Practical aspects of Yankee hood humidity control

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The typical Yankee hood serves several important functions. It performs as a convective dryer, driving water out of the sheet by defined heat transfer mechanisms. It also efficiently removes the evaporated water out of the hood/cylinder interface and into a dedicated exhaust system.

The total burner load requirement is the sum of:

- Heat to sheet
- Heat to evaporate water
- Heat to radiation
- Heat to makeup air.

The fuel operating cost for a Yankee hood is directly related to the system exhaust humidity loading.

In this paper, we will suggest a practical way to measure and control the Yankee exhaust humidity.

Hood balance

Figures 1 and 2 show the two most common system air flow arrangements in Yankee hood design. Figure 1 is the standard concept, typically seen in North American mills, with separated fresh air makeup intakes to the wet-end and dry-end supply fans. Both makeup air streams pass through an air/air economizer. Figure 2 illustrates the cascade concept, typically seen in European installations, of routing dry-end exhaust air, as makeup, into the wet-end hood. The dry-end makeup passes through an air/air economizer prior to entering the adjoining supply fan.

In both cases, the greater the recirculation volume to the burner chambers, the higher the overall hood system exhaust humidity and the lower the fuel consumption, as illustrated in the graph in **Fig. 3**.

From a heat and mass balance analysis of the two arrangements, one can see that the air streams which ultimately affect the overall balance are the ones which cross the control volume boundary (dotted lines):

- Exhaust to atmosphere
- Fresh makeup
- Wet-end combustion
- Dry-end combustion.

The difference in mass flow between the exhaust air and the other three supply streams is physically evident as hood infiltration or spill.

Combustion air is a small portion of total fresh intake air flow and is automatically controlled by the burner. The makeup and exhaust dampers, therefore, are the only controllable elements which can be used to balance most Yankee hoods. The following description is a simple method which can be used to balance typical Yankee hoods.

Step 1

Preset the makeup dampers to 20% open. Preset the exhaust fan damper to 50% open. Preset the exhaust dampers to 50% open.

Step 2

Do a simple mechanical check at the hood sides (front and back) by holding out a strip of tissue paper and observing whether the hood is under positive or negative pressure.

Step 3

Adjust the exhaust dampers until there is a slight negative at the hood periphery. This infiltration, if measured with a manometer, would be in the order of -0.10 in. water column.

Step 4

Measure the exhaust humidity. Compare the actual reading to the design setpoint and repeat the previous steps.

Mechanical seals around the hood/cylinder edge do not prevent hood spill or buildup hood humidity. Therefore, adjustable edge seals and peripheral exhausts only marginally assist the all-important damper position control (i.e., humidity control).

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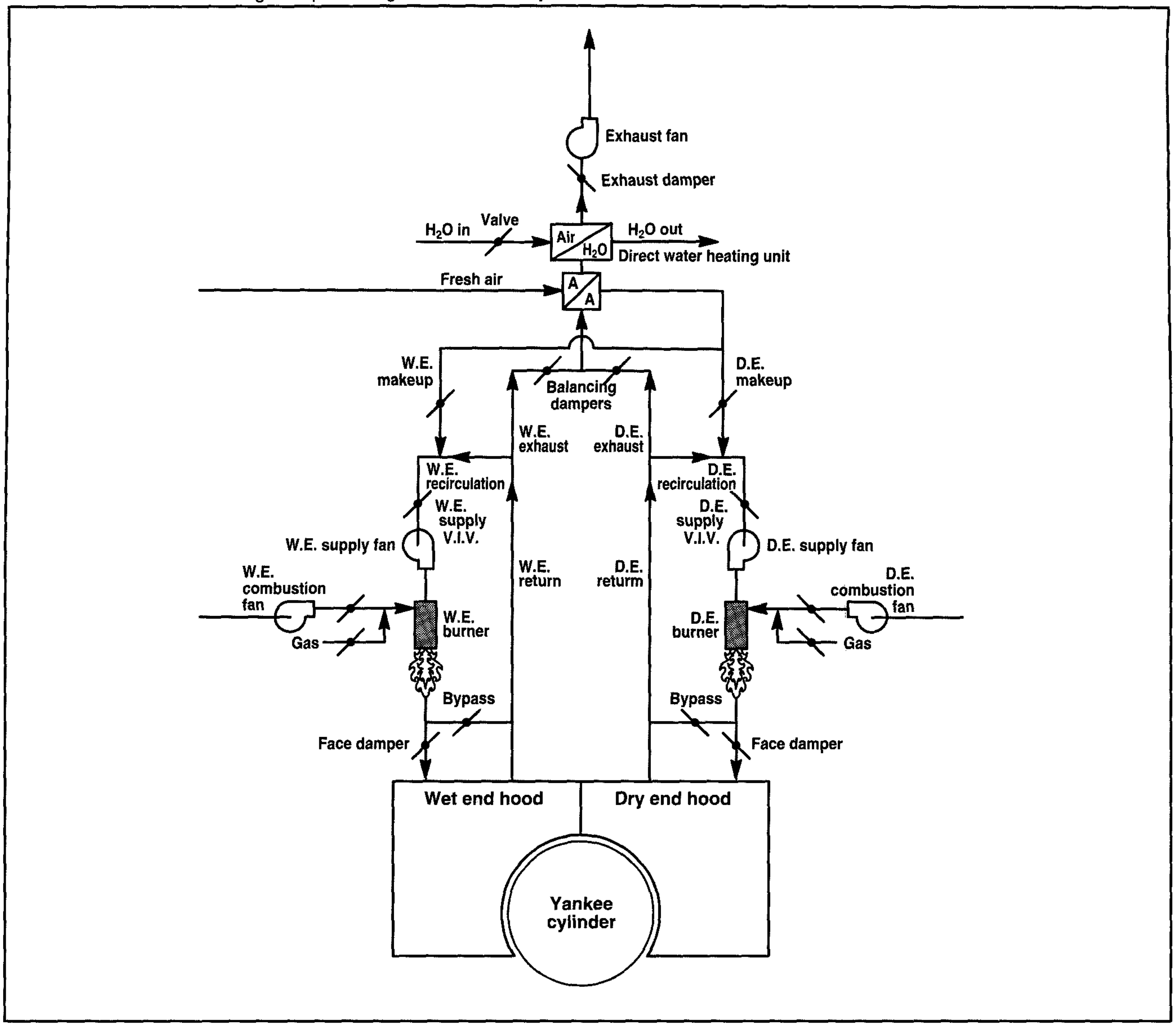
1. Schematic for a standard high temperature gas or oil heated system



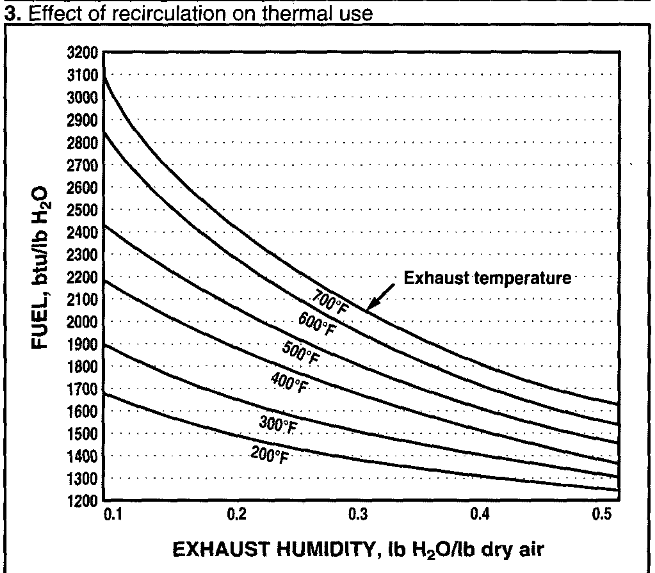
Measuring humidity

Despite periodic balancing of the system air flows, changing machine operating parameters can have a significant effect on the system humidity and thermal efficiency. It is therefore essential to be able to measure simply and accurately the hood exhaust humidity (i.e., lb H_2O/lb dry air) to complete Step 4 of the system balancing procedure.

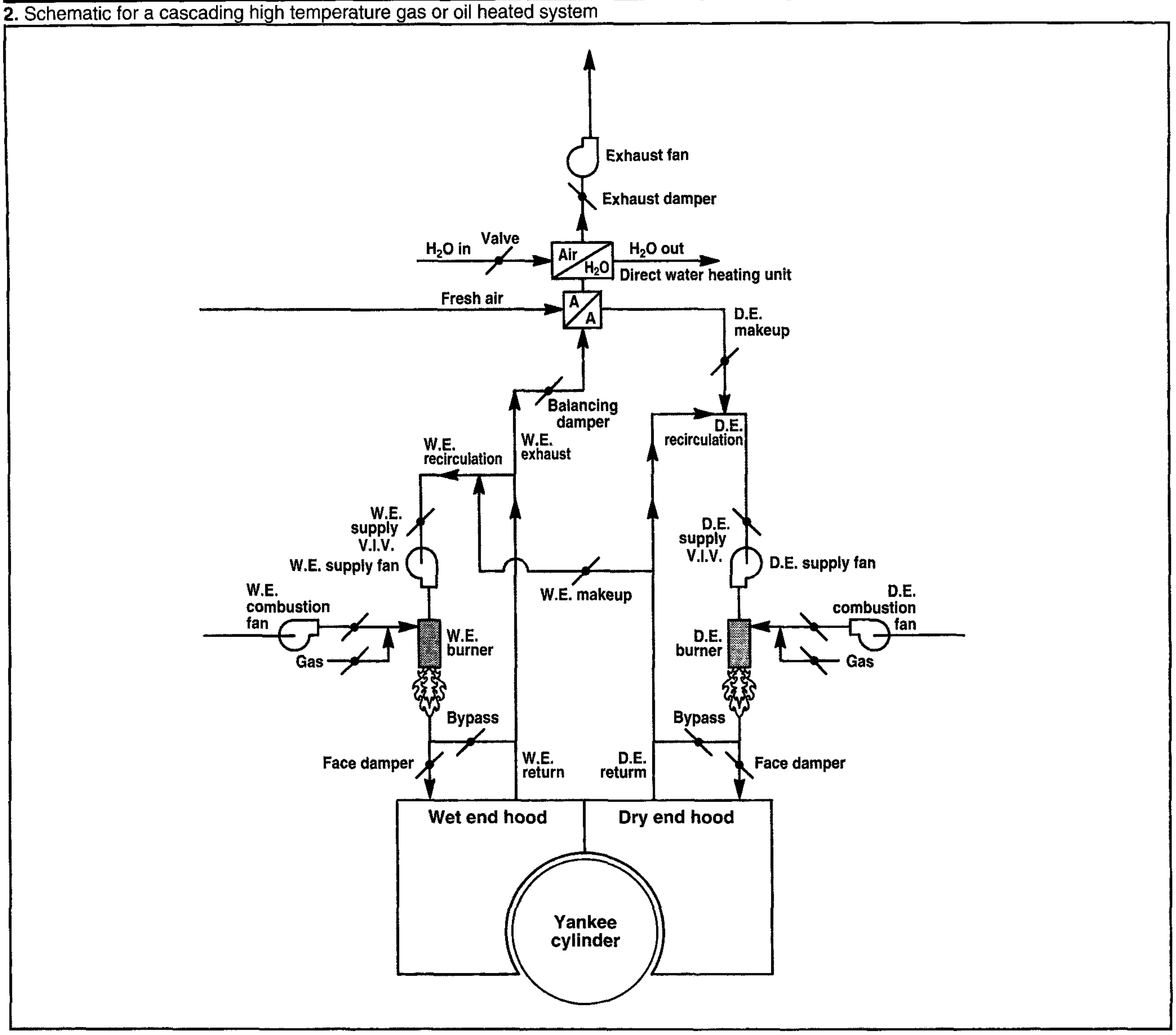
On Yankee systems operating at supply temperatures above 400°F, conventional wet bulb thermometers are inaccurate. Furthermore, there are many computer-controlled humidity sensors based on monitoring available, including dewpoint (heat flux controller), sound velocity (frequency oscillator), and UV light absorption (optical filter).

All such sensors require periodic calibration and therefore become maintenance items. Spare parts for some computer-controlled items can be costly, and often the mill maintenance group may neglect what on the surface appears to be a low priority (i.e., hood thermal efficiency).

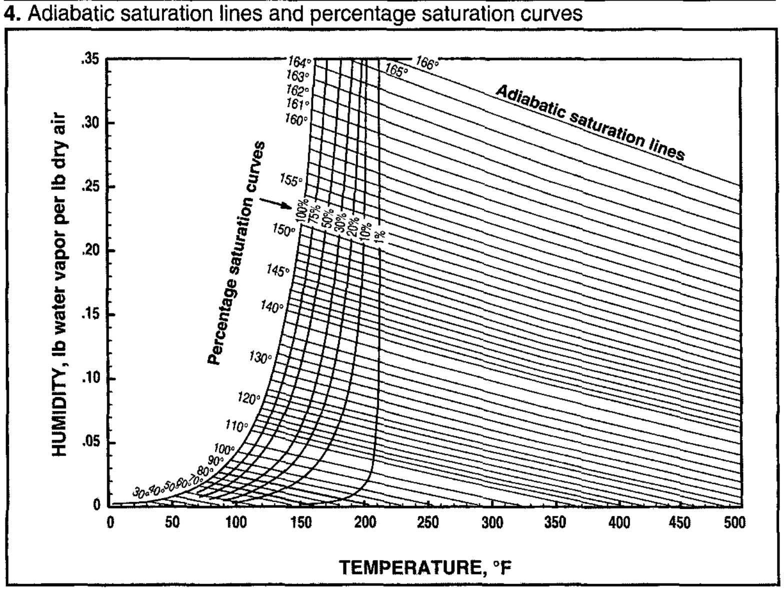
3. Effect of recirculation on thermal use



2. Schematic for a cascading high temperature gas or oil heated system



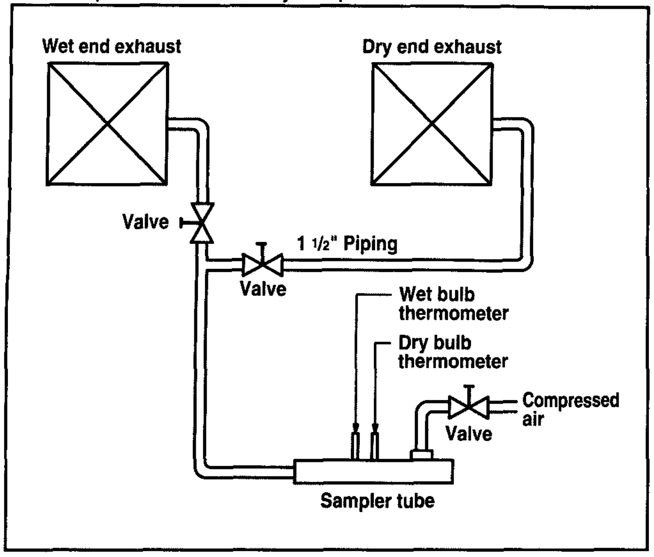
4. Adiabatic saturation lines and percentage saturation curves



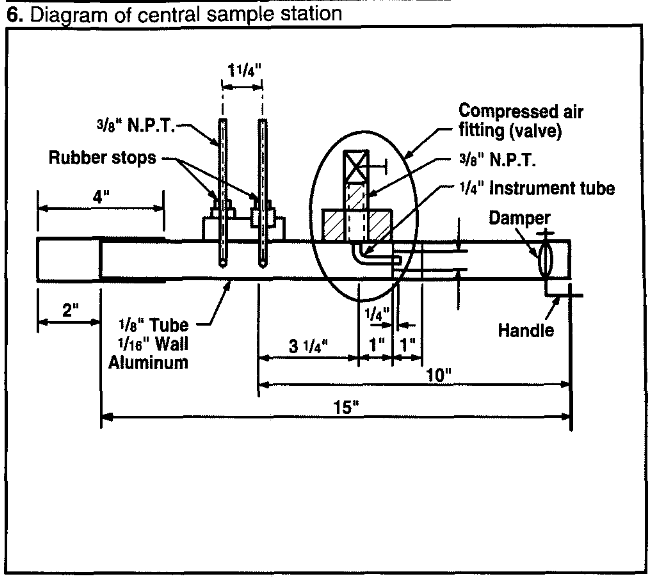
To measure humidity manually at high temperatures in an accurate fashion, the tissue maker needs a device to cool down a sample of the hot air to where a wet bulb reading can be taken. With a common psychrometric chart, as shown in **Fig. 4,** the absolute humidity can then be determined. The system can then be rebalanced instantly using remote (manual) controlled damper regulators. This procedure can be done as little as once or twice a month, depending on grade changes, to ensure fuel savings.

A simple exhaust stream humidity sample station is shown in **Fig. 5.** Steel pipes are permanently connected to both the wet- and dry-end exhaust ducts and brought down to a central sample station, illustrated in **Fig. 6,** located on the mezzanine.

5. Hookup of Yankee humidity sample station



6. Diagram of central sample station



When wet and dry bulb temperatures are required, a compressed air line induces an exhaust sample past two thermometers or thermocouples. The readings reflect the actual humidity at a cooler condition. This arrangement costs very little, is permanent, requires no maintenance, and, with a little operator practice, is extremely simple to understand and operate.

Conclusion

Reducing the exhaust (fan) air flow will result in increased recirculation and reduced makeup air flows. The system absolute humidity will build up accordingly. On gas- or oil-heated air systems, the optimum humidity is between 0.40 and 0.50 lb H_2O/lb dry air.

Routine hood balances can save, on average, about 15% in fuel consumption. In addition, bypassing all makeup and combustion air through an air-to-air heat exchanger (using counterflow exhaust) can save another 20% in the total heat load. These percentages apply whether a hood is steam or burner heated.

A simple humidity sample station can allow the operator to maintain his Yankee air system at top thermal efficiency.