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Trismawati, I. N. G. Wardana, Nurkholis Hamidi, and Mega Nur Sasongko

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Characteristic of Flotation Deinking Using Bio and Synthetic Surfactant at Different Air Flow Rate

Trismawati [1,2 a)] and ING Wardana, [2,b)], Nurkholis Hamidi, [2,c)], Mega Nur Sasongko [2,d)]

[1]*Faculty of Engineering, Panca Marga University, Probolinggo, Indonesia*
[2]*Department of Mechanical Engineering, Brawijaya University, Malang, Indonesia*

[a)]*Corresponding author: trisma.saja@yahoo.com*
[b)]*wardana@ub.ac.id*
[c)]*hamidi@ub.ac.id*
[d)]*megasasongko@ub.ac.id*

Abstract. Flotation deinking has industrially applied but several problems keep unsolved because limitations have to compete with several variables present. Flotation deinking is multi variables process, so studying flotation deinking is still interesting. In this research, the amount of variables was reduced and focused to the performance comparison between flotation deinking of old newspaper (ONP) using biodegradable fatty acid of morinda citrifolia as the raw bio surfactant (RBS) and biodegradable fatty acid of palm oil that had been converted to be commercial surfactant (CS). The flotation was done at laboratory flotation cell equipped with orifice at different diameter (orifice number 20, 40 and 60) with adjustable airflow rate. Brightness and Effective Residual Ink Concentration (ERIC) of the deinked pulp were measured. The best results were achieved on orifice number 40 with the highest brightness of 41.96 ^{o}ISO and 40.96 ^{o}ISO when using CS and RBS respectively, and lowest ERIC of 896.82 ppm and 1001.72 ppm when using CS and RBS respectively. The percentage delta of deinking power characteristic between CS and RBS was 2.36% and 11.70% for brightness and ERIC, respectively.

INTRODUCTION

Ink removal from ink-printed waste paper needs deinking process that consists of several steps such as re-pulping, screening, cleaning, dispersing, flotation, washing, and bleaching. Thorough study of deinking process (re-pulping until bleaching) has many times present in articles. Special study focused on certain interest has also been done. Ink detachments from paper surface (fibre) need mechanical forces (friction forces) that cause the detachment or the loose of bonding between fibre and ink [1]. Other researchers mention that ink detachment from fibre is caused by several factors such as hydrodynamic flow of liquid phase in a pulper, fibre development, tension and bending on fibre, abrasion during friction between fibres [2].

The removal of ink particles from recycled paper has focused on column without agitation using dissolved air flotation (DAF) and compared with induced air flotation (IAF). The flotation experiments were conducted using $Ca(oleate)_2$, $CaCl_2$, sodium oleate, SDS (sodium dodecyl sulfate) and SBDS (sodium benzene dodecyl sulfate). The ink removal was more efficient with the use of $Ca(oleate)_2$ and SDS in the two processes studied in this work. The efficiency of the process was measured by the pulp's brightness and yield [3].

Deinking of xerographic and laser-printed paper using block copolymer was investigated. The investigated block copolymer was commercially composed of poly-ethylene oxide (PEO) and poly-propylene oxide (PPO) in certain proportion combination. Variation in the relative proportions of PEO – PPO results a copolymer in difference hydrophobic characters, variation in colloidal and surface chemical properties with direct impact on ink removal efficiency [2].

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Enzymatic versus chemical deinking of non-impact ink-printed paper has been studied for mixed office waste paper (MOW). The effectiveness of the fibre/ink particle separation method depending on the ink particle's size was compared. Different pulps may react differently to similar deinking protocols, either enzymatic or chemical. The effectiveness of enzymatic process depends more critically on the furnish characteristics than on the chemical one, and to achieve a good result an aware should be focused on the decrease of fibre strength [4].

The influence of surfactant chemistry on flotation deinking is unique. The non-ionic surfactants based on ethylene oxide/propylene oxide (EO/PO), the ethoxylated fatty alcohol, and the fatty acid ester of a poly(ethylene glycol) and other molecular structure were studied. In this study, the use of fairly large, non-ionic surfactants with a molecular weight of several thousand g/mol turned out to be favorable, but very low molecular weight of non-ionic surfactants showed good ink detachment in the flotation step, also producing large amounts of reject [5].

Different type of surfactants such as, cationic, anionic or non-ionic were employed in pulping and flotation processes. Two surfactants, 2-Octanol alcohol (C=8) and 4-Heptanol alcohol (C=7) were used in this comparative study. The effect of concentration and type of surfactant, consistency, pH and temperature on the deinking was investigated. The highest brightness was achieved by using 2-octanol alcohol (as a non-ionic surfactant) in flotation stages. Under optimum conditions for this surfactant, a brightness of deinked bleached pulp 86% was obtained from a feed of 44%. The surfactant with longer carbon chain obtains better result compared to shorter one. The higher brightness of flotation product was achievable at pulp pH 7, 11 and 12 for nonionic, anionic and cationic surfactants, respectively [6].

EXPERIMENTAL PROCEDURE

Old newspaper (ONP) was tears into small pieces and disintegrated at 5% consistency for 10 minutes. 500 ml slurry of ONP pulp was pour into flotation tank filled up with water to 70% level of volume (0.3% consistency). Papylase enzyme and Sodium Lauryl Sulfate (SLS) as foaming agent was injected at 1.0% and 0.6 % dosage respectively. The Raw Bio Surfactant (mostly consist of fatty acid) and the Commercial Surfactant was added comparatively in flotation cell. Flotation was done for 10 minutes at 30 psig constant pressure and the air flow rate varies (1, 3, 4, and 5, up to 10 liter/minute). The orifice used in this research was number 20, 40, and 60 where the diameter was quite difference. The ink-contaminated froth was removed from the upper part of flotation tank and the deinked pulp was measured for brightness and ERIC using Technidyne – Color Touch 2 models ISO. Floatation arrangement was schematically shown in Fig. 1.

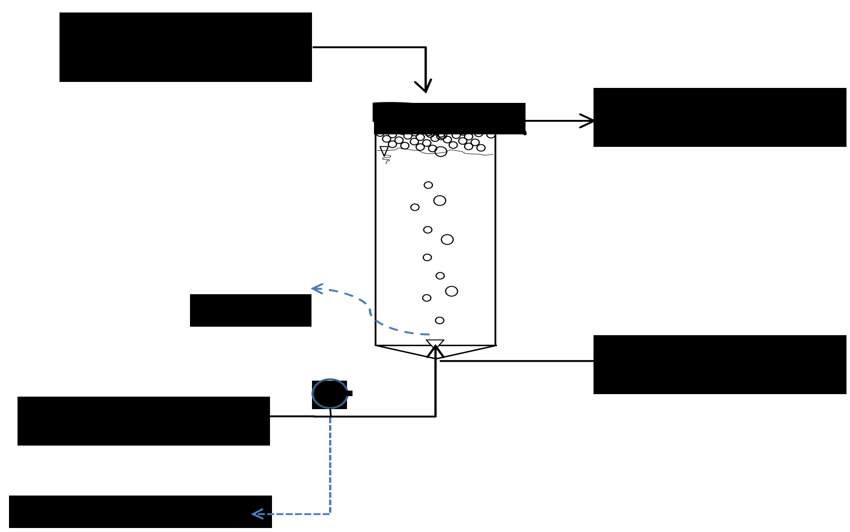
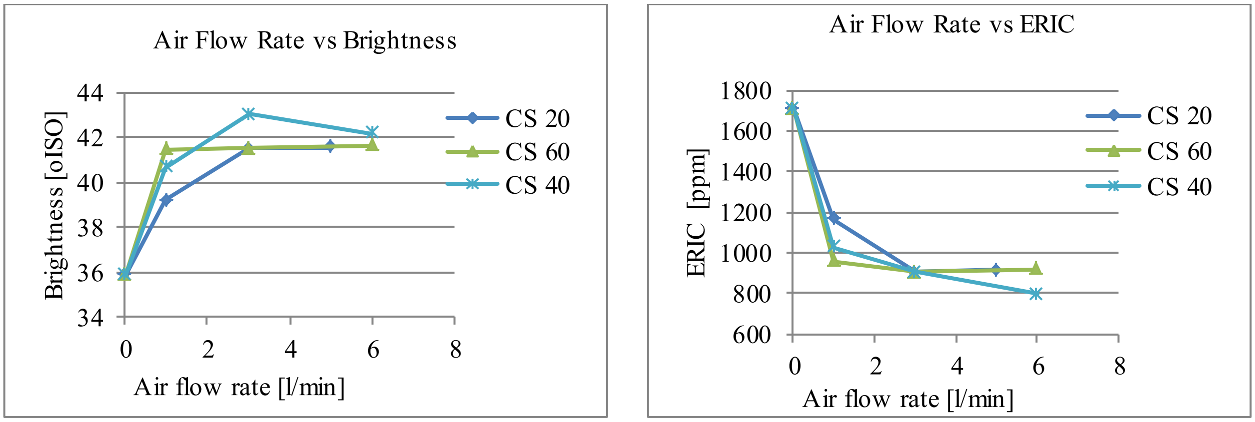


FIGURE 1. Floatation arrangement

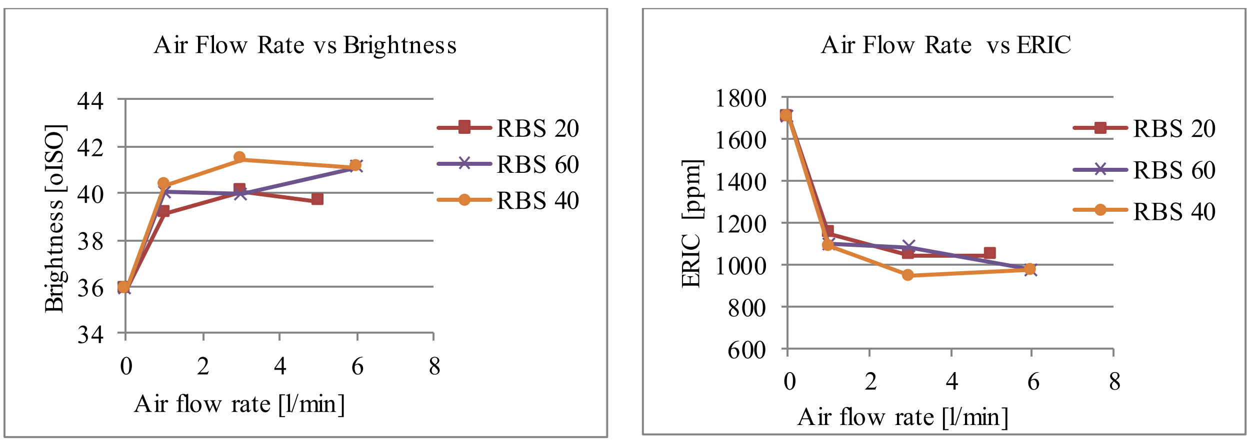
RESULTS AND DISCUSSION

The research results presented in Fig. 2 (a and b) until Fig. 6 (a and b).



(a) (b)

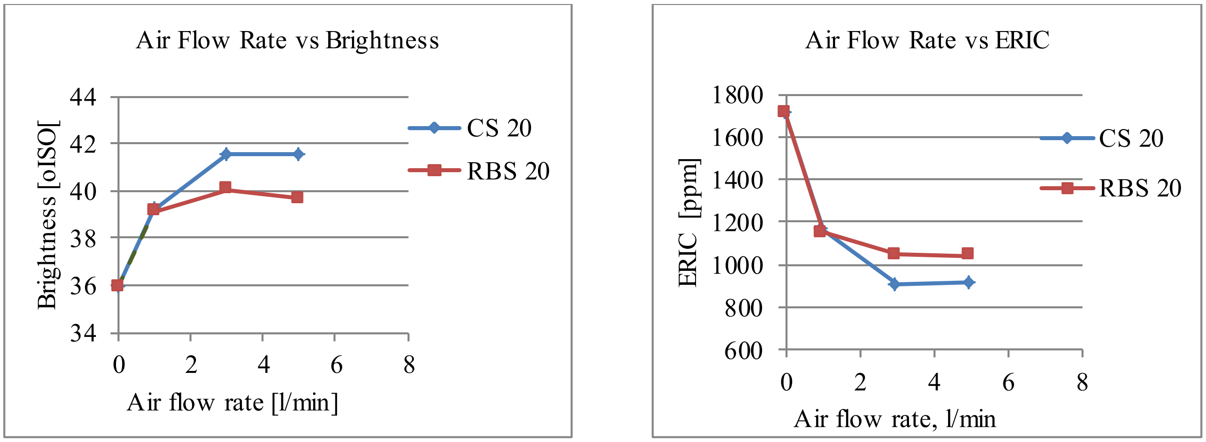
FIGURE 2. (a) Brightness of deinked pulp after flotation at different air flow-rate through several orifice diameter using commercial surfactant (CS), (b) ERIC of deinked pulp after flotation at different air flow-rate through several orifice diameter using commercial surfactant (CS)



(a) (b)

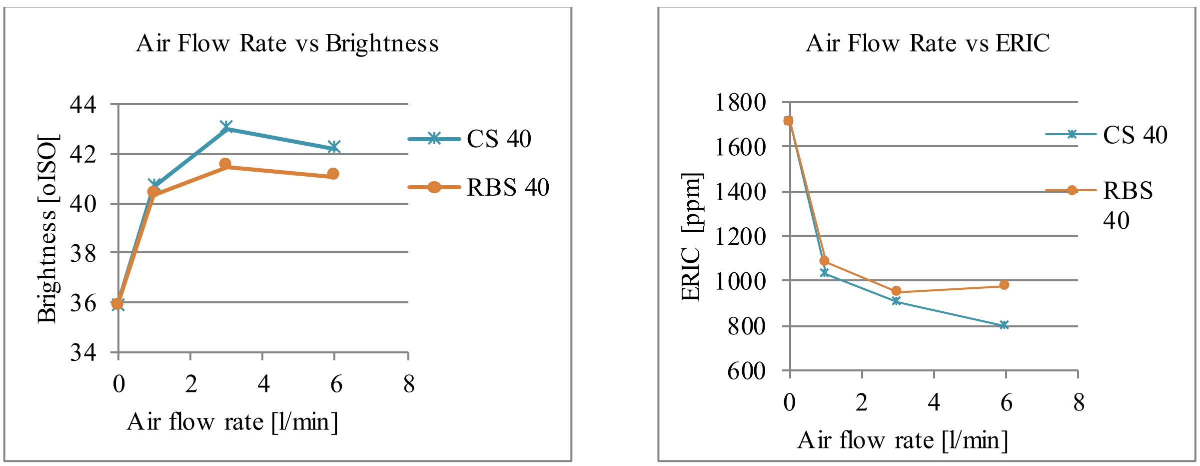
FIGURE 3. (a) Brightness of deinked pulp after flotation at different air flow-rate through several orifice diameter using raw-bio surfactant (RBS), (b) ERIC of deinked pulp after flotation at different air flow-rate through several orifice diameter using raw-bio surfactant (RBS)

From Fig. 2 and Fig. 3 , it is clearly seen that all flotations using orifice diameter number 40 give the best result. It has the tendency to the highest brightness and lowest ERIC for both flotation using commercial surfactant and raw-bio surfactant. It was happened because the turbulent created on flotation media has effect on the surfactant-covered bubbles in lifting detected-ink particles from paper surfaces. The lower the turbulent the less ink detacted from the paper surfaces, eventough the detected-ink particles lift effectively (elutration process) but the purpose of flotation did not achieve well. On the contrary the higher the turbulent the more ink detected from the paper surfaces but the detected-ink particles will not lift well and mixed well and this is not the purpose of flotation process.



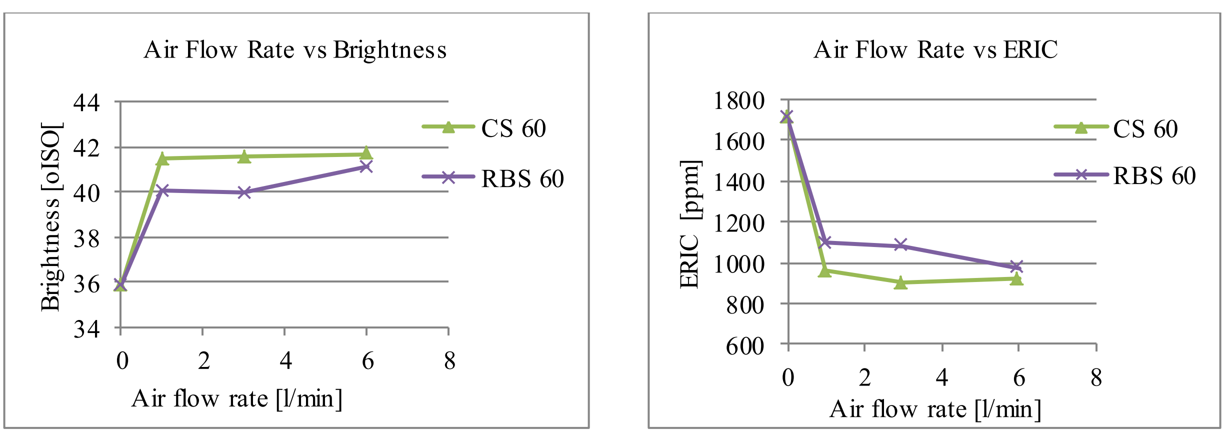
(a) (b)

FIGURE 4. (a) Brightness and (b) ERIC of deinked pulp after flotation at different air flow-rate through orifice diameter 20 using commercial surfactant (CS) and raw-bio surfactant (RBS)



(a) (b)

FIGURE 5. (a) Brightness and (b) ERIC of deinked pulp after flotation at orifice diameter number 40 using commercial surfactant (CS) and raw bio surfactant (RBS).



(a) (b)

FIGURE 6. (a) Brightness and (b) ERIC of deinked pulp after flotation at orifice diameter number 60 using commercial surfactant (CS) and raw-bio surfactant (RBS).

Comparing with the effectiveness of CS and RBS, Fig. 4a and 4b, Fig. 5a and 5b, and Fig. 6a and 6b, proves that raw-bio surfactant (RBS) has deinking power lower than that of commercial surfactant (CS). The brightness and ERIC measurement of deinked pulp gaves results in which flotation using raw-bio surfactant (RBS) produces pulp with lower brightness and higher ERIC compared to the one with commercial surfactant (CS). It is sugested that the oily properties of RBS will promote the RBS micelles penetrate into the ink particle but the hydrophilic forces did not as good as the hydrophylic forces of CS, in other word the HLB value of CS more suitable for flotation deinking than the HLB value of RBS.

In case of air flow rate, most figures show that 3 l/min air flowrate has good indication providing best result for ink separation processes during flotation as shown in Fig. 2 (a and b) until Fig. 6 (a and b). These prove that 3 l/minute air flowrate gave the most suitable turbulent for flotation deinking.

TABLE 1, Average value of brightness and ERIC measurement result

Orifice Number	Comercial Surfactant (CS)		Raw-Bio Surfactant (RBS)		Delta (%)	
	Brightness	ERIC	Brightness	ERIC	Brightness	ERIC
20	40.76	993.96	39.62	1079.71	5.28	9.49
40	41.96	896.82	40.96	1001.72	2.36	11.70
60	41.55	926.88	40.35	1051.73	2.88	13.47
Average					3.51	11.55

From Table 1, in case of orifice number 20, the flotation process did not proceed well for both flotation using commercial surfactant (CS) and raw-bio surfactant (RBS). The result presents the lowest average brightness (40.76 ^{o}ISO and 39.62 ^{o}ISO) and highest average ERIC (993.96 ppm and 1079.71 ppm) for both flotation using commercial surfactant (CS) and raw-bio surfactant (RBS). The percentage delta was highest for brightness (5.28%) and lowest for ERIC (9.49%).

In case of orifice number 40, the flotation process proceeded well. The result presents the highest average brightness (41.96 ^{o}ISO and 40.96 ^{o}ISO) and lowest average ERIC (896.82 ppm and 1001.72 ppm) for both flotation using commercial surfactant (CS) and raw-bio surfactant (RBS). The percentage delta was lowest for brightness (2.36%) and a few higher than the lowest figure for ERIC (11.7%).

In case of orifice number 60, the flotation process proceeded better than the one on orifice 20 and a little bit poorer than the one on orifice 40. The results present a fewer higher brightness and a fewer lower ERIC for flotation using commercial surfactant (CS) and raw-bio surfactant (RBS) compared with the one of flotation result on orifice 20. The percentage delta was lowest for brightness (2.88%) and highest (13.47%) for ERIC. This gave an indication that a homogenous mixing was present in line with flotation so the detached ink did not separated well and scraped with froth. It can be concluded that the raw-bio surfactant (RBS) has lower strength than commercial surfactant (CS), 3.51% lower in brightness and 11.55% higher in ERIC for their deinking power.

CONCLUSSION

Raw-bio surfactant (RBS) can be used in deinking flotation even though the deinking power is poorer than commercial surfactant (CS), 3.51% lower in brightness and 11.55% higher in ERIC for their deinking power. Orifice diameter number 40 is the most suitable orifice for flotation with 2.36% lower in brightness and 11.7% higher for ERIC for their deinking power. The result presents the highest average brightness (41.96 ^{o}ISO and 40.96 ^{o}ISO) and lowest average ERIC (896.82 ppm and 1001.72 ppm) for both flotation using commercial surfactant (CS) and raw bio surfactant (RBS). In case of air flow rate, 3 l/min air flow rate gives the suitable flowrate for flotation and the best result for ink separation processes during flotation. The HLB value of CS is more suitable for flotation deinking than that of RBS value.

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