# Practical aspects of calender steam showers

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*Treating the sheet with steam during calendering improves the response to calendering. Smoothness improvements of 10–20% are normal, along with improved CD profiles and elimination of two-sidedness.*

The use of calender steam showers to improve smoothness and gloss of various paper grades has been reviewed by others (*1, 2*). The use of steam enhances sheet temperature and sheet surface moisture with the results that:

- Sheet smoothness can be improved up to 30%.
- Sheet gloss is improved.
- Sheet smoothness and two-sidedness can be reduced.
- Sheet bulk can be manipulated.
- CD control of smoothness and gloss is possible.

For the most part, these results were based on laboratory experiments or on pilot trial studies. Here, we will review the use of calender steam shower technology in full-scale production machines, primarily manufacturing newsprint at speeds up to 1300 m/min.

## Description of concept and process

The absorption of steam into a paper web has two immediate effects. First, when the steam condenses, it releases its latent heat of vaporization, increasing the sheet temperature. Second, the condensed steam selectively enhances the moisture content of the sheet surface. The response of the paper is a complicated function of sheet weight, the nature of the furnish, machine speed, incoming sheet temperature, and the location of the steam device. Processes are described as hot calendering, temperature-gradient calendering, or moisture-gradient calendering.

**Figure 1** shows a typical steam application device specifically designed for use on high-speed newsprint calender stacks. These steam showers are divided into CD application zones 150 mm or 300 mm wide (6 in. or 12 in.) to facilitate cross-direction control of the appropriate sheet profiles.

These steam showers have been carefully designed for:

- Uniform CD steam distribution
- Condensate removal to prevent steam spitting and dripping
- Negligible mechanical deflection from static and thermal loads to maintain a close clearance from the sheet
- Simple customized retraction to facilitate sheet threading
- Both top and bottom side sheet heating.

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**1.** An example of a calender steam shower designed for Location B, Fig. 2

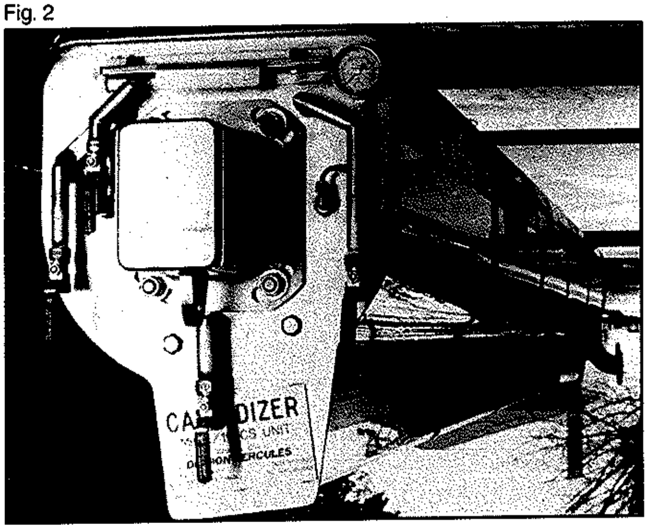
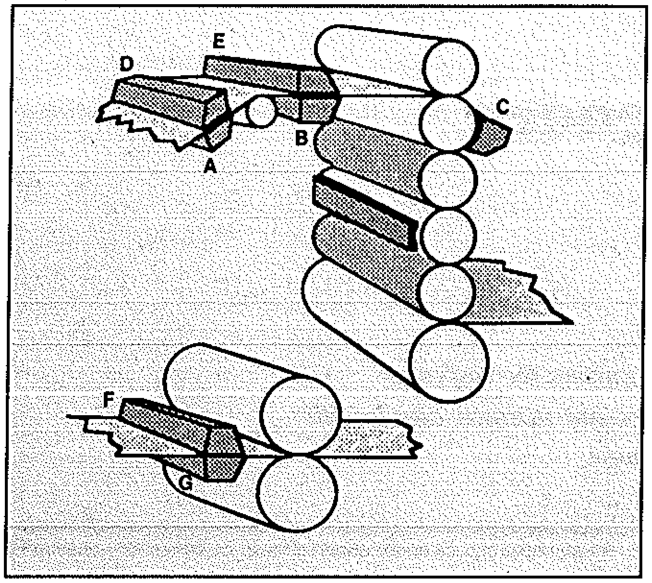


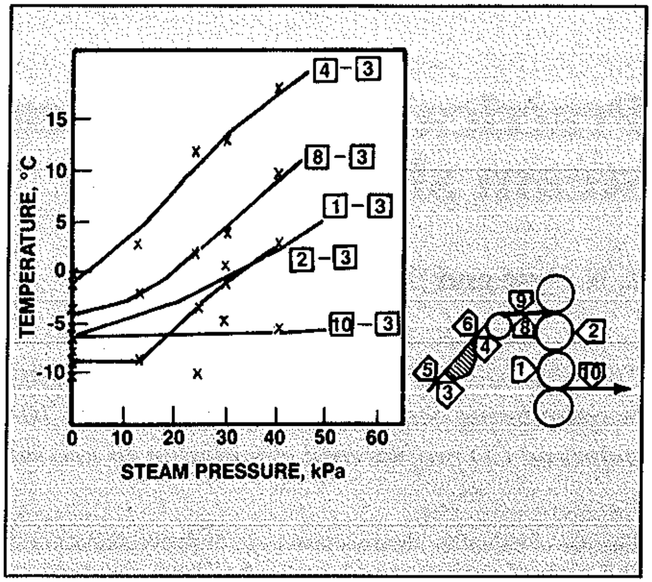
**Figure 2** shows locations that may be selected for the steam shower on a calender stack. Steam supplied to the shower will typically be less than 60 kPa (8 psig) and will be at a temperature of 115–125°C (240–260°F).

## Results

**Table I** summarizes the major operational characteristics of five production calender steam showers. The smoothness data were obtained during startup of the equipment and are based on mill-supplied testing. Temperature results were obtained using an infrared temperature pyrometer set at 0.95 emissivity.




2. Typical locations for steam showers on multi-nip and single-nip stacks




3. Temperature increase as a function of steam pressure for the steam shower installation on Machine B

I. Typical results for calender steam showers

| | Machine | | | | |
|---|---|---|---|---|---|
| | *A* | *B* | *C* | *D* | *E* |
| Grade | Newsprint | Newsprint | Newsprint | Newsprint | Specialty groundwood |
| Calender design, rolls | 4 | 4 | 6 | 6 | 2 (resilient nip) |
| Basis weight, g/m² | 45-52 | 45-55 | 48.8 | 43.8 | 50 |
| Speed, m/min | 1300 | 950-1000 | 820 | 830 | 500 |
| Steam shower location[a] | A | A | C | B | F |
| Incoming sheet temp., °C | 75-82 | 66 | 64 | 70 | 57 |
| Sheet temp. increase across steam shower, °C | 9 | 18-19 | 15 (minimum) | 17 (minimum) | 23 (minimum) |
| Smoothness before | | | | | |
| Top | 96[b] | 101.5[b] | 3.90[c] | 102[b] | 2.6[c] |
| Bottom | 90 | 110.5 | 3.35 | 106 | 2.8 |
| Smoothness after | | | | | |
| Top | 92[b] | 89.5[b] | 3.28[c] | 84[b] | 2.4[c] |
| Bottom | 82 | 90.5 | 3.25 | 85 | 2.4 |
| Smoothness improvement, % | | | | | |
| Top | 4 | 12 | 16 | 16 | 23 |
| Bottom | 9 | 18 | 3 | 20 | 14 |
| Caliper reduction, % | ... | 3 | 3 | 7 | ... |

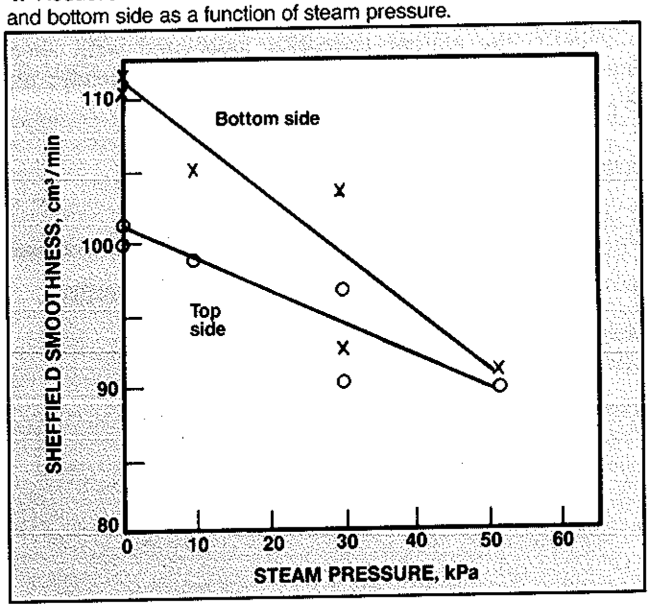
[a]See Fig. 2. [b]Sheffield smoothness, units. [c]Parker Print-Surf.

The results shown in the table were for the steam shower operating at pressures typically in the 30-50 kPa range (4.5-7.5 psig). **Figure 3** illustrates the temperature change across the steam shower on Machine B and through the calender stack as the steam pressure was varied from 0 to 40 kPa. Each curve plots the temperature increase from a location before the steam shower to one of the locations after steam application. The curves show that at higher steam pressures, sheet temperature increases are higher and are maintained longer. Measurements on the other machines produced similar results.

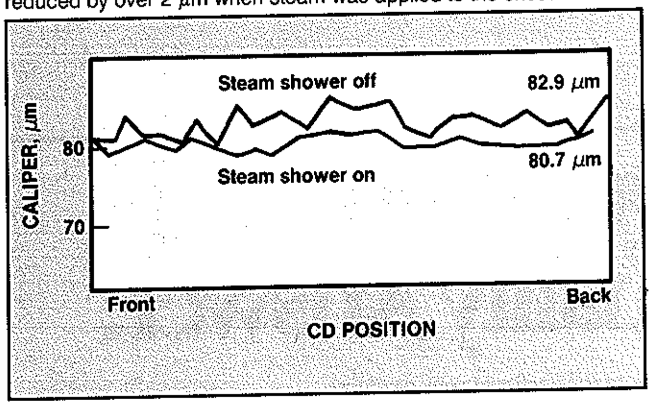
**Figure 4** shows, for the same machine, the smoothness changes as the steam pressure was varied from 0 to 50 kPa. Both top- and bottom-side smoothness improved as steam pressure increased, with greater reduction in Sheffield smoothness on the side of steam application. Similar graphs resulted from studies on the other machines.

**Figure 5** shows a CD caliper profile obtained with the calender steam shower on and with it off. In this instance, the average caliper dropped from 82.9 to 80.7 μm when the steam was applied. The profiling valves in the steam

4. Reduction in Sheffield smoothness number on the sheet's top side and bottom side as a function of steam pressure.




5. Caliper profiles with the steam shower on and off. Caliper was reduced by over 2 μm when steam was applied to the sheet.




shower were all set to a constant opening when these profiles were obtained.

## Discussion

### Basis weight

All sheet weights were similar. However, there were differences in furnish composition. Machine A had a high TMP component plus semi-bleached kraft in the furnish; the other machines used stone groundwood plus sulfite or semi-bleached kraft.

From the work of Eklund and Salminen (*3*), furnish should play a part in the location of condensed moisture in the sheet. However, the available data were inconclusive on this point.

### Speed

Machines running between 500 and 1300 m/min were covered in the study. The duration of steam application might be expected to be a factor in steam pickup, and this does seem to be the case for Machine A, for which the sheet temperature increase is smaller than for the other machines. However, other factors, such as incoming sheet temperature, must be considered.

### Incoming sheet temperature

Studies indicate that the lower the incoming sheet temperature, the larger the temperature increase across the steam shower. However, it is not possible to separate this effect from that of machine speed. The machine with the lowest incoming sheet temperature is also the slowest machine, and the highest incoming sheet temperature is on the fastest machine.

### Sheet temperature increase across the steam shower

In some steam shower configurations, it is not possible to make a good temperature measurement immediately after the steam shower, and some sheet cooling may have occurred before the sheet temperature could be measured. In these cases, the temperature increase is noted as the "minimum."

Further details on temperature increase and maintaining the increased temperature through the calender stack can be derived from Fig. 3. In most calender stacks, there is significant sheet cooling once the sheet leaves the dryer section. The calender steam shower is effective at reversing this cooling action.

### Smoothness

Smoothness improvements of 3–23% were seen on the machines reviewed (with 3% being on the unsteamed side of the sheet). Significant improvements in gloss were also seen where this was measured. In the case of Machine E, gloss improvements between 23% and 47% were seen on the unsteamed and steamed side of the sheet, respectively.

In general, the steamed side of the sheet shows a larger smoothness improvement than the unsteamed side, which can be quite useful in reducing sheet two-sidedness. Figure 4 shows the reduction in two-sidedness achieved on one machine. Interestingly, this effect is somehow related to sheet structure because the effect seems strongest for those sheets that are inherently two-sided (as with Machine C) and weakest for sheets that are relatively even-sided (as with Machine D). Further studies are in progress to identify the exact contribution of the steam shower location on reducing two-sidedness.

### Caliper

As would be expected, a caliper reduction is generally seen when the calender stack loading remains constant and the sheet is steamed. Figure 5 shows a typical result on newsprint, where caliper was reduced by 2 μm. In Table I, Machines B, C, and D exhibited caliper reductions of 3%, 3%, and 7%, respectively, when no stack loading changes were made.

### CD caliper profile

Uniform steam application in the cross-machine direction generally has no noticeable effect on the CD caliper profile (Fig. 5). However, in one instance, the combined effect of a heated sheet and a hotter calender accentuated a crown loading problem, which was overcome with some minor changes in variable crown-roll loading.

### Sheet moisture

Condensing steam in the sheet adds moisture to the sheet, typically 0.5-2%. For a fixed setpoint value for moisture at the reel, the dryer pressures should accelerate slightly to present a slightly dryer sheet at the end of the dryer section.

Our observations are inconsistent on this point. In some instances, an increase in dryer pressure has been observed, but in most instances, no increases were noticed. A possible explanation is that the sheet is heated by steam condensing on it, producing more surface moisture. This moisture is lost by evaporation as the sheet cools; therefore, the evaporation rate is increased by the higher sheet temperature.

## Summary

Results from several full-width, calender-stack steam showers have confirmed the benefits reported earlier (*1*, *2*) on the basis of pilot trials or laboratory studies.

Specifically, the temperature of the incoming sheet at the calender stack can be increased—by more than 20°C. The increase depends on machine speed, the sheet temperature exiting the dryer section, and the location of the steam shower.

Sheet smoothness improves by 3-23%. The steamed side of the sheet generally shows a greater smoothness improvement than the unsteamed sheet side. This effect is more pronounced on two-sided sheets than on even-sided sheets. Reduction in sheet two-sidedness is therefore possible.

Finally, the caliper reduction associated with sheet smoothness improvement is 3-7%, when the calender nip load is kept constant.

## Literature cited

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