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Steam shower applications at the wet end of the paper machine

Scope

This TIP discusses general guidelines for the proper installation and operation of steam showers at the wet end of paper machines.

Definitions

Steam shower or steam box - A device designed to apply steam to a web of paper or press fabric where it condenses and heats the web or fabric.

Non-profiling or preheat steam shower - A steam shower designed to uniformly deliver steam in the cross machine direction (CD).

Profiling steam shower - A steam shower equipped with capability to control volume of steam delivery to individual areas or zones of the sheet in the CD.

Coupling - Migration of steam in the CD from one compartment to an adjacent compartment, due to excessive steam flow to the first compartment (more steam supplied than can be condensed in the sheet).

Mapping - Aligning the CD zones of the steam shower with a moisture sensor downstream. Correct mapping is critical for automatic computer control of a profiling steam shower.

Air-steam interface - A zone often seen near the discharge face of a steam shower where pure transparent steam meets air and condenses into white visible fog.

Safety precautions

Installation, operating and maintenance instructions of the steam shower supplier must be followed. Well-designed steam piping and valves to a steam shower are essential to prevent uncontrolled discharge of steam into the machine room. The steam lines to steam showers whose operating pressures are limited to one atmosphere must include safety interlocks or relief lines to prevent damaging the steam shower or harming operators. Certain designs of steam showers may be subject to implosion or collapse if the suction boxes below are not allowed to suck either steam from inside the steam shower or air from outside the steam shower. Appropriate interlocks are required in steam supply to prevent steam application to a stalled fabric or press roll. Press roll suppliers should be consulted prior to installing a steam shower to confirm the cover will not be damaged by heat. Extreme care should be

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considered when heating nips with natural stone press rolls. Pressure gauges and thermometers should be maintained. Prior to starting a new installation, steam controls should be tested under controlled conditions. If a valve is installed backwards or debris such as pebble gets jammed in the valve, full line pressure could be supplied to the steam shower endangering operators. After machine shutdowns, steam should be introduced slowly to a steam shower to prevent thermal shock or an abrupt spilling of condensate onto the sheet. Steam supply lines to a steam shower should be insulated, both for operator safety and to reduce condensate in the system. Flexible braided steam lines to the steam shower should be protected by shrouding and never stepped on. Assume the endplates and outer skins of any steam shower are the same temperatures of the steam being supplied to it. Before touching, you might spit on surfaces to see if it boils. Blocks should be used under all support legs of raised steam showers equipped with lift cylinders to prevent sudden lowering in the event of an air failure. A sleeve placed around each lift cylinder shaft is effective. Catwalks near a steam shower should be used with caution. Before crossing a catwalk or approaching a steam shower, test the area with your hand, or a thermocouple. Exposed skin should be protected when working near steam showers. Shirtsleeves should be rolled down. Be aware that pure steam is transparent and may be detected only by shimmering heat waves. The white vapor associated with steam is actually “fog” consisting of a mixture of air and steam.

Introduction

Thousands of steam showers have been installed on all types of pulp and paper machines since the 1940's. The earliest steam showers were primarily installed over the flatboxes on the fourdrinier table. This area is generally clean and open so mounting of the steambox and piping steam to it was quite simple. Steam application on the fourdrinier takes advantage of high water removal by a suction couch immediately downstream. An added benefit of the suction couch is it cools the sheet surface reducing potential harm to temperature sensitive press roll covers and fabrics in the press section.

By the 1980's improved temperature resistance of press rolls and fabrics allowed for installation of steam showers in suction press nips and over uhle boxes. At present, many machines use one or more steam showers in the press section in addition to the fourdrinier. Unfortunately, over the years many steam showers have been removed or scrapped due to poor design, lack of maintenance, poor choice of installation location, rebuilds of the paper machine and improper use by the machine operators.

A properly installed and operated steam shower at the wet end is a useful tool to help papermakers control sheet caliper, density, basis weight, production, drainage, strength and moisture variation in both the CD and MD. Improved paper machine controls and sensors and tighter quality demands by the end consumer assure that steam showers will increase in popularity and sophistication.

Applications

The primary purpose of any steam shower at the wet end of the paper machine is to condense steam in or on the web to elevate the temperature of water and fiber in the sheet. Advantages of heating the sheet at the wet end include:

a) Reduced viscosity - The higher the temperature, the lower the viscosity of the water hence the easier it is to press or suck water from the sheet. Because the viscosity curve of water is steepest at the lower temperatures, heating the web from 100°F to 130°F (38-54°C) has almost twice as much effect on viscosity than heating it from 130° -160°F (54°-71°C). Hence, there are diminishing returns from multiple steam showers on a paper machine.

b) Cross machine moisture profiling - Preferential steam delivery in the CD with a Profiling Steam Shower can dramatically improve moisture profiles. A profiling steam shower is typically equipped with at least as many zones in the CD as the number of lip adjustment screws on the headbox. Extreme care must be taken to ensure proper “mapping” or lining up the zones of the steam shower with the zones of the moisture detection device downstream, especially when the Profiler is automatically controlled.

c) Web consolidation – Increasing the temperature and dryness of the sheet allows for easier pressing hence a denser stronger sheet. This can be detrimental to bulk sensitive grades such as fluff pulp or cup stock. Reduced

surface tension and reduced spring back of the hotter sheet, or press fabric reduces rewet leaving the press nip. If very high sheet temperatures of more than about 84°C (180°F) are achieved the fibers in the sheet will soften and a shoe press downstream can have profound effects on sheet strength.

d) Dryer steam savings - Sending a sheet with higher sheet solids from the press section will obviously require less energy in the dryer section to achieve the desired moisture content.

e) Improved sheet quality – Heating the sheet in the press section can reduce sheet crushing in a press nip and allow for higher press loading. Elevating the web temperature entering the dryer section may allow use of higher-pressure steam in the first dryer cans that can be important for sheet characteristics such as linting, cockles and casehardening. Increasing the temperature, cleanliness and dryness of a press fabric may enable a machine to use a finer press fabric and improve sheet surface properties such as smoothness.

There are two types of steam showers available for the wet end of the machine: a non-profiling steam shower, sometimes called a preheater, or a profiling steam shower equipped with individual compartments in the CD. A well designed and operated preheater delivers a uniform flow of steam to the sheet in both the machine direction (MD) and CD. Some older steam shower designs and poorly maintained modern steam showers apply steam in an uncontrolled fashion and can be detrimental to machine performance and moisture profiles. Profiling steam showers can manually or automatically control the volume of steam flow to the sheet in the CD therefore influence the CD temperature and moisture profiles downstream. Most profiling steam showers have as many zones in the CD as the number of lip adjustment screws on the headbox. Considerations papermakers should use for choosing the type and design of a steam shower include:

- Customer requirements for uniform CD moisture or bulk - A machine making coated paper requires finer CD control than one making market pulp. A machine with a bone dry sheet entering a coater or size press will not benefit from a profiling steam shower upstream unless the machine speed is increased to maintain “the last dryer can steaming”.
- Stability of the pulp or paper machine - A machine that makes just one grade and shuts down only for felt changes might do better with manual CD control than automatic computer control.
- Sophistication of existing moisture and basis weight detectors at the dry end. You can’t control what you don’t know.
- Computers controlling the machine.
- Availability of steam supply for shower and limitations of the dryer for various grades.
- Attitude of the machine operators - A profiling steam shower not controlled by computer is only as good as the operators adjusting it. A poorly maintained steam shower with inoperable actuators may do more harm than good.
- Budget and future grade structure predictions of the machine.

Regardless of the type of steam shower, for steam application to be effective it is necessary to:

- A. Condense steam in or on the web so it's latent heat is transferred,
- B. Choose the best location for the steam shower,
- C. Remove hot condensate from the hot sheet downstream by either sucking or pressing it out,
- D. Properly operate the steam shower
- E. Properly evaluate the steam shower and
- F. Properly maintain the steam shower.

A brief discussion of each of these points follows.

A. Condense the steam in or on the web - The sheet must be sufficiently porous to allow steam to be pulled into it (and air out of it) by the vacuum located underneath. Otherwise, the sheet will not be heated, and excessive steam supplied will escape into the machine room.

A fourdrinier steam shower must be installed after the dry line if steam is to be pulled into the sheet by vacuum. Wet streaks extending under a steam shower will prevent absorption of steam, heat transfer and dewatering where it is

most needed. This effect can amplify wet streaks. The effectiveness of a fourdrinier steambox may be dramatically reduced when a top wire-dewatering device is added in a machine upgrade or rebuild. Bringing fines to the surface can seal the sheet and reduce porosity. Aggressive vacuums during the sheet forming process upstream can also seal the sheet. A steam shower in the press section can be located such that steam is encouraged to condense on surfaces other than the sheet itself such as adjacent press fabrics and press rolls. Shrouding or shelves can be attached to a steam shower to increase the time of exposure and improve condensing rates.

It has been widely reported that the use of superheated steam retards condensing rates since the steam must cool down before it can condense. This is particularly important in situations where condensing times are limited, i.e., at higher speeds. Excess superheated steam can also be detrimental to the actuators of some profiling steam showers. A steam shower fed with superheated steam however is less likely to drip, which is important for machines making fine paper and those in cold climates. Superheated steam is also advantageous for locations that a steam shower cannot be mounted very close to the sheet such as a suction press nip or bi-nip “tunnel”. The entire discharge area of a steam shower should be exposed to a vacuum source to prevent excess steam from entering the machine room as fog, and encourage transfer into the sheet. Exhaust ducts can be helpful for evacuating excess fog from the machine room. However, in poorly ventilated machine rooms, exhaust ducts have a tendency to pull cold air to the area, exacerbating the problem. A good remedy is to supply hot dry air to the problem area. Heating catwalks and overhead drip pans will help prevent condensation and dripping.

B. *Choose the best location for the steam shower* - General considerations for properly locating a steam shower include:

- Weight and characteristics of the paper grades produced
- Safety of the installation and susceptibility of neighboring equipment such as press rolls and doctor blades to elevated temperature
- Cleanliness and accessibility of the installation are
- Available vacuum opposite to pull steam into the web of paper
- Ease and expense of installing and maintaining the steam shower
- Available dewatering devices downstream

For most grades of paper heavier than 80 gsm (16 lbs/1000 sq. ft.) the location of first choice for a steam shower is over a suction couch or the last suction boxes on the fourdrinier. That includes fourdriniers making pulp, linerboard, bag or corrugating medium. For machines making lighter grades or those with unique features, the steam shower should be installed in the press section or multiple steam showers can be used as required.

Safety was discussed earlier and should be a primary consideration of any steam shower installation. The forming or press fabric should not be adversely affected unless live steam is applied to a stalled or slow moving forming fabric. It is unlikely that live steam over 84°C (180°F) will be pulled through the sheet and fabric into the suction box exhaust system but the temperature rating of internal vacuum seals should be considered. Steam application over a suction device will sometimes increase vacuum levels if it completely replaces air entering the system. The hot vapor and steam entering the system will raise the temperature within the vacuum system. Adding a cold water condensing spray will increase vacuum capacity and reduce corrosion in older systems. Transfer of stickies from the hot sheet into the forming or press fabric is a concern for mills lacking adequate screening in the stock prep area. Certain stock chemical additives, such as bulking and sizing agents, may be adversely affected by high temperatures achieved with a steam shower. The temperature of shower water applied to a fabric should be as high as the sheet temperature it contacts to prevent thermal shock. Installation of steam showers directly over uhle boxes to heat and clean press fabrics is increasingly popular but the fabric must be designed to tolerate high temperatures to prevent shrinkage. Unless water-cooled or lubricated, a press roll cover or doctor blade will typically run as hot as the surface of the sheet or fabric it is pressing. Roll cover surfaces not protected by sheet coverage, and doctor blade assemblies exposed to superheated steam, can be elevated to temperatures higher than the sheet so prior to installing a press section steam shower, the suppliers should be consulted. Certain designs of stone granite rolls are especially susceptible to elevated temperatures, especially if variable in the CD. TAPPI TIP 0404-37 “Press roll cover application guidelines” and TIP 0404-41 “Granite roll material and surface requirements” discuss press roll limitations in some detail.