A pilot paper machine evaluation of the effects of pressing on newsprint quality

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ABSTRACT

The effect of forming and pressing was investigated on a pilot paper machine equipped with two different wet ends and a press section with four nips. The design of the former has the greatest effect on sheet structure, strength, surface properties, and print density index. Increasing the loading of either the first or fourth press to a critical value increases the strength of newsprint. Strength will decrease if the loading is increased beyond this critical value. The print density index of the sheet is directly related to the consolidation of the sheet in the press section and the calender.

Application:

Two-sidedness in roughness and print density can be minimized by the proper selection and operation of the former and press sections.

INTENSE WET PRESSING OF PRINTING grades is intended to maximize the web solids entering the dryer section. A higher web solids content after pressing leads to higher productivity for two reasons: (a) the web is stronger, which improves runnability, and (b) less water needs to be removed in the dryer section, which increases its maximum operating speed.

With more intense pressing, there are concerns that the quality of the paper will be affected. In a previous report, we used a combination of pilot paper machine and laboratory pressing experiments with handsheets to examine the effect of a fourth press on the surface and printing properties of newsprint and fine paper sheets *(1)*. That work was based on a series of earlier pressing studies with handsheets on a laboratory press *(2)* and continuous webs on a pilot paper machine equipped with a two-nip, three-roll press *(3–5)*. The main findings of Paprican's pressing research to date was summarized in a review article *(6)*.

We have shown that press section configuration has an effect on the two-sidedness of roughness and print quality. Paper tends to be rougher on the side that contacts the felt in the last nip. Print quality, as measured by print density index, is primarily determined by the structure of the sheet imparted in the forming section and the consolidation that takes place in the calender. However, the first press can have an effect on the two-sidedness in print quality. In a single-felted first nip, the print density index generally shows more improvement on the side adjacent to the felt.

Multinip roll presses are capable of pressing newsprint to a web solids content of over 40% at high machine speeds. Four conventional press nips are required to reach this web solids content at machine speeds near 1500 m/min without damaging the web, and more nips might be needed at higher speeds. Such a multinip press section would have a high capital and operating cost. An alternative solution would be to apply a high load with a wide-nip shoe press. Laboratory studies *(7, 8)* have shown the potential for a pressed sheet dryness of up to 50%, with Parker Print-Surf roughness values similar to a sheet pressed with a Tri-Nip press.

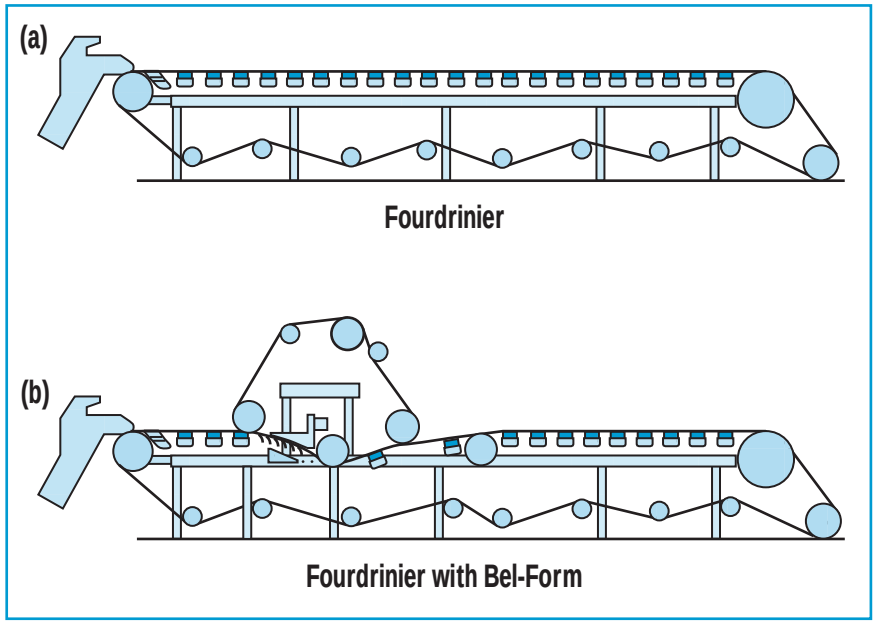
In our previous experimental work *(1)*, the effect of up to four press nips was simulated by combining pressing on a pilot paper machine with off-machine pressing. In this report, experiments were conducted with a 100% thermomechanical pulp (TMP) newsprint furnish on a pilot paper machine equipped with four press nips comprised of a Tri-Nip followed by a fourth press. The effect of pressing on water removal, dry paper strength, and print quality as a function of former type (fourdrinier or top former) was evaluated by varying the loading in the first and fourth press nips. Offset linting measurements from these experiments were reported in the literature *(9)*. The experiments with a fine paper furnish are described in a separate paper *(10)*.

DESCRIPTION OF EXPERIMENTS

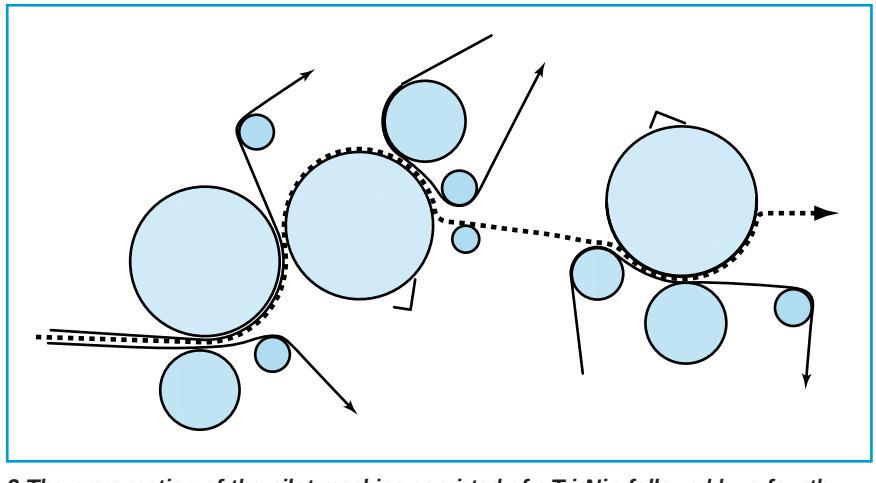
Pilot paper machine

The experiments were performed on a pilot paper machine located in Beloit's Research & Development Center in Rockton, IL. This machine was equipped with a seven-channel Concept III headbox. Two wet ends were used in the course of these experiments: a fourdrinier [**Fig. 1(a)**] and a Bel-Form top former [**Fig. 1(b)**], which was adapted to the fourdrinier table in an overnight changeover. The press section was a Tri-Nip press followed by a fourth press (**Fig. 2**). For this press configuration, the paper contacts two felts in the first nip, felts on the top side in nips two and three, and a felt on the bottom side in the fourth nip, as shown in **Fig. 3.**

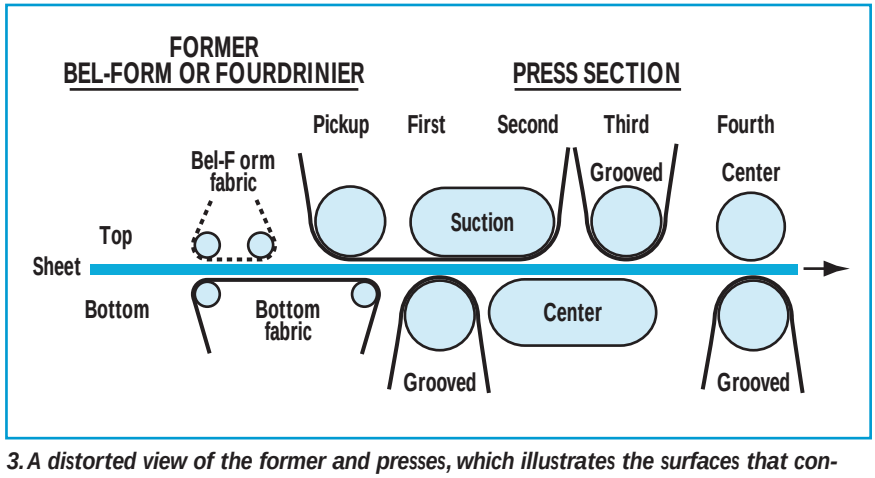
In the course of these experiments, the loadings in the first and fourth presses were varied independently (**Table I**) to evaluate the effect



1. The wet end of the Beloit pilot paper machine was converted from a fourdrinier to a Bel-Form top former for these experiments.



2. The press section of the pilot machine consisted of a Tri-Nip followed by a fourth press.



3. A distorted view of the former and presses, which illustrates the surfaces that contacted the paper.

of pressing conditions on water removal, strength, and print quality. For the zero-loading condition of the first press, the bottom felt was roped to avoid contact with the paper. In effect, the press operated as a Twinver followed by a third press for this condition. The paper machine was run at 700 m/min using a 100% TMP furnish prepared by reslushing paper rolls from several different mills.

Fines distribution

The paper was split into four layers with the Beloit Sheet Splitter *(11)*. The fines distribution was measured by weighing material passing through a 200-mesh screen in the Britt jar.

Drying, calendering, and printing

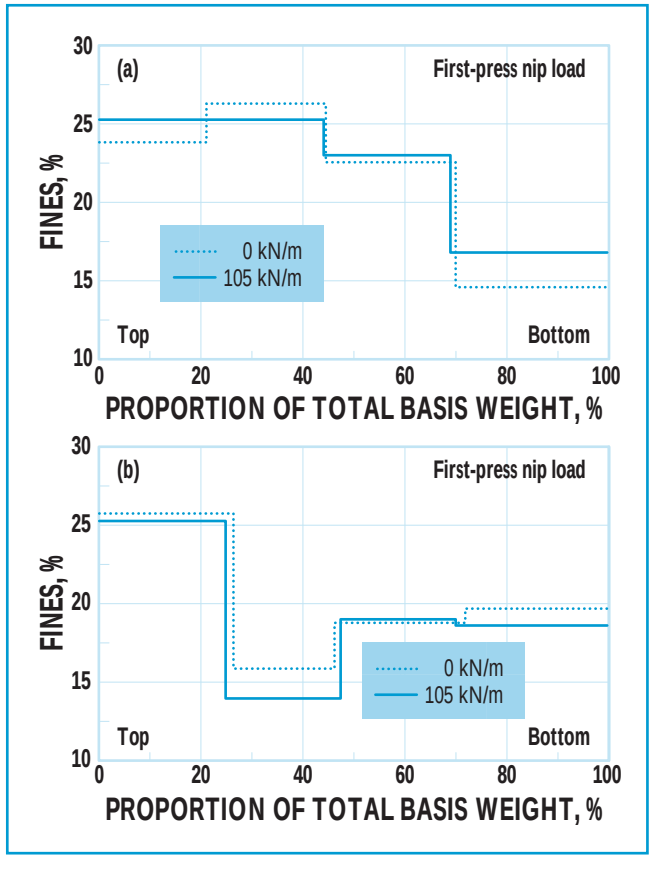
After the press section, the wet paper was reeled into rolls. The paper was subsequently unwound and dried over a series of 14 steam-heated dryer cylinders. Dry paper was calendered as a continuous web using Paprican's laboratory calender *(12)* at nip loads of 20, 40, 60, and 80 kN/m at 50 m/min, with roll temperatures of 50°C.

Letterpress printability was determined by means of proof prints with the IGT laboratory press using the solid plate. Print density index, i.e., the print density at the maximum of the ink transfer curve divided by the amount of ink transferred to the paper, was determined using the procedure developed by Paprican *(13, 14)*. Offset linting, measured using a method developed for the IGT *(15, 16)*, is reported elsewhere *(9)*.

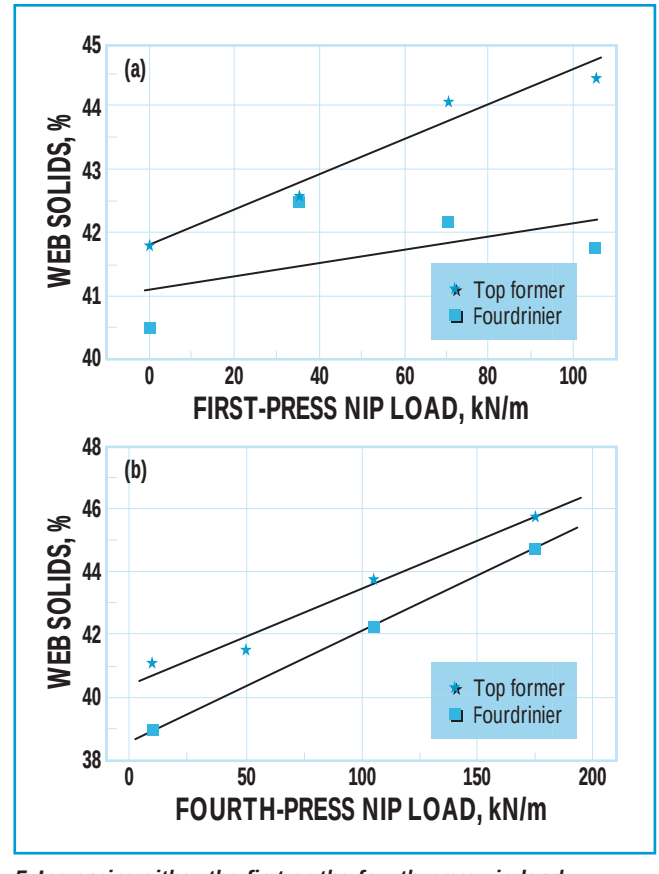
RESULTS

Fines distribution

The fourdrinier paper had a lower proportion of fines on the bottom side [**Fig. 4(a)**]. On switching to the top former, the fines tended to be redistributed from the middle of the sheet to the bottom side, making the fines distribution profile more uniform [**Fig. 4(b)**]. Unloading the first press had little effect on the fines distribution for both the fourdrinier



4. The top former sheet had more fines in the surface layers than the fourdrinier sheet. Removing the first double-felted nip did not change the fines distribution of either the fourdrinier (a) or the top former sheet (b).



5. Increasing either the first or the fourth press nip load increases the solids content of the sheet after the fourth press. The top former sheet had a higher solids content than the fourdrinier sheet.

[Fig. 4(a)] and the top former [Fig. 4(b)] sheets. This could mean that either pressing does not change the distribution of fines in a paper sheet or that small changes in the distribution are not detected if the sheet is split into just four layers.

Water removal

Web solids content after the fourth press was greater for the top former than the fourdrinier wet end (**Fig. 5**). Although the top former sheet had a higher web solids content at the couch than the fourdrinier sheet, because of the larger dewatering forces and two-sided dewatering, this alone would not increase the dryness after the fourth press. The higher web solids content of the top former sheet was probably related to differences in formation and sheet structure. Increasing the nip load of either the first or the fourth press, even at high levels of press loading, led to a significant increase in web solids for both formers.

Physical properties

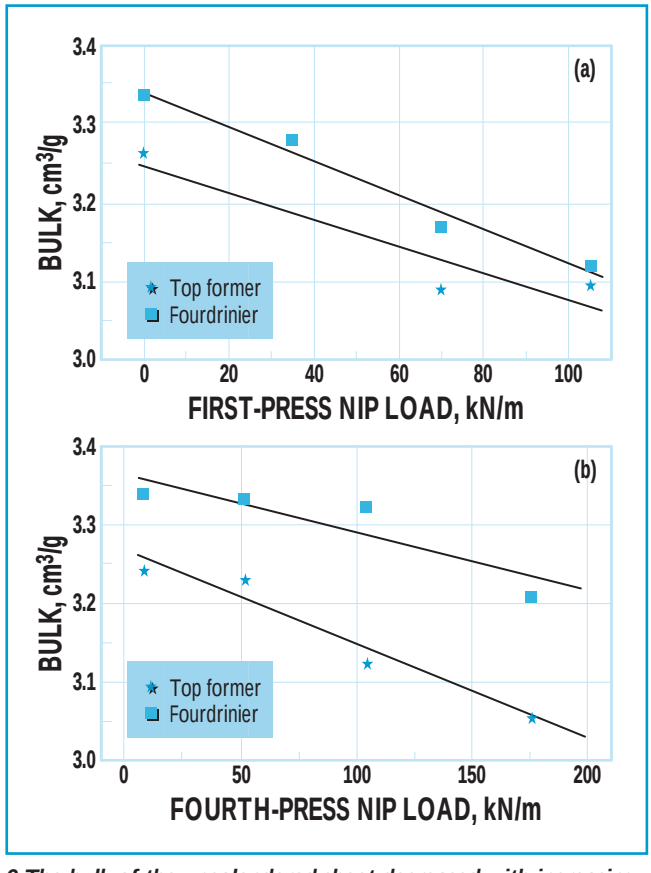
The bulk (caliper divided by basis weight) of the dried paper was reduced by increasing the loading on either the first or the fourth press (**Fig. 6**). The uncalendered top former sheet had a lower bulk than the fourdrinier sheet, but the fourdrinier sheet was easier to calender.

NIP LOAD, kN/m		WEB SOLIDS CONTENT AFTER FOURTH PRESS, %	
First	Fourth	Fourdrinier	Bel-Form
0	105	40.5	41.8
35	105	42.5	42.6
70	105	42.2	44.1
105	105	41.8	44.5
50	10	39.0	41.1
50	50	-	41.5
50	105	42.3	43.8
50	175	44.8	45.8

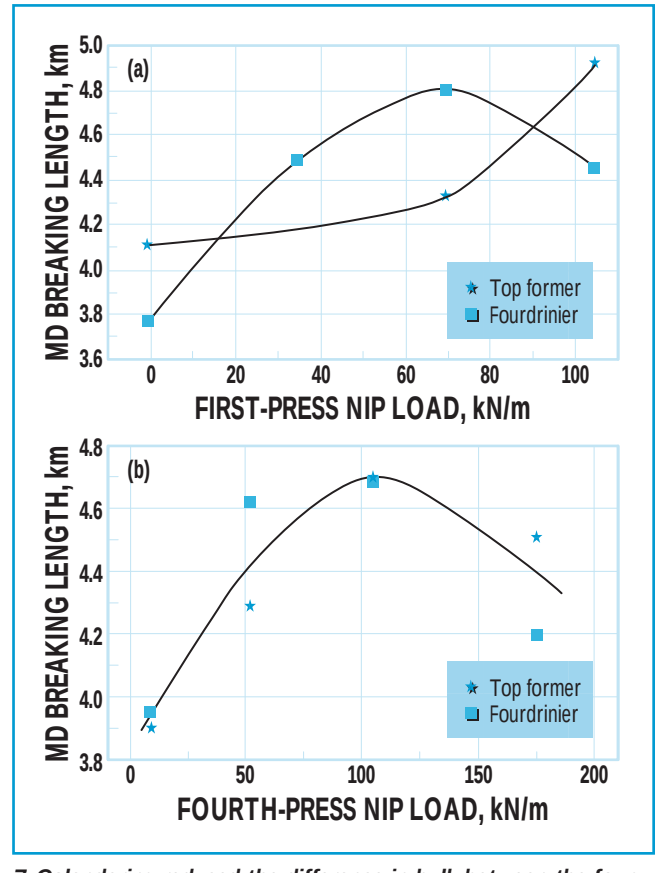
*The second and third press nips were loaded to 70 and 90 kN/m, respectively.

*I. Conditions for pilot paper machine trial**

Apparently the pressure between the two forming fabrics of the top former leads to better formation, which gives a denser sheet. The fiber orientation might also influence sheet structure; e.g., the tensile strength ratio was 1.8 for the top former and 2.2 for the fourdrinier. Calendering, however, eliminated [**Fig. 7(a)**] or diminished [**Fig. 7(b)**] the bulk differences in sheets from the two formers.



6. The bulk of the uncalendered sheet decreased with increasing first (a) or fourth (b) press nip loading.



7. Calendering reduced the difference in bulk between the fourdrinier and top former sheets.

Breaking length in the machine direction generally increases with first press nip load [**Fig. 8(a)**]. However, at the highest first press loading, the strength of the fourdrinier sheet appeared to diminish.The fourdrinier sheet entered the first press with a higher moisture content than the top former sheet, and the strength drop observed at a nip load of 100 kN/m might be caused by incipient crushing in the first nip *(17)*. The breaking length of paper from both formers peaked at a fourth-press nip load of 100 kN/m and dropped at 175 kN/m [**(Fig. 8(b)**]. It is not clear whether incipient crushing could occur with well dewatered webs in the fourth press, but it is important to note that pressing beyond the optimum nip load can impair the strength of paper.

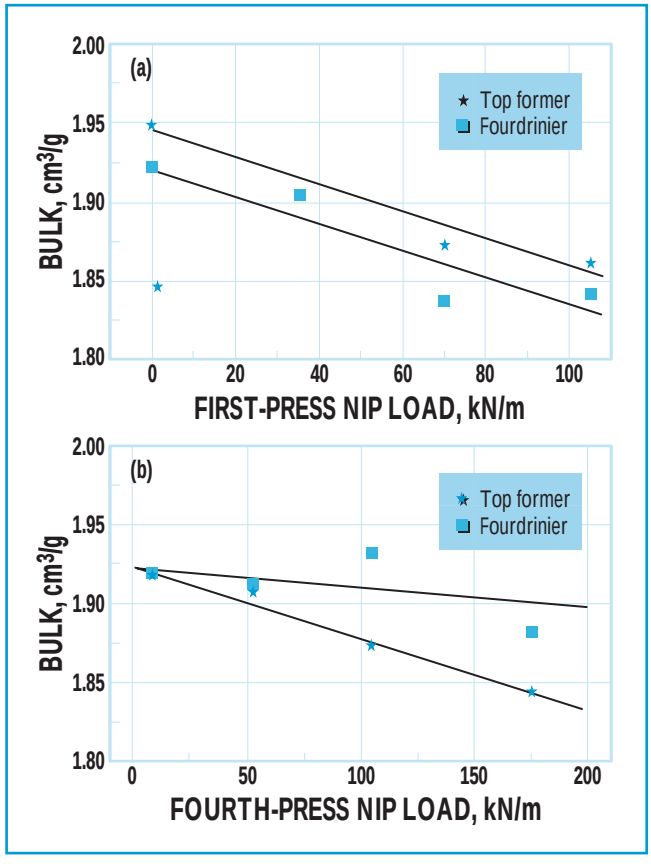
The Gurley air resistance of uncalendered paper increased with the loading of the fourth press [**Fig. 9(a)**]. The top former paper had a higher air resistance than the fourdrinier paper. Furthermore, the air resistance of calendered paper increased with the loading of the first press [**Fig. 9(b)**]. Both the strength and air resistance measurements suggest that the top former makes a more consolidated sheet with better bonding between fibers.

Surface and printing properties

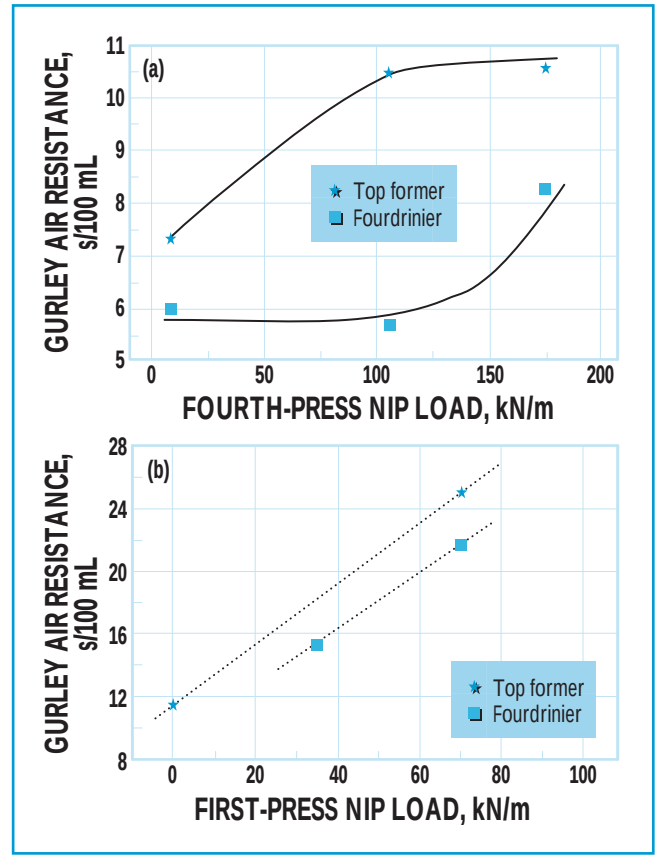
The top former sheet was rougher on the bottom side than the top side, whereas the roughness on both sides of the fourdrinier sheet was equal [**Fig. 10(a)**]. These relationships persist after calendering [**Fig. 10(b)**]. Increasing the fourth-press nip load reduced the roughness on both sides of the uncalendered paper [Fig. 10(a)]. However, for calendered sheets, increasing the fourth press load beyond 50 kN/m showed no further roughness reduction [Fig. 10(b)].

Print density index (PDI) was higher for the top former sheet than the fourdrinier on both the top and bottom sides (**Fig. 11**). This index increased on both sides of the paper with increasing first press nip load up to 70 kN/m but tended to decrease at higher nip loads [Fig. 11(a)]. Increasing the fourth press nip load to 50 kN/m increased the print density index (Fig. 11(b)]. For fourth press nip loads greater than 50 kN/m, the PDI is either the same or less than the value at 50 kN/m. Print density index is sensitive to calendering, and some of the trends in Fig. 11 may be a result of uncontrollable variations in calendering conditions. This is supported by the linear rela-

KEYWORDS
Fillers, fines, forming sections, presses, print quality, printing papers.



8. The breaking length of the uncalendered paper generally increased with first press nip load but dropped for the fourdrinier sheet at the highest load (a). As fourth-press nip load was increased, the MD breaking length first increased, went through a maximum, and then decreased (b).



9. Gurley air resistance on uncalendered paper increased with fourth-press nip load (a). Air resistance of calendered paper also increased with the load of the first press (b).

tionship between PDI and bulk shown in **Fig. 12.**

The difference in bulk between each sample is a combination of different pressing conditions and uncontrolled variations in calendering. This finding is in agreement with our previous laboratory and pilot machine experiments *(3, 18)*. Print density index is related to the final bulk of the sheet as determined by the combined effect of consolidation processes such as pressing and calendering. At the same bulk, the sheet from the top former always had a higher PDI than that from the fourdrinier. This appears to be related to the compaction of the sheet surfaces caused by the higher drainage forces in the top former.

SUMMARY

Experiments conducted on a pilot paper machine with the different wet ends followed by four press nips have shown that:

- Former design has the greatest effect on sheet structure, strength, surface properties, and print density index.
- Increased loading of the first or fourth press will increase the dry strength of newsprint up to a critical nip load. If the loading is increased beyond the critical load, strength will decrease.
- The felt side of the paper becomes rougher after a press nip, with the last nip having the greatest effect.
- Print density index is augmented by sheet consolidation in the press section and calender. TJ

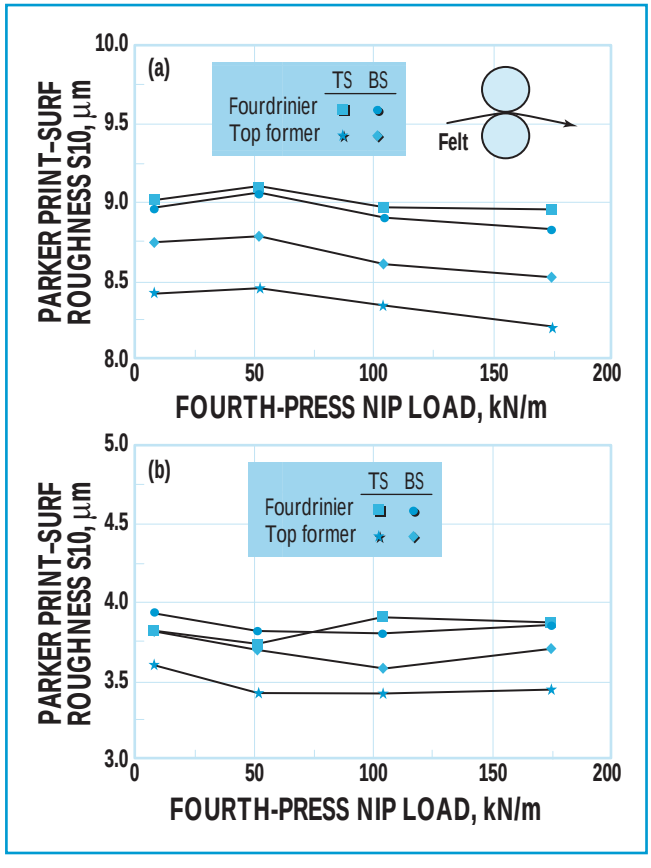
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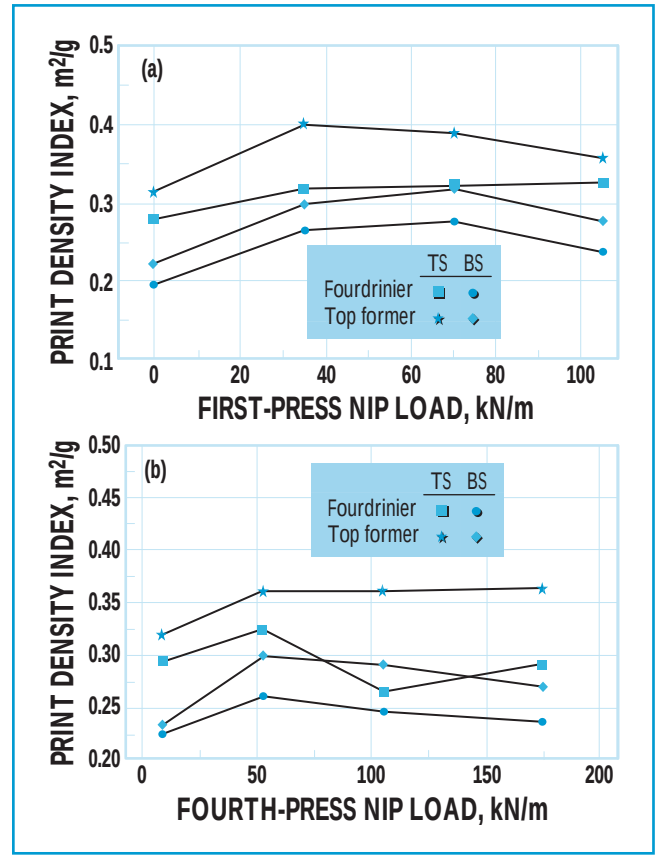
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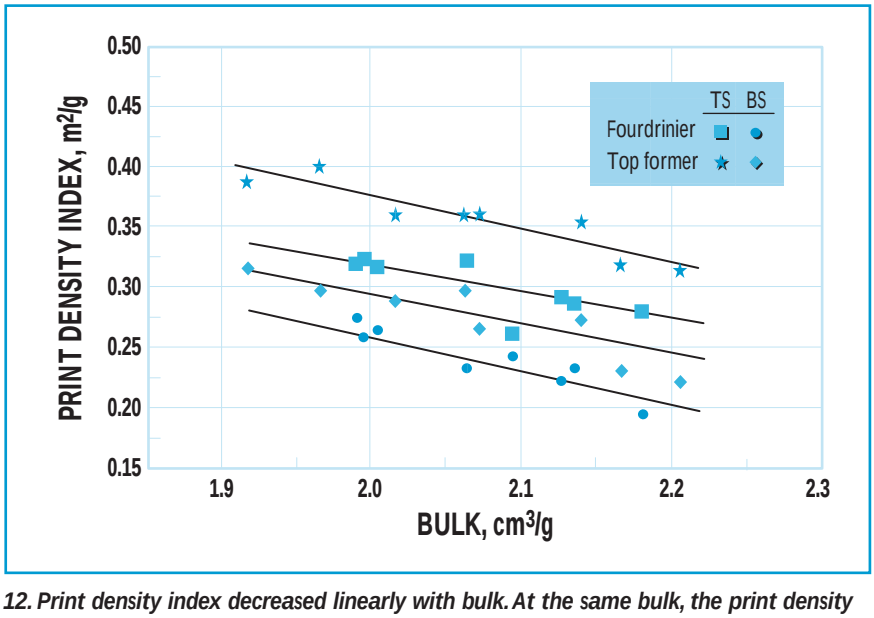
Presented at the TAPPI 1997 Engineering/ Papermakers Conference.



10. Parker Print-Surf roughness for uncalendered (a) and calendered (b) paper decreased on both sides of the paper with fourth-press nip load. The top former paper was rougher on the bottom side, whereas the fourdrinier paper had equal roughness on both sides.



11. Print density index increased for the first (a) and fourth (b) press nip loads below 50 kN/m.



12. Print density index decreased linearly with bulk. At the same bulk, the print density index of the top former sheet was greater than that of the fourdrinier.

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