TIP 0404-25

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Through drying

Scope

Through drying is a process in which a hot, unsaturated gas is forced through a wet, porous material by imposing a pressure differential across the material. As the gas passes through the porous material, the gas heats the material and supplies energy to evaporate the water. The gas leaves at a reduced temperature and increased water vapor concentration. It is the intimate contact between the hot gas and the material, coupled with the large internal surface area of the porous material that gives the high drying rates and low-energy consumption associated with the through-drying process.

In the paper industry, this process has found its greatest application in the drying of lightweight, permeable webs, such as tissue, toweling, filter paper, and nonwovens. In such applications, the through dryer may be of either the flat bed or the rotary design. The former configuration is illustrated in Fig. 1, and the latter in Fig. 2. In this second configuration, the hot gas can be forced through the web by pressurizing the porous cylinder, in which case the hood collects the spent gas, or the hot gas can be drawn through the web by applying a vacuum to the porous cylinder, in which case the hood is used to distribute the hot, unsaturated gas (as shown).

The gas can be heated either indirectly through a heat exchanger or directly by mixing with the products of combustion of a clean fuel. In either case, the thermal efficiency is significantly increased by recirculating and reheating part of the through dryer exhaust. Typical recirculation rates range from 80 to 95% of the process air. This recirculation system is shown schematically in Figs. 1 and 2. Part of the through dryer exhaust is exhausted from the recirculation system to remove the evaporated water and, if direct fired, the combustion water vapor. The mass of dry gas that is exhausted from the system is made up by infiltration, through a fresh air intake, and by the dry products of combustion.

Considerable progress has been made in the last decade in the analytical treatment of both the recirculation system and the through drying process itself. Details may be found in the references listed at the end of this Technical Information Paper. Only an abbreviated analytical description of the through drying process will be presented here, to provide a basic knowledge of the process.

Safety precautions

This TIP includes equations for calculating the drying rates for through air dryers, using known values of basis weight, machine speed, moisture contents, and dryer area. Equations are also provided for calculating the drying rates using known values of air flow rate and supply and exhaust humidity. Safety precautions, appropriate to the method used, should be taken in determining these parameters. Particularly, care should be taken to avoid direct contact with rotating components and with hot ducts, supports, burners, dampers, and fans.

Definition of drying rate

The drying of paper and packaging grades is defined (TIP 0404-07 “Paper Machine Drying Rate”), in terms of the total cylinder area, even though the actual heat transfer to the sheet takes place over the contact area of the cylinder. However, for through drying applications, it is customary to define the drying rate in terms of the actual efficiencies are achieved at the higher supply humidities, but the maximum achievable supply humidity is often limited in practice by the leakage of air into and out of the hood. The spent air stream, however, still represents a high potential for heat recovery. As much as 30,000 MJ/h can be recovered from a 1850 kg/min (dry air) flow stream (30 MBtu/h).

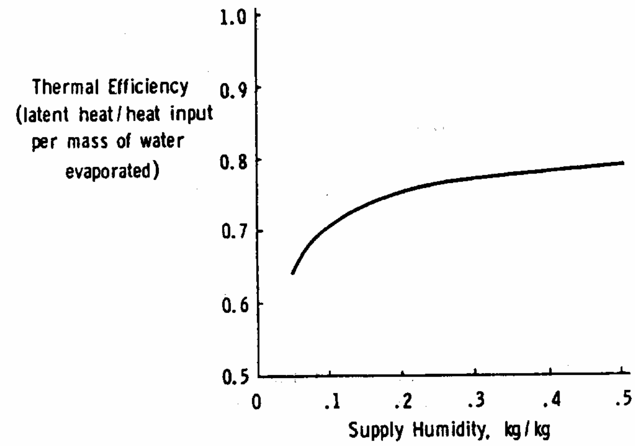

Fig. 4. Effect of supply humidity on through dryer thermal efficiency.

Non-uniform through drying occurs when a wet web enters the dryer with a poor moisture profile – either due to poor formation or nonuniform dewatering. Dry areas of the web will have higher permeability. This results in higher air flow rates through the web and accelerated drying in that area, thereby accentuating the poor entering moisture profile. This is called "strike-through" drying. Technical improvements in modern tissue paper machines and the resulting uniformity of formation and high entering sheet dryness have made strike-through drying much less of a concern today than in the past.

Permeability

An important parameter in the through drying process is the flow resistance, or permeability, of the material. If the flow resistance is too large, then either the pressure drop across the web will be excessive in forcing enough air through the web to achieve high drying rates, or the drying rate will be low because a sufficient quantity of air does not pass through the web.

Table 1. Relative drying rate coefficient (Ref. 16).

Drying application	Range of air approach velocities, m/min	Range of temperature,°C	Typical values
Tissue	150-450	230- 300	0.55-0.85
Toweling	100- 400	150- 300	0.70-0.90
Filter	100-250	150-320	0.70-0.90
Nonwovens	100-400	150-370	0.40-0.90

The flow resistance is greatly affected by moisture content, basis weight, and freeness. Normally each new application will require the determination of flow resistance curves similar to those shown in Fig. 5.