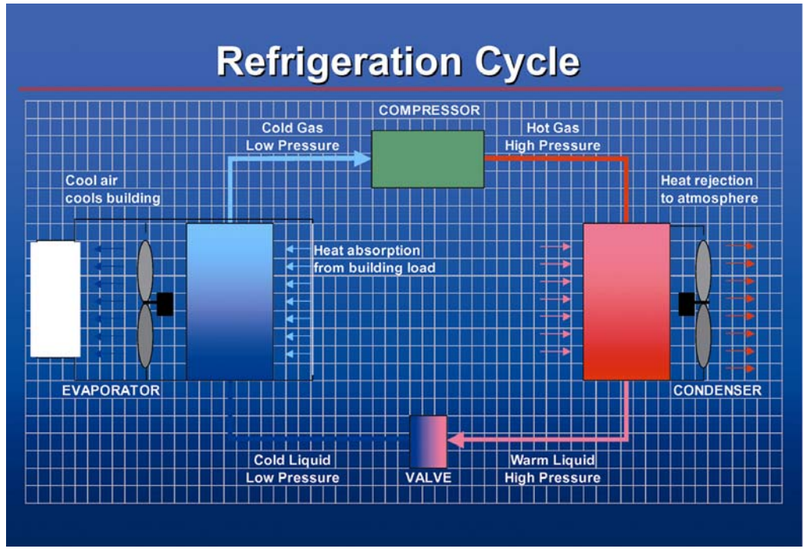

TTC compressors are on the way to generate 73 PJ in energy savings per year by 2012. The potential cumulative energy saving is estimated at 347 PJ over the first 10 years. Roughly 10% of these savings would accrue to Canadian end users.

The company's achievement places Canada at the forefront of HVACR compressor technology worldwide. Canadian businesses are expected to profit widely, both from supplying components to Turbocor and from fabricating and distributing HVACR equipment and systems that exploit and extend the TTC concept in end-use applications.

The environment, also, will benefit from the TTC's higher energy efficiency. Based on projected North American sales, widespread adoption of Turbocor's TTC technology (combined air and water-cooled product) would lead to a drop in CO_2 emissions by 4.1 million metric tons per year by 2012.

"Working with the IERD program was a pleasure," says Richmond-Smith. "The IERD project officers were completely professional and very understanding of what we were trying to do, and the real-world pressures we were dealing with. To my mind, anyone with a marketable idea that offers the energy-efficiency and social advantages that the IERD program stands for shouldn't hesitate to seek the program's support."

Your Invitation to Work with Us

We are interested in collaborating with you. Please contact the Business Office to discuss your particular needs.
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CETC CANMET ENERGY TECHNOLOGY CENTRE

INDUSTRY ENERGY RESEARCH & DEVELOPMENT PROGRAM

CLEAN ENERGY TECHNOLOGIES

AN ENERGY-EFFICIENT REFRIGERANT COMPRESSOR FOR AIR-COOLED CHILLERS

With support from the IERD program, a small Canadian company has developed a revolutionary, energy-efficient refrigerant compressor for use in mid-sized air-cooled chillers and related HVACR applications. Featuring advanced DC motor design, oil-free operation and no CFCs, Turbocor's twin-turbine centrifugal compressor brings the performance advantages of central-plant variable-speed compressors to the mainstream HVACR middle market, while offering significant energy savings.

Air-cooled chiller

The Opportunity

At the heart of most heating, ventilation, air conditioning and refrigeration (HVACR) systems is the compressor. The compressor pumps refrigerant through the system and creates the pressure changes that drive the refrigeration cycle. It also uses a lot of energy. Of the energy used for air conditioning, for example, some 60-70% is consumed by the compressor (the rest powers various motors, pumps, fans and controls). Improving compressor efficiency is seen as one of the keys to cutting energy use in the HVACR industry, which alone consumes 30% of all electricity generated world-wide.

Many HVACR systems use chillers—large pieces of refrigeration equipment that produce chilled water for commercial air conditioning and certain industrial processes. Chillers come in air- and water-cooled varieties. The compressors that drive these systems are mostly screw and reciprocating machines with coefficients of performance (COPs) in the range 3.3 to 3.8 for water-cooled chillers, and 2.0 to 2.4 for air-cooled chillers (compressor designs are optimized for one application or the other). Lately, these figures have improved somewhat thanks to the development of better materials and electronic controls. But as building owners switch to non-CFC refrigerants in response to environmental concerns, these gains are being lost. Using alternative refrigerants in a compressor designed for CFCs or HCFCs can drive its COP down as much as 30%.

Recognizing a market opportunity, Ron Conry and Roger Richmond-Smith co-founded the Turbocor business in Melbourne, Australia in 1995 to pursue the development of a compact, mid-capacity, high-efficiency compressor that pumped non-CFC refrigerants. In 1999 the company relocated to Montreal where, two years later, as Turbocor Inc., it started to introduce the TT300—the world's first

Canada

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Turbocor's TTC Compressor

totally oil-free centrifugal refrigerant compressor designed for mid-sized water-cooled chillers.

Optimized for use with R134a, an environmentally friendly alternative to traditional refrigerants, the TT300 features a compact, twin-turbine, two-stage design that reliably delivers 60-90 tons of refrigeration (TR) with a COP that ranges from 5.5 (full load) to well over 10.0 (part load). The compressor's outstanding energy efficiency is the product of a unique fusion of cutting-edge technologies, including:

- high-speed, brushless DC permanent magnet motor with integral variable-speed drive;
- magnetic bearings;
- state-of-the-art power electronics and digital control electronics.

With field prototypes well-proven in water-cooled applications, the company now tackled the challenge of extending its compressor technology to create a machine that could be used in air-cooled chillers, which comprise some 70% (by volume) of the international chiller market. Lacking sufficient financial resources of its own, and reluctant to defer the work until sales of the TT300 could generate the needed capital, the company turned to the IERD program for help.

Recognizing the enormous potential for energy savings inherent in the project, the federal government responded with a repayable advance of $1.9 million towards the project's estimated $9.8-million costs. The IERD program, which is administered by the CANMET Energy Technology Centre of Natural Resources Canada, helps Canadian firms develop and commercialize new, energy-saving technologies, products and processes. Part of the federal contribution was provided by the Technology Early Action Measures (TEAM) program, a component of the federal government's Climate Change Action Fund.

The Project

Because air-cooled condensing is thermally less efficient than water-cooled condensing, the new compressor would have to produce higher impeller tip speed and higher lift than its precursor to transfer the same amount of heat. By harnessing recent advances in brushless DC motor design, Turbocor's hand-picked team of 16 engineers was able to boost the motor's power output by 10% and push its efficiency to 94%. Impeller tip speed was increased 30%, to 48,000 rpm. To offset the increased heat buildup and induced stresses, the team developed a new motor cooling system, redesigned the rotor/impeller and bearings, and optimized the compressor's inlet guide vanes for air-cooled operation.

The power electronics systems were redesigned to operate reliably at more extreme temperatures. New labyrinth seals were developed, as well as new materials for some internal components. Bearing stability was also upgraded: the new bearings now routinely handle rapid shutdown from any operating speed. Using sophisticated mathematical modelling techniques, the researchers also redesigned the path of the refrigerant through the compressor to enhance the system's fluid dynamics.

Prototypes were constructed and extensively tested in a range of demanding environments, using the company's in-house test facilities.

The Achievement

In late 2002 Turbocor unveiled the fruit of its labours—the TT300AC: a compact, high-performance, CFC-free centrifugal compressor designed specifically for mid-sized (50-500TR) air-cooled chillers and other HVACR applications.

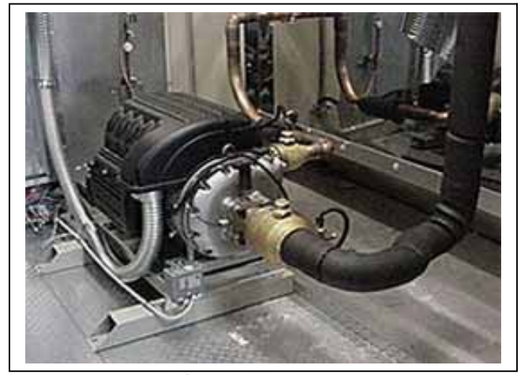
Like its water-cooled cousin, the TT300AC boasts continuously variable motor output. This feature, normally found only on large, central-plant centrifugal compressors, reduces compressor speed as condensing temperature and/or heat load drop, optimizing the machine's energy performance throughout its entire operating range, from 100% to well below 20% of rated capacity. As a result, the TT300AC reliably delivers 85 tons of refrigeration with a COP ranging from 3.3 (full load) to well over 5.8 (part load). That translates into an integrated part load values (IPLV) efficiency advantage of more than 30% over competing technologies. The greatest improvement is in the critical part-load range—an important consideration, given that 99% of real-world HVACR operation is under part-load conditions.

Both TTC models are totally oil-free. In conventional compressors, oil is added to the refrigerant to lubricate the compressor's mechanical bearings and other moving parts. Turbocor's ground-breaking design does away with all that. During operation, the compressor's one major moving part—its rotor shaft and impellers–rides on a frictionless magnetic cushion generated by strategically placed permanent magnets and electromagnets. Position sensors at each magnetic bearing provide real-time feedback to the bearing control system, repositioning the shaft 100,000 times a second to ensure centred rotation. The technology, adapted from the aerospace industry, eliminates the need for lubrication and oil-management hardware and controls. It reduces mechanical wear, boosts compressor efficiency and reliability, and minimizes noise and vibration.

The compressor's onboard digital controller proactively manages compressor operation while enabling external control and Web-based performance monitoring. It replaces many of the control functions performed by conventional HVACR power and control panels, further reducing system costs.

Best of all, the convergence of aerospace and industrially proven mechanical, electronic and control technologies enables Turbocor's TTC compressors to achieve the highest compressor efficiencies for mid-range water-cooled, evaporately cooled and air-cooled chillers, allowing building owners to save up to 40% on the yearly power cost of chiller operation.

With the development of the TT300AC, Turbocor added 2 more patents to the 11 it already holds for its water-cooled compressor design. Turbocor is further developing its TTC technology to achieve levels of performance that will enable its compressors to function in extreme conditions, such as those found in some industrial applications and in very hot climates. It is also developing a larger capacity model that will allow the company's products to fully penetrate the North American chiller market.



Turbocor's TTC Compressor

The Rewards

Turbocor will initially target the U.S. market, home to the big four HVACR OEM manufacturers that dominate the worldwide industry. Additional markets beckon in Europe and Asia. The air-cooled segment of the North American mid-size chiller market is estimated at $US 350 million annually, and its share is growing. Turbocor expects to penetrate over 30% of this market and markets overseas (combined air- and water-cooled models) by 2012.

As of late 2002 the company was processing orders from the U.S., China, Australia and Italy for demonstration units intended for chiller design and testing. Once production is in full swing, Turbocor's proprietary technology is expected to generate 100 permanent manufacturing jobs at the company's assembly and test facilities in Montreal.

"This project has given us access to three-quarters of the mid-sized compressor market that we didn't have before, quadrupling our potential sales," says Roger Richmond-Smith, the company's director and executive vice-president. "Thanks to IERD's support, we're able to bring our product to market two years sooner than if we'd relied on our own resources. That translates into a significant market advantage."

Compared with conventional reciprocating and screw designs in the 50-500TR range, Turbocor's compressors deliver an energy saving of about 23 kWh per machine-hour. Based on this figure and projected sales of its line of air- and water-cooled compressors throughout North America, Turbocor's