



Engineering Pumps for
Better Performance and Longer Life



Full Refurbishment for Island Refinery



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The process of reopening the plant had uncovered more than 500 pumps that needed considerable refurbishment and repair. The most important of these was a critical jet pump used for hydraulic decoking. It was badly damaged and sent to the original equipment manufacturer (OEM) for inspection. The OEM recommended that the refinery replace most of the pump parts, as well as a costly repair that would require 35 weeks to rebuild.

Viable alternative

Instead, the refinery sent the pump to global aftermarket pump service provider, Hydro, Inc. in Chicago, where it was refurbished for just over half the cost of the OEM proposal. The time involved was also significantly improved to just eight weeks by using a non-destructive evaluation and rebuild process at a 46,000 ft² facility where Hydro develops and implements engineering modifications for improving the performance of critical pumps and then verifies that performance in their Hydraulic Institute certified test lab.

Significant reopening

The original refinery opened in the mid-1960s. In the early 1970s, it was re-rated at 650,000 barrels per day. It had been one of the largest refineries in the western hemisphere, so the impact of reopening the plant would be significant. In this case, Hydro was tasked to work with the critical highenergy pump to prepare for its reopening. The new owners began the process two years ago and it is expected that the plant will be open for operation in the first quarter of 2020. Once restarted, the plant will be able to process up to 210,000 barrels per day of oil, a fraction of the 1,500- acre (607-hectare) plant's peak capacity in the 1970s of 650,000 bpd.

When the plant was shut down, the pumps and other equipment in the refinery were either left in place or went into storage where they were kept in poor condition. Time constraints prohibited proper preventative maintenance before the refinery shut down. The tropical climate is hot, salty, humid, oppressive, and several hurricanes occurred during this time. All of these extreme conditions can contribute to the deterioration of heavy rotating equipment. Over the course of the year, the temperature typically varies from 72°F to 88°F and is rarely below 68°F or above 90°F.



Decoking pump





The pump is a high-energy barrel multi-stage pump that is used in a decoking operation. A delayed coker is a type of coker whose process consists of heating the residual oil feed to its thermal cracking temperature in a multi parallel pass furnace. This cracks the long-chain heavy carbon and hydrogen molecules of the residual oil into coker gas oil and pet coke. Cracking begins in the furnace, continues in the transfer line and finishes in the coke drum. The final product at the end of the process is coke.

The purpose of the decoking system is to provide a high pressure, high-velocity water jet to break up coke from the coker drum into pieces small enough to be washed out of the bottom manway of the drum. The jet pump provides high-pressure water flow to cut the coke out of the decoker drum.

The challenge

When the new owners of the refinery decided to restart the plant, all the pumps needed to be examined. While hundreds of these pumps were sent to several of the pump service provider's facilities throughout North America, the most critical project was the decoking jet pump. After taking it through the non-destructive evaluation, it was determined that everything could be saved except for the shaft.

For the decoker pump, coke fines and water mixed together to create a highly acidic layer on the element. The element itself was also very old and had already suffered significant wear and tear, including:

- The shafts which had major corrosion;
- The impellers had corrosion and cavitation damage;
- The pump cover/casing also had erosion damage;
- The bearing housings needed cleaning;
- The bearing housing discharge head needed modification;

If they had placed the pump into installation, it would have failed immediately upon start-up (Figure 1).

The solution

The pump was delivered to Hydro's facility in Chicago, where the nondestructive evaluation of the barrel discharge head and the rest of the components was performed. It was determined that the equipment was repairable.

A forensic analysis was also performed to understand why there was so much corrosion and erosion on the pump parts. The impellers and covers were reverse-engineered in order to evaluate them and make them to its original shape.

The following steps were taken to correct the issues:

- The shafts were replaced by going forward with a 410 forging instead of a rolled shaft so that the denser structure would avoid sagging;
- Using Direct Laser Deposition (DLD) laser cladding, the impellers were reversed engineered and then welded in order to fix the damage;
- The bearing houses needed to be cleaned and checked for parallel, concentricity and perpendicularity. The bearing housings' discharge also had to be modified from the discharge



head by cutting the carbon steel off the back and inserting some 309 stainless steel to prevent corrosion;

- The barrel itself needed to be set up and machined to remove the corrosion from the high-velocity areas. A weld overlay 309L was also used through laser DLD;
- The areas around the ring have been modified so the pump can now run hard-on-hard through the rings;
- The covers of the pump were also reverse-engineered. The diffusers in the return channels were in very bad shape. Those areas were welded to improve their condition, but should the need arise, the files are available to create an emergency part for installation/repair.

Improving durability

The Direct Laser Deposition (DLD)/ Laser cladding processes have the ability to create superior surface properties on critical clearance parts, improving pump reliability and durability. The DLD welding process metallurgically bonds a metal powder to the base material. Due to a controlled and localized heat input, this process can be applied to various base metals without distortion or the need for post-weld heat treatment.

This process improves pump reliability, reduces the chance of galling and reduces the chance for cracking. It significantly increases mean time between repairs, improves the life of wear parts and maintains performance and efficiency. It restores worn pump components, repairs them to "as design" geometry, upgrades to superior surface characteristics and salvages used parts that would otherwise be scrapped (Figure 2). The corrosion was machined out of the barrel and then a $\frac{1}{4}$ -inch thick layer of 309 stainless steel was inlaid.

As part of the extensive pump repair, Hydro executed pump performance testing services at its 5,000 horsepower test facility located in Chicago (Figure 3). The testing services included a Hydraulic Institute certified pump performance test, a mechanical vibration test, and an assessment of the pump's balance line flow and pressure conditions.

The pump performance test consisted of operating the pump from its maximum flow capacity, to its best efficiency points, to its rated operating condition, all the way to its minimum flow rate with several additional test points in-between. During the performance test, flow capacity is measured along with differential head and pump input power. With these two pump performance characteristics determined, the pump efficiency can be calculated and determined for each test point.

During the performance test, mechanical vibration data was also measured and recorded. The pump vibration report included overall vibration levels and Fast Fourier Transform (FFT) plots showcasing the primary excitation frequency of the observed overall vibration. By measuring the overall vibration levels and the excitation frequencies, the service provider can verify the pump's mechanical performance before sending the pump into the field for installation.

The results

The equipment remains in its hot, salty, humid environment, but the rebuilt equipment with proper



maintenance could run smoothly for another six or eight years.

The biggest problem with this kind of pump is the process it is in. As the coke is blasted out of the drum, the water recycles back into the pump. Coke fines can be abrasive and have a tendency to worn out the pump badly, causing a lot of abrasion on the rings and on anything that's rotating.

Rather than replacing the pump, it was able to be refurbished for just over half the cost and in considerably less time. Over 200 pumps were also refurbished by Hydro and have been shipped back to the customer; all with different levels of damage.

The solution ensured that the refinery did not have to extend the shutdown of its facilities or delay the reopening procedures due to not having the critical pump on hand. Further, the metallurgical upgrades and modifications mean that the equipment won't have to see the same degree of damage as they did before.

Source: <https://www.worldpumps.com>