Alkaline Extraction Of Bagasse To Get Rid Of Silica

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ABSTRACT

Alkaline extraction of bagasse prior to pulping is a useful idea in removing silica from the raw material. Out of the total silica present, 75% of this could easily be removed by extraction of bagasse with 2% sodium hydroxide at 60°C for two hours. The pulp produced from extracted-bagasse even by using lower cooking chemical, was of lower kappa and of identical physical strength properties to that of the unextracted bagasse pulp. Lower kappa of the extracted bagasse pulp can reduce the bleach chemical consumption in bleaching and pollution load generated during bleaching. Removal of silica can also help in improving the recovery boilers efficiency of chemical recovery units in addition to its many other advantages, Removal of silica from the raw material is more easy, advantageous and economical over the silica removal from black liquor.

INTRODUCTION

India is a developing country with the present paper and board production around 2.8 million tons. Out of which 50% is being produced by large paper mills and rest by small and medium size paper mills. Large mills with the complete chemical recovery system based mainly on wood and bamboo and to some extant on agro-residue. Small and medium size paper mills based mainly on agroresidues, waste paper etc. and these mills are without chemical recovery because of different reasons like high silica and low lignin content in the agroresidues, and economically non viable size of the mills for conventional chemical recovery.

Fast depletion of the natural forest in the country has resulted in acute shortage of forest based raw materials for the paper industry, Efforts were made for the plantation of fast growing trees like eucalyptus etc. but the supply of wood is not sufficient to meet out the growing demand of the paper industry. Because of this short supply of eucalyptus and bamboo, the agricultural residues have gained importance. Wheat straw, rice straw and other grasses are being used since long but the bagasse which is a waste, obtained after extraction of sugar juice is gaining importance day to day. Wheat straw is not available in plenty because it is a regular cattle feed and rice straw is not a suitable raw material for large and medium paper mills specially for the production of good quality papers. Bagasse is a suitable raw material for most grade of paper and its availability is increasing day to day as more and more sugar mills improving their boiler efficiency to spare more and more bagasse for paper industry.

Increasing cost of pulping chemicals and very strong legislation for pollution abatement, it had become necessary that the small and medium size paper mills should seriously think for chemical recovery. Lot of efforts are going on for the recovery of chemicals in small and medium size paper mills world wise, but the most appropriate chemical recovery today is the conventional soda

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recovery system. In conventional recovery system the silica in the raw material is a major problem which needs to be over come. Efforts have already been made in CPPRI on the silica removal from the black liquor generated from the pulping of bamboo etc. but very little efforts have been made on the silica removal from the raw material prior to pulping. In alkaline pulping operation, the silica present in the raw material get dissolved as sodium silicate. As more and more alkali is consumed and pH goes down below 10.5 particularly at the end of the cooking, a part of the silica get adsorbed on the pulp surface. If pH at the end of cooking is much below 10.5, a part of the silica get adsorbed on pulp and goes with the pulp and a part goes to black liquor. Because of the abrasive nature of the silica, the silica going with the pulp caused hard scale deposition on brown stock filter, bleach plant filter, screening and cleaning equipment, paper machine parts, machine cloth, couch rolls, suction rolls, calendar rolls which causes difficulty in its removal. Presence of silica in the pulp also reduces the life of the pulp refiner plates and paper cutters (2).

Silica going with the liquor also causes hard scale deposits on the evaporators tubes particularly at concentration above 30% T.S. which results poor heat transfer and higher heat steam consumption in evaporation of black liquor. It also causes poor burning of black liquor in recovery furnance, poor castisizing and lime settling in green liquor and poor burning of lime sludge in lime klins.

As evident from the table I, indicating the silica in different raw materials, the wood contains negligible amount of silica and need not to be removed. Bamboo though has 0.5-2.5% of silica, but due to its limited availability and its little proportion to the wood (10-20%) being used in most of the mills, the overall impact of silica on recovery system is very little. Presence of silica in wheat and rice straw is quite high and difficult to remove to required extant. Bagasse being used very widely in Indian Paper Mills and presence of silica in bagasse is ranging 0.5-1.5%. The removal of which can be tried, so that the liquor generated in pulping be free from silica as much as possible.

Studies are now initiated to remove silica from bagasse by alkaline extraction before it is used for pulping to get rid of the problem associated with the presence of silica in the pulp and the spent liquor generated. As the silica get dissolved in alkali at elevated temperature in the form of sodium silicate and can easily be removed from the agro residues like bagasse etc. There is a possibility of using the extract again and again by adding fresh dose of sodium hydroxide till the extract becomes quite saturated with sodium silicate. The dissolved silica in the form of sodium silicate can be precipitated by the addition of sulphuric acid or carbon dioxide or lime. It can easily be separated from the extracted liquor as in case of silica removal from black liquor. In case of silica precipitation from black liquor by reducing the pH lignin also get precipitated and needs to be redissolved. While in this case the presence of lignin in extracted liquor is negligible and there is almost negligible lignin precipitation and hence cost involved in this redissolution of lignin is avoided.

The sodium present in the extracted liquor in the form of sodium sulphate or sodium carbonate or sodium hydroxide. can be recovered by using the silica free extracted liquor for further extraction and washing of bagasse, in maintaining raw material to liquor ratio in pulping and also in pulp washing preferably at the second stage of counter current washing system.

Chemical Reaction :

Silica Dissolution

1. $SiO_2 + 2NaOH \xrightarrow{60_0C,\ pH\text{-}10.5} Na_2SiO_3 + H_2O$

   1 eq. SiO_2 = 2eq. NaOH

   or 60g SiO_2 = 80g NaOH,

   1g SiO_2 = 1.33g NaOH

Silica Precipitation

1. $Na_2SiO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + SiO_2 + H_2O$

   or

2. $Na_2SiO_3 + CO_2 \longrightarrow Na_2CO_3 + SiO_2 + H_2O$

   or

3. $Na_2SiO_3 + H_2O + CaO \longrightarrow CaSiO_3 + NaOH$

EXPERIMENTAL

Raw Material Preparation:

Moist depithed samples of bagasse were collected from different paper mills and stored in seperate polythene bags after determination of moisture content.

Silica Determination:

Depithed bagasse samples were taken for determination of ash content and finally silica content, using HF treatment.

Extraction of silica from Bagasse:

For the alkaline extraction and other experiments of bagasse, a representative sample of bagasse having moderate silica content (around 1%) was taken and extracted in different set of experiments as indicated below and silica contents were determined.

In Ist set of experiments, alkaline extraction was carried out at elevated temperature 75°C for 2.5 hrs keeping bath ratio 1:8 and varying alkali dose 0.5-2.5% in order to find out the optimum dose of the sodium hydroxide needed.

In IInd set of experiments of extraction, optimum dose of sodium hydroxide (ie 2%) was used for extraction at different temperature ie ambient temperature for overnight soaking, and 40°C, 60°C and 80°C for 2.5 hrs, in order to optimize the temp. required for optimum extraction.

In IIIrd set of experiments the extraction was carried out at optimum temperature ie 60°C by using optimum dosage of sodium hydroxide for different treatment time in order to optimize the treatment time.

Finally the bagasse was extracted in large scale by using optimized conditions and sodium hydroxide dosage for further pulping experiment.

Pulping:

Kraft pulping of unextracted and extracted bagasse were carried out in a series digester consisting of six bombs each of 2.5 ltrs. capacity, rotating in an electrically heated polyethylene glycol bath under the conditions given below and by using pulping chemical doses 14,15 & 16% as Na_2O.

Constant cooking condition:

Raw material to liquor ratio - 1:5

Raw material in each bomb - 200 g.

Cooking Schedule:

Time taken from amb. to 100°C - 30 min

Time taken from 100 to 168°C - 100 min

Time at 168°C - 90 min

After thorough washing the pulp was screened in laboratory Sarla Screen by using mesh of 0.25 mm slot width. Yield and kappa number of the pulp were determined as per the standard procedure (1).

Pulp Evaluation:

Beating of pulps were carried out in PFI mill under standard conditions as per ISO DP 5264 and handsheets were made. Testing of sheets for physical strength properties were carried out as per ISO & SCAN standards given in manual of Laboratory Research Methods (1).

RESULT AND DISCUSSION

Table I indicates the presence of silica content in various paper making raw materials. Wood contain negligible silica while agroresidues mainly rice straw contain higher silica (6-14%) while silica content in moist depithed bagasse varies from 0.5-1.5%. The removal of which is economically viable because of the lower dosage of sodium hydroxide needed

Table-I

Silica Content in Different Raw Materials

S.No.	Raw Material	Average Silica Content%
1.	Wood (Eucalyptus)	0.10 (0.05-0.15)
2.	Bamboo	1.50 (0.5-2.5)
3.	Wheat straw	4.00 (2.0-6.0)
4.	Rice straw	10.00 (6.0-14.0)
5.	Bagasse	1.00 (0.5-1.5)

for its removal. As evident from the chemical equation and also on the basis of experiments performed, higher dosage of sodium hydroxide will be needed for the removal of silica from the silica rich raw materials like rice and wheat straw.

Table II indicates the ash and silica content

Table-II

Silica Determination in Different Bagasse Samples

S.No.	Ash %	Silica %
1.	1.68	0.99
2.	1.91	0.86
3.	1.89	1.16
4.	1.55	0.82

in various bagasse samples. In different bagasse samples ash was varying from 1.55-1.91 and silica from 0.82-1.16%.

Table III and fig I indicate the effect of alkali concentration on alkaline extraction of bagasse at 75°C in 2.5 hrs with varying sodium hydroxide dosage from 0.5-2.5%. Maximum extraction around 75% of the silica present was noticed with 2% sodium hydroxide dose while the pH at the end of

Table-III

Effect Of Sodium Hydroxide Dosage On Silica Extraction From Bagasse

S.No.	NaOH added, %	Silica Extraction %
1.	0.5	10%
2.	1.0	35%
3.	1.5	65%
4.	2.0	75%
5.	2.5	75%

Constant Condition:
Temperature : 75°C
Time : 150 min.

the extraction was above 10.5. There was no further increase in silica extraction by raising the dosage to 2.5 from 2.0%.

Table IV and fig II indicate the effect of temperature, on silica removal in alkaline extraction. Optimum extraction was at 60°C in 2.5 hrs time.

Table V and fig III indicate the effect of extraction time on silica extraction. Maximum silica

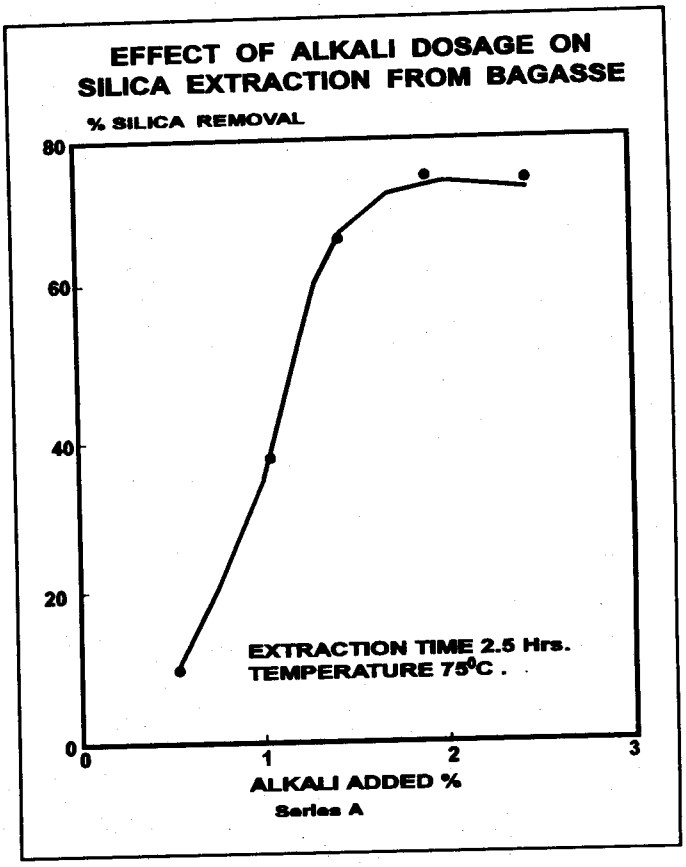

Fig. I

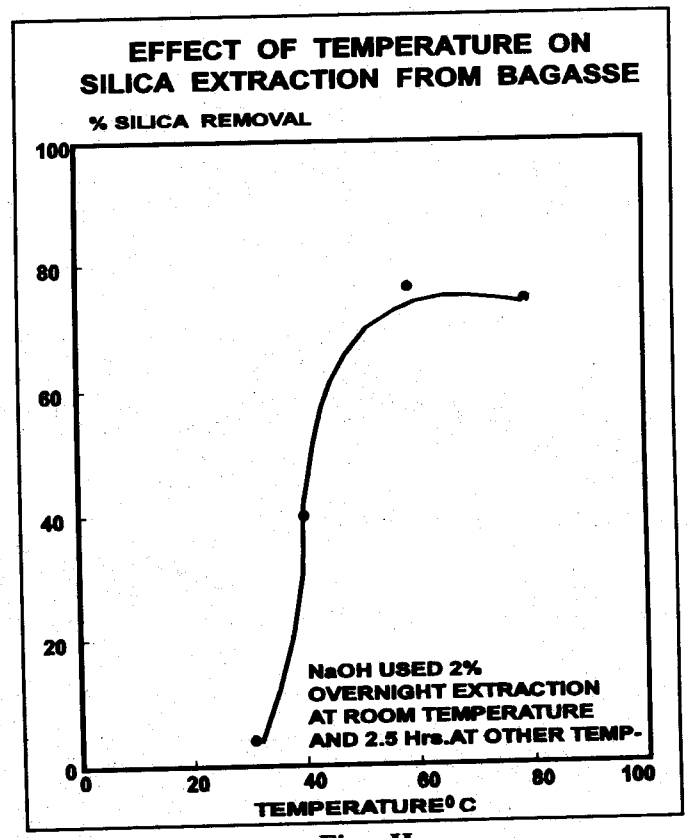

Fig. II

Table-1V

Effect Of Temperature On Silica Extraction From Bagasse

S.No.	Temperature °C	Time	Silica Extraction%
1.	30°C	Overnight	5%
2.	40°C	150 min	40%
3.	60°C	--do--	75%
4.	80°C	--do--	75%

Constant Condition : Conc. of NaOH 2.0%

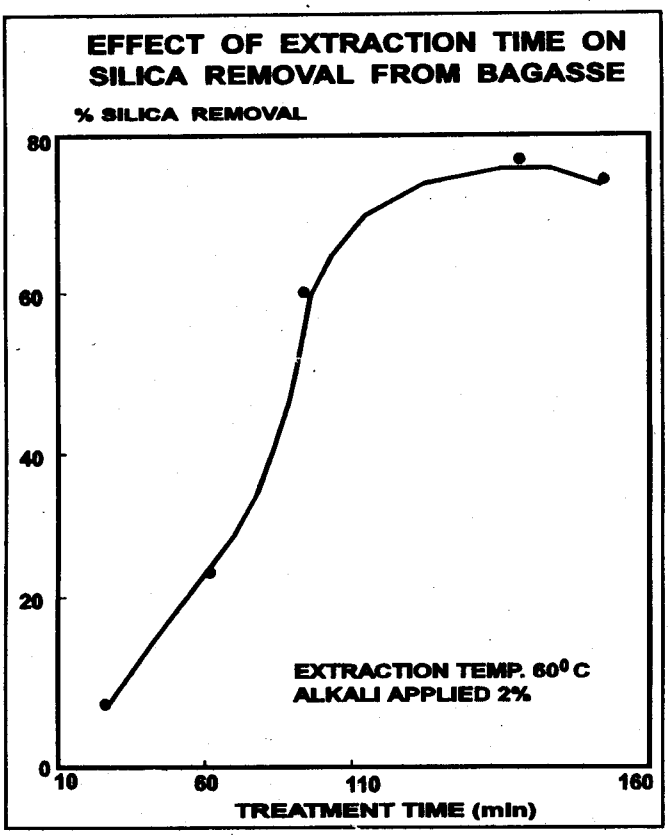

Fig. III

III extraction of 75% was noted in 2 hrs time at 60°C and by using 2% sodium hydroxide.

Table-V

Effect Of Extraction Time On Silica Extraction From Bagasse

S.No.	Treatment Time (Min)	Silica Extraction %
1.	30	10.0
2.	60	25.0
3.	90	60.0
4.	120	75.0
5.	150	75.0

Constant Conditions:
Temperature at 60°C
NaOH conc. 2.0%.

Table VI and Fig IV indicate the results of kraft pulping of unextracted and extracted bagasse samples. It is evidenced from the table that much lower kappa pulp was obtained from extracted bagasse even at the lower dose of pulping chemicals including the sodium hydroxide used in extraction.

Table-VI

Kraft Pulping Of Unextracted And Extracted Bagasse

S.No. Particulars	Unextracted			Extracted		
	1	2	3	4	5	6
1.NaOH used in extraction as Na_2O%	-	-	-	1.5	1.5	1.5
2. Cooking chemicals as Na_2O%	14	15	16	14	15	16
3. Total cooking chemical as Na_2O%	14	15	16	15.5	16.5	17.5
4. Unscreened Pulp yield,%	52.84	51.4	51.0	48.34	47.84	47.2
5. Kappa No.	29.1	22.3	20.0	13.8	13.0	12.0
6. Spent liquor analysis:						
a. pH	10.7	10.7	10.8	10.7	10.8	10.8
b. Total solids, w/w%	8.5	9.4	10.6	6.8	7.7	8.7
c. Residual active alkali as Na_2O	3.4	4.5	4.6	2.8	3.7	4.2

Constant cooking condition:

Raw material in each bomb	-200 g
Raw material to liquor ratio during pretreatment	-1:8
Raw material to liquor ratio during pulping	-1:5
Sulphidity of cooking liquor	-20%
Time taken for pretreatment	120 min
Temp during pretreatment	60°C
Cooking schedule :	
Time taken from amb. to 100°C	30 min.
Time taken from 100°C to 168°C	100 min.
At 168°C	90 min

Table VII indicates the physical strength properties of the unbleached pulp obtained from extracted and unextracted bagasse. Even by using lower dosage of pulping chemicals for extracted bagasse i.e. 15.5% Na_2O including sodium hydroxide used in extraction, almost identical physical strength properties to that of the unextracted bagasse pulp produced with 16% Na_2O were obtained.

The Comparison of Proposed Silica Removal From The Raw Material With The Silica Removal From The Black Liquor:

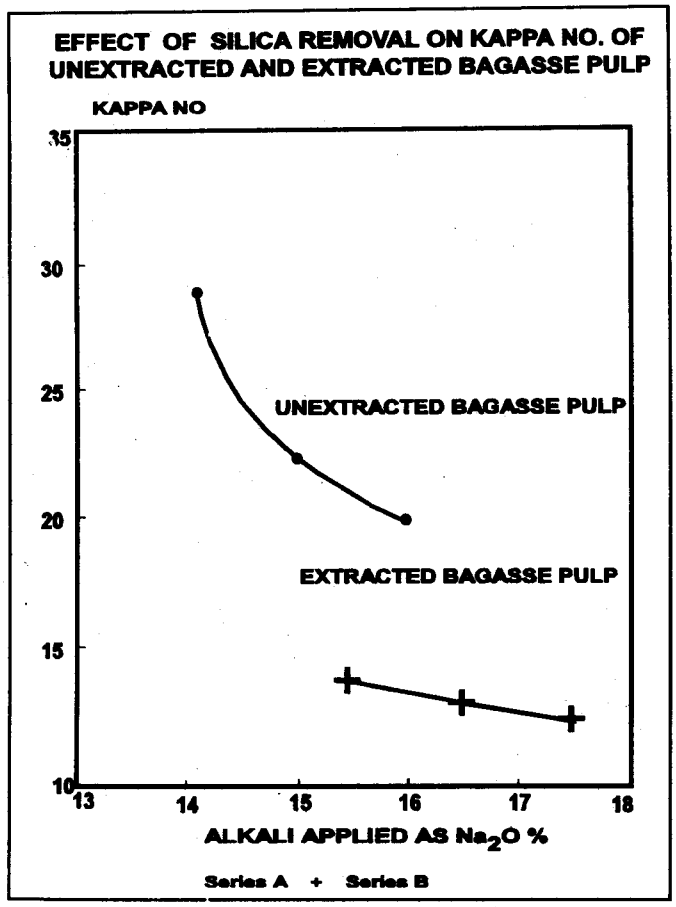

Fig. IV

1. Present technique of silica removal from the raw material take care of the silica going to pulp as well as going to the black liquor and save the damage caused by both in different section of mills while the other techniques take care only of the silica going with the liquor and does not solve the problems caused by silica going with pulp.

2. The proposed method reduces cooking chemical concentration and produces pulp of low kappa which further reduces the bleach chemical consumption. Other methods of disilication do not contribute these advantages.

3. In carbonation technique the large amount of lignin also get precipitated along with the silica which needs redissolution while in present method negligible amount of lignin is extracted during the extraction so the additional step of silica redissolution is discarded.

Table-VII

Comparsion Of Strength Properties Unbleached Pulp Of Uextracted And Extracted Bagasse At ~ 250 ml CSF

S.No.	Strength Properties	Bagasse Unextracted (16% Na_2O)	Unbleached Pulp Extracted (14% Na_2O)
1.	Apparent density (g/cm³)	0.86	0.86
2.	Burst index (kPam²/g)	3.45	3.50
3.	Tensile index (N.m/g)	68.0	70.0
4.	Stretch (%)	2.8	2.9
5.	Fold Kohler molin log	1.84	1.89
6.	Tear Index (mN.m²/g)	3.70	3.80
7.	Porosity Bendtsen(ml/min)	20.0	15.0

CONCLUSIONS

I. Alkaline extraction of raw materials mainly agro residues at elevated temperature (60°C) is a useful idea in extracting silica from the agro based raw material due to their open structure while it is bit difficult from raw materials like bamboo which require destructuring for the proper extraction of silica.

II. Bagasse is a raw material which contain least silica amongst the agro residues like bagasse, wheat straw and rice straw etc. and is being used as a major raw material in agro based mills in the country. This removal of silica in bagasse compared to straws is economically viable as almost equal amount of NaOH is required for its extraction. In an alkaline extraction of bagasse by using just 2% sodium hydroxide at 60°C for two hrs., about 75% of the silica present in the bagasse could easily be removed.

III. This dissolution of silica by alkaline extraction can easily be done in the existing digesters in the mill as a pretreatment while removal of silica from black liquor needs sophisticated infrastructure which may be difficult to arrange for many mills.

IV. There is a possibility of recovering the sodium content used in silica extraction by using the extract in further extraction of silica from fresh bagasse by adding more sodium hydroxide. When the extracted liquor is quite

saturated with sodium silicate, the silica can be removed by precipitation. Silica free extract can be reused in further extraction of bagasse, in pulping to maintain the raw material to liquor ratio, and in pulp washing system.

V. Even by using the lower dosage of pulping chemical (15.5% Na_2O in this case) including the sodium hydroxide used in extraction for extracted bagasse, the lower kappa pulp with identical physical strength properties to that of the unextracted bagasse pulp by using 16% Na_2O was obtained.

VI. Lower kappa of the extracted bagasse pulp can also reduce the bleach chemical consumption and the bleach effluent generated in pulp bleaching. Around six point drop in kappa in the above referred case can give a saving of 1.2% chlorine.

VII. Removal of silica by alkaline extraction can avoid the presence of silica in pulp which can further avoid the formation of hard scale on various parts of paper mill to minimize the problems associated with the presence of silica in the pulp.

VIII. This removal of silica from the bagasse by alkaline extraction can help in improving the efficiency of existing recovery boilers and can provide avenues for putting up more recovery units.

IX. This type of removal of silica from the raw material may be advantageous and economical over the silica removal from the black liquor.

X. Alkaline extraction of raw material for the paper mills even without chemical recovery can also be beneficial because of the reduction in pulping and bleaching chemicals etc. without altering the pulp qualities and by taking care of the damage caused due to the presence of silica in the pulp.

XI. In case the silica could be separated from the extract efficiently and economically the removal of silica from the silica rich raw materials like wheat and rice straw, before pulping, can also be applied. Action in this direction are on.

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