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Guidelines for the design, operation, performance evaluation, and troubleshooting of a paper machine hood and air systems

Scope

This Technical Information Paper outlines minimum guidelines for the operation, performance evaluation and troubleshooting of dryer section hoods and air systems. Effective application of this and several other associated TIPs could result in reducing cost per ton and improved profitability and/or runnability.

Purpose

Understanding and optimizing a paper machine hood and air systems will:

1. Create a uniform drying environment.
2. Contain and remove heat and evaporated water.
3. Reduce energy consumption.

Safety precautions

Below are the minimum safety requirements when working around paper machines . OSHA safety rules will always take precedent.

1. Appropriate personal protective equipment and procedures should always be used when working around and troubleshooting dryer section hoods and air systems.
2. There are mechanical and thermal hazards that require utmost care and respect in order to avoid injuries.
3. Rotating equipment, nip points, slippery floors due to oil leaks, compromised hood panels, etc., are some of the mechanical hazards present in the drying section.
4. High temperature and humidity in the hood ambient air, steam leaks, steam heated drying cylinders, infra-red dryers, etc., are the thermal hazard sources.
5. Dryer explosion, due to both cylinder internal and external problems, have been documented in different mills worldwide.
6. Newer high dew point hoods (HDP) are designed with “walkable roofs.” Extreme caution must be exercised when walking on the hood roof. Crane lock-out and fall protection are minimal requirements.
7. Single sheet construction hoods of metal or cement board, or tongue and groove panel (TG) hoods are NOT designed to support any weight.

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8. Front lifting doors must be mechanically locked in place when in the raised position during a prolonged shutdown.
9. Never walk under hood lifting door when being raised or lowered.
10. Proper asbestos abatement is required when modifying older hoods constructed out of asbestos panels as well as removal of insulated panels from hoods constructed prior to 1967.
11. Even though the writers of this TIP documented herein the best and most current technology and best practices, neither TAPPI, nor any of the committee members guarantee the completeness or the accuracy of any TIP. User takes all responsibility in the implementation of the design, operation, performance evaluation and troubleshooting guidelines presented in this TIP.

Definitions

Dryer section hood

A dryer section hood is the enclosure that surrounds the dryers. Its function is to capture the evaporated moisture from the sheet without any spill to the machine room and to provide a uniform drying environment by controlling exhaust and supply air flows, temperature and humidity. The type of hood also determines the energy requirement and the specific air consumption to support the design production rate.

There are two types of hoods: open and closed (see Figs. 1 and 2):

1. An open hood is characterized by a roof and four walls that extend from the roof down to a point 2.4 to 2.7 m (8 ft to 9 ft) above the operating floor. These hoods are usually constructed of insulated panels to reduce condensation and radiant heat that would otherwise be lost to the machine room. However, hoods of asbestos fiber-cement resin board and of single-sheet metal construction are still in use. Special attention to air circulation rates and temperatures must be given with these constructions. Consultation between the user and hood vendor is recommended.
2. A closed hood has all the features of an open hood but also has tending and drive side movable doors, and often sheet opening doors, to isolate the dryer section from the machine room.
 - a. A totally closed hood also has an enclosure at the basement level to create a controlled drying environment and minimize infiltration.
 - b. On the other hand, in a closed hood with no basement enclosure, the process air system design is nearly the same as an open hood. The hood air design balance and the specific air consumption, kg of dry air/kg of water-evaporated (lb dry air /lb water-evaporated) are almost the same.
 - c. A high performance hood is an extension of the totally closed hood concept with additional insulation and improved joint seal designs to allow operation at higher exhaust humidities and thus a lower exhaust air flow rate, reducing the specific air consumption..

Hood components and construction

Basement enclosure

A basement enclosure surrounds the dryer section below the operating floor and isolates it from the machine room. Enclosures are typically constructed of sheet metal or concrete block.

Exhaust plenum

An exhaust plenum is the area between the underside of the hood roof panels and a false ceiling. The hood roof and a machine-direction false ceiling create the plenum, where evaporated water and transporting air mix before being evacuated. Balancing dampers in the false ceiling plenum are used to balance/regulate the moisture removal from various parts of the dryer section.

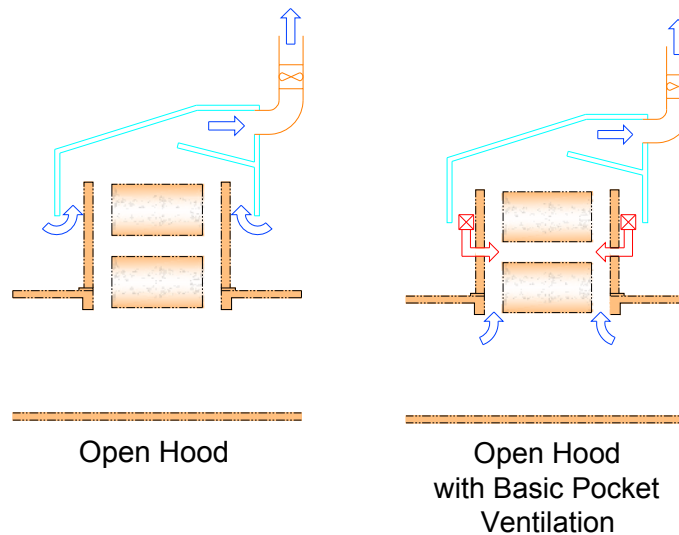


Fig. 1. Dryer section open hood types

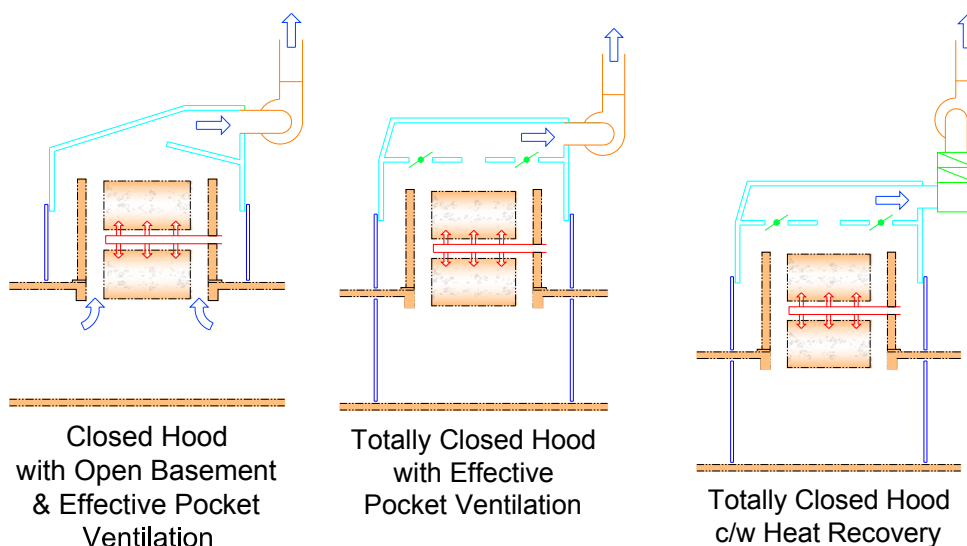


Fig. 2. Dryer section closed hood types

Panels/ Construction

Tongue and groove panels – Historically, the predominant method used for joining adjacent insulated hood panels and enclosure panels for air supply systems. Panels are fabricated such that a tongue shape on one edge slips into a mating groove shape on the edge of an adjacent panel to create a joint. Tongue and groove panels are not reliable for high performance hoods since the joints are difficult to seal and cannot be kept vapor-tight. Through-metal framing construction prevents use at high exhaust temperatures.

High dew point, high performance hood panels – Constructed of an insulated sheet mounted on a support frame to provide a continuous seal. These panels are usually provided with additional insulation, about 100 mm (4 in.) as opposed to 75 mm (3 in.) for tongue and groove panels. Improved joint and seal designs prevent vapor leakage to allow operation at higher exhaust humidities. Framing construction minimizes through-metal and allows use at high exhaust temperatures.



Front lift doors

The doors on the front, or tending side, of the machine that are raised and lowered for machine access and isolate the dryer section from the machine room. Doors are most frequently operated by independent pneumatic cylinders or an electric motor, line shaft, and cable arrangement that are raised in groups to minimize control components and cost.

Rear sliding doors

The doors on the rear, or drive side, of the machine that slide or are lifted off for machine access, provide for isolation of the dryer section from the machine room. Doors are generally supported from the underside by heavy duty casters and wheels and slide in a guide track at the base of the rear fixed panels. Occasionally these doors will be designed as lifting type for rapid access.

Hood air systems

Hood air systems are comprised of exhaust systems that remove evaporated water from the dryer section and are balanced with supply systems such as pocket ventilation, hood makeup, and runnability systems that replace a portion of the exhausted air, to promote drying and stabilize the sheet.

The two principal forms of exhaust systems are hood exhaust systems and vacuum roll exhaust systems. Hood exhaust systems remove air from the exhaust plenum. Vacuum roll exhaust systems exhaust directly from vacuum rolls in the dryer section. Some forms of sheet stability systems use direct vacuum and should be included in the total exhaust calculation as well.

Principal forms of supply systems include pocket ventilation, blow box supply and vapor absorption systems. Other devices such as dryer fabric loop ventilators, used to achieve a minimum hood air supply balance, and cross machine ventilators, used to introduce sensible heat in the serpentine dryer section, are also contributors.

Exhaust humidity

Water vapor content of exhaust air is expressed in terms of absolute humidity or humidity ratio; water vapor mass per mass of dry air (DA), kg H₂O/kg DA (lb H₂O/lb DA). It has become commonplace (in North America) to express exhaust humidity in terms of “grain loading,” based on 1 lb = 7000 grains or 7000 times the humidity ratio. Conventional practice uses the term “grain loading” sometimes without units, but the proper units are “grains H₂O/lb DA.” Comparable metric unit is g H₂O/kg DA, 1000 times the humidity ratio. Exhaust humidity is the sum of the evaporated water (pickup) plus water from ambient conditions (supply air and/or infiltration).

Infiltration

Uncontrolled airflow into the hood is referred to as infiltration. It is natural ventilation caused by the difference between powered or forced exhaust air flow and powered or forced supply air flow.

Zero point or null point and hood balance

Variation in air temperature and humidity, (i.e., density) within the hood compared to the conditions outside the hood create a pressure gradient inside the hood from the ground floor or basement to the top of the hood. This gradient is commonly referred to as stack effect or chimney effect since it is similar to air rising through a chimney. The upper part of the hood is pressurized and the lower part is under a negative pressure. At some level from the ground floor to the top of the hood, a zero or null point occurs where the pressure difference between the inside and the outside of the hood is zero. Any hood openings above the zero point allow hood air to spill out into the machine room. Any hood openings below the zero point allow cold room air to infiltrate into the hood. The zero point height should be at least around the level of the top of front lifting and rear sliding doors, and if possible above the sheet entrance and exits, to contain heat and water vapor inside the hood. Normally, sheet entrance and exit openings are high enough that they require special attention and sealing techniques to prevent spillage. Blow back nozzles or air knives are used at sheet entry and sheet exit openings in modern hood design to prevent condensation or other conditions that may negatively impact quality or

sheet handling. The zero point height is primarily determined by the amount of open area to the hood and the hood supply to exhaust balance. Large openings in the hood or basement enclosure increase the amount of air infiltrating into the hood, and lower the zero point causing more heat and water vapor to “spill” into the machine room above the zero point. Raising the hood balance by increasing supply airflow rate or reducing exhaust air flow rate similarly lowers the zero point (and vice versa.) A tightly sealed basement is critical. If basement doors are left open it is impossible to control zero level.

Runnability components

Devices used to stabilize the sheet as it passes through and between dryer sections. The two most common forms of runnability components are referred to as blow boxes and vacuum boxes. See TAPPI TIP 0404-44 “Sheet handling devices” for detailed information on these devices.

Sizing or dimensioning

Calculations

Design and operating evaporation rates must be determined to size or evaluate hood performance. Production, evaporation, and hood exhaust rate calculations for an unsized and uncoated sheet are calculated for both SI and Imperial units are shown in Table 1:

Table 1. Production, evaporation, and hood exhaust rate calculations for an unsized and uncoated sheet

		S.I.	Imperial
Machine speed	(S)	m/min	ft/min
Basis weight	(BW)	g/m ²	lb/ft ²
Sheet width	(W)	m	In
Entering sheet moisture	(M ₁)	%, wet basis	%, wet basis
Exiting sheet moisture	(M ₂)	%, wet basis	%, wet basis
Ambient air humidity	(H _{air})	kg H ₂ O/kg dry air	lb H ₂ O/lb dry air
Exhaust air humidity	(H _{exh})	kg H ₂ O/kg dry air	lb H ₂ O/lb dry air
Exhaust air specific volume	(SV _{exh})	m ³ /kg dry air	ft ³ /lb dry air

Paper production	(PP)	$= S \times 60 \times BW / 1000 \times W$ $(S \times 60 \times BW \times W / 12)$	kg/hr	(lb/hr)
Fiber production	(PF)	$= (100 - M_2) / 100 \times PP$	kg/hr	(lb/hr)
Moisture in	(X _i)	$= M_1 / (100 - M_1)$	kg H ₂ O/kg fiber	(lb H ₂ O/lb fiber)
Moisture out	(X _o)	$= M_2 / (100 - M_2)$	kg H ₂ O/kg fiber	(lb H ₂ O/lb fiber)
Evaporation Ratio	(X)	$= X_i - X_o$	kg H ₂ O/kg fiber	(lb H ₂ O/lb fiber)
Evaporation Rate	(m _w)	$= X \times PF$	kg H ₂ O/hr	(lb H ₂ O/hr)
Exhaust Mass Rate	(m _{exh})	$= m_w / (H_{exh} - H_{air})$	kg DA/hr	(lb DA/hr)
Exhaust Volumetric Rate	(V _{exh})	$= m_{exh} \times SV_{exh} / 3600$ $(m_{exh} \times SV_{exh} / 60)$	m ³ /s	(ft ³ /min)