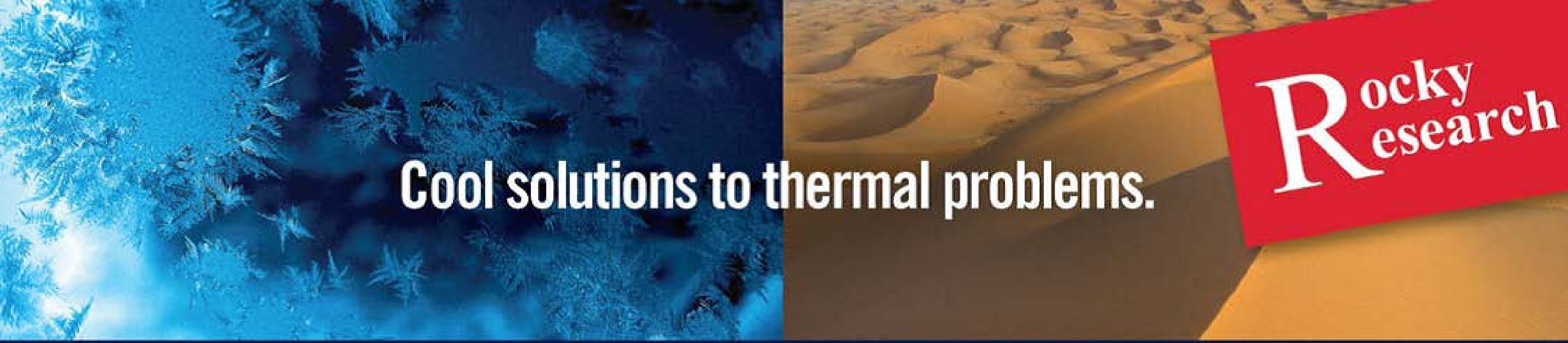

HVAC&R Solutions: Aqua-Ammonia Absorption Systems

Rocky Research combines an uncommon amount of expertise in thermal management with a focus on energy efficiency to develop dynamic solutions for the HVAC&R industry. From overall heating & cooling systems to flow control valves and operational controls management, our engineers, chemists, scientists and technicians have the experience and know-how to develop an HVAC&R solution for you.

Aqua-Ammonia Absorption Technology

Natural gas-fired absorption air-conditioning systems, which were briefly popular in the 1960’s, use ammonia as the refrigerant and water as the absorbent. In such systems, ammonia is boiled out of the water then condensed in an outdoor coil. The refrigerant is then expanded and evaporates in the evaporator at low pressure, producing the cooling effect. The ammonia is then reabsorbed into the water.

Ammonia is a much more effective refrigerant than fluorocarbons in terms of heat transfer and cycle thermodynamics. In addition, ammonia has no ozone-depletion potential and no global-warming potential, and is not harmful to the atmosphere if released in the environment. Ammonia/water absorption systems also have fewer moving parts than vapor-compression systems and exhibit long life. In spite of this, in the past, these gas-fired systems have exhibited very low levels of efficiency.

Over the past two decades or so, many researchers have been trying to improve the efficiency of ammonia/water absorption systems, most notably by trying to capture and reuse the heat that is released when the ammonia is reabsorbed into the water. This approach, described as generator-absorber heat exchange, or simply GAX, has been shown to raise efficiency levels dramatically, if implemented properly.

The new chiller/heat pump technology developed at Rocky Research also utilizes a GAX cycle, but the GAX aspect represents only one part of the solution to the performance limitations of the past.

Another important aspect of the design is the achievement of high-efficiency vapor separation. Rocky Research’s generator has a special construction that allows high generated vapor purity despite having very low ammonia concentration liquid. For example, on the hot end of the generator, the ammonia concentration in water which is used for absorption is in the range of 3 percent to 5 percent, while the vapor generated is Between 99.5 to 99.8 percent ammonia. This performance is indicative of an extremely effective distillation process.

The absorber design includes a very unique heat-transfer surface enhancement that provides high heat transfer in conjunction with good surface wetting at part-load conditions, which makes it amenable to accepting variable-flow rates.

The combustion process includes a low-emission, variable-capacity burner, which is unlike other products on the market that are single-speed, on/off.
Rocky Research's aqua-ammonia absorption technology is unique in that it includes a true variable speed operation technology with the capability of load tracking. The variable-capacity is made possible by a variable speed gas burner and by a new means of actively controlling the refrigerant. Instead of employing a traditional orifice pack, which will not function optimally under part-load or off-design ambient temperature conditions, a pulsing, thermal expansion valve is used that allows for refrigerant flow control over a wide range of capacities and temperatures.

These improvements put together deliver an absorption chiller with much higher efficiencies. However, a greater goal in Rocky Research's exploitation of the technology has been the development of a gas-fired, ammonia/water absorption heat pump, which has backing from the Department of Energy and a consortium of energy companies for the project. Taking the technology to that level required another key innovation, an efficient, positive-return, solution pump.

Conventional solution pumps on absorption systems are designed so that the diaphragm action depends on the pressure of the solution being higher than the ambient pressure. Taking into account friction losses, this manifests itself as limiting the lowest possible operating pressure for the solution to 30 psi to 35 psi, which limits operating solution temperature to somewhere in the mid-30's. Together, this means that an absorption heat pump using this conventional type of solution pump would not work below the range of 45ºF outdoor, which is where heating load hours typically increase significantly

In response to this conventional limitation, Rocky Research has developed a solution pump with a positive return, which gives the necessary delta-P capability and allows low side pressure to go as low as 8 psia to 10 psia. Operation was tested in all six of the ASHRAE-defined climate conditions and it worked fine in all, which means that it worked at -22ºF.

The new solution pump is also smaller and significantly more energy efficient than the conventional pumps.

The first gas-fired absorption units built were dedicated 5-ton chillers. The goal was to achieve a COP (Coefficient Of Performance) of 0.70 at the 95ºF ambient temperature rating point for chillers. The goal was surpassed slightly, with some units hitting 0.71 COP.
Another traditional and significant downside to gas-fired absorption systems when compared to vapor compression technology is the issue of cycling losses. Every time a gas unit shuts down, the entire solution in the system cools off and pressure equalization also occurs. When the unit restarts, the solution has to be reheated and pressure differential re-established before the system begins cooling again. This wastes a lot of energy, and it can also irritate the consumer, who may have to wait 5 to 15 minutes after restart for the unit to begin producing cool air again.

These cycling losses can cause up to a 30 percent decline in efficiency. Therefore, even if a chiller has a 0.7 COP at steady state, that could translate into a 0.48 or 0.49 seasonal energy efficiency rating (SEER) due to cycling losses. For this reason, Rocky Research developed a system with variable capacity, allowing operation at part-load capacity without frequent on/off cycling and also a load tracking capability for optimal operation. Therefore, when operated at a part-load point of 85ºF, instead of the integrated COP dropping from 0.7 to 0.5or less, the variable-capacity unit actually goes up to 0.84. This represents a significant breakthrough in aqua-ammonia technology at the operational level

The 5-ton gas-fired absorption heat pump being tested also utilizes this technology with impressive performance. Because it is able to pump heat at lower ambient temperatures, it can provide a heating COP of 1.44 at the 47ºF rating point. That is total gas efficiency, not internal cycle efficiency. More importantly, the unit is able to provide heat pumping down to -22ºF. This is extremely significant in light of the temperature operating range for existing electric heat pumps.

When compared to a vapor compression heat pump, one significant issue is its high capacity. A 5-ton, 13 SEER electric heat pump can deliver roughly 55,000 BTUs at 47ºF. Its balance point, where supplemental electric resistance heating has to be utilized, is somewhere between 32ºF and 35ºF, at which point the heat pump is typically only delivering about 30,000 BTUs. Depending on the model, that particular electric heat pump quits pumping heat altogether between 22ºF and 24ºF, which puts the heating burden solely on the electric heater. This is why in many cold climates it does not make sense to use electric heat pumps.

By contrast, Rocky Research's heat pump delivers 108,000 BTUs at 17ºF, that's 6º lower than where the electric heat pump has already ceased to provide any heat at all. Our heat pump's balance point, is approximately 0ºF. That means that this heat pump could be used in most sections of the country with no supplemental heating.

Rocky Research's heat pump delivers twice the heating capacity of its cooling capacity. Therefore a 5-ton cooling capacity unit for heating purposes is equivalent to a 10-ton heater

An independently performed, operating-cost study showed that if the gas heat pump replaced both the gas furnace and vapor-compression air conditioner typically found in a Chicago-area home, the homeowner would save roughly $1,000 a year in combined heating/cooling operations, based on current Chicago-area utility rates.

Another potentially interesting application for the new technology is waste heat utilization from the exhaust of engines, gas turbines and high temperature fuel cells. Because of the generator's unique design, direct integration with these exhaust effluents is possible in many applications.