The Top Ten Pump Problems You Can Solve with One Small Change

By Robert Aronen, Boulden International

Pumps fail for dozens of reasons. No single change can eliminate all pump failures, but one small change can help to make your pumps more reliable, efficient, and safe. The change can take place at the time of repair and does not require any other modifications to your installation.

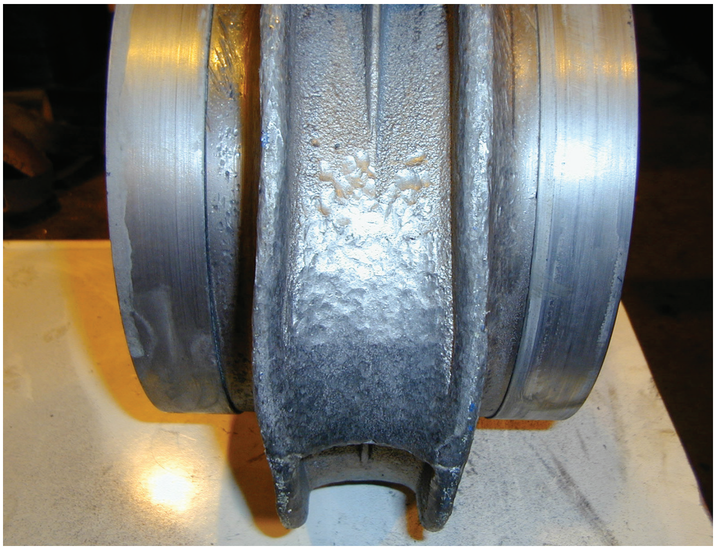
That change is to upgrade the stationary wear components (wear rings, shaft bushings, throttle bushings) to the composite material DuPont™ Vespel® CR-6100 and reduce the internal running clearances within the pump. The rotating parts remain whatever metal you are currently using with the same surface finish you currently use. Long term studies of this upgrade have shown that this small modification can double the life of "bad actor" pumps (see Aronen/Russek 2011).

Once the upgrade is complete, the metal-to-metal interfaces within the pump are eliminated and replaced by metal-to-composite interfaces. The metal-to-composite interfaces do not seize, minimizing the risks associated with metal-to-metal contact in the pump. Because seizure risk is minimized, clearance at the wear interfaces can be significantly reduced, improving pump reliability and efficiency.

Here are the top ten pump problems this upgrade will help you solve:

1. RUNNING DRY

In a perfect world, pumps would not run dry. The reality of many applications, however, often creates a dry-running situation. Tanks need to be emptied, light products vaporize, and sometimes debris (or a closed valve) blocks the pump suction. In these situations, metal wear components can seize and cause severe damage. Conversely, Vespel CR-6100 wear rings can survive running dry for significant periods of time, minimizing damage to pump internals. In some cases, the pump can continue running without repair.



2. PUMP SEIZURE

Pumps running dry is only one cause of pump seizure. A wide range of off-design conditions can also lead to high-energy pump seizures. Foreign objects can enter the pump, low flow operation can cause excessive shaft deflection, or fatigue stresses can cause a shaft to break. Again, a pump with metal wear components runs the risk of seizure and excessive damage. Replacing the wear components with Vespel CR-6100 mitigates the damage under such scenarios.

For example, in the photos a piece of metal is lodged in the impeller of the pump, causing extreme vibration. Operators immediately shut down the pump and switched to the installed spare. Fortunately, the pump had been rebuilt with composite case rings, which did not seize. The rotor spun down, the seals did not leak, and the plant continued to operate at

About The Author

Robert Aronen is the managing director (Europe) and rotating equipment engineer for Boulden Company and can be reached at **robert@bouldencompany.com**. For more information, visit **www.bouldencompany.com**.

full capacity. Even after being exposed to such extreme loads, the composite rings were intact with minimal wear.

3. GALLING DURING ALIGNMENT

Although less dangerous than a full pump seizure, pumps that gall during alignment can be a major annoyance. The most common type of pump to experience this problem is a horizontal multi-stage pump. These pumps rely upon the wear rings to create hydraulic forces that "lift" the rotor once the pump is running at full speed. While the rotor is being turned during alignment, the rotor experiences shaft sag, which often causes the center-stage bushing and middle-stage wear rings to contact. During this contact, some metals will gall, cause the rotor to stick, and require a return trip to the maintenance shop for disassembly, cleaning, and rebuild. Alternatively, small particles can enter the tight clearance between the wear rings, pick up a piece of metal and roll it like a snowball until it causes the rotor to gall during alignment. Using Vespel CR-6100 stationary wear components essentially eliminates this risk by eliminating the metal-to-metal contact points in the pump.

4. CAVITATION

In classic pump cavitation, the net positive suction head available (NPSHA) is less than the net positive suction head required (NPSHR). Sometimes, the problem can be easily solved by raising the level in the suction tank or making other small modifications to the suction system. Unfortunately, the easy fixes are rarely available. More commonly, the choices are a complete redesign of the suction system, a hydraulic rerate of the pump, or a complete replacement of the pump.

In this evaluation, the wear rings are often overlooked, but they shouldn't be. The NPSHR for a pump is directly related to the wear ring clearance. Reduce the wear ring clearance and the NPSHR is reduced. Increase the clearance and the NPSHR increases. Worn out pumps that have been in service for many years begin to cavitate because their wear rings are worn out.

By upgrading the wear rings, you can dramatically reduce the wear ring clearance to 50 percent of the API610 minimum values and reduce the NPSHR of the pump. The magnitude of the change is a function of the pump specific speed and the percentage by which the clearance can be reduced. In many situations, the extra margin from tighter wear ring clearance is all that is needed to avoid pump cavitation.

5. SUCTION PROBLEMS AT START-UP

Directly related to cavitation is the ability of a pump to achieve suction at start up. There are many services such as hot water condensate, LPG, LNG, and other flashing hydrocarbons where pumps can fail to achieve suction at start up because the process fluid vaporizes. This can cause the pump to run dry (see problem #1), cause premature wear of the wear components (see problem #9), or cause repeated efforts to start and stop the pump until it runs. Reducing the wear ring clearance significantly improves the ability of a pump to achieve suction at start-up due to the reduction in NPSHR.

6. MECHANICAL SEAL FAILURES FROM EXCESSIVE SHAFT DEFLECTION

Many older pump designs, and some new pump designs, incorporate a long, slender shaft. During operation, the thin shaft can deflect, putting undue stress on the mechanical seal, leading to premature seal failures.

The wear rings have a powerful impact on shaft stiffness through hydraulic forces called the "Lomakin Effect." In short, when you reduce the clearance of wear rings by 50 percent, the stiffness and damping forces from the Lomakin Effect double. This leads to lower shaft deflection, and more reliable mechanical seals.

In a long-term study of pumps at a refinery using Vespel CR-6100, seal leaks in volatile organic compound (VOC) service were reduced by 60 percent. The twelve pumps in VOC service required monthly emissions testing to comply with local environmental regulations. Before the composite wear rings were installed, the testing detected an average of six leaks per year. After the installation with reduced clearance, testing detected an average of two leaks per year.

7. HIGH VIBRATION

The Lomakin Effect described above also reduces overall pump vibration levels. In the same long-term study, the overall vibration readings from twenty-five horizontal pumps were tracked for one year before the conversion to the Vespel CR-6100 composite and for 4.5 years afterwards. The average reduction in vibration resulting from the upgrade was 25 percent, and this improvement persisted for the full 4.5 years. Some of the pumps experienced vibration reductions by as much as 50 percent.

8. POOR EFFICIENCY

Pump wear rings also act as the "seal" between high pressure and low pressure areas in the pump. Reducing the wear ring clearance reduces internal recirculation within the pump and improves pump efficiency. For a typical process pump, the efficiency gain from a 50 percent clearance at the wear rings will be in the range of 2 to 5 percent. Where the internal clearances can be reduced by more than 50 percent, efficiency gains can be substantially higher. For a pump running near its limit, this added efficiency can help achieve full production rates.

For example, a fertilizer plant in Alberta upgraded their wear rings, inter-stage rings, and throttle bushings of a nine-stage boiler feed water pump to Vespel CR-6100 and reduced the clearance to 50 percent of the API610 standard for metal wear rings. This change allowed the plant not only to run at full load with one pump but to do so with a 5 percent reduction in power usage.

9. EXCESSIVE CLEARANCE AT WEAR RINGS AND SHAFT BUSHINGS

Pumps are often supplied with materials like bronze or cast iron for wear rings or shaft bushings. These materials are often chosen because they are cheaper and resist seizing somewhat better than stainless steels. The cost, though, is a high wear rate. High friction from metal-to-metal contact at the wear parts opens the clearance and within a short time, the pump is running with low efficiency, high vibration, and lower reliability.

Vespel CR-6100 exhibits a very low wear rate running against a rotating metal component. The wear rate is reduced because it has a very low coefficient of friction, high load carrying capability, and exceptional dimensional stability. When contact occurs between the rotating and stationary parts, there is lower friction and less wear. The pump runs longer, with higher efficiency and a lower life cycle cost.

10. LIMITED MATERIAL SELECTION DUE TO CHEMICAL COMPATIBILITY PROBLEMS

Some pump services significantly restrict the materials which can be used for the wear components. It is not uncommon for strong acids or other chemicals to restrict the metal parts to a single alloy. For example, in hydrofluoric acid, wear parts are almost universally made from Monel.

This situation creates a unique challenge because when the rotating and stationary wear components in a pump are made from the same material, pump seizure is a significant risk. This is often avoided with increased clearance, which as you understand by now, significantly reduces the reliability and efficiency of the pump.

Vespel CR-6100 is made from Teflon® PFA resin and carbon fibers. With this composition, it is chemically compatible with nearly all process fluids used in industry. Furthermore, because of DuPont's patented manufacturing process, the material possesses exceptional dimensional stability. This unique combination of properties replaces metal alloys, carbon or graphite components, filled PTFE components, or polyetheretherketone components in nearly any kind of rotating machine.

CONCLUSION

While no single change can eliminate all causes of pump failure, some changes offer significant upside across a broad range of services. Changing the stationary wear components in a pump and reducing the clearance addresses many causes of pump failure, while increasing the pump efficiency and safety. With the material properties of Vespel CR-6100, this upgrade can be considered for nearly all non-slurry services within the temperature range of -325 to 500 degrees Fahrenheit (-200 to 260 degrees Celsius).

In conjunction with reduced clearance, maintenance personnel will want to review pump rebuild practices to ensure adequate rotor concentricity so that the rotor retains freedom of movement within the pump case. The standard check is to turn the rotor once the repair is complete. If the pump in question is a long-shaft vertical pump, the rotor should also be free to move after the pump has been coupled in the field. With proper rebuild practices, tight clearance, and Vespel CR-6100 stationary wear parts, plants all over the world have experienced significant reliability gains. ■