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STUDIES ON WASTE PAPER UTILIZATION FOR PRODUCING WRITING AND PRINTING GRADE PAPERS

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Abstract

An attempt was made to produce better quality paper by using waste paper from different sources, viz. white paper cuttings, office refuse and magazine waste. White paper cuttings were easily converted into acceptable quality pulp by simple dispersion method, whereas office refuse and magazing waste required deinking. Office refuse could be deinked without much problem using conventional belaching agent such as calcium hypochlorite (1.5%) in the presence of sodium silicate (1.0%) at 60°C with continuous agitation for 20 minutes at 3.3% consistency, followed by washing on a 40 mesh sieve. This pulp had a brightness value of 68% ISO and screen yield of 60%. A blend of this pulp and the pulp from white paper cuttings and rag pulp in the ratio of 18:72:10 produced writing and printing grade paper which had breaking length of 2142 meters, tear factor 66.3, burst factor 9 and brightness 70% ISO. It was reasonable free from ink and dirt specks. Magazine waste could not be converted into acceptable quality pulp even by deinking employing either washing or flotation. When treated with 1.5% sodium hydroxide, 2.0% sodium silicate and 2.0% detergent at 3.5% consistency for 45 minutes under continuous agitation and subsequent washing, a pulp having brightness value of 50.3% ISO was obtained. Further bleaching with 8% calcium hypochlorite increased the brightness to 55% ISO. Deinking by flotation technique also using 2.0% NaOH, 5% sodium silicate, 1.0% fatty acid and 1.0% hydrogen peroxide

could not increase the brightness beyond 55% ISO. Blending studies taking this pulp and the pulp obtained from white paper cuttings showed that a maximum of 10% of the deinked magazine waste pulp could be used for producing writing and printing grade paper having proper brightness nad reasonably free from ink specks and fibre bundles. There was no significant degradation of the pulp during deinking or washing is indicated by the acceptable strength properties.

Introduction

Recycling of waste paper for the manufacture of paper and paper board is important as it helps in the conservation of unconventional raw materials-wood, bamboo & agricultural residues etc. Use of waste paper as raw material in paper industry is increashing the world ver and it will further increase not only for the manufacture of grey papers and boards where the presence of ink does not mattermuch but also in the manufacture of newsprint and other writing and printing grade papers. Indian paper industry is facing acute shortage of conventional raw materials. Small paper mills which use agricultural residues face problems of pollution, chemical recovery and inferior quality of the end-products. However, utilization of secondary fibres has greatly helped them in overcoming these problems to a reasonable extent. The quality of paper being manufactured bythem has also improved substantially. With the over all increased use of secondary fibers, the availability of certain varieties has become scarce and the prices have also shot up in the national and international markets. Many papers mills, small ones in particular, now think of upgrading the pulp from cheap and inferior quality waste papers like office refuse, old magazines etc. through deinking nd bleaching sothat a part of the upgraded pulp could be blended with good quality fibre for producing superior grade paper.

The present studies were conducted with the aim to utilize easily available waste papers in the furnish for writing and printing grade papers along with white paper cuttings as the main component. Office refuse and magazine waste are the two varieties which are easily available and have their own merits and demerits. Office refuse is relatively easier to deink, however, the pulp obtained is not strong enough. Magazine waste having mechanical pulp component is difficult to deink and bleach, however, its long fibre fraction contributes towards the strength properties of the pulp blend.

Denking is an essential step for upgrading the printed waste papers and involves two basic steps i. e :

-- dissolving or looseing the ink by chemical means.

-- removing the ink from the pulp by mechanical washing.

Once the ink is dislodged from the fibre, generally in the paper, by chemical or mechanical means, there are two methods to remove it from the aqueous pulp slurry-froth flotation or washing. Froth flotation is a chemi-mechanical process that selectively flots ink particles from a dilute suspension. It is preferred for waste papers having chemically non-dispersable inks or when filler retention is desired. Washing technique is basically a mechanical process which rinses ink, fillers and dirt particles from the pulp. It can be performedover a wide range of stock consistencies and operating conditions using various types of devices.

In the recycling of waste papers there can be problems in defibring certain types of papers. In the majority of cases, however, only conventional type of chemicals are used for repulping. Common types of chemicals which help in defibering and removal of ink particles are caustic soda, soda ash, calcium hypochlorite, hydrogen peroxide, detergents and sodium silicate etc. Restricted use of waste paper for the production of quality papers is mainly due to the lack of appropriate deinking procedure. Consistency, cooking time, temperature, cooking chemicals and their dosages, belaching and washing etc. were some of the parameters which were also studied during the course of the present investigations.

RESULTS & DISCUSSION

Brightening the pulp from white paper cuttings.

White paper cuttings which were used as major component in the paper furnish were already bright and required very small quantity of calcium hypochlorite for enhancing the brightness. Defibration and bleaching effect was simultaneously obtained bytreating the cuttings with calcium hypochlorite in hot water at 60°C for 20 minutes. Sodium silicate 1.0% was added as buffer to maintain the pH around 8.5. The applied chlorine was consumed completely in the stipulated time. The yield of unwashed pulp was 96% and the brightness obtained was 68%.

Higher dosage of Ca-hypochlorite was also tried and it was observed that 0.75% calcium hypochlorite could increase the brightness by 4-6 units. Pulp could be bleached without the aid of sodium silicate as well. A perusal of Table-1 shows that addition of sodium silicate results in margincal increase of brightness however, it reduced the burst factor slightly probably due to a part remaining embeded in the hand sheets.

Effect of pulp washing after hypo addition on the yield, brightness and strength properties

It was considered that the pulp may not require washing as it would result in excessive loss of fines without substantial gain in the brightness. The evaluation of unwashed and the pulp washed on 40 mesh screen confirmed the expectation (Table-1). Tear factor as expected was higher for washed pulp.

TABLE - I

EFFECT OF BLEACHING AND WASHING ON STRENGTH AND OPTICAL PROPERTIES OF WHITE PAPER CUTTINGS

Calcium hypo-chlorite(%)	Sodium silicate (g)	Treatment of pulp	CSF (ml)	Burst factor	Breaking length (m)	Tear factor	Bright-ness(ISO) (%)
0.25	1.0	washed	490	10.2	2400	79	70
0.25	1.0	unwashed	260	10.2	2180	57	68
0.25	nil	washed	495	14.8	2805	78	68
0.25	nil	unwashed	260	15.3	2450	52	69
0.75	1.0	washed	460	9.5	1950	75	77.5
0.75	1.0	unwashed	230	14.0	2400	63	74.8
0.75	nil	washed	400	12.0	2200	74	75.5
0.75	nil	unwashed	280	16.0	2250	64	73.4

Pulp yield - (unwashed) -96 %
Pulp yield - (washed) -70 %

Deinking of office refuse

Office refuse which consisted of mainly typed and hand written papers, excercise books, etc. was subjected to deinking using calcium hypochlorite (0.25 to 2.5%) and sodium silicate. The addition of mineral dispersant like sodium silicate or an organic dispersant like polylactone or a surfactant gives a further increase in brightness. The chemicals improve the elimination of the ink pigments with the filtrate water during washing.

A pulp having brightness of 68% could be obtained with 1.5% calcium hypochlorite and 1% sodium silicate. Yield obtained was 60% when washed on a 40 mesh without circulating the backwater.

TABLE - II

EFFECT OF CALCIUM HYPOCHLORITE ON THE DEINKING OF OFFICE REFUSE

S.No	Calcium hypo-chlorite(%)	Yield(%) (after washing)	Brightness (%) ISO
1.	0.25	60	53.4
2.	1.00	60	63.3
3.	1.50	60	68.0
4.	2.50	60	68.0

Constant conditions :

1. Sodium silicate (%) - 1.0
2. Temp ^{0}C–Initial - 60
   Final - 40
3. Disintergrated time (in minutes) - 20
4. pH - 8.5

The pulp beaten to a CSF value of 335 ml in PFI mill was having good strength properties i.e., breaking length 2856 meters and burst factor 15.3 (Table–III).

TABLE - III

STRENGTH PROPERTIES OF PULP FROM OFFICE REFUSE

S.No	Properties	PFI REVOLUTIONS		
		O	500	1000
1.	Freeness, CSF,ml	520	425	335
2.	Apparent density (g/cm^3)	0.59	0.66	0.66
3.	Burst factor	2.0	14.3	15.3
4.	Breaking length,m	1428	2856	2856
5.	Double fold	3	9	12
6.	Tear factor	66	60.2	55

Strength & Optical Properties of various pulp blends

Blending of this pulp, pulp from white cuttings and the pulp from white hosiery cuttings in various proportions was carried out and hand sheets prepared. Brightness values of all the blends (Table–IV) are within tolerable limits. However, visual examination of the hand sheets suggests that more that 18% of this pulp in the furnish increased the visible specks. Strength properties can be compared with that of writing and printing papers. Breaking length will further improve withfibre orientation i.e. in the mchine direction.

TABLE - IV

STRENGTH AND OPTICAL PROPERTIES OF THE HANDSHEETS PREPARED FROM PULP BLENDS OF DEINKED OFFICE REFUSE, WHITE PAPER CUTTINGS AND BLEACHED HOSIERY CUTTINGS

S.No	Bleached rag pulp (%)	Bleached white paper cuttings	Deinked office refuse (%)	free-ness CSF (ml)	Burst factor	Breaking length (m)	Tear factor	Brightness (%)
1.	10	54	36	280	13	2295	69.4	69.8
2.	10	63	27	295	12	2295	67.3	69.9
3.	10	72	18	310	9	2142	66.3	70.0

Constant Conditions :

Pulp	- Freeness(m)
Rag pulps	- 320
Office refuse	- 335
White Paper cuttings	- 265

Deinking by washing

Chemical charge : Effect of different chemical dosages on the deinking efficiency of magazine waste was studied. The chemicals used were sodium hydroxide, sodium carbonate, sodium silicate and detergent. Studies revealed that 1.5% sodium hydroxide, 2% sodium silicate and 2% detergent was found to be optimum to achieve a maximum brightness valu of 50.3% ISO.

Disintegration time : Effect of disintegration time on brightness was examined by subjecting the waste paper to 20, 30, 45 and 60 minutes disintegration. It was observed that stretching the slushing time beyond 20 minutes resulted in reduction of brightness values from 50.3% ISO at 20 mts to 46.6% ISO at 45 mts. As the dispersion redues and it becomes difficult to remove the ink from the pulp which results in brightness reduction.

Bleaching : Effect of bleaching of deinked pulp was also studied using calcium hypochlorite in varying dosages and keeping other conditions constant. As expected a large dosage of hypo i.e. 8% improved brightness by only about 5 units (Table–V). Therefore in the subsequent studies on pulp blend only deinked pulp from magazine waste was taken without subjecting it to bleaching.

TABLE - V

EFFECT OF CALCIUM HYPOCHLORITE ON BRIGHTNESS DEVELOPMENT OF DEINKED MAGAZINE WASTE

Calcium hypochlorite (%)	Brightness (%)ISO
0	50.3
2	51.3
4	51.4
6	53.4
8	55.0

Strength & Optical properties of various blends of pulps from magazine waste and white paper cuttings.

Deinked magazine waste having brightness of 50.3% was blended with white paper cuttings (brightness 72.1%) for manufacturing writing and printing papers. A perusal of (Table-VI) shows that only upto 10% of the pulp from magazine waste was able to produce acceptable quality of writing and printing papers having tensile index 25 Nm/g and brightness 68% ISO. Beyond 10% the visible specks were more due to which the brightness decreased (64% ISO), the strength properties, however, were acceptable.

Flotation Deinking

Chemical charge : The effects of various chemicals such as sodium hydroxied, sodium slilicate, hydrogen peroxide and fatty cids on the brightness development were studied. Results indicated that a combintion of 2% sodium hydroxide, 5% sodium silicate, 1.0% fatty acid and 1.0% hydrogen peroxide could produe a pulp possessing brightness of 55.0% ISO. It was possible to get 50.6 brightness in flotation deinking using 0.5% NaOH, 2% sodium silicate and 1% fatty acid without any hydrogen peroxied.

Flotation time and water quality : Flotation time was also optimised that it was observed that 45 minutes flotation time was sufficient to get 55.0% ISO brightness.

Effect of Ca ions on froth formation was also studied by the addition of calcium chloride and it was found that by increasing the amount of CaCl2 from 200 mg/1 to 700 mg/l the brightness of the pulp increased from 48.6% to 55.0%, beyond 700 mg/l the brightness started decreasing though the pulp yield in flotation was better than washing, yet flotation was discarded due to the high cost of chemicals used.

Effect of washing of deinked magazine waste

Effect of washing on brightness development was studied by subjecting the pulp after deinking to various stages of washings at one per cent consistency in a dynamic retention jar using 200 mesh screen with continuous agitation.

Results indicated that loss of yield takes place by increasing the number of washings. Yield dropped from 77% in single stage to 50.4% in four stage without any improvement in brightness (Table-VII). The filtrate collected from washings contained 30% solids consisting of fillers and fines.

TABLE - VI

STRENGTH & OPTICAL PROPERTIES OF THE HANDSHEETS PREPARED FROM THE PULP FROM MAGAZINE WASTE AND WHITE PAPER CUTTINGS

S.No	Blending conditions White cuttings (%)	Mag. waste(%)	Freeness CSF(M1)	Burst Index Kpam²/g	Tensile index Nm/g	Tear index mN.m²/g	Brightness (%)	Opacity (%)
1.	100	0	145	0.90	23.5	5.00	72.1	89.9
2.	90	10	170	1.20	25.0	4.80	68.0	90.7
3.	80	20	185	1.10	26.0	5.50	64.0	90.1
4.	0	100	325	1.30	33.0	6.80	50.3	92.0

TABLE - VII

EFFECT OF WASHING STAGES ON THE BRIGHTNESS AND YIELD OF MAGAZINE WASTE DURING DEINKING

S.No	Washing Stages	Yield (%)	Brightness (%) ISO
1.	First stage	77.0	50.3
2.	Second stage	67.0	50.3
3.	Third stage	51.0	50.4
4.	Fourth stage	50.4	50.5

Conclusions

1. Pulp with a brightness of 75% could be produced from white paper cuttings by using o.75% hypochlorite at 60°C for 20 minutes. Washing was not needed after bleaching because hypochlorite dosage was too small to cause any degradation to pulp.
2. Deinking of office refuse could be successfully carried out using 1.5% hypochlorite and 1% sodium silicate at 60°C for 20 minutes. Brightness obtained was 68% at 60% yield.
3. Belending experiments revealed that it might be possible to mix 18% deinked office refuse with a furnish containing major proportion of white paper cuttings and small amount of rag pulp for the manufacture of writing and printing papers.
4. Deinked pulp having brightness of 50.3% could be produced from magazine waste using 1.5% sodium hydroxide, 2% sodium silicate and 2% detergent followed by washing. Further bleaching with 8% hypochlorite resulted in only 5 units increase in brightness, which is on lower side & could be discarded.
5. Blending experiments have shown that 10% deinked magazine waste could be blended with 90% white paper cuttings without adversely affecting the optical properties of the final product.
6. In flotation deinking it was found that besides chemicals, flotation time and hardness of water are important parameters for achieving maximum efficiency.
7. Washing was economical compared to flotation due to high chemical costs in flotation process.

EXPERIMENTAL

Preparation of pulp from white paper cuttings :

White paper cuttings were defibred as per the following conditions :

Pulp cosistency ---------- 2.60 %

Slushing time ---------- 20.0 min.

Temperature ---------- 60.0°C

Chemicals

Calcium hypochlorite ---------- 0.25 and 0.75%

Sodium silicate (Buffer ---------- 1.0%

pH ---------- 8.5

After bleaching the pulp was washed on a 40 mesh using tap water at room temperature.

Preparation of pulp from office refuse

Deinking : Office refuse papers were cut into small pieces and subjected to deinking as per conditions given below :

Consistency ---------- 3.3%

Slushing time ---------- 20.0 min.

Temperature ---------- 60.0°C.

Chemicals

Calcium hypochlorite ---------- 0.25 to 2.5%

Sodium silicate ---------- 1.0%

pH ---------- 8.5

After slushing the pulp was washed on a 40 mesh sieve to remove the ink particles.

Pulp evaluation : Evaluation of pulps was carried out after beating in PFI mill as per 150 DP 5264.

Hand sheet prepared as per 150 DP 5269

Physical strength properties determined as per ISO methods.

Preparation of pulp from magazine waste by deinking by washing

Waste papers were cut into small pieces and processed as follows :-

Mild beating in PFI mill at 15% cy.

Consistency during deinking ---------- 5.0%

Temperature ---------- 60.0°C

Time ---------- 20.0 to 65.0 min.

Washing on a 200 mesh screen with continuous stirring.

Bleaching conditions with hypochlorite

Consistency of pulp ---------- - 8.0%
Temperature ---------- - 40.0°C
Time ---------- - 60.0 min
pH ---------- - initial - 11.0
Final - 20.0

Flotation Deinking Pulping Conditions

Pulp consistency ---------- - 3.5%
Time ---------- - 45.0 min.
Temperature ---------- - 50.0°C
Sodium silicate ---------- - 2.0 to 5.0%
Sodium hydroxide ---------- - 0.5to 2.0%
Detergent ---------- - 0.2%
Peroxide (H_2O_2) ---------- - 1.0%
Oleic acid ---------- - 1.0%

Flotation Conditions

Pulp consistency ---------- - 0.5%
Time ---------- - 20 to 60 min.
pH ---------- - 10.0
$CaCl_2$ hardness ---------- - 200.0 to 800.0 mg/l

Equipment

Flotation was carried out in a cylindrical made of stainless steel. Compressed air was introduced from the bottom of the vessel and froth formed was skimmed off manually.

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