Stock Preparation and Paper Machine Operation for the Manufacture of Bagasse-Based Paper

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In view of the increased scarcity of conventional fibrous raw materials bagasse as an agricultural waste is gaining more and more prominence as a fibrous raw material. In India bamboo and sabai grass have been the main raw material for paper-making. Use of limited quantity of hard-wood, straw hemp, jute sticks and rags etc. have started to supplement the growing demand of more paper production. The Mandya National Paper Mills have the unique distinction of being the first paper-mill in the country which has started production of paper using bagasse as its primary raw material. The mill after operating for 3 to 4 years with this new raw material has been able to establish that bagasse can be economically and commercially utilised to produce high quality printing and writing grades of papers. The stock refining and manufacturing of paper in a conventional fourdrinier machine based on bagasse needs a considerable amount of reorientation in operating techniques which are discussed below:

Stock Preparation System:

The mill employs a continuous stock preparation system same as continuous operation invarious stages of operation in the pulp mill. The stock preparation system essentially consists of 2 Black Clawson (Miami "0") hydrafiners and 2 finishing Black Clawson 4-A jordans. Each hydrafiner is driven by 200 HP motor, and each jordan by 170 HP motor. The hydrafiners are equipped with 16 mm s.s. bars and the Jordans are equipped with 6 mm s.s. bars.

The bleached bagasse pulp received from the bleachery is continuously pumped to the hydrafiners in a metered quantity depending on the requirement of the papermachine. Rosin size emulsion is injected at the suction of the pump in desired quantity by a rotameter before the pulp is delivered to the hydrafiner. Rosin size is added at this stage so as to allow intimate dispersion in this stock, ahead of the use of alum for fixation of the size. The refined stock discharged from the hydrafiner is stored in a horizontal mid-feather type stock chest.

The refined stock is pumped to a metering box where filler, alum and broke are suitably proportionated. The blended stock is stored in a similar chest as that of a refined stock chest. The agitator provided in the blending chest mixes the refined stock as well as the additives thoroughly and the stock is continuously pumped to the finishing jordans through an overhead box. The overflow from the overhead box goes back to the blending chest. The stock outlet from the jordan is connected with the paper machine fan pump. The stock consistency after the jorden is maintained between 3 and 3.5% which is diluted with the rich backwater from the papermachine at the suction inlet of the fan pump. The resultant consistency of this stock at the outlet of fan pump is between 0.4 to 0.7% depending on the basis weight of paper produced.

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The finally refined stock has the following freeness characteristics:

Table 1

No.	Basis Wt. gms/m^2	^{0}SR unrefined bagasse pulp	^{0}SR after hydrafiners	^{0}SR after jordans
			(SINGLE PASS THROUGH)	
1.	52/55	25	33/34	40/42
2.	52/55	22	32/37	37/39
3.	52/55	25	35/37	43/45

Due to high pentosan content in bagasse pulp, refining of virgin stock does not present any problem. It is easily hydrated and fibrillated as evidenced from the power requirements. Although the installed capacity of the stock preparation system has got high connecting load, 35 tonnes of bagasse pulp can be refined to produce accepted stock for various grades of paper with the operation of one hydrafiner and one jordan through a single pass. It has been estimated that the power consumption is in the order of 8 to 9 HP/tonne as against 20 to 25 HP/tonne of bamboo pulp. The unrefined bleached bagasse pulp has an initial freeness of 20 to 23^0 SR and a freeness value of 40 to 45 is easily attainable by a single pass through one hydrafiner and one jordan. The high pentosan content in bagasse causes a distinct swelling of fibre and helps in rapid hydration. Due to the easy refining properties of bagasse pulp, the stock preparation system of bagasse-based paper mill need not be so elaborate as compared to long fibre pulp. Therefore, bagasse pulp refining has a decided advantage over bamboo or other long fibre pulp since it requires less equipment, less floor space, less electrical power and short time for refining.

Paper Machine Operation:

From the fan pump the diluted stock is led through a two stage centricleaning system to remove the silicious and other foreign impurities. The accepted stock from the centricleaning system is passed through a Black Clawson 24-P pressurized selectifier screen where fibre bundles and lumps are removed from the stock before it enters the headbox of the paper machine.

The paper machine has got an open type head box with an overall wire length of 26 metres and 3.5 metres wide. The wet part of the paper machine is equipped with 25 table rolls, 10 deflectors, 6 suction boxes, and a suction couch. The press part of the paper machine consists of a first suction press and a second plain reverse press. The paper web after passing through both the presses enters into a smoothing press before it enters the dryer assembly. the dryer assembly of the paper machine consists of 25 drying cylinders, 8 felt dryers each of 1500 mm dia., two cooling cylinders, a calendar stack of 8 bowls and the popereel. The dryers are divided into 4 groups and a vertical size press is located between the 3rd and 4th group of dryers.

Over the short period of operation, the mill has been steadily increasing the bagasse pulp in the fibre furnish and presently the mill is able to manufacture almost all varieties of paper with 80% bagasse pulp in the fibre furnish. With medium and heavy gramweight papers the bagasse fibre has been used as high as 90%. The mill has also produced on several occasions a sizeable quantity of paper exclusively out of bagasse pulp which has been considered a great technological success. The mill uses mostly unbleached sulphite wood pulp as the long fibre component, presently imported from U.S.S.R. Since the mill has no provision for separately bleaching this wood pulp unbleached bagasse pulp and unbleached sulphite wood pulp are mixed together in a proportion of 80 : 20 and are bleached in the 3-stage bleachery. The mixed bleached pulp is treated in the stock preparation system, as described earlier. It is no doubt very advantageous to refine both these pulps separately and blend them together after refining before it is used for the manufacture of paper in the machine. In recent times, mixed refining has been claimed quite successful, although it still remains a controversial problem. Separate refining of long fibre and short fibre will no doubt involve additional equipment and therefore additional capital investment. The advantage of separate refining over mixed refining is a subject which requires very close investigation. Mixed bleaching and mixed refining at Mandya has been quite successful mainly due to the use of bleachable variety of sulphite wood pulp. This long fibre has got more or less the same bleachable characteristics as that of bagasse pulp and when blended together no problem is encountered in refining this mixed stock. It has been however observed that refining of bleached sulphate wood pulp or bleached sulphate bamboo pulp together with the bleached bagasse pulp does present problem. The softness of the bleachable sulphite wood pulp and its easy hydrating property has been a sheer coincidence and therefore mixed refining has been quite successful at Mandya. While refining 100% bagasse in the existing stock preparation system requires the minimum electrical power, the blended stock refining shows a slightly higher power consumption.

Flow box and slice adjustment:

The inherent slow drainage property of the bagasse pulp or any other short fibre necessitates certain critical adjustments on the slice opening, stock consistency and maintenance of stock head at the headbox. These variables definitely make a departure from the conventional long fibre pulp used in the manufacture of paper. The ratio between the slice jet velocity and the wire speed is of great importance for good sheet formation and improved strength characteristics of paper. For a given basis weight of paper normally there is fixed constant between these two factors. With the conventional pulp to operate the machine at high speed the jet velocity is usually 90% of the wire speed. However, this constant cannot be maintained in case of paper manufactured with 100% bagasse pulp or paper produced with high percentage of bagasse pulp in the fibre furnish. Figure no. 1 shows the relative curves for the jet velocity versus the paper machine speed in case of paper produced with conventional long fibre and paper produced either with 100% bagasse pulp or with substantially high percentage of bagasse pulp in the fibre furnish. For a given speed the head and the opening of the slice is kept relatively lower than it is necessary in case of conventional long fibre.

Table no. 2 below illustrates the machine speed with its corresponding head at the flow box for conventional fibres as well as with 100% bagasse pulp in the fibre furnish or with high percentage of bagasse pulp in the fibre furnish:

Table 2

Machine speed vs. stock head in flow box for bagasse-based pulp stock

No.	Machine speed in fpm	Conventional head in inches	Approximate head with 100% and high percent bagasse furnish stocks
1.	280	4	4
2.	297	5	5
3.	330	6	5.5
4.	363	7	6.5
5.	400	9	8
6.	465	11.5	10
7.	500	13	11
8.	530	14.5	12
9.	560	16	13.5
10.	600	18.5	15
11.	625	20.5	16.5
12.	660	23	18.5
13.	700	25.5	20.5

However, low head and increased consistency at the head box tend to give rise to floc formation and precipitation of fibre lumps. These matters find their way periodically to pass through the slice forming blotches on the paper web. This situation to some extent is obviated by keeping the stock more free and increasing the slice opening. Precipitation of long fibre and flocs to a large extent is eliminated by these adjustments.

For imparting better drainage, an open adjustible slotted forming board has been provided at thewire part immediately after the breast roll. The two gates provided at both ends of the formation board can be adjusted to remove water at this stage in desired quantity. Installation of this forming board has to a large extent made it possible to maintain the slice openings, stock consistency as well as the head corresponding to a given speed of the machine comparable to the conventional practice.

pH Control:

Control of pH at the headbox of the paper machine, tray water as well as in the stock preparation system plays a decisive role in the operation of the machine. Within the limits of 4.2 to 4.6 pH value the paper machine operation is more stabilized. When the pH by any chance shifts more towards 5 to 5.5 severe foaming conditions are encountered in the paper machine which gives rise to bed formation, froth spots, uneven caliper and press stickiness becomes prominent resulting in innumerable breaks at the press part of the paper machine, with a consequent loss of production. When pH values are maintained between 4.2 and 4.6 the press stickiness is at the minimum and also the paper is hard-sized.

Due to the closed white water system of the paper machine the accumulated fibre debris and non-fibrous constituents periodically develops severe press stickiness at the paper machine. Fluff and fuzz formation at the first few drying cylinders shows the signs of excessive carry over of this fibre debris and other fluffy materials. These constituents also tend to plug up the suctionboxes and the suction couch. Clogging of the wire is also experienced due to the presence of fibre debris and other non-fibrous constituents. Use of diacol, a monogalactan gum, has proved highly successful in overcoming these difficulties. These pulp fines and flurry materials bind with the fibre furnish in the presence of this monogalactan gum and enhances the wet strength of the paper web, thereby reducing the press stickiness. Although this particular compound is a conventional beater additive for better hydration, its application at Mandya is largely to avoid press stickiness and to have better formation and finish. Excessive use of this material greatly retards the drainage property and therefore its application should be carefully regulated.

Paper Machine Speed:

With 90% bagasse pulp in the fibre furnish, most grades of writing and printing paper in the basis weight range of 45 to 65 gms/m^2 has been produced at a machine speed ranging from 180 to 230 metres/min. Lightweight papers such as manifold and typewriting in the basis weight range of 33 to 40 gms/m^2 has been manufactured at a machine speed range of 180 to 200 metres/min. with 70 to 75% bagasse pulp in the fibre furnish. In the medium and heavy gramweight papers filler retention has shown a marked improvement compared to paper produced out of conventional fibres. Invariably the clay retention has been 60% on the clay input and as high as 75% has been retained in the paper without the addition of any special reagents. This has been possible largely due to the inherent close formation of paper that could be made out of this short fibre.

The paper web after the suction couch of the paper machine still holds a considerable amount of water as evidenced from the following analysis:

The moisture content of paper web after suction couch 82—83%

After suction press 73—74%(with 2.5 kg/cm^2 pressure)

After the reverse press 66—67% (with 1.5 kg/ cm² pressure)

In other words paper web enters the drying assembly with 66-67% moisture which is higher than the normal moisture content with conventional fibres. Normally more open-type felts are used in the first press so as to enable better water extraction and also to avoid clogging of the felts. Considerable quantity of fines and lighter stuff which floats over the paper web on the wire part are carried over to the press where it is removed from the top stonite press roll of the first press by scrapping them off with the doctor blade. Continuous removal of these materials at the first press prevents press stickiness as well as clogging of the felts.

Dry End Operation:

With high moisture content in the paper web entering into the drying assembly the temperature curve of the dry end has to be reoriented as opposed to paper made out of conventional fibre. The normal procedure of drying of paper web cannot follow the same pattern as that of long fibre. The temperature curve resembles that of drying of speciality papers such as grease-proof or tissue papers made out of conventional fibre. Figures 2 and 3 show typical drying curves when paper is manufactured with 90% and 70% bagasse pulp in the fibre furnish respectively.

From the two curves it will be observed that with higher percentage of bagasse pulp the temperature at the first few dryers has to be maintained at a slightly low elevation compared to pulp with increased percentage of long fibre. The temperature gradient at the final stages of drying follows a different pattern as that of paper produced with increased percentage of long fibre.

The drying of bagasse-based paper requires slightly high steam consumption because of the increased moisture content in the paper web entering into the dryer assembly. As the sheet enters the dryer it needs slow heating at initial stages. Otherwise, the sheet loses its dimensional stability with resultant cockling and creasing effects. Evaporation of water from the paper web has to be carefully regulated so that there is a uniform moisture profile as the web proceeds towards the calendar stack. Uneven drying and local overheating give rise to cockling and creasing effects which in turn gives innumerable breaks at the calendar as well as uneven finish in the paper. Therefore, drying of paper has to be carefully regulated. In the first few dryers the temperature is kept lower which gradually rises and continues at a constant level up to the end of the third group with a further rise in the last group of the dryer assembly. Finally the temperature drops in the last few dryers before the paper enters into the cooling cylinders.

The following tabulation illustrates the fibre furnish, basis weight of the paper and the machine speed at which most of the grades of paper are successfully manufactured at the Mandya National Paper Mills Ltd.

Table 3

Bagasse pulp	Sulphite wood pulp	Basis weight	M/c. speed
100%	—	60/75 gms/m²	160/175 M/min.
90%	10%	52/55 gms/m²	200/210 M/min.
80%	20%	50/52 gms/m²	200/210 M/min.
70%	30%	40/49 gms/m²	200/220 M/min.
65%	35%	33/35 gms/m²	190/200 M/min.

It will be observed from the above table that with 100% bagasse pulp the machine speed has to be reduced due to slow drainage at the wire part and consequent high moisture content of paper web entering into the dryer assembly. However the paper produced with 100% bagasse pulp and also in varying proportions of long fibre have excellent strength properties. The paper had good sheet formation, opacity, dimensional stability, high brightness and good printability characteristics. The strength properties of paper are very well comparable to any paper produced exclusively out of long fibre.

Conclusion :

Although the mill has produced on a commercial scale a good quantity of paper exclusively out of bagasse pulp, blending the stock with 10-15% long fibre is considered essential for smooth running of the paper machine. Paper with 100% bagasse pulp definitely puts certain limitations on the rated capacity of the paper machine. A few tonnage of paper has got to be sacrificed if the paper mill intends to manufacture paper exclusively out of bagasse pulp. For running 100% bagasse pulp on the paper machine without affecting the speed the wet part of the paper machine should have a longer wire and should be equipped with other dewatering accessories.