Retention, drainage, and formation on high-speed formers

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All two-way drainage formers have very similar dryness levels after the couch (14–17%) at speeds above 900 m/min. Higher vacuums with more volume may not be the answer to sheet dryness.

There are two basic types of formers: roll formers and static element formers. The fundamental difference between them is the pressure generated between two wires as drainage takes place (*1*). **Figure 1** is an example of roll-type forming. Two wires wrap a roll, and the pressure generated between the wires follows the equation of

$$P = T / R \qquad (1)$$

where

P = pressure

T = wire tension of the outer wire

R = roll radius.

Figure 2 is a static element former, in which the wires wrap around some type of nonrotating element. The pressure generated at the static elements is more complicated than the simple roll pressure. It is a function of the angle of wrap, α, the velocity of the fluid, and the amount of fluid drained between elements that impact on the static element.

Pressure measurements

Pressure measurements have been made on a roll former with a small transducer mounted flush to the roll surface (*2*). **Figure 3** is the pressure profile generated by a roll former. There is a sharp rise in pressure developed by the roll radius and wire tension that remains constant until drainage reaches a consistency high enough to mechanically support the wire by the fiber network (probably around 6–8%).

On a static element former, pressure was measured by introducing a small pressure probe into the wedge formed by the converging wires. **Figure 4** represents the first 4 blades of a Bel Baie forming zone (*3*). This profile shows the pulsating effect of a static element on the slurry trapped between the two wires. This pulsating effect means that the slurry must decelerate in the rising

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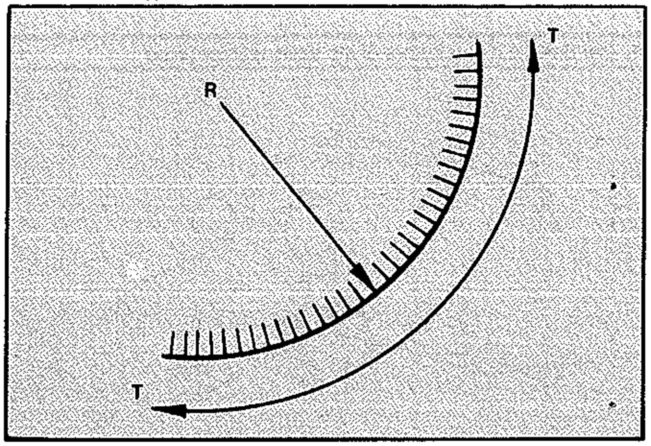
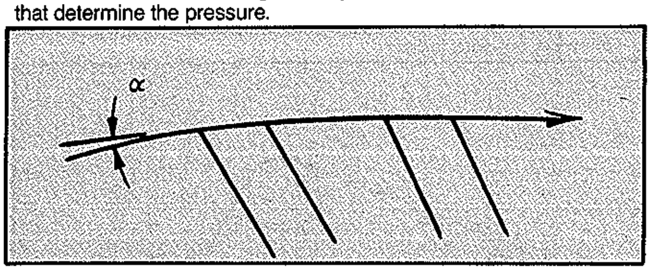
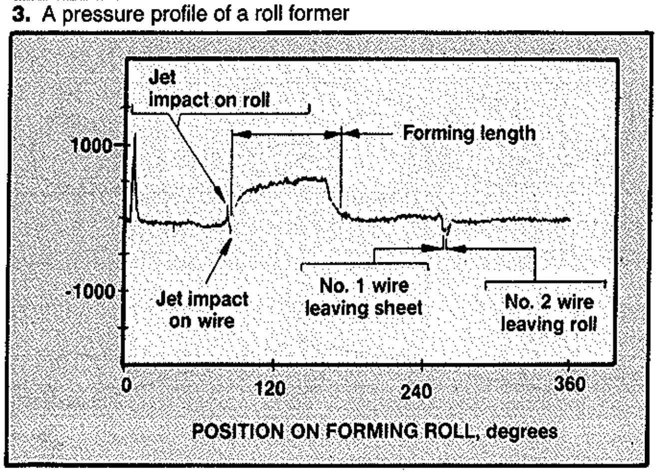
1. In roll forming, two wires wrap a roll of radius *R*



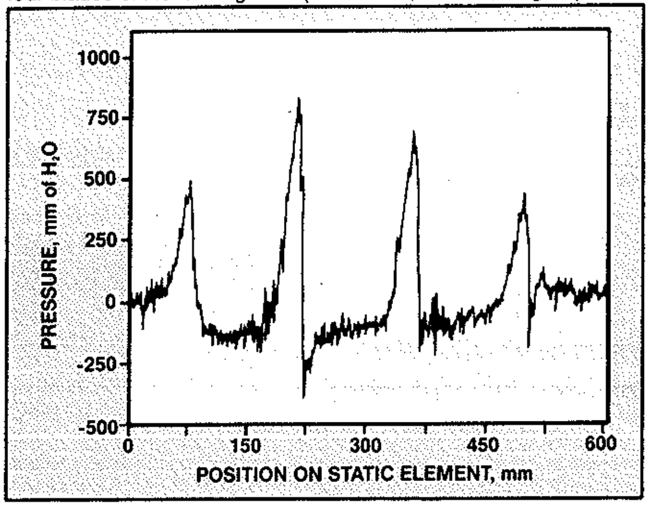
2. In static element forming, the angle of wrap, α, is one of the factors that determine the pressure.



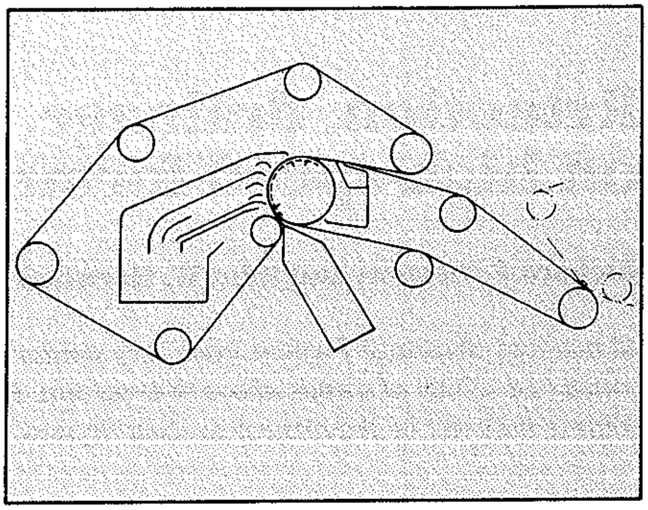
3. A pressure profile of a roll former



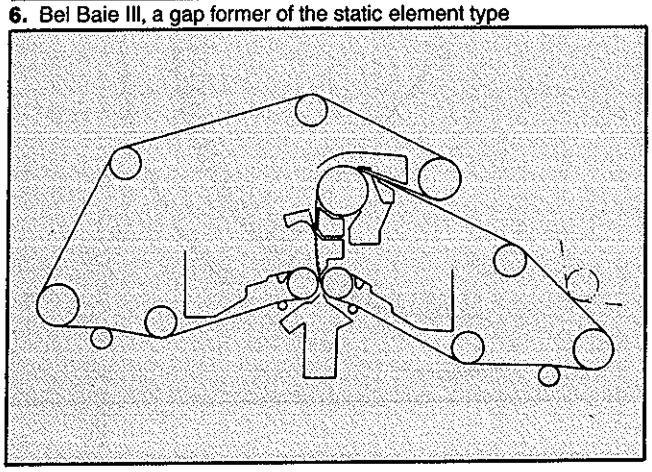
4. A pressure profile for a static element former, showing the first four blades of the forming zone (915 m/min, 7 kN/m, 49 g/m²)



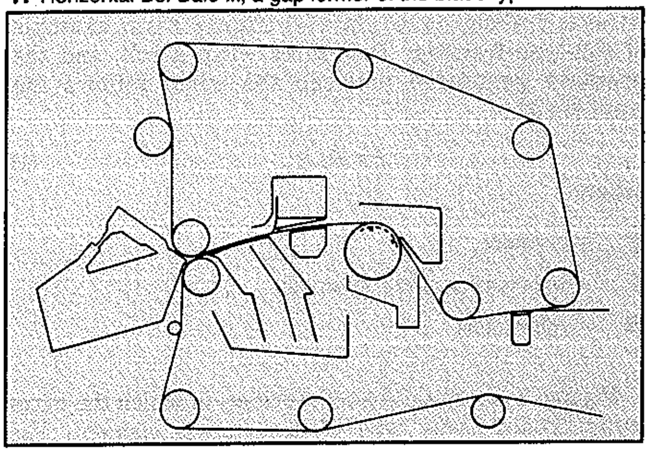
5. Suction roll former as an example of a roll-type gap former



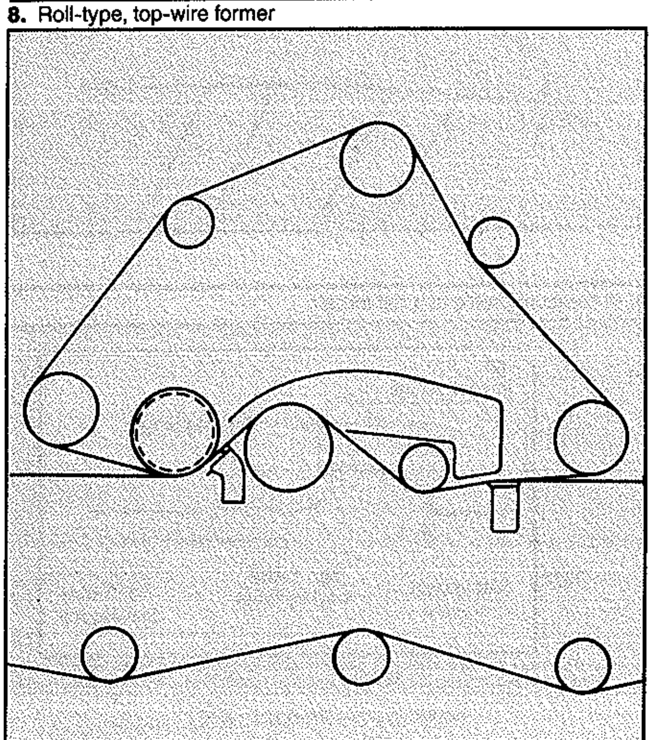
6. Bel Baie III, a gap former of the static element type



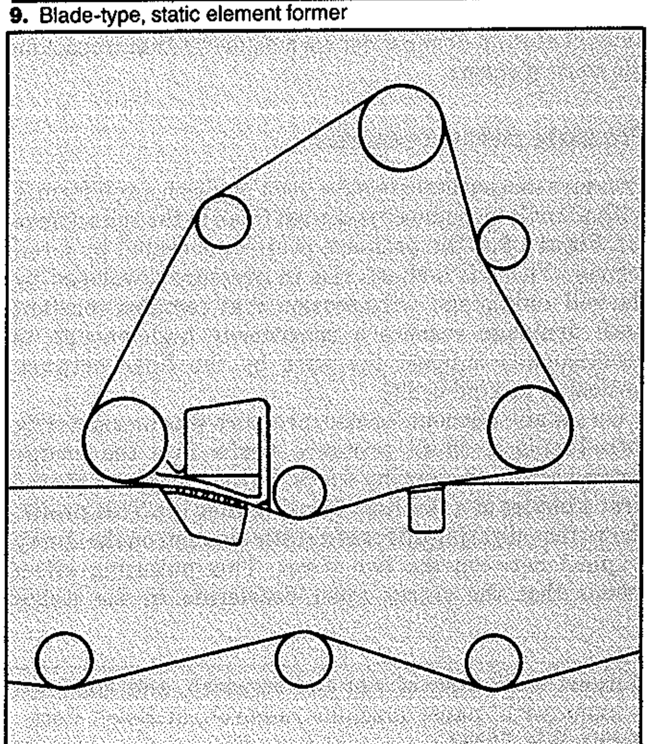
7. Horizontal Bel Baie III, a gap former of the blade type



8. Roll-type, top-wire former



9. Blade-type, static element former



I. Drainage comparisons for a newsprint furnish

Machine	Top side	Bottom side			Upward water drainage, %
	No. 1 wire, lpm/cm	No. 2 wire, lpm/cm	Suction box, lpm/cm	Suction roll, lpm/cm	
Bel Baie III	34	22	10	12	44
Roll former	36	...	...	30	55
Horizontal Bel Baie III	31	22	12	7	43
Bel Form	25	49	...	...	34
Bel Roll	27	37	...	16[a]	34

[a]Throw off open roll.

II. Consistency comparisons for a newsprint furnish

Machine	Top side	Bottom side			First pass retention, %
	No. 1 wire, lpm/cm	No. 2 wire, lpm/cm	Suction box, lpm/cm	Suction roll, lpm/cm	
Bel Baie III	0.29	0.30	0.27	0.07	65
Roll former	0.21	...	...	0.22	71
Horizontal Bel Baie III	0.27	0.32	0.27	0.10	65
Bel Form	0.27	0.32/0.21	...	...	65
Bel Roll	0.22	0.29/0.22	...	0.15[a]	68

[a]Throw off open roll.

III. Formation comparisons for a newsprint furnish, NUI

Machine	Furnish A	B	C	D	E	F
Bel Baie III	12	...	12	7	8	9
Roll former	14	...	...	10	12	...
Horizontal Bel Baie III	10	...	...	8	8	8
Bel Form	13	10	10	9	10	9
Bel Roll	...	12	15	18	...	13

A = 55% groundwood, 45% softwood kraft. B = repulped newsprint (northwest Canada). C = repulped newsprint (northeast U.S.). D = 100% TMP. E = 80% TMP, 20% softwood kraft. F = 90% TMP, 10% softwood kraft.

pressure zone and accelerate in the zone of decreasing pressure, thereby introducing shear on the fiber slurry. This shearing repositions fibers on a small scale, producing a well-formed sheet.

Drainage

Formers can be further classified as to whether they are true twin-wire formers, or the so-called "hybrid formers," or those formers that have a fourdrinier predrainage section prior to the top wire drainage (*4*). **Figure 5** is an example of a gap former of the roll type, and **Figs. 6 and 7** are examples of gap formers of the static element and blade type, respectively. **Figure 8** shows a roll-type, top-wire former, and **Fig. 9** illustrates a blade-type, static element former.

Table I contains data for drainage of the various units. These are typical drainages and consistencies for a newsprint furnish. The most obvious difference in drainage is the upward water drained with the hybrid formers. This amount is about two-thirds that of the gap former, for which drainage is about equal on both sides of the sheet.

Retention

Evident in **Table II** are the lower consistencies when draining around a roll than when draining over static elements. This lower consistency leads to a higher first-pass retention, defined as the sum of the headbox consistency minus the white water consistency divided by the headbox consistency. For the static element former, the pulsing effect of the blades loosens the mat, allowing for more fines to be washed out of the mat. As a result, the white water consistency in the short recirculation loop

IV. Tensile ratio, MD/CD

Machine	Furnish A	B	C	D	E	F
Bel Baie III	3.5	...	3.1	3.1	2.7	3.0
Roll former	2.8	...	...	2.1	3.0	...
Horizontal Bel Baie III	3.3	...	...	3.2	3.2	3.1
Bel Form	1.5	1.8	1.0	2.2	2.2	2.0
Bel Roll	...	1.5	1.7	1.8	...	2.5

A = 55% groundwood, 45% softwood kraft. B = repulped newsprint (northwest Canada). C = repulped newsprint (northeast U.S.). D = 100% TMP. E = 80% TMP, 20% softwood kraft. F = 90% TMP, 10% softwood kraft.

V. Dryness on the wire, where suction boxes were added between the two suction rolls

Speed, ft/m	Dryness, % First couch	Second couch	Suction boxes with or without second couch
2000	10.4	15.3	17.7
3000	11	16.5	17.5

around the former will be higher on a static element former than on a roll former, given that in a closed system the fines in the sheet will be the same for both.

Formation

Sheet formation results produced from the previously described formers are shown in **Table III** for several different furnishes. Formation as measured by the NUI formation meter (*5*) is lower for the static element formers than for the roll formers. Comparing a roll former to a Bel Baie III, the results show better formation for the Bel Baie III. Similarly, in comparing hybrid formers, the Bel Form has much better formation than the Bel Roll.

All comparisons were made with the same furnish and speed. Tensile ratios shown in **Table IV** are similar for the hybrid formers. The gap formers produce a sheet with a higher tensile ratio than hybrid formers, as a result of the jet deceleration that takes place between the two wires and effects all the fibers.

In a hybrid former, only the top third is effected by deceleration when the top wire converges on the slurry, because two-thirds of the sheet has already been formed. The Bel Baie has the highest tensile ratio, resulting from multiple deceleration and acceleration, as the two wires pass over the blades.

Water removal

High-speed forming (greater than 3000 ft/min) has shown that all two-wire formers have lower dryness off the couch than do fourdriniers. For commercial machines, typical consistencies are 14–17% after the couch on hybrids as well as gap formers. We believe this percentage to be the result of the limitation of dewatering by vacuum at high speeds, or, in other words, the short dwell time over the vacuum elements.

Adding more vacuum volume at high speeds does not appear to be effective. **Table V** shows laboratory data from trials in which vacuum boxes were added between the two suction rolls on a pilot Bel Baie III. At high speeds, these additions increased dryness by one point at best.

Conclusions

The mechanism for producing well-formed sheets has an adverse effect on first-pass retention. Shear generated between two wires to reposition fibers also loosens the mat, allowing more fines to be removed by the drainage flow. Dewatering by vacuum at high speed is an ineffective way to increase dryness after a former.

Literature cited

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Received for review Jan. 13, 1988.

Accepted Jan. 26, 1988.

Presented at the 1988 Papermakers Conference.