High Speed Paper Machine Design for Bagasse Containing Papers

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INTRODUCTION

Bagasse can be produced in a variety of types of pulp for different paper grades. Fully bleached chemical pulps can be produced from Soda or Kraft process and can be used in :

Fine papers	up to 90% of furnish
Newsprint papers	up to 60% of furnish
Tissue papers	up to 75% of furnish

Unbleached or semi-bleached pulps can be produced from Kraft or NSSC process and can be used in :

Bag and Wrapping papers	up to 65% of furnish
Kraft Packing papers	up to 50% of furnish
Multi-ply and Corrugating papers	up to 60% of furnish

The recent developments by Beloit indicate that mechanical pulps can be produced, which can be used in :

Newsprint	up to 75% of furnish
Board Grades	up to 50% of furnish

The indication of amount in furnish is a guide only and of course, depends upon the exact product specification and the other furnish components.

As far as the availability of bagasse is concerned, this is well discussed elsewhere and suffice is to say, that for many countries of the world and particularly India, it is readily available. There are technical hurdles to utilisation and reference to properties of bagasse compared with wood, indicates some of the areas of difference. Refer to table No. 1.

TABLE NO. 1

COMPARISONS OF BAGASSE WITH WOOD

	Ash %	Lignin %	Pentosans %	Cellulose %	Typical Fibre Length (L) mm	Typical Fibre Width (W) mm	L/W
Typical Indian Bagasse	1.8	16.5	25.8	55	1.5	0.022	68/1
North American Spruce	0.2	27	8	61	3.5	0.030	120/1
Hardwood (Aspen)	0.3	18	17	64	1.3	0.023	56/1

*Beloit Walmsley and Jessop and Co.

Note the low level of lignin and high level of Pentosans. These are problems for the pulp mill design, together with the well discussed problems of physical form, handling and harvesting and pith content.

For the paper maker and paper machine designers, we concern ourselves with the other aspects of the bagasse pulp, the typical fibre properties. Note the differences af a bagasse fibre to softwood. Of particular importance is the relatively low fibre width. This together with the narrow walled parenchyme cells, which are typically present in bagasse pulps from the pith element, produce the major technical problems.

The thin-walled fibres and other elements, produce problems in Refining, Drainage, Pressing and Calendering and produce tendencies in the paper of high sheet density, compaction and low porosity. However, despite this, the properties of the fibres, with regard to strength and optical properties are good and so bagasse must be considered on excellent raw material. Refer to table 2.

Having note of the areas of concern, it is the paper machine designers job to design out the problems. We will consider more closely these specific areas.

Refining of Bagasse Pulps

The specific edge load theory and total net power consumption are the criteria most often used to quantify refining. The specific edge load theory is really a way of describing the gentleness or severity of impact which the fibres undergo.

It is then possible to classify the severity of refining action at the bar edges as the bars cross by use of the term Intensity or specific edge load.

$$\text{Intensity} = \frac{\text{HP}}{\text{inch crossings/min}}$$

$$\text{Specific edge load} = \frac{\text{W}}{\text{km/sec}}$$

The levels of intensity of refining can then be ascertained, by experimental trial and evaluation of

TABLE NO. 2

TYPICAL PROPERTIES OF SOME CHEMICAL PULPS

PROPERTIES	UNITS	TYPES OF PULP		
		CBP	HWP	BKP
FREENESS	ml	480	480	445
BULK	cc/g	1.7	1.8	1.8
BREAKING LENGTH	m	6000	6000	8600
BURST FACTOR	—	35	32	37
TEAR FACTOR	—	55	60	180
SCATTERING COEFFICIENT	cm^2/g	300	500	190

LEGEND :

CBP — Chemical Bagasse Pulp
HWP — Hardwood (Eucalyptus) Pulp
BKP — Bleached Kraft Pulp (Softwood)

NOTE :

1. All pulps are bleached—brightness 78°GE
2. BKP was refined in a PFI mill

Beloit Walmsley[2]

operating units. Typical results for wood pulps are then :

Pulp Type	HP / Inch crossings/min	W.S. / km
Unbleached Softwood Kraft	2.5	4375
Bleached Softwood Kraft	2	3500
Lleached Hardwood Kraft	0.8	1400
Groundwood	0.7	1200

Bagasse pulps, being of similar length to hardwood pulps but being thinner fibre wall, require refining at a lower intensity than the hardwoods. Thus a target value of 1000 W.S/km would be typical.

This causes a problem in refiner selection, due to the normal limitation of bar width and groove width and normal limitation of refiner speed, due to increasing no-load.

The solution is two-fold. Firstly, the pulp strength must be maximised in the pulp mill via correct handling, cooking, refining must be carried out with specially designed refiner plates to give low intensity. The Beloit Jones DD 4000 Series refiner will accomplish this and the new development of Multi-disk refiner will even produce strength improvements, so far not considered possible for bagasse pulps.

Drainage on the Pnper Machine

The area we consider mostly with regard to drainage is the forming section of the machine. Within this area, the most important item is the headbox giving the correct fibre dispersion and flow of stock into or into the forming wires. The Beloit design is termed Converflo and many hundreds of such boxes are working around the world.

The Converflo headbox (Figure 1.0) comprises a rectangular tapered header, which normally runs with ten percent recirculation to ensure even pressure distribution across the width of the machine. From the header, the flow proceeds to a tube bank distributor, which acts as a pressure diffuser to ensure that the fibre suspension is changed from cross-machine direction to machine direction uniformly. Following the tube bank, the individual stream tubes emerge into a stilling chamber which evens out any pressure and flow variations. Immediately following the stilling chamber is a drilled support plate and converging flow section comprising a series of sheets (or vanes) which are attached to the drilled plate at their upstream ends by means of dovetail slots.

FIG. 1.0

The Converflo sheets form a series of small channels which are some 12 to 37 mm wide at the upstream end and down to the order of 4 mm or less at their downstream ends. Of course, this exact dimension on the downstream end depends on the number of channels and the slice opening, which varies from grade to grade and depends on the prevailing operating conditions.

The heart of the headbox is the converging flow zone (Figure 2.0) where the trailing sheets provide shear planes, which cause the accelerating fibre suspension to have macro scale turbulence supressed and micro scale turbulence promoted.

FIG. 2.0

The ensuing jet issues from the slice with fine scale micro-turbulence which ensures well dispersed fibres and promotes excellent sheet formation.

Bagasse pulps, like wood pulps, always suffer when run on fourdrinier paper machines, from the single-sided drainage action. This may be more severe in the case of bagasse, due to the fibre characteristics already mentioned. Correct fourdrinier table length and table make-up are then important design parameters. However, the inherent two-sidedness can only be overcome with twin wire forming.

The Beloit Bel Baie II has been in the forefront of formers developed to overcome this problem over the years. This itself has now been developed into the Bel Baie III. (Figure 3.0)

This has left many fourdrinier user in something of a quandary, since they may be using relatively new fourdrinier equipment with good efficiency and as such a total new wet end would put the operation into an economically unviable situation and yet on the other hand, they cannot compete with the quality of twin wire producers.

To help solve this problem, Beloit have developed three formers which can be installed onto existing fourdriniers to enable two-way drainage to take place and thus alleviate, to a large extent, these problems. Only two of these formers are applicable to bagasse containing papers and it is these we are now going to discuss.

Top wire formars (sometimes called hybrid formers), are the result of adding a top wire forming unit to a fourdrinier. The papermaking goals, as outlined, are to eliminate the normal two-sided characteristic of a fourdrinier sheet whilst improving overall sheet quality. Another common goal is to eliminate wet end drainage limitations so that production rates can increase. The fourdrinier generally exists (although new installations can and do take this form) and maximum use is made of existing equipment and its supporting structure. Minimum change to existing plant and equipment results in short shut-downs to install top wire units.

FIG. 3.0

Bel - Bond Former

The Bel-Bond Former is a vaccum former capable of satisfying a wide range of speed and weight conditions (Figure 4.0). It utilises a wire wedge which, in combination with turning radius and wire tension, moves surface water to the inside of the top wire (Figure 5.0) for eventual extraction to the machine silo. Equipped with the necessary operation controls, this area becomes a tool to achieve the best combination of formation and sheet test, prior to "freezing" the sheet by application of vacuum. Vacuum dewatering occurs by allowing the two wires (and the sheet) to warp the curved, inverted vacuum box (Figure 6.0) where substantial amounts of water are removed. Entering consistencies vary with basis weight and grade (.9 to 1.5%) and exiting consistencies also vary from 12% to 14%. The Bel-Bond can remove in excess of 50% of the headbox flow, although most applications operate in a 40/60 relation-ship – 40% up and 60% down.

FIG. 4.0

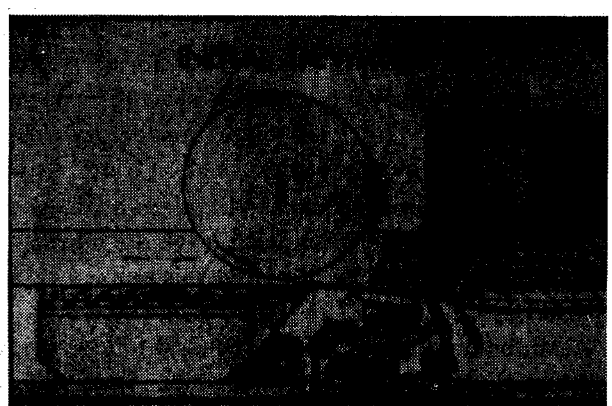

FIG. 5.0

FIG. 6.0

This unit is currently producing highly filled woodfree papers with ash levels in the 20% + range.

Bel-Form Former

The Bel-Form Former (Figure 7.0), Beloit's most recent top wire former, combines the best papermaking features of other Beloit formers whilst retaining the low energy characteristics of a roll former. Stock enters the wire wedge formed by the top and bottom wires as they converge on the radiused first strip of the lead-in box (Figure 8.0.). The lead-in roll is adjustable vertically so the "wedge" can be "opened" or "closed" by the operator as he optimises formation and/or other properties. Wedge shear and its effect on formation is proven by every Bel-Bond installation. The sheet then moves to the bladed portion of the forming shoe (similar to the Bel-Baie forming shoe) where low intensity pulsing further enhances formation. These blades scribe a continuous radius and the water removed here (as high as 3 litres per minute per millimetre of wire width) is extracted by the auto-slice and ultimately to the machine silo. Additional dewatering in two directions occurs at the "centre" roll (via centrifugal force and "pumping" effect) as the wires (and sheet) return to wire elevation. Final dewatering occurs as the sheet is transferred to the bottom wire. This former is energy conscious (reduction in drive load is anticipated) and spray and mist are minimised by the proper control of white water and air (Figure 9.0.). It allows the operator to optimise formation-compensating for stock and freeness variations within the former (Figure 10.0).

FIG. 7.0

FIG. 8.0

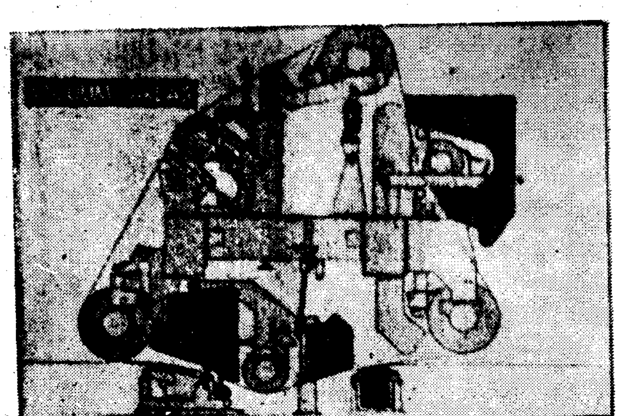

FIG. 9.0

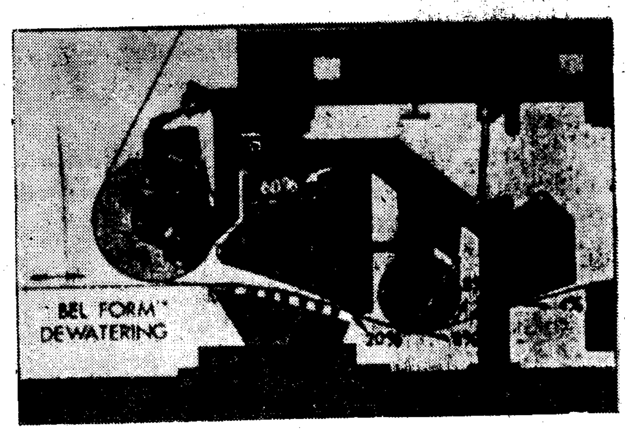

FIG. 10.0

Fourdrinier Impact

It is easy to forget that an important part of every top wire former installation is the fourdrinier table which precedes it and the vacuum section which follows it. Fourdrinier technology varies only slightly from long-accepted standards, but it does vary.

1. Slice, breast roll and forming board relationships (level, square, settings, conditions etc.) become more important than before, time must be taken during the top wire installation to make necessary improvements and/or adjustments.

2. It is important to have a good supply of flat, true, low angle foil blades available-quantities required are much reduced but every blade becomes critical when so few are in service. Experimentation with spacing and angles is encouraged because every installation is a little different.

3. At least one vacuum-assisted foil box should be available for use just ahead of the former. Blade quantity can vary, but narrow spacing is a must and flat angles (0°, 1/4°) are mandatory. Hign angles, poor quality blades, and/or wide spacing create stock jump and disturb the sheet at the worst possible time. Low vacuum levels are all that is necessary to set the fibre mat at this point.

4. A minimum of flatboxes are required following the former. Drive loads will escalate, fines will be pulled from the sheet and little additional dryness is achieved if flat boxes are used injudiciously. Most

formers run with only one or two boxes when they used anywhere from four to six as a fourdrinier. If intermediate wire support is necessary, a conventional foil in reverse attitude is used to avoid fines extraction from the sheet.

5. Excessive fourdrinier wire tension levels are not necessary. It is important that tensions at the dewatering point are uniform top to bottom but rebuilding fourdrinier wire runs to increase slack wire tension level is rarely required.

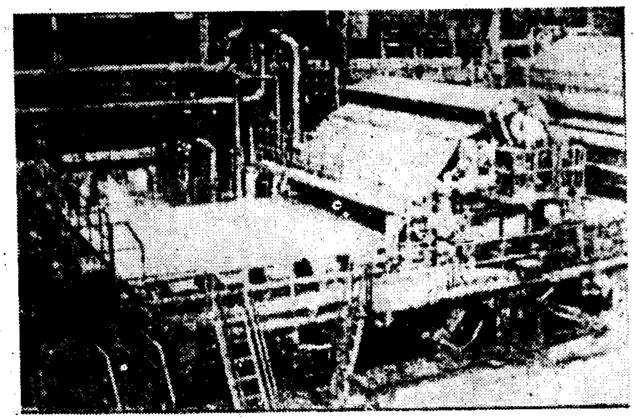

FIG. 12.0

Application of Beloit Top Wire Formers

The Bel-Bond end the Bel Form allow for application on literally any weight at any spced with the ability to meet a wide variety of special requirements. This is best illustrated graphically (Figure 11.0) where we see Bel-Bond applications from 100mpm to 1000 mpm with paper weights as high as 500 grammes per square metre at the low speed end. The Bel-Form range is from 270 mpm and upwards with basis weights in excess of 150 grammes per square metre.

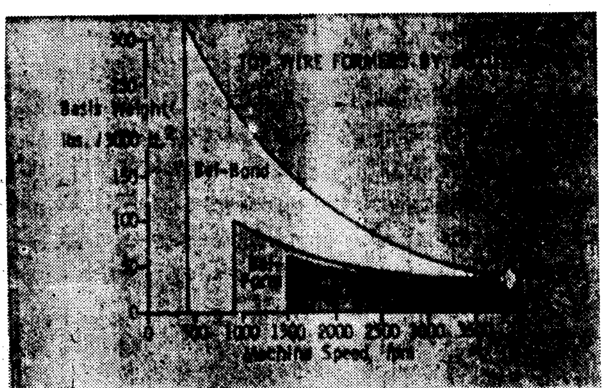

FIG. 11.0

The Bel-Bond pictured here is on a fine paper machine (Figure 12.0). The machine was making 60 to 110 grammes per square metre fine paper (woodfree furnish) when the top wire was added to improve quality.

Pressing of Bagasse Pulps

Having seen how to overcome the poor drainage characteristics of bagasse, the same type of consideration must be given to press part design. We must note the limitation of press- nip intensity and low flow of water within the sheet structure during pressing, due to the thin wall af the fibres and the low porosity/high debris level of the sheet.

Again, we point out the absolute essentials of correct handling, depithing and refining of the pulp, to avoid the worst problems. The desirable press function are :

1. Produce the dryest sheet possible into dryer section for energy saving.

2. Give good efficiency and runnability. Efficiency in the form of reduced downtime for felt change, runnability, meaning minimum lost time due to press breaks.

3. Ensure uniform sheet dryness from press.

There are many factors which influence the final choice of press, machine speed, basis weight, furnish and quality being the main influences.

However, one result of bagasse pulp is the difficult pressing and thus the generally lower outgoing press dry content, compared to wood pulps. This together with the physical low fibre length and fibre narrowness, results in usually lower wet web strength, again as compared with wood pulps. Thus the press section design must utilise :

Minimum open draw
Maximum number of nips at
lower intensity

Speed not only influences the number of press nips required, it also imposes limits on press configuration.

Basis weights below say 50 g/m² tend to necessitate closed draw presses even at relatively low speeds. Figure 13.0. Here we see a typical Compress with straight-through Venta nip second press.

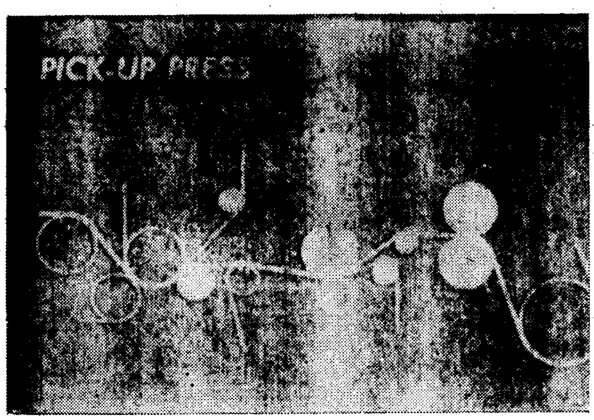

FIG. 13.0

There are many examples of this design press in operation, it provides good dryness, efficiency and dryness, uniformity at speeds up to 600 m/min. Paper qualities are good since there is a smooth roll surface presented to opposite sides of the sheet. The runnability of this press becomes worse with increased filler or increased speed. In recent years, basis weights have been reduced, speeds increased, filler levels have also increased, thus resulting in a reduced wet web strength and more wet end breaks.

The modern machine concept is to run speeds well above the 600 m/min rate. With this in mind, the most commonly chosen press on woodfree @papers has been the "Tri-Nip". Figure 14.0.

We have (32) such presses in operation on woodfree grades alone, in almost all cases, the main factor which influenced final choice was runnability.

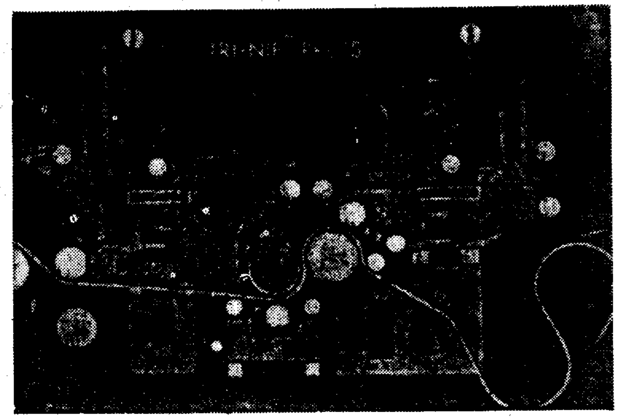

FIG. 14.0

This press as the name implies, has three nips with no open draws Runnability is excellent, wet end breaks almost eliminated. There are however some minus points in this press concept. Firstly, it gives two press nips over the same row of holes in the suction roll, therefore shadow marking can be a problem. Shadow mark can be overcome by correct choice of felt, small holes in the suction roll or running inner fabric. The other disadvantage and one which affects the sheet symmetry, is that since the last two presses act against the same side of the sheet, a two-sidedness is imparted to the web. Smoothness and ink absorption are significantly affected.

When uniform smoothness or ink absorption are important, then one must look to a press which presses the web on alternative sides against the hard roll. With this in mind, we consider the "BI-VENT" press as being the best overall suitable unit to provide the functions as previously mentioned without loss of paper qualities. Figure 15.0. This press provides the same double felted arrangement in the first press position as the TRI-NIP,

FIG. 15.0

however, after the first press we separate the second press nip into a Venta roll against the hard plain roll.

The Venta roll is a variable crown roll, this gives control of moisture profile and allows on-the-run nip load variation. The third press is a separate straight-through press, again a variable crown bottom Venta roll allows nip control and profile control, the hard top roll now contacts the opposite side of the sheet, thus enhancing surface symmetry of the sheet.

Another possible solution is the incorporation of a 4th press, single felted, after the TRI-NIP press. In this case, the sheet should run with the side which was pressed against the centre roll of the TRI-NIP against the felt. In conclusion, the final choice of press is a factor of all the installation parameters, including exact furnish, product, economics and operation.

Calendering Bagasse Papers

The caliper-smoothness interrelation which is influenced by calendering, is particularly important for bagasse, due to the caliper constraints mentioned. Therefore, the solution is good control, low nip intensity and good ingoing paper. The design of successful calender can then be brought easily within the range of modern practice.

The two roll, high nip calender is of limited use in bagasse containing papers. The high nip pressures required to achieve an objective are usually too high for the fibres. The fixed Queen calender is a suitable design. Figure 16.0 shows that the stack consists of a large diameter, driven, plain calender roll mounted

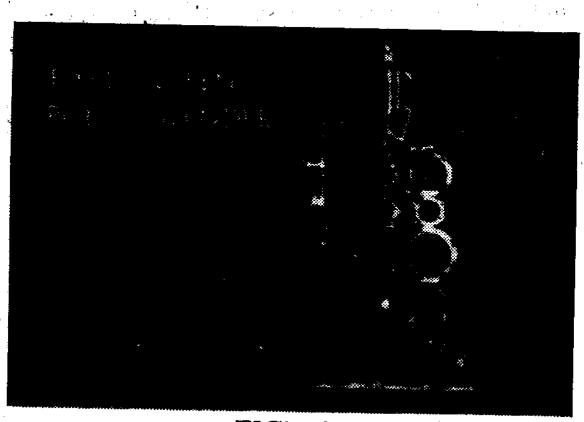

FIG. 16.0

directly to the framework with a Controlled Crown roll loaded against the bottom. This portion is basically the single nip calender. Above the Queen roll are two other rolls with the top being a Controlled Crown roll to accommodate ease in maintaining sheet profile for these upper nips. The top roll also has the capability of being loaded if additional nip pressure is required.

The fixed Queen is used on non-groundwood fine paper and unbleached Kraft grades. The fixed Queen allows sheet smoothness to be obtained at lower nip pressures than the single nip because now there are three nips to do the job. The loading arrangement of the fixed Queen allows for a wide pressure range at each nip. The arrangement also allows for nip relief to be incorporated for obtaining a level sheet where required. The fixed Queen too has some limitations. The bottom roll load is still limited to the medium width machine range because of roll size. The stack has relatively high nip pressures which are not suitable for all paper grades.

The Versa-Nip calender has been developed to provide a broad range of finishes basically independent of caliper requirements. Because of the great flexibility of this calender, it can be used on wide, high speed machine, required to run a large range of grades and on newsprint machines to run a single stack while maintaining desired caliper and eliminating vibration.

The general arrangement of the Versa-Nip is shown in Figure 17.0. The stack normally consists of a driven bottom Controlled Crown roll and one or more Controlled Crown rolls in the intermediate positions. The quantity of intermediate Controlled Crown rolls is determined by the range of grades to be run on the machine. Arrangements can also be designed for top roll loading if required. Intermediate roll nips are designed for roll relief and, with the Controlled Crown roll, roll loading if needed. The design of the entire stack is based on the concept of the straight, level nip. Therefore, the intermediate Controlled Crown rolls are designed with dual shoes to allow load compensation at the top and bottom of the roll.

To illustrate operating principles of the Versa-Nip, let us compare it to a conventional calender equipped with roll relieving and an anti-deflection bottom roll.

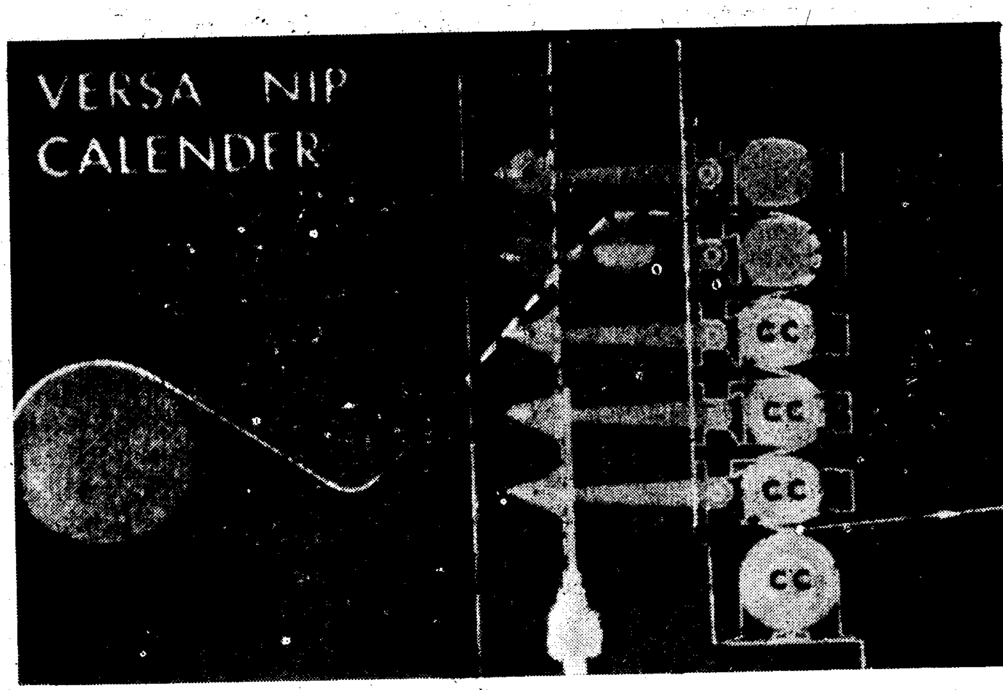

FIG. 17.0

In the conventional stack with relieving, the overhung weight at the roll journals is relieved and sufficient compensation is applied to the bottom roll so that all of the rolls run as straight cylinders and all the nips are level, but as the sheet approaches the lower nips in the stack, it encounters higher and higher nip pressure, due to the added roll weights. As the data presented shows, the quantity of nips may produce the desired smoothness but the higher nip pressure is likely to produce undesired caliper reduction.

The Versa-Nip design, on the other hand, allows independent adjustment of the pressure while still maintaining a straight roll shape. This calender through roll loading and relieving allows a controlled nip pressure regardless of the number of nips or roll weight. This is a very desirable feature since the number of nips and the pressure at each nip affect both caliper and smoothness. The straight-line nip is desirable for retaining good draws in and out of the calender. The straight-line nip also reduces calender cuts and simplifies problems with spreading at the reel.

Conclusion

By careful design of the discussed problem areas, it is possible to utilise Bagasse pulp successfully to very high levels in many grades of paper and board. However, the detail required and the technical experience are important in being successful with Bagasse.

Beloit have delivered complete machines and rebuilds, in most of the technical areas discussed. Many of those installations are in Mexico, Africa and and the Middle East. It is this experience which is the final point that we wish to make.