EMERGING TECHNOLOGIES

ENERGY↔WATER CONNECTION

Adjustable Magnetic Coupler

Efficiency in terms of power consumption is vital and continues to be increasingly important. The use of adjustable speed pumps can reduce energy consumption and improve controllability of pressure or flows. One such technology, the MagnaDrive™ coupler, has been developed for service in a variety of applications.

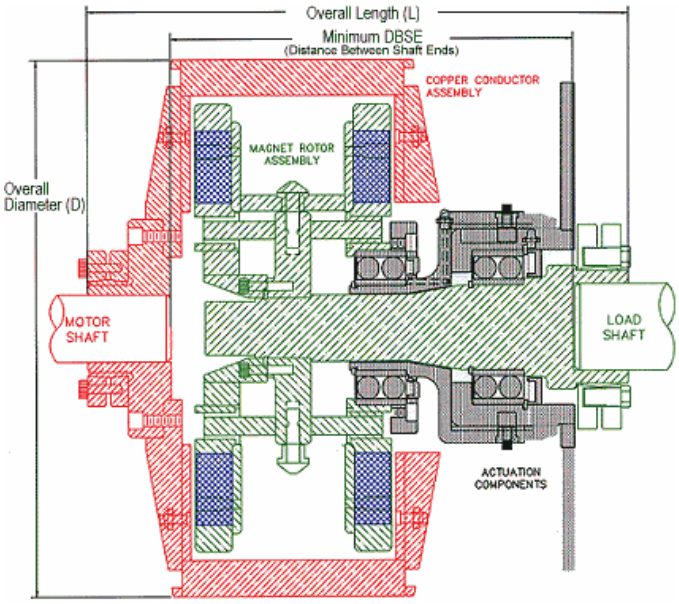

Figure 1. MagnaDrive Coupler Schematic (Courtesy of MagnaDrive Corporation).

Operation

The MagnaDrive coupler is produced by the Seattle, Washington-based MagnaDrive Corporation. The coupler utilizes the attractive properties of rare earth Neodymium-Iron-Boron (NdFeB) magnets, which do not consume electricity. Figure 1 illustrates the configuration of the coupler whereby the magnets are attached to a rotor assembly located on the load side of operation. This assembly is coupled with the load shaft. A copper plated assembly is attached to the motor shaft and as the motor turns, the load turns with only a 2-3% slip when operating under a full load condition. Since no physical connection exists between the load shaft and the motor shaft, the load can be gently applied to the motor by adjusting the space between the magnetic rotor and the copper plates. The amount of

space between the two assemblies relates to the amount of slip. Actuation components regulate the space between the magnets and the copper plates. Two double row bearings rated for a ten-year life at 3600 rpm support these components as well as the magnetic rotor.

Either a pneumatic or electric actuator can adjust the space between the magnetic rotor and the copper plates. The actuator may be controlled by a Programmable Logic Controller (PLC) with either a 4-20 mA, 1-5V DC or a 0-10V DC control signal. By slowly applying the load via this actuator, the amount of current inrush is significantly reduced, thereby extending the life of the motor. In addition, other electrical components within the system will not be as affected as there is not a large current draw upon start-up of the motor.

Figure 2. MagnaDrive Installation (Photo courtesy of Teichert Aggregates)

Design

MagnaDrive representatives require detailed information on the setup of the motor. Such items include the shaft size, motor HP and motor configuration. Based upon this information, the proper size of the coupler can be determined. The necessary components for installation are built and shipped, ready to install. The time required for installation may vary from site to site depending upon the existing configuration.

Investigation

The Irrigation Training and Research Center (ITRC) at California Polytechnic State University located the MagnaDrive at three locations as described in Table 1. A 50 HP vertical centrifugal pump is used at the Oxnard Wastewater Treatment Plant in Oxnard, a 150 HP horizontal centrifugal pump at Roza Irrigation District in Sunnyside, WA, and a 300 HP pump at Teichert Aggregates in Sacramento, CA. Operators at each location described their experiences.

Table 1. Facilities interviewed by ITRC (June, 2001).

Facility	Location	Motor
Oxnard Wastewater Treatment Plant	Oxnard, CA	50 HP @ 900 RPM
Roza Irrigation District	Sunnyside, WA	150 HP @ 1760 RPM
Teichert Aggregates	Sacramento, CA	300 HP@ 1430 RPM

Oxnard Wastewater Treatment Plant, Oxnard, CA

John Carter, Project Manager

In the past, the water treatment plant has had difficulties with electrical harmonics and utilization of Variable Frequency Drives (VFDs) only seemed to amplify the problem. Parts for an existing older VFD on a 50 HP pump were difficult to obtain.

Not only was the pump affected by the harmonics, but the VFD also created a lot of noise, augmented by the fact that the pump is in an enclosed environment. The treatment plant wanted to install a product that did not have these difficulties, yet was still able to provide flexibility in flow rate.

Since the pump is vertical and the MagnaDrive coupling requires additional space on the shaft, the motor had to be raised by approximately 24" from the original location. The motor was then attached to the motor stand with square tubing for structural support. Total installation time for the coupler was approximately 3 ½ hours, completed by MagnaDrive installers. Only ½ hour of the total installation time was required to calibrate the actuator completed by Mr. Carter from the provided instructions. In addition, he remarked that performing this task would be much faster the second time, perhaps taking as little as 10 minutes. Removal of the unit requires approximately 2 hours.

Monitored by a PLC, the motor is allowed to start under no load and run for 20 seconds. The load is then slowly applied by adjustment of the actuator. The amount of time allotted for this no load condition is based on the size of the load and also the time required to obtain full speed of the motor.

Roza Irrigation District,
Sunnyside, WA
Mark Barnett, Lead Engineer

One of MagnaDrive's first irrigation applications was at Roza I.D. where the coupler was installed to maintain a water level in a weir box that fed grower turnouts. In the past, a ditchtender would have to attempt to maintain the water level in the box based on the fluctuations in the system, which proved difficult. The pump has a static lift of 139 feet and by using the MagnaDrive coupler, could be responsive to the demand. Modifications to the motor stand (Figure 3), motor shaft, and babbit bearings were necessary for the installation of the MagnaDrive coupler. The primary reason for the modifications was due to the fact that the setup was over 50 years old.

Figure 3. Motor Stand Modifications at Roza I.D. (Photo courtesy of Roza I.D.).

Some problems did occur after the initial installation. Due to the extreme heat generated by the rotation of the coupler, the copper on the rotor had melted off. This meltdown was likely caused by water flowing back down the pipe, turning the coupler in the opposite direction at an estimated 5000 rpm. This problem was corrected with the installation of a check valve downstream of the pump, preventing the flow of water backwards.

Four other efforts were necessary to complete the MagnaDrive configuration. Problems included faulty actuators, small shaft size, and an unbalanced coupler.

The main problem, however, seemed to be correlated with the size of the load shaft. Representatives from MagnaDrive decided that by turning the coupler around so that the heavier magnetic rotor rested on the larger diameter motor shaft, the associated vibration problems would be significantly reduced and possibly disappear. To make certain of this fact, Chip Corbin, a vibration specialist at Impact Engineering, was asked to examine the setup. Measurements were taken and Mr. Corbin concluded that the resonant frequency of the coupler was approximately 1450 rpm before and 2300 rpm after the switch of the rotor. The former speed gave a clear indication of why the motor was vibrating prior to reaching full speed. The latter (2300 rpm) was much greater than the operating speed and was believed to pose no threat to operation. No other problems were observed after this switch and Mr. Barnett remarked that he appreciated the dedication of the MagnaDrive representatives to fixing the problem.

Teichert Aggregates,
Sacramento, CA
Mike Hurley, Asst. Plant Manager

Energy efficiency and the prospect of experimenting with a new technology lured Teichert Aggregates to the MagnaDrive. Before the coupler was installed, the flow rate at the facility was regulated rather inefficiently using a gate valve. Mike worked closely with John Brain of the Sacramento Municipal Utilities District to find a product that would meet their needs and be energy efficient. The company currently uses VFDs in other areas of the plant, but experienced problems due to harmonic vibrations.

Representatives from MagnaDrive determined that the 21.5” coupler model was required and were able to install the unit in 6 hours (Figure 4). This amount of time was necessary because, upon dismantling the pump, the crew discovered that the impeller was very badly worn and needed to be replaced.

Figure 4. MagnaDrive Installation at Teichert Aggregates. (Photo courtesy of Teichert Aggregates).

Following complete installation, the motor was started with no load applied. Engaging the actuator, the load was slowly increased on the motor, which is when the system experienced some vibration. In order to eliminate the vibration, the heavier magnetic rotor assembly was switched with the drive assembly, placing the magnetic rotor on the larger motor shaft. By installing the coupler in this fashion it was believed, as in the case of Roza I.D., that the vibrations would likely disappear because of the change of the resonant frequency. As an added measure, the base of the motor was built up so that any vibrations that may occur

would not be amplified. The coupler has worked very successfully for Teichert after these modifications, requiring virtually no maintenance. As a safety precaution, an 1/8" steel plate was installed over the coupler to prevent injury from entanglement. A small glass window was also incorporated into the plate so that a visual inspection can be made on the drive at any time. The plate does, however, cause some abstract movement of the air resulting in a slight whirring noise.

Conservation and Efficiency

- Energy efficiency is achieved since the pump is operating at or near the optimum pressure.
- Soft start feature reduces the current inrush.
- Improved flexibility of flow rate means less spillage in cases where flow is routed back to the source.

Benefits

- Very little maintenance, primarily grease.
- Soft start, saving on the life of the motor.
- Typically a smaller control panel is required compared to a VFD.
- Unaffected by power quality and harmonic distortion.
- No physical damage, should the load stop suddenly.
- No wear except for the bearings and actuator.
- Laser alignment of the shafts is not typically required since the unit can tolerate up to 0.030" misalignment.

Cost

The total costs to install the MagnaDrive coupler, including labor and the actuator for the systems at the three locations described, are illustrated in Table 2. As a comparison, ITRC estimated the total costs for a Variable Frequency Drive to be installed on the same horsepower motors including typical equipment and installation costs. Both cost figures are based on an existing pump and motor.

Table 2. Cost Comparison between MagnaDrive couplers and VFDs.

Facility	Size of MagnaDrive	Cost of MagnaDrive	Est. Cost of VFD
Oxnard	14.5	$ 20,000	$ 25,000
Roza	16.5	$ 35,000	$ 50,000
Teichert	21.5	$ 30,000	$ 75,000

The relative cost of the MagnaDrive at Roza ID was reported to be high due to the control package selected.

Energy Savings

Teichert Aggregates in conjunction with the Sacramento Municipal Utilities District, found that the energy savings from one year nearly paid for the initial capital outlay for the MagnaDrive as indicated by Table 3. This equates to savings of over 24% in energy consumption per year. The data is based on a demand of 236 kW before installation, 179 kW after installation and operation of the pump 16 hours per day, 6 days per week, 48 weeks per year. Such savings are site specific and in this case may be influenced more by the impeller change than the switch to a variable speed.

Table 3. Energy and Monetary Savings of the MagnaDrive at Teichert Aggregates.

	Cost / kW	Demand (kW-hrs / year)	Cost / Year
Before	$ 0.07	1,087,488	$ 76,124.16
After	$ 0.07	824,832	$ 57,738.24
Total Savings		**262,656**	**$ 18,385.92**

Certainly, installations that require recirculation of pumped water or partly closed valves to maintain a desired flow or pressure will use less energy with a variable speed pump.

For Further Information

- **MagnaDrive Corporation**
  1177 Fairview Avenue North
  Seattle, WA 98109
  (206) 694-4700
  www.magnadrive.com

- **Irrigation Training and Research Center**
  California Polytechnic State University
  San Luis Obispo, CA. 93407
  Dr. Charles Burt
  (805) 756-2379
  cburt@calpoly.edu

  

  www.itrc.org

- **California Energy Commission**
  Ricardo Amon
  (916) 654-4019
  Ramon@energy.state.ca.us

- **Roza Irrigation District**
  P.O. Box 810
  Sunnyside, WA 98944
  Mark Barnett
  Engineer
  (509) 837-5141

- **Sacramento Municipal Utilities District**
  6301 S Street.
  Sacramento, CA 95817-1899
  John Brain
  Energy Specialist II
  (916) 732-6667

- **Teichert Aggregates**
  3500 American River Drive
  Sacramento, CA 95864-5805
  Mike Hurley
  Asst. Plant Manager
  (916) 386-6873

- **Oxnard Wastewater Treatment Plant**
  6001 S. Perkins Street
  Oxnard, CA 93033
  John Carter
  Instrument Technician
  (805) 271-2213

- **Energy-Water Connection**
  (916) 654-4070

This information was developed by ITRC under the PIER End Use Agricultural Sector Program, administered by the California Energy Commission.