Combined Deinking Technology To Improve The Quality Of Recycled Paper

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ABSTRACT

The use of secondary fibre is growing over the years and thus the interest for more work in the area of deinking is evident worldwide. The combined deinking technology of Ultrasound and enzymatic methods was introduced into the deinking process of recycled paper. Biodeinking technology has opened up a new way for recycled paper. The conventional deinking technology with chemicals is combined with ultrasonic and enzymes technologies in this paper. Deinking operation was studied in two stages; first difiberization at high temperature and with suitable chemicals in hydrapulper and then removal of separated ink as foam in a flotation cell. The result shows that ultrasonification of pulp with only enzyme is effectively improved in strength properties, pulp freeness and sheet density while lesser improvement in bulk density. Results indicate that enzymatic deinking does not improve ink removal efficiency infact Brightness and ERIC value decreases in comparison to the chemical deinking.

KEYWORDS: Ultrasound, Deinking, Wastepaper (Photocopier), Recycling, Biodeinking, Ink detachment, Cellulase, ERIC, ISO Brightness,

Introduction

Paper manufacturing is a major industry and a continuously growing one. Increased production of paper imposes a severe demand on plant raw material and thus harms the environment. Recycling of used paper is an alternative that can alleviate the stress that is exercised on the environment. The three major sources of raw material for such recycling are newsprint, photocopier paper and inkjet-printed papers. Recycling of paper requires the removal of the printed ink from the used paper, called deinking, so that the processed material is brighter [4]. Printing on paper is accomplished by using two types of inks, the impact and the non-impact inks. In impact inks, used for newsprints, the ink does not fuse with the paper and is, therefore, easy to remove or dispersed during the deinking, or recycling process. Such recycling is now well known and has been carried out for years. On the contrary, non-impact inks used in photocopying, ink-jet printing and laser printing results in the ink fusing with the paper and makes it non-dispersible, thus rendering the deinking process much more difficult. Printing toner is made up of carbon black, thermoplastic resin and electric-magnetic iron oxide. Thermoplastic resins that we commonly use are polystyrene, the copolymerization of ethylene and vinyl acetate, nitro cellulose, polyvinyl chloride (PVC), polyamide and polyester, etc [12].

The reuse of the recycle paper fibers for writing and printing papers is essentially dependent on their deinking. Deinking is a sophisticated process for recycling of the paper and for the proper future growth of the paper industry. There is need for the application of effective equipments that will give the best results for recycling of the waste paper. Application of flotation cell found to be one of the best choices for the waste paper recycling [2, 3].

In order to favour deinking, chemical products have been used for a long time. More recently, enzymes appeared as an alternative deinking technology [8, 9, 10]. Enzymatic deinking is advantageous for industrial usage because it is efficient, quick and has a low environment impact. Besides, Ultrasonic and other technologies have begun to be investigated by some researcher, which is still in its starting stage [5, 6, 12]

In the present work chemical and enzymatic deinking technology combined with sonification is studied for deinking of xeroxwaste. The research of biodeinking technology has opened up on a new way for paper deinking.

The deinking efficiency of the process has been evaluated by means of Brightness and ERIC measurements, as indicated in TAPPI standard T452 using an Elrepho 2000 from Data Colour International, Lawrenceville, N.J, U.S.A. To quantify this deinking efficiency, the brightness of the hand sheets must be compared with a reference. The brightness of the unprinted paper subjected to the same disintegration and flotation condition is considered as a reference value. Further various strength and physical properties of paper also studied to understand the impact of combined deinking technology [1].

Materials and Methods

Paper Furnish

The current work aims to study the potential of enzymes and sonification of Photocopier waste paper. The sample was procured from the office of DPT, IITR, Saharanpur.

Chemical Deinking

Photocopier paper was individually cut into 6-8 cm squares. Pulping was

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carried out using 120g oven dry mass. The sample was prepared by soaking Xerox printed paper in warm water and disintegrating for about 30 minutes. After a 10 minutes fiberization step with water, deinking chemicals sodium hydroxide (2.0%), sodium silicate (2.5%), hydrogen peroxide (1.0%), Triton X-100 (1.2%), DTPA (0.5%) were added in the hydrapulper. The consistencies, temperature, pulping time and rpm were 10%, 50°C, 15 min and 900 rpm maintained in all the experiments. These chemicals were procured from Qualigens Fine Chemicals (Fisher Scientific- AR Grade).

Enzymatic deinking

In the Enzymatic Deinking, Photocopier paper was individually cut into 6-8 cm squares. Pulping was carried out using 120grams oven dry mass. After all the paper and cellulase enzyme (0.3 IU/g od paper) had been added to the hydrapulper, the pre-soaking time with enzymes for 15 min.The consistency, temperature, pulping time and rpm were 10%, 50°C, 15 min and 900 rpm were maintained in all the experiments. The Commercial cellulase was obtained from Anil Biochem limited (Pulpase RF 15), Gujarat. The enzyme activity of cellulase was 25 IU/ml.

Flotation Cell

In the Flotation stage, about 100 gm oven dry repulped stock from the hydrapulper was diluted to 1% consistency and about 10lit. Diluted stock was sent to the batch flotation cell. The flotation was performed in the Lamort type flotation cell. The rotor speed was 2100 rpm.The reason for taking a reasonably high agitation speed was that the air was sucked in through the tube and air bubbles went out through the annular holes from the nozzle plate in the bottom of this tube. The flow of the air is proportional to the speed and thus adequate flow rate was maintained for good flotation. Proper ink particles size and air bubbles ratio is important for good flotation. Researchers have proposed that the optimum bubbles size is approximately five times the size of ink particle agglomerates to be removed. Similarly flotation time of 10 minutes is adopted because further increased in flotation time produces minimal variation in efficiency. Proper flotation time ensures that all the particles had sufficient time to float and further time shall only use power with no additional advantages in flotation efficiency. In both pulping and flotation stages, tap water was used as it contain some salts of calcium and magnesium, which helps in the flotation process.

Ultrasonification

Ultrasonic treatment was performed with an ultrasonicator (UNITECH, India). The power, frequency and temperature were 230 W, 20kHz, and 50°C respectively. About 50gm oven dry repulped stock from the hydrapulper was diluted to 1% consistency. The ultrasonification timing (5, 10 and 15) minutes were maintained in all the experiments.

Physical and Optical Properties

The optical property was measured on sheets with a basis weight of around 75g/m^2 for (photocopy paper), prepared before and after flotation on British standard hand sheet machine. ISO brightness is measured on both sides of the sheet, is reported as an average of the two. ISO brightness and ERIC 950 measurements have been done by Technibrite ERIC 950, Technibrite corporation (New Albany, in) USA.

Result And Discussion

Hand sheets of deinked pulp obtained after pulping and flotation in different experiments were prepared in British sheet former and various properties were measured as per standard method. The optical properties are reported in Table 1 and physical properties are reported in Table 2.The comparison of

Table 1: Optical properties of hand sheet prepared by deinking pulp using different treatments methods.

Parameters	After pulping	After flotation	Ultrasonic treatment following flotation		
			5 mins	10 mins	15 mins
ISO Brightness					
Chemical Deinking	85	89	87	90	90
Enzymatic Deinking (0.3 IU/g od paper)	77	85	80	86	85
ERIC Value					
Chemical Deinking	79	64	67	54	41
Enzymatic Deinking (0.3 IU/g od paper)	95	68	58	65	40

Table 2: Physical properties of hand sheet prepared by deinking pulp using different treatments methods.

Parameters	After flotation	Ultrasonic treatment following flotation		
		5 mins	10 mins	15 mins
Chemical deinking				
CSF (ml)	640	640	620	610
Tensile index (N.m/g)	25	26	27	31.7
Tear index (mN.m^2/g)	3.6	4.02	4.23	4.80
Burst index (kPa.m^2/g)	1.52	1.82	2.1	1.13
Sheet density (kg/m^3)	650	650	590	650
Bulk density (m^3/kg)	1.54	1.54	0.91	1.54
Enzymatic deinking				
CSF (ml)	720	670	700	720
Tensile index (N.m/g)	37.8	38.8	40	42.1
Tear index (mN.m^2/g)	4.8	4.8	5.73	6.03
Burst index (kPa.m^2/g)	1.60	1.90	1.67	1.60
Sheet density (kg/m^3)	650	720	650	650
Bulk density (m^3/kg)	1.53	1.38	1.53	1.53

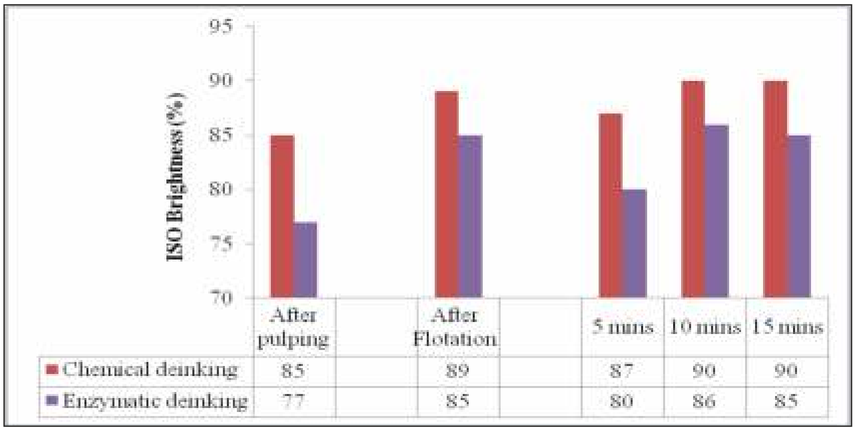

Fig 1: ISO Brightness (%) of deinking pulp using different treatment methods

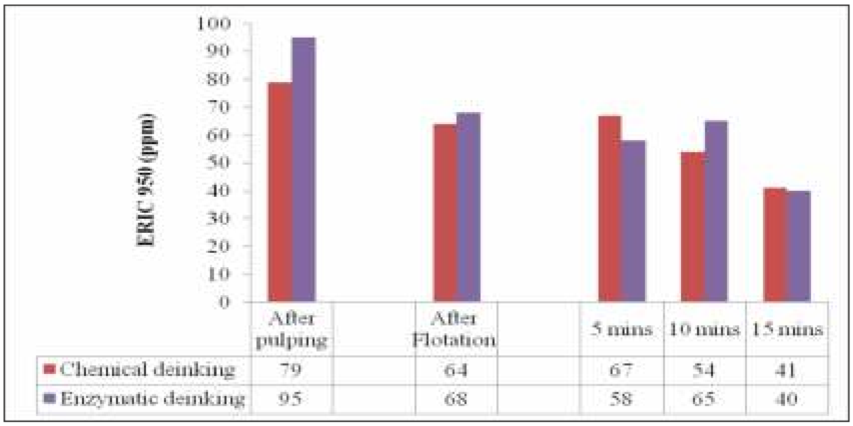

Fig 2: ERIC 950 (ppm) of deinking pulp using different treatment methods

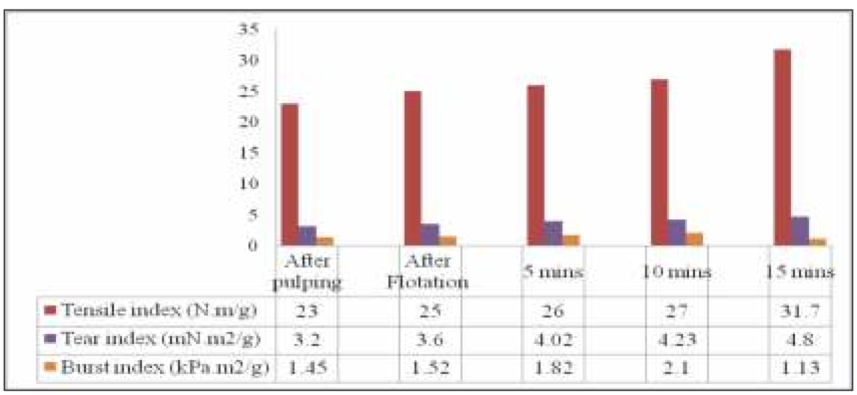

Fig 3: Tensile index (N.m/g), Tear index (mN.m²/g), Burst index (kPa.m²/g) of chemical deinking.

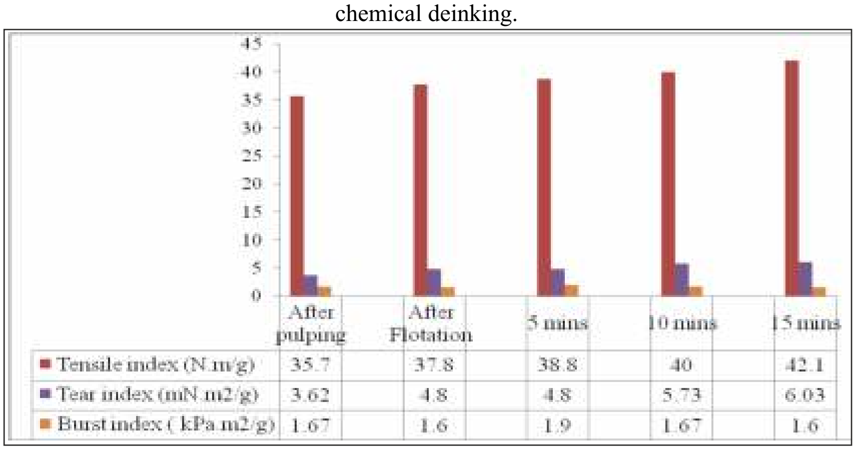

Fig 4: Tensile index (N.m/g), Tear index (mN.m²/g), Burst index (kPa.m²/g) of enzymatic deinking

brightness and ERIC 950 value as shown in fig 1 and 2 respectively while strength properties are shown in fig 3 and 4.

Results indicate that enzymatic deinking does not improve ink removal efficiency infact Brightness and ERIC value decreases in comparison to the chemical deinking. Various researchers have reported unpredictable actions of enzymes in case of furnish containing photocopier waste paper [8, 13]. Sonification seems not to have any impact in ISO brightness. However good reduction in ERIC value is observed with the use of sonification before flotation in both chemical and enzymatic deinking. In chemical deinking process ERIC value reduces from 64 (deinking without sonification) to 41 (deinking with sonification treatment with 15 min). In case of enzymatic deinking process the ERIC value reduces from 68 (deinking without sonification) to 40 (deinking with sonification treatment with 15 min).

Reduction in ERIC value of sonification is may be due to agglomeration of ink particles during ultrasonic treatment. Hence the removal of ink improves. The ink particles size distribution should be studied further to establish the same.

Fressness was improved in case of enzymatic deinking. It has been proposed that such an increase in freeness is due to selective removal of fine fibres by enzymatic [11]. Freeness may also be improved by enzymatic action on small colloidal particles.

Sheet density was improved [6] in all the cases while in case of bulk density less improvement in enzymatic and ultrasonic treatment as compared to conventional deinking.

Ultrasonic treatment leads to decrease in CSF in case of chemical deinking, which may be due to the increase in water sorption of fibers. The same has been reported in the literature [6, 12].

Conclusion

In the present work improvement of ultrasonic treatment have been investigated in chemical and enzymatic deinking. Ultrasonic treatment was carried before flotation. The studied should be concluded as follows:

1. Enzymatic deinking of photocopier paper shows unpredictable results in term of ink removal, strength properties and pulp freeness. Earlier researchers also have reported similar behaviour. Several investigation is required as the

activity taking in the present work is filter paper unit. Independent activity of all the three components of cellulase enzyme should be studied to analyse the mechanism of enzymatic deinking.

2. Investigation of ink particle size distribution is required to understand the mechanism of ink removal with ultrasonic treatment.
3. Ultrasonification shows improvement in the ink removal as well as in paper properties.

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