Opportunities for AirCap Humidity Control

Humidity control can help to optimize the performance of the hot air / direct contact drying processes used in the pulp and paper industry. These processes include Yankee Hoods and Through Air Dryers used in tissue manufacturing and Air Float dryers and Flash Dryers used to dry pulp. Humidity control has the potential to improve thermal efficiency, reduce sheet moisture variability, and assist in process diagnostics.

The exhaust humidity is one of the most important factors determining dryer thermal efficiency. Increasing the exhaust humidity reduces the dry air flowrate into/out of the dryer. The energy required to heat up dry air to the exhaust temperature is reduced proportionately. Figure 1 shows the relationship between exhaust humidity and energy consumption per lb of water evaporated in a Yankee AirCap dryer.

In the majority of dryers, the dry air feed-rate is maintained relatively constant over the entire operating range. The Makeup Air/ Exhaust Air damper positions are rarely adjusted. This approach means that the exhaust humidity will vary with the evaporation rate. At high production rates the evaporation rate is high (achieved by increasing the drying air temperature) and the exhaust humidity will also be high. The reverse is also true. If the production rate is constant but the incoming sheet moisture content decreases, the evaporation rate will decrease and the exhaust humidity will decrease. In most mills, the makeup and exhaust damper positions are set conservatively and the average humidity is substantially lower than necessary.

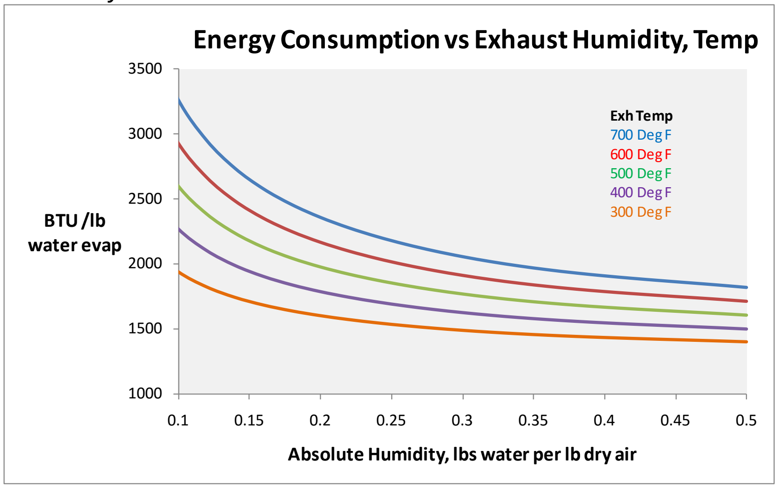

Figure 1 shows Energy Consumption versus Exhaust Humidity and Temperature in Yankee Aircap

Benefits of Humidity Control on a Yankee Aircap

In this update we will focus on the potential benefits of Humidity Control on the Yankee AirCap in a case study format.

Process and Control Description

The operating and design conditions are shown in Table 1. The sheet enters the Yankee / Aircap dryer at 40% dryness and leaves at 96.5% dryness. The AirCap control strategy is straightforward. The Wet End (WE) and Dry End (DE) supply temperature controllers operate in cascade mode, receiving a remote setpoint from the post dryer sheet Moisture controller. The temperature controllers adjust the fuel flow to the respective burner. The WE and DE Hood Inlet and Discharge Pressures are measured but not controlled. The Makeup Air Dampers and Exhaust damper positions are fixed.

The AirCap exhaust stream passes through an air to air heat exchanger (economizer) to preheat the Makeup Air.

TABLE 1 – YANKEE AIRCAP OPERATING CONDITIONS

Production Rate	
Reel Sp fpm	4500
Sheet Width inch	180
Basis Wt lb/3000	11
Production, TPD	178.2
Production, BDTPD	173
Evaporation Rate	
Inlet Dryness, %Solids	40
Reel Dryness, % Solids	96.5
Lb H2O/Lb Paper	1.41
H2O Evap, TPD	251.7
H2O Evap,lb/min	349.6
Operating Conditions	
Hood Exhaust Temperature, Deg F	600
Economizer Exhaust Temperature, Deg F	300
Makeup/Combustion Air Temp Deg F	60
Sheet Inlet Temperature Deg F	100
Yankee Steam Pressure, psig	100
Combustion Air, % Excess	20

Thermal Efficiency Discussion

Developing the case for energy savings is reasonably straightforward. The evaporation rate can be determined if the production rate and the inlet / product sheet moistures are known. If the temperatures of the Hood exhaust, Economizer exhaust and Makeup Air are known, then a reasonably accurate mass and energy balance can be calculated for a given exhaust humidity.

Figure 2 shows the estimated flowrates at the original exhaust humidity of 0.2 lb water/lb dry air. The water vapour and dry air exhaust flowrates are 403 and 2013 lbs/hr respectively. The estimated gas firing rate is 512 SCFM. Figure 3 shows that the cost of heating the dry air from 60 Deg F (Room Air Temp) to 300 Deg F (Economizer exhaust temperature) is approximately $365000 per year. The energy cost to evaporate water and raise the water vapour temperature to 300 Deg F is approximately 4 times higher than the dry air heating cost.

The thermal benefit of increasing the exhaust humidity to 0.4 lb water per lb of dry air is shown in Figures 4 and 5. The gas firing rate, the combustion air flow and the exhaust air flow have been reduced by approximately 20%. The dry air heating cost has been reduced to $179000, a savings of $186000.

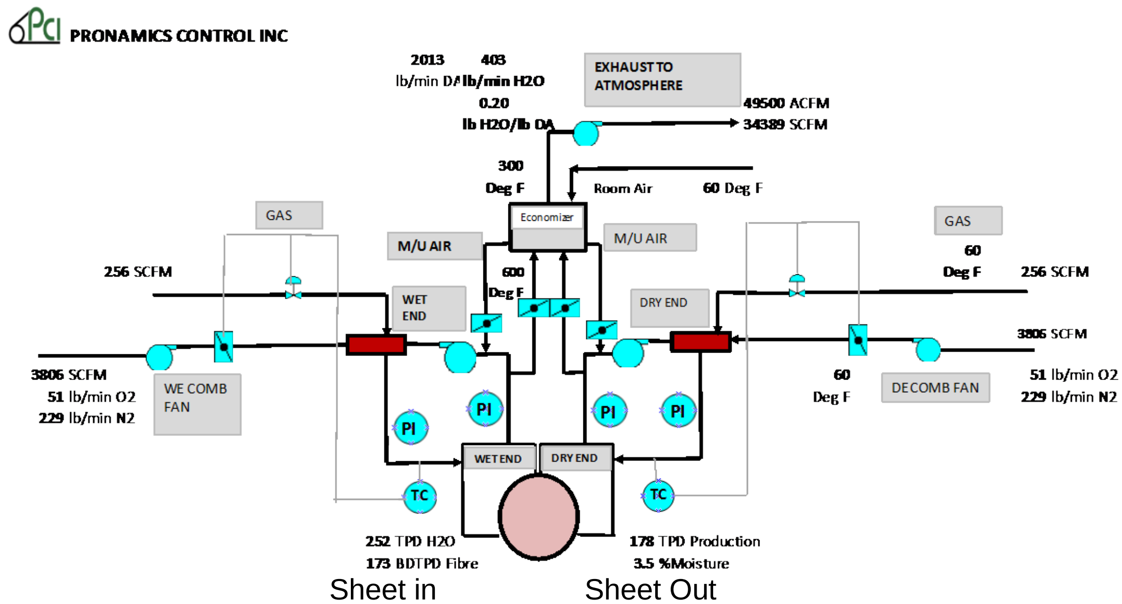

Figure 2 AirCap Flow Balance at 0.2 lb water per lb dry air

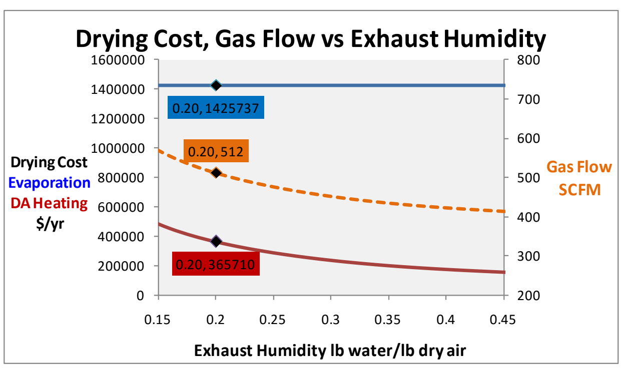

Figure 3 shows that approximately 512 SCFM of natural gas is required at an exhaust humidity of 0.2 lb water/lb dry air. The annual cost of heating the dry air to the economizer exhaust temperature is $365,000

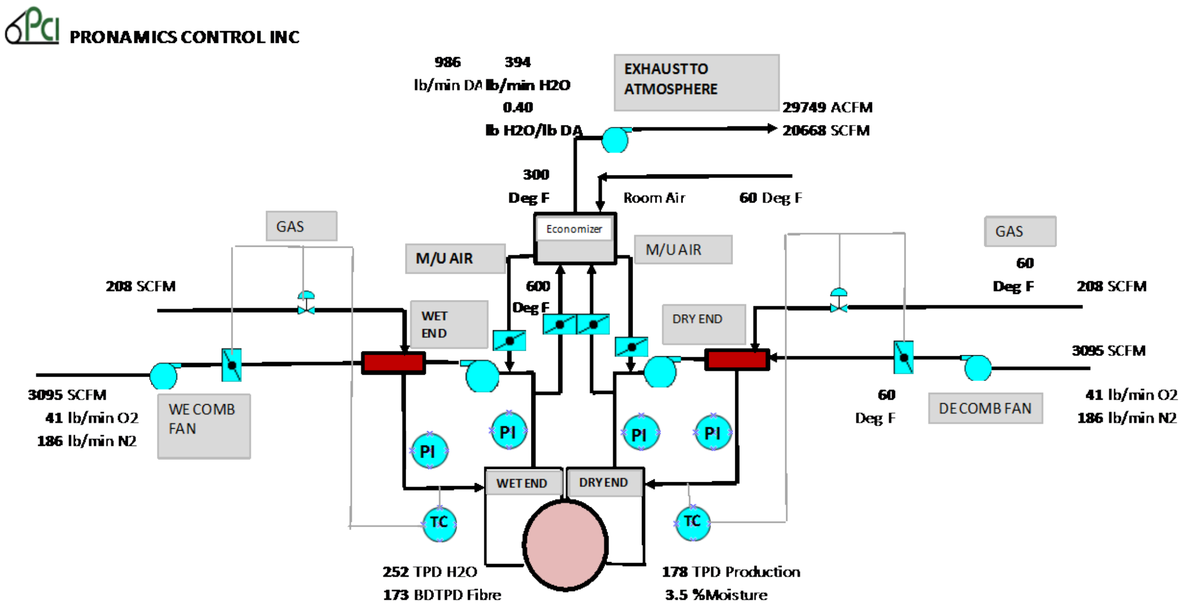

Figure 4 AirCap Flow / Energy Balance at 0.4 lb water per lb dry air

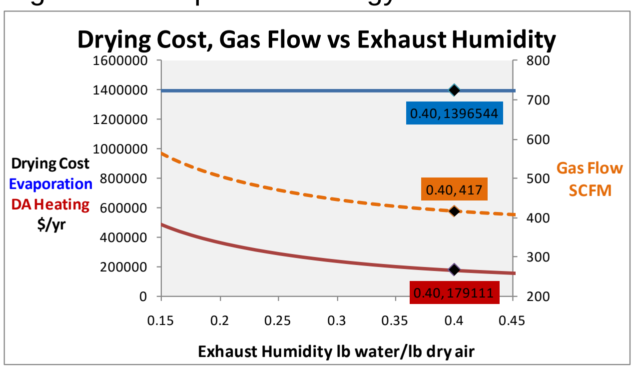

Figure 5 shows that approximately 416 SCFM of natural gas is required at an exhaust humidity of 0.4 lb water/lb dry air. The annual cost of heating the dry air to the economizer exhaust temperature is $179000.

Impact on Air Density

One outcome of a higher humidity is lower drying air density. The density of water vapour at 300 Deg F is 0.0365 lb/ft^3 - much lower than the dry air density of 0.052 lb/ft^3. The mass flowrate delivered by a Fan will decrease as the humidity increases. The Supply Fan needs to operate at higher speeds to deliver the same mass flowrate. The resulting increase in electrical power costs typically offsets the decrease in gas firing costs by approximately 20%.

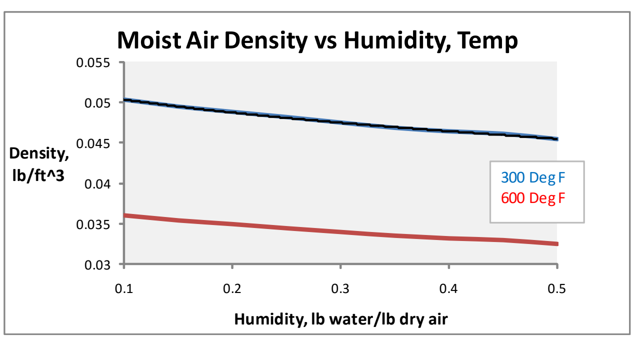

Figure 6 shows the relationship between drying air density and humidity.

Humidity Control Strategy

The humidity controller functions by adjusting the dry air flow into the dryer system. An increase in the evaporation rate must be offset by an increase in the dry air flow if the humidity is to be maintained constant. The dry air flowrate can be increased either by opening the Exhaust damper or opening the Makeup damper. In terms of overall control performance, the Makeup Air damper is the preferred final control element. As the Supply Air Temperature increases, the evaporation rate and drying air humidity increase. The Humidity controller will then open the Makeup Damper, allowing more fresh air into the system. In order to ensure that the Hood remains balanced, the Hood discharge pressure controller will open the Exhaust Damper to maintain the Discharge Pressure constant.

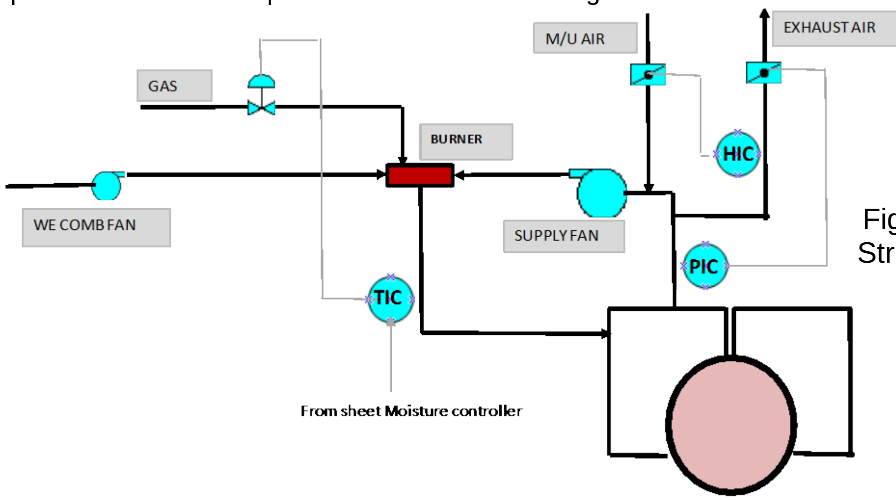

Figure 7 - Humidity Control Strategy