DOWNTHRUST MEASUREMENT IN VERTICAL PUMPS PREVENTS FAILURE

THE BENEFITS OF MEASURING AXIAL FORCE IN REAL-TIME.

S.HIMMELSTEIN & COMPANY

WHAT IS THRUST?

Thrust is an important factor in vertical turbine pumps because it directly affects the performance and reliability of the pump.

Where torque is the force in a rotating direction, thrust is the force or stress in an axial direction. Axial thrust is generated by the internal pressures acting on exposed surfaces of the rotating element combined with the rotor weight. In a standard operation, the net force is downward, and the vertical motors used to drive the pumps are designed for continuous downthrust operation. The thrust bearing—typically in the motor, but in some cases in the pump—is sized to absorb this net force. Excessive axial thrust can cause this thrust bearing to wear faster, run at a higher temperature, and/or fail if overloaded. This results in a higher total cost of ownership by reducing equipment operating life, forcing unexpected downtime, and requiring costly emergency work.

The net thrust force is governed by the hydraulic forces acting during operation, meaning that it will change across the performance curve. At higher flow capacities, the upthrust force generated is larger—lowering the net force or even creating a positive net upthrust—and at lower flow capacities the downthrust is larger.

As facilities age and the needs of customers grow and evolve, the flow required by the system will often change from the originally specified value. This change could be precipitated by a number of factors, such as uprating a plant to meet growing demand or converting existing systems to handle new feedstocks or processes. As a result, users need to operate their equipment at flow rates that are different from the rated design.

Changes in the pump operating point have an impact on both performance and reliability. These changes manifest in more than just differences in pressure and flow; they impact power, efficiency, and ultimately the axial thrust developed during operation. Having real-time axial thrust data can be an important piece of a successful condition monitoring strategy. By monitoring critical pump and motor data, end users are empowered to be more predictive in their approach to maintenance by detecting emerging problems and making the best possible decision for their equipment and plant.

Historically, thrust has been a calculated value based on the impeller design and other pump parameters; this calculation is an approximation and has a margin of error. Axial thrust can be more accurately assessed through testing, but direct measurement of the thrust across the profile of a pump performance curve is not typically performed by OEMs. However, S. Himmelstein has created a thrustmeter that provides users with an accurate and reliable measurement of thrust in their system. Not only does this result in more accurate thrust readings across the range of expected operation during performance testing, thrust can be measured in the field to detect unexpected changes.

> "Himmelstein's Thrustmeter has proven to be accurate and repeatable, which are two of the main things that define quality in an instrument. It's been a reliable instrument to help us differentiate and diagnose areas of failure for our customers"
>
> – Thomas Papadakos, Test Lab Manager, Hydro, Inc.

CASE STUDY

Hydro's certified performance test lab in Chicago tests and measures hydraulic performance on a wide variety of pumps for the aftermarket. A key parameter that is measured as part of that process is power, or input power, to the pump. While power measurements were historically recorded using a kilowatt reading from the motor, the invention of the torque sensor changed that. Because it is mounted directly between the motor and pump couplings, the torque sensor has made it possible to measure the direct power between the motor and the pump. About five years ago, Hydro reached out to the instrument manufacturer S. Himmelstein and Company to supply a torque sensor for use on vertical pumps. "We've used that since then, and it has been a great success in terms of improving the way that we measure power going into vertical pumps," shared Ares Panagoulias, Director of Condition Monitoring and Test Lab at Hydro.

Recently, a power generation end user approached Hydro regarding a vertical turbine pump that experienced multiple thrust bearing failures at low flow conditions. There was a concern that the bearing was overloaded due to an unexpectedly high downthrust produced at that flow rate, resulting in premature failure of the equipment. The downthrust had been calculated by the OEM, but not tested.

Hydro worked with S. Himmelstein to develop and calibrate a new device to measure axial thrust directly. Similar to the way power was being successfully measured directly using the torque sensor. The thrustmeter that was developed accomplishes this by measuring the force between the pump and motor via calibrated strain gauges. A telemetry device allows this data to be transmitted to the Hydro Test Lab's data acquisition system, which also measures parameters such as pressure, flow, temperature, and power in real time. Incorporating this data into the existing data acquisition system allows Hydro to develop a thrust versus flow capacity curve and correlate thrust to any other measured variable. It was also important to provide a sensor that was sensitive enough to capture this measurement while not compromising performance. The sensor's ability to handle loading was also taken into consideration to avoid the risk of sensor damage.

With the calibrated thrustmeter, Hydro was able to reveal that the power generation end user's net thrust at low flow capacities exceeded the thrust bearing's load capacity—directly explaining the source of failure experienced by the end user. This critical information allowed the end user to temporarily modify the minimum allowable flow rate in the system to prevent additional failures. Having thrust measurements across the range of operating flow allowed the end user to make an informed decision on where the minimum flow threshold could safely be established to avoid bearing overload. In parallel, engineering analyses were performed to upgrade the bearing size and allow the system to be operated at the original minimum flow capacity of the pump.

> "Our focus primarily is to make sure that we develop products and offer features in our products that give them technical advantage over the competition. So, they either have better accuracy, better performance, better characteristics than what our competitors offer."
>
> – Steven E. Tveter, Vice President, S. Himmelstein and Company

As expected, having the actual force across the entire flow regime, including runout, shutoff, and minimum flow, provides end users and their partners with the information they need to make equipment perform better and last longer. "What's really cool about this device is that we've seen an immediate impact on not just traditional power utilities, but nuclear power utilities in particular," Panagoulias said. The thrustmeter provides a holistic perspective as to what the axial thrust demands are going to be on a motor or bearing. Armed with accurate and repeatable results, many systemic issues can be identified and solved through engineering expertise.

ADDITIONAL BENEFITS

Thrustmeters have high accuracy in real-world applications, not just in the laboratory environment.

- Thrustmeters can aid in product development research, allowing companies to evaluate the performance of multiple designs.
- In a newly designed pump, manufacturers can measure the actual thrust, just as you would with any other parameter to ensure the pump meets the design specification. For example, if the motor has a known bearing capacity that the tested pump

> "The thrustmeter has taken a parameter that used to be something that was calculated and turned into something that is tested. I think there's a big distinction and big advantage of having actual data versus having theoretical data." – Ares Panagoulias, Director of Condition Monitoring and Test Lab, Hydro, Inc.

exceeds, then the user would have data to show that the pump and motor won't be a good match.
- Thrustmeters can provide in-the-field monitoring to track how the pump is behaving at any given time and detect anomalies that require further investigation

For more information on how thrustmeters can benefit your system, visit himmelstein.com.

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ABOUT S. HIMMELSTEIN AND COMPANY

A manufacturer of torque sensors and signal conditioners in the United States, S. Himmelstein and Company has focused solely on torque since 1960. Himmelstein boasts an expansive product line and a highly accurate knowledge base. Located in Hoffman Estates, Illinois, Himmelstein continues to keep up with advances in technology to enhance and improve its torque sensors. Designing and manufacturing torque measurement transducers and instrumentation with significant advantages over competitive models and enhanced performance under real-world conditions is the company's goal.

Himmelstein's offerings include 200%, 400%, 500% and 1,000% overload models and the flexibility to select sensor mechanical overload, which allows optimal sizing of the sensor to suit the application, even in the presence of peak torques that exceed the average running torque. This ensures the best measurement accuracy for the application.

All Himmelstein torque transducers and instruments with high-level DC analog output voltages have significant electrical overrange (130% to 300% depending on model). This means that the output signal does not clip at full scale. By offering significant electrical overrange, Himmelstein transducers provide accurate measurement, even beyond full scale.

Himmelstein bearingless torque flanges are the best choice for dynamic measurement and control because the high torsional stiffness yields wider installed bandwidth and faster installed response. The company's flanges also feature the industry's highest overrange and greatest isolation from clamping and other extraneous loads, which reduce errors from clipped torque peaks and parasitic loads.

Superior temperature compensation results in sensor temperature performance that greatly reduces errors caused by drive heating and thermal gradients. This level of temperature performance allows S. Himmelstein and Company to offer dual-range torque transducers with high accuracy.

For more information about S. Himmelstein and Company and its products, visit himmelstein.com.

ABOUT HYDRO, INC

Extensive experience across manufacturers, an unwavering commitment to quality, and a focus on reducing life cycle costs have made Hydro a trusted source for comprehensive pump support for over 50 years. As an independent, unbiased company, Hydro is committed to its customers- not a brand.

Hydro's core business of engineered repair and field service is bolstered by a wide range of other services designed to help end users improve their operational efficiency. These services are designed to reduce the total cost of equipment ownership by addressing factors that impact equipment availability, reliability, and performance. Some examples include certified performance testing, field testing and troubleshooting, condition monitoring, system optimization, and expedited parts supply.

Learn more at hydroinc.com.