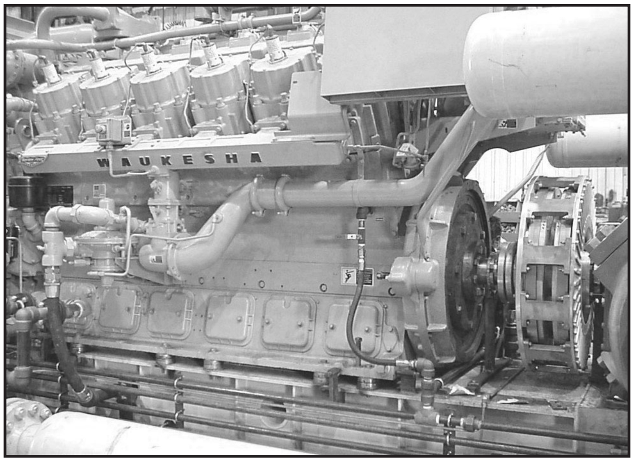

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COMPRESSORTech Two

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■ A Waukesha 5774-LT gas engine, rated 1250 hp (932 kW) at 1200 rpm is shown connected via a MagnaDrive magnetic coupling to one end of the Gemini D604-DT dual-shaft compressor at Hanover`'s South Loop fabricating facility in Houston, Texas. It is believed to be the first use of a magnetic coupling in a reciprocating compressor drive application.

DUAL DRIVE COMPRESSOR USES BOTH GAS AND ELECTRIC POWER

Energy Transfer and Hanover Compression Use MagnaDrive Coupling to Turn New Gemini Compressor

By Jake Elliott

Energy Transfer Company of Dallas, Texas and Hanover Compression of Houston, Texas, U.S.A., have developed what they believe to be the world's first gas compression package capable of being driven by either natural gas or electric power, and giving the operator the choice of switching from one to the other at speed and under load.

The new package utilizes a reciprocating gas engine driver on one end of the compressor and electric motor drive on the other. The companies believe the new configuration could offer a solution to equipment reliability and fluctuating fuel cost issues faced by operators attempting to achieve higher operating efficiencies, reduced emissions and higher throughput to market.

The secret to achieving this "dual-drive" compressor arrangement involved two technological innovations. First, GE Power Systems stepped up with a newly configured Gemini D604-DT compressor capable of being driven from either end of its extended crankshaft. Gemini expedited the design and manufacture of the compressor to support the tight packaging schedule established by Energy Transfer and Hanover. Next, Hanover, relying on its past successes with magnetic couplings, commissioned specially designed MagnaDrive magnetic couplings that allow the compressor to be driven alternatively by either the engine or electric motor without interruptions while the compressor remains at speed on full load.

The couplings act as magnetic clutches, but have no direct mechanical linkage between the power sources and the compressor. "What this means," said Jeff Badders, MagnaDrive's regional sales manager, "is that we're transferring torque through air via a 'motion-induced' magnetic field."

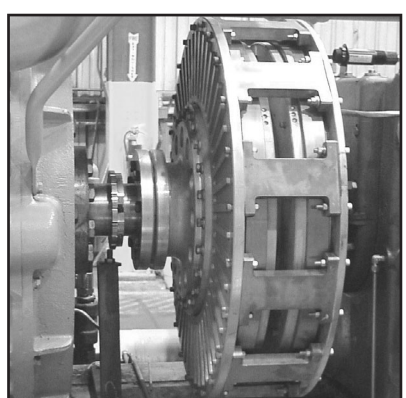
The MagnaDrive couplings use "powerful rare-earth neodymium-iron-boron magnets that are far more powerful than conventional iron magnets," according to an article in Industry Week (IW) magazine (December 2001/ January 2002). As IW describes the couplings, "a plate studded with magnets is connected to the system load, while a copper conducting plate is connected to the driver. As the motor (or engine) rotates, the relative motion between the magnets and the copper plate creates a magnetic force arising from eddy currents induced in the copper plate causing the load to turn. The amount of torque applied to the load is controlled by the width of the air gap between the motor (or engine) and load. A smaller air gap increases the magnetic fields at the copper plate and increases the torque."

With the MagnaDrive coupling, the normal air gap between the magnetic rotor and the conductor rotor is 0.350 in. (8.89 mm), or 0.700 in. (17.78 mm) total across all three pieces of equipment. This allows for a "generous misalignment capability," according to Badders. The dual-drive compressor is further equipped with overload protection in the event of a major compressor failure, such as with the main bearings or crankshaft. A Hilliard overrunning clutch is integrated into the coupling. A thermal probe is also part of the safety control system. It provides a warning if the temperature at the coupling should reach 300°F (149°C), at which temperature the magnetic capability begins to erode. Normally, the rare earth magnets can be expected to retain their properties for some 22,000 years.

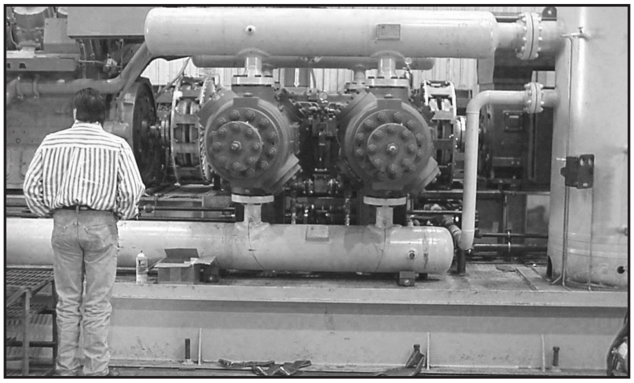
When we witnessed a test run of the assembled unit in February, Hanover's controls expert, Hubert Breaux, started and brought the Waukesha engine up to speed. As the engine speed increased to 1200 rpm, the compressor was smoothly accelerated through the magnetic coupling. The coupling mounted on the alternate end of the compressor and the Siemens motor were inactive except for a small amount of "freewheeling."

Later, Breaux activated the Seimens motor, bringing it up to the rated speed. At that point both the engine and the motor were driving the compressor at the same time with no apparent vibration or other detrimental effects. As the engine was slowed down below the motor speed of 1180 rpm, a seamless transfer of load responsibility from the engine to the motor took place. The transition was effected by overrunning clutches that are integrated into the magnetic couplings. The Waukesha engine was then shut down to complete the transition. Each transition took only moments. It was an impressive demonstration of the ease with which the dual-drive process was accomplished.

The concept of a dual-drive compressor



■ Close-up of the MagnaDrive coupling between the Waukesha gas engine and Gemini D604-DT compressor, on test at Hanover's fabricating facility. The couplings use rare-earth Neodymium-iron-boron magnets, which are far more powerful than conventional iron magnets, and act as a magnetic clutch.



■ **View of the Gemini D604-DT compressor and the dual-drive of a Waukesha gas engine (left) and Seimens motor (right), each capable of transferring power via MagnaDrive couplings. The transfer of power from gas engine to electric motor (and vice versa) is achieved smoothly while the compressor continues to operate fully loaded.**

began, according to Energy Transfer's Mike Warren, "with our belief that the best way to move gas was with electricity. We began exploring the potential of electric drives in 1996, at which time the use of electricity was not widely accepted by the natural gas pipeline industry. Less than two percent of natural gas compression employs electric drives (out of an estimated total of 17 million hp, or 12,677 MW, of compressor drive applications nationwide). With the advent of electric industry deregulation, along with that of the natural gas industry, it became evident to us that electric-powered compression would soon become more competitive with gas, as both fuels became commodity products.

"With reliability being the number one issue with pipeline compressor operators, and with equipment efficiency and operating costs close behind, we began studying the possibility of doing it both ways (gas and electric). The problems of maintaining high availability of the equipment (98-99%) that would allow users to take advantage of off-peak electric costs and overcoming torsional stresses were the primary conditions needing solutions," said Warren.

"Not only does this system address reliability," said Warren, "but it makes the electric load, capable of employing interruptible and time-of-use characteristics, more attractive to the electric company. We had good internal talent at Energy Transfer who did the preliminary design work, after which we applied for patents and began looking for a development partner. We found our partner with Hanover Compression and Mike Paris, who readily agreed in early 2001 to work with us in developing the first dual-drive compressor."

Paris said that, "Hanover and Energy Transfer worked closely with the MagnaDrive people to design a coupling large enough to handle a 1500 hp (1119 kW) load, either from an engine or motor, with the magnetic power capable of transferring torque to a reciprocating compressor operating up to 1000 psi (69 bar) discharge pressure. The test results have been hugely successful."

The initial compressor package, designed by Mike Garza at Hanover's corporate office and assembled at Hanover Compression's South Loop fabricating facility in southeast Houston, includes a Waukesha 5774-LT gas engine rated 1250 hp (932 kW) at 1200 rpm on one end of a GE Gemini D604-DT, 4-throw compressor, and a Siemens CG-2, 1500 hp (1119 kW), 1185 rpm, 4160 volt induction motor on the other end. The Gemini compressor is equipped with four 7 in. (178 mm) diameter cylinders. Operating pressures are 250 psi suction (17 bar) and 950 psi (66 bar) discharge.

The Gemini D604-DT compressor is based on the existing Gemini D frame compressors, but has an extended crankshaft that was designed to allow auxiliary equipment to be driven from the extension. Motor-driven lube oil pumps are utilized with the design. The compressor was designed with bearing surface on the extended end of the shaft sufficient to handle the driving load. The complete package includes three skids. One skid contains the drivers, compressor and couplings. A second skid houses the Allen-Bradley control system equipment, and a third skid, an Air-X-Change cooler.

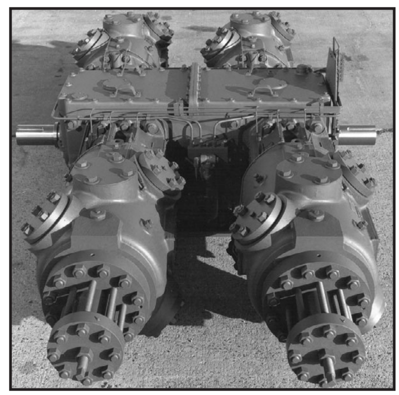
One of the major problems with electric drives in compressor operations, according to information supplied by Energy Transfer, is that the majority of pipeline compressors are installed in rural locations with weak electric distribution systems. Electric capacity can be unreliable in such areas, and power outages can be routine. Even with adequate capacity, starting currents required by large compression drives can cause unacceptable voltage fluctuations.

Energy Transfer believes the E.Select Compression system solves the problem of reliability in these areas where a firm supply of electricity is problematic. Rural or extended electric distributions will more often be sufficient, as gas power can provide complete backup to even the most tenuous electric supply. The ability to shift from gas drive to electric drive under load means that starting currents are minimized. The gas drive can be used to overcome inertial effects, with the electric drive taking load only after it reaches operational speeds.

Warren indicated that the biggest advantages of the system are more flexible resource allocation and lower maintenance costs. "As to fuel costs," he said, "we may be looking hour-to-hour for the cost of electricity at these locations, where a negotiated off-peak price would offset the cost of gas fuel. Electric companies are being very aggressive in pricing electricity to E.Select applications, reflecting their desire to sell more off-peak electric service. And, policymakers instantly recognize that this technology reduces emissions and has the effect of converting a lot of coal, used for generation, into the natural gas we don't burn."

While the initial prototype dual-drive compressor system including the MagnaDrive couplings is designed for ratings up to 1750 hp (1305 kW), "we believe the limit is short-termed," said Warren. "Most of the hardware exists (for higher horsepower ratings) and if the market demands, we feel confident they can be met."

The initial dual-drive E.Select Compression Technology System package developed by Energy Transfer Group and Hanover Compression has been purchased by a gas pipeline customer located in Northeast Texas. It is expected to be in service during the summer of 2002. Hanover has ordered five additional compressors for future use. ■



■ **The GE/GEMINI D604-DT compressor is equipped with an extended crankshaft, allowing it to be connected to two separate power sources. The compressor, designed by GE Power Systems Gemini group, is equipped with adequate bearing surface on the extended end of the shaft sufficient to handle the driving load. The four-throw compressor provided for the Energy Transfer project is equipped with four, 7 in. diameter (178 mm) cylinders that will operate at 250 psi (17 bar) suction and 950 psi (66 bar) discharge pressure.**

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