Frictonless compressor technology

Recently, ceramic In Chicago, may have a significant effect on the future of mild-range By HUGH CROTCHET, PEE, roller bearings, which avoid issues and related to oil and reduce power controllers and rooftop applications EUGENE SCIMITAR, PEE gumption, were introduced to the in water-cooled, operatively HAVE Industry. The lubrication of cooled, and air-cooled Clearwater and direct-expansion (DXL) systems. These bearings is provided by the refrigerant itself. L Designed and optimized to take full advantage of magnetic-bearing technology, the compressor was awarded Touchdown Permanent-magnet the first RAH Expo Innovation bearings synchronous motor

Award in the energy category, as well as Canada’s Energy Efficiency Award for its potential to reduce utility-gentians and impellers aerated greenhouse-gas emissions. The cooling compressor is key to a new watercolors centrifugal-chiller design, with Inlet-guide- vane Magnetic bearings Air-conditioning and Refrigeration assembly Institute (AR’) tests indicating integrated part-load values (Pills) not normally seen with conventional chillers in this tonnage range.

This article describes this new The 30TH compressor’s onboard digital electronics manage operation compressor technology and its first use while providing external intros and Web-enabled access to a full array of in an AIR-certified chiller design. Performance and reliability information. Hugh Crotchet, PEE, is the global director of applications for McKay International in Minneapolis. With more than 15 years of experience in large-HAVE-system design, he has written numerous articles and application guides related to HAVE design.

Contact him at Hugh. Com. FRICTIONLESS Magnetic-bearing technology is significantly different.

A digitally controlled magnetic- bearing system, consisting of both permanent magnets and electromagnets, replaces conventional lubricated bearings. The frictionless compressor shaft is the compressor's only moving component. It rotates on a levitated magnetic cushion (Figure 1). Magnetic bearings? two radial and one axial? old the shaft in position (Figure 2). When the magnetic bearings are energize, the motor and impellers, which are keyed directly to the magnetic shaft, levitate. Permanent-magnetic bearings do the primary work, while digitally controlled electromagnets provide the fine positioning.

Four positioning signals per bearing hold the levitated assembly to a tolerance of 0. 00002 in. As the levitated assembly moves from the center point, the electromagnets' intensity is adjusted to correct the position. These adjustments occur 6 million times a minute. The software has been designed to automatically insensate for any out-of-balance condition in the levitated assembly. Y-axis position sensor Target sleeve Channels 0-1 X-axis position sensor 2-3 Channel 4 Impellers Z-axis Sensor Front position ring radial bearing Motor Sensor ring Rear radial Axial bearing FIGURE 2.

A digitally controlled magnetic-bearing system consisting of two radial and fail, the touchdown bearings (also known as backup bearings) are used to prevent a compressor failure. The compressor uses capacitors to smooth ripples in the DC link in the motor drive. Instantaneously after a power failure, the motor becomes a " generator," using its angular momentum o create electricity (sometimes known as back NEFF) and keeping the capacitors charged during the brief coastland period.

The capacitors, in turn, provide SHUTDOWNS AND POWER FAILURES enough power to maintain levitation When the compressor is not running, during coastland, allowing the motor the shaft assembly rests on graphite-lined, rotor to stop and dilapidate. This feature radically located touchdown bearings. The allows the compressor to see a power magnetic bearings normally position the outage as a normal shutdown. Rotor in the proper location, preventing contact between the rotor and other OIL-FREE DESIGN Oil management, particularly as it metallic surfaces.

If the magnetic bearings pertains to the lubrication of compressor bearings, is a critical issue in reapportionment's design. But with magnetic bearings, this issue is avoided. Only a very small amount of oil is required to lubricate other system components, such as seals and valves; often, however, experience shows that even this small amount of oil is not needed. Avoiding oil-management systems means avoiding the capital cost of oil pumps, sumps, heaters, coolers, and oil separators, as well as the labor and time required to perform alerted services. Reports indicate that FIGURE 1.

Electromagnetic cushions continually change in field strength to keep for many installations, compressor- maintain rotor shaft centrally positioned. Tenancy costs have been cut by more than 50 percent. Most air-cooled products (including chillers, rooftop units, and condensing units) use DXL evaporators. Most DXL systems allow oil to travel through the refrigeration circuit and back to the compressor oil sump. Great care must be taken during design to provide oil return, particularly at part load, when refrigerant Water-cooled chillers often use flooded evaporators.

In a flooded evaporator, even small amounts of oil can coat evaporator tubes and significantly diminish chiller performance. This can lead to an elaborate oil-recovery system. Magnetic bearings eliminate the need for these systems and oil management in general. In fact, the only required regular maintenance of the compressor is the quarterly tightening of the terminal screws, the annual blowing off of dust and cleaning of the boards, and the changing of the capacitors every five years. Complete service agreements and extended maintenance contracts can be provided by the manufacturer.

THE MOTOR Most hermetic compressors use induction motors cooled by either liquid or suction- gas refrigerant. Induction motors have copper windings that, when alternating current is run through them, create the magnetic fields that cause the motor to turn. These copper windings are bulky, adding size and weight to the compressor. Two-pole, 60-Hz’s induction motors operate at approximately 3, 600 RPM. A higher number of revolutions per minute can be obtained by increasing the frequency. Compressors that require higher shaft speeds tend to use gears.

While gears are a proven technology, they create noise and vibration, consume rower, and require lubrication. The magnet-bearing compressor features a synchronous permanent-magnet brushes DC motor with a completely integrated variable-frequency drive (BFD). The stator windings found on conventional induction motors are replaced with a permanent-magnet rotor. Alternating current from the inverter energize the armature windings. The stator (excitation) and rotor (armature) change places. No commutate brushes are required.

The motor and key electronic cooling is required for the BFD or the motor. The use of permanent magnets instead of rotor windings makes the motor smaller and eighth than induction motors. Using magnetic-bearing technology, a 75-ton compressor weighs 265 lb? about one-fifth the weight of a conventional compressor. A variable-speed drive (VS.) is required for the motor to operate. The VS. varies the frequency between 300 and 800 Hz’s, which provides a compressor-speed range from 18, 000 to 48, 000 RPM. This avoids a gear set.

The VS. is integrated into the compressor housing, avoiding long leads and allowing key electronic components to be refrigerant-cooled. The VS. also acts as a soft starter; as a result, the compressor has an extremely low startup in-rush rent: less than 2 amps, compared with 500 to 600 amps for a traditional 75-ton, 460-v screw compressor with a cross-the-line starter. COMPRESSORS With the integration of the motor, VS., and magnetic-bearing system, the capacitors required for the motor and drive can be used as a backup power source for the bearings in the event of a power outage or emergency shutdown. . NET projects are expanding the range and duty of the compressor wheels and promise to offer even greater efficiency for water-cooled and air-cooled duties and different capacities. CAPACITY AND EFFICIENCY Among the key parameters affecting reference are capacity (tons) and efficiency (kilowatts per ton). The compressor’s capacity ranges from 60 to 90 tons, depending on the operating conditions. Plans call for that range to be extended to 150 tons water-cooled and 115 tons air-cooled by the end of 2004 with the use of R-AAA refrigerant.

An R-22 version is planned for retrofit applications. A combination of the centrifugal com- CONTROLS The new compressor effectively is a computer. It provides diagnostic and performance information through Modus to the refrigeration system, which then communicates to the building automation system through Modus, Loanwords, or Backed. CHILLER APPLICATION The compressor manufacturer and a major chiller manufacturer teamed up to develop a line of AIR-certified watercolors chillers, which were expected to be introduced in January 2004.

The combination of flooded-evaporator technology and an oil-free system has allowed very close approaches and, subsequently, enhanced performance. The integrated BFD allows excellent part-load performance as power consumption drops off, depending on the head relief, near the cube root of the shaft speed. The compressor includes wheels tuned for water-cooled duty in the dual-compressor format, which further enhances part-load performance. Tested in accordance with AIR standard 550/590-98, water Chilling Packages Using the Vapor Compression Cycle, a 1 50-ton (nominal) chiller has a upload performance of 0. 29 K per ton (5. 6 COP) and an PILL of 0. 375 K per ton (9. 4 COP). All Pills are weighted for standard operating conditions and the time spent at those conditions. Specific operating points for a 150-ton nominal-capacity chiller are shown in Figure 3. Magnetic-bearing compressors offer economic, energy, and environmental benefits, including increased energy efficiency, the elimination of oil, and considerably less noise and vibration. Magnetic bearings. Within the compressor, efficiency is affected by the compressor isentropic efficiency (the efficiency of the wheels), the motor, and the bearings.

Traditional induction motors of this size typically are in the 92-percent efficiency range. This compressor’s permanent-magnet motor has an efficiency of 96 to 97 percent. Efficiency is further enhanced with the use of magnetic bearings, which avoid the friction of rubbing parts associated with traditional oiled bearings. Conventional bearings can use as much as 10, 000 w, while magnetic bearings re- SOUND AND VIBRATION Because the rotating assembly levitates, quire only 180 w. That amounts to 500 mimes less friction loss. Current develop- there essentially is no structure-borne vibration.