five pumps, is more than $12,000 per year.

The average cost of an EdP transmitter is $4,000. If the efficiency of the pumps is increased to 75%, using the techniques described in this article, annual savings amount to about $8,000 per year or $667 per month, providing a return on investment in about six months.

About the Author

Vinay Nagendran is a product manager at Endress+Hauser. He previously worked at Cummins for 10 years and Agco for one year in engineering and marketing functions. He has a MS in mechanical engineering from West Virginia University and a MBA from Arizona State University.

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