"Rebuild—an opportunity to use new dryer technology"

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INTRODUCTION :

The fundamental objective of any paper machine rebuild is to improve the mills overalls economic operation.

The rebuild can range from the simple elimination of a single troublesome bottleneck right through to a complete redesign of a given production line.

Judgement must be exercised to ensure that the rebuild represents a wise investment cost for the highest practical return. It should also be remembered that any production chain is only as strong as its weakest link and that the chain extends from having sufficient incoming raw materials at one end to having sufficient market for the outgoing product at the other.

The rebuild could address many different aspects of the mills operation.

* — Production Rate Increase.
* — Quality Improvement.
* — Better Product Uniformity.
* — Reduced losses.
* — Energy savings, and so cn......

It is both natural and understandable that mills tend to look in detail at what they already have in order to improve their operation—this is a necessary and important contribution.

The more dynamic companies, however urged on by IPPTA'S paper technologists will additionally see the occasion of a rebuild as an opportunity to take advantage of developments in technology.

This paper illustrates one of Beloits most recent technological advances in the dryer part of the machine.

DRYING RESTRAINT IN A SINGLE TIER DRYER SECTION

We will be discussing about a very exciting concept for high speed dryer section runnability. What makes this concept so exciting is that we can, for the first time, provide complete support of the sheet as it is dried. As we will see, this has a positive effect, not only for sheet runnability, but also for sheet quality.

The origin of this dryer section concept can be traced back to 1968. It was then that a Beloit Research Engineer by the name of Ralph Mohoney applied for a patent on a dryer section that had no open draws. Ralph Mohoney realized 20 years ago that the dryer section of the future would not, in fact could not, tolerate any areas in which the sheet was unsupported. The concept which Ralph proposed 20 years ago eventually evolved into a dryer section which we now call a single-felt or serpentine or unofun dryer section. Fig (1).

In this single-felt dryer section, the sheet and dryer felt travel together over and under alternate dryers. This eliminates the open draws and many of the associated problems with sheet flutter, baggy edges, sheet wrinkling, and sheet breaks. But single-felt dryer section did not eliminate all of the problems of high speed dryer section runnability, it simply increased the speed limit by about one hundred mpm.

At higher speeds, a new set of problems developed. One of the most serious of these problems was the

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SINGLE-FELT DRYER SECTION
Has No Open Draws

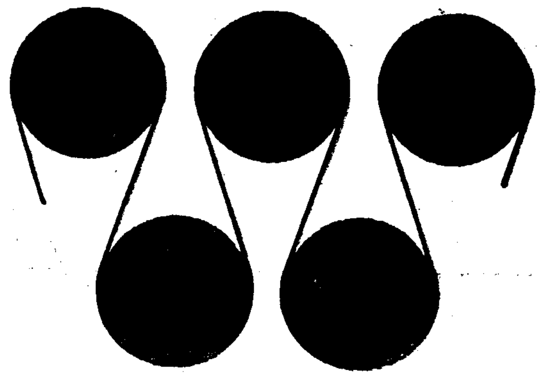


FIG 1

tendency for the sheet to separate from the felt in the down-run and wrinkle in the felt nip in the following up-run.

This particular problem was eventually solved by installing blow boxes Fig. (2). These boxes created a slight vacuum in an effort to hold the sheet to the dryer felt to minimize the tendency to wrinkle.

BLOW BOXES
Minimize Separation

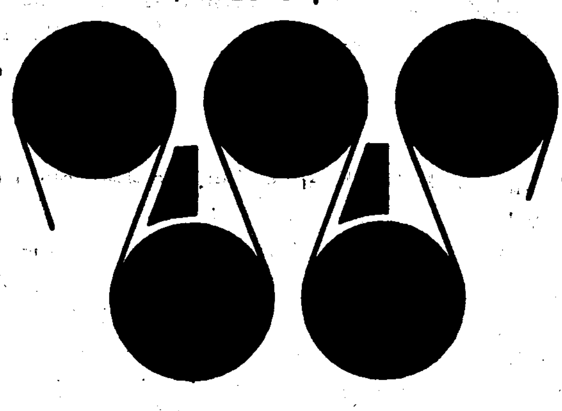


FIG 2

The combination of the blow box and Ralph Mahoney's single-felt dryer section added 100 to 200 mpm to the operating speeds of many paper machines. The blow box single-felt dryer section was the best commercial no-draw dryer section available. But it still had four basic problems: Fig. (3).

SINGLE-FELT PROBLEMS

- **Ineffective Bottom Dryers**
- **Difficult Tail Threading**
- **Sheet Tension Required**
- **Dryer Gears Stressed**

FIG 3

The first problems was drying capacity. The sheet was now on the outside of the felt as together they wrapped the bottom dryers, and so the bottom dryers were generally ineffective in drying the sheet.

The second problem was sheet threading. Ropes were, of course, required to guide the tail through the dryer section, but the single felt could not overlap the ropes and the tail would often fly out of the ropes, reducing the threading efficiency.

The third problem was sheet tension. Although the blow boxes were holding the sheet on the felt in the down runs, centrifugal force would tend to lift the sheet off of the felt as together they wrapped the bottom dryers. Sheet tension was needed to hold the sheet up and to keep it from separating from the felt.

The fourth problem with the blow box single-felt dryer section was mechanical. The bottom dryers were no longer cooled by contact with the sheet, so they were hotter, larger in diameter, and rotating at higher surface speeds. We then had a situation which the dryer gears were forcing the top and bottom dryers to turn at equal rotational speeds, regardless of their diameters, and the felt was trying to force the dryers to rotate with equal surface speeds. This placed an excessive load on the dryers gears, and caused many gear failures.

But this is all history. What we would like to discuss about is the latest technology in dryer section design. It is a special no-draw dryer section which we call the Bel-champ.

In the Bel-champ dryer section, the bottom ineffective dryers are eliminated and replaced by special vacuum rolls Fig. (4). These vacuum rolls apply vacuum directly to the sheet as it passes around the roll. They also apply vacuum in the ingoing fabric nips, just like the blow box, as well as in the outgoing nips-the side the blow box ignores Fig. (5). In this way, the sheet is supported throughout its entire run through the no-draw dryer section. The sheet tension normally needed to held the sheet against the felt is replaced by this direct application of vacuum. There are no open draws, no ineffective dryers, and no need for sheet tension.

BEL-CHAMP DRYER SECTION

Vacuum Rolls Replace Bottom Dryers

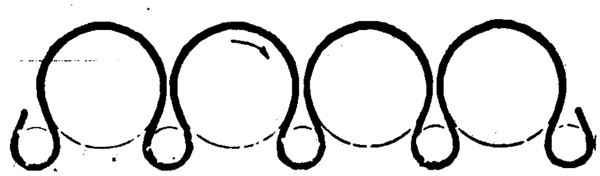


FIG 4

BEL-CHAMP VACUUM ROLL

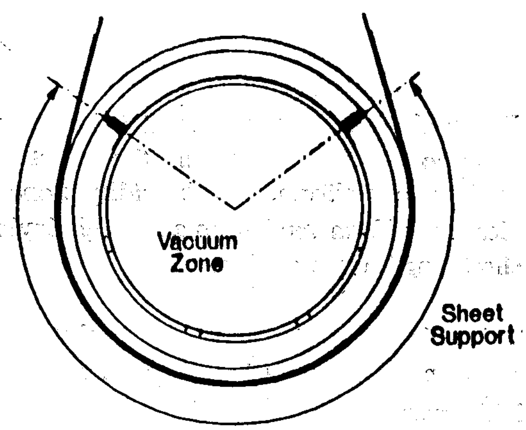


FIG 5

The first new paper machine to use this technology was started up in 1985. This was the newsprint machine at Maclaren in the Quebec, Canada Fig. (6). This machine was designed for 1200 mpm. The first dryer section at Maclaren has 6 Bel-Champ dryers, all under a common felt. These 6 dryers are equivalent to a 12-dryer serpentine section which has the same number of effective dryers.

MACLAREN, MASSON, PM 3

First New Machine Bel-Champ

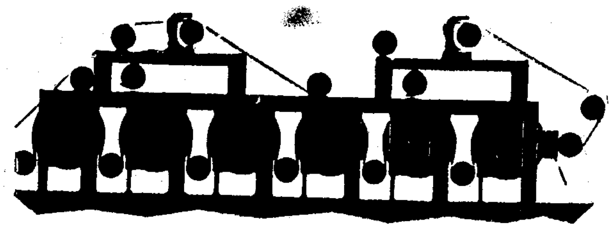


FIG 6

SCA, ORTVIKEN, PM 5

Second New Machine Bel-Champ

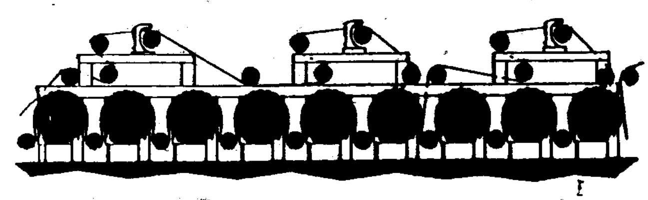


FIG 7

BEL-CHAMP GEOMETRY

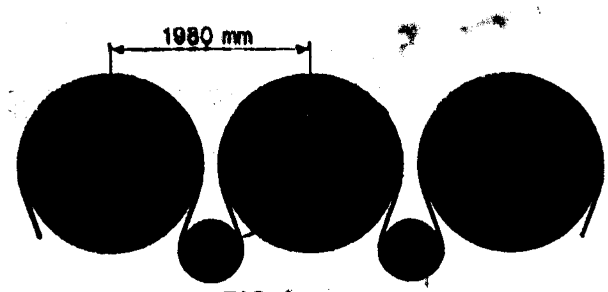


FIG 8

The second new machine to use this technology was Svenska Cellulose in Sweden Fig. (7). This machine was designed for 1370 mpm and has 9 dryers in the Bel-Champ section.

There are now 40 machines around the world which have Bel-Champ dryers and they look quite different from these first two machines. I would like to show you some of the most recent designs. As with all developments, there have been some evolutionary changes. One of the most obvious changes has been the geometry. Fig (8).

The dryers have been moved closer together, this has reduced the machine length, increased the felt wrap on the dryers, and shortened the lengths of the felt-supported draws. A natural result of this dryer geometry is the elimination of closed dryer pockets Fig (9). This has exposed the sheet in the evaporating zone to dry air. In normal two-felt dryer section Fig. (10), the moisture tends to accmulate in the closed pockets, reducing both the drying rate and the profile uniformity.

Even in the open pocket of the single-felted dryer sections, there is a tendency for the water vapour to collect in the stagnant pockets between dryers Fig (11).

BEL-CHAMP DRYER SECTION
• Eliminates Closed Pockets
• Avoids Stagnant Areas

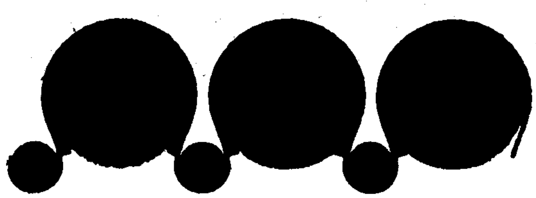


FIG 9

TWO FELT DRYER SECTIONS
• Have Enclosed Pockets

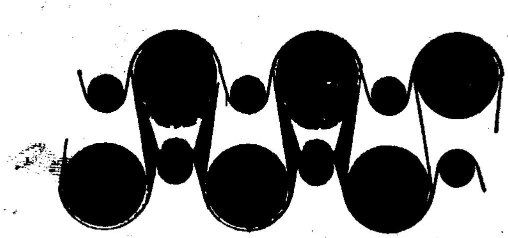


FIG 10

SINGLE FELT DRYER SECTION
Has Stagnant Areas

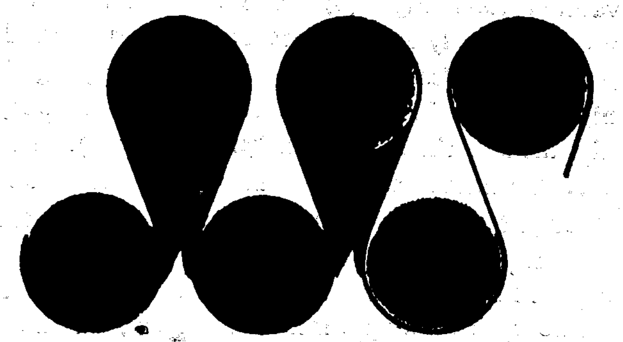


FIG 11

AIR HUMIDITY
Lowest in the Bel-Champ

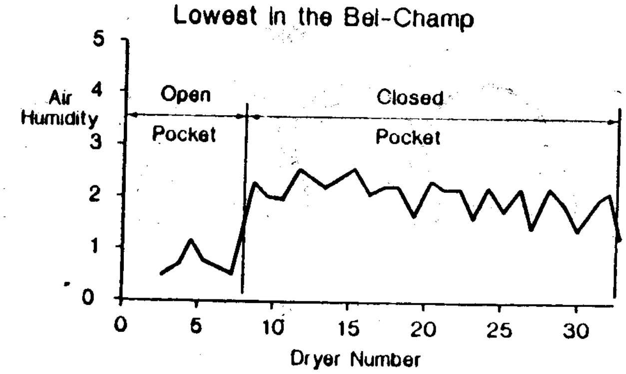


FIG 12

But with the low profile Bel-champ geometry, there are no stagnant areas and the sheet moisture flashes into a uniform, low-humidity zone. This provides for uniform ventilation and high drying rates in a short length dryer section.

This slide Fig. (12) shows the pocket humidities measured on a commercial newsprint machine. The humidities measured below the Bel-Champ dryers were less than 0.8 kg H_2O/Kg dry air absolute. The humidities measured in the adjacent enclosed pockets were approximately 0.22 Kg H_2O/Kg dry air very common for well-ventilated enclosed pockets. This difference in humidity represents an 8% increase in drying capacity of the Bel-Champ section.

In addition to the Bel-Champ geometry, the Bel-Champ framing Fig. (13) has given improved access, better visibility, and a very stable support for both the dryers and the vacuum rolls. This latest frame design has a critical speed of 10,000 mpm. Even with a conservative rating of 40% of the critical value, these frames are good for over 4000 mpm.

The back side of the Bel-champ dryer section is virtually identical to the front side. There are no longer any large interconnecting dryer gears or their cast iron gear cases. These have all been replaced with special independent, frame-mounted gearboxes Fig. 14. Two of the dryers in each section are driven through these gear boxes and the rest of the dryers are driven by the felt.

BEL-CHAMP FRAMING
Has Improved Stability and Access

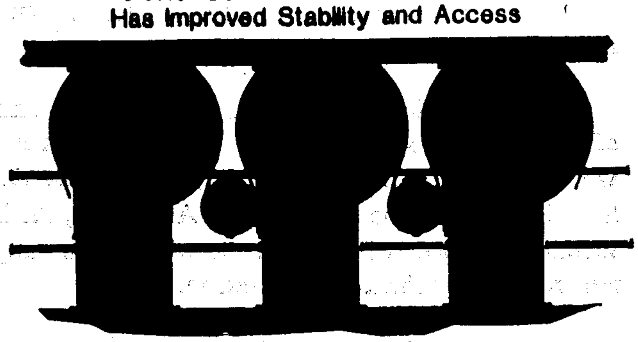


FIG 13

BEL-CHAMP DRIVE
Eliminates Gearing

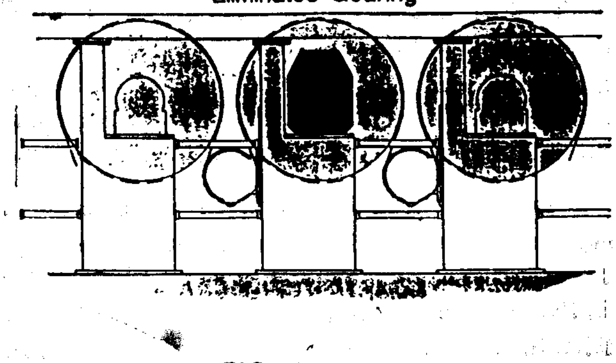


FIG 14

Instead of gears forcing each of the dryers to rotate at equal RPM, this dryer drive concept allows each dryer to rotate at equal surface speeds, which is precisely what is needed for best runnability.

Over 50 machines are today operating with felt-driven sections. They are enjoying a reduction in noise, the elimination of gear failures, and the improvement in dryer section runnability.

The next step in the Bel-Champ development was more revolutionary than evolutionary. The Bel-Champ concept was extended to cover the entire length of the machine. This is what we now call the "total" Bel-Champ Dryer Section Fig. (15).

TOTAL BEL-CHAMP DRYER SECTION

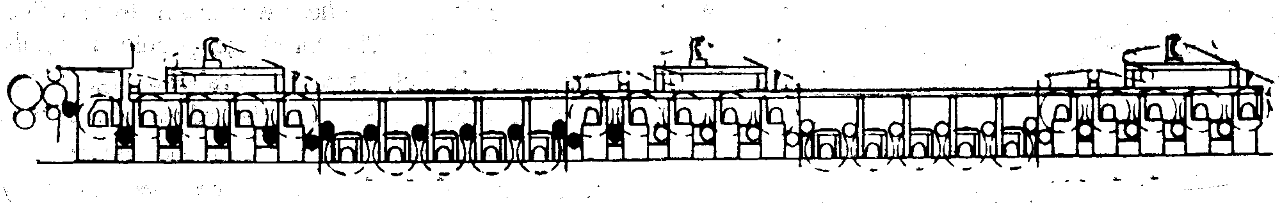


FIG 15

In the total Bel-Champ, two-sided drying is achieved by alternating between top-felted Bel-Cham sections and bottom-felted Bel-champ sections. With this geometry, the sheet is entirely supported during process: At no point does the sheet have pass through an open draw until it reaches the end of the dryer section.

Even the transfers between dryer sections are closed by the use of a unique transfer arrangement Fig (16). The sheet is positively held by the vacuum in the first vacuum roll, then between the two dryer felts, then by the vacuum in the second vacuum roll.

CLOSED DRAW TRANSFER

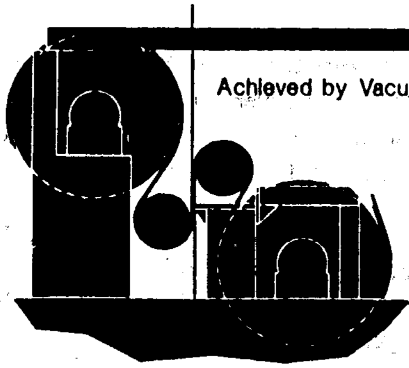


FIG 16

The total Bel-Champ dryer section also allows the extension of a concept which was first pioneered by Maclaren in their Bel-Champ dryer section : threading the tail through a no-draw section without the use of threading ropes Fig. (17). The vacuum rolls play a very important part in this threading operation.

BEL-CHAMP VACUUM ROLLS
Eliminate Ropes

FIG 17

Each vacuum roll has an internal damper roll which is closed during threading Fig. (18). This concentrates the vacuum in front side threading chambers

BEL-CHAMP VACUUM ROLL
Has a vacuum threading chamber

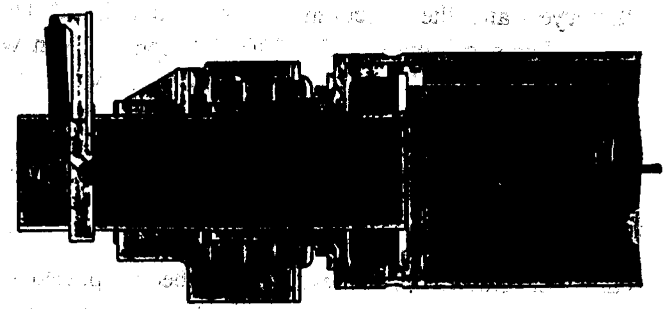


FIG 18

to grab the tail and transfer it to the next dryer. These high-vacuum chambers look the tail in place and prevent it from wandering as it is passed down the machine.

Except for the Bel-Champ dryer sections, we know of no other single-felt, no-draw dryer sections in the world that are routinely, efficiently, and commercially threaded without the use of ropes. And again, the high vacuum chambers of the vacuum rolls play an important role in this threading operation.

But these same vacuum rolls also play a second equally important role in the total Bel-cham. In order to fully undrstand this role, we need to take a fundamental look at the drying process. Specifically, we have to look at how and where the sheet shrinks as it is dried. This can be done by marking the sheet with ink at the headbox and measuring the amount of shrinkage which occurs as the sheet is dried, measuring how much the ink marks move together before they reach the reel.

The data shown here was taken from a fine paper machine. The CD shrinkage profile is highly non-uniform, in fact, is nearly parabolic Fig. (19). The highest shrinkage occurs at the edges where there is no cross-direction restraint, and the lowest shrinkage occurs near the centre where the sheet is partly restrained by the outer portions.

This non-uniform shrinkage also results in non-uniform properties in the finished sheet. This graph shows the corresponding cross-machine elongation profile Fig. (20). The highest stretch occurs at the

SHRINKAGE PROFILE

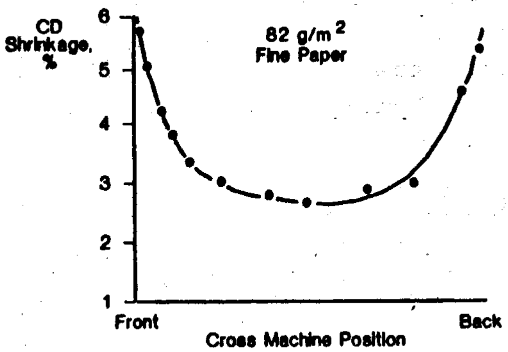


FIG 19

STRETCH PROFILE

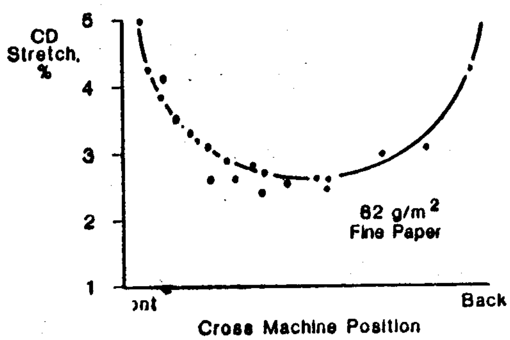


FIG 20

edges, where the shrinkage is the greatest, and the lowest is found near the centre, where the shrinkage is the least.

The non-uniform sheet shrinkage also affects other sheet strength properties. For example, the MD/CD tensile ratio is highest on the edges Fig. (21).

Similarly, the tensile energy absorption (TEA) profile Fig. (22) reflects the same general shape, while the elastic modulus profile Fig. (23) shows the expected inverse.

A recent analytical study has predicted that the sheet curl will also be affected by these non-uniformities. And so the sheet curl was measured at several cross direction locations on this same fine paper machine. The curl profile Fig. (24) was found to follow the same shape as the CD stretch profile, an inverse of the elastic modulus profile, just as predicted.

TENSILE RATIO

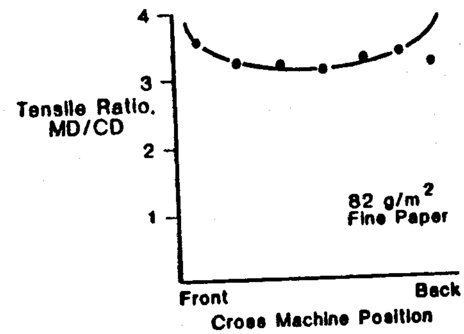


FIG 21

TENSILE ENERGY ABSORPTION

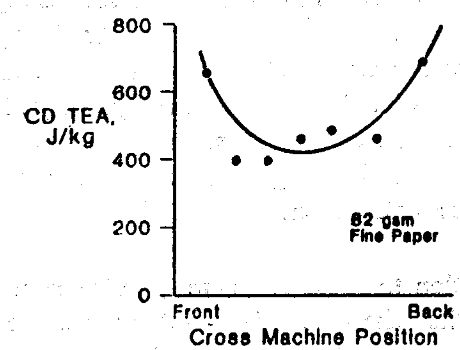


FIG 22

ELASTIC MODULUS

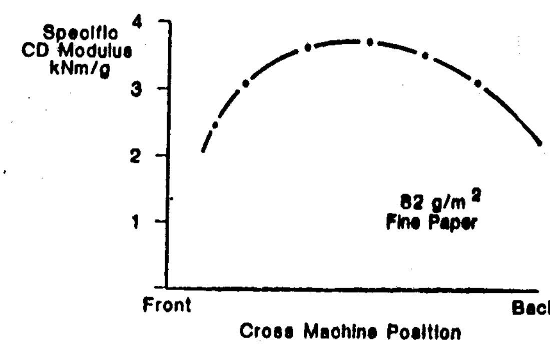


FIG 23

CURL PROFILE

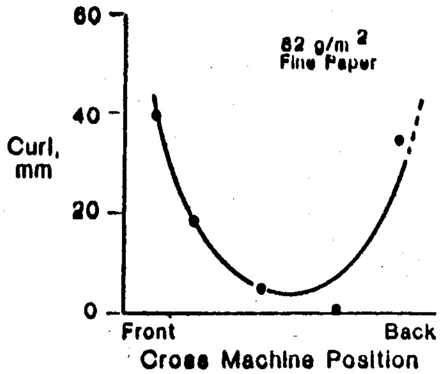
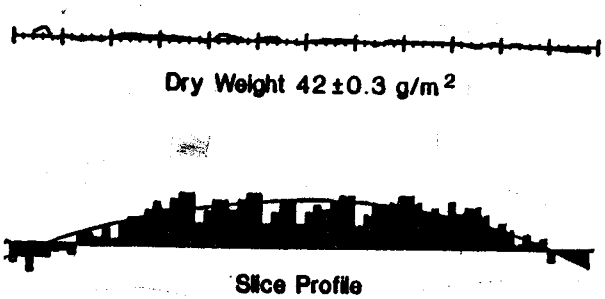


FIG 24

The increased edge shrinkage also affects the headbox performance. In order to produce a level basis weight profile at the reel, the slice opening must be closed down at the edges to compensate for the higher edge shrinkage Fig. (25). That is, the sheet goes through the presses with light edges which get heavier as the edges shrink. Not only do the light edges have an adverse affect on wet end sheet runnability, but the non-uniform slice opening can cause a non-uniformity in fibre orientation.

The solution to all of this is to provide complete restraint of the sheet as it is dried so that the CD shrinkage is controlled. This requires not only to eliminate the open draws where the shrinkage is occurring, but also to replace the open draws with positive, continuous sheet restraint. This is the second role of the total Bel-Champ dryer section.

HEADBOX SLICE PROFILE
Also Affected by Non-Uniform Shrinkage



The normal dryer felt tension provides a restraint pressure on the sheet of about 1.5 KPa, but this restraint is released between dryers Fig. (26). With the Bel-Champ, however, drying restraint is also applied between the dryers by the vacuum in the vacuum rolls Fig. (27).

CONVENTIONAL DRYING

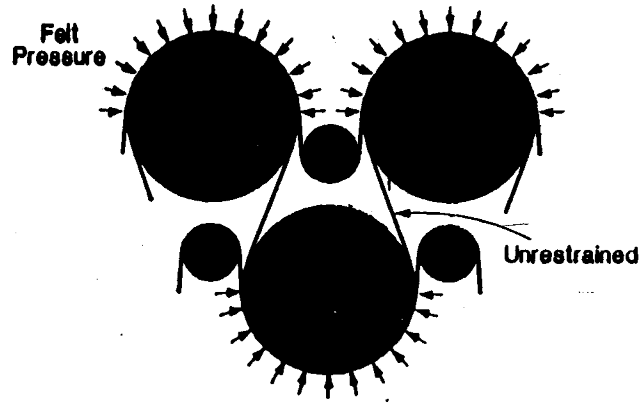


FIG 26

BEL-CHAMP DRYER SECTION
Applies Continuous Restraint

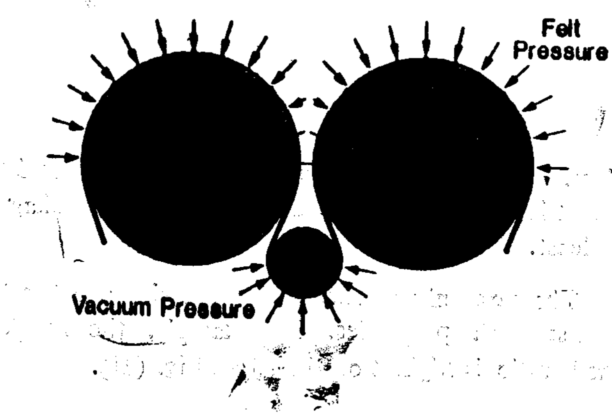


FIG 27

This graph Fig. (28) shows the effectiveness of the vacuum restraint on controlling the sheet shrinkage. With no vacuum in the rolls, the edges shrink virtually unrestrained. But by increasing the vacuum in the rolls to 2.5 KPa, the CD sheet shrinkage is substantially reduced. This produces a more uniform fibre orientation, and uniform sheet strength properties.

In order to achieve these improvements, the Bel-Champ vacuum restraint must be applied continuously, or at least in those sections where the sheet is shrinking the most. The question is, where is the sheet shrinking the most.

To answer this question, the change in sheet width was measured for several commercial furnishes. This graph Fig. (29) shows one of them.

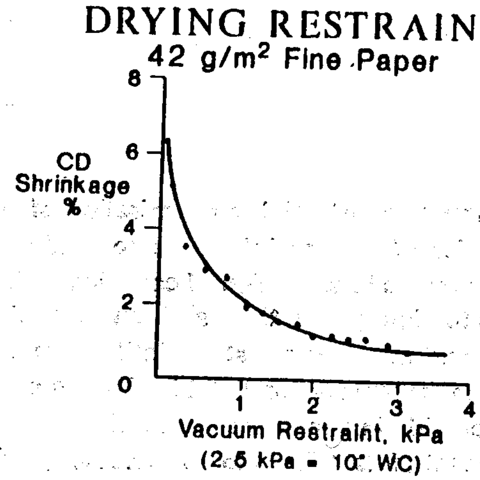


FIG 28

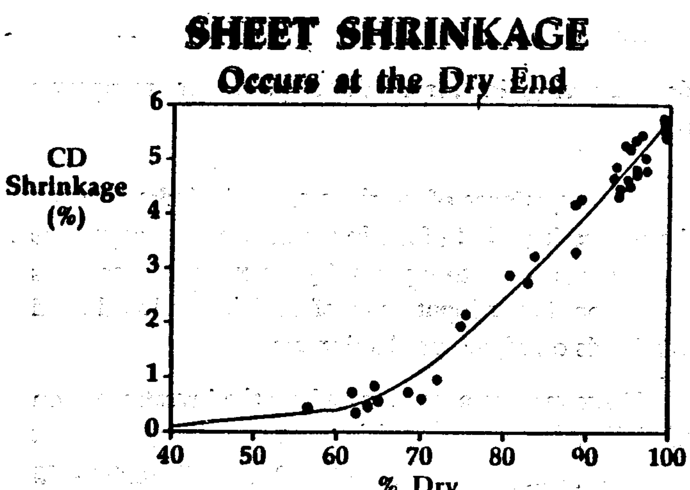


FIG 29

The *initial* shrinkage when the sheet is 40-50% dry is quite low. As the sheet dries, the shrinkage rate starts to increase This higher rate continues untill the sheet is nearly dry.

Based on this data, the Bel-Champ should be applied closer to the dry end of the machine in order to reduce sheet shrinkage. But for best runnability, it should be applied to the wet end of the machine. The total solution is the total Bel-Champ.

We would request our Papermakers to take a careful look at their finished reel. Check to see if the edges of the sheet have a higher cross-direction stretch than the centre. Look at the headbox and see if the slice is closed down at the edges trying to produce a level basis weight profile. Then consider the potential for continuous drying restraint, for producing a sheet with uniform cross-directional properties, and for eliminating all open sheet draws.

We believe that the Bel-champ dryer section is the only dryer section that has the potential for improving runnability, for eliminating threading ropes, and for controlling sheet strength and surface properties. We are just now starting to recognize the full significance of eliminating the open draws and restraining the sheet.

Of the 40 machines with Bel-Cham dryer sections, there are now two machines in operation with the total Bel-Champ technology, and there are ten more under construction.

Based on our commercial results, there is no doubt in our minds that this is the dryer section of the future.

ACKNOWLEDGEMENTS

The Presenter wishes to thank Gregory Wedel for preparing the paper.