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Application of dryer bars

Scope

The purpose of this Technical Information Paper is to provide guidelines for identifying appropriate applications for dryer bars for increasing drying capacity and improving sheet moisture profiles in the dryer sections of conventional papermaking machines.

Safety precautions

Follow normal safety precautions when working around paper machinery. Tag, disconnect, and lock out all dryer drives and steam systems and follow vessel-entry procedures before entering dryers. Do not allow loose clothing or equipment to contact rotating machinery or ropes. Beware of thermal and slip hazards around the dryer section. Avoid direct contact with hot surfaces. Use hearing protection in noisy areas. Eye protection should be worn in all production areas. Safety shoes and safety helmets should also be worn where required.

Inspect dryer internals regularly for proper dryer bar and syphon installation. Follow manufacturer's guidelines. Make sure that bars have not shifted from their original position ("shadow marks" visible); if they have moved, the reason must be determined and corrected. Check all fasteners, springs, washers etc for tightness and condition, and replace as applicable.

Utility

Dryer bars can be attached to or held against the inside surface of the dryer shell and spacing between bars adjusted to increase turbulence in the rimming condensate layer. Increased turbulence can be used to increase rate of heat transfer through the condensate layer and improve uniformity of the moisture profile of the paper. This Technical Information Paper reviews the theory of operation and offers guidelines for proper application of dryer bars.

Background

Condensate behavior inside a rotating cylinder depends on several variables, including steam pressure, amount of condensate inside the dryer, and dryer speed. This in turn affects heat transfer from steam to paper. At speeds over 300–350 m/min (1,000 ft/min), centrifugal forces typically overcome gravity and condensate inside dryers is generally in a rimming condition (1–3).

Rimming condensate produces resistance to heat transfer from steam to the dryer shell. As a result, heat is transferred through the condensate layer by convection.

Heat transfer through the rimming condensate layer can be increased by one of the following three methods:

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- Bypassing the condensate layer
- Reducing condensate thickness
- Generating turbulence in the condensate.

The first method involves casting and machining ribs or fins on the inside surface of the dryer. This approach is usually applied to large diameter Yankee dryers (4).

The second method for reducing condensate resistance consists of minimizing depth of the rimming condensate layer. This is done by using large or multiple syphons located very close to the dryer shell and by reducing siphon clearance (5), and sometimes locating syphons in a groove.

The third method for increasing heat transfer rates consists of increasing the level of turbulence in the condensate layer. This is accomplished by the use of dryer bars and is the subject of this Technical Information Paper.

Theory

A stagnant layer of condensate is a very good insulator. However, gravity causes deceleration and acceleration of the rimming condensate layer relative to the dryer shell. As the dryer turns, gravity retards the rotational speed of the condensate layer on the “rising” side and advances the speed on the “falling” side during each revolution of the dryer. This relative motion produces turbulence that improves convective heat transfer.. This natural turbulence is highest at speeds just above rimming, but diminishes at high speeds.

Dryer bars are a series of bars which are attached to or held against the inside surface of the dryer to increase the natural turbulence in the condensate layer.

Turbulence is increased by creating resonance in the condensate layer as it sloshes back and forth between the bars, as shown in Figure 1.

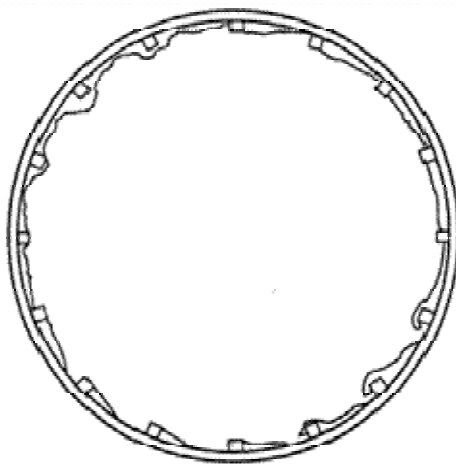


Fig. 1. Dryer bars

Spacing between bars that produces resonance (turbulence) in the condensate layer was found to be nearly independent of dryer speed. Optimum spacing is given by the following approximation (6.7):

$$S = \pi (hR)^{1/2}$$

where

S = the spacing between bars

R = dryer radius

h = depth of rimming condensate

As this relationship shows, a wide range of bar spacings (S) may be used in a dryer, provided the appropriate condensate depth (h) can be achieved.

There are two practical limitations on spacing between dryer bars:

1. If spacing between bars is too small, optimum condensate depth is so thin that it cannot be achieved with normal siphons.
2. If spacing between bars is too large, optimum condensate depth is so thick that drive power required to get the condensate to rimming speed is excessively high.

In practice, the number of bars is generally in the range of 16 to 30 bars per dryer.

Applications

Full-width dryer bars are generally used in dryers that operate over rimming speeds to establish a more even dryer surface temperature in the cross-machine direction, to increase the drying rate, or both. Partial-width dryer bars are sometimes used to correct chronic moisture profile problems, although this approach is generally recommended only when other attempts to correct the fundamental nonuniformity problems have been unsuccessful.

Drying capacity increase

Dryer bars are installed across the entire width of the dryers to increase drying capacity. These bars generate turbulence and increase heat transfer across the full dryer face.

If average condensate depth inside the dryer is close to optimum for condensate resonance, dryer surface temperatures will be uniform across the width, despite normal variations in condensate depth. This is because the condensate coefficient is not sensitive to small changes in condensate depth (δ), as shown in Figure 2, when condensate layer thickness is close to the optimum. Size and configuration of the siphon, must be properly selected to ensure that the depth of condensate remains close to the optimum value corresponding to configuration of dryer bars in the dryer.

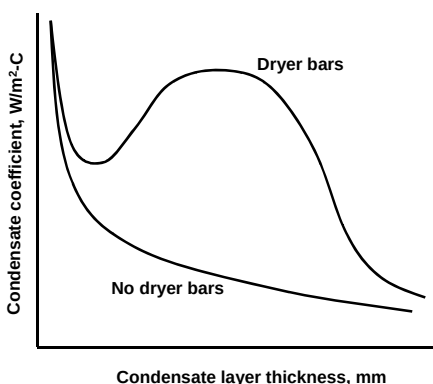


Fig. 2. Dryer bar condensate heat transfer coefficient