

USE OF STEAM SHOWERS TO CONDITION PRESS FABRICS

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ABSTRACT

Since 1969 more than fifty non-turbulent steam injector showers have been installed over uhle boxes to heat press fabrics. A hot fabric runs drier, cleaner and more open. Mill personnel using steam showers to heat their fabrics report that steam application makes it easier to remove contaminants, particularly waxes from the system thereby reducing cleaning chemical usage and in some cases eliminating the need to batch wash. Dryer limited production increases of more than 1% or equivalent steam savings have been documented by heating one or more press fabrics with a steam shower over the uhle box. This paper discusses the effect that steam application has on fabric temperature, moisture and porosity as well as its effect on dryer steam reduction and increased machine speed. It also outlines which fabrics and paper grades benefit the most from steam application.

Key Words - Press Fabrics, Conditioning, Water Removal, Temperature, Steam Showers, Steam Injectors, Lazy Steam, Uhle Box, Contaminants, Wet Press, Dewatering, Sheet Properties

INTRODUCTION

It is well known to papermakers that hot press fabrics are easier to dewater and clean than cold fabrics. The water used on uhle box lubrication, flooding and high-pressure needle showers can be heated to as much as 180°F (82°C) with heat exchangers or by injecting steam directly into the water line but most mills use 120°F- 140°F (49-60°C) shower water. An alternative method of elevating fabric temperature is to install a steam shower over the suction area of a uhle box. Instead of sucking cooling air through the fabric the uhle box pulls in pure steam, which immediately condenses elevating the fabric temperature significantly.

Since 1969 more than fifty non-turbulent steam showers have been installed over uhle boxes on machines making containerboard, pulp and fine paper with generally excellent results. The proper installation of a steam shower produces a fabric that is drier, cleaner and more open heading to the press section. Mill personnel also report that heating their fabrics with steam leads to reduced steam load in the dryer, chemical savings, longer fabric life, improved machine runnability and dryer limited production increases.

IMPORTANCE OF TEMPERATURE

The familiar viscosity curve of figure 1 illustrates the benefit of elevating sheet and fabric temperatures in the press section above the operating process standard. The viscosity curve is steepest at lower temperatures. Heating the water in the fabric 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).

Viscosity of Water

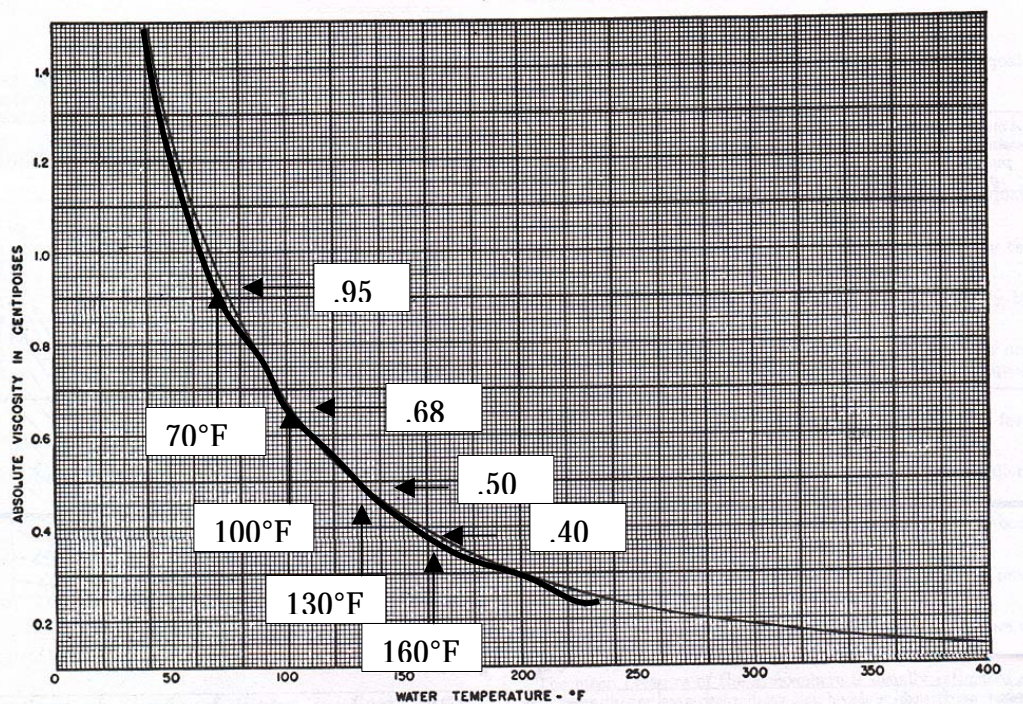


Figure 1 – The first amount of temperature increase has the greatest impact on the viscosity of water

A hand held infrared pyrometer is an excellent tool for monitoring temperatures on a paper machine. It can be used to help determine which way water is moving in the press section as well as pinpoint inefficient press nips or suction boxes. The accuracy of the pyrometer is influenced however by the emissivity setting on the gun, fog on the lens or fog between the gun and the target. Evaporation from the surface of the sheet or fabric can make temperatures appear cooler than they actually are so care must be used when collecting and comparing temperature data.

Virtually all paper machines making pulp, containerboard, and newsprint are presently using at least one steam shower on the fourdrinier and/or in the press section to heat the sheet to enhance water removal at the wet end. Sheet surface temperatures immediately downstream of a steam shower typically exceed 170°F (77°C). When the sheet passes over a suction couch / lumpbreaker or through a press nip some of the hot condensate applied by the steam shower is pulled and pushed towards the bottom of the sheet resulting in an average sheet temperature of perhaps 150°F (66°C) going to a press nip.

By contrast, average fabric temperatures entering a press nip typically run 20°F – 50°F (11°-28°C) cooler, especially the backside of the fabric, which never contacts the hot sheet. Particularly cold press fabrics rob valuable temperature from the sheet reducing the effectiveness of press nips downstream.

Press loading, fabric design, uhle box vacuum levels and fabric permeability and moisture levels all influence the migration of hot water through the fabric but it is rare to see a significant temperature increase in the back side of the fabric through a press nip. If the backside of the fabric is 115°F (46°C) going into the nip it should be very close to 115°F (46°C) coming out. If the backside of the fabric does increase in temperature through the nip it can be a sign of a flooded nip or of a felt with not enough void volume. This condition is often seen on multi-ply cylinder board machines making heavy grades as well as pulp machines using a double felted first suction press. Crushing of the sheet is a symptom of a flooded nip.

In a simplistic view of the fabric- sheet - fabric sandwich in a double felted press nip the cold water in a fabric can be thought of as a barrier to the movement of hot water into the fabric from the sheet (figure 2). It makes sense that heating the water in the fabric to reduce its viscosity makes it easier for water to flow

from the fabric into a blind drilled, grooved or suction roll. Making it easier for water to leave the fabric should make it easier for water to flow into the fabric from the sheet thereby dramatically reduce crushing of the sheet in the nip.

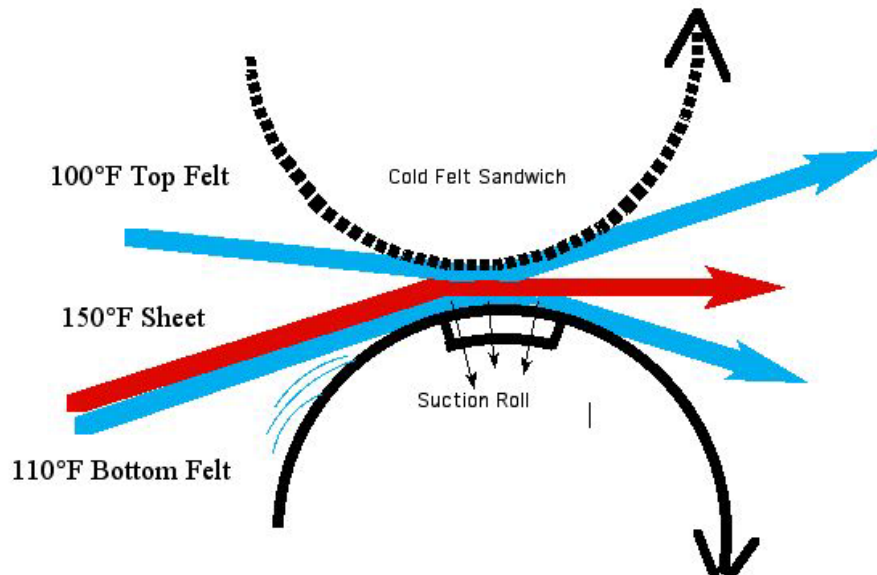


Figure 2 – Cold press fabrics can be thought of as a barrier to water movement into the fabric from the sheet.

HISTORY OF STEAM APPLICATION TO PRESS FABRICS

Weyerhaeuser was one of the earlier paper companies to recognize the value of using steam showers to heat the sheet and press fabrics to improve dewatering on their paper machines. As part of their research division a “Steam Applications Section” of four people headed by Roger Wells was set up to design steam showers in the laboratory and install full sized steam showers on virtually all of their machines. Senior management claimed that the increased production gained from the more than 300 steam showers installed between 1970 and 1980 was worth 90 million dollars so funding was rarely an issue.

The Weyerhaeuser steambox basically consists of an insulated pipe with rows of drilled holes over which is packed stainless steel wool. The steel wool absorbs the high velocity of the exiting steam creating non-turbulent “Lazy” steam. Because there is no turbulence in the steam exiting the shower there is no contamination or mixing in of air. What is pulled into the sheet or fabric by vacuum opposite is pure transparent steam, which immediately cools and condenses giving up its valuable energy (figure 3). The steam shower is lightweight, compact, very simple and carefully designed not to drip or bow in operation.

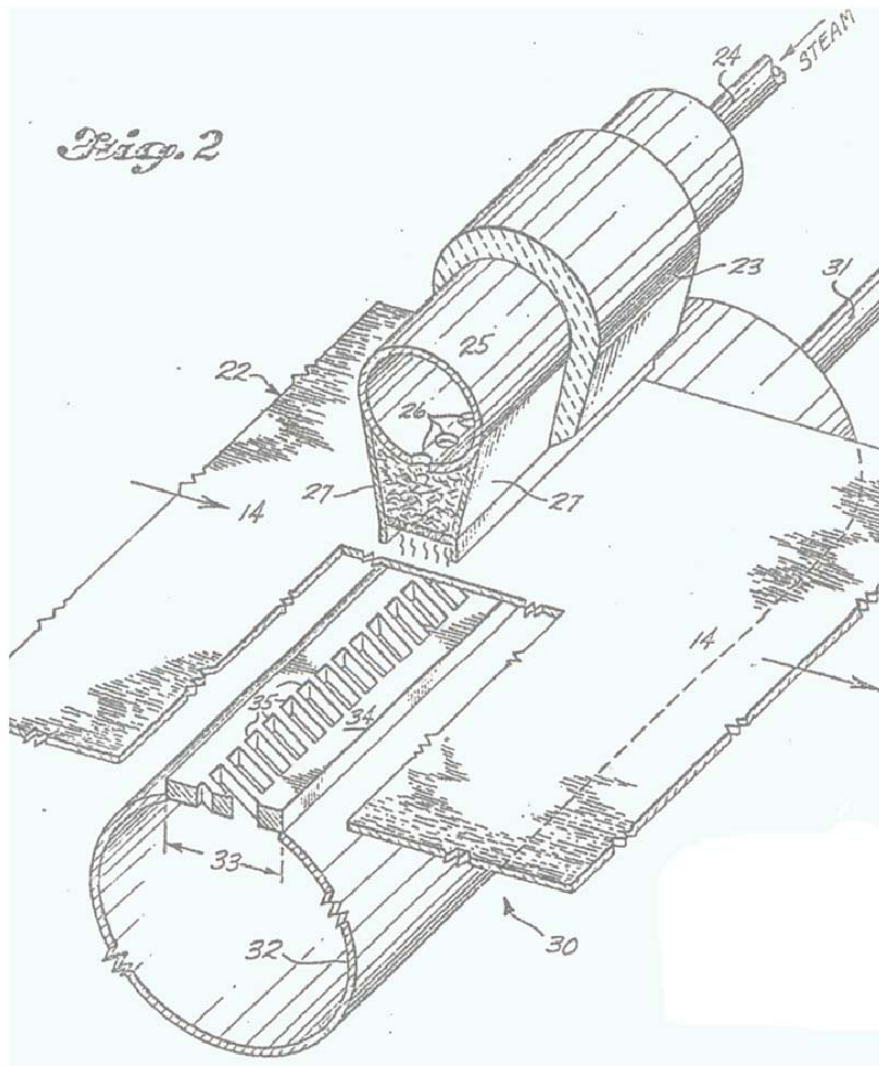


Figure 3 – Weyerhaeuser’s non-turbulent steam injector design

Part of the Steam Applications Section research in the early 70’s involved applying steam to press fabrics in Weyerhaeuser’s laboratory as well as on the pilot machine of Albany Felt Co. They quickly learned that heating the press fabrics dramatically increased water removal by the uhle boxes. Vacuum in a uhle box below the steam shower typically increased when it was supplied with pure steam / water vapor instead of air. Felts with low permeability of 5 cfm (110 ml/min) did not dewater as readily as felts with permeability’s of 36 cfm (1000 ml/min). Not surprisingly it was found that dwell time, uhle box cover

design and the velocity of air pulled through the fabric were important variables. Optimum dewatering of a fabric at high speeds was obtained by applying steam over just the leading of two slots of the uhle box allowing the trailing slot to suck the hot condensate through and out of the fabric. Despite advances in fabric technology much of the laboratory data generated in the 70's is still valid today.

Between 1969 and 1979 Weyerhaeuser installed at least ten full sized non-turbulent steamer showers to heat the fabrics of machines making pulp, linerboard and fine paper. However, a major drawback was that felts containing wool shrank when heated. Also, steam showers installed inside of a seamless fabric run had to be moved or lifted for every fabric change. Perhaps more importantly to boost dryer limited production it was arguably more beneficial to use a steam shower to heat the sheet directly. If a mill had funds to install only one steam shower it was more efficient to install it on the fourdrinier, at the couch or in a suction press nip.

PRESENT TECHNOLOGY

In the last ten years there has been renewed interest in steam application to press fabrics for several reasons.

- Fabric technology has improved. Modern synthetic fabrics can now handle temperatures in excess of 180°F (82°C) as long as the fabric is moving and heat set during manufacture.
- Most machines are now using one or more steam showers to heat the sheet as much as possible. If a mill desires even higher temperatures, hence greater water removal in the press section, the logical next place to add it is to the fabrics.
- The development of seamed fabrics makes it possible to permanently install equipment inside the fabric run with minimal clearance.
- Increased press loadings require better control of fabric moisture to prevent crushing in the nip.
- The increased use of recycled fiber has led to increased contamination of the press fabrics. Most contaminants, particularly waxes, are easier to remove from a hot fabric than a cold fabric. The cost of steam, especially low-pressure flash steam can be significantly less than the cost of fabric conditioning chemicals. Also, the application of condensate, (pure distilled water) to the fabric is more environmentally friendly than chemicals.

At present more than fifty non-turbulent steam showers supplied by Wells Enterprises are installed over uhle boxes to heat the press fabrics of more than 25 machines. Many more machines are using homemade or steam showers from other suppliers.

Following is a discussion of results obtained on several machines using non-turbulent steam showers to heat press fabrics. These machines make fine paper, linerboard, corrugating medium and market pulp.

CASE STUDIES

Fine Paper

The first example is an application from 1977 on a fine paper machine in Wisconsin.

They were using very cold 67°F, shower water on their press fabrics, which contributed to inadequate dewatering by the uhle boxes. Because the fabrics were so wet this machine had trouble with sheet crushing when the first press was fully loaded. A non-turbulent steam shower was installed over the leading of two uhle boxes to heat and dry the fabric (figure 4). Fabric temperature increased from an average of 65°F to 113°F (18°C – 45°C) and water load leaving the uhle box was reduced from 0.67 parts water per part fabric to 0.51.

Steam Flow lb/hr.	Uhle Box Exhaust Temp °F	Fabric Temp. °F Top / Bottom	% Water in Fabric After Uhle Box	Grams water/gram fabric	% Decrease in water load
0	77	65/65	40.2	.67/1	-
2100	85	83/70	38.8	.63/1	6.3
3100	90	98/73	38.6	.63/1	6.7
4100	98	108/78	38.3	.62/1	8.0
5050	102	115/82	37.7	.60/1	11.7
6100	106	128/85	36.5	.57/1	17.5
7150	110	130/87	35.3	.54/1	24.0
8200	115	134/92	33.9	.51/1	31.3

Figure 4 – Result of Heating Press Fabric on Fine Paper Machine

Drying up the fabric eliminated crushing and allowed for full loading of the press, improved water removal from the sheet and a big speed increase. The mill also reported a 10% reduction in rejects and reduced wet end breaks. Unfortunately because the press fabric contained at least 50% wool, its life was significantly shortened when heated so the original steam shower is no longer used.

Linerboard

Figure 5 is a diagram of temperatures collected on a lightweight linerboard machine using 100% recycled furnish. The steam shower installed under the transfer roll was turned off because heating the sheet caused contaminants to be transferred to the cold fabrics downstream, especially the top fabric.

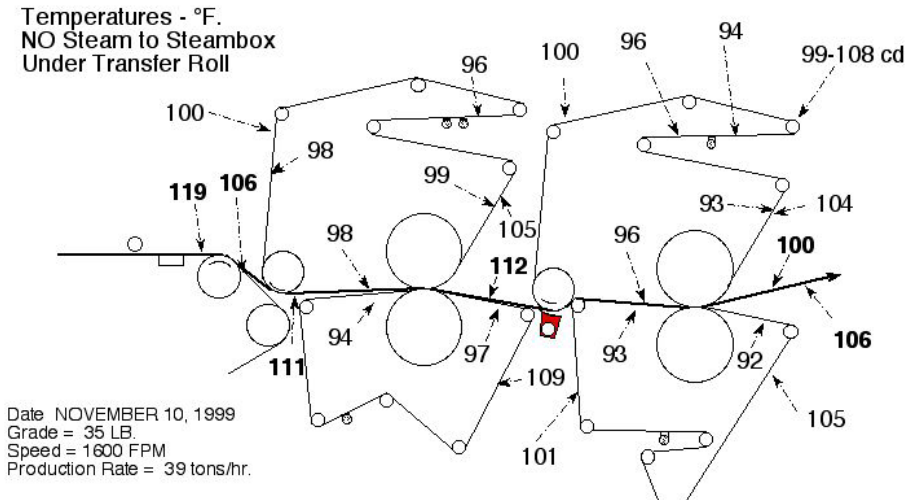


Figure 5 - When the steam shower under the transfer roll was used stickies were transferred to the cold last press fabrics.

Assuming that the stickies would be less likely to transfer if the fabrics downstream were the same temperature as the sheet, a non-turbulent steam shower was installed over the single uhle box of the last press top fabric in 1997. A second steam shower was installed over the bottom fabric shortly after.

Figure 6 is a photo of the non-turbulent steam shower over the top fabric uhle box. A simple pedestal bolted to the machine framework supports the 4" (102 mm) header of the steamer. The bottom of the steam shower is centered 1" (25 mm) above the vacuum area of the uhle box. It is supplied with 20 lb (138 kPa) flash steam via a 3" (76 mm) steam line at the drive side of the machine. .



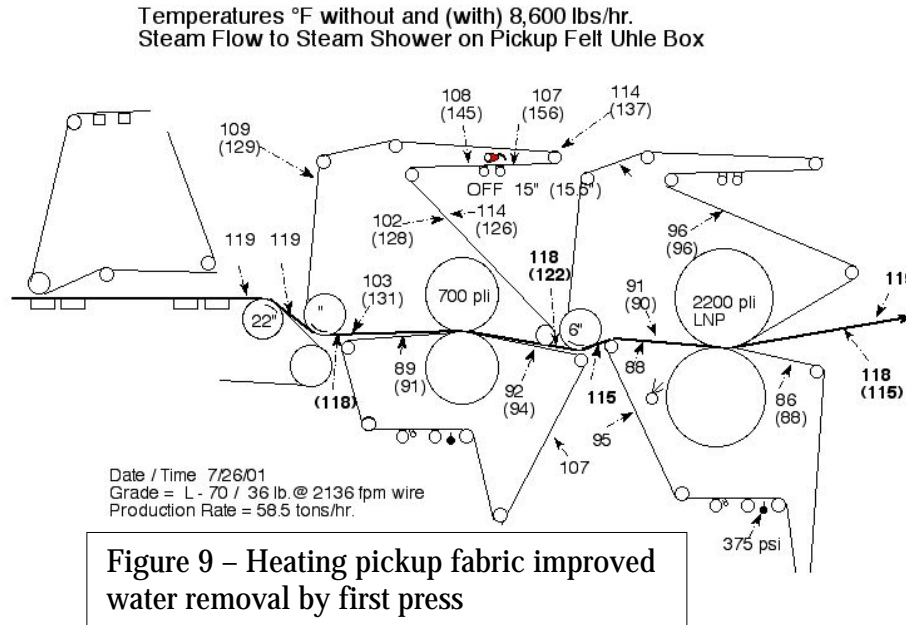
Figure 6 – Non-turbulent steam shower centered 1" above top fabric uhle box

The temperatures of figure 7 illustrate that the last press fabrics now run 30°F (17°C) hotter. The mill can now use the steam shower under the transfer roll without transferring stickies to the fabrics.

The mill has documented that use of the top fabric non-turbulent steam injector alone also increases production. Under speed optimization control ramping up steam flow to the injector from zero lb/hr. to 5000 lb/hr (2272 kg/hr) led to a production increase of more than 1 ton/hr. On a different occasion the mill documented that supplying the fabric steam shower with just 2,700 lb/hr. of 20 lb. flash steam reduced 185 lb (1275 kPa) steam demand in the dryer by 5,000 lb/hr. (2272 kg/hr). The mill also observed an increase in both volume and temperature of the weir water from the last press fabrics and longer life of their membrane fabrics.

machine over the course of the day. Too often the only feedback we get is the “gut feel” of the Machine Superintendent that the fabrics stay more open and run cleaner.

Instrumentation on some machines is better than others and it a joy to work on stable machines with sophisticated DCS systems that can cleanly track trends. This lightweight linerboard machine using 100% recycled furnish is a case in point (figure 9).



The machine has plenty of dryers so a steambox is not used to heat the sheet directly. Like most machines, the pickup fabric is the workhorse. It has a moisture to fabric ratio of 0.56 parts water per part fabric before the uhle box and 0.35 parts per part fabric after the uhle box. There was frequent ringing of water from the top roll of the first press. This machine typically uses only one of the two uhle boxes on the top fabric. The pickup fabric suffered particularly from “stickies” buildup that required them to shut down the machine to batch wash the fabric every 3 - 6 days. Since the dryer was not the bottleneck the project had to be justified by reduced chemical usage, longer fabric life and better up time. These savings are more difficult to quantify than steam savings or production increases.

Use of the steam shower heated the average temperature of the pickup fabric from 106°F to 130°F (41-54°C) entering the first press. The volume and temperature of the weir water from the uhle box discharge increased and they no longer have water ringing from the top roll of the first press.

As illustrated by the trend average printout of figure 10 steam demand by the fourth dryer section immediately dropped when steam flow to the injector was stepped up from 1000 lb/hr. to 5,200 lb/hr. (454-2364 kg/hr). When steam flow to the injector was increased another 3,400 lb/hr. (1545 kg/hr) more steam would have been pulled from the dryer but they speeded up 30 fpm (13 mpm). Not shown on this printout was the effect of abruptly turning off the injector at 2:45 PM when we saw 4th section steam load increase from 116 to 133 psi (800 to 916 kPa) and supply to the 5th section increase from 122 psi to 138 psi (840 to 950 kPa).

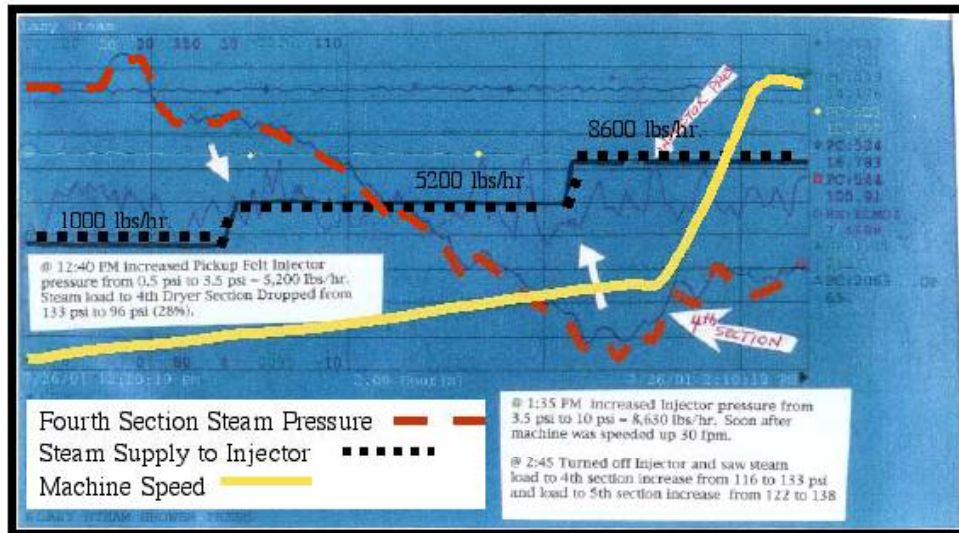


Figure 10 - Steam pressure to the last dryer section dropped from 133 psi to 96 psi (28%) when the pickup fabric was heated with non-turbulent steam shower.

Corrugating Medium

Figure 11 illustrates a different machine that makes corrugating medium using 50% semi-chemical pulp and 50% recycled OCC. This machine was not severely dryer limited but did suffer runnability problems. They were venting very wet 20 psi (138 kPa) flash steam to atmosphere but also had 35 psi (240 kPa) low pressure steam available. The machine has only two tandem fabrics with two uhle boxes on each. The fabrics suffered from compaction - especially the top fabric which the sheet would frequently follow exiting the second press at startup. Since the primary goal on this machine was to open up the top fabric so a non-turbulent steam shower was positioned over the leading of two uhle boxes hoping that trailing uhle box would pull the hot condensate through and out of the fabric along with contaminants.

To prevent damage in the event the sheet followed the top fabric all the way to the uhle box 5" wide flexible nomex skirts were included on the base of the steam injector similar to those of figure 12. This material is used to thread a pulp sheet through a Flakt dryer and holds up nicely in this application. The skirts also allow a tied knot or clamp on a seamed fabric to be pulled through.

The injector's effect on fabric cleanliness was more difficult to quantify than its effect on sheet temperature or dryer steam usage. The temperatures of figure #11 were collected over the course of an afternoon with zero and 2,500 lb/hr (1135 kg/hr) steam flow to the injector when running 26 lb. medium. According to the monitors in the control room immediately after steam to the injector was turned on, sheet moisture content at the reel dropped and 135 psi (930 kPa) steam demand by the dryer automatically dropped from 79,582 lb/hr. to 71,512 lb/hr to compensate for the drier sheet. The charts in the control room suggested that supplying the injector with 2500 lbs/hr. of 35 lb steam reduced 135 lb steam usage by the dryer by an impressive 8,070 lb/hr (3660 kg/hr).

It should be noted that quantifying the benefit of a fabric steam shower is easily influenced by machine direction variability and the reliability of a machines' control system. Since this trial was conducted in early 2001 the machine has shifted most of their production to lighter 23 lb. grades and has upgraded their steam monitoring system. Mill personnel have not been able to duplicate the dramatic steam savings on the lighter grades.

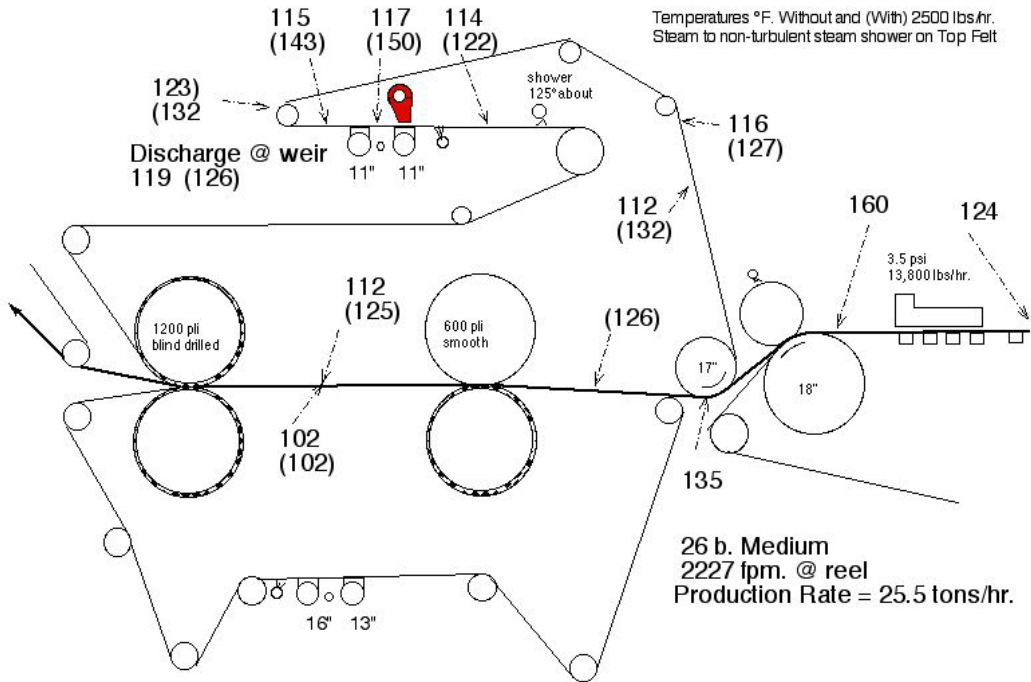


Figure 11 - Medium machine heating compacted top fabric

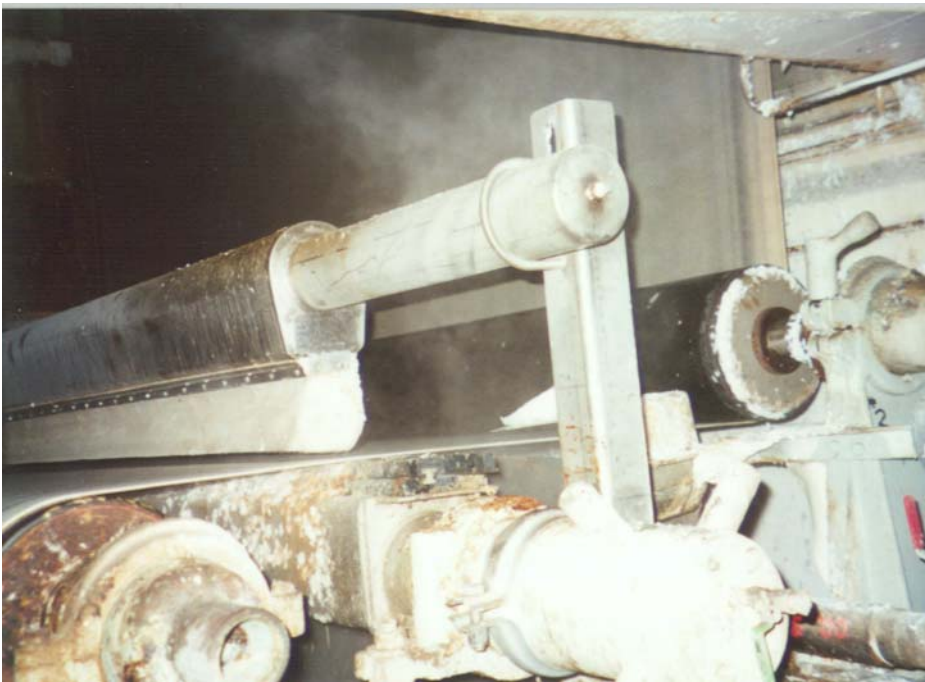


Figure 12 - Flexible nomex skirts can be included on the base of the injector to allow threading a seamed fabric

Figure 13 illustrates temperatures with steam supply to an injector heating the pickup fabric of a large medium machine with a tri-nip press. This mill claims that heating the fabric has eliminated the need to batch wash the fabric and yields an extra week of felt life. They report that use of the injector enables them to hold 18" hg of vacuum in their uhle box throughout the life of the pickup fabric. Vacuum in the uhle box used to increase to as much as 21" hg after about 4 weeks of running.

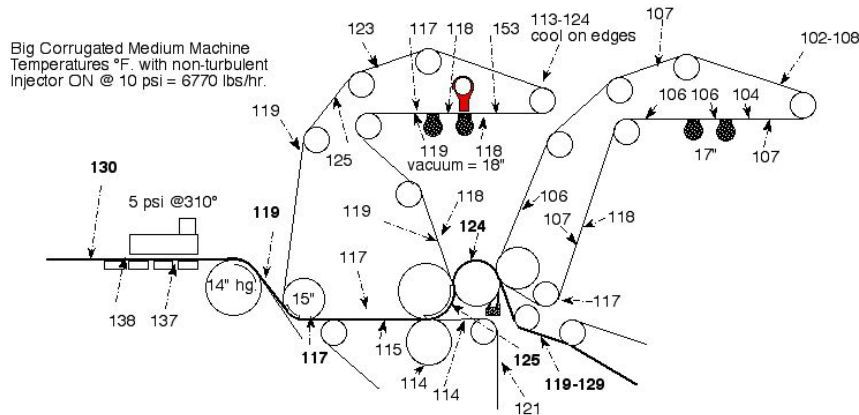


Figure 13 – Heating pickup fabric keeps the fabric more open and eliminated need for batch washes

An identical non-turbulent steam shower was later added in the tunnel of the tri-nip press with great success. It would be curious to test whether heating the pickup fabric improves the performance of the injector over the sheet. At least in theory making it easier for the center suction roll to pull water from the fabric should encourage water removal from the sheet therefore encourage steam movement into the sheet from the steam shower (figure 14). Unfortunately mill management is reluctant to risk turning the fabric steamer on and off abruptly.

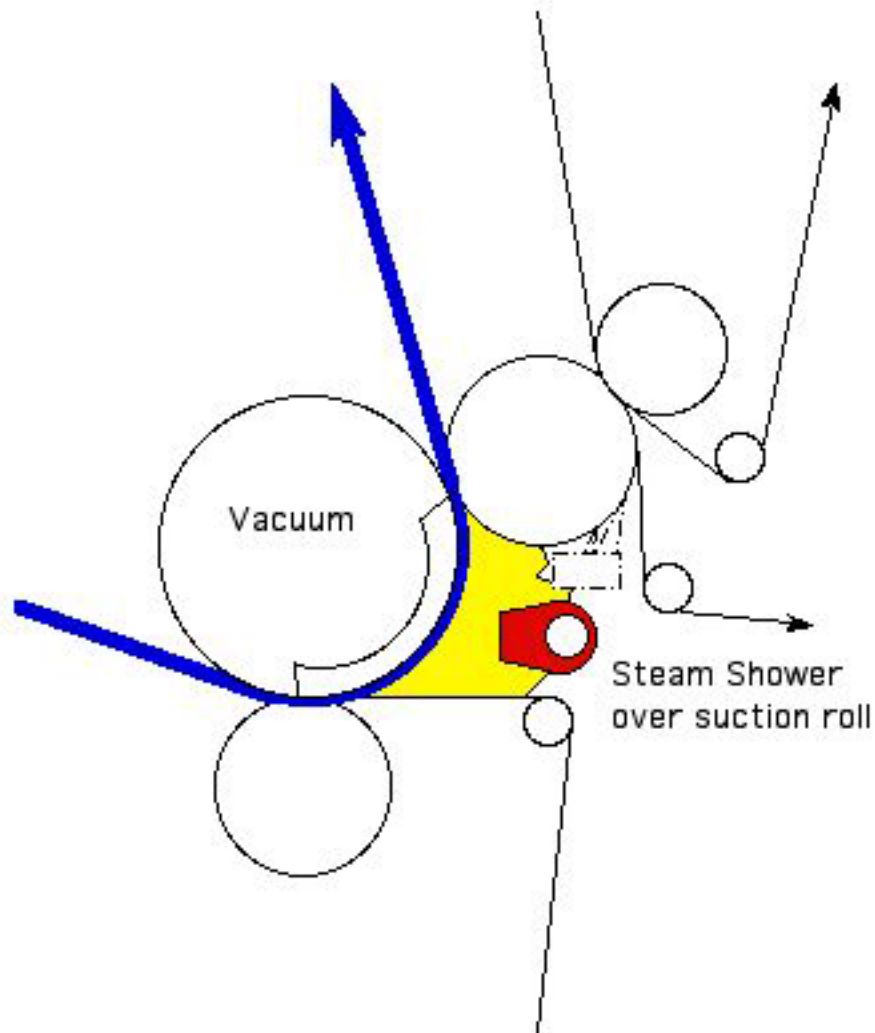


Figure 14 - Heating the fabric in contact with a suction roll may improve penetration of steam into the sheet.

The previously described applications were all on machines making fine paper, linerboard or medium.

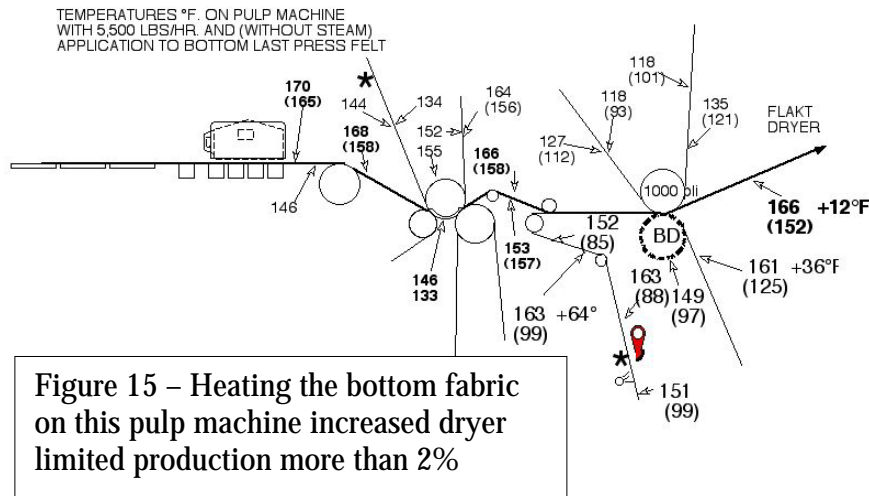
At present there are no non-turbulent steam injectors heating the fabrics of high-speed tissue or newsprint machines but we expect to run trials in the future. The fabrics on a tissue machine are so much heavier than the sheet it may be extremely beneficial to heat them.

There are at least four multi-vat cylinder board machines heating their press fabrics with non-turbulent steam injectors with success. One mill in particular maintains that heating their making fabric keeps the screen of the first vat clean and open improving sheet surface properties.

Pulp

Heating the press fabrics can also benefit machines making pulp. This machine historically ran a very cold bottom fabric in the last press that robbed about 6°F (4°C) from the bottom of the sheet before it entered the Flakt dryer (figure 15). The bottom roll is blind drilled. Thinking that heating that fabric would encourage

water movement into the blind drilled holes of the press roll hence water movement into the fabric from the sheet we installed a non-turbulent steamer over the single uhle box of the bottom fabric. Just hours after start-up the Machine Superintendent phoned excitedly saying the machine's production rate was up 1 1/2 tons/hr! Bottom fabric temperatures are now hotter than the sheet entering the nip and the sheet temperatures entering the dryer significantly higher than in the past. The bottom of the sheet it is now hotter after the last press than it is before it!



By contrast here is a different pulp machine that desired increased production (figure 16). They were running a grooved bottom roll in the last press and were short of vacuum on the last press bottom fabric uhle box. Based on the success the machine outlined in figure 15, and this current mill's cool fabric bottom fabric temperature I recommended heating the bottom fabric.

The mill did a fine job installing the injector but at the same outage they replaced the former grooved bottom roll with a solid steel roll. When the non-turbulent steam injector was started up it heated the fabric to the same temperature as the sheet entering the last press. The temperature of the discharge piping from the uhle box went up to as high as 154°F vs. 110°F (68° vs. 44°C) with no steam. Vacuum in the uhle box increased 1/2" hg when supplied with pure steam instead of air.

However, we saw no change in air dry at the layboy or increased solids entering the dryer.

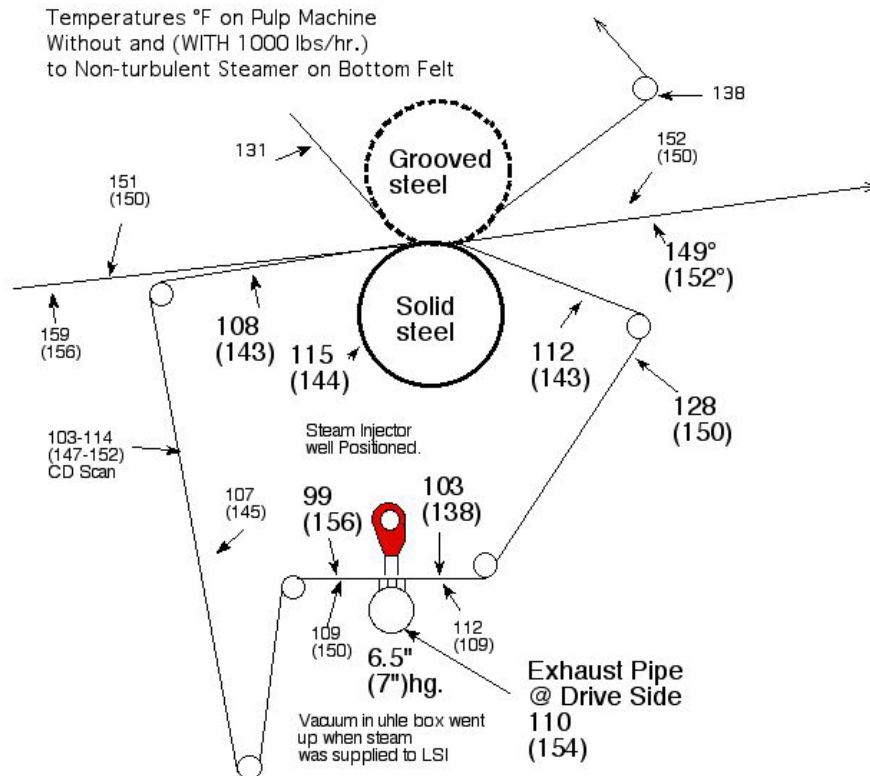


Figure 16 – With a solid last press bottom roll, heating the bottom fabric with a non-turbulent steamer had no influence on sheet moisture at the lay boy.

Unfortunately moisture scans of the fabric were not collected with and without steam application to the uhle box. It is possible that the additional 1700 lb/hr (772 kg/hr) of water added by the injector filled the available void volume of the felt and with a solid bottom roll it had nowhere to go in the nip. Perhaps if air were allowed to be pulled through the fabric as it left the uhle box a dryer fabric and reduced sheet moisture would have resulted. We should have experimented with the injector's exact position over the uhle box cover before refunding the purchase price and taking the steam shower back.

GENERAL OPERATING SUGGESTIONS

Optimum steam usage for a fabric application will depend on the porosity of the fabric and degree of vacuum in the uhle box. Most fabric steamers are using between 0.05 - 0.10 pounds of steam per pound of production. Running a production rate of 50 tons/hr steam usage should be about 7,500 lb/hr (3400 kg/hr). Steam temperature, at atmospheric pressure, should be kept below 300°F (150°C) to prevent damage to the fabric. Automatic shutoff is required in the steam supply line to prevent steam application a stalled fabric.

The steam shower can be designed to operate at any desired pressure simply by drilling more or bigger holes in the header. Because the area of the header pipe is significantly greater than the area of the drilled holes in the header there is no pressure drop from the steam inlet end to the tending side.

Virtually any type of steam can be used for a fabric steam shower including low pressure flash steam which might otherwise be vented to atmosphere or inefficiently introduced into the wire pit. Dripping from a steam shower on a press fabric is not as great a concern as from a steam shower over the sheet. However, large slugs of condensate coming through with the steam could be enough to cause the sheet to crush out in the press if the uhle box does not remove it. To help exclude the infiltration of air into the fabric the bottom

of the steam shower should be mounted 3/4" - 1" (20-25 mm) above the uhle box. Positioning of the steam shower in the MD over the uhle box can be critical and might require experimentation.

Use of homemade shower pipes with rows of drilled holes is discouraged. The turbulence of steam blasting out of a drilled hole causes the mixing in of air and can lead to non-uniform fabric temperatures downstream. The fabric is so porous that a pattern similar to that produced by a needle shower could be noticed in line with the drilled holes. If a pipe with drilled holes is used, care should be taken to design it such that it doesn't warp or bow when it heats up.

OPTIMUM FABRICS TO HEAT WITH STEAM SHOWERS

- The best fabric to heat with a steam shower is one that runs particularly wet and has limited void volume. Any fabric carrying over 0.65 parts water per part fabric is a good target. Mounting the injector over the leading of a pair of uhle boxes should knock that moisture ratio down to 0.40 or less. Increasing the void volume in the fabric can eliminate sheet crushing in the nip.
- Fabrics that suffer from buildup of petroleum waxes with a melting point below 160°F (70°C) are excellent targets. It may be necessary to segregate and sewer the discharge water from that fabric's uhle boxes however since it will be noticeably loaded with wax.
- A single tandem bottom fabric is a logical choice to heat since it is in contact with the sheet for its entire run through the press section. Some temperature will likely be transferred into the sheet from the hotter fabric.
- Fabrics that come in contact with a center suction roll of a bi-nip or tri-nip style press should be good candidates especially if there is a steam shower mounted over the sheet on that roll. Making it easier for water to be pulled from the fabric should encourage migration of water into the fabric from the sheet and improve penetration of steam into the sheet.
- Compacted fabrics that the sheet tries to follow leaving a press nip can benefit from heating since they will run more open. Also, reduced surface tension in the hotter water in the fabric should encourage sheet release and reduce rewet of the sheet leaving the nip.
- Any machine not using a steam shower to heat the sheet can benefit from indirectly heating the system with fabric steamers. This includes fine paper machines that cannot tolerate dripping from a steam shower above the sheet.
- Machines making bulk sensitive grades with a suction press may be able to increase water removal by heating the fabric that comes in contact with the suction roll.

CONCLUSIONS

Installation of a steam shower over a uhle box is a simple, efficient method of raising fabric temperatures on a paper machine.

Increased fabric temperature leads to improved water removal by the uhle boxes hence a dryer fabric with greater void volume entering a press nip. Improved water removal in a press nip and reductions in dryer steam usage or sheet moisture at the reel are often seen when heating press fabrics.

Heating the fabrics can dramatically improve their cleanliness and reduce the need for chemical treatment or batch cleaning.

Modern fabric designs and materials are not harmed by heating with saturated steam but the uhle box, fabric and press roll suppliers should be informed before installing a steam shower over a uhle box. Excessively high steam temperatures should be avoided.

The best fabric to heat depends on the press section, fabric surveys and whether the goal is to increase production or improve fabric conditioning.

Vacuum pumps feeding uhle boxes under a steam shower often run at a higher vacuum level when pulling pure steam instead of air. The higher exhaust temperature from the uhle box may improve the efficiency of the vacuum system.

Quantifying the benefit of a fabric steam shower is influenced by the sophistication of a machines computer monitoring and control system as well as short term changes in operating variables. The value of heating a press fabric often is reported as a "gut feel" by mill personnel.

TAPPI recommendations of air flow and suction box designs should be met before installing a steam shower over a uhle box.

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