Case Study

ITT Pump Recovers Energy for Industrial Gas Supplier

In an air separation process at a major manufacturer of industrial gases, the company was reducing the pressure in a cooling water stream with a pressure let-down valve. This provided an opportunity to install an ITT Goulds brandprocess pump, run it backwards as a turbine, and recover some of the available energy.

Air Products and Chemicals, Inc. is the world's only combined gases and chemicals company. In their Baytown, Texas facility, Air Products operates a world-scale air separation plant to supply customers with oxygen requirements as well as other gaseous and liquid products to serve local markets including nitrogen and argon. The Baytown facility produces 2,600 tons of oxygen per day.

As part of the gas production process, the Baytown facility uses an air separation unit which takes atmospheric air and splits it into its component parts; being nitrogen, oxygen and argon. Each of those products is sold to customers either through pipeline or tanker truck.

The air separation process is a cryogenic distillation process. Compressed air is liquefied and put through a distillation process where the different weights of the oxygen, nitrogen and argon molecules allow the raw air feedstock to be split it into its component parts.

Pressure Reduction Provides Energy Recovery Opportunity

As part of the process, a large centrifugal compressor, known as the Main Air Compressor, sends pressurized air into a direct contact aftercooler (DCAC) at a discharge pressure of approx. 70 psig. The DCAC is essentially a large vessel where the air flows in at the bottom and exits at the top. Cooling water is injected into the vessel with one of two ITT Goulds brand 3196 pumps, at a rate of approximately 3900 gpm. Within the DCAC, the water and the air have direct contact, which cools the air prior to being sent on to the cryogenic distillation process. After contact with the air, the water drains from the bottom of the

Seen here is the overall installation at Air Products including the 3196 chemical process pump from ITT's Goulds Pumps brand.

DCAC where it is let down across a pressure (level) control valve back down to about 15 psig, which is the back pressure of the facility cooling tower.

Letting down the water pressure from 70 to 15 psig provided an opportunity to recover available energy from the water stream. Kevin Leigh, rotating equipment engineer for Air Products in Laporte, Tx. explained that where previously the water was let down across the control valve it is now let down across the turbine, thereby giving valuable power recovery.

Hydraulic Turbine Selection / Testing

With many pump products from ITT running throughout the plant, Leigh contacted ITT to see if they could supply a suitable pump, operating as a hydraulic turbine for this application. Gene Sabini, director of new product development at ITT's Goulds Pumps unit recalled, "I looked at the numbers, modeled it and found an existing 3196 chemical process pump that could do the job. I gave the customer conservative numbers and devised a way - because the pump is operating in reverse - to keep the impeller on the shaft using a key system." The original performance curve dur-

ing testing showed that the predicted power recovery of the turbine would be 85 bhp.

Before the turbine was delivered, a performance test was carried out at the Goulds, Seneca Falls factory. The test was useful for validating the predicted performance curve.

To implement the turbine into the process in an economical manner, it was decided not to attach a separate generator to the turbine. This eliminated the cost of the generator with all of the associated installation costs. The existing DCAC circulating pumps, ITT's Goulds brand 3196 pumps, utilize 200 hp induction motors. During the installation of the turbine, the motor on one of the two pumps was removed and replaced with a double shaft extension motor. The turbine was then connected to the rear shaft of the motor. This arrangement uses the turbine to partially unload the motor.

The system at the Air Products plant is continuous, running 24 hours a day. An initial performance summary of the turbine shows that the turbine power recovery is at 93.5 bhp, at a turbine DP of 52 psi. This performance was determined by measuring the motor current without the turbine, and then again with the turbine installed, also taking into account the motor efficiency and power factor at the two different loads. "ITT's initial performance curve predicted the power recovery would be 85 bhp, so we appear to be well above that, approximately 10% higher," noted Leigh. This may be due to entrained air expanding as it passes through the turbine. The circulating pump motor still has to supply some power, but the turbine is unloading the motor and it is drawing less current, so Air Products ends up with a power savings. On a yearly basis, using a power cost of approximately 4 cents per kW hour, Air Products estimates that they are saving about $24,000 per year in energy costs. The original estimated payback time for the project was 2.4 years. However, with the slightly higher actual power recovery, the payback is closer to 2.1 years.

It was found that fabricating a reducer with a long, tapered section would minimize the pressure loss through the reducer, making more pressure change available to produce power in the turbine.

Piping Analysis Aids in Energy Recovery

Because the air separation process could not be shut down during installation, the piping scheme was fairly complicated. A major concern with the piping was to make as much of the 55 psi pressure difference available to the turbine for recovery. Any flow restriction across the line would reduce the pressure drop available for the turbine. In the operating curve for the turbine, at the normal operating point, the turbine will handle about 3,700 gpm, which leaves several hundred gpm passing through a bypass valve. "If you start dropping the DP across the turbine, you can easily get to a point where you have no power at all coming from the turbine," said Leigh. "Because of the shape of the flow/head curve, if we were to drop the DP down to about 42 psi, you would have about 1800 gpm flowing through the turbine and we would get zero

power." With an 18 inch diameter inlet pipe that needed to be reduced to an 8 inch diameter for the turbine inlet nozzle connection, it was found that using standard concentric reducers would create too much of a drop in pressure. Using pressure drop theory and calculations, it was found that fabricating a reducer with a long, tapered section would minimize the pressure loss through the reducer, making more pressure change available to produce power in the turbine.

In summary, the hydraulic turbine retrofit project has been very successful for Air Products. According to Leigh, "Thanks to all involved at ITT, we have improved on the project payback period that we developed in our original project cost justification."