Initial operating trials of a dandy roll former

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The top wires of roll-type formers may well be superfluous. Add a suction box under the forming roll, and they may run just as well without a top wire.

The relatively small degree of wrap of the two fabrics around the forming roll of roll-type top-wire formers suggested to us some years ago that most of the dewatering, sheet formation, and web compaction of these devices occur in about the first 20°–30° of this wrap. The rest of the pathway of the joined fabrics serves primarily to return the lower fabric to the plane of the preforming section, while the superstructure returns the top fabric back to the forming roll.

If this is the case, why not separate the two fabrics at the point where the wet sheet leaves the forming roll? Why not simply wrap the top fabric around the forming roll, using, in other words, a dandy roll as the forming roll. After all, many papermakers have long referred to top wire formers as "oversized dandy rolls."

To ensure that the wet sheet follows the fabric, we relocated the vacuum box, which is normally positioned at the point at which the fabrics separate, to the comparable point below the dandy roll. To return the sheet to the plane of the pre-forming section, the fabric travels over a return roll and on to the couch roll in a slightly tilted straight line, or via a second return roll.

After discussing this simple-minded concept with several colleagues, we were all but convinced it wouldn't work. The sheet would not be fully formed; it would split, with part of it following the dandy roll. The water removed by the dandy roll would be flung back onto the sheet, either spotting it horribly or completely destroying it. The wet sheet would head for the ceiling when the fabric traveled over the return roll, and so on.

But being simple-minded, we bulled ahead, applied for patents (U.S. No. 4,561,938 and others pending), and ultimately built an experimental device to run on the pilot paper machine at The Institute of Paper Chemistry in Appleton, Wis. The first trials were run in December 1987, and the results were dramatic.

The M/K Plank dandy roll

This new former, shown in **Fig. 1**, looks just like the lower half of a roll-type, top-wire former, as it should. Only the top fabric and its associated hardware are missing.

As mentioned, the partially formed wet sheet and the residual stock above it first contact the dandy roll tangentially at its six o'clock position, where an intense, fine-scale machine-direction (MD) shear force is imparted to the stock in the entry nip. This action is identical to that produced by any roll-type, top wire-former. As long as the average stock consistency entering it is under roughly 2%, this shear force is effective in redispersing the residual stock, resulting in an overall improvement in sheet formation.

The fabric wraps the 122-cm-diameter dandy roll for 40° of its circumference, or from 6:00 to 4:30 o'clock, for a total of 48 cm of fabric wrap around the roll. The last 20 cm of this fabric wrap is over the low-vacuum half of a two-compartment vacuum box. The second half of this vacuum box is a suction box mounted against the first 20 cm of free travel of the fabric after it disengages from the dandy roll. This high-vacuum zone ensures that the wet sheet does not follow the roll.

The return roll is a spirally wound open roll, 40 cm in diameter, with a 10-mesh wire cover. It is mounted as close as possible to the vacuum box, and it contacts the fabric at a point about 18 cm from the end of the vacuum box. The vertical travel of the fabric and wet sheet is about 16 cm of rise from the point of fabric–roll separation. This arrangement minimizes rewetting of the sheet by any spray released by the dandy roll.

Figure 2 shows the theoretical trajectory, neglecting air resistance, of two particles leaving a 122-cm dandy roll at a point 42° from the 6:00 o'clock position, where the fabric leaves the roll at 40°. The initial velocities of these particles were assumed to be 375 cm/s (750 ft/min) and 450 cm/s (900 ft/min). At 900 ft/min, the particle completely clears the return roll, while it barely intersects the roll at 750 ft/min . Thus, for this particular geometry, the minimum theoretical machine speed at which a spray released by the dandy roll will not rewet the sheet is roughly 242 m/min (800 ft/min).

On the pilot machine, the fabric travels at an angle from the return roll to the couch roll in a straight line over three suction boxes. We envision a comparable arrangement for a commercial installation, or the inclusion of a second return roll as shown in Fig. 1.

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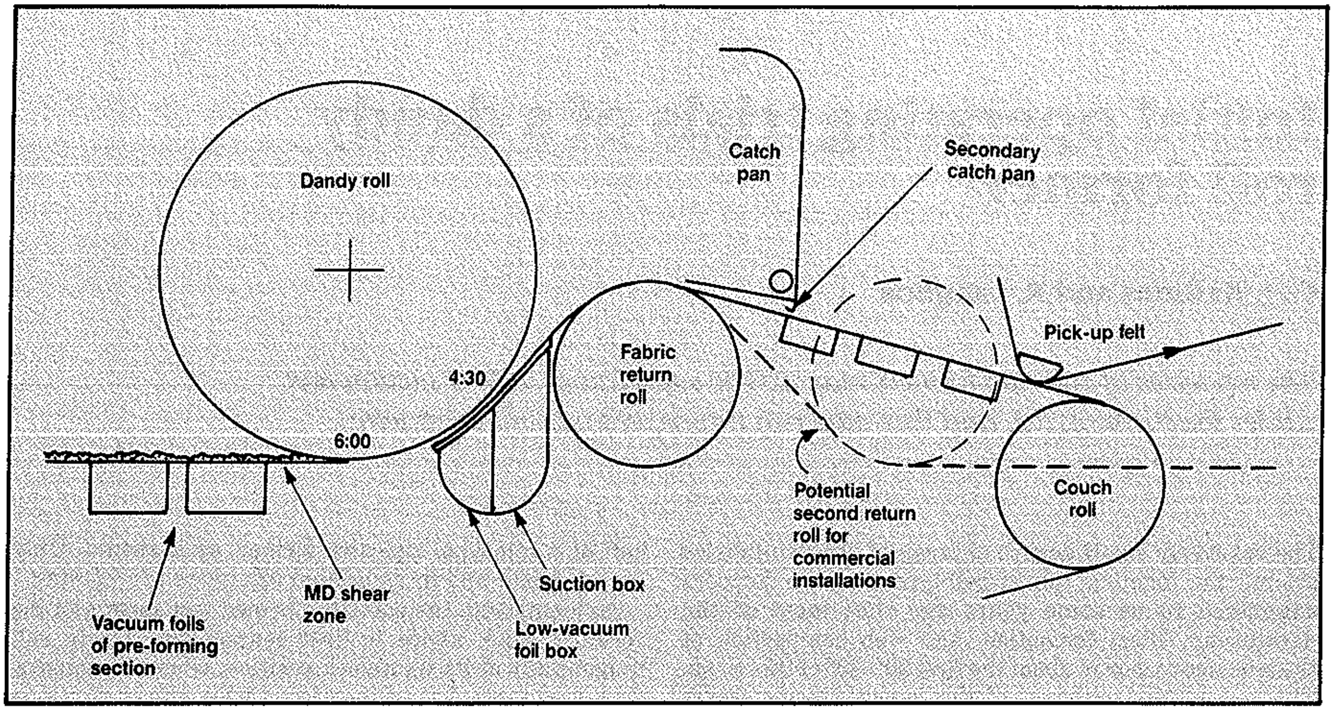
1. The scheme of M/K Dandy Roll Former on the pilot machine at The Institute of Paper Chemistry



Results of initial trials

The trials were run on the 56-cm-wide pilot paper machine at The Institute of Paper Chemistry because it was the only machine available to us capable of running at machine speeds up to 850 m/min (2800 ft/min). This machine has a state-of-the-art Beloit Concept III Converflo headbox. However, the preforming section is only 106 cm long and has three contiguous, small, vacuum foil boxes.

The wet sheet is picked off the fabric by a felt right after the three suction boxes; there is no couch roll. The wet sheet then passes through a plain press. No Uhle boxes were available for the trial, and every sheet was severely crushed. In addition, the sheet was removed from a press roll by a doctor blade for recirculation. Analyzing sheet formation between crush and crepe marks was challenging.

To test out the former over a wide operating range, a 50:50 bleached furnish of northern softwood and hardwood was refined to two freenesses: (a) a relatively "free" range of 400-660 mL CSF and (b) a "slow" value of 140 mL CSF. Under the circumstances, the basis weight, BW, of the sheet could only be calculated from the mass balance equation:

$$BW = 6135 \times T \times C \times R \tag{1}$$

where

6135 = a metric-to-English units conversion factor

T = the slice opening in cm

C = the consistency expressed as a fraction

R = the overall retention also expressed as a fraction.

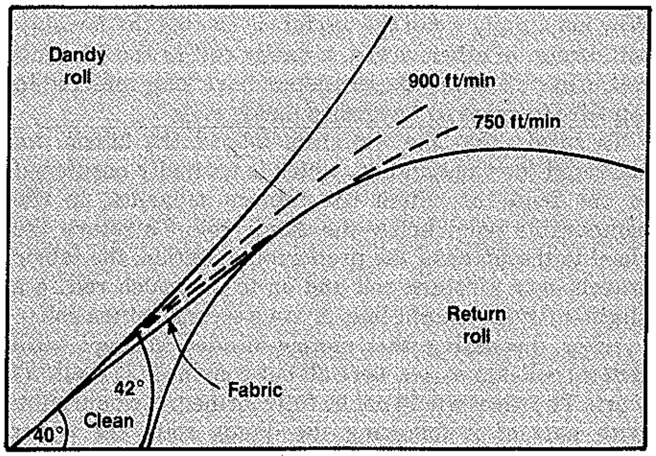
For example, in the run with the free furnish (660 mL CSF), T = 0.95 cm, C = 0.46%, and R = 0.9. The basis weight is calculated as:

$$BW = 6135 \times 0.95 \times 0.0064 \times 0.9$$
$$= 33.6 \text{ lb/3000 ft}^2$$

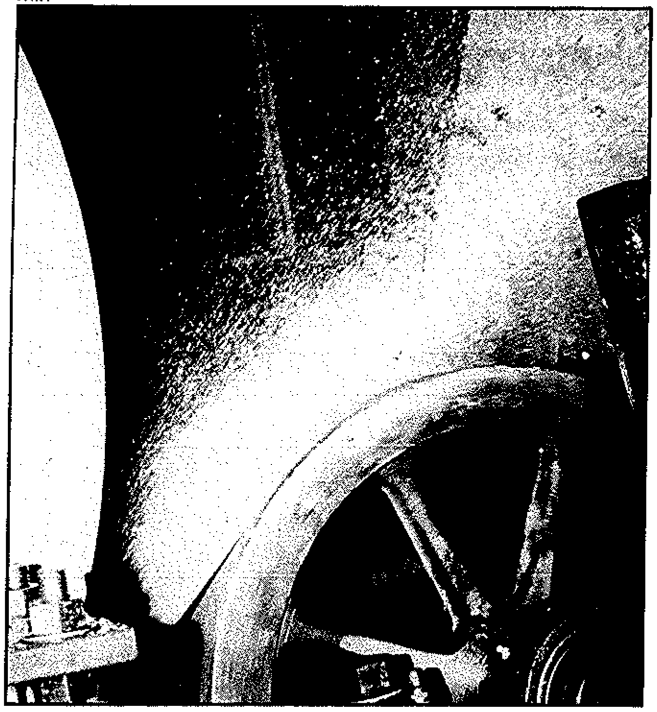
or 55 g/m^2.

Because the preforming zone of the experimental machine is so cramped, it was not possible to obtain a sample of the "sandwich" of the residual stock and partially formed web entering the "twin-wire" zone. All we could do was stick a finger into the stock after the last vacuum foil box and "feel" that there was plenty of residual free stock left. In other words, the average consistency of the sandwich of wet sheet and stock impinging on the dandy roll was low indeed, probably in the range of 1.0-1.5%.

2. Theoretical trajectories of particles thrown from the fabric at an angle of 42° when the fabric leaves the dandy roll at 40° from the tangent of the 6:00 o'clock position



3. The spray released by the dandy roll when running at 1200 ft/min



Forming a sheet from "free" furnishes

Initially, an unrefined furnish (660 mL CSF) was formed into a 55-g/m^2 sheet at machine speeds ranging from 240 m/min (800 ft/min) to 850 m/min (2800 ft/min). All of the sheets were fully formed by the time they exited the dandy-roll-fabric-nip. Surprisingly, there was no spray discharged from the dandy roll.

The vacuums achieved in the two boxes under and just past the dandy roll were generally between 10 in. and 15 in. H_2O. The consistency of the sheet after it passed over the return roll was an astonishingly high 9.4%.

To determine the importance of the applied vacuum to achieving this high consistency, the vacuum was turned off, and the sheet consistency after the return roll dropped only to 8.25%. This result indicates that this sheet was formed and compressed primarily by the tension of the fabric against the dandy roll.

In the rest of the runs with this furnish, the stock had a freeness of 400-500 mL CSF. With the vacuums back on, the headbox consistency was raised to 0.8%, giving a sheet weight of 45 lb/3000 ft^2. At 1200 ft/min, this consistency represents all the stock which the fan pump could deliver. At this heavier weight, the consistency of the wet sheet dropped to only 3.6% after the return roll, which still represents the sheet in a fully formed condition.

The machine was sped up in increments of about 150 m/min to 850 m/min, always at a headbox consistency of about 0.6%. At 725 m/min and 850 m/min, a small amount of a mistlike spray came out of the dandy roll. We did not have a chance to sample the stock on the fabric after the return roll at these high speeds because we feared that the machine might self-destruct. Consequently, it was slowed momentarily after reaching this maximum speed. However, the appearance of the wet sheet after it passed over the return roll was no different from that at 360 m/min (1200 ft/min).

At no time were any of our four initial fears realized. Amazingly, the sheet was so well retained by the monofilament fabric that it was all but impossible to scrape it off the return roll, even at the top operating speeds. On the other hand, it was readily picked up by the water-logged felt.

Forming a sheet from a slow newsprint furnish

In these trials, the headbox consistency was always maintained at about 0.6-0.65%, and the machine speed was initially set at 360 m/min. After the spray-free trials on the furnish of 400-660 mL CSF at speeds up to 850 m/min, we were surprised to see a stream of water spray (not mist) exit from the dandy roll just above the point of separation of the dandy roll and fabric. It looked just like the spray released by the forming roll of high-speed, newsprint top wire formers.

Viewed with a high-intensity strobe light, the spray was seen to travel with and just above the wet sheet up to the top of the return roll, where it broke up into a much larger spray (**Fig. 3**). At 1200 ft/min and faster, this result was in line with our expectations, based on the calculations leading to the theoretical trajectories of Fig. 2. In addition, the wet sheet leaving the dandy roll could have been carrying a boundary layer of air which prevented water particles from falling back into it.

Even if a small amount of white water did fall back onto the wet sheet, it probably caused no harm, because its speed relative to the wet sheet was small. This situation is totally different from the spray released by undersized dandy rolls, which can fling water drops from a great height back onto a sheet and produce water spots.

Once the wet sheet reached the top of the return roll and began its descent, it probably created a small vacuum in the air just above the sheet, causing an expansion in the spray before it reached the pan. With the leading edge of the pan set about 1/4 in. above the sheet, only a negligible amount of water splashed onto its underside. This water flowed into the small C-shaped secondary pan mounted under the trailing edge of the catch pan. As viewed from the press section, the wet sheet after the return roll had a smooth, glistening appearance, with no evidence of drops hitting it.

The consistency of the wet sheet formed at 360 m/min was 3.5% after the return roll, indicating that it was fully formed and had received little or no rewetting between the dandy roll and the return roll. In other words, sheet formation from this "slow" furnish was still completed in the "twin-wire" zone between the dandy roll and the fabric, just as such formation occurs around the forming roll of the top wire formers.

To check whether there was any rewetting of the wet sheet between the dandy roll and the catch pan, samples of the sheet were taken at 300 m/min and 450 m/min, with the spray travelling normally into the pan and with the bulk of it deflected. For all four cases, the sheet consistency was $3.8 \pm 0.1\%$, direct evidence that virtually all of the spray is caught.

There is further evidence that the spray came from the dandy roll and not from the sheet. At a headbox consistency of 0.6%, the spray had a consistency of 0.1%, while the white water of the pre-forming section had an average consistency of 0.05%. This ratio is about the same ratio as the comparable white waters of top-wire newsprint machines.

When the headbox consistency was raised to 0.66%, the spray consistency was enhanced to 0.19%, which was not a surprise. However, the consistency of the wet sheet after the return roll remained at 3.5%.

It was possible to run the stock of 0.6% consistency and 140 mL CSF at a speed up to 2150 ft/min, with no apparent change in the appearance of the wet sheet. Imminent self-destruction of the machine again prevented us from sampling the wet sheet after the return roll.

Conclusions and implications

All of our fears of the performance of a top wire former based on a dandy roll and using a single fabric were totally unfounded. Our dandy roll former performed identically to twin-wire, roll-type, top wire-formers. Could it be that these formers are unnecessarily complex and don't really require a top fabric?

One most important characteristic of our former is its operating limits, which could not be evaluated in these trials. The consistency of the sheets formed from the fine-paper stocks was high: 8-9%. This high consistency, coupled with the low consistency of the stock entering the dandy roll former on this pilot machine with its limited preforming section, 1-1½%, and the lack of a spray discharged from it indicate that this design can accommodate much greater quantities of fiber than we processed in these trials.

We would like to thank the Plank Corporation, and especially Bill Plank, for supporting this radical concept, and the machine crew at The Institute of Paper Chemistry, especially Bruce Andrews, for making it work.

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