Report on Laboratory Testing of the AirGreen Solution to HVAC Problems in October 2015

Introduction

AirGreen is going launch a revolutionary Commercial HVAC product in the next year. This product represents a major change in the way air conditioning is carried out and a solution to the problems of:

- high energy use
- high humidity in buildings
- cold, clammy conditions in hot, humid weather

To be sure that the products for field trials are designed and built appropriately, AirGreen built a Beta unit and sent it for testing at an HVAC test laboratory.

The problems above can be solved by using a different way of conditioning air that involves removing a large amount of the humidity without over-cooling the air. Conventional systems can remove about 20% of the energy content of the air in the form of humidity, but if higher amounts are present it is necessary to over-cool and then reheat the air. This process is wasteful of energy because it reduces the cooling carried out while increasing the energy used and it too has a technical limit commonly quoted in technical articles of around 35%.

When conventional air conditioning was first introduced, the limit of 20% did not cause too many problems because the heat (sensible) energy far exceeded the humidity (latent) energy in the combined indoor and outside air that needed conditioning. However, with increased energy and insulation standards the sensible heat load has fallen while the latent heat load from inside the building has remained constant. At the same time, ventilation standards (ASHRAE 62 2001) have increased the required amount of outside air. This outside air contains the bulk of the humidity that needs to be removed to reach the comfort level of below 50% Relative Humidity (RH). In most high efficiency buildings (LEED for example) the latent heat ratio has risen from below 20% to above 40%. The greater is the insulation, the higher is the latent ratio, which can reach 60 or 70% in typical Commercial buildings.

The AirGreen products are designed to maximize the humidity removal while remaining cost-effective. The tests carried out in October 2015 were designed to show that even at the high heat and humidity reached in Florida summer conditions AirGreen equipment:

- removes large amounts of humidity effectively
- uses sources of cold and hot water at a high effectiveness ratio
- has low levels of parasitic energy (for pumps and fans)
- operates simply and reliably

This report gives the results of two days of testing at different conditions and shows that the performance parameters were met.

The findings show that AirGreen units can condition air with a latent heat ratio of 80%.

Experimental Setup

1. Air Flows

The equipment consisted of two AirGreen units that were installed in a test laboratory.

The inlet air to the Air Conditioner/Dehumidifier section simulated a summer Florida condition (approximately ASHRAE Miami 1%).

The other AirGreen unit was set up as a Regenerator for the liquid desiccant. The inlet air was at typical ASHRAE test conditions (79-81^{o}F, 67^{o}F WB).

The test lab had limitations that allowed only 1,500 cfm at a hot and humid condition and 2,000 cfm at a milder condition.

2. Energy to the AirGreen Units

The Air Conditioner was supplied from a cold-water loop chilled by an array of heat pumps. The hot water was supplied from a boiler system. The laboratory staff controlled the temperature semi-automatically and flow rate of the water manually as needed. (See results.)

The laboratory system was able to provide cold and hot water as required for the AirGreen system at 60^{o}F and 130 to 135^{o}F respectively. It should be noted that competitor units require much higher hot water temperatures and chilled water temperatures. Additionally, these temperatures enable the use of direct geothermal energy and heat pump energy recovery.

Evaluation of AirGreen Liquid Desiccant Dehumidification System

The system performed as expected with a range of adaptability when energy sources in the form of hot and cold-water flows were provided to the system. The liquid desiccant system is very effective in removing large amounts of moisture and can reach leaving air conditions with much lower humidity levels than are possible with mechanical refrigeration.

General conclusions:

1. System air pressure drops were very low. The pressure drop was 0.5" on the regenerator at 1500 cfm. This pressure drop includes the pressure drop across a MERV8 air filter and the air-to-air exchanger.
2. The pressure drop was 0.25" on the dehumidifier at 1500 cfm. This pressure drop includes the pressure drop across a MERV8 air filter.
3. There was no carry over of liquid desiccant as observed in the ductwork immediately downstream of the Air Conditioner even though the unit had been run for over an hour at 3,500 cfm (design 2,000 cfm).
4. The operation of the system was stable and predictable based on water temperatures and entering air moisture content). At part-load the air temperature and humidity could be varied over a significant range.

5. The system was tested at a hot and humid inlet air:
    a. Dehumidifier section
        - Inlet (ambient air) 87 - 89°F DB 81 - 82°F WB
        - Outlet Air (41%RH) 70 °F DB 56 °F WB
        - Airflow 1500 cfm (due to test limitations)
        - Inlet chilled water temp 60.5°F
        - Tonnage at 1500 cfm 11.0 tons
        - Tonnage at 2000 cfm 14.6 tons (calculated)
        - Enthalpy reduction 20 – 21 Btu/lb
        - WB depression 22 - 23 °F
    b. Regenerator
        - Inlet air 81 - 82 °F
        - Inlet water temp. 135-136 °F
        - Tonnage 10.8 tons

6. The system was tested at a mild condition:
    a. Dehumidifier section
        - Inlet (ambient air) 76°F DB 66°F WB
        - Outlet Air (40% RH) 70°F DB 55.5°F WB
        - Airflow 2,000 cfm
        - Inlet chilled water temp. 60°F
        - Tonnage … at 1500 cfm 5.2 tons
        - Enthalpy reduction 7.3 Btu/lb
        - WB depression 10.5°F
    b. Regenerator
        - Inlet air 79°F
        - Inlet water temperature 127°F
        - Tonnage 5.2 tons

7. In both test conditions above, the laboratory staff estimated the effectiveness of the usage of the cold and hot water energy to be very close to 100% within the limits of measurement error.
8. The system cooled and dehumidified air at a SHR (Sensible Heat Ratio) of 19 to 21% compared with a conventional system, which typically will not do less than 80% SHR.
9. The pump parasitic load was 4.5% in the hot, humid case and 8% in the mild case.
10. At the test conditions, the AirGreen unit met and exceeded AirGreen's specifications.

The above is based on an analysis of data recorded at the laboratory, and analyzed and reviewed by AirGreen.

Andrew Mongar, President, AirGreen
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Test Results taken from log of AirGreen run on October 22nd, 2015 at Hot and Humid conditions

Air Conditioner (dehumidifier) Section

Entering Conditions		
CFM	1,500	
Entering db	88	°F
Entering wb	81.5	°F
Rel Humidity	76	%
Humidity Ratio	0.0219	
	153	grains/lb
Enthalpy	45.2	BTU/lb
Dew Pt	79.6	°F

Leaving Conditions		
CFM	1,500	
Leaving db	70.5	
Leaving wb	57.5	
Rel Humidity	45	%
Humidity Ratio	0.0071	
	50.3	grains/lb
Enthalpy	24.8	BTU/lb
Dew Pt	48.4	°F

AirConditioner Capacity		
Moisture removed	103	gr/lb
Moisture removed	99	lb/hr
Sensible Capacity	27,968	BTU/hr
Latent Capacity	103,646	BTU/hr
Total Capacity	131,614	BTU/hr
Total Capacity	11.0	Tons

Chiller Tons		
Entering Water	60.5	°F
Leaving Water	68	°F
GPM	37	
Calculated tons	11.6	

Regenerator Section

Entering Air DB	79	°F
Entering Air WB	67	°F
Entering Water	136	°F
Leaving Water	129	°F
CFM	1,500	
GPM	37	

Test results taken from log of run on October 23rd, 2015 at Mild Florida conditions

Air Conditioner section

Entering Conditions		
CFM	2,000	
Entering db	76	°F
Entering wb	66	°F
Rel Humidity	60	%
Humidity Ratio	0.0114	
	80	grains/lb
Enthalpy	30.8	BTU/lb
Dew Pt	60.9	°F

Leaving Conditions		
CFM	2,000	
Leaving db	70.5	
Leaving wb	55.5	
Rel Humidity	38	%
Humidity Ratio	0.0060	
	42	grains/lb
Enthalpy	23.5	BTU/lb
Dew Pt	43.9	°F

Main Unit Capacity		
Moisture removed	38	gr/lb
Moisture removed	49	lb/hr
Sensible Capacity	11,741	BTU/hr
Latent Capacity	50,917	BTU/hr
Total Capacity	62,658	BTU/hr
Total Capacity	5.2	Tons

Chiller Tons		
Entering Water	60	°F
Leaving Water	65	°F
GPM	25	
Calculated tons	5.2	

Regenerator Section

Entering Air DB	79	°F
Entering Air WB	67	°F
Entering Water	127	°F
Leaving Water	122	°F
CFM	1,500	
GPM	25	