EXTENDING THE MACHINE DIRECTION LENGTH OF STEAM SHOWERS WITH SHELVES TO IMPROVE PERFORMANCE

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ABSTRACT

Non-turbulent lazy steam showers have been used to increase dryer limited production by 5% on more than fifteen multi-vat paper machines manufacturing heavyweight 100% recycled grades. Their performance is enhanced by using simple "shelves" to extend the steaming length up to 30 feet (10 m) in the machine direction. This paper discusses the development of non-turbulent steamers with shelves and their effect on sheet temperature, moisture at the reel, increased production and reduced fog in the machine room. The potential for unique applications of shelves on fourdriniers is also addressed.

INTRODUCTION

The point of any steam shower is to heat the sheet to reduce its viscosity and enhance dewatering by a suction device or press downstream. To increase production with a steam shower you must; 1) condense the steam in or on the sheet; 2) remove the hotter water and condensate from the sheet before it enters the dryer by either sucking it out or pressing it out; 3) keep air (non-condensable gas) away from the steam transfer location.

The steamers discussed in this paper are designed to deliver steam which is pure, transparent, has essentially zero pressure and above all, is non-turbulent so air is not allowed to mix in. This non-turbulent "Lazy" steam technology was developed by Roger Wells and Weyerhaeuser from 1969 - 1983 during which time it was held as proprietary. Over the years more than 140 non-turbulent steamers have been used on all types of paper machines.

NON-TURBULENT STEAM APPLICATION

Figure 1 is an example of transparent non-turbulent steam discharging from an open 11-inch (264 mm) wide compartment of a profiling steamer. The adjacent compartments are closed. At the bottom of the compartment you can see where pure, transparent non-turbulent steam meets air and condenses into a white "fog".

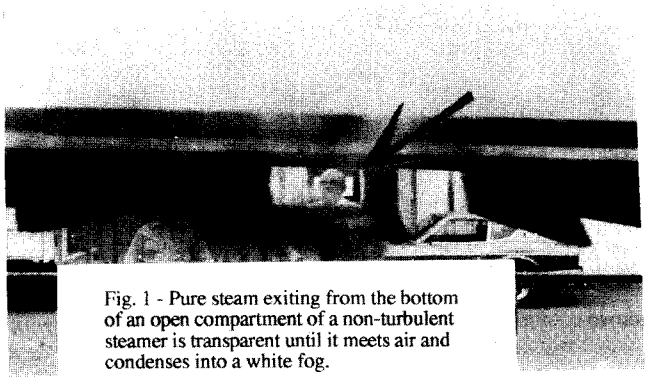

Fig. 1 - Pure steam exiting from the bottom of an open compartment of a non-turbulent steamer is transparent until it meets air and condenses into a white fog.

This unique phenomenon is also seen in an application at the ingoing nip of a straight-through suction press where a wavy "air-steam" interface line can often be seen behind a non-turbulent steam Injector (Figure 2). When pressure to the steamer is adjusted up and down this interface line moves in and out of the nip. The point at which the sheet will not absorb any more steam is obvious since fog starts spilling into the machine room.

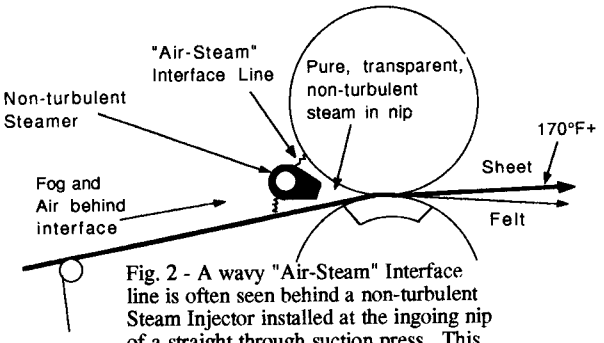

Fig. 2 - A wavy "Air-Steam" Interface line is often seen behind a non-turbulent Steam Injector installed at the ingoing nip of a straight through suction press. This interface moves in and out of the nip as steam flow to the Injector is changed.

The use of steamboxes on fourdrinier machines is well proven. Most paper machines have either a profiling or non-profiling steambox on the fourdrinier wire, in the press section or over uhle boxes and felts.

STEAM APPLICATION TO MULTI-PLY BOARD MACHINES

Less well known are steam applications to multi-vat cylinder board machines which use 100% recycled furnish to make heavy multi-ply grades used for cereal boxes, core tubes or the backing of pads of paper. Calipers of these grades vary from 20 point to 60 point (0.5 - 1.5 mm) with weights of 80 lb./1000 sq. ft. - 206 lb./1000 sq. ft. (390 g/m - 1000 g/m) In general, the heavier the grade, the slower draining the stock and the more dryer limited the machine.

Figure 3 illustrates a typical multi-vat cylinder board machine which is commonly 96 inches (2.43 m) wide in the CD. It consists of a series of vats filled with a slurry. Vat temperatures are usually less than 110°F (43° C). Layers of pulp are couched onto a felt which carries the sheet around a suction drum or turnaround roll and then into a standard press section.

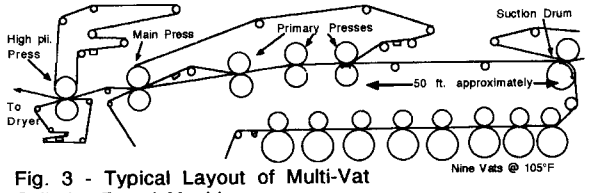

Fig. 3 - Typical Layout of Multi-Vat Cylinder Board Machine

The press nips are usually double felted and occasionally flooded. Typically, there is a long horizontal run of about 50 feet (16 m) between the turnaround roll and press section where the sheet is single felted and exposed.

The first multi-vat cylinder board machine to install a non-turbulent steamer was a Weyerhaeuser machine in Fitchburg, MA. back in 1970. It was installed over the suction turn around roll. Although

use of the steambox increased dryer-limited production by 4%, the application died since they couldn't sell the heavier grades made on the machine as it was. For the next 19 years Weyerhaeuser and Wells concentrated their efforts on fourdrinier machines.

It wasn't until 1989 that Wells Enterprises agreed to supply a non-turbulent steamer for a similar suction drum on a multi-vat board machine in California. The suction drum is a simple and convenient location to add a steamer since there is already a vacuum source to pull the steam into the sheet (Figure 4).

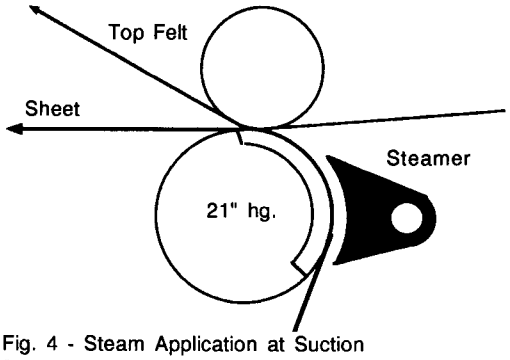

Fig. 4 - Steam Application at Suction Drum on Multi-Vat Board Machine

There are disadvantages to this location however. First, the sheet cools significantly as it travels to the press section. Second, the sheet is often non-porous, wet and sloppy. Third, excess steam or fog coming off the hotter sheet and felts can fill the room at the wet end without proper ventilation.

A better location for a steamer is at a point closer to the press section where the sheet is more consolidated; for example, over one or two uhle boxes installed under the single felted sheet just before a press. In an early trial of such an application, when a relatively high flow was supplied to the steamer, the sheet temperature entering the dryer increased 18°F (10°C) despite severely flooded nips (Figure 5). The backtender reported moisture dropped more than 2% at the reel when the steamer was turned on.

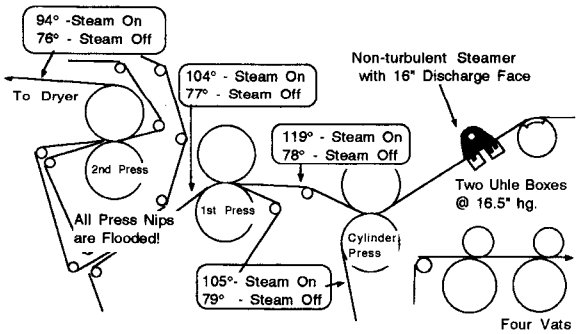

Fig. 5 - Temperatures -°F measured with and without pressure in steamer upstream of first press on 4 vat board machine

However, the hotter system of sheet, felts, press rolls and discharge effluent caused the wet end of the machine room to fill with fog so steam flow to the steamer had to cut back. The mill has since top felted the cylinder press which helps contain excess fog.

A similar application is this 18-inch (457 mm) wide compartmented steamer installed ahead of the first main press on a machine in Massachusetts (Figure 6).

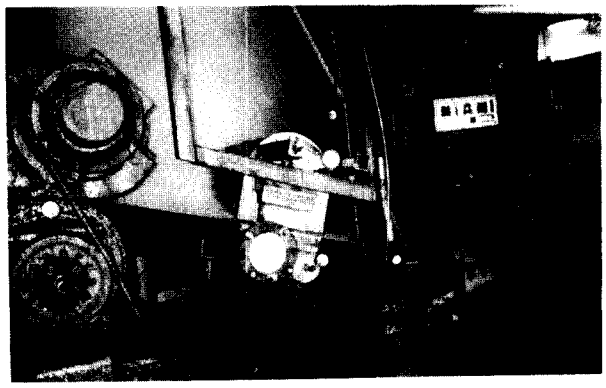

Fig. 6 - Profiler installed upstream of first main press. Note fog escaping into room.

In an early evaluation when several six-inch (153 mm) wide compartments were closed, sheet temperatures in line entering the dryer dropped 9° F (6°C). To reduce the amount of steam entering the room, another suction box was eventually added upstream under the steamer.

Over a period of two years, non-turbulent steamers were installed on nine board machines in these simple, traditional press section applications. All reported dryer limited production increases of 4% - 9% depending on the grade and amount of steam flow to the steamer. Most also complained of fog filling the wet end of the machine room.

DEVELOPMENT OF SHELVES

This eight-inch (203 mm) wide steamer with profiling capability was installed in 1991 over a suction box just upstream of the first primary press on CCA's board machine in Tacoma, WA. (Figure 7). As with the other applications the best results were achieved at higher steam flows but an excessive amount of steam entered the room.

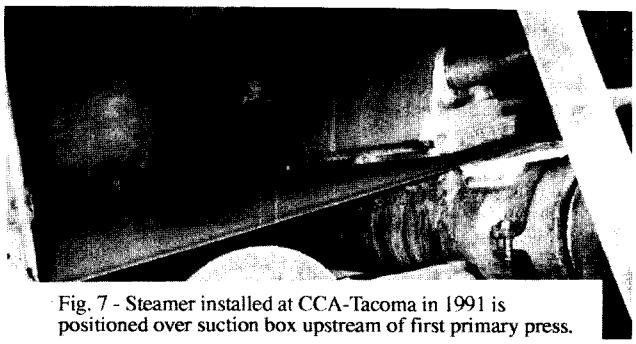

Fig. 7 - Steamer installed at CCA-Tacoma in 1991 is positioned over suction box upstream of first primary press.

To try to contain the non-turbulent steam against the sheet for a longer time and keep excess steam from escaping into the room, we conducted a simple trial. A sheet of heavily sized gasket paper was stapled to a piece of wood and clamped to the machine frame. When unfolded it draped over the steamer and dragged on the sheet downstream forming a tent which effectively doubled the steamer's length from 8 inches to 16 inches (203 - 406 mm). When pressure

to the steamer was turned on for a short time, the tent downstream quickly filled with pure, transparent superheated non-turbulent steam (Figure 8). You could see right across the machine through this area.

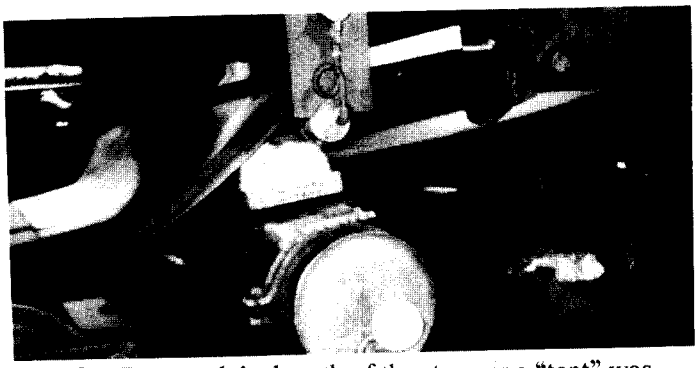

Fig. 8 - To extend the length of the steamer a "tent" was created downstream. When steam was turned on this filled with transparent, non-turbulent steam.

Sheet temperatures entering the dryer were about 5°F (3°C) higher when the tent was used than when it was not used. A total sheet temperature increase entering the dryer of about 15°F (9°C) was obtained by doubling the length of exposure with the tent (Figure 9).

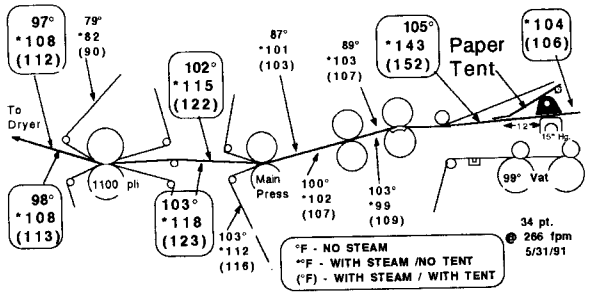

Fig. 9 - Sheet Temperatures -°F
CCA-Tacoma "Tent" Trial

When steam flow was abruptly turned off to fold back the paper tent, the sheet was marked and followed to the reel. Moisture immediately increased 2% in the center of the sheet and 2.5% on the edges when the mark went by. The last dryer can steaming moved from #51 to #55.

To cover a larger area, a sturdy piece of gasket paper was temporarily draped about three inches (76 mm) above the sheet upstream and downstream of the steamer while we figured out a better material to use.

We wanted the new shelf to be lightweight, simple enough for one person to assemble alone, and inexpensive. After much searching we settled on heavy duty corrugated fiberglass panels similar to those used on the walls of many machine rooms. To withstand the heat they must be made with a thermo-setting resin, not polyvinyl chloride! To support the panels we fabricated a stainless steel shroud with angles at the base which fit snugly over the steamer. Simple three-inch (76 mm) angle irons spanning the machine in the CD were used to support the other ends of the panels.

These eight-ounce fiberglass panels measure 26 inches (76 mm) wide and overlap each other by two inches (51 mm). They can easily be cut to length with a saw in the mill. The corrugations of the panels lend some stiffness and help channel the steam in the machine direction. At the next shutdown a five-foot (1.5 m) long section was added downstream and two-foot (0.6 m) long section added upstream (Figure 10). A small non-turbulent steamer was also added at this time over a uhle box immediately before the first vat to help heat and clean the carrying felt.

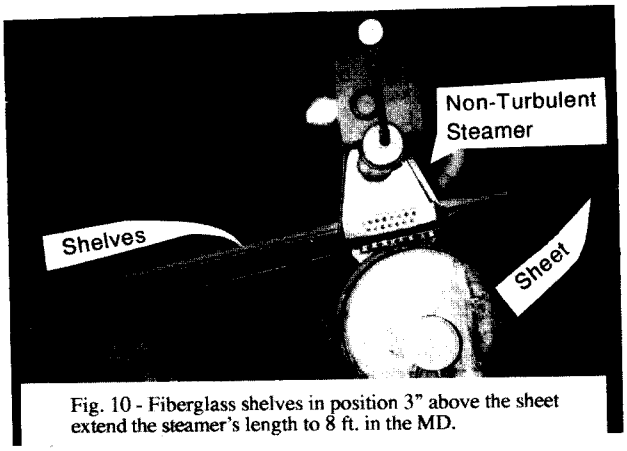

Fig. 10 - Fiberglass shelves in position 3" above the sheet extend the steamer's length to 8 ft. in the MD.

RESULTS FROM SHELVES AT TACOMA

When 4.5 psi. (31kPa.) steam pressure to the steamer with shelves was applied at startup on a relatively light 22 pt.(.55 mm) 82 lb/1000 sq. ft. (400 g/m) grade, transparent non-turbulent steam at a temperature of 240°F (116°C) quickly filled the two-inch (51 mm) gap between the downstream shelf and the sheet. Under the upstream shelf visible white fog was observed. The vacuum level of the suction box below the steamer went up from six inches of hg. to eight inches hg. as soon as steam (pure water vapor) was pulled through the sheet instead of air.

Sheet and felt temperatures in the press section immediately increased dramatically (Figure 11). Temperatures of the white water and press rolls increased more gradually. Machine speed automatically increased 5.5%.

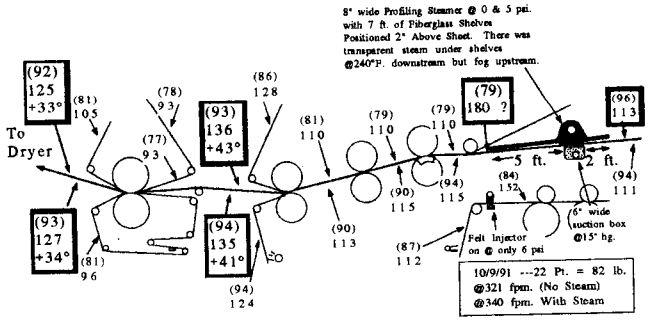

Fig. 11 - Sheet temperatures °F measured @ Tacoma with and (without) steam in steamers

The mill feels that the small steamer installed over the uhle box just ahead of the first vat keeps the felt more open which helps formation. A second non-turbulent steamer has recently been installed over the uhle box of the bottom felt of the last press. Non-turbulent steam application directly to felts over uhle boxes is being evaluated on several other machines.

CCA-Tacoma has documented automatic speed increases of more than 5% on at least three grades when steam is abruptly turned on

and off to the steamer with shelves. Their sheet temperatures entering the dryer usually exceed 130°F (54°C).

At least two other multi-vat board machines using steamers with shelves report average sheet temperatures entering the dryer of more than 145°F (63°C).

The effect of vacuum on or off under the steamer has been tested in at least three mills. On one occasion, making a lightweight sheet, Tacoma's machine speed automatically increased 4% when the vacuum box under the steamer was abruptly turned on from off. The general consensus of most mills using steamers with shelves is the more vacuum below the better.

OBSERVATIONS OF SHELF APPLICATIONS

Several phenomena can be observed in combination with the use of shelves. One of these is the location of the "air-steam" interface where the pure, transparent non-turbulent steam meets air and condenses into white fog. As pressure to the steamer is increased this interface moves upstream and downstream under the shelves. Figure 12 illustrates temperatures measured with a thermocouple under the tending side edge of the shelf on a machine in Wisconsin.

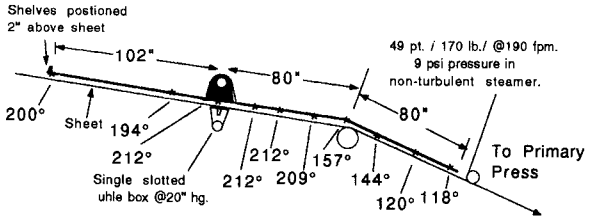

Fig. 12 - Temperatures °F measured 1" above sheet 12" in from front edge of shelves on Wisconsin machine. The "air-steam" interface was over carrying roll downstrean

At the point where the pure, transparent, non-turbulent steam is contaminated by air, it condenses and the temperature drops. This is particularly noticeable at the leading edge of the shelf and along the edges. If not enough steam is supplied to the steamer with shelves to keep the air out, the edges of the sheet entering the dryer may be 5°-10°F (3°-6°C) cooler than the center. Side skirts of old felt hung along all edges of the shelves dramatically help contain the non-turbulent steam and keep the air out.

Optimum steam flow to a steamer equipped with shelves depends on their length, degree of vacuum below and porosity of the grade. Most mills are using steam flow of approximately 0.15 pounds of steam per pound of pulp produced.

PROFILING POTENTIAL

Although there are presently two non-turbulent steamers with profiling capability installed on multi-vat board machines targeting 6% moisture at the reel, neither is frequently adjusted, due in part to lack of reliable moisture scanners. However, there is a need for profiling on machines making coated product where a single narrow wet streak limits machine speed. A 10-foot - 30-foot (3 m - 10 m.) long shelf can simply be compartmented so non-turbulent steam is preferentially applied just to the wet streaks (Figure 13). With such a design the length of time the sheet is exposed to steam can be controlled.

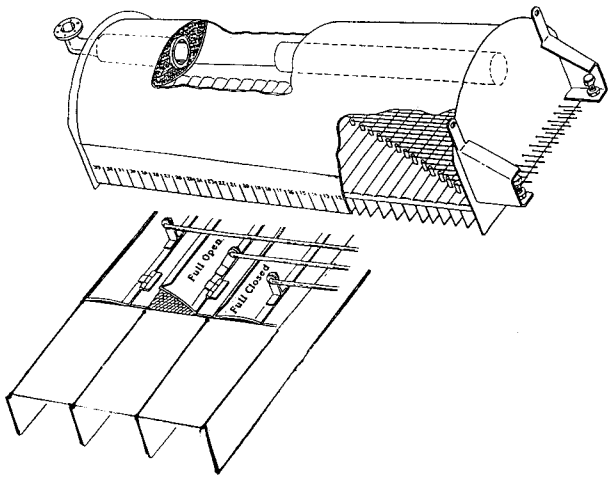

Fig. 13 - Compartmented shelves used to preferentially apply steam to wet streaks.

POTENTIAL SHELF APPLICATIONS ON FOURDRINIERS

Some of the multi-vat board installations I have described above are obviously similar to fourdrinier machines. A logical application is to extend compartmented shelves up and downstream from an existing steamer so steam is pulled into the sheet by all suction boxes downstream of the dry line as well as the suction couch (Figure 14).

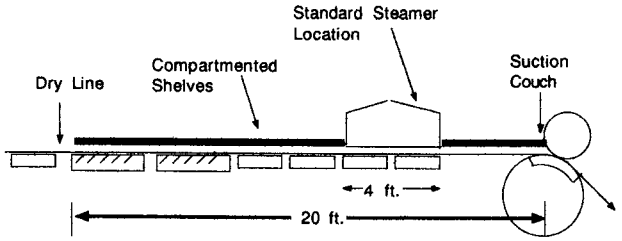

Fig. 14 - Shelves could be used to hold steam down against the sheet from the dry line to the suction couch

Another location for a shelf or shroud of fabric is under the suction roll of a bi-nip press where a traditional steambox positioned one-inch (25 mm) from the sheet can plug up with stock and cause housekeeping nightmares (Figure 15). The important function of the shelf is to prohibit air from contaminating the steam before it can condense on, or be pulled into, the sheet.

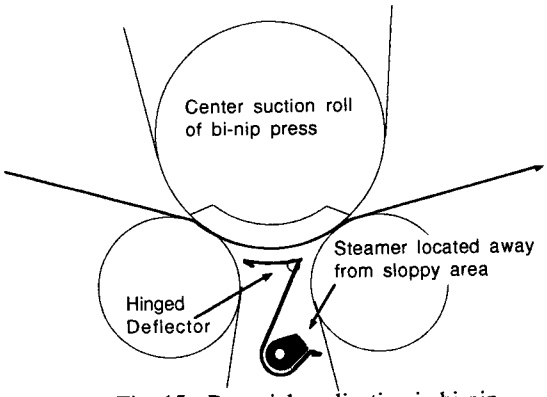

Fig. 15 - Potential application in bi-nip press for a non-turbulent steamer with a shelf or shroud to eliminate air.

CONCLUSIONS

How well a steam box equipped with shelves will perform on your particular machine will depend on many factors including the grade mix, amount of refining and porosity of the stock, layout of the press section and degree of vacuum below the steamer.

It is safe to assume that if smoke or air is pulled into the sheet by a vacuum source below then steam applied over the suction box will also be pulled in and sheet temperatures downstream will increase dramatically. If you now have excess fog in the machine room a simple shelf or shroud should help contain it. Although the shelf material can be insulated stainless steel, aluminum, temperature resistant canvas or an old felt, the fiberglass panels are simple, lightweight, inexpensive and readily available in hardware stores.

We are actively upgrading the designs of non-turbulent steamers to incorporate shelves. New results are frequently reported. At this time (June 1993), based on results from more than ten multi-vat board machines using non-turbulent steamers with shelves we can safely draw the following conclusions.

1) The addition of shelves upstream and downstream of a non-turbulent steamer will double dryer-limited production increases obtained with a traditional non-turbulent steamer.

2) Steam application with shelves benefits heavier weights of paper more than lighter weights due in part to the slower machine speed and longer time of exposure of the sheet to pure steam.

3) The uniform application of steam improves the moisture profile at the reel since more water is removed from wet streaks than dry streaks.

4) Moisture reduction at the reel is greater when a vacuum source under a non-turbulent steamer is used.

5) For maximum dewatering by heating the sheet, the first steamer should be installed upstream of the press section where there is plenty of room for the addition of shelves. Steamers installed in the press section will additionally increase sheet temperatures entering the dryer, but each will yield about 50% the benefit of the first steamer. For instance, if the first steamer gives a dryer-limited production increase of 6%, the second steamer will yield another 3%.

6) Modification of felts and roll covers on the machine may be necessary to handle higher temperatures and different drainage characteristics when using the steamer.

7) Steamers with shelves can be a simple, inexpensive solution on all dryer limited paper machines but they must be designed for the specific application.