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# COMPRESSION AND EXPANSION OF CTMP-CONTAINING SHEETS IN A WET PRESS NIP

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**ABSTRACT**

The expansion in the Z-direction of individual layers in a wet sheet after leaving the nip of a double-felted press nip has been studied. In this investigation, pads of up to five wet sheets of CTMP, bleached kraft or mixtures of the two pulps, were used to simulate multilayer high-grammage sheets such as carton board. Using different lay-ups it was thus possible to study the expansion of both homogeneous and heterogeneous sheets.

The expansion of 350 $g/m^2$ sheets is illustrated by the air fraction in the wet sheet immediately after the nip. The results show that a sheet of CTMP can expand up to ten times as much as a sheet of bleached kraft. It is also shown that CTMP has the ability to expand even when sandwiched between bleached kraft as middle layer in a stratified sheet.

**INTRODUCTION**

During the last 30 years, research on wet pressing has received considerable attention. One of the first successful attempts to find theories suitable to describe the wet pressing operation was made by Wahlström (1), from which much of our present understanding of the subject derives. An overview of recent research in the field has been presented by Carlsson (2).

The main aim of recent research has been to find out what really happens to the paper web inside the press nip in terms of compression and water removal. Some investigators have tried to evaluate the thickness of the web inside the press nip by measuring the separation between the press rolls (3), in order to understand the compression within the nip and the expansion after the nip. The limitation of this method though is that only the minimum and not the average thickness in the nip is evaluated, due to the uneven surface of the press felt used (4).

A different approach was introduced by Wicks (5), who combined five sheets to form a single pad of 300 g/m² that was run through a two-roll press. Density and solids content gradients in the Z-direction were measured and the conclusion was drawn that sheet two-sidedness developed with pressing.

Different types of pulps have been studied with regard to compression, densification, rewetting etc. in the pressing operation (6-8), but little has been written about CTMP and pressing.

Interest in CTMP has increased considerably during recent years, especially as it has shown to have great potential as middle layer raw material in board and in fine paper (9,10). The porous web structure caused by the long stiff CTMP-fibres can contribute to an increase in bending stiffness.

This paper surveys the behaviour of different types of CTMP in and immediately after a double-felted two-roll press nip. The expansion phase has been studied in both homogeneous and heterogeneous constructions.

**EXPERIMENTAL**

In order to investigate the expansion of different types of CTMP, five 70 g/m² sheets of an initial dryness of about 30 % were combined to form a single 350 g/m² pad. This pad was run through a double-felted two-roll press nip at an average pressure of 1.6 MPa and a speed of 26 m/min at room temperature. As shown in Figure 1, a dry blotter was placed on each side of the pad. The blotters were used to minimize rewetting, as blotters have a greater tendency to absorb water than ordinary press felts even though the flow resistance is similar (5). Directly at the nip exit the blotters were removed and the pad was immediately separated into five individual sheets. The dryness and thickness of each of the five sheets were then determined. All thickness measurements were made using the STFI micrometer with spherical platens (11).

Both homogeneous and heterogeneous constructions were run through the press. The homogeneous constructions consisted of five sheets of either CTMP, bleached kraft or a mixture thereof (the pulps used in this investigation are listed in Table 1). The heterogeneous constructions consisted of five sheets with one or two of the outer sheets on each side made up of bleached kraft and the middle layers made up of different types of CTMP.

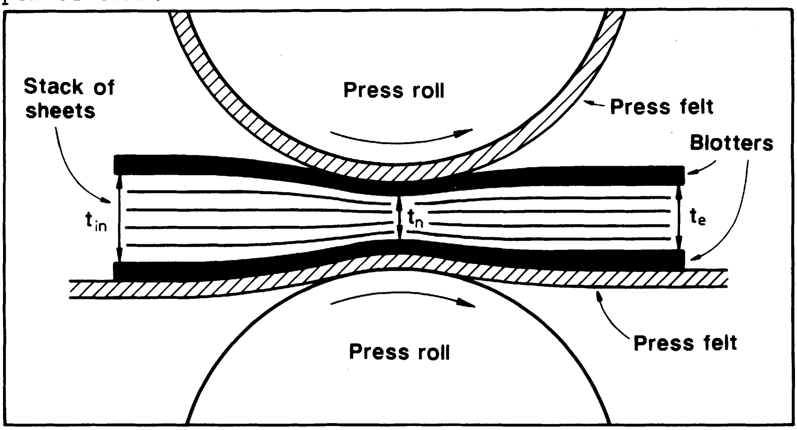


Figure 1 A 350 g/m² pad formed from five separate 70 g/m² sheets pressed in a two-roll press between blotters ($t_{in}>t_e>t_n$).

| Pulp | Wood type | CSF [ml] | WRV [%] |
|---|---|---|---|
| CTMP | spruce | 360 | – |
| CTMP | spruce | 535 | – |
| CTMP | pine | 640 | – |
| CTMP | aspen | 305 | – |
| Bl kraft | 50 % pine, 50 % birch | 505 (25 SR) | 140 |

*Table 1 Pulps used in the investigation. All pulps were dried.*

To be able to calculate the amount of fibre, water and air in a sheet after the press nip, it was first assumed that no air is present at midnip, i.e. that the sheet was completely saturated with water. Secondly it was assumed that no rewetting (internal, external or separation) occurred and consequently that the solids content was the same inside and outside the nip. The thickness at midnip was then calculated from the equation:

$$t_n = W_f \left(\frac{1}{\rho_f} + MR \cdot \frac{1}{\rho_{H_2O}}\right) \quad (1)$$

where $t_n$ is the thickness at mid press nip, $W_f$ is the dry grammage, $\rho_f$ is the fibre density, $\rho_{H2O}$ is the density of water, and MR is the moisture ratio of the pressed sheet.

The volume fractions of fibres, water and air at the nip exit were then calculated using the equations:

$$\text{Fibre fraction} = \rho_e/\rho_f \quad (2)$$

$$\text{Water fraction} = MR \cdot \rho_e/\rho_{H_2O} \quad (3)$$

$$\text{Air fraction} = (\rho_n - \rho_e)/\rho_n \quad (4)$$

where $\rho_n$ is the density of the paper web (excluding water) in the nip, i.e. $W_f/t_n$, and $\rho_e$ is the density of the sheet (again excluding water) at the nip exit, $W_f/t_e$, where $t_e$ is the sheet thickness at nip exit. The density of water was assumed to be 1000 kg/m³, and the fibre density 1550 kg/m³ for bleached kraft and 1460 kg/m³ for the CTMP fibres.

It was thus possible to estimate the expansion of a sheet coming out of the press, the expansion being represented by the air fraction.

## RESULTS AND DISCUSSION

Data obtained in this study are shown in Figure 2. The fibre, water and air fractions in the 350 g/m² pad are represented in five "positions", where each position represents an individual 70 g/m² sheet. Illustrated to the left are four different types of CTMP and to the right four batches of a bleached kraft pulp (50 % pine and 50 % birch). Note that the air fraction ranges from 40 to 55 % for the different types of CTMP whereas it is only about 5 % for the bleached kraft. In a commercial paper machine this difference might be less since

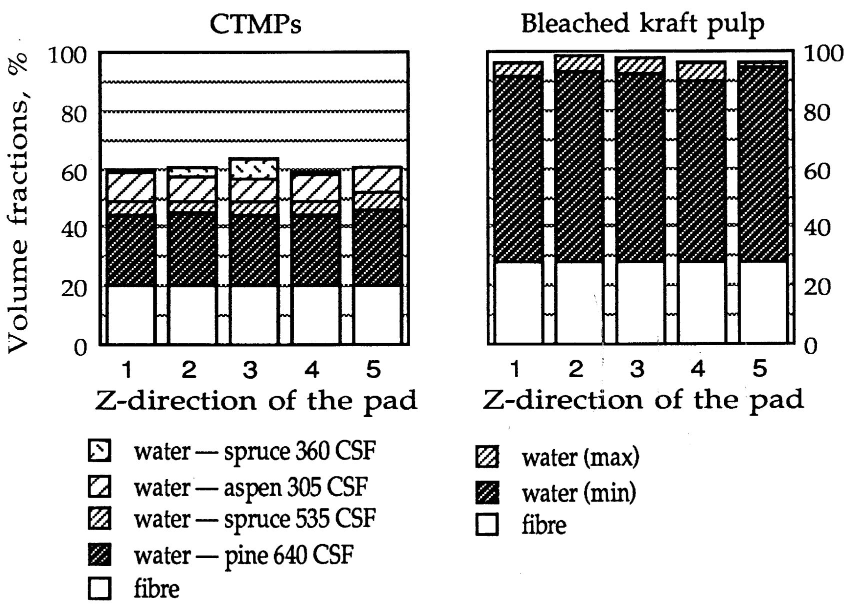


Figure 2 The distribution of fibre and water fractions in the Z-direction of 350 g/m² pads. To the left four different types of CTMP are illustrated and to the right examples from four corresponding trials on one type of bleached kraft (50 % birch, 50 % pine).

the press sections are usually run at a temperature closer to the softening temperature of the lignin in CTMP (12), and this might have a negative effect on the expansion.

When an increasing amount of CTMP is mixed with bleached kraft the expansion indicated by the air fraction increases as could be expected. This increase is linear for homogeneous mixed furnishes but not for heterogeneous constructions as can be seen in Figure 3. The reason why a heterogeneous pad has an air fraction about 2-10 % lower than a homogeneous pad is probably to be found in the web structure. As shown in Fig. 2 it is basically CTMP that has the ability to expand. When CTMP is mixed with bleached kraft it "opens up" the whole web structure, whereas when it is sandwiched in the centre of a heterogeneous construction the outer layers have a more closed web structure and the pad does not expand as much.

Evidence that CTMP is responsible for the expansion in a three-layer sheet is also given in Figure 4, where it is quite clear that CTMP is capable of expanding even though it is sandwiched in the centre.

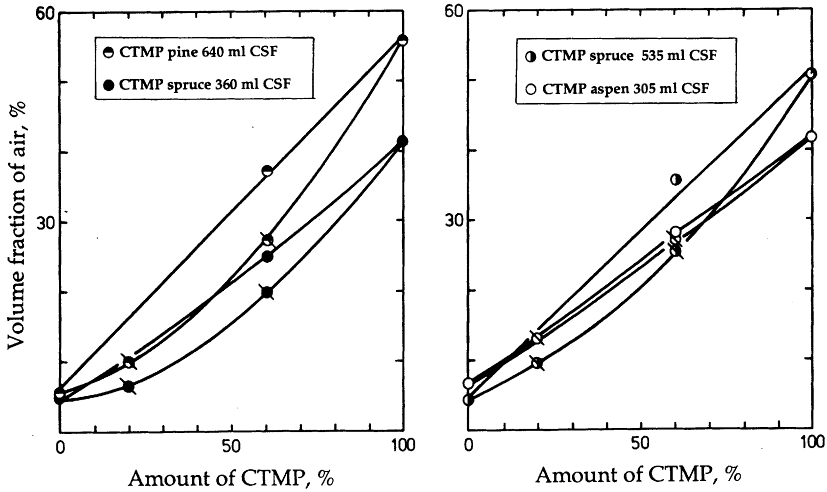


Figure 3 Air fractions of heterogeneous (ȸ) and homogeneous (o) 350 g/m² constructions with an increasing amount of CTMP.

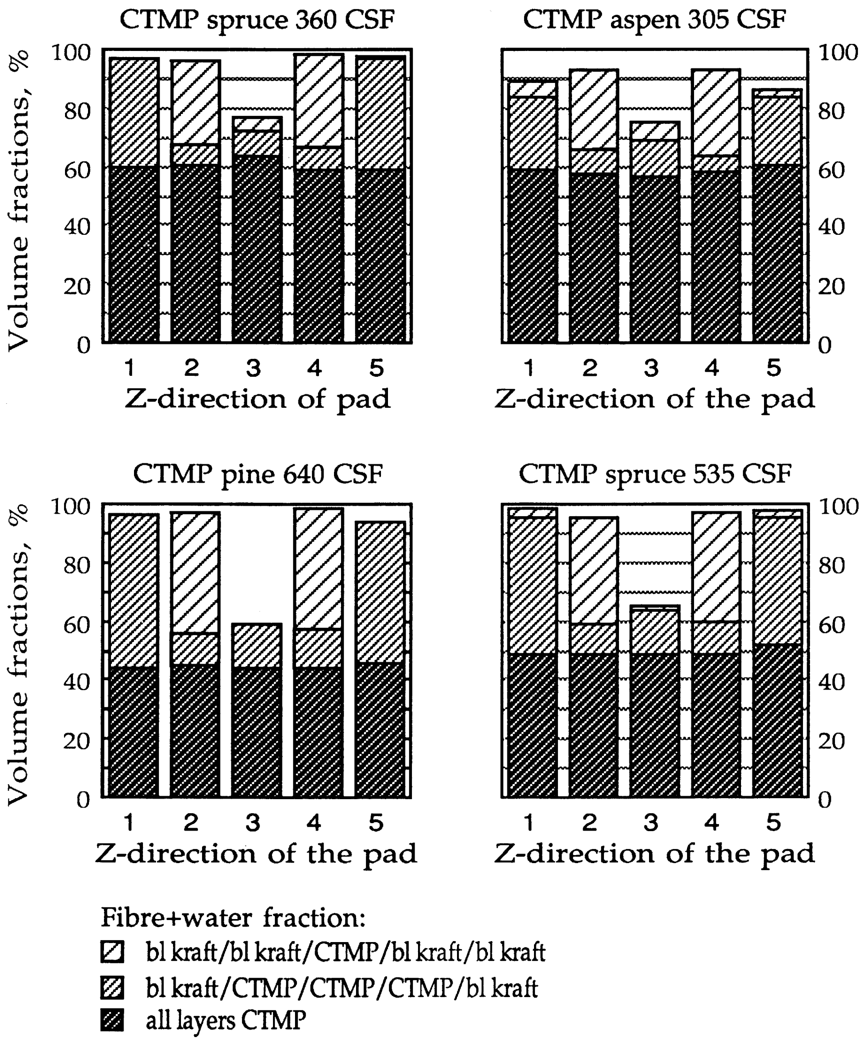


Figure 4 Fibre and water fractions in 5-layer pads. One or three middle layers of CTMP sandwiched between bleached kraft pulp. Data for five layers of CTMP are shown as a reference (cf. Fig. 2).

The expandability of CTMP of high freeness differs from that of CTMP of low freeness. The air fraction at the mid position is the same in high freeness CTMP, regardless of the number of outer layers of bleached kraft. Low freeness CTMP on the other hand shows about 4 % lower air fraction with 140 g/m² bleached kraft in the outer layers than with only 70 g/m² in the outer layers.

The air fraction is also dependent upon the solids content of the sheets, as is shown in Figure 5. When the solids content increases the amount of air in the sheet also increa-

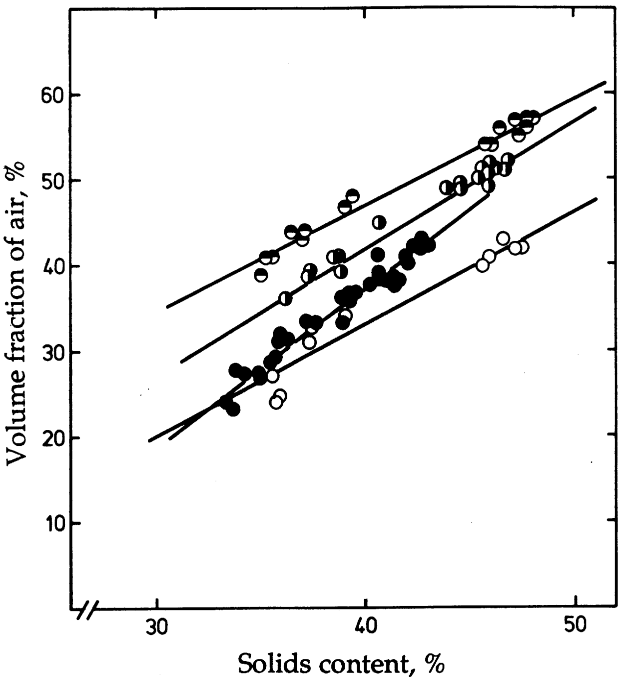


Figure 5 The correlation between solids content and air fraction in the wet CTMP sheets immediately after the press nip.

ses. Figure 6 illustrates that the solids content is considerably higher in homogeneous than heterogeneous constructions. This is also an explanation of the difference shown in Fig. 3. As the outer layers consisting of bleached kraft in the heterogeneous pad hinder the water from being pressed out, the possibility of air entering decreases. Irrespective of the type of CTMP used as middle layer, all heterogeneous pads have approximately the same solids content. The solids content of the homogeneous pads is however highly dependent upon the coarseness of the CTMP. The coarser the CTMP, the higher the solids content. It should here be remembered that this investigation has excluded separation rewetting because blotters have been used instead of press felts. In reality this rewetting can never be avoided if ordinary press felts are used.

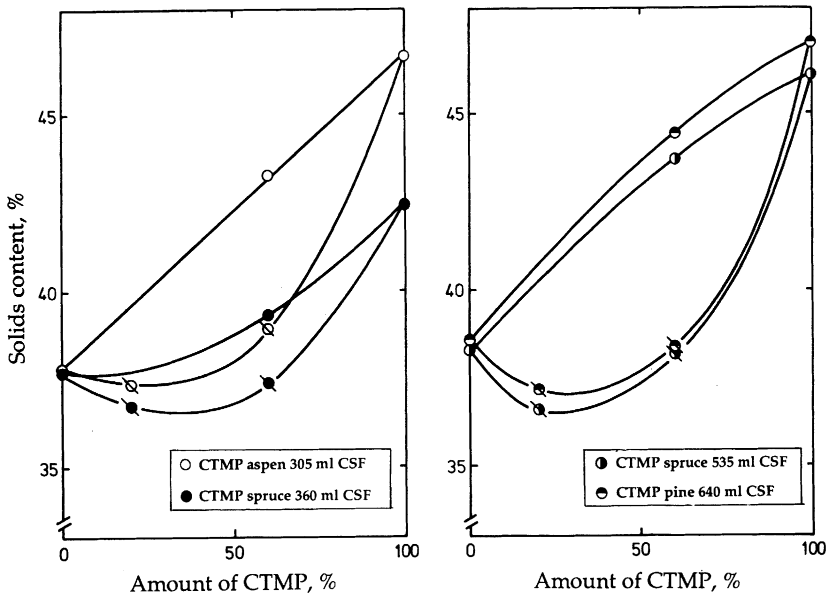


Figure 6 Solids contents of heterogeneous (ȸ) and homogeneous (o) 350 g/m² pads with an increasing amount of CTMP (where 100 % bleached kraft is depicted to the left in each figure).

Figure 7 shows an example of this. These 100 g/m² sheets (homogeneous and stratified in three layers) are taken from a separate trial on the STFI pilot machine FEX under ordinary press conditions. Compared with Fig. 6, the situation is reversed: the stratified sheet is about 1 % dryer than the homogeneous, and consequently the air fraction is higher in the stratified sheet. In an attempt to account for these differences rewetting has to be considered.

When a homogeneous mixture of CTMP and kraft fibres is compressed in a real nip, water can easily be pressed out of the web and into the press felt. At the nip exit, however, water flows back into the paper web since the web structure is quite open. In the stratified sheet, on the other hand, the water flow out of the sheet is hindered by the outer layers, but these outer layers also prevent the water from re-entering. This means that stratified sheets in a real press have a higher solids content than a homogeneous sheet. When no rewetting occurs, homogeneous sheets will have a higher solids content than stratified sheets, as is the case in this study.

Figure 6 also shows that a heterogeneous pad with 20 % CTMP has a lower solids content than a pad consisting of 100 % bleached kraft. The explanation of this "dip" in solids content can possibly be found in differences in pressure distribution between the two sheets, both in the plane and in the Z-direction.

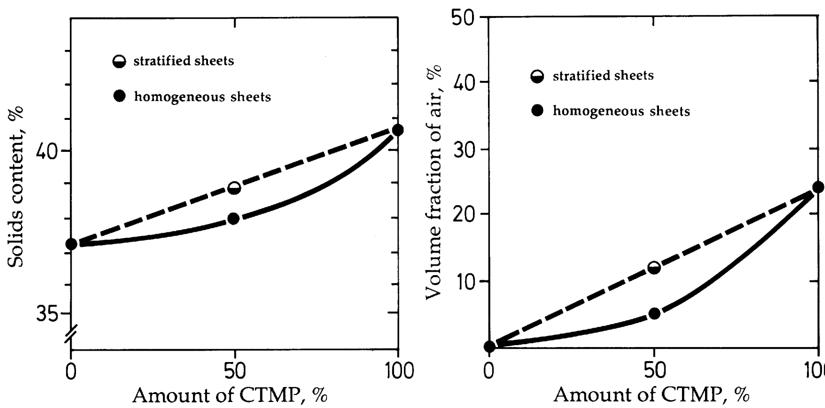


Figure 7 Solids contents and air fractions of stratified and homogeneous 100 g/m² sheets run on a pilot paper machine.

**CONCLUSIONS**

Even if CTMP is sandwiched in the middle layer of a three-layered sheet of paper, it is still able to expand after a press nip. Although the expansion is less than that in the middle layer in a sheet made of 100 % CTMP, it is surprisingly only about 10 % less.

**ACKNOWLEDGEMENTS**

The authors thank Ms. Berit Möllerberg and Mr. Lennart Hermansson for their skilful help with practical problems and tedious work associated with this study. The authors also thank Dr J.A. Bristow for the linguistic revision.

**REFERENCES**

1. Wahlström, B. (1960).
   A long term study of water removal and moisture distribution on a newsprint machine press section – Part I.
   Pulp Pap. Mag. Can. 61(8):T379-T401.

2. Carlsson, G. (1983).
   Some Fundamental Aspects of Wet Pressing of Paper.
   Ph. D. Thesis, R. Inst. Technol., Stockholm.

3. Andersson, N., Gärdh. H. (1970).
   The compression and recovery of a paper web in a felted press.
   Sven. Papperstidn. 73(13.14):425-429.

4. Norman, B. (1987).
   On the mechanisms of dewatering in the twin-wire and press sections.
   Nordic Pulp Pap. Res. J. 6(8):39-46.

5. Wicks, L. (1982).
   The influence of pressing on sheet two-sidedness.
   Tappi J. 65(9):73-77.

6. Busker, L.H. (1985).
The effects of wet pressing on paper quality.
TAPPI Eng. Conf., Atlanta, GA. September 16-19, pp. 117-129.

7. Busker, L.H. (1980).
Wet-press water removal over a wide parameter range.
Pap. Technol. Ind. 21(3):91-96.

8. MacGregor, M.A. (1983).
Practical effects of sheet stratification caused by wet pressing.
Tappi J. 66(7):65-69.

9. Mohlin, U-B. (1987).
The use of high yield pulps in different paper grades.
Paper Week '87, York, England, 1-2 April, Paper Industry Technical Association Conference Papers.

10 Westman, L. (1985).
Bleached CTMP as middle-layer in fine papers.
Proc. Int. Mech. Pulp. Conf., Stockholm, May 6-10, pp. 258-262.

11. Fellers C., Andersson, H., Hollmark, H. (1986).
The definition and measurement of thickness and density.
Paper Structure and Properties, (J.A. Bristow, P. Kolseth, eds.), Marcel Dekker, NY, pp. 151-167.

12. Htun, M. (1987).
Personal communication.

## Transcription of Discussion

# THE COMPRESSION AND EXPANSION OF CTMP-CONTAINING SHEETS IN A WET PRESS NIP

Ms P. Bergstrom
SCA-Teknik

**Dr. J.D. Lindsay, Royal Institute of Technology**

You have a slide where the centre layer has a lot of air and the outer layers are quite saturated still with water. From studies of flow through porous media, we know that when you have a saturated sheet, the permeability to air will be quite low, whereas the permeability to water will be high. What I would like to know is how the air gets into the middle of the sheet from the edge of your sample, and, if so, would you get different spring back results in which you had a wide sample through which lateral flow of air would be more difficult?

**Ms P. Bergstrom**

To answer your question I have to admit that this is a bit puzzling, but if you look carefully into the slides you will see that the outer layers made of bleached kraft are not totally saturated and will thus allow air to come through.

To avoid the possible negative effects from the edges you were referring to we used large samples and cut off the edges before further investigations.

**P. Gane, ECCI**

This is more of a comment. Our recent studies of fibre relaxation and swelling underneath the coating layer suggests that the spring back that you show to be absent in the case of CTMP, does in fact reappear when the sheet is re-wetted during coating.