The Hydra-Nip dryer: the easy way to surface smoothness

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On paper grades, the Hydra-Nip produces smoothness usually unobtainable with on-machine calendering alone. A Parker Print-Surf of 3.2 μm was obtained on a newsprint sheet at normal production caliper.

Improvements to the surface smoothness of a sheet of paper or linerboard are usually made with either an on-machine calender or a supercalender. These improvements are limited by the relationships between the surface properties and the bulk. For a given increase in smoothness, a certain decrease in bulk and therefore in caliper will occur. Furthermore, if on-machine calendering is taken too far, areas of high moisture may blacken.

Crotogino (*1*) and others have shown that the relationship between surface smoothness and bulk may be altered by selectively altering the rheological properties of the sheet. This was done by Crotogino and by Kerekes and Pye (*2*) by setting up a temperature gradient through the sheet at the calender. The surfaces of the sheet, being at a much higher temperature than the center, were more affected by the nip. Thus, a high surface smoothness could be obtained, while the center of the sheet remained resistant to compaction.

A similar technique was demonstrated by Lyne (*3*), whereby a moisture gradient, rather than a temperature gradient, was set up through the sheet. Water was sprayed onto the surface of a sheet immediately prior to a heated calender nip. The moist surface was therefore more affected by the calender nip than the dry and resilient center of the sheet.

In this study, press nips were applied to the sheet in the dryer section. Unlike calender rolls, the pressure rolls used were rubber covered, providing relatively soft nips. Different sheet moisture levels were tried, and in some cases, a moisture gradient was set up through the sheet prior to the nip.

This process is not intended to replace the conventional calender but rather to act as a prelude to it. The objective is to allow a final sheet smoothness (after calendering) higher than could otherwise be obtained without either mottling, blackening, or excessive densification.

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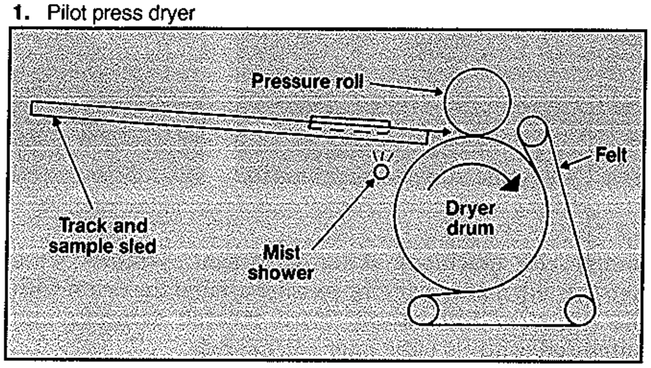
1. Pilot press dryer



Trials

Trials were conducted on several pilot machines and on some small-scale test units mounted on commercial machines. Most of the later trials were conducted on the pilot machine shown in **Fig. 1**.

The unit consists of a 0.5-m diameter, steam-heated dryer drum, with a rubber-covered nip roll in the 12 o'clock position. A felt run wraps 90° of the drum immediately after the nip. Sheet samples are placed in an open nylon "sled" and are propelled down a track. At the end of the track, the sled hits a stop as the protruding leading edge of the sample reaches the nip. In this way, the sample simulates a portion of a moving paper web. Atomizing water sprays are located under the track, immediately prior to the nip.

Drum speed may be varied continuously up to 300 m/min. Maximum steam pressure is 340 kPa, and maximum nip pressure is 100 kN/m. Different pressure roll covers were tried, and the cover selected had a hardness of 15–20 P&J.

Basic parameters varied were in-going sheet moisture, nip pressure, and the number of passes through the nip (representing the number of nips in a full size machine). Trials were run both with and without the moisture spray. Both the quantity of water sprayed and the dwell time of the spray before the nip were varied.

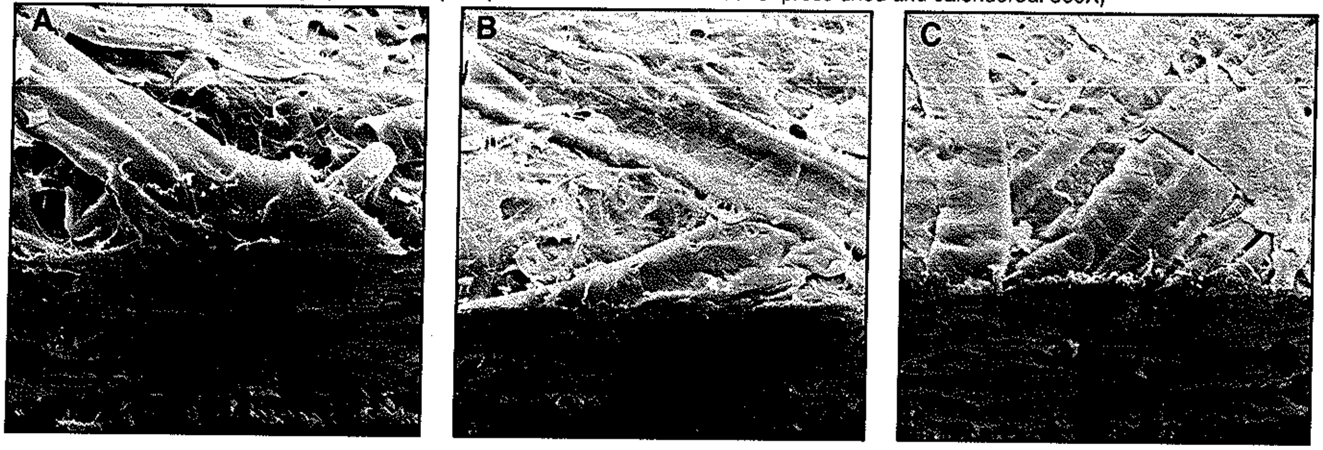
Samples were obtained from the dryer sections of

I. Newsprint results

Treatment	Caliper, mm	Sheffield smoothness units	Parker Print-Surf,* µm	75° Hunter Gloss, %	TAPPI opacity, %	Wax pick
Untreated	0.154	415	8.50	4.4	88.2	12
Calendered	0.075	77	4.25	11.0	88.2	13
Press-dried and calendered	0.072	64	3.21	16.9	87.9	13

*At a clamping pressure of 10 kg/cm².

2. Electron microscope photographs of newsprint (A: untreated. B: calendered. C: press dried and calendered. 500X)



commercial machines. After treatment, samples were finish dried, if necessary, by passing around the drum with the pressure roll raised. Both treated samples and untreated controls were later calendered.

The calender used is a supercalender located at the State University of New York College of Environmental Science and Forestry, in Syracuse, N.Y. This unit was run as a two-roll stack, at normal calendering pressures and ambient temperature, with the solid roll against the side of the sheet being studied. Control tests showed that it gave results comparable to commercially calendered sheets.

Results

For samples tested without the spray, a moisture content of 34–45% was found ideal for developing smoothness. Higher moisture content led to picking problems and excessive densification. Lower moisture content did not allow full development of smoothness. Optimum nip pressures for all tests were in the range of 17-35% kN/m. Steam pressure was kept at maximum, to give a drum surface temperature of around 130°C.

Paper grades such as newsprint or fine papers showed excellent smoothness after the combination of press drying and calendering. **Table I** shows results for a normal Canadian newsprint sheet. Calender nip pressure was the same for both press-dried sheets and the controls. With a caliper loss of only 0.003 mm, Parker Print-Surf improved with press drying from 4.25 µm to 3.21µm. Hunter Gloss improved from 11.0% to 16.9%, while opacity remained virtually unchanged.

Electron micrograph pictures were taken of typical sheets from this particular trial. The differences in the sheet surface can be seen in **Fig. 2**.

When setting up a moisture gradient through the sheet with a spray, the optimum in-going sheet moisture content is 20% or less, to avoid densification in the nip. The quantity of water then applied should bring the surface of the sheet only to 35–45% moisture.

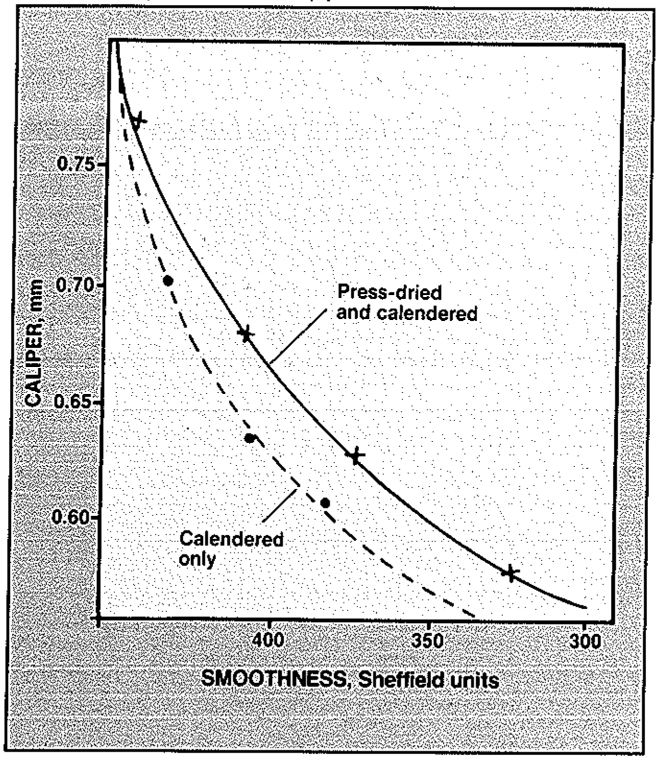
Setting up a moisture gradient in a relatively dry sheet works particularly well for linerboard grades, where it may be important to preserve bulk. If desired, one side only may be treated. This practice reduces densification still further and may be applicable to, for example, food linerboard grades with a white top liner. Such grades may require high top-side smoothness for coating or printing but may not need improved bottom-side smoothness. Typical results are shown in **Figs. 3** and **4**, for 0.6-mm boxboard and 440-g/m² milk carton board, respectively.

In all cases for calendering, the relationship between caliper and smoothness followed a fixed curve. With this form of press drying prior to calendering, the curve changed as shown. It would thus be possible either to produce a smoother sheet at the same caliper or, by reducing the degree of calendering, to produce a sheet of higher caliper at the same smoothness. Reducing the degree of calendering could produce benefits in strength characteristics, while increased caliper would impart greater sheet stiffness.

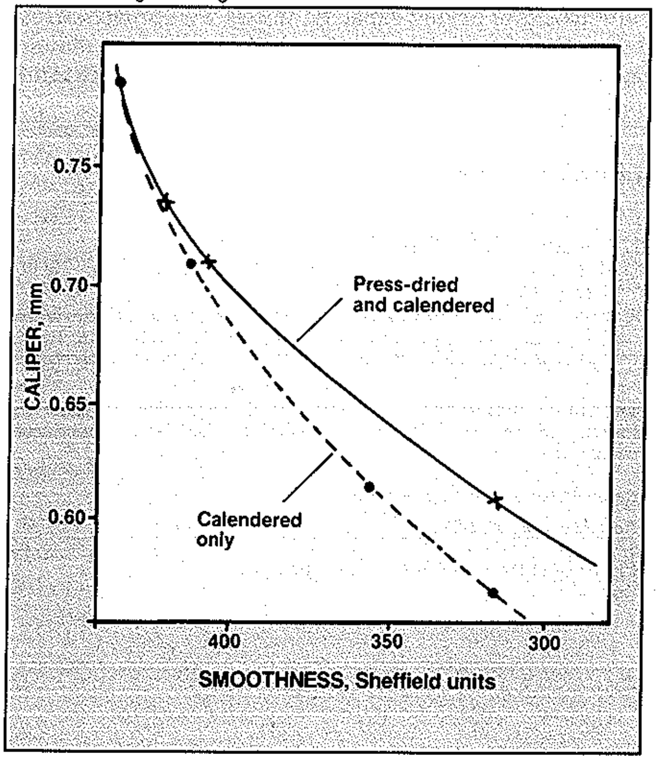
Commercialization

These concepts are not radical, but they follow from related ideas that have been tried and proven over the years. The breaker stack, smoothing press, and gloss calender all have similarities to the Hydra-Nip, but none of these employ the same combination of heated surface, soft nip, and sheet moisture content. When used with the surface re-wet

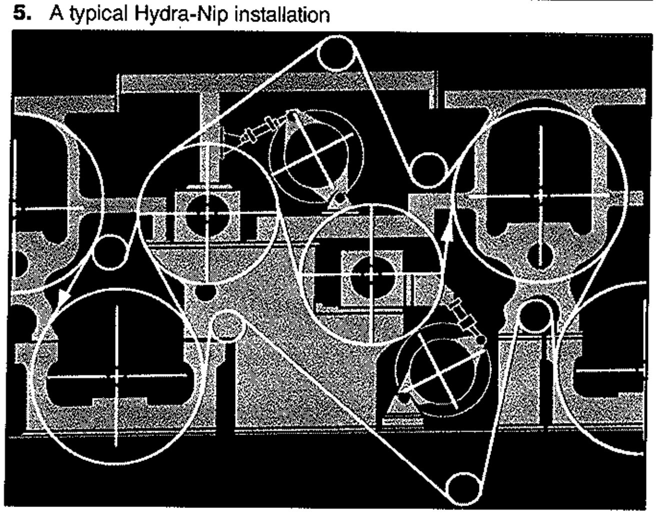
3. Smoothing of 0.6-mm multi-ply boxboard



4. Smoothing of 440-g/m² milk carton board



5. A typical Hydra-Nip installation



spray, the moisture gradient set up through the sheet prior to the nip makes the patented Hydra-Nip truly unique.

The technology required to build such machinery commercially is already well understood, and it presents no problems. In fact, two installations have already been built and have been running successfully for more than a year. One operates on lightweight paper. Moisture entering the nip is around 35%. After startup, Sheffield Smoothness improved by more than 20%.

The other operates on multi-ply boxboard. A carefully controlled quantity of water is sprayed onto the top liner, when the sheet is 90% dry. Early indications suggest that this unit should improve Parker Print-Surf by at least 12%, with no loss of caliper.

The design is such that it may easily be installed in an existing dryer section. One unit is required for each side of the sheet to be smoothed. Replacing an existing dryer, each unit consists of a special heavy-wall dryer with a rubber-covered pressure roll. Depending on whether or not a moisture spray is to be used, the pressure roll may be located either at the beginning or the end of the web wrap around the dryer. A typical installation is shown in **Fig. 5.**

Pressure roll loading may be either hydraulic or pneumatic. Modified framing, doctors, and press roll water cooling are provided. If necessary, the new dryers may be made smaller in diameter than the existing dryers, to make room for the pressure roll. There will be no loss in overall drying capacity because the better contact between the sheet and the drum more than offsets the loss in drum surface area.

The simple nature of the machinery and the ease with which it may be fitted into an existing dryer section minimizes both the cost of the equipment and the downtime needed for installation.

Summary

The simple equipment described has been shown to have benefits for all grades of paper boxboard or board that require a smooth surface on one or both sides of the sheet, without the need for supercalendering and without losing too much caliper. Suitable to a wide range of paper and linerboard grades, the process improves surface smoothness and increases gloss.

The process gives minimum bulk loss, and bulk gain is possible on board grades. It does not reduce opacity or produce mottling or blackening on paper grades. Strength may be improved as a result of less calendering.

The process is easily installed in existing dryer sections, with no loss of drying capacity. It uses well-proven design technology for high reliability and trouble-free maintenance. The capital cost is low, and the minimum downtime required for installation is short.

Literature cited

1. Crotogino, R. H., Tappi J. 65(10): 97(1982).
2. Kerekes, R. J. and Pye, I. T., Pulp Paper Can. 75(11): T379(1974).
3. Lyne, M. B., Transactions of symposium on fiber-water interaction in papermaking, The British Paper and Board Industry Federation, Technical Division, Oxford, Sept. 1977.

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CORRECTION

Guidelines for reporting of SQC data by pigment suppliers to the paper and paperboard industries

On page 194 of the July issue of *Tappi Journal*, the correct Technical Information Sheet should be noted as TIS 106-04.

For pricing information, contact TAPPI PRESS (ext. 224) at TAPPI headquarters.

Tappi Journal regrets any inconvenience due to this error.