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The Merits of Adiabatic Humidification

Welcome to the next level of HVAC Energy Efficiency

Too many peas in the pot

In 1978, when David White, the founder of Humidifirst, was in school at the University of Pittsburgh, he had a course entitled "Energy and the Environment". As an engineering student, the times were exciting for him and there were many challenges: the oil embargo of 1973; lines at the gas pumps were long; Jimmy Carter was president and talking about nuclear energy because that's what Carter knew as a engineer himself; and saving energy was a hot topic. David's professor used to say that making engineering improvements to save energy was like scooping peas from a pot of boiling water. In your first few scoops it is easy to remove a lot of peas. It was chasing around those last few peas that took a lot of effort.

It's 2018, and there are still too many peas in the pot

It is 2018, and electricity costs continue to rise while natural gas prices have tumbled. It's true that many HVAC systems have become more energy efficient (economizers, variable speed drives, energy recovery wheels, Variable Refrigerant Flow), but how often are they put to use in our facilities? Yes, engineers are designing energy efficient HVAC systems, but some aspects are being left untouched. Humidification remains an area of HVAC that has **not** been given the amount of attention that it is rightly due.

Steam humidifiers, without exception, use a tremendous amount of energy. The reduced cost of natural gas offsets the inefficiency in gas fired steam humidification however the environmental cost is still significant. In this day and age, at the portly consumption rate of 35 Kilowatts per hundred pounds/hour of humidification, how can we justify boiling water using electricity to humidify? Our buildings are now well insulated and their internal heat gains, are higher. So most commercial/industrial buildings are cooling throughout the winter. As air side economizers are being used humidification loads have climbed then, one surely hopes that this outside air is being humidified with an adiabatic humidifier because boiling water to humidify- at .350 kilowatts per pound- is both financially and environmentally unsound. The energy consumed by steam humidifiers is so wasteful that one might think it would be against the law. And, guess what? It is illegal in the State of Washington to use steam humidifiers when air side economizers are incorporated. The State of Washington passed a law twelve years ago that says: "If an air side economizer is required on a cooling system for which humidification equipment is to be provided to maintain a minimum indoor humidity levels, then the humidifier shall be of the adiabatic type *Washington State Energy Code*, Ch. 51-11 WAC, Section 1413.4 (2005)).

Adiabatic humidification - it saves energy and has many other benefits

Regardless of the law, adiabatic humidifiers should be the standard, especially when used in conjunction with air side economizers. With newer technologies and recent improvements in design, adiabatic humidifiers have become much easier to apply to HVAC systems. HVAC engineers should consider designing with adiabatic humidifiers, and the main reasons are these:

1. *Sizing of adiabatic humidifiers for use with air side economizers*. Steam humidifiers must be sized for 100% outside air at approximately 55˚F. With adiabatic humidifiers, evaporative free cooling will reduce the amount of outside air needed for free cooling. Typically the adiabatic humidifier can be sized for 25% less outside air than the steam humidifier. Think of it this way: Total Free Cooling = Sensible Cooling from Cool Outside Air + Latent Cooling from the Adiabatic Humidifier. An example is provided later in the article.

2. *Reduction in the building energy requirements by approximately 325 watts per pound of humidification.* Ultrasonics use 25 watts per pound of humidity compared to 350 watts per pound with steam. That's a savings of 65 KW on a typical 200 pound per hour system. That's $19,500.00 per year in electricity savings at 10¢ per kilowatt•hour and 3000 hours of usage per year.

3. *Superior control.* Ultrasonics provide instant on/off of the humidifier and require no flush cycle. This means very precise humidity control. There is no lag time while waiting for water to boil to produce a mist. And, there is no shut down period since there is no dirt to be flushed.

4. *Ease of evaporation*. With ultrasonic adiabatic humidifiers, droplet volumes are approximately 0.52 cubic microns – similar to steam so evaporation is quick and easy.

5. *Suitable for high velocity applications*. Ultrasonic adiabatic humidifiers are now designed with adjustable discharge nozzles that allow the humidifier module to

operate in air velocities of between 200 to 2000 feet per minute. Old design standards limited operating between a 300 to 800 fpm air velocity range. This technological advancement makes ultrasonics very effective in high velocity ductwork.

6. *Stepping and Pulsing the mist*. Ultrasonic control systems can shorten evaporative distances by orchestrating a stepping and pulsing process of their transducers. The instant on/off capability of the ultrasonic transducers allows for these methods of precise humidifier operation.

7. *Increased free cooling hours of the economizer*. For example using American data as it is more easily available, in Harrisburg, Pennsylvania, there are 4582 hours per year when the ambient air temperature is 55˚F or less. If evaporative cooling via the adiabatic humidifier reduces the air temperature by 10˚F, then you can actually operate the economizer with an ambient temperature of 65˚F. In Harrisburg, this increases the potential economizer hours from 4582 to 6064 hours and leads to even greater energy savings.

8. *LEED Points.* Given the energy profiles and design advantages, adiabatic is a natural for LEED

Adiabatic humidifiers: There are three adiabatic humidifier technologies used in the industry today: ultrasonic, spray nozzle, and evaporative pad.

a. **Ultrasonic adiabatic humidifiers:** Ultrasonic humidifiers use a multiple of transducers (physically similar in size to a nickel) that are mounted under a pan of water. The transducers vibrate 1.65 million times per second, causing a mushroom shaped water finger to form, off of which steam sized, 1 micron diameter droplets (.52 cubic micron sphere volume) are produced. The droplet size remains constant regardless of the life of the transducer.

   Ultrasonic humidifiers provide free cooling <u>and</u> have full evaporation of water droplets. When added to HVAC systems with air side economizers, two **natural** cooling effects occur: 1) cooling from the outside air, and 2) free evaporative cooling. This combined free cooling permits the system to achieve its design sensible cooling with a smaller ultrasonic humidifier than would be possible with a steam humidifier.

   Using the following formula:

   Total sensible cooling = [free cooling from outside air] + [free cooling from humidifier evaporation]

b. **Spray nozzle adiabatic humidifiers:** Spray nozzle systems force water through a machined nozzle to create water droplets. They are available in two technologies: very high water pressure (1000 to 3000 psi) or a combination of

compressed air and water (30-70 psi air). High water pressure systems, being the most prevalent in the spray nozzle industry today, will be chosen for this discussion. Multiple nozzles, typically rated between 9 and 15 #/hour each, are used to achieve the desired capacity. The size of the droplet will vary depending on the water pressure variations and/or maintenance of the system. Spray nozzle droplet sphere volumes typically range from 523 to 33,510 cubic microns (10-40 micron diameters), based on data from a leading manufacturer.
Spray nozzle humidifiers provide free cooling but have very large water droplets that do not fully evaporate. As a result, 25% to 60% of the droplets created do not get evaporated and go to drain

c. **Evaporative pad humidifiers**:
While these units have a place in manufacturing for process loads, this technology presents several problems: principally it requires large volumes of standing water which if not properly treated can be an excellent breeding ground for legionella; biocides are forbidden to treat the bacteria in ducted systems as they will be distributed throughout the air system; and worst of all 60-70% of the water goes to drain because the droplet size is too large to be evaporated efficiently

First-Cost Justification
There are many cases where the incremental costs of adiabatic humidifiers over steam humidifiers are paid for by these government agencies.

There are cost considerations in determining the appropriate humidifier technology to use. These are:

1. Power consumption of the compared systems (make sure that you have current data on the price of fuel, as the fuel surcharge element of utility bills can fluctuate).

2. First cost of the humidifier.

3. First cost of the reverse osmosis system (RO) for the humidifier technologies being compared. Supply water should be treated by an RO system, regardless of the humidifier technology. Otherwise, dissolved solids from the water will be transferred to the air stream, causing dust to form.
   a) Reverse osmosis systems will be similar in size for Ultrasonic and Steam humidifiers.
   b) RO is Superior technology because the membrane removes contaminating solids from the water

4. Water softeners are a poor substitute for reverse osmosis
   a) Softeners exchange chlorine carbonate and magnesium carbonate with sodium carbonate; the sodium carbonate raises the total dissolved solids

(TDS) of the water by 15% but is softer and easier to flush to drain; it precipitates out faster fouling the heat exchangers thereby retarding the heat transfer.

b) Labour intensive: weekly flush cycles are required on softeners to prevent buildup as well as the labour to recharge the salt reservoirs

5. Operating cost of the reverse osmosis system.

Ultrasonic adiabatic humidifiers used in a large telecom application

Conclusion

Now is the time to re-examine those areas where large amounts of energy are still being consumed in the HVAC industry, or as David's professor said so many years ago"…time to start searching for those last peas ". They're sitting right in front of you.

David White - Humidifirst

David graduated in 1980 from the University of Pittsburgh with a degree in mechanical engineering. He completed the Graduate Training Program at the Trane Company where he worked as a sales engineer before moving to McClure Company Mechanical Contracting. After a stint at Liebert , David joined Stulz GMBH before founding his own company Humidifirst. David passed away in 2006

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Gary has worked in the HVAC for 46 years starting with the Trane Company in 1971 as an office clerk. He left the Trane Company in 1999 as General Sales Manager worked for Enwave District Energy before joining his family's firm, the DSL Group of Companies. The DSL Group is the Canadian representative for Humidifirst through CTM, one of its members.