Influence of Pith on Bagasse Pulp, Paper And Black Liquor Properties

Paul S.K., Kasiviswanathan K.S.

ABSTRACT

Worldwide, bagasse has established itself as a very useful non-woody fibrous raw material for pulp and paper industry. Though it is superior to other agricultural residues in its properties for pulp and paper manufacture, the innate deficiency of bagasse is the presence of pith cells. A well depithed bagasse not only provides better pulp and paper quality, it also improves process efficiency and properties of black liquor compared to undepithed bagasse. This paper deals with the studies on cooking chemical consumption for obtaining target pulp kappa number of 15 +/- 1, pulp yield, water drainage, paper properties and mobility of spent liquor at high solids level using the bagasse at different fiber to pith ratio level. In the present study, special effort has been made to analyse the effect of pith on various black liquor properties.

INTRODUCTION

The non-wood fibers which are useful for paper making are bagasse, cottonstalks, straws, reeds, bast fibers such as hemp, jute, kenaf etc. Among these, the use of bagasse for manufacture of paper has become more popular because of its availability in large quantity at one point (i.e. sugar mill) and ease of transportation to the point of use. Bagasse plays an important role in the development and growth of the paper industry in most of the sugarcane growing countries. In recognition of its usefulness as an alternate raw material to hardwoods Government of India extends excise duty concessions on papers made with not less than 75% bagasse pulp in the furnish.

Bagasse has all basic requisites for being used as a raw material for paper making and compares well with raw materials like bamboo and wood for economic manufacture of paper. One plus point for bagasse based paper mill is that it need not depend on forest land. It is estimated that, about 10 MT bone dry bagasse can be obtained per hectre of land which ultimately can produce about 3.60 BD MT of unbleached pulp. For every 6.0 tons of as such bagasse utilised for pulp and papermaking about 4.0 tons of forest wood (as such basis) is saved from felling. Bagasse is the fibrous residue of sugarcane left after crushing and extraction process. It forms about 30% of sugarcane consisting of 50% moisture and 50% fiber along with pith cells. Bagasse is composed of three principal components:

(1) The rind fibers including the epidermis, cortex and pericycle.

(2) The fibrovascular bundles comprising of the thin walled conducting cells, associated with relatively thin walled rather short fibers with narrow lumen.

(3) Ground tissue (parenchyma tissue) or pith with fiber bundles distributed irregularly.

The proportion of pith, fiber bundles and epidermis (rind fibers) vary considerably with age of stem and the variety of sugarcane. Approximately 50% of dry weight of stack consists of high quality fiber bundles concentrated in the hard and dense rind. The fiber content of whole bagasse is around 65%, pith around 30% and water solubles around 5%. The maximum fiber length and diameter of pith are about 0.84 mm and 140 micrometer respectively, whereas, average length and diameter of bagasse fiber are about 1.0 mm and 20 micrometer respectively. The

Seshasayee Paper And Boards Ltd,
ERODE-638 007 (T.N.)

pith is composed mainly of parenchyma cells. Pith cannot be converted into a satisfactory pulp despite its resemblance to the fiber in chemical composition, because of its small dimensions, non-fibrous physical nature and close association with dirt.

The drawbacks of pulping bagasse alongwith pith are:

(a) lower yield and higher cooking chemical consumption as pith offers low resistance to the penetration and action of chemicals.

(b) slower drainage rate at all dewatering stages. Typically a higher soda loss during Brown Stock washing operation.

(c) requirement of more bleaching chemicals.

(d) press 'pick up' on paper machine.

Therefore, depithing of bagasse before digestion is imperative. However, the level of depithing of bagasse is limited by factors such as fiber loss during depithing, damage to bagasse fiber and power consumption for depithing.

An attempt has been made regarding the influence of pith at various proportion in bagasse on pulping, bleaching, paper properties and special reference to black liquor properties.

COLLECTION OF SAMPLES

Different bagasse samples were collected for this study from various points of bagasse depithing processes. Bagasse with fiber to pith ratio of 0.86:1 was collected from the outlet of moist depither. Whole bagasse with fiber to pith ratio of 1.84:1 was collected from sugar mill prior to moist depithing process. Bagasse samples having fiber to pith ratio of 2.25:1 and 2.79:1 were collected after moist depithing process in different days. Similarly, bagasse samples having fiber to pith ratio of 3.43:1 and 3.80:1 were collected after wet depithing process in different days. Bagasse at fiber to pith ratio level of 5.20:1 was obtained by wet depithing process in laboratory disintegrator.

Ranges of fiber to pith ratio in bagasse at various stages of depithing process is presented in **Table-1.**

EXPERIMENTAL

At the begining of the study, proximate chemical analysis of bagasse pith, whole and depithed bagasse were done and the test results are presented in **Table-2.**

Table-1

Fiber to pith ratio of bagasse

Particulars	Fiber to pith ratio
Bagasse pith	0.60:1 to 0.86:1
Whole bagasse	1.80:1 to 2.00:1
Moist depithed bagasse	2.60:1 to 2.80:1
Wet depithed bagasse	3.00:1 to 3.80:1

Table-2

Proximate chemical analysis

Particulars	Unit	Bagasse Pith	Whole Bagasse	Depithed Bagasse
Fiber:pith	-	0.86:1	1.84:1	3.43:1
Cold water solubility	%	12.2	11.4	2.2
Hot water solubility	%	16.2	14.8	4.0
1.0% NaOH solubility	%	48.7	44.8	33.7
Alcohol-Benzene solubility	%	12.4	11.5	3.4
Lignin (ash corrected)	%	12.5	16.9	19.4
Pentosans	%	25.4	24.4	27.0
Ash	%	2.7	2.0	1.0
Silica in raw material	%	1.27	1.20	0.37

Pulping experiments were carried out for bagasse at different pith level seperately in laboratory CCL digester to obtain pulp kappa number of 15 +/-1 at 385 H-factor. The pulping results are tabulated in **Table-3.**

Several black liquor properties like pH, total solids, residual active alkali content, swelling volume ratio, silica, organic content and viscosity at different solids level etc. were evaluated for all bagasse samples separately and the results are presented in **Table-4.**

Unbleached pulps from various bagasse samples were evaluated for various fiber fractions in Bauer-Mc. Nett fiber classifier and the strength properties of handsheets of all bagasse samples were determined at 40 +/- 1^0SR freeness level. The results are shown in **Table-5.**

All unbleached pulps were bleached separately in C/EH/H bleaching sequence to obtain final pulp

Table-3								
Pulping data of bagasse								
Particulars	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Fiber to pith ratio	-	0.86:1	1.84:1	2.25:1	2.79:1	3.43:1	3.80:1	5.20:1
Active alkali charge (as such)	%	22.0	18.0	16.0	16.0	16.0	15.0	15.0
Steaming time to 170~C	min	60	60	60	60	60	60	60
Cooking time at 170~C	min	18	18	18	18	18	18	18
H-factor (at 170~C)	-	385	385	385	385	385	385	385
Unbleached pulp kappa number	no.	14.0	15.0	15.0	15.0	14.0	14.0	14.0
Unbleached screened yield	%	45.8	52.0	53.5	53.6	54.0	54.4	55.3
Screened rejects	%	0.6	5.8	2.7	2.0	1.4	nil	nil
Freeness of pulp	~SR	53	40	35	32	29	26	24

brightness level of 80 +/- 1%. The bleaching data and strength properties of all bleached pulps at 40 +/- 1 ^{0}SR level are presented in **Table-6.**

RESULTS AND DISCUSSIONS

(A) Influence of pith on bagasse pulping properties

- Bagasse having fiber to pith ratio of 0.86:1 is characterised by having low molecular-weight carbohydrates, high water soluble substances and volatile hydrocarbons compared to the depithed bagasse with fiber to pith ratio of 3.43:1, which reflects in high cooking chemical consumption and low pulp yield during pulping.
- Bagasse with high pith content is having high ash content and silica compared to other bagasse samples having low pith content.

Table-4								
Black liquor data of bagasse								
Particulars	**Unit**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Fiber to pith ratio	-	0.86:1	1.84:1	2.25:1	2.79:1	3.43:1	3.80:1	5.20:1
pH of black liquor	-	12.48	11.70	11.60	11.43	11.29	11.40	11.30
Total solids	gpl	133	121	118	116	108	107	90
R.A.A. as Na_2O (at 200gpl solid)	gpl	16.1	16.9	13.1	12.9	13.0	12.8	12.6
Swelling volume ratio	ml/g	7	8	8	9	10	10	12
Organic content	%	65.8	68.0	68.5	69.3	69.6	69.0	70.0
Gross calorific value	cal/g	3360	3540	3550	3620	3630	3630	3660
Silica as SiO_2 (at 200 gpl solids)	gpl	4.67	4.10	3.00	2.90	2.60	1.50	0.90
Viscosity at 80~C: at 50% solids level	cps	1840	1800	1440	620	600	510	400
at 55% solids level	cps	7400	6500	4600	1480	1080	1075	780
at 61% solids level	cps	26000	22500	20000	13500	11000	8400	6800

Table-5

Unbleached bagasse pulp data

Particulars	Unit	1	2	3	4	5	6	7
Fiber to pith ratio	-	0.86:1	1.84:1	2.25:1	2.79:1	3.43:1	3.80:1	5.20:1
Initial freeness of pulp	~SR	53	40	35	32	29	26	24
Final Freeness of pulp	~SR	53	40	40	41	39	40	40
Burst factor	-	33	31	32	34	36	36	41
Tear Factor	-	36	43	49	51	55	58	68
Breaking length	m	6200	6500	6700	6800	7000	7200	7700
Wet web tensile str. (25% dryness)	N/m	50	65	76	80	85	93	106
Fiber Classification								
Retained on 50 mesh	%	20	29	35	38	44	46	51
Retained on 65 mesh	%	26	24	21	23	24	23	25
Retained on 100 mesh	%	21	16	18	17	15	16	13
Passing thro's100 mesh	%	33	31	26	22	17	15	11

- Consumption of cooking chemical in case of bagasse with maximum pith content (0.86:1 of fiber-pith ratio) is as high as 22% on OD raw material basis. The same has gradually decreased to 15% as pith content has decreased in bagasse **(Fig:1).**
- It has observed that beyond certain level of pith content in bagasse there is no further decrease in chemical consumption.
- Results presented in Table-3 shows the influence of pith in bagasse has negative effect on unbleached screened pulp yield at same kappa number level of 15 +/-1 **(Fig.2).**
- Screened rejects (retaining over 18 mesh) is low (0.6%) in case of bagasse with maximum pith content, which may be due to very low fiber content in it. At fiber to pith ratio of 1.84:1, the rejects percentage is high

Table-6

Bleached bagasse pulp data

Particulars	Units	1	2	3	4	5	6	7
Fiber to pith ratio	-	0.86:1	1.84:1	2.25:1	2.79:1	3.43:1	3.80:1	5.20:1
Total chlorine consumption	%	3.96	5.85	5.18	5.05	4.92	5.00	5.12
Total caustic consumption	%	1.1	1.3	1.4	1.1	1.15	1.15	1.2
Brightness of final pulp	%	78	78	79	80	79	78	80
Bleaching shrinkage	%	13.3	8.2	8.0	7.6	7.4	7.2	6.5
Strength properties of pulp								
Final freeness of pulp	~SR	51	40	40	39	40	39	41
Burst factor	-	28	34	36	38	40	40	42
Tear factor	-	34	46	50	51	54	56	65
Breaking length	m	6100	6600	6700	6700	6800	6900	7200

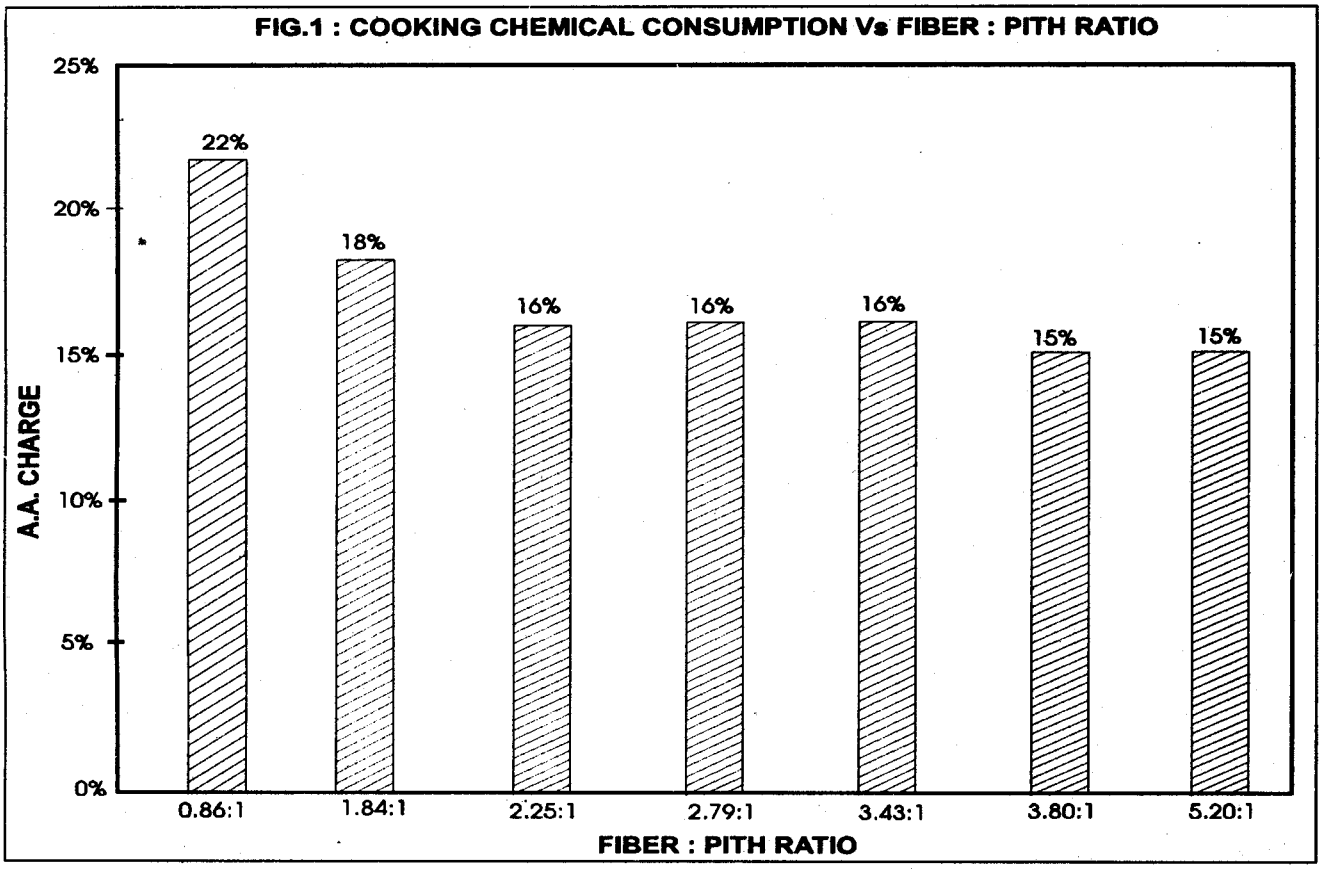
FIG.1 : COOKING CHEMICAL CONSUMPTION Vs FIBER : PITH RATIO
A.A. CHARGE
25%
20%
15%
10%
5%
0%
22%
18%
16%
16%
16%
15%
15%
0.86:1
1.84:1
2.25:1
2.79:1
3.43:1
3.80:1
5.20:1
FIBER : PITH RATIO

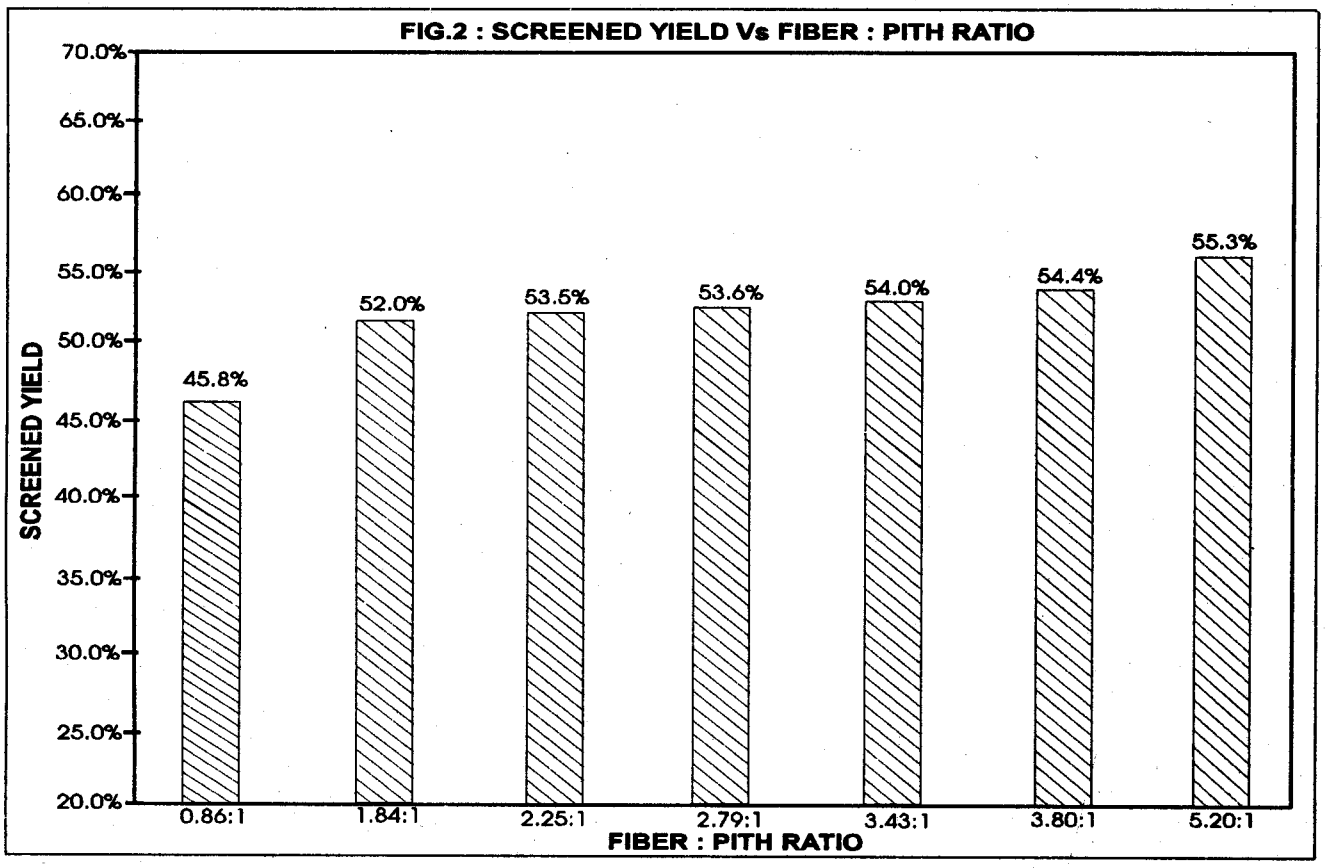
FIG.2 : SCREENED YIELD Vs FIBER : PITH RATIO
SCREENED YIELD
70.0%
65.0%
60.0%
55.0%
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
45.8%
52.0%
53.5%
53.6%
54.0%
54.4%
55.3%
0.86:1
1.84:1
2.25:1
2.79:1
3.43:1
3.80:1
5.20:1
FIBER : PITH RATIO

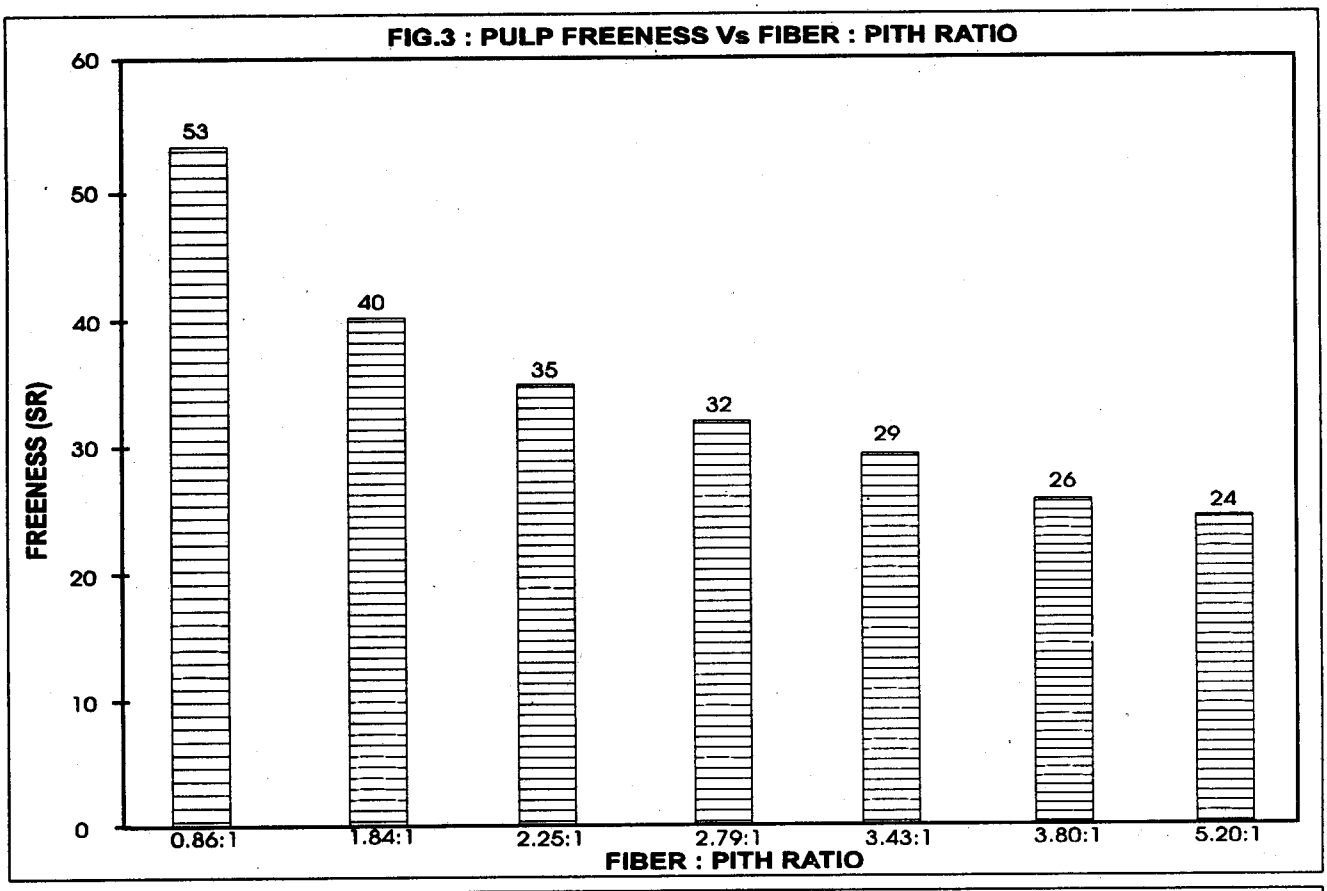
FIG.3 : PULP FREENESS Vs FIBER : PITH RATIO
FREENESS (SR)
60
50
40
30
20
10
0
53
40
35
32
29
26
24
0.86:1
1.84:1
2.25:1
2.79:1
3.43:1
3.80:1
5.20:1
FIBER : PITH RATIO

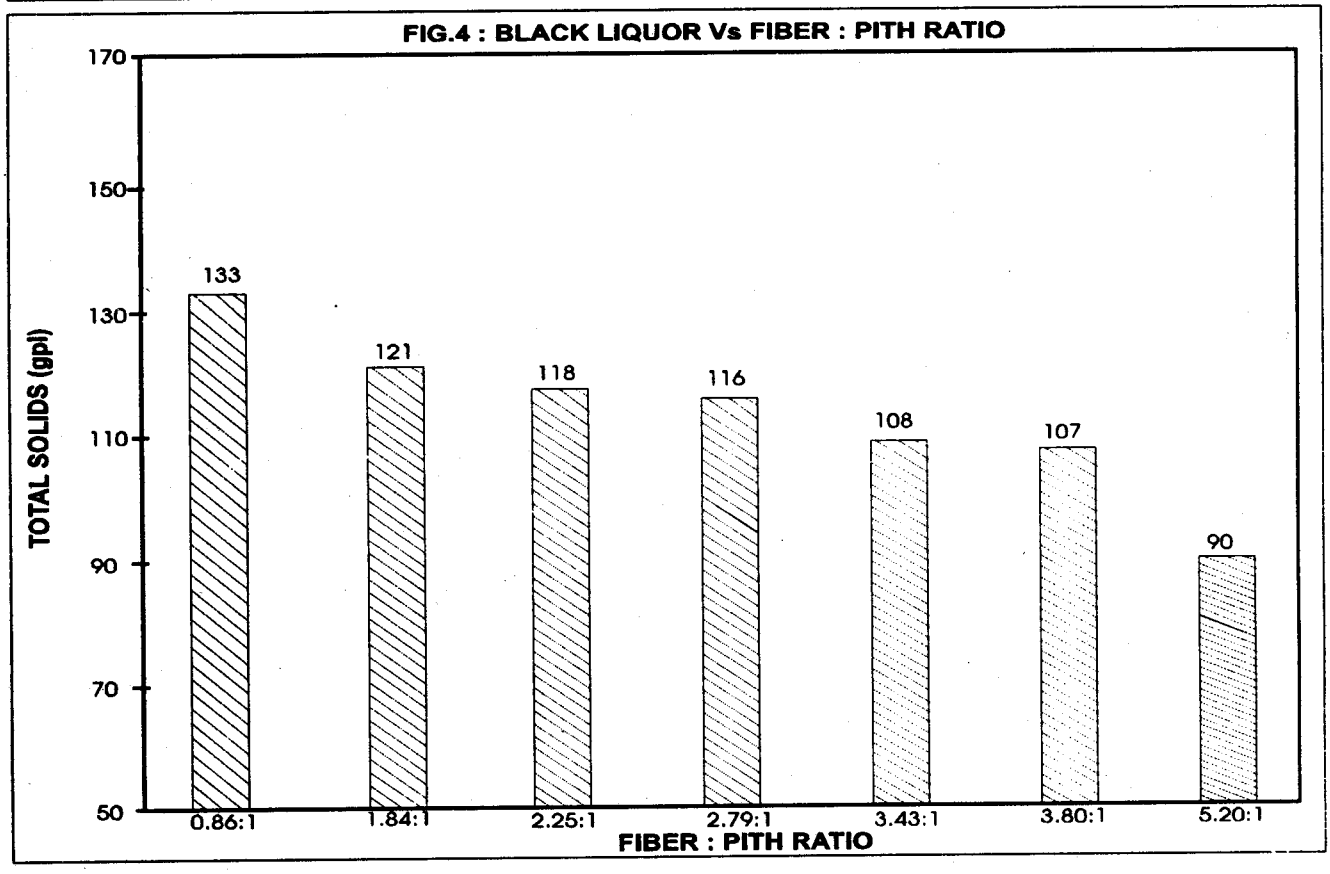
FIG.4 : BLACK LIQUOR Vs FIBER : PITH RATIO
TOTAL SOLIDS (gpl)
170
150
130
110
90
70
50
133
121
118
116
108
107
90
0.86:1
1.84:1
2.25:1
2.79:1
3.43:1
3.80:1
5.20:1
FIBER : PITH RATIO

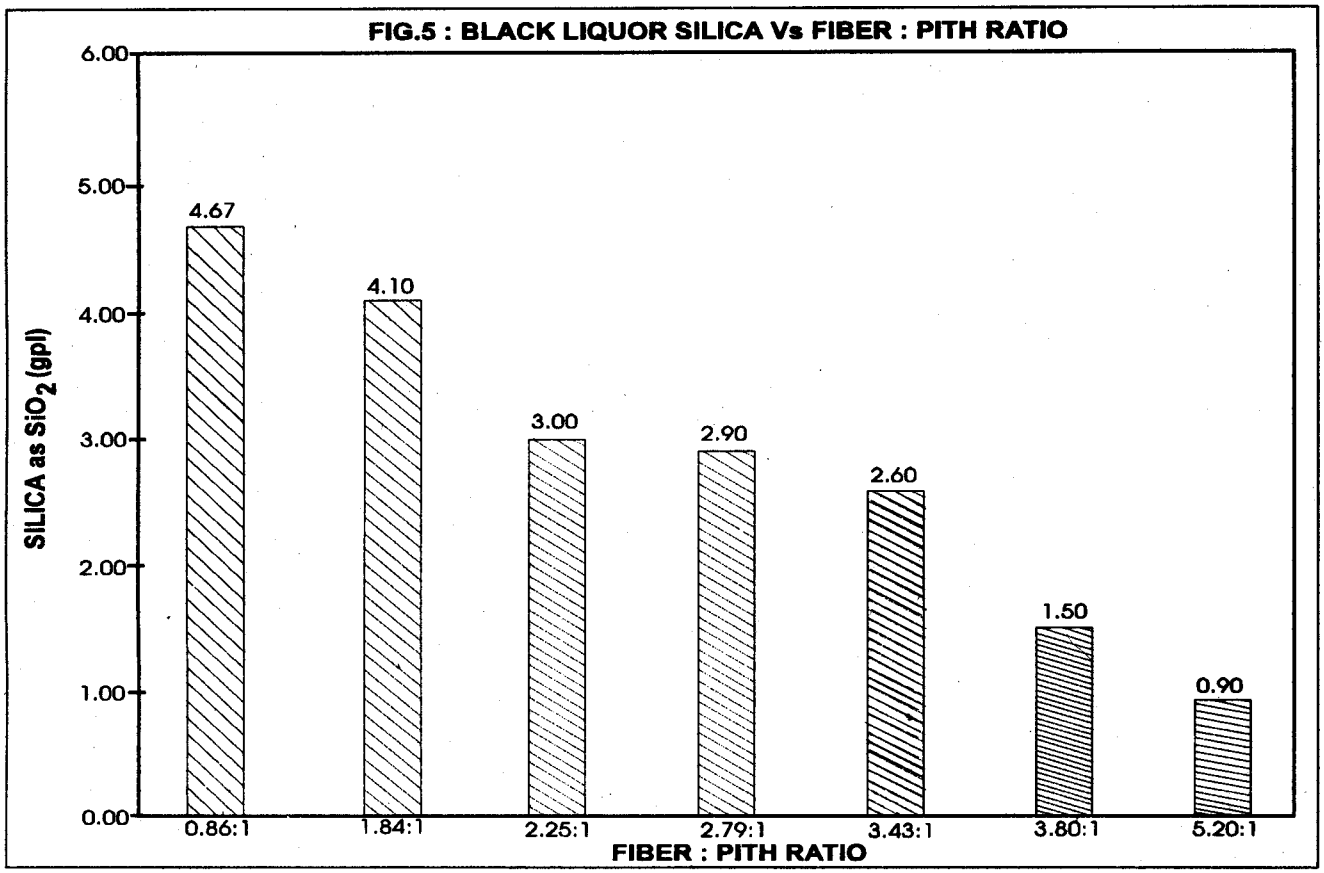
FIG.5 : BLACK LIQUOR SILICA Vs FIBER : PITH RATIO
SILICA as SiO_2 (gpl)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
4.67
4.10
3.00
2.90
2.60
1.50
0.90
0.86:1
1.84:1
2.25:1
2.79:1
3.43:1
3.80:1
5.20:1
FIBER : PITH RATIO

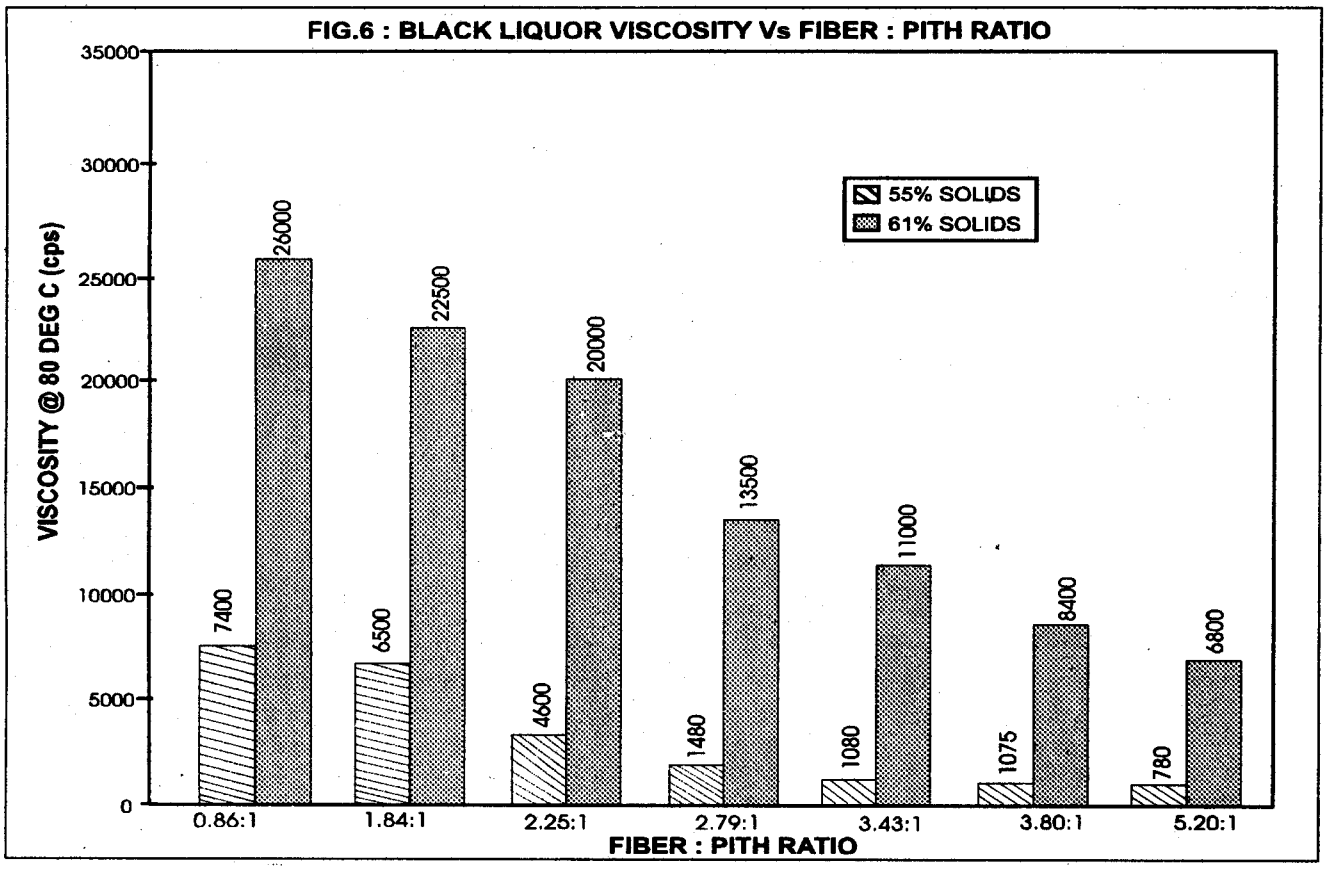
FIG.6 : BLACK LIQUOR VISCOSITY Vs FIBER : PITH RATIO
VISCOSITY @ 80 DEG C (cps)
35000
30000
25000
20000
15000
10000
5000
0
55% SOLIDS
61% SOLIDS
7400
26000
6500
22500
4600
20000
1480
13500
1080
11000
1075
8400
780
6800
0.86:1
1.84:1
2.25:1
2.79:1
3.43:1
3.80:1
5.20:1
FIBER : PITH RATIO

(5.8%), which gradually decreases to nil at 3.80:1 of fiber to pith ratio level and beyond this.

- Influence of pith in bagasse is also having adverse effect on washing of pulp as it can be seen that the freeness of pith pulp is very high (53 °SR) and the same decreases progressively with decrease in pith content in bagasse (Fig.3).

(B) Influence of pith on black liquor properties

- By decreasing pith content in bagasse, total solids in black liquor decreases and the swelling volume ratio increases, which can be attributed to the high hemicellulose content in bagasse pith than depithed bagasse (Fig.4).

- Removal of pith from bagasse has advantage on black liquor properties with respect to heat value and organic content.

- As silica content in black liquor obtained from the bagasse with maximum pith content is high and the same is showing decreasing trend with the removal of pith from bagasse (Fig.5), processing of well depithed bagasse black liquor will give better steam economy in evaporation process as the tendency of scale formation will be less in this case.

- From viscosity data of black liquor (table-4) it can be seen that, pith is having adverse effect on mobility characteristics of black liquor at higher solids level. This may be ascribed to the high hemicellulose content in bagasse pith. A tremendous reduction in black liquor viscosity is observed at 61% solids level of black liquor obtained from bagasse having fiber to pith ratio of 3.80:1 and 5.20:1 compared to the bagasse pith even at lower residual active alkali (RAA) level (Fig.6.) This shows a significant benefit can be obtained by depithing the bagasse in chemical recovery operation.

(C) Influence of pith on bleaching and paper properties

- It can be seen from table-5 that, compared to depithed bagasse pulp, the pith pulp (unbleached) is weaker in tearing strength but only somewhat inferior in tensile and bursting strength.

- Pith is having another adverse effect on runnability of paper machine, as it can be seen for pith pulp wet-web tensile strength at 25% dryness level (table-5) is only 50 N/m against 95-100 N/m which is required for proper runnability of machine. Bagasse pulps having fiber to pith ratio of 3.80:1 and 5.20:1 are satisfying the requirement in this respect.

- From Bauer-Mc. Nett fiber classification study, it is ovserved that, presence of pith influences the percentage fraction of fiber retaining on 50 mesh and passing through 100 mesh. This indicates the presence of higher percentage of pith in bagasse will result low tearing strength of paper.

- From table-6, it can be observed that, pulp obtained from maximum percentage of pith is easily bleachable compared to other pulps in terms of chlorine consumption.

- Bleaching loss is very high (13.3%) in case of pith pulp and the same reduces progressively as the percentage of pith decreases in the bagasse raw material.

- Bleached pulp strength properties are having similar trend as in case of unbleached pulps.

INFERENCES

Presence of bagasse pith has various negative effects on pulping, paper machine runnability, paper properties and especially on chemical recovery operations due to it's non-fibrous physical nature and close association with sand particles. Mechanical depithing of bagasse is most popular world wide. Level of depithing should be limited in order to have less fiber damage/loss and minimum power consumption during depithing process. However, the removal of pith from bagasse can be improved by selecting and using appropriate depithing system. From our present study, it can be concluded that, for good pulping, paper making and soda recovery operations, the target fiber to pith ratio of bagasse should be 3.80:1.