Effect of Cooking Time at Top Temperature on Properties of Pulp and Pulping Spent Liquor in Soda Pulping

Naithani Sanjay, Singh S.V. and Sinha Anil K.,

INTRODUCTION

To conserve the forest resources and to protect the ecological balance for better environment the paper mills in India are forced to use non woody fibrous raw materials to meet the increasing demand of pulp and paper. Bagasse, Straws and cereal are the main source of non wood fibres for papermaking not only in India but also in other parts of the world. Among the cereal straws, rice straw is an important source of raw material for writing, printing and pacaking varieties of paper.

While processing the rice straw for pulp and paper manufacture, there are number of factors which need attention. The most important of which is high silica content which influence the various stages of chemical recovery. It is well known that straw contains high percentage of ash, which is mostly silica (8-12%) and is located in the epithelial cells called silica cell. It is also reported that most of the silica is retained throughout the washing of straws, thus indicating that silica is chemically bound in structure. Most of the chemically bound silica dissolve in the cooking liquor which is normally caustic soda. However the dissolution of silica depends on the cooking process and pulping conditions employed. Total silica entering the process is distributed between the pulp produced and pulping spent liquor generated.

Rice straw is open structure and requires milder cooking conditions. 70-80% of cooking chemical is consumed by the hemicellulose reactions, 10-15% for lignin dissolution and about 5% for neutralisation of acetic acid formed. Rice straw contains about 23-25% pentosans and 12-14% lignin, the cooking chemical applied is being consumed in the initial stage of cooking and no free alkali is left after certain time. In these points of view the present study was undertaken to examine the effect of cooking time at top temperature on the residual active alkali (R.A.A), silica behaviour in spent liquor and strength properties.

RESULT AND DISCUSSION

Effect of cooking time at top temperature on residual active alkali (R.A.A.)

Presence of some amount of residual alkali is required so as to maintain the pH level of about 10.0 to keep the degraded lighin in solution. From the Table-1 it is clear that as the cooking time at top temperature increased from 0 to 10 min, R.A.A. level first decreased and again increased upto 30 min of retention time at top temperature and from 30 to 50 min, R.A.A. again decreased R.A.A. in the spent pulping liquor once decrease cannot increase unless until extra cooking chemical is added. The increase in R.A.A. after certain retention time at top temperature may be due to the formation of sodium bicarbonate ($NaHCO_3$) Which is not precipitated with barium chloride during R.A.A. determination. The pH of the $NaHCO_3$ is in the alkaline range and consumes acid. Therefore the presence of sodium bicarbonate in the liquor will influence the R.A.A. level. The formation of $NaHCO_3$ is only

TABLE-1

Residual Active Alkali In Spent Liquor At different Cooking TimeAt Top Temperature

Retention time at top temperature (minutes)	pH	Residual active alkali (% on dry solid basis)
0	11.23	0.124
10	11.12	0.10
20	10.94	0.124
30	10.88	0.152
40	10.42	0.116
50	10.84	0.098

Cellulose and Paper Division
Forest Research Institute,
P.O. New Forest, Dehradun - 248006 (U.P.)

possible when free NaOH is nil in the spent liquor, If NaOH is present in the solution, the $NaHCO_3$ formed will quickly be converted into sodium carbonate.

$$NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$$

The test was further confirmed by addition of sodium hydroxide in supernatant of barium chloride precipitated liquor. It was observed that addition of sodium hydroxide resulted in precipitation of Na_2CO_3 meaning thereby that above equation hold true and this is why spent pulping liquor precipitate on storage even at 1-2 g/l R.A.A. level.

Effect of cooking time at top temperature on silica dissolution

The extent of dissolution of silica during pulping depends on the cooking process and pulping conditions employed. From the Table-2 it is observed that

TABLE-2

Silica Content in spent Liquor, Washing and Pulp at different cooking time at top temperature

Retention time at top temperature (minutes)	Percent silica		
	Spent liquor	washing	pulp
0	18.0	10.5	71.5
10	8.9	7.2	83.9
20	5.0	10.0	85.0
30	4.8	8.7	86.5
40	4.5	8.6	86.9
50	3.9	8.6	87.5

silica dissolution in spent liquor decreases with increase in retention time at top temperature i.e. 18 percent to 3.9 percent and same trend was observed in case of washing spent liquor, upto 30 min of retention time at top temperature and thereafter it remains constant, this means that silica dissolutions is directly proportional to the retention time at top temperature. R.A.A. results also show decrease in R.A.A. value with respect to retention time at top temperature. The reduction in silica, dissolution in spent pulping liquor is because of decline in R.A.A. level. The silica present in spent pulping liquor at higher retention time at top temperature is in the form of macromolecule which acts as nuclei for the precipitation of spent liquor at lower solid concentration on evaporation or on storage and hence the higher retention time at top temperature is not desirable from recovery point of view. Keeping strength properties also in view the results indicate that 10-20 min retention at top temperature (160°) is adequate.

Effect of cooking time at top temperature on pulp properties

Kappa Number:

Kappa No. is an indication of extent of delignification. At low R.A.A level dissolved lignin get adsorbed on fibre and is difficult to remove during washing. From Table-3 it is observed that Kappa No decreased from 13.23 to 10.60 for 30 min, retention time at top temperature and again increased. This is because the R.A.A. of spent pulping liquor was very low and readsorption of precipitated lignin of the fibre occur. The readsorbed lignin does not pass into spent pulping liquor even on washing.

TABLE-3

Effect of Retention time at top temperature on Kappa Number

Retention time at top temperature (min)	Kappa number
0	13.23
10	11.73
20	11.50
30	10.60
40	12.87
50	12.87

Strength properties:

The results of strength properties of unbeaten pulps are recorded in Table 4-5. It is observed from the Table that Tear Index, Tensile Index and Burst Index was highest at 10 min retention at top temperature. When pulps were beaten to same CSF level (140 ml.) the Tear Index (3.64 mNm^2/g), Burst Index (4.53 $Kpam^2/g$) was highest at 10 min retention time at top temperature while Tensile Index (61.32 Nm/g) was highest at 20 min retention time at top temperature. The pulp on retaining at top temperature beyond 20 min leads to deterioration of strength properties due to higher lignin content as indicated by Kappa No. Thus holding of pulp for a time more than 10 min at top temperature is not advantagenous from strength point of view, under the conditions reported.

TABLE-4

Strength Properties of Unbeaten Pulp

Retention time at top temp (min)	Basis weight (g/m^2)	Tensile index (Nm/g)	Tear index (mNm^2/g)	Burst index ($Kpam^2/g$)	Initial freeness CSF (ml)
0	67.0	30.52	3.69	1.82	280
10	69.0	39.45	4.21	2.31	290
20	68.0	31.37	3.68	1.64	415
30	65.0	38.46	3.75	1.90	320
40	67.5	32.76	3.23	2.03	330
50	66.0	29.97	3.52	1.44	370

TABLE-5

Strength Properties of beaten Pulp

Retention time at top temp (min)	freeness CSF (ml)	Basis weight (g/m^2)	Tensile index (Nm/g)	Tear index (mNm^2/g)	Burst Index (Kpam2/g)
0	160	65.4	45.12	3.69	2.56
10	140	66.5	59.82	3.64	4.53
20	140	66.5	61.32	3.54	4.11
30	140	65.5	52.93	3.55	3.23
40	145	65.5	56.56	3.05	3.86
50	125	66.0	52.19	3.06	2.97

EXPERIMENTAL

The rice straw was collected from local areas and it was cut into small size of about 2 inch long. 200 gm oven dry rice straw was taken for digestion in air bath rotatory digester using soda process. The pulping conditions maintained were as follows:

Alkali as NaOH % (on even dry basis)	-	10
Bath ratio (raw material: liquor)	-	1:5
Top temperature, °C	-	160
Time to raise the maximum temperature (min)	-	90
Time at top temperature (min)	-	0, 10, 20, 30, 40, 50.

After blowing, the pulps were squeezed to recover spent liquor and then washed and screened on a flat vibratory screen of slot size 0.35 mm.

Residual active alkali- The R.A.A. in spent liquor was determined as per Tappi method.

Total solids- The total solids in spent liquor was determined as per Tappi method.

Kappa number- The kappa no. of pulps were determined as per Tappi method

Pulp evaluation- The screened pulps were beaten in a Lampen mill to a desired freeness level. Standard sheets of beaten and unbeaten pulps were made and tested for strength properties after conditioning at 65 percent humidity and 20 °C.