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New Developments In Gas Cooling

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There is no secret to the price volatility in the energy industry today. Dramatic increases in electric prices follow high summer-cooling demand periods. High gas prices track high winter-heating demand.♦ Attempts to control high summer electric prices with price caps have led to power shortages as wholesale spot prices soar beyond the price caps and suppliers decline to provide power.

On the gas side, the wildly high prices during the heating season of 2000–2001 immediately crashed as summer weather set in and demand evaporated.

As a nation, we have a large investment in energy delivery systems that are far out of balance. Our electric delivery system is oversized to cover peak summer needs. The gas delivery system is sized to meet peak winter loads.

The electric industry has understood this problem. It responded by promoting electric resistance heating in the 1960s, which remains popular for some commercial applications. More recently, electric air-to-air heat pumps have made significant market inroads in the South.

However, in the northern areas of the United States the system is most out of balance, with high heating loads in the winter, and summer peak cooling loads as high as those in the south, but of shorter duration. Unfortunately, short duration does not help. The electric system must be sized to supply power for those brief periods of peak demand.

The electric industry has made some strong moves to help rebalance this load by promoting ground-source heat pumps, a technology that can efficiently provide sufficient heating capacity in more northern climates. However, the ground loops needed for these systems have made them extraordinarily expensive to install, on the order of $2,000 or more per ton depending on system size.

Gas cooling also can be useful by moving some of the most volatile summer load — cooling — from the overloaded electric system to the underused gas system. In the 1990s, this led to a growing popularity of large gas-fired lithium bromide/water absorption or engine chillers. However, these systems have been predominantly used in large commercial buildings with central chiller systems.

Fully 70% of all commercial floor space is in buildings of less than 100,000 ft^2 (9290 m^2). Smaller buildings and homes tend to use packaged AC systems. Unless some solution can be found for this large segment of the market, balancing the energy delivery system will be difficult.

One approach is to revive a technology popular in the 1960s, but not widely seen since that time — gas air conditioners. Totally unlike large lithium bromide absorption chillers, these small capacity, packaged, air-cooled ammonia-water absorption gas air conditioners are designed for residential or light commercial uses. Widely used in the 1960s, these systems fell by the wayside due to their low efficiencies. Since that time, the technology has evolved to nearly double the efficiency of these systems. In today's deregulating energy industry, market forces are converging to bring these technologies back into the market.

A Quick Primer

Most of today's HVAC experts are unfamiliar with ammonia water air-conditioning systems. So, what is this old/new gizmo?

An ammonia water absorption system works like any absorption chiller except that ammonia is the refrigerant and water is the absorbent. Ammonia is boiled out of water by heat from a gas-fired burner and condensed in an outdoor air coil. The liquid ammonia is then evaporated at low pressure, producing cooling, and reabsorbed into the water.

Wait a minute — ammonia refrigerant — isn't ammonia dangerous? Actually,

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ammonia makes a great refrigerant. With 2.5 times the heat of vaporization of fluorocarbons, ammonia is highly effective, has no ozone depletion potential, and no significant global warming potential. If released, ammonia is swept out of the atmosphere by rainfall, and is environmentally benign. In fact, ammoniated water is the basis for most modern fertilizers.

Ammonia is only dangerous in large quantities or if released indoors. To avoid this, these systems are located entirely outdoors. Limited to 5–8 tons (18 –28 kW) of capacity per unit, the total ammonia charge is small. Even if released at one time, this small charge quickly disperses.

Ammonia/water has advantages over the more common lithium bromide/water absorbers.

- Ammonia is a high-pressure refrigerant, meaning that it can be directly air cooled in a compact coil. No cooling tower is required.
- There is no salt to crystallize in an ammonia water system.
- The system is under positive pressure, making components more compact and eliminating the need for air purge systems.
- Located entirely outdoors, these systems need no vent line or mechanical room space.

In comparison to conventional vapor compression air-conditioning systems, ammonia water air conditioners:

- Have very few moving parts and a reputation for long life (some units from the 1960s are still in operation).
- Require only single-phase power even at the 5 ton (18 kW) size.
- Require less than 300 W/ton of power for pumps and fans, liberating electric services for other uses. This compares well to 1.2 kW/ton for a 10 EER electric AC package in the 5 ton (18 kW) range.

New Systems, New Possibilities

But what about installing these systems? Depending on the opportunity, that may be the most interesting aspect of these gas air conditioners. The system provides chilled water/glycol solution to the building. By adding an optional gas boiler to the AC package, hot or chilled glycol/water can be provided to handle cooling and heating needs.

Gas air conditioners are and will likely remain significantly more expensive than electric AC packages. With new higher levels of efficiency, these units can provide operating cost savings in areas of the United States that have seen precipitous electric rate increases in recent years, such as California. However, most residential and light commercial air-conditioning customers have not been concerned enough about operating cost to try a new technology.

To interest customers and justify the added cost of gas air conditioning, we need to exploit the advantages of "all-water" (actually glycol-water) systems into new customer benefits or features. Using fan coils for delivery, features will include:

- Replacing duct-work with small chilled water lines (a major advantage in difficult retrofit situations or in high cooling demand applications).
- Clean architectural roofs (no rooftop units).
- A zonable system using individually controllable fan coils (a major plus in larger high-end homes).
- Lower delivered air temperatures than most residential systems (better dehumidification).
- Controllable chilled water temperature delivery to control dehumidification as needed.
- Using multiple gas air conditioners in one chilled water loop allows full AC redundancy (an advantage in medical, computer service, or other high reliability applications).
- Reducing peak electric loads reduces the required capacity of backup generators (another high reliability application advantage).
- Units can be located more remotely from the building (a quieter yard for high-end homes).
- Brings the advantages of central system "diversity" to smaller applications. One 5 ton (18 kW) unit can often replace three 2-ton (7 kW) standard electric DX units in a zoned application.

These are only some of the advantages. The inherent flexibility of water/glycol delivery opens up new vistas for the designer. Although small electric water chillers have long been available, they are as expensive as gas AC systems, and have no operating cost advantages.

Finally, one concern that has always limited chilled water

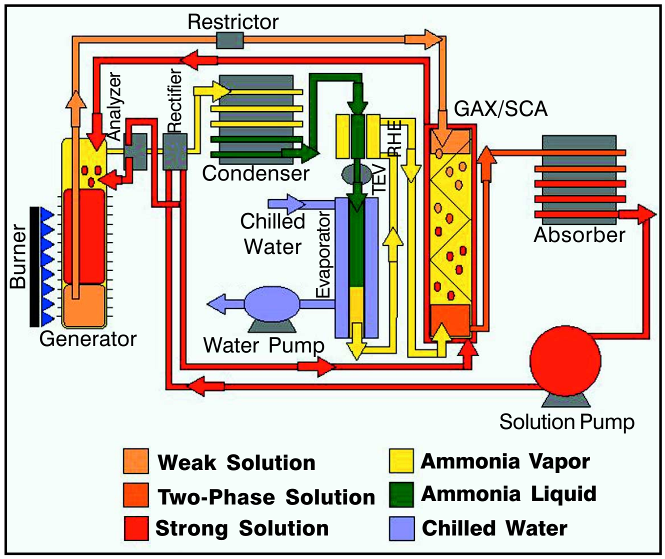

Figure 1: The generator-absorber heat exchange (GAX) cycle.


Figure 2: Early GAX unit circa 1995.

Today's Products

Figure 3: The left photo shows a high-efficiency gas air conditioner (chiller/heater model). The gas air-conditioning system in the center photo uses 5-ton (18 kW) units in three 25-ton (88 kW) modular configurations. The right photo shows a new chiller-heater link system.

systems in the United States is the higher cost of piping installation versus ductwork installation. Fortunately, the evolution of new, flexible plastic piping systems, which have revolutionized the in-floor heating system market, may have a major role here.

New Technical Developments

If this is all so great, why haven't we seen these systems widely applied? Aside from the lack of familiarity by designers, ammonia-water absorption systems have traditionally been low in efficiency, requiring as much as 125,000 Btu/h (36 638 W) of gas to fire a 5 ton (18 kW) system. New units requiring as little as 85,000 Btu/h (24 913 W) (32% less) are now coming to the market. So what is the secret?

Ammonia/water has a quirk that doesn't exist in lithium bromide absorption systems. When the water reabsorbs the ammonia, it releases heat. But unlike bromide systems, this heat is partly released at a high temperature. This high temperature heat can actually be recycled to replace some of the gas firing and reduce fuel input.

Sounds simple? It wasn't. This process has been in development, by the Department of Energy and the Gas Research Institute, for more than 15 years, and is still being improved. But this technology, referred to as generator-absorber heat exchange (GAX), has been proven and has entered the market

New Products

Today's Products

Ammonia water air conditioners have been continuously available since 1964. One manufacturer[1] recently has converted entirely to the GAX cycle.

Entering the Market

A high-efficiency GAX system, with development roots at Ohio State University and Battelle Laboratories, is being introduced to the market by another manufacturer.[2]

The core of this product line is to replace the conventional shell-and-tube heat exchange technology used in previous gas air conditioners with more compact nickel-brazed plate heat exchangers, originally developed for aerospace applications, for the absorber and the evaporator components.

Entering the Market

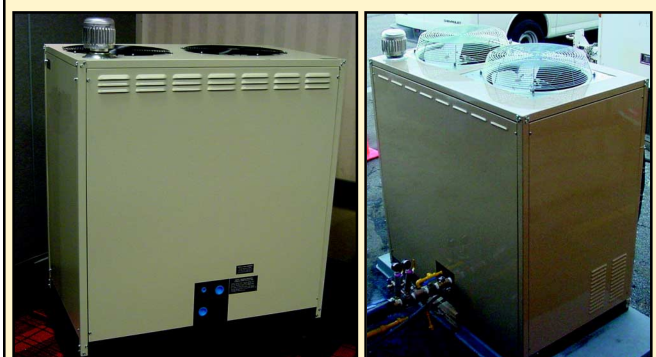

Figure 4: A new gas air conditioner is shown at left. This higher efficiency unit shown at right is entering field demonstrations.

Unlike previous gas air conditioners, this unit uses a thermostatic expansion valve and multi-speed condenser fans to improve controllability and to decrease start-up time

Soon to Arrive

A third GAX gas air conditioner is under development by a team of manufacturers.[3] This system features another aggressive approach to high-efficiency GAX operation. Commercial introduction is planned for Spring 2003.

Future Developments

Ammonia absorption systems present a range of possible future applications beyond air conditioning. One development firm[4] is working on advanced ammonia water concepts, with cost share assistance from the Department of Energy and others. These systems feature even higher efficiency cycles, and new applications.

- One new heat pump is for light commercial space conditioning. This 8-ton (28 kW) chiller/heat pump has achieved a gas cooling COP of 0.87 when air-cooled, and 1.1 when wa-

Soon to Arrive

Figure 5: Five-ton (18 kW) gas air conditioner in development.

Future Developments

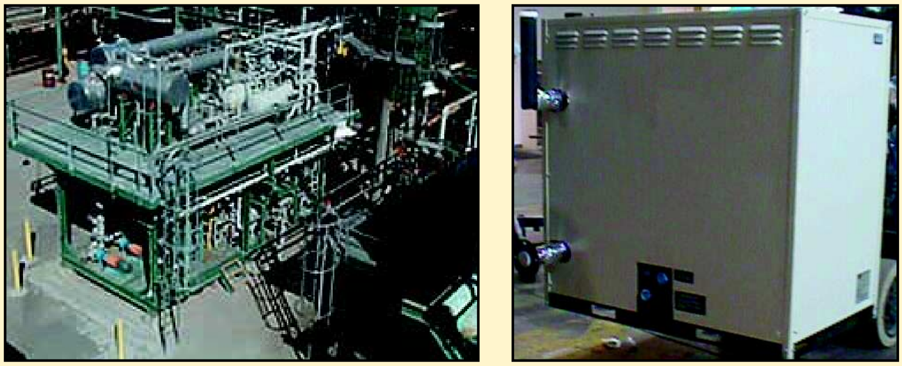

Figure 6: The left photo shows a 260-ton (914 kW) waste-heat-fired absorption refrigeration unit that provides –25°C (–13°F) chilling at an oil refinery. The ammonia water air conditioner, shown at right, is designed for microturbine waste heat operation.

ter-cooled. This is the highest performance ever documented for an ammonia water absorption system. The heat-pumping COP is 1.45. This unit has completed testing in a semi-packaged configuration and is being repackaged for field testing.

• A range of designs has been developed with capacities from 10 to 300 tons (35 kW to 1055 kW), and evaporator temperatures from 0°C to –50°C (32°F to –58°F) for industrial refrigeration. These designs are adaptable to either waste heat-firing or direct gas-firing. The waste heat can be from engines, turbines, fuel cells, or other exhaust streams.

• A new gas-fired heat pump is for service water applications. This appliance produces +60°C (+140°F) hot water at better than 130% efficiency and co-produces useful chilling. Heating capacities range from 200,000 to 3 million Btu/h (58 600 to 879 000 W), with corresponding cooling capacities from 8 to 100 tons (28 to 350 kW). The unit is scheduled to be field demonstrated this summer.

• A waste heat-powered inlet air cooler has been developed for microturbine applications. This appliance prevents the warm-ambient degradation that microturbines otherwise experience, while co-producing additional chilling plus service water heating.

The performance of all of the previous applications is enhanced with new heat and mass exchange components.

Finally, using waste heat from microturbine applications to produce space cooling directly is an attractive future technology. The microturbine would be relieved of the electric air-conditioning load and free to serve other, more continuous, electric loads.

Gas Prices

One question on everyone's mind after the unusually high gas prices in the winter of 2000-2001 is why using another gas technology is desirable. The continuing trend is for the demand for natural gas to hit rock bottom in summer. Even after the high prices of the 2000-2001 heating season, wholesale gas prices plummeted as summer came on, dropping to less than 20% of those seen the previous winter. Gas AC allows this market dynamic to be exploited.

Summary

After a long absence from the mainstream, new gas air-conditioning products are once again being prepared for the market. These systems will never be as inexpensive as mass-produced electrical air-conditioning systems and are not expected to move into the mass market in the near future. However, gas AC allows the HVAC designer new freedom in challenging design situations, and can provide significant customer benefits in specific situations.

Acknowledgments

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Bibliography

1. For more information on Robur/Servel equipment, visit www.robur.com.

2. For more information on Cooling Technologies, visit www.coolingtechnologies.com.

3. For more information on Ambian® Climate Technologies, contact Rocky Research at 702-293-0851.

4. For more information on Energy Concepts, visit www.energy-concepts.com.

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