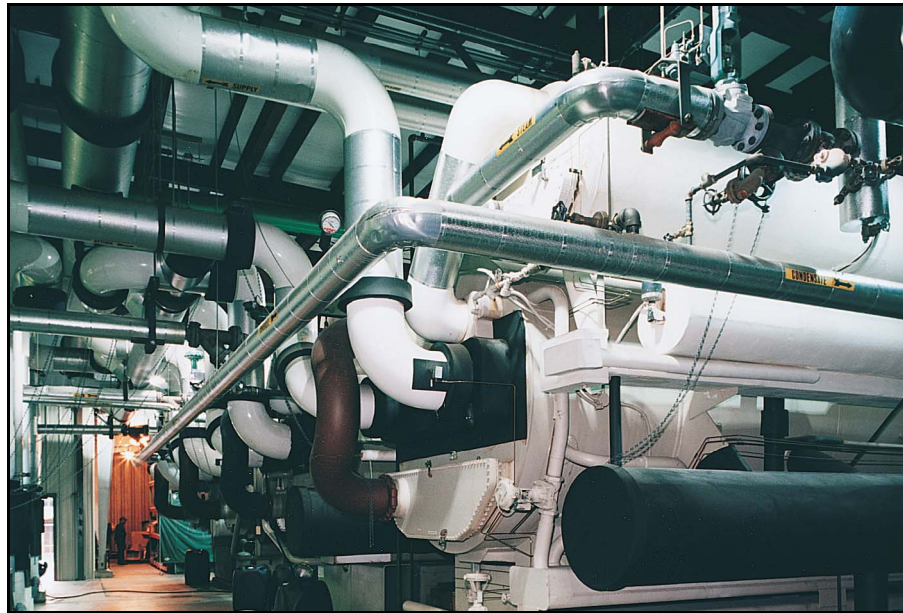




1997
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Award



The upgrade included consolidating all chilled-water production into a 2,700 ft² (251 m²) addition to the central energy plant. The installation included these 850-ton (2 989 kW) and three 1,000-ton (3 517 kW) two-stage, steam absorption chillers.

Upgrading the Steam and Cooling Systems At a Machine Tool Manufacturing Complex

By **Gary R. Davies, P.E.**
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Cincinnati Milacron, Inc., one of the world's largest machine tool manufacturers, decided to upgrade the steam and cooling systems that serve Milacron's multi-building 1.5 million square foot (139 350 m²) headquarters complex in Cincinnati, Ohio. The upgrades were begun in 1993 and were operational by March 1995.

Program objectives were to:

1. Provide mechanical cooling of manufacturing areas for better temperature control to gain closer tolerances on machined parts. This was to support a corporate objective to obtain ISO 9000 Certification which has been achieved.
2. Phase-out use of ozone-depleting chlorofluorocarbon (CFC) refrigerants in existing electric chillers and packaged air-conditioning (DX) units.
3. Minimize waste oil and wood leaving the complex to reduce disposal costs and environmental liabilities.

4. Reduce operating and maintenance costs to enhance industrial competitiveness.

With co-funding help from the local utility company, Cinergy Corporation, we assisted Milacron in analyzing the feasibility of various mechanical cooling concepts such as single vs. two-stage steam absorption vs. electric chillers. This analysis provided the data needed to select the concepts which best met the program objectives.

Summary of Project

- All chilled-water (CHW) production was consolidated into a 2,700 ft² (251 m²) addition to the central energy plant. The installation in-

About the Authors

Gary R. Davies, P.E., is owner and co-founder of ThermalTech Engineering, Inc., a mechanical and electrical consulting firm in Cincinnati. He has been a member of ASHRAE for 23 years, and has earned 15 ASHRAE awards.

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This project won in the category for Industrial Facilities or Processes.



Members of the project team are shown in front of a 5,000-ton (17 585 kW) cooling tower. Team members are Jim Drye, Gary Davies, Dan Sheehy, Larry Gottlieb, Bob Fahrubel, Mike Craner and Ed Wortman.

cluded: 850-ton (2 989 kW) and three 1,000-ton (3 517 kW) two-stage, steam absorption chillers; crossflow cooling tower with five 1,000-ton cells; primary/secondary pumping with three, 75-hp (56 kW) primary pumps with variable-frequency drives, and over 13,000 lineal feet (3 962 m) of CHW piping; 10 air handlers ranging from 8,000 to 76,000 cfm (3 775 to 35 864 L/s), some with economizers; and, over 1,700 lineal feet (518 m) of ductwork. The design allows for expanding the total absorber capacity to 6,000 tons (21 100 kW). The chillers produce CHW using steam from four boilers with total capacity of 320,000 PPH. The CHW distribution system is convertible at low flows to a single loop at which time secondary pumps are bypassed.

- To significantly reduce the use of CFC refrigerants, chiller capacity was provided to eliminate 620 tons (2 181 kW) of electric chillers and DX units throughout the complex, and to connect existing compressed air dryers to the CHW loop.

- Steam is used for process, space heating and producing CHW, and is sold to three neighboring industrial firms. To reduce cost, a 50-ton/hour wood chipper, 10-ton capacity (9 Mg) storage silo, conveyor system and oil burners were installed to enable waste wood, oil and oil filter paper to be co-fired with coal in three of the four boilers.

Energy Efficiency

The use of steam absorption chillers, burning waste wood, oil and oil filter paper in Milacron's central boiler plant and creative design strategies for air and CHW distribution systems have improved energy efficiency in several ways:



50-ton/hr chipper, 10-ton storage silo and conveyer system are used to convert waste wood to solid fuel for co-firing with coal.

1. Low-cost steam is used to generate CHW for cooling.
2. Producing CHW with steam enables boilers to operate in a more efficient range during months when cooling is required.
3. The plant electric load was reduced and leveled by replacing electric chillers and DX units with absorbers.
4. New air handlers have economizers for free cooling.
5. The CHW system incorporates variable-speed pumps and cooling tower fans, and CHW coils with high temperature rise.

IAQ and Thermal Comfort

Because manufacturing and office areas were being connected to the central CHW system, existing air-handlers had to be investigated to determine if adequate outdoor air was being provided, per *ASHRAE Standard 62-1989 - Ventilation for Acceptable Indoor Air Quality*. Allowances were made in the CHW coil selection to increase the flow rate of outdoor air where deficiencies were found. The new air-handlers have several design features to promote good IAQ and thermal comfort:

1. High ventilation effectiveness.
2. Adequate outdoor air flow, adjustable by season.
3. Improved air cleanliness with pre-filters and cartridge filters.

Innovation

Innovative techniques used in this project have resulted in the following benefits for Milacron:

1. Co-firing wastes with coal reduced steam-production and waste-disposal costs.

Installing a wood chipper, storage silo, conveyor and oil burners enabled wastes to be co-fired with coal thus reducing steam production costs. Reducing steam costs has enhanced Milacron's industrial competitiveness.

2. Consolidating CHW production reduced operation and maintenance costs.



Innovative coupling of steam generation and absorption cooling technologies created financial opportunities at Cincinnati Milacron's 1.5 million ft² (139 350 m²) headquarters complex.

Generating CHW with large, two-stage absorption chillers using low-cost steam, instead of with small electric machines, has resulted in reduced operating costs/ton-hour of cooling produced. This centralizing of cooling equipment has facilitated preventive maintenance, and allowed faster and more efficient response to maintenance problems, resulting in reduced maintenance costs.

3. Use of increasingly more costly CFC refrigerants was reduced.

Costs and environmental liabilities associated with ozone-depleting CFCs were eliminated by replacing approximately 620 tons (2 181 kW) of electric chillers and DX units with the steam absorption chillers. Also, refrigerated compressed air dryers were connected to the CHW loop.

4. Use of previously-installed equipment saved capital costs and time.

Equipment was purchased from a broker and the plant design was adapted to it. The cooling towers and pumps had previously been part of the World Trade Center temporary cooling system for one year after the bombing occurred. The use of this equipment resulted in a substantial cost savings and allowed the first phase of the project to be completed in a reduced time frame.

Operation and Maintenance

Providing cooling and filtration for manufacturing areas has improved housekeeping and product quality as well as worker morale and productivity.

The central plant air compressors had been served by cooling towers that needed to be replaced. These were tied into the same cooling towers as the chillers, thereby avoiding an extra capital expense as well as cooling tower maintenance costs for separate units.

Cost-Effectiveness

Total annual savings and revenues from co-firing waste wood, oil and oil filter paper are \$354,400. When labor costs are subtracted from these savings and revenues, the positive annual cash flow is \$236,400. With the installation of the wood chipper, storage silo, conveyor and oil burners, costing

\$480,000, the waste minimization program has resulted in a simple payback on investment of about two years.

The objectives for the cooling portion of this program were to provide better temperature control in manufacturing areas to improve product quality and to phase out use of CFC refrigerants. Though cost savings were not motivating this portion of the program, the improvements had significant direct economic benefits, as follows:

1. Reduced chiller energy costs compared to the local electric chillers and DX units that were displaced: \$15,000 per year difference in steam vs. electric costs.
2. Reduced equipment maintenance and water treatment costs for chillers and cooling towers: \$30,000 annually.
3. Elimination of chiller refrigerant conversion costs and air-compressor cooling tower replacement costs: about \$1 million.
4. Increased boiler efficiency by operating at higher loads.
5. Improved worker productivity and enhanced product quality afforded by improved temperature and humidity control in manufacturing areas.

By innovatively coupling steam generation and absorption cooling technologies, the project has turned the environmental, economic and

logistical challenges associated with mechanically cooling an industrial complex into practical, financial opportunities. The objectives of providing cooling to improve product quality, phasing out the use of CFCs, minimizing wastes leaving the complex and reducing operating costs have been creatively met. ■

By innovatively coupling steam generation and absorption cooling technologies, the project has turned the environmental, economic and logistical challenges associated with mechanically cooling an industrial complex into practical, financial opportunities.

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