Canal Pump Lift Station Modernization

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Abstract. *Case study of the Orchard Mesa Irrigation District's replacement of an old vertical turbine lift pump, and incorporating new technology in the station. Upgrading the pump station required a new: 75 horse power pump, 480 volt electrical service, a VFD, and a water level spread spectrum telemetry link. The new pump station has increased pumping capacity, improved the water delivery service to the growers, and has the potential to conserve both water and energy for the irrigation District.*

Keywords.

Grand Valley, Orchard Mesa Irrigation District, Colorado, Colorado River, Bureau of Reclamation, pumps, irrigation pumps, vertical turbine pumps, variable frequency drive, variable speed drive, water conservation.

Introduction.

The Orchard Mesa Irrigation District (OMID) is in the Grand Valley. The OMID is located south of the Colorado River and East of the junction between the Gunnison and Colorado Rivers, in Western Colorado. The OMID is part of the Bureau of Reclamation's Grand Valley Project. Irrigation water is transported to the OMID lands through the Orchard Mesa Power Canal, which transports 800 CFS to a Reclamation power plant and the OMID's hydraulic pumps, which serve 9,000 irrigated acres.

The Vinelands is a part of the OMID that straddles the Power Canal, before the canal reaches the power and pumping plants. One-hundred-sixty acres of trees and vines are located above the Power Canal. This acreage is served by a canal-side pump station and piped lateral.

Operation. The canal-side pump is referred to as the Vinelands Pump. The pump lifts water 103 feet, through a 12 inch diameter, 3,000 foot pipeline, to a concrete stand-pipe. The stand-pipe is the start of a three-mile gravity pipe lateral that supplies water to 160 acres of irrigated land.

The historic operation was to run the 60 horse power, 3 phase, 230 volt canal side pump continuously throughout the seven month irrigation season. About 3.3 CFS was continuously pumped from the canal to the stand-pipe. The gravity piped lateral from the stand-pipe to the farms, is a demand delivery system. There are no water orders and no limits on the duration of water deliveries. The delivery rate is somewhat controlled by the size of the on-farm irrigation systems. There is no standard water delivery measurement system on the lateral.

During low irrigation demand on the system, the quantity of water pumped exceeded the demand. The stand-pipe spilled into an overflow pipe that returned the excess water to the Colorado River. In normal operation the stand-pipe maintains a head on the lateral pipe, and no water is spilled to the river. When peak demand exceeds the 3.3 CFS delivered from the canal pump (9.2 gpm/acre), the water level drops in the stand-pipe and air enters the lateral pipe. The farm deliveries on the upper end of the lateral pipe loose their water. The ditch rider then negotiates with the users on the lower end of the lateral pipe to reduce their demand on the system, so that the upper end deliveries can resume. Under this operating strategy the pump was running in the service factor continually, and both the pump and motor had been rebuilt numerous times.

Modernization. The plan involved the replacement of the pump/motor combination and adding a Variable Frequency Drive (VFD) to maintain a somewhat constant water level in the concrete stand-pipe. The hydraulic calculation indicated that a two stage 75 horse power vertical turbine pump, with a 3.8 CFS maximum discharge (10.7 gpm/acre) would provide sufficient irrigation flexibility to operate the piped lateral without irrigation scheduling. To reduce the electric current requirement, a new three phase 480 volt power service replaced the existing 240 volt service. By using the higher input voltage, the wire size in the motor and the current requirements of the VFD are reduced.

The telemetry between the pump site and the stand-pipe use two spread spectrum 900 MHz radios. The Distance is only 3000 feet, but the line-of-sight is blocked by a ridge. The radio communication works fine, despite not having a clear line-of-sight. A 4-20 milliamp pressure transducer is mounted in a PVC pipe stilling well, that is attached to the high water level of the concrete stand-pipe. The controlled water level is about 2-inches below the overflow pipe inside the stand-pipe.

The VFD chosen for this application is an ABB-800 series. This VFD is actually two VFD mounted back-to-back within a single unit. One VFD manages the harmonics fed back to the power grid. The second VFD manages the power to the pump motor, and controls the pump speed. The combination of VFD's eliminates the need for a line filter, to cancel harmonics, and maintains the power factor at about .98. This coupled with a premium efficient motor makes for high electrical power efficiency.

Control strategy. For the on-farm delivery system to operate effectively, a constant water surface level in the stand-pipe is necessary. The pressure transducer generates a 4-20 milliamp signal that represents the water level in the stand-pipe. This signal is transmitted by spread spectrum radio to the VFD. A PID logic controller is used to control the pump motor speed in relation to the water level in the stand-pipe. A change in irrigation demand is signaled by a change in the water level in the stand-pipe, which in turn changes the pump speed to maintain the head on the lateral pipeline.

The old control strategy was to run the pump at the maximum speed and spill the excess water to the river. The new strategy is to adjust the pump speed to maintain the water level in the stand-pipe and during periods of low demand, run the pump at a minimum speed of 1300 rpm's and spill some water (up to 1 CFS) back to the river.

This strategy is not a no-spill operation, but it is a reduced spill from the constant flow strategy.

Results. There were no complaints of water shortages on the lateral this year. The demand for water on the Vineland's pipeline lateral will likely grow to match the available supply. With the new bigger pump, more water was pumped. Despite the improved electrical efficiency, more power was consumed by the pump. The irrigators experienced greater flexibility in their water delivery, but the speculation is that the annual on-farm irrigation efficiency may have decreased

Lessons Learned. The ABB field engineer, the integrator, and the electrician were all working on the VFD at various times. At one point an external PLC was added to the communication link, and the output from the PLC's PID algorithm was the analog input to the VFD's PID algorithm. That didn't work. There were too many cooks in the kitchen.

When this pump modernization proposal was presented to the OMID Board of Directors cost was a concern. The old pump didn't have a check valve on the discharge, or a flow meter; therefore, the new pump didn't "need" them either. Pump maintenance was a concern, so a flush water bearing system was used instead of the traditional product lubrication for the pump bearings. When the realization that domestic flush water was expensive, a canal water filtration system was substituted for domestic water. That didn't work. A flush water bearing system needs very clean water.

Conclusion. The pump station modernization was successful in that it increased the amount of water available to the irrigators. This may have resulted in more flexibility or it may have led to lower on-farm irrigation efficiencies. A power and water cost savings was not achieved, because the irrigation water delivery demand increased. Were the crops previously under irrigated? The crops were not stressed from an undersized irrigation delivery system. The new system will deliver water more efficiently (less spill), but the on-farm management may negate any cost savings.