Effects of Surfactants in Flotation Deinking of Old Newsprint

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Effects of surfactants in flotation deinking operation of ONP has been studied using 5 surfactants namely Triton x-100, Tween 80, Brij-35, Anmol surfactant DI and Oleic acid. It is observed that Tritron x-100, Brij-35 and Oleic acid have optimum dosage after which the deinkability factor and flotation rate constant starts decreasin with increasing dosage. In case of Tween 80 and Anmol DI with the increase in their dosage, the deinkability factor and flotation rate constant goes on increasing resulting in better quality pulp while the loss of fines and fibres also increases. It appears that Tween 80 and Anmol DI also accumulate dust or fines along with the ink to form the medium size agglomerate which can be carried away with the air bubble as foam with the increase in dosage. The ink agglomerate size increases with the increase in dosage of Triton X-100, Brij-35 and Oleic acid resulting in its reversal back to the pulp beyond optimum dosage.

INTRODUCTION

Paper recycling, in an increasingly environmentally conscious world, is gaining importance. With rapid developments in deinking processes for the reuse of secondary fibers, the recycling process is becoming more and more efficient. The quality of paper made from secondary fibers is approaching that of virgin paper. The process is a lot more eco-friendly than the virgin-paper-making process.

The process is very chemistry-intensive and has been studied extensively. Conventional processes use chemicals that are easily available and are cheap. The standards attempted to be met for the quality of the deinked pulp are the same as those for virgin paper pulp. However, there are still a few rough edges in the processes being used commercially today that need to be smoothened out. Deinking processes, though far more eco-friendly than virgin-paper-making processes usually are, still use some chemicals that are harmful when released as effluents. Due to processes generally being highly proprietary, not all industries are being run at an optimal level. Besides, some very promising results obtained at the laboratory level, if incorporated into industrial processes, could be of great benefit.

Most industrial processes are designed to handle a particular type of input waste paper. This communication is an attempt to assimilate promising laboratory results obtained and technologies that are currently in industrial use to design an optimal deinking process for commercial application. The objective is to achieve an eco-friendly and effective deinking process for old newsprint (ONP).

Old newsprints (ONP) represent a major source of raw material for the reproduction of newsprint grade paper. ONP is widely available and is usually of uniform quality, which makes it valuable. The technology for removing conventional oil-based inks such as offset and letterpress is well established [1]. The newsprint portion is mostly mechanical fiber, containing most of the dry content of wood. In the original production of the pulp, the wood is converted either Chemi thermo Mechnical Pulping (CTMP) or by thermo mechanical refining of chips (TMP). These mechanical pulping processes produce a wide distribution of fibers. If ONP is exposed to sunlight; some of it may be considerably more yellow than fresh newsprint pulp. The most common form of ink applied to newspapers consists mainly of carbon black particles dispersed in heavy oil. Only in the case of premium newspapers does the ink contain soyabean oil or additives to promote drying or setting. Rather, the oil mainly absorbs into the fibers. The surface charge of ONP, after it has been dispersed in water, tends to be highly negative due to the presence of wood extractives, dispersants from the coatings on various glossy inserts, and byproducts of peroxide bleaching [2].

The efficiency of the process has been evaluated by means of brightness measurements, as indicated in TAPPI Standard T 452. using an Elrepho 2000 from Datacolor International, Lawrenceville, N.J, USA. To quantify this efficiency, the brightness of the handsheets must be compared with a reference. The brightness of the unprinted paper subjected to the same disintegration and flotation conditions is considered as a reference value. Therefore, global efficiency of the deinking process would be defined by the following Deinkability Factor [3]:

$$EF = \frac{BF\ BD}{BBF - BD} . 100 \quad \ldots\ldots\ldots(1)$$

Where -

E_F = Deinkability Factor (%)

B_D = brightness of pulp after pulping (%ISO)

B_F = brightness of pulp after Flotation (%ISO)

B_{BF} = brightness of unprinted paper subjected to the pulping and flotation stages carried out in the same conditions (%ISO).

One theory states that flotation is a first order process (4). The number of particles removed is proportional to the number of particles in the suspension and is given by:

$$- dN/dt = kN \quad \ldots\ldots\ldots(2)$$

On Integration of equation (2) we get

$$N/N_0 = \exp(-kt) \quad \ldots\ldots\ldots(3)$$

where N = is the number of particles per liter pulp slurry at any time t

N_0 = is the number of particles per liter pulp slurry at time t = 0

t = the flotation time, minutes

k = the flotation rate constant that depends on the type of contaminants, chemicals, temperature, type of pulp, consistency of the pulp, bubble size distribution , and flotation cell design

The integrated process equation 3 can be composed with equation 1, and can be written as (5,6):

$$\ln \frac{B_{BF}\ B_D}{B_{BF} - B_F} = kt \quad \ldots\ldots\ldots(4)$$

Plot of the calculated values of ln $[(B_{BF}\ B_F) / (B_{BF}\ B_D)]$ with time, allows measurement of the constant k.

AIMS AND OBJECTIVES OF THE WORK

In view of the above information, it is evident that Chemical dosages of different surfactants have effect on Deinkability Factor on the basis of ISO Brightness and Flotation Rate Constant. To observe the above effects, suitable experiments were planned for ONP, with varying chemical dosages of different surfactants to observe their effects on ISO Brightness after pulping and after flotation.

EXPERIMENTAL METHODOLOGY

The wastepaper used was a combination of offset printed old newspapers (The Indian Express). Old newsprint (ONP) had age less than 6 months. The fiber analysis of the ONP samples had shown that the ONP contained a blend of softwood chemical and mechanical fibers with some hardwood chemical fibers.

ONP was slushed in a hydropulper and its subsequent flotation was carried out in a flotation cell, to remove the separated ink in the form of foam. The principle and equipments have been discussed in our earlier paper. The slushing of ONP is carried out in the laboratory 35 litre capacity hydropulper, having provision for controlling rpm and temperature, at varying conditions. Pulping was carried out using 500 gm air dry mass at 650C temperature and 6 % pulp consistency with approximately 7 % AD moisture content. The deinking chemicals added in the hydropulper at the operating conditions, are sodium hydroxide, sodium silicate, DTPA, Hydrogen peroxide and active chemicals, prior to addition of the waste paper (Table 1). The retention time for pulping operations is 15 minutes and was kept constant for all the experiments [7]. The pH value for all these experiments during pulping is between 9.0 to 10.5.

In the flotation stage, repulped stock from the hydropulper, was diluted to 1 % consistency and about 10 lit diluted stock is sent in the batch flotation cell. The flotation was performed in a Lamort type flotation cell for 10 minutes retention time at a consistency of 1 %. The rotor speed was fixed at 2000 rpm. The reason for taking a reasonably high agitation speed was that the air was sucked in through the tube and air bubbles went

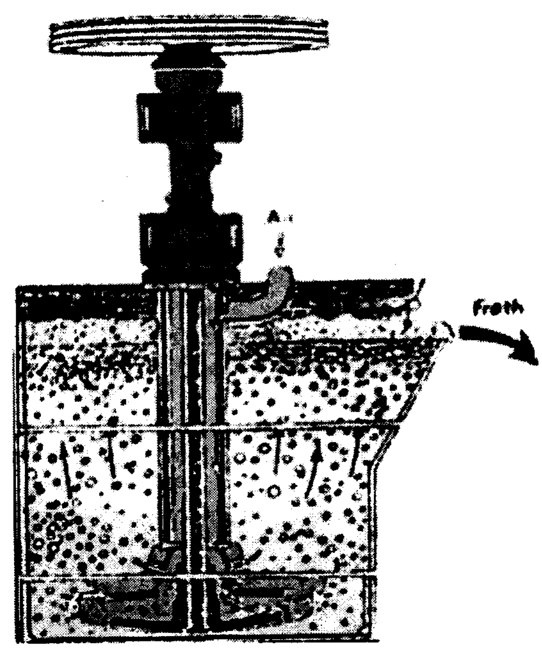


Figure 1 : Flotation Cell

Table 1 :

PULPING CONDITIONS (7, 12)	
Temperature	65 0C
Consistency	6%
Pulping Time	15 min
Flotation time (t)	10 min
Flotation Consistency	1 %
Blank Run	
(ISO Brightness %)	56
CHEMICALS	
(On the basis of OD Raw material)	
NaOH	2 %
H_2O_2	1 %
Na_2SiO_3	2.5 %
DTPA	0.5 %

out through the annular holes from the nozzle plate in the bottom of this tube [8] as shown in Fig. 1. The flow of the air is proportional to the speed and thus adequate flow rate was maintained for good flotation. Proper ink particle size and air bubble ratio is important for good flotation [9]. Szatkowki and Freybergar [10] have proposed that the optimum bubble size is approximately five times the size of ink particle to be removed. Similarly flotation time of 10 minutes is adopted because further increase 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 advantage in flotation efficiency [11]. In both pulping and flotation stages, tap water was used as it certain salts of Calcium and Magnesium which help in flotation process. The pH value range after flotation cell, is between 8.0 9.5. The optical properties were measured on sheets with a basis weight of 60 ± 2 g/m2, prepared before and after flotation on British Standard handsheet former according to TAPPI Standard method T-205. Brightness measurements were carried out on pads using a Technibrite ERIC 950, Technidyne Corporation (New Albany, IN).

Fig. 2 Tirton x 100 Dosages Vs. Deinkability Factor, Flotation Rate Constant

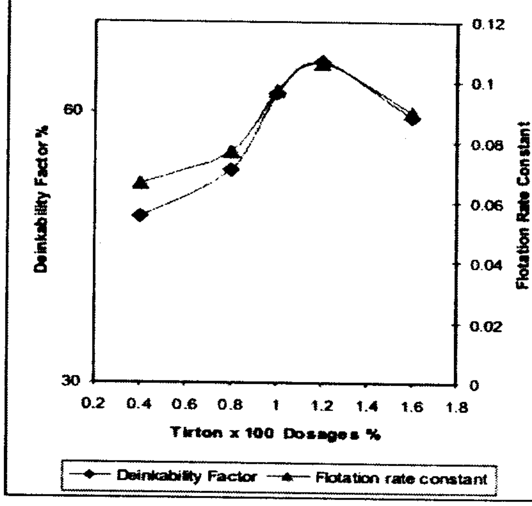
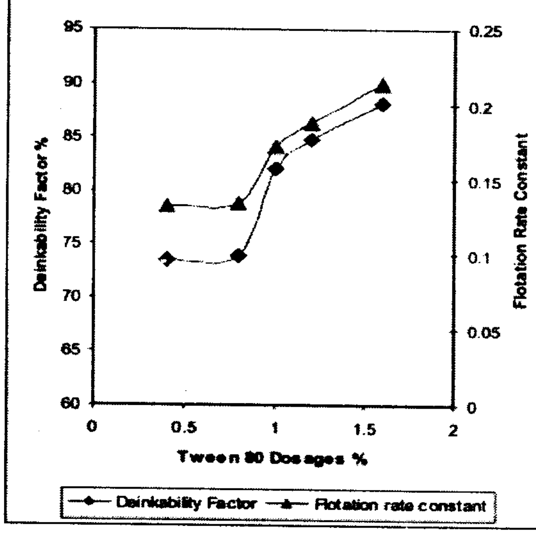


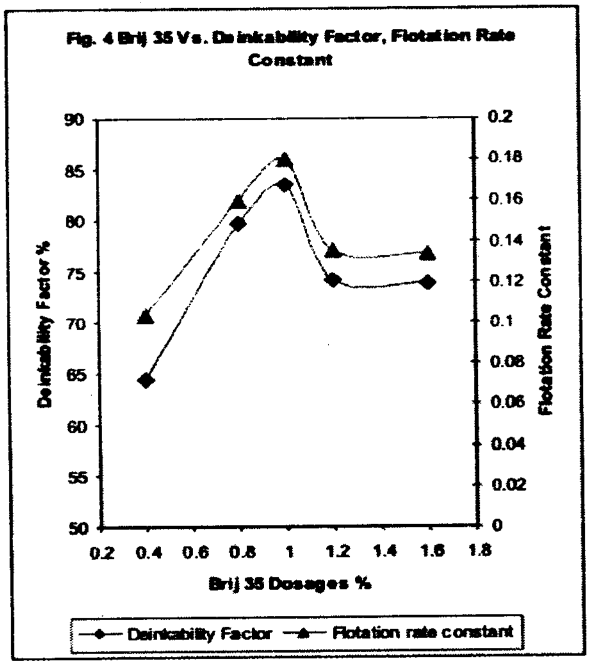
Fig. 3 Tween 80 Vs. Deinkability Factor, Flotation Rate Constant

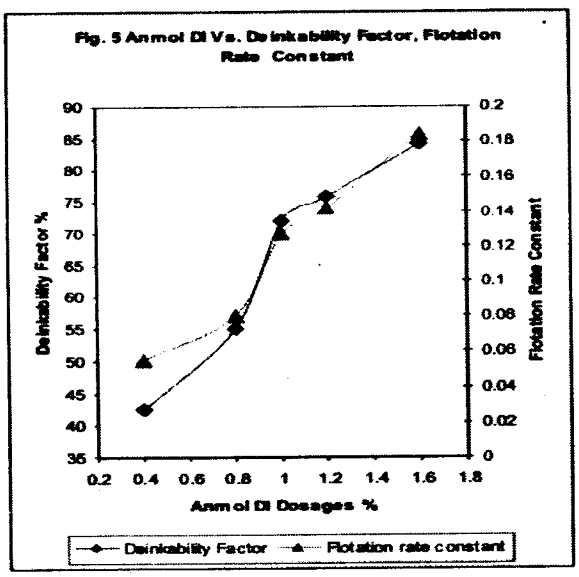


RESULTS AND DISCUSSION

The results have been shown in Fig. 2 to 6 for slushed pulp before flotation and after flotation in the flotation cell which include Deinkability Factor and Flotation Rate Constant. Fig. 2 shows the effect of chemical dosage of Triton x 100 (Iso-octyl phenoxy polyethoxy ethanol), in terms of Dinkability Factor and Floatation Rate Constant. In this figure, as the chemical dosage of Triton x 100 increases, the Deinkability Factor and Flotation Rate Constant increases to optimum value. After optimum conditions the Deinkability Factor and Flotation Rate Constant decreases. This shows that high chemical dosage of Triton x 100 beyond 1.2 % has started affecting the deinkability and the ink has started reversing back in the system, after dissociation from the pulp earlier. Fig. 3 shows the effect of chemical dosage of Tween 80 (Polyoxyethlene sorbittan mono oleate) in terms of Dinkability Factor and Floatation rate constant. In this case too, the Deinkability Factor and Flotation Rate Constant increases with the increased dosage of chemicals, but no reversal is obtained as in the case of Triton x 100. Fig. 4 shows the effect of chemical dosage of Brij 35 (Polyoxyethylen lauryl ether), in terms of Dinkability Factor and Floatation Rate Constant. As the chemical dosage of Brij 35 increases, Dinkability Factor and Floatation Rate Constant increases up to the optimum value and after the optimum chemical dosage, the Dinkability Factor and Floatation Rate Constant decrease as in the case of Triton x 100.

Fig. 5 shows the effect of chemical dosage of Anmol Surfactant DI from Anmol Polymer Pvt. Ltd, in terms of Dinkability Factor and Floatation Rate Constant. In this figure, also as the Deinkability Factor and Flotation Rate Constant increases with the increased dosage of chemicals, but no reversal is obtained as in the case of

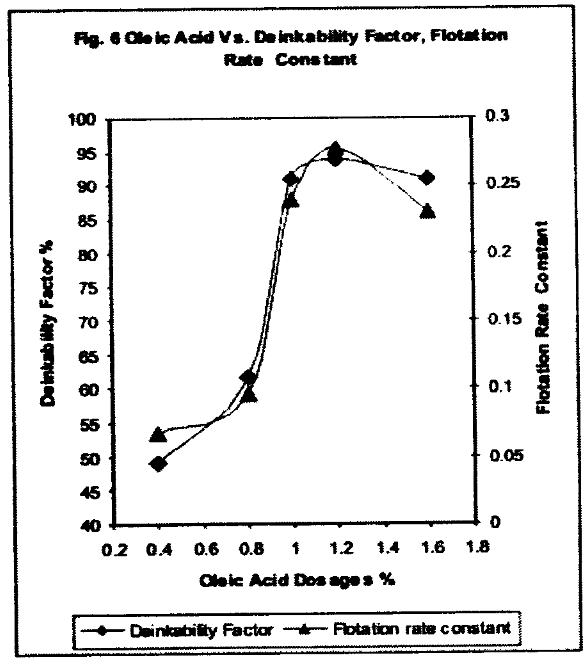




Triton x 100. Fig. 6 shows the effect of. chemical dosage of Oleic Acid in terms of Dinkability Factor and Floatation Rate Constant. As the chemical dosage of Oleic Acid increases, Dinkability Factor and Floatation Rate Constant increases up to optimum value and after the optimum chemical dosage, the Dinkability Factor and Floatation Rate Constant decrease as in the case of Triton x 100.

CONCLUSIONS

From the above results and discussion, it is evident that the used surfactants can be classified in two category: No.1: Triton x 100, Brij 35, and Oleic Acid show a behavior where the ink goes on accumulating on the fixed size air bubbles with the increase in surfactant dosage and reaches to an optimum dosage of surfactant. Beyond this point, the ink agglomerate size is more and is not sustainable on the air bubble. This large size ink



agglomerate goes back in the system leading to lower Deinkability Factor and Flotation rate Constant with increased dosages. These types of results have been observed by us in our earlier work too [12].

No. 2: Tween 80 and Anmol DI surfactants show a behavior where perhaps the surfactant is not only helping the ink agglomeration but also forming intermediate size agglomerate with dust or fines. The size of agglomerate with dust, fines or ink is such that it goes out on the air bubbles forming foam and leads to relatively cleaner pulp resulting increasing Deinkability Factor and Flotation rate Constant. It has been observed that the loss of fines is relatively more with these surfactants in comparison to Triton x 100, Brij 35, and Oleic Acid, which is probably possible with the above possible reasoning.

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Table 2 : Effects of Different Surfactants on Deinkability factor & Kinetic Constant On basis of ISO Brightness:

S. No.	Chemical Dosage %	ISO Brightness% (B_D)	ISO Brightness% (B_F)	Deinkability Factor% (E_F)	Flotation Rate Constant k(min-1)
	Tirton x 100				
A1	0.4	47.32	51.52	48.41	0.066194
A2	0.8	48.25	52.40	53.54	0.076676
A3	1	46.65	52.45	62.03	0.096843
A4	1.2	46.57	52.75	65.53	0.106524
A5	1.6	49.35	53.30	59.39	0.090137
	Tween 80				
B1	0.4	50.52	54.55	73.51598	0.132863
B2	0.8	47.93	53.89	73.85	0.134147
B3	1	51.67	55.22	82.08092	0.17193
B4	1.2	52.72	55.50	84.73282	0.187947
B5	1.6	52.82	55.62	88.18898	0.213614
	Brij 35				
C1	0.4	43.62	51.60	64.45	0.103448
C2	0.8	50.57	54.90	79.72	0.159571
C3	1	50.70	55.12	83.49	0.180124
C4	1.2	49.62	54.35	74.13	0.135239
C5	1.6	46.90	53.62	73.84	0.134117
	Anmol Surfactant DI				
D1	0.4	50.00	52.55	42.50	0.055339
D2	0.8	51.10	53.80	55.10	0.080078
D3	1	49.92	54.30	72.01	0.127355
D4	1.2	50.22	54.60	75.77	0.141793
D5	1.6	53.47	55.60	84.15	0.184253
	Oleic Acid				
E1	0.4	44.50	50.15	49.13	0.067591
E2	0.8	46.47	52.34	61.57	0.095698
E3	1	49.89	55.44	90.94	0.238925
E4	1.2	50.37	55.65	93.77	0.277704
E5	1.6	49.86	55.39	90.94	0.230912

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