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# FACTORS INFLUENCING THE STRENGTH PROPERTIES OF WET-WEBS

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***Synopsis*** The importance of wet-web strength in the manufacture of newsprint is considered. A number of case histories are presented, which illustrate how the assessment of wet-web strength can be effectively used to clarify practical observations on paper machines. These observations were concerned with the influence on paper-machine operation of normal fluctuations in the properties of the mechanical and chemical pulp components of a newsprint furnish. Wet-web strength measurements were carried out at moisture contents of the web which reflect its ability to release water under standard drainage and pressing procedures. A rapid wet-web burst testing technique was developed that is suitable for evaluating wet-web strength in a mill environment.

### *Introduction*

ONE of the major factors influencing the efficiency of large, high speed newsprint machines is the frequency of wet-web breaks. Under normal operating conditions, the frequency of breaks is governed by the ability of the web to survive the stresses imposed upon it in the unsupported draws of the machine.[1–3] This stress carrying ability of the web is characterised by its wet-web strength. With the trend towards lower basis weights for standard newsprint, the sensitivity of the papermaking process to wet-web strength variations has become increasingly important, and an understanding of the factors controlling wet-web strength is now more vital than ever.

In addition to its role in governing the operating stability of the paper-machine, wet-web strength has come to be increasingly recognised as an important aspect of overall pulp quality monitoring for process control and optimisation.[6–10]

It is well known that, in the range of solids contents of wet-webs normally encountered in the first few unsupported draws, the wetter a web is the lower

*Under the chairmanship of J. Mardon*

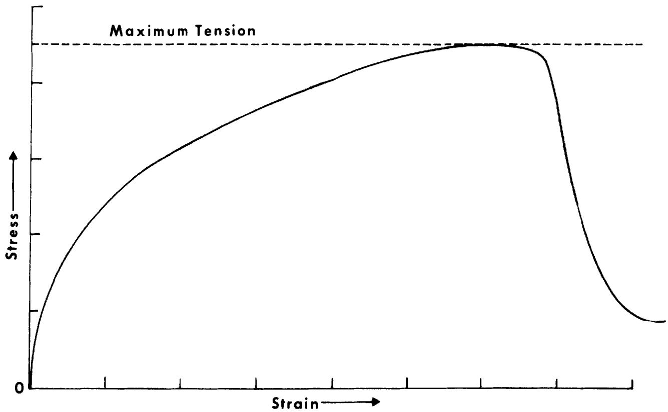


*Fig. 1*—Typical stress/strain curve of a wet-web

its stress carrying ability will be. Thus, the wet-web strength in the first unsupported draw is of primary importance in governing the ability of the web to transfer across the draw without rupture. On most modern newsprint machines, the first open draw occurs after two or even three press nips.

Information on the stress carrying ability of wet-webs can best be obtained from their stress/strain curves, a typical example of which is shown in Fig. 1. This has been recognised in the paper industry for a long time,[1–3, 7, 8, 11, 12] and it has been extensively discussed in a recent publication.[4] A variety of parameters, obtainable from the stress/strain curves of wet-webs, has been employed to characterise wet-web strength in the past. These include the breaking length[8] or tensile strength[12] of the wet-webs, their work to rupture,[11] work to $3\frac{1}{3}$ per cent strain,[4] or a combination of two or more of these.[3]

A general characteristic of previous works on wet-web strength is that, regardless of the parameter employed to represent the strength of the web, measurements were corrected to a fixed solids content of the wet web. Early works, concerned with machines having an open draw after the couch, corrected to solids contents in the region of 20 per cent,[12] while more recent work on modern paper-machines corrected to solids contents in the region of 36 per cent.[4] Nevertheless, it is well known from practical experience, supported by experimental observations,[5] that water removal from the wet-web on the paper-machine is strongly dependent on the furnish composition. Since the stress/strain properties of wet-webs are greatly influenced by their solids contents, a truly meaningful evaluation of wet-web strength must be made at solids contents representative of the dewatering behaviour of the web on a paper-machine. A possible reason that this aspect of wet-web testing was not given more attention in the past is the obvious difficulty of obtaining reproducible solids contents in the laboratory in the range of variation normally encountered on a paper-machine.

In the first part of this paper, it is shown that the effect of furnish changes on the behaviour of the stock at the draws of the wet-end of the paper-machine can indeed be predicted by means of correctly carried out wet-web strength measurements. Six case histories are presented to illustrate practical applications of the techniques.

The second part of the paper deals with the development of a wet-web tester which is sufficiently rugged, simple, and portable for application in the investigation of everyday, practical mill problems. It is based on wet-web tests of the 'burst' type. This concept of wet-web testing is not new.(13) It had not been pursued, largely because wet-web testing has generally been regarded as the preserve of the research laboratory; forces applied in burst type testers do not readily lend themselves to precise analysis. The proposed instrument is useful, because it works.

## Part 1—Case histories

THE prime goal of a diagnostic test of pulp quality, such as wet-web strength evaluation, is to relate furnish changes to paper-machine operation. This is a notoriously difficult task to accomplish, especially over the long term, since a multitude of constantly changing and interacting factors have a bearing on the operating stability of paper-machines. In practice, it is virtually impossible to isolate the effect of one parameter from that of the others. Nevertheless, several observations on short term changes in paper-machine operation, brought about by changing stock parameters, have been made, which correlate well with the results of wet-web tensile strength tests performed using the experimental techniques outlined in Appendix 1. As detailed in this Appendix, the parameter generally used to characterise wet-web strength and correlate with paper-machine operation was maximum wet-web tension, at solids contents which reflect the ease of water removal from the wet-webs under standard conditions of drainage and pressing.

Most of the practical observations were performed on a high speed (850 m/min) Fourdrinier paper-machine making offset news. A non-contact, microwave moisture measuring gauge located at the first unsupported draw, after two press nips, was used to obtain a continuous readout of the sheet solids content (typically about 39 per cent) at this point. More details about the paper-machine can be found elsewhere(5) where it is designated as machine S. It is also discussed, in this reference, that the determining factor, influencing paper-machine stability, is wrinkling in the first few unsupported draws of the dryer section. This problem can be primarily contained by an increase in web dryness after the last press nip, which results in increased stiffness of the wet-web and less susceptibility to wrinkling.

### *Case 1*

### *Effect of variations in the kraft pulp content of a newsprint furnish on wet-web strength and paper-machine operation*

THE cost of the chemical pulp component of newsprint may be as high as three times that of the groundwood component, and reduction of the chemical pulp proportion of the furnish is a natural choice of projects aimed at reducing production costs. However, any modification of the furnish (e.g. kraft pulp refining), aimed at reduction in chemical pulp content, must not be accompanied by reduced paper-machine efficiency resulting from lower wet-web

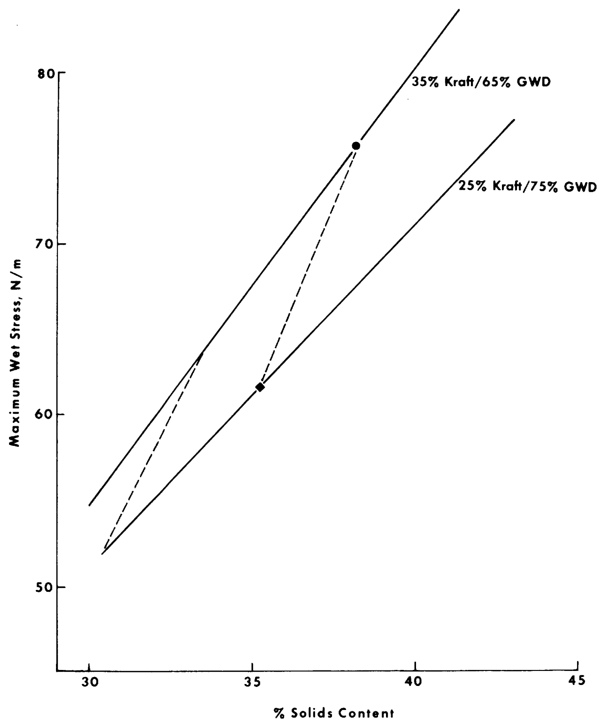


***Fig. 2***—The effect of varying the kraft content of a newsprint on wet-web strength. (Broken lines join points of equivalent pressing)

strength. Thus, it is important to assess the magnitude of the influence of variations in kraft content on a newsprint furnish wet-web strength.

Fig. 2 is a plot of wet-web strength as a function of solids content for two levels of unrefined semibleached kraft (SBK) content in a newsprint furnish. Broken lines join points of equivalent pressing. An increase of about 3 percentage points in solids content results when the SBK content is changed from 25 to 35 per cent in the furnish. At the same time, wet-web strength rises by 25 per cent (from 60 to 75 kN/m for the points of equivalent pressing indicated in Fig. 2). It is clear that comparing wet-web strengths at a fixed solids content (as opposed to a fixed pressing sequence) in Fig. 2 would significantly underestimate the influence of kraft content on wet-web strength.

The above observations agree with those of practical experience on high speed news machines, where increased proportions of kraft pulp are known to enhance water removal and reduce wet-web breaks. An opportunity to establish the magnitude of the increase in solids content with the proportion of kraft in a newsprint furnish, under practical conditions, occurred during a special lightweight newsprint trial on the paper-machine. The SBK proportion of the furnish was raised in steps from 30 to 34 per cent during the trial, in order to return to stable operation of the paper-machine. This was necessitated by unstable conditions which set in shortly after the basis weight was reduced, as a result of the deleterious influence of rewetting in the outgoing press nips. Fig. 3 is a plot of solids content, monitored by the microwave moisture gauge, as a function of SBK content. The rate of increase of the

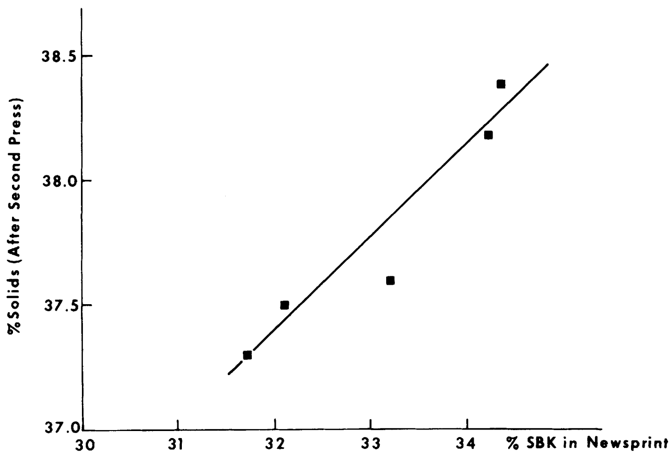


*Fig. 3*—Percent solids after second press on paper-machine S as a function of percent kraft during lightweight newsprint trial

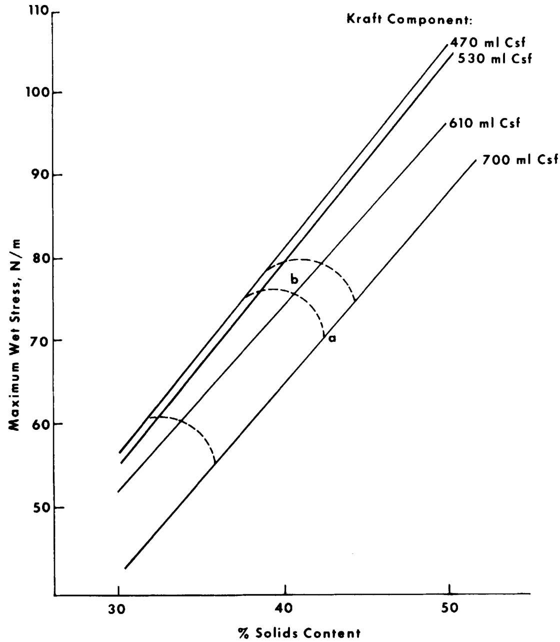


***Fig. 4***—The effect of beating the kraft component of a newsprint furnish on wet-web strength. (Broken lines join points of equivalent pressing)

former with the latter is comparable to that found in the laboratory observations in Fig. 2.

### *Case 2*

*Effect of refining the SBK component on newsprint furnish wet-web strength*

In connection with other mill studies, it was required to establish whether, and to what extent, refining of the SBK component of the furnish will have a positive effect on mixed furnish wet-web strength. In order to investigate this, the SBK component of a newsprint furnish was refined in a laboratory PFI mill to four freeness levels ranging from 700 ml Csf (unrefined) to 470 ml Csf. Fig. 4 contains results of wet-web strength as a function of solids content. Broken lines again join points of equivalent pressing.

As SBK refining progresses, the mixed furnish releases water less readily, resulting in lower solids contents following fixed drainage and pressing sequences. This effect has a negative influence on wet-web strength. Opposing this, fibrillation of the surface and flattening of the kraft fibres, as well as increased fibre flexibility, permit the fibres to come into closer contact with each other. This has a positive influence on wet-web strength through increased opportunity for surface tension forces to act. The latter effect appears dominant in the early stages of refining, resulting in a net increase in wet-web strength as seen in Fig. 4. The figure also indicates that refining beyond the 600 ml Csf level is of little use in improving wet-web strength, and can even prove detrimental to paper-machine stability, because it inhibits water removal on the wire and in the press section of the paper-machine.

These results are in direct agreement with practical experience in one of our mills, where refining of the kraft component of newsprint is carried out. It should also be noted, from Fig. 4, that comparing wet-web strength at a fixed solids content would grossly overestimate the beneficial effect of kraft refining.

#### Case 3

*Effect of adding broke on the wet-web strength of a newsprint furnish and on paper-machine operation*

It is well known that the characteristics of broke are quite different from those of the corresponding virgin fibre. Paper-makers often take advantage of this to effect changes in paper-machine stability by varying the proportion of broke in the furnish. The influence of broke content on the wet-web properties of a newsprint furnish was investigated by wet-web strength testing of a furnish with no broke and with 30 per cent broke. The results are shown in Fig. 5. Comparing the results at solids contents corresponding to fixed drainage and pressing procedures (broken lines), the furnish containing broke is drier by about 1 to 1·5 percentage points, and possesses a marginally higher wet-web strength. Had the results been compared at a fixed solids content instead, the wet-web strength of the furnish containing broke would have been found lower. Again, two interacting physical effects are evidently influencing wet-web strength. First, the broke fibres tend to be stiffer than those of virgin stock, thus having a reduced capacity to conform to each other and come into closer contact in the web. This has a detrimental effect on wet-web strength. On the other hand, the furnish with the broke component releases water more easily under fixed drainage and pressing procedures. This has a beneficial effect on wet-web strength. The net effect is that the furnish with the broke possesses a marginally higher wet-web strength; its main influence on paper-machine operation is increased stability of operation as a result of the higher solids content in the first few unsupported draws.

The above observations are again in general agreement with practical experience on newsprint machines. The increased ease of dewatering of the

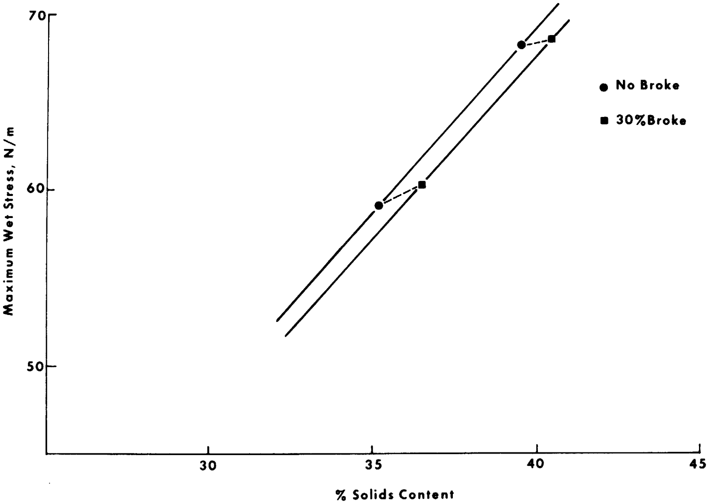


***Fig. 5***—Effect of addition of broke to a newsprint furnish on wet-web strength. (Broken lines join points of equivalent pressing)

web on the paper machine by the addition of broke to the furnish was confirmed during a special two-hour trial, in the course of which the proportion of broke in the furnish was increased from 5 to 30 per cent. The microwave gauge, situated after the second press nip, indicated that, within a half hour after the change, the solids content of the sheet increased from 38·4 to 39·6 per cent. The solids content was observed to decrease to 38·5 per cent when the proportion of broke in the furnish was reduced to 5 per cent at the end of the two hour period. The 1·2 per cent increase in solids content observed at the high level of addition of broke is comparable to that found in the labaratory observations (Fig. 5).

***Case 4***

*Effect of using previously dried as opposed to never-dried SBK on newsprint furnish wet-web strength and paper-machine operation*

NEWSPRINT is produced at both integrated and non-integrated mills. The latter generally purchase market kraft pulp, in bales or sheets, which is re-pulped prior to being blended in the mixed furnish. It is well known that drying has a significant effect on the wet and the dry strength properties of kraft pulps. In order to examine the influence of previous drying of the SBK component of a newsprint furnish on its wet-web properties, dried and never-dried samples of SBK were obtained at the dry end and the headbox respec-

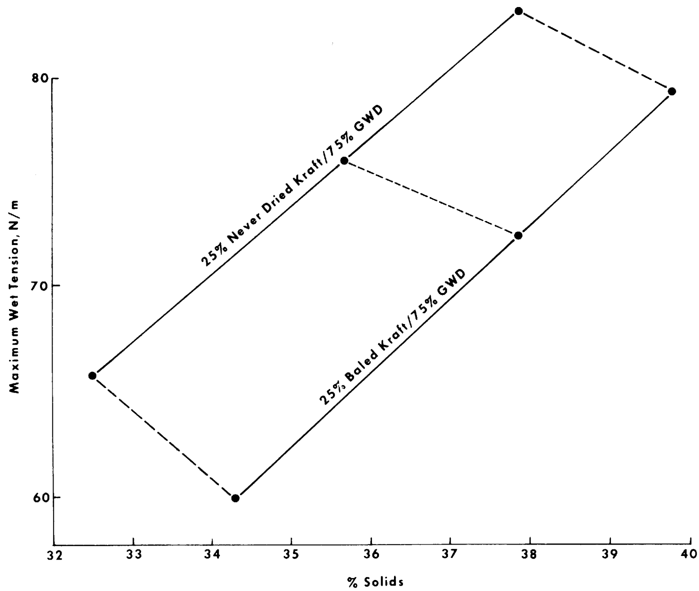


***Fig. 6***—Wet-web strengths of newsprint furnishes with baled (and repulped) and never dried kraft pulp in the furnish

tively of a pulp machine. The samples were taken within minutes of one another in order to eliminate changes in pulp quality due to causes other than drying.

Results of wet-web strength tests, carried out on newsprint furnishes containing the two types of kraft pulp, are given in Fig. 6. The furnish containing the previously dried SBK exhibits approximately a 2 per cent higher solids content following fixed drainage and pressing procedures (broken lines in the figure) than the one with the never-dried SBK. At the same time, the former furnish exhibits a wet-web strength which is roughly 5 per cent lower than that of the latter one, evidently as a result of the stiffening up of the SBK fibres upon drying, and a consequent reduction in their capacity to come into close contact in the web (a form of negative refining). Again, it must be stressed, that interpretation of the data at a fixed solids level, rather than at solids levels attained by each web following fixed drainage and pressing procedures, significantly overestimates the difference in wet-web strength between the two furnishes.

These conclusions of the laboratory work were largely confirmed during repeated trials on the paper-machine, in the course of which increases in solids content of the web after two press nips ranging from 1·9 to 2·2 percentage points were observed, when previously-dried SBK was substituted for never-dried SBK in the newsprint furnish. The increased dryness and stiffness of the wet-web has been known to improve paper-machine stability and to minimize wrinkling tendency in the first few unsupported draws (see also Reference 5).

### *Case 5*

*Influence of thermomechanical pulp on newsprint furnish wet-web properties and paper-machine operation*

FOLLOWING the startup of a thermomechanical pulp (TMP) plant at one of our newsprint mills, a number of trials have been run during the last year to study the impact of TMP on mixed furnish properties and paper-machine stability. Consistent observations were that, at a TMP:kraft replacement ratio* of 5:1, wet-web strength and ease of water removal from the furnish remained virtually unchanged. No significant changes in paper-machine stability were observed. The major change in paper-machine operation, brought about by the addition of TMP to the newsprint furnish, was a necessary reduction of the draws in the paper-machine press section of up to 30 per cent when TMP was the only component of the furnish (i.e. complete groundwood and kraft removal from the furnish).

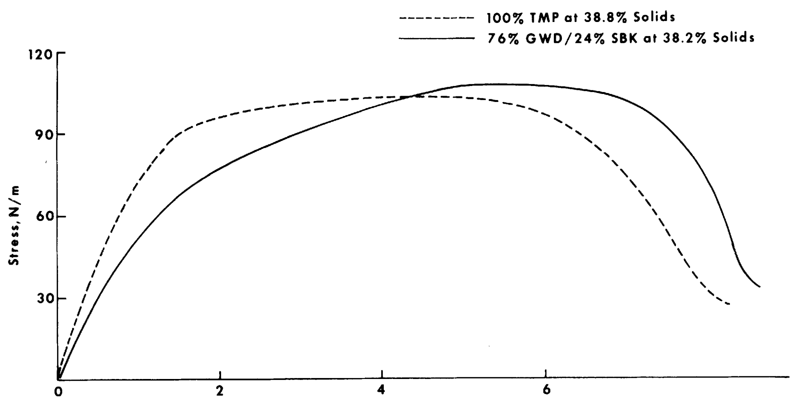


*Fig. 7*—Wet-web stress/strain curves of 100 per cent TMP and a 76 GWD/24 per cent SBK sheet

* For example: Addition of 25 per cent TMP to furnish made up initially of groundwood and kraft in the ratio 75:25 per cent, results in groundwood:kraft:TMP proportions of 55:20:25 per cent respectively.

The change in the press section draws observed on the paper-machine when TMP was included in the newsprint furnish, was readily explained upon examination of the wet-web stress/strain curves of a wet-web composed of groundwood and SBK (in the ratio 75:25 per cent respectively) and of a wet-web made up entirely of TMP. The curves, at solids contents obtained following fixed drainage and pressing procedures, are given in Fig. 7. There is virtually no difference in solids content or maximum tension between the two cases. It is obvious from the figure, however, that the draw (strain) to reach a comparable level of stress in the region of strain about 2 per cent (typical of that found in a high-speed newsprint machine press section) is significantly lower for the TMP sheet than it is for the standard groundwood:kraft sheet. This implies that a TMP sheet is stiffer than a groundwood:kraft sheet of approximately the same solids level. This conclusion was further supported by reports from the paper-machine operators that the wrinkling tendency diminished during trials with TMP in the furnish.

### Case 6

*Effect of variations in the zeta potential of the groundwood component on newsprint furnish wet-web strength and paper-machine operation*

THE rapid escalation of costs of installing new papermaking capacity in recent years has forced most newsprint manufacturers to turn to speeding up existing paper-machines in their efforts to increase production volume and reduce unit costs. A prerequisite to effecting an increase in speed, on many paper-machines, is enhanced water removal from the wet-web on the wire and in the press section of the paper-machine. One of the conditions that should be met for the optimum water removal is for the pulp slurry to possess the correct zeta potential.

A laboratory investigation of the influence on a newsprint furnish wet-web strength, of variations in the zeta potential of the groundwood component, was conducted on three mixed furnish samples; a control sample with zeta potential of the groundwood component unadjusted at $-16$ mV, a second sample with groundwood at a zeta potential adjusted to 0 mV by the addition of aluminium sulphate, and a final sample containing groundwood made highly electronegative by the addition of sodium hexametaphosphate.

Table 1 contains the results of wet-web strength testing following two fixed pressing sequences, as well as the oven dry basis weights of the test sheets made from each sample. The basis weight target was 44·9 g/m$^2$ in all three cases, and sheets were made from the same volume of pulp slurries possessing the same consistency. Thus, any differences in the oven dry basis-weight, among the three samples, reflect corresponding differences in retention of fibres during the sheet making process.

TABLE 1—WET-WEB STRENGTHS OF NEWSPRINT FURNISHES WITH GROUNDWOOD COMPONENT OF VARYING ZETA POTENTIAL

| *Zeta potential of groundwood component (mV)* | *Oven dry basis weight ($g/m^2$)* | *Solids* content (%)* | *Wet-web† strength (kN/m)* |
|---|---|---|---|
| 0 | 44·1 | 35·2 | 49 |
| | | 45·5 | 73 |
| −16 | 43·1 | 33·7 | 47 |
| | | 42·6 | 66 |
| −26 | 42·0 | 35·3 | 51 |
| | | 45·0 | 69 |

* Obtained by two fixed pressing sequences
† Corrected to 44·9 $g/m^2$ oven dry basis weight

A first observation from Table 1 is the fact, that the less electronegative the groundwood component is, the better the retention will be. A second observation is that the control sample (groundwood at a zeta potential of −16 mV) is the weakest as well as the one with the lowest solids content following fixed drainage and pressing procedures. In comparison, the least electronegative sample (groundwood at a zeta potential of 0 mV) dewaters more readily through an effective reduction in the hydrodynamic volume associated with its fibres; while the most electronegative sample (groundwood at a zeta potential of −26 mV) dewaters more easily as a result of an effective increase in chemical pulp component of the wet web, through the relatively high loss of groundwood fines in the sheet making process.

The paper-machine involved in practical observations in this case was a relatively slow (500 m/min) Fourdrinier which has an open draw between the couch and first press. On two separate occasions, the effects of modification of the zeta potential of the groundwood component of a newsprint furnish on the operation of the paper-machine were monitored, and they are detailed below.

In the first, replacement of groundwood, made from a predominantly hemlock and balsam fir wood supply, by one made from Douglas fir, led to a significant change in the groundwood zeta potential from −6 to −14 mV, as a result of the reaction of the different wood species to brightening chemicals. The electrokinetic change had a significant effect on the operation of the paper-machine. The stock was more difficult to drain, and several adjustments to the operating conditions, such as an increase in stock temperature of 8° C, were necessary to maintain constant operation. These changes could be attributed to different fibre characteristics of the two groundwoods, despite the fact that the wood species change was accompanied by a relatively small change in freeness. However, when the wood supply reverted to the original hemlock: balsam mixture, its zeta potential, as measured on headbox samples, remained at the high electronegative level associated with the Douglas fir groundwood. This was apparently caused by the influence of residual chemical in the recirculating white water; and its effect on paper-machine operation was evident for some time until the white water characteristics returned to normal.

In the second case, the zeta potential of a standard newsprint furnish was deliberately changed from $-17$ to 0 mV by the addition of cationic starch (20 kg/tonne) to the groundwood. In this case, drainage improved and fines retention increased, as evidenced by the reduction of vacuum box white water consistency from 0·068 to 0·047 per cent, and single pass retention of stock on the wire increasing from 56·6 to 61·6 per cent.

Variations in drainage effected by changes in the electrokinetic characteristics of the stock occurred, in both cases, towards the end of the drainage section, while there was only a marginal change in white water consistency in the early part of the drainage table. This behaviour appears to be typical of such situations, and has been noticed in other areas of papermaking, such as the improvement in filler retention during wet pressing of fine papers. It would appear that the electrokinetic effects come into prominence only after the subsidence of the relatively turbulent hydrodynamic disturbance of the stock normally associated with the early stages of drainage.

## Part 2—Comparison of wet-web burst, with wet-web tensile strength

IN order to establish the feasibility of assessing wet-web strength by wet-web burst testing, groundwood, kraft, broke and headbox stock, collected from a high-speed Fourdrinier, were evaluated on the wet-web burst tester which is described in Appendix 1, and the RMK wet-web tensile stress/strain analyser. The same drainage and pressing sequences were used in both cases to obtain two or three solids contents and corresponding strengths for individual pulps. Fig. 8 shows the results of one method of measurement plotted against those of the other. The relative wet-web strength levels measured by either method correlate well for the various pulps. The wet-web burst test also differentiates quite readily the relative strength levels of various pulps of the same type, as evidenced by results for groundwood and thermomechanical pulps given in Table 2.

These data indicate clearly that the wet-web burst test represents a simple, rapid and reliable means of assessing the relative wet-web strength of pulps at the mill. An improved version of the prototype instrument, equipped with

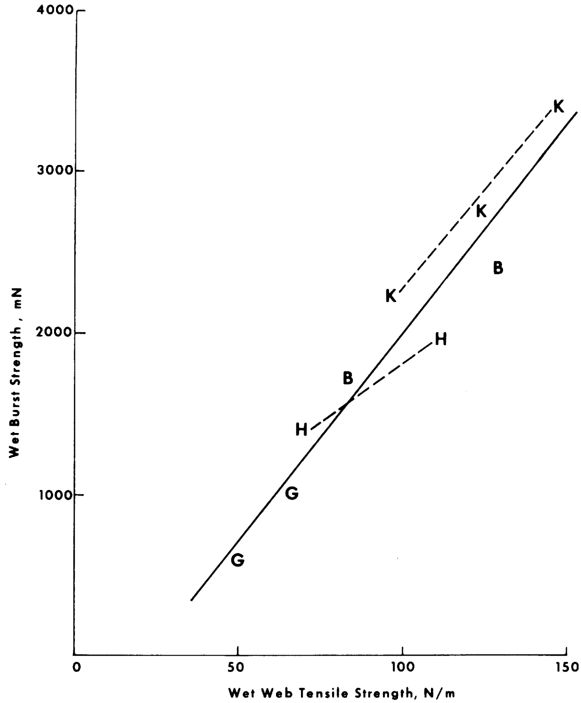


***Fig. 8***—Correlation between wet-web tensile and wet-burst strength for groundwood (G), semi-bleached kraft (K), broke (B), and headbox (H) stocks

electronic stress/strain gauges and readouts, is under construction. Ultimately, it may prove possible to monitor the wet-web burst strength of couch trim sampled directly off a paper-machine (collected ahead of the trim showers), without having to resort to the long and tedious procedure of sheet prepara-

TABLE 2—WET- AND DRY-BURST STRENGTHS OF GROUNDWOOD (G) AND THERMOMECHANICAL (T) PULPS

| *Pulp* | *Freeness (ml Csf)* | *Dry-burst index (kPa·m²/g)* | *Wet-burst strength (mN)* | *Solids (%)* |
|---|---|---|---|---|
| G1 | 80 | 1·10 | 540 | 25·2 |
| G2 | 170 | 0·49 | 145 | 28·5 |
| T1 | 128 | 2·2 | 860 | 25·0 |
| T2 | 142 | 1·7 | 645 | 24·8 |

tion prior to testing in the laboratory. The potential benefits afforded by this capability in monitoring paper-machine stability are very great. An initial evaluation of the wet-web burst strength of couch trim, off the high-speed Fourdrinier paper-machine discussed earlier, has given a mean wet-web burst strength value of 700 mN with the 95 per cent confidence limits at 40 mN from 30 individual tests carried out in about 10 minutes.

### Discussion and conclusions

The ease with which a pulp dewaters on the wire and in the press section of a paper-machine is an integral and important aspect of paper-machine stability, and one that should always be included in any meaningful and realistic evaluation of wet-web strength properties.

It has been demonstrated that simple laboratory techniques can, with care, be employed to differentiate pulps from the point of view of their water holding tendency in a realistic manner. These techniques were used successfully in the preparation of wet-webs for strength evaluation. Results from the tests were shown to correlate closely with practical observations of the behaviour of webs on newsprint paper-machines.

Increasing the kraft content of a newsprint furnish benefits process stability by improved dewatering and higher wet-web strength, while refining of the kraft component in the furnish benefits wet-web strength but inhibits the dewatering process. Refining the chemical pulp component of newsprint to a freeness level of about 600 ml Csf appears to represent an optimum condition for the kraft component of a newsprint furnish.

The beneficial influence of repulped broke to runnability appears to arise from dewatering, as is the case when previously dried and repulped kraft is used instead of never-dried kraft in a newsprint furnish.

Adjusting the zeta potential of the groundwood component of newsprint to zero, from its normally electronegative level, improves fines retention on the wire and enhances dewatering. The major impact that news grade thermomechanical pulp has on paper-machine operation is that it causes a reduction in press section draws. Both wet-web strength and ease of dewatering of mixed furnishes remained virtually unchanged when thermomechanical pulp was used to replace kraft in the ratio (TMP:kraft) of 5:1 in a newsprint furnish.

Wet-web strength evaluation has, in the last few years, assumed increasing importance to both pulp and paper mills. Since most of the work to date has been performed in the laboratory, commercially available wet-web testers have tended to be precise but, at the same time, delicate, slow, intricate, and expensive, thus being generally unsuitable for routine testing in the mill environment. Recognising this deficiency of commercial equipment currently available, an attempt at circumventing these problems has resulted in the design of a rapid, simple, rugged and inexpensive wet-web burst strength tester. An initial evaluation of the tester has shown that its results correlate well with those of well established wet-web tensile testers. The speed, simplicity and versatility of the wet-burst tester should make it a valuable diagnostic tool for process monitoring and optimisation in the mill.

In conclusion, wet-web strength testing has reached a mature stage in its development; it can be taken from the research laboratory to the commercial plant where its use in process monitoring, control and optimisation, in both the pulp and the paper mill, will prove invaluable.

*Acknowledgements*

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**Appendix 1**—*Experimental techniques*

*Sheet making*

SHEET preparation is as important to wet-web testing as the test procedure itself. The method followed is to make sheets of 44·9 g/m² oven dry basis weight (corresponding to 48·8 g/m² air dry basis weight assuming a 7 per cent moisture content) in the British Standard sheet machine. A mold is used on top of the wire, giving three $12 \times 2{\cdot}54$ cm strips per sheet. Following couching in the normal manner, the sheet is pressed as outlined below.

*Sheet pressing*

In the initial stages of the work the pressing procedure consisted of sandwiching the couch blotter and sheet between two dry blotters and passing the sandwich under the nip formed between a slow turning rubber roll and a rigid plate. The solids content of the sheet can be varied by varying the number of passes underneath the press roll and/or loading the roll with varying weights. Fresh blotters are used prior to each pass. This method works exceedingly well provided a supply of uniform blotters is available, and it is most suitable for short-term investigations.

A more recently used technique, which circumvents the problems of changes in the uniformity of blotter quality, is to use a slow laboratory felt press to press the sheet and couch blotter in a single pass. The resulting solids content can be changed by varying the line pressure in the press nip.

With care, following the same sequence on the same pulp, the solids content of the wet-web varied on average by 0·2–0·3 per cent.

*Sheet testing*

*Commercial wet-web tensile tester* As soon as pressing of a sheet is completed, the sheet is tested at an absolute strain rate of 5 cm/s on an RMK wet-web stress/strain analyser.(4) Following the rupture of individual strips, they are immediately folded in aluminium foil sections for subsequent weighing to assess basis weight and moisture content. Six individual tests are carried out on wet-web strips pressed by each of two or three predetermined pressing sequences to solids contents representative of the dewatering capacity of different pulps. In all cases, wet-web strength and solids contents are reported at points of equivalent drainage and pressing procedure.

With regard to the parameter employed to characterise wet-web strength, the approach followed has been one of maximum simplification coupled with making the results as meaningful as possible. Since no single wet-web parameter (stress at break, wet-rupture energy, energy to $3\frac{1}{3}$ per cent strain(4)) has been consistently identified as the most relevant parameter to correlate with paper-machine runnability, maximum wet tension was chosen as the representative parameter. The logic behind this is that a web will transfer successfully across an unsupported draw, as long as it is capable of withstanding the stresses necessary for its transfer across the draw. In fact, this and the modulus of elasticity of the web determine the draw.

It was first confirmed that wet-web strength, as defined here, varies linearly with basis weight and solids content in the range of interest (20–30 per cent for a paper-machine with an open draw after the couch, and 30–45 per cent for a machine equipped with vacuum pickup). The rate of change of wet-web strength with basis weight of solids content, however, may be different for different pulps.

*Rapid wet-web burst strength tester* Fig. 9 is a schematic diagram of the prototype wet-web burst strength tester which was developed for use in a mill environment.

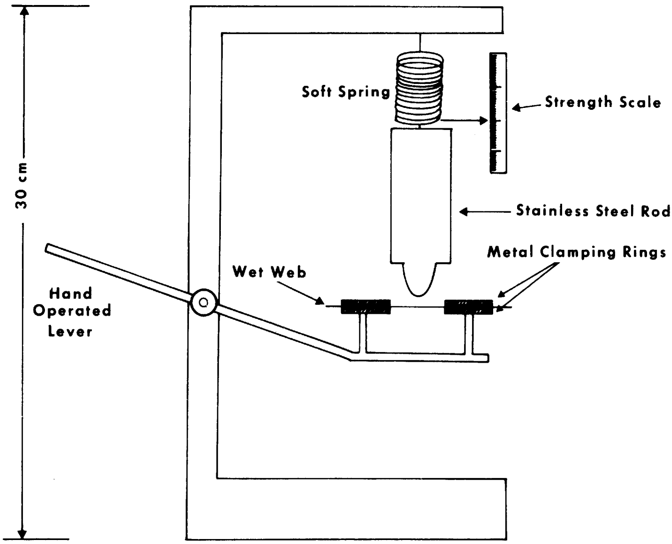


***Fig. 9***—Original wet-burst tester

A wet-web is clamped between two metal rings of internal diameter 2·5 cm. The rings are then moved slowly upwards, pushing the web against a 1·25 cm diameter stainless steel cylinder rounded at its lower end. The cylinder is suspended from a soft spring. The maximum force required to puncture the web is obtained on a calibrated scale, and it is used to characterise wet-web strength. For the mill laboratory, the sheet pressing procedure has also been simplified in this case. Following couching, the couch blotter and sheet are sandwiched between two dry blotters on a flat surface, and the couch pin is rolled over the sandwich twice.

## Transcription of Discussion

# *Discussion*

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*Mr J. L. De Yong* I understand that when you are testing wet webs the maximum tensile strength is dependent on the rate of loading. And I was interested to know how you managed to get such consistent results with your hand operated instrument.

*Ionides* From the start we realised that this might be a problem so we decided to operate at very low rates. We take about thirty seconds per test. Our new tester which is equipped with stress/strain gauges will be able to perform the test in less than half a second. With our current instrument all you need is a reasonable amount of care.

*Dr J. Mardon* If I could just add one point. With conventional testers, if you are operating at low rates then for example the difference between two inches a second and three inches a second are relatively small, whereas the differences between two inches a minute and two inches a second are relatively large.

*Prof. R. Marton* When and where will this instrument be on the market?

*Ionides* I will be able to answer that question in a few months' time.

*Mr J. W. Swanson* In making wet web strength tests one of the difficulties is in ensuring the uniformity of moisture content of the specimen during the test. Usually the clamping causes an increase in moisture content round the clamp. Did you find any non-uniformity in your specimens?

*Ionides* Most of our problems were associated with the tensile tester where we often found that breaks occurred close to the clamp. Those measurements were of course rejected from the final result. With the burst tester the stainless steel finger takes out a neat hole through the paper. This happens up to solids contents of about 45 per cent.

*Under the chairmanship of J. Mardon*

*Mr D. M. Wilkinson* Do you think breaks which occur in the wet web are attributable only to the strength of the wet web or to the ratio between the wet web strength and the adhesion of the wet web to the roll from which the web is being pulled? If the latter, and our experience is that it is, I think a study of the ratio of those two parameters could be useful.

*Ionides* To peel off a web from a surface and draw it across a gap you must exert a certain amount of tension. A large number of breaks occur close to the peeling point as a result of the response of the viscoelastic wet web to the step increase in tension encountered upon entering the open draw.