

OLD NUMBER 014-60
ISSUED – 1983
REVISED – 1988
REVISED – 1994
WITHDRAWN – 2001
REVISED AND REINSTATED – 2005
REVISED - 2009
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Recommended dryer differential pressures

Scope

This Technical Information Paper provides guidelines for establishing operating differential steam pressures for conventional paper machine dryers with stationary or rotating siphons.

Safety precautions

Follow normal safety precautions when working around paper machinery. 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.

Introduction

During normal paper machine operation, a difference in pressure between the dryer steam supply and condensate return headers (“differential pressure” or “DP”) is required to remove condensate from the dryers. A steam and condensate system is responsible for maintaining these differential pressures. This TIP provides a review of the theory of condensate evacuation and offers guidelines for selection of the operating differential pressures. These guidelines apply to properly sized siphons and equipment. In some cases, steam systems are designed to operate outside the range of these guidelines. Care must be taken to ensure that operating differential pressures match design of the steam and condensate system.

Condensate behavior

DP that is required to achieve stable condensate evacuation depends on behavior of condensate in the dryer. Condensate may be in a ponding, cascading, or rimming condition (1-3). Condition depends on dryer speed, steam pressure, dryer diameter, and volume of condensate in the dryer. For example, if the dryer is rotating slowly, condensate will run down the dryer shell and form a puddle at the bottom of the dryer. This is called “ponding” condition. As dryer speed is increased, condensate begins to fall away from the rotating shell, back toward the bottom of the dryer. This is called the “cascading” condition. At a higher speed, generally over 300-350 rpm, condensate will be rimming

These conditions are shown in Figure 1.

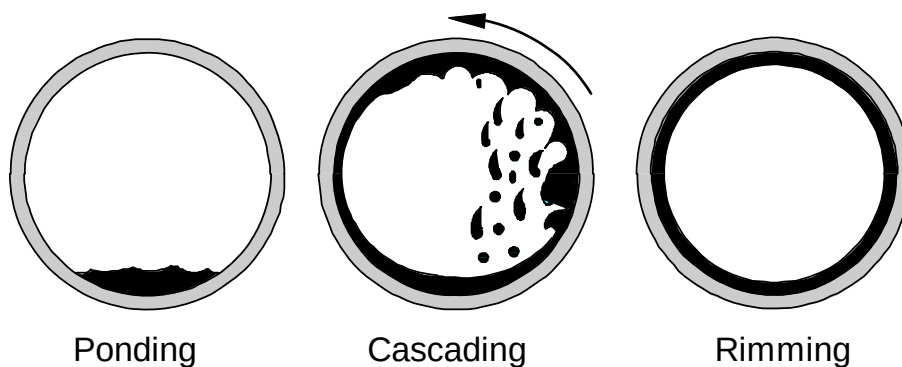


Fig. 1. Condensate behavior

Operating objectives

The primary requirement in selecting operating differential pressure is to ensure that condensate is being removed as fast as steam is condensing. If this requirement is not met, dryers will begin to fill with condensate or “flood.” Flooded dryers can cause a substantial increase in drive load (2-4) and a marked reduction in drying capacity. In order to ensure that condensate is removed continuously, operating differential pressures are controlled above the minimum required. This causes a certain amount of uncondensed steam to pass through the siphon. This uncondensed steam is referred to as “blow-through” because it simply blows through the dryer without condensing.

Quantity of blow-through steam can be expressed in mass flow (kg/hr or lb/hr) or as a percentage. The percentage can be expressed either as a percentage of total steam flow to the dryer or as a percentage of the amount of steam that has condensed. For example, if 2000 kg/hr of steam is condensing in the dryer and there is 400 kg/hr of blow-through steam leaving the dryer with the condensate, then blow-through can be expressed either as 17% ($400 / 2400$) or as 20% ($400 / 2000$). The latter is the more common.

Blow-through steam serves several purposes: 1) It lowers required differential pressure by reducing density of the two-phase mixture, 2) It entrains and evacuates non-condensable gases, and 3) It helps stabilize evacuation of the condensate over a wider range of operating conditions.

Blow-through steam is generally separated from condensate and reused, either by cascading it to a group of dryers that are operating at a lower steam pressure or by boosting its pressure with a thermocompressor, so it can be used in that section or another section.

Often dryer sections are found to be operating with differential pressures higher than required for stable operation. Excessive differential pressures cause high blow-through flow rates. Excessive blow-through may accelerate erosion of piping, increase pressure drop and decrease steam pressure in cascade sections, increase thermocompressor motive steam usage, cause steam venting, and increase steam flow to the vacuum condenser.

A careful balance of differential pressure and steam flow is necessary to ensure satisfactory performance of the steam and condensate system.

Dryer siphon types

Blow-through characteristics are significantly influenced by the type of dryer siphon. There are two types of siphons: stationary and rotary. A stationary siphon is cantilevered from the rotary joint through the journal of the dryer. It remains stationary as the dryer shell rotates around it. An example of a stationary siphon is shown in Figure 2.

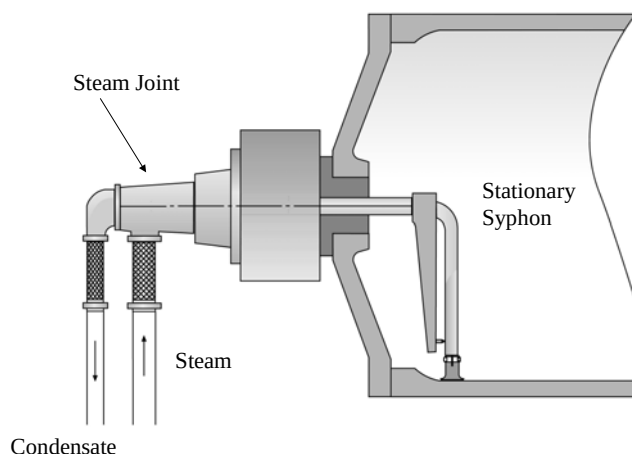


Fig. 2. Stationary siphon

A rotary siphon is attached to the inside surface of the dryer shell, either by spring loading or bolting. It rotates with the dryer shell. An example of a rotary siphon is shown in Figure 3.

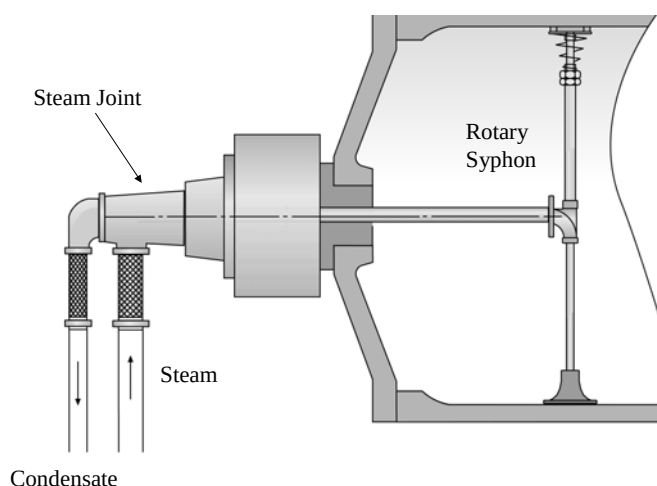


Fig. 3. Rotary siphon

Siphon performance curves

Overall siphon performance curves reflect the sum of internal and external pressure losses between the steam and condensate headers. Internal losses include frictional, gravitational, and centrifugal pressure losses in the dryer siphon shoes, internal siphon pipes, and rotary joints. External losses include steam supply and condensate return lines, flex hoses, pipefittings, orifice restrictions, shut-off valves, and control valves. External losses may be quite significant. Many stationary siphon systems are designed with the major pressure drop taken across an external restriction orifice plate that is sized and placed in each condensate return line. It is important that condensate piping be properly sized, not only to avoid unwanted pressure losses, but also to minimize erosion of piping.

The combination of these various components determines the shape of the siphon performance curve. These various components must each be sized to achieve the correct siphon performance curve to match the steam and condensate