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Sulzer White Paper



Optimizing vertical suspended
pump performance

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Vertical suspended pumps are used to move large volumes of liquid throughout the water, petrochemical and power generation sectors. The performance of these assets is directly linked to their design as well as installation, both of which have a significant effect on running costs, especially in high-energy units. Using modern manufacturing techniques and maintenance procedures can considerably improve pump efficiency and reliability of legacy units, reducing costs for operators.

The challenge

Water is a vital resource that is used in industry for cooling processes and other non-API (American Petroleum Institute) applications. At the same time, the need to move water between two points for irrigation, drainage or flood control, often sees vertical pumps being used because of the reliability of their design.

However, vertical suspended pumps can be overlooked when it comes to routine maintenance. The reliability of their design means that they rarely suffer from situations that attract attention. Over time, there is an expected gradual decline in efficiency as various components wear, which can be exacerbated if proper maintenance is not carried out.

For example, the operator of a power station was running three vertical cooling water pumps, originally designed as duty, standby and backup. Due to a lack of routine maintenance, the performance of the pumps changed to a point where all three were required to keep up with cooling demand. After retrofitting one of the pumps, it was able to handle normal cooling demand on its own, leaving the other two on standby.

Furthermore, such a durable design means that a typical service life can be several decades, but during this time, the pumping application can change. This means that the best efficient point (BEP) of the original design no longer holds true. Without expert intervention, this situation will remain or deteriorate further, resulting in a preventable increase in operating costs.

Application alignment

Maintaining hydraulic alignment to the application is very important to the reliability and performance of the pump. Operating within a tolerance band either side of the BEP for the pump increases the resistance to failure. Moving away from this region can lead to increased vibration, reduced bearing life, reduced mechanical seal life, increased random failures and a reduction in overall pump life.

A common situation is where a pump has been in service for many years, but during that time the application profile has changed. For example, the flow rate has been reduced, often by using a control valve downstream from the pump. This means that the pump could be operating at less than 50% of its design flow rate, which increases operating costs and affects the service life of the control valve. To compound the situation, any loss in pump performance will go unnoticed; the operator will likely open the control valve slightly to compensate.



The solution is to adjust the hydraulic profile of the pump so that it is better matched to the revised application. This allows the control valve to be used for its intended purpose, rather than as a restrictor, and the pump is able to work close to its BEP. However, making a single change, such as trimming an impeller may achieve one desired outcome but at the same time it could present other challenges, so it needs to be carefully analyzed.

Flow considerations

Operators understand the need to ensure minimum flow at the pump inlet to avoid cavitation, which can quickly cause significant erosion inside the pump. Recycle valves are often used to ensure the minimum continuous stable flow (MCSF) is achieved to protect the pump from low flow damage.

However, all the water that flows through these valves amounts to wasted energy. To compound this issue, these systems are often set up incorrectly and over time this relatively small issue can have significant consequences, such as cavitation damage to the impellers, the exact issue they are designed to prevent.

Operators may replace a recycle valve but not have the knowledge or understanding to ensure it is correctly installed and set up. From that point, the pump that is supposed to be protected, can suffer accelerated wear.

Parts replacement

Even in a pump design that has proven reliability, parts will eventually wear and need to be replaced. At this point it is important to understand the difference between replicated and re-engineered parts as well as how the advances in materials, design analysis and manufacturing processes have enabled new parts to deliver increased performance.

Simply replicating an existing part can lead to reduced efficiency, early bearing and seal failures, as well as increased vibration. Without applying expert design engineering techniques, as-new dimensions are not achieved, the surface finish is below standard and clearances are sub-optimal.

However, by using the original part as a starting point and applying current engineering standards to enhance the design, it is possible to create a new part that has the best hydraulic profile for the application. Using this opportunity to benefit from advances in materials and machining techniques, an optimized component can be developed, that can also improve efficiency and reliability.

Furthermore, minor alterations can also enable improved seal and bearing designs to be incorporated as part of the project, extending service life and reducing maintenance costs.

Sealing systems

When reviewing an original pump design, it is essential that the sealing system is also considered. While packing has been the predominant design in the past, it still very much has a place in today's pumping applications. When correctly maintained, packing supports the shaft radially, dampening vibration and promoting longer bearing life. Packing offers an effective sealing method for non-hazardous fluids but requires continuous maintenance intervention to tighten the packing gland and replace worn packing rope. Packing also damages more expensive pump components creating a more expensive pump repair. Depending on the application, innovations such as Sulzer's Liqui-Seal™ or mechanical seals offer substantial benefits in terms of operating expenditure.

The Sulzer Liqui-Seal is a zero maintenance alternative to packing and mechanical seals that can be retrofitted in any OEM's vertically suspended pump. This option also increases radial shaft support to further dampen vibration and protect bearing life. This seal system is designed to last the life of the pump bearings, meaning no maintenance is required until the pump needs to be refurbished.

Mechanical seals are another alternative to packing that can reduce maintenance intervention significantly and virtually remove leakage, but switching to a mechanical seal carries an important risk to include in the evaluation process. Increased vibration related failures have been documented often on vertically suspended pumps that switch from packing to a mechanical seal because this alternative does not support the shaft radially. Before making the switch, finite element analysis (FEA) from a company like Sulzer can identify vibration risks and provide options to mitigate these in a retrofit project.

Extending bearing performance

In many cases, the wear in the bearing system determines the maintenance program for the pump, so the choices that are made at this point can have significant consequences for the future. Taking advantage of composite materials can help to protect against dry running, as well as offering improved anti galling properties and corrosion resistance.

Each installation has an optimal bearing design, including the lubrication technology that is employed. Some situations, such as dirty water applications, are better suited to bearing tube enclosures, which provide clean lubrication to lineshaft bearings. However, this system requires regular maintenance and there is an increased risk of dry running bearings.

Other situations may perform better using product lubricated bearings. This is now a standard design for most vertical pumps and the bearings are maintenance-free. Due to the improved material technology in these components, this design is commonly specified in abrasive applications.

Specialist metal repair

In these more challenging environments, legacy equipment can benefit from the application of modern coatings, since some of the older materials may not have adequate properties to withstand the modern-day operating conditions. Minimizing oxidation and corrosion rates is an important step in reducing downtime as well as expenses for maintenance, improving productivity and the asset's return on investment.

Solid and liquid particle erosion or fretting wear can be minimized by using coatings that increase the hardness of the protected material surface. Stellite, chrome-carbide and tungsten-carbide are examples of hard face coatings and have a hardness value in 50-60 HRC range. Additionally, metal spray processes can be used to improve or restore original dimensions and save significant expense by reconditioning the existing components instead of replacing them altogether.

For pumps that are expected to operate around the clock, on-going processes such as erosion, corrosion and galling are to be expected. In some cases, these may have been caused by changes in the application, or they were a foreseen consequence that needs to be remedied as part of the planned maintenance routine.

Improving durability

Today, there are a number of techniques for applying layers of new metal to an existing component to restore dimensions and improve performance. Four of the most popular are:

- High velocity oxygen fuel (HVOF)
- Chemical vapor deposition (CVD)
- Plasma spray
- Direct laser deposition (DLD)

Deciding on the most appropriate solution depends on the application, the type of damage and the design of the original component. Each process has specific capabilities and advantages that can extend the service life of components as well as improve their durability.

Different coatings have slightly varied bonding properties with different substrates, so it is essential to understand the conditions required to achieve a suitable bond. A coating's bond is one of the most critical aspects of its success in service. As such, it should be in focus during all processes associated with coating.

Furthermore, the remaining range of properties of the finished coating must be sufficient for the application – the hardness value is an indicator of the proper application of wear coatings while the surface roughness will have a major impact on flow efficiency. By inspecting the micro-structure and mechanical properties of the coating it is possible to verify that it was applied to required specifications and that it will provide all of the expected benefits in operation.

Identifying concentricity

Having repaired or refurbished a vertical pump, reassembly and installation must be completed in such a way that all the components line up correctly and the tolerance stack up for concentricity is acceptable. It is possible for individual components to pass inspection but still have an alignment issue, which can cause vibration, excessive bearing wear and seal failure.

Similarly, the re-installation of the pump must ensure a perfectly perpendicular position. Anything beyond approximately one thousandth of an inch per linear foot out of true can affect performance and reliability. In older installations, it may be prudent to use an engineered sole plate to simplify maintenance operations and reduce the time required to complete the installation process.

Throughout any vertical pump maintenance project, it is essential to establish continuous communication with the team carrying out the work. Their expert knowledge can improve existing installations and offer solutions for improved efficiency and reliability. In many cases, there will be more than one option and it is important to understand the costs and benefits of each.



Conclusion

The design of vertical suspended pumps makes them ideal for round-the-clock service. However, their inherent durability can mask drops in efficiency, which can continue unnoticed without expert intervention.

Having identified a concern, delivering the most cost-effective solution that will improve performance takes experience as well as technical expertise. At the same time, taking advantage of modern materials and implementing cutting-edge designs can reduce energy consumption while boosting durability.

When performing maintenance or considering changes in pump design to better match an application, it is important to consult with a pump original equipment manufacturer (OEM) such as Sulzer. They will be able to provide a solution and apply computational fluid dynamics (CFD) analysis if necessary, to highlight any other changes that may be needed to ensure efficient and reliable operation. Any design alteration needs to consider all aspects of pump operation for the project to be considered as a success and this is best achieved through close collaboration with a trusted engineering partner.

About the authors:

Dave Clarke is a Regional Sales Manager with 20+ year experience supporting various Canadian markets. He has been with Sulzer for the last few years and brings a focus of reliability through Engineering and field support to enhance the experience.

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