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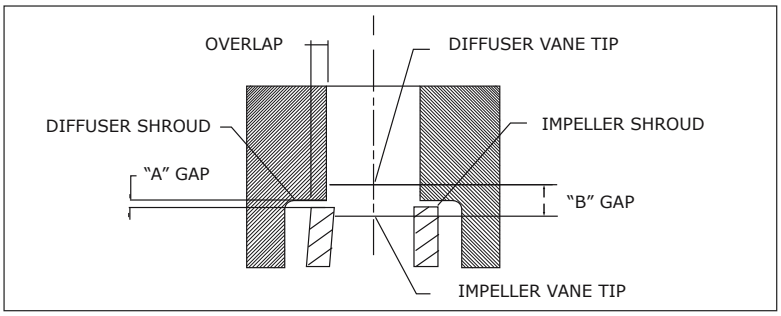
General processing

Cooperation helps to eliminate pump failures

Pump failure is an expensive problem. Not only does it cost money to have the pump repaired, but there is also the loss of productivity and resulting impact on the business which has suffered the failure. Following the failures of two Worthington 10-stage split case diffuser style pumps, engineers at a hot strip mill enlisted a new repair provider. The resulting improvements saved their company thousands of dollars in rebuild costs.

When a hot strip mill experienced failures in its Worthington 10-stage split case diffuser style pumps, the results were costly: each rebuild was put at approximately $85,000 when failure of seals, bushings and shafts made it necessary to rebuild the pumps every 18 to 24 months. Additionally, difficulties in running the two pumps supplying hydraulic pressure to the coiler resulted in reduced production and made for a higher scrap rate.



Hydro's Drawing of A Gap, B Gap and Overlap (Image provided courtesy of Hydro Inc.)

So the mill's engineering team looked for a new repair provider and selected Hydro Inc, the engineering pump rebuilding company from Chicago, to apply new technology to the pumps, using Graphalloy, a self-lubricating graphite/metal alloy bearing material manufactured by the Graphite Metallizing Corporation. Hydro implemented engineered upgrades including A and B gap modifications, rotor centralisation and manufacture of new impellers and diffusers. Following its work at the steel mill, it is estimated that the mill has saved over $250,000 in potential rebuild costs.

Prior to the steel mill selecting the Chicago-based company, it was found that the seals of the Worthington WT-810 split case pumps, which are designed to produce up to 1,400 PSI fluid pressure (with two split mechanical seals were originally used in the coupling and thrust ends of the stuffing box) would wear prematurely and would have to be replaced every six months.

The bronze bushings used on each of the ten stages failed every 18 to 24 months, and required a full element rebuild. The steel mill also experienced four broken shafts in one pump over the course of two years. Hydro's engineers determined that this most likely occurred because the seals ran dry under various operating scenarios, and when this happened, they failed quickly. As a result of these failures, the two pumps that supplied hydraulic pressure to the coil ran inconsistently, resulting in lower than optimal production and a higher scrap rate.

New approach needed

A new approach was required to address the problem's root cause, and after the mill contacted it, Hydro performed an inspection referred to as 'rotor condition analysis'. This involved a review of field operating conditions including vibration, temperature, flow and past repair history.

This was followed by a thorough dimensional study to determine the physical condition of the pump. This analysis provided sufficient evidence to understand the pump's problems and would serve as the basis for solving its performance issues.

Engineers from the Chicago company worked with the mill's maintenance staff to identify the root causes of the pump failures, and it was found that the previous material used for the stuffing box seals and diffuser bushings performed well when fully lubricated but failed quickly under run dry conditions. Because there was no way to prevent the pump from running dry under certain operating scenarios, a new bearing material was key to solving this problem.

Hydro's engineers also noted that the pump was being operated off its best efficiency point, close to shutoff, causing axial shuttling and hydraulic instability. The report additionally noted that the previous repair shop had provided a shaft manufactured from incorrect material and had not used accepted manufacturing techniques. This caused stress risers to occur in the threaded areas leading to shaft failure. After years of operation, there was also deterioration in the pump's base plate and

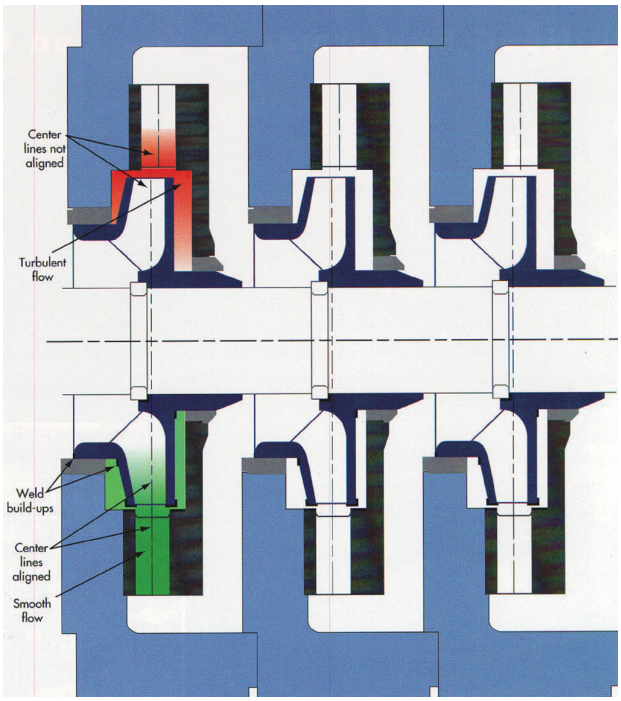
foundation as well as leaks throughout the piping system causing pressure drops which, in turn, contributed to the overall instability of the pump while in operation.

Hydro recommended upgrading the stuffing box and diffuser bushings to Graphalloy because of its run dry capabilities. Graphalloy is a graphite/metal alloy with enhanced chemical, mechanical and tribological properties. This self-lubricating bearing material survives dry starts, flashing and loss of pumpage for prolonged periods without damage and allows immediate restarts.

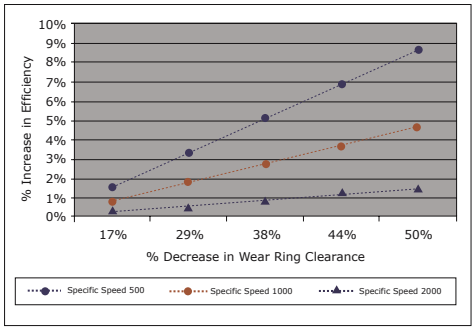
The material provides a constant, low coefficient of friction rather than just a surface layer, helping to protect against catastrophic failure. Graphalloy wear components also improve reliability under conditions such as low-speed operation, frequent starts and stops, and switching from standby to continuous running.

Hydro's engineers recommended changing the A gap (between the impeller vane tip and diffuser shroud) and B gap (between the impeller shroud and impeller vane tip) to reduce turbulent flow in the pump, increase rotor stability, and reduce axial shuttling and vibration. The company's team performed rotor centralization, a process they pioneered involving centering the rotating impellers within the stationary diffusers and volutes. Hydro also manufactured new impellers and diffusers using upgraded materials. The impellers were upgraded from bronze to high-grade special stainless steel. The diffusers and return channels were upgraded from cast iron to high-grade special stainless steel.

The company also manufactured a new shaft using the proper grade of stainless steel. The maintenance department at the mill worked with its application engineering team to develop recommendations for structural changes to the pump's mounting and to relieve piping strain.



A detailed dimensional inspection is performed by Hydro to establish the centerline relationship of stationary and rotating components. (Image provided courtesy of Hydro Inc.)



*Bloch, Heinz; Geitner, Fred: *Major Process Equipment Maintenance and Repair*, Gulf Publishing, 1985, P.32

Quantitative results of Hydro's upgrades.

Rebuilding the pump

Hydro utilised stringent practices in rebuilding the pump. Tighter fits and tolerances were achieved to improve pump efficiency. Precise manufacturing and balancing techniques were used to achieve a rotor balance of less than 1W/N (W = component weight and N = pump rotating speed) to reduce vibration thereby extending the life of the pump. The maximum shaft total indicator reading (TIR) was held to 0.001 in which is more stringent than the industry standard of 0.003 in TIR.

Because Graphalloy is non-galling, pumps can be designed with tighter clearances. Hydro was able to reduce the clearances between the bushings and shaft sleeves to 0.005 in or 0.0025 in per side. Pump elements were assembled in the vertical position to accommodate the much tighter assembly tolerances. It took checked the balancing the coupling with the rotor. Since even a perfectly rebuilt rotor cannot operate as intended if there are issues with the pump's casing, Hydro inspected the casing and performed split line and line boring to restore the entire casing fits.

The project has surpassed the expectations of the mill's management team, and the Graphalloy stuffing box and diffuser bushings have lasted through two six-year pump rebuild cycles without any failures. When the pumps were disassembled during the scheduled rebuilds, only minimal wear was observed on the seals and bushings. The bushings and seals were replaced although they could have easily lasted many more years.

The mill has estimated the design improvements have saved a quarter of a million dollars by avoided three rebuilds over six years, and that it has achieved improved reliability that eliminated lost production time. The rebuilt pump is now considerably more efficient resulting in reduced energy consumption. The pump requires substantially less maintenance, providing additional cost savings.

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