Studies On Deinkability Factors of Old Newsprints By Using Different Surfactants And Process Variables

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ABSTRACT

Effects of chemical dosages and flotation time, on Deinkability Factor based on ISO Brightness and ERIC Value in the flotation deinking of old newsprints (Hindustan Times) have been studied using fatty acids and surfactants namely oleic acid, palmitic acid, stearic acid and triton x 100. From the experimental results, it is shown that 10 minutes flotation time is sufficient for ink removal. It appears that beyond 10 minutes flotation time the removal of ink is not significant. The optimum chemical dosage for oleic, palmitic and triton x 100 is 1.2% and optimum chemical dosage for stearic acid is 1.0%. The rpm of rotor of flotation cell or indirectly the air flow rate should be maximum to have maximum flotation efficiency. It is found that 2000 rpm gives maximum flotation efficiency. Consistency of flotation should be 1% to have great probability of ink particles attachment due to their high concentration. From the experimental data it is observed that Deinkability Factor increases with increase in chemical dosages up to the optimum condition. Beyond the optimum chemical dosage the agglomerate size increases to a limit, where the ink agglomerates remain back in the system, leading to lower Deinkability Factor.

KEY WORDS: Deinkability factor, Flotation time, Deinking chemicals, ERIC, ISO Brightness, Ink agglomerate, ONP.

Introduction

Paper recycling is gaining importance in an increasingly environmentally conscious world. The use of de-inked fibers in the paper industry has increased dramatically in recent years, and with the current environmental awareness and legislation this trend is expected to continue. The importance of recycling is increasing for the pulp and paper industry because of decreasing forest resources, land fill problems, pressure from the environmental regulations and associated legislation. Forest preservation and sustainability of the environment is an important burning issue in today's world. An exponential growth in demand for paper based product coupled with increased efforts for forest conservation has popularized the use of recycled fiber. Without recycling, the paper fiber supply in the world will not be sufficient to cope up with the demand. Deinking has taken lead in today's scenario of increased use of secondary fiber. Only after deinking, one can effectively use the recycled fiber.

Deinking is a sophisticated process for the benefits of recycling the paper. Deinking operations utilize chemical, mechanical and thermal energies to produce a fibrous suspension from printed waste paper, which is sufficiently clean and bright for use in various high quality grades of paper. The technology advancement has given us opportunity to use waste paper in manufacturing specialty papers too, like writing and printing grades. For manufacturing writing and printing grades, efficient deinking of waste paper is an essential operation of the paper making process. Flotation deinking operation is found to be the most efficient process.

Many authors [1, 2, 3 and 4] have explained in their studies that deinking is a two step process. In the first step, the ink particles are detached from the fibers using thermo chemi-mechanical action with the presence of chemicals in the pulper. In the second step, the ink particles detached from fibers are removed from the pulp suspension by froth flotation. In flotation deinking, initially the ink particles are dispersed by breaking up the recovered paper in an alkaline solution with the aid of surfactants and other additives. Flotation deinking process is an extremely complicated process to analyze and model. Many processes occur simultaneously during flotation where chemical, physical and hydrodynamic aspects are involved.

Many researchers [5, 6, 7, and 8] in their studies have stated that the efficiency of a deinking operation may be defined as the ratio of amount of ink removed by flotation cell, to the amount of ink present in the pulp before deinking by the flotation cell. Deinkability factor based on ERIC values (D_E), for any process where ink particles have been

$$D_E = \frac{9_P - E_F}{E_P - E_B} \times 100 \quad [\%]$$

removed, is defined as:

Where, D_E = Deinkability Factor based on ERIC value, % ; E_B = ERIC value in the absence of ink particles (blank) ; E_F = ERIC value after flotation deinking ; E_P = ERIC value of the sample sheet before ink removal (after pulping).

The ERIC values E_P and E_F were determined for the sheet before and after flotation process. E_B was measured for a hand sheet prepared from the cuttings of the unprinted portion of the waste paper taken for the study and pulped with the same chemical composition used for deinking of printed paper.

Several researchers [9, 10, 11, and 12] have reported in their studies that the deinking ability of printed paper depends mainly on three factors: ink formulation, printing conditions and paper surface. Ink composition and printing conditions are important since they strongly influence deinkability. The efficiency of the process has been evaluated by means of brightness measurement as indicated in TAPPI standard T452. Deinkability factor

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based on hand-sheet brightness after pulping and after flotation was used to evaluate process efficiency and establish the optimum pulping and flotation deinking conditions. The ISO Brightness (special reflectance factor R_{457}) of the unprinted paper subjected to the same disintegration and flotation conditions is considered as a reference value. Therefore, efficiency of the deinking process would be defined by the following deinkability factor based on ISO Brightness:

$$D_B = \frac{B_F - B_P}{B_B - B_P} \times 100 \quad [\%]$$

Where, D_B = Deinkability Factor based on ISO Brightness, % ; B_P = Brightness after Pulping (ISO %) ; B_F = Brightness after Flotation (ISO %) ; B_B = Brightness of the sample paper without the presence of ink particles (blank) (ISO %)

The ISO Brightness B_P and B_F were determined for the sheet before and after flotation process. B_B was measured for a hand-sheet prepared from the cutting of the unprinted portion of the waste paper taken for the study and pulped with the same chemical composition used for deinking of printed paper.

Experimental Methodology

The wastepaper used is offset printed newspapers. ONP is taken from batches of recently printed newspaper (Hindustan Times). ONP contained softwood chemical and mechanical fiber with some hardwood chemical fiber. The quantities of the chemicals charged in the deinking formulations were calculated as a percentage of the oven dry weight of paper fed to the pulper. Stearic acid, Palmitic acid, Sodium silicate and DTPA were from Himedia Laboratories Pvt. Ltd., Mumbai. Sodium hydroxide and Triton x 100 were from Qualigens Fine Chemicals, Mumbai. Hydrogen peroxide and Oleic acid were from RFCL Limited, New Delhi.

Waste papers were individually torn in approximate 1 inch square for the preparation of pulp. In all the experiments, pulping in hydrapulper was carried out using 525 grams air dry mass at a consistency 6% with approximately 5% moisture content depending upon weather. Waste paper was torn and added to the pulping solution when the required temperature and other process variables were maintained constant. In the first stage, the repulping experiments were carried out in a laboratory helicon pulper supplied by Universal Engineering Corporation, Saharanpur. It has provision for controlling rotor speed and temperature at varying conditions. It was adapted to operate at rotor speeds ranging from 0 to 650 rotations per minute.

Ferguson [13 – 14] has reported that pulper as the "brain" of the system, if the pulper does not work properly or if the chemistry of the chemicals added is unbalanced the batch has little chance of success. The pulper has provisions for supplying heat to obtain and maintain the desired temperature at the desired mixing speed and consistency. Pulping variables such as temperature, consistency, rotor speed and pH have a significant effect on both the speed of wetting and defibering as well as on ink and other contaminants dispersion.

Table 1 shows the pulping conditions taken for all the experiments based on literature [10, 11, 13 and 15].

In the flotation stage, the deinking experiments were performed in a laboratory flotation cell supplied by Universal Engineering Corporation Saharanpur. In flotation process about 100 gm oven dry pulp of the repulped stock from the hydrapulper, was diluted to 1% consistency. 1% consistency has been reported as optimum by literature [13, 15]. About 10 litre diluted stock is then sent in the batch flotation cell. The agitation 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 out through the annular holes from the nozzle plate in the bottom of this tube. Ferguson [13, 14] has reported in their study that 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. Carrasco et al. [11] have indicated in their study that deinking factor increased with increased agitation speed of rotor in flotation deinking. Adequate flotation time should be provided so that the foam had sufficient time to float out. Flotation time variation from 2 minutes to 14 minutes was also studied to get optimum flotation time for flotation deinking.

Table 1 Pulping Conditions

SPECIFICATIONS		CHEMICAL ADDITION (on the basis of O.D. sample)	
Hydrapulper Consistency	6%	Sodium Hydroxide	2.0%
Retention time of hydrapulper	15 min	Sodium Silicate	2.5%
Temperature	65°C	Hydrogen Peroxide	1.0%
Flotation Cell Consistency	1%	DTPA	0.5%

Table 2 shows the results of brightness and Eric values obtained from the blank run.

Table 2 Blank Run

Cuttings of unprinted portion of the waste paper taken for the study were pulped with same chemical composition used for deinking of printed paper and after flotation the results are as shown:	ISO Brightness %	ERIC value (ppm)
	59	120.86

Only different fatty acids and surfactants were varied in the experiments and they are added in the hydrapulper at the desired pulping conditions prior to the addition of the waste paper. All chemical dosages used in these experiments were based on oven dry paper basis. After all the paper had been added to the pulper the rotor speed of hydrapulper was increased. After the pulping process is completed, the slurry from the hydrapulper was sent to the second stage of flotation deinking.

The optical properties were measured for hand-sheets with a basis weight of 60 gm/m^2 prepared before and after flotation on British Standard Hand-sheet machine. Brightness is measured on both sides of the sheet, reported as an average of the two. It is possible that some of the smaller size ink particles which have been separated from the pulp but have not agglomerated may leave with the drained water during hand-sheet formation. ISO Brightness and ERIC values have been measured by using the instruments supplied by Fibretec™ (ISO 9001, 2000 reg.) and Lorentzen & Wettre (071/70).

Results And Discussions

A comparative study is carried out for Deinkability Factor on the basis of ISO Brightness and ERIC values. In the present investigations, data was obtained from the laboratory experiments for specific set of input parameters such as temperature, consistency, process time and various chemical dosages variations of different fatty acids and surfactants.

1. Effect of Chemical Dosages variations on Deinkability Factor:

Figure 1 shows the effect of oleic acid dosages in terms of deinkability factors D_B and D_E. In this figure as the chemical dosage increases, the D_B and D_E increase up to the optimum value of 75.36 % and 74.81 %, respectively, and after the optimum chemical dosage of 1.2 %, the value of D_B and D_E decreases. This shows that high dosages of chemical beyond 1.2 % has started affecting the deinkability and the ink has started reversing back in the system, after dissociation from the pulp earlier.

Figure 2 shows the effect of stearic acid dosages in terms of deinkability factors D_B and D_E. In this figure as the chemical dosage increases, the D_B and D_E increase up to the optimum value of 80.02 % and 78.98 %, respectively, and after the optimum chemical dosage of 1.0 %, the value of D_B and D_E decreases. This shows that high dosages of chemical beyond 1.0 % has started affecting the deinkability and the ink has started reversing back in the system, after dissociation from the pulp earlier.

Figure 3 shows the effect of palmitic acid dosages in terms of deinkability factors D_B and D_E. In this figure as the chemical dosage increases, the D_B and D_E increase up to the optimum value of 77.57 % and 71.62 %, respectively, and after the optimum chemical dosage of 1.2 %, the value of D_B and D_E decreases. This shows that high dosages chemical beyond 1.2 % has started affecting the deinkability and the ink has started reversing back in the system, after dissociation from the pulp earlier.

Figure 4 shows the effect of triton x 100 surfactant dosages on

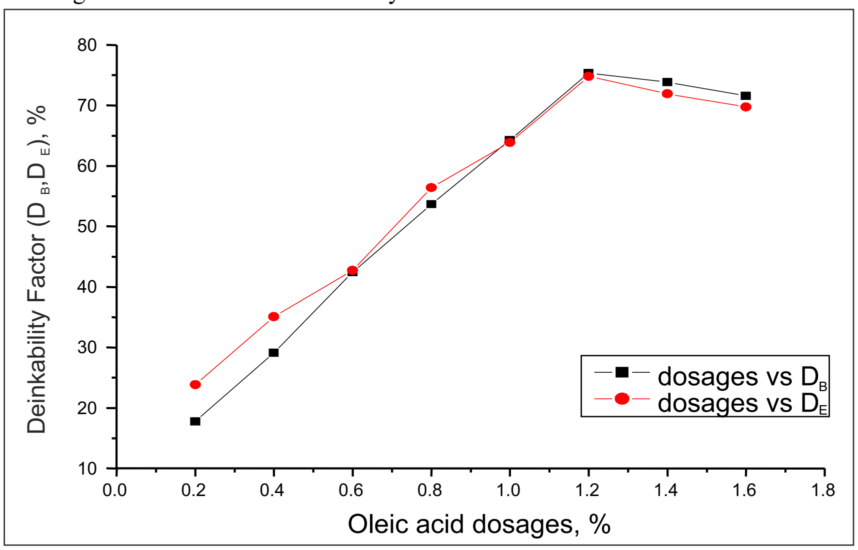

Figure 1 Effect of Oleic acid Dosages on Deinkability Factor

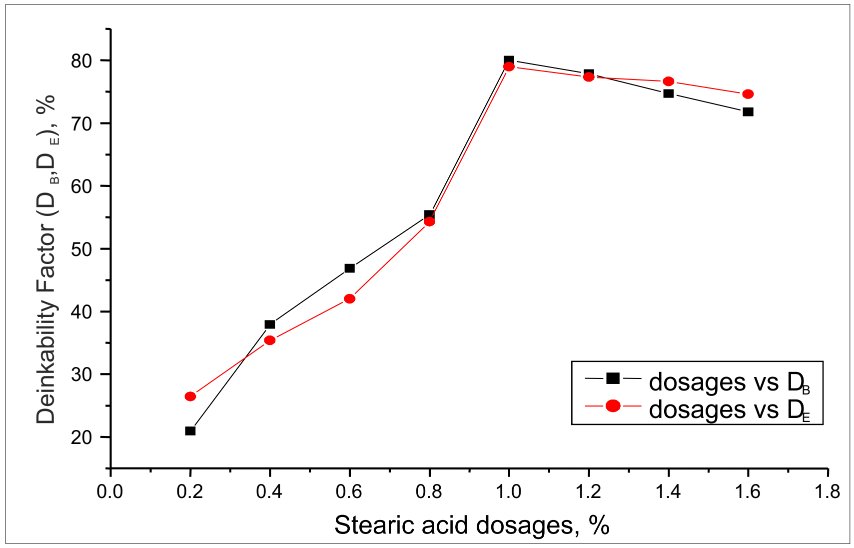

Figure 2: Effect of Stearic acid Dosages on Deinkability Factor

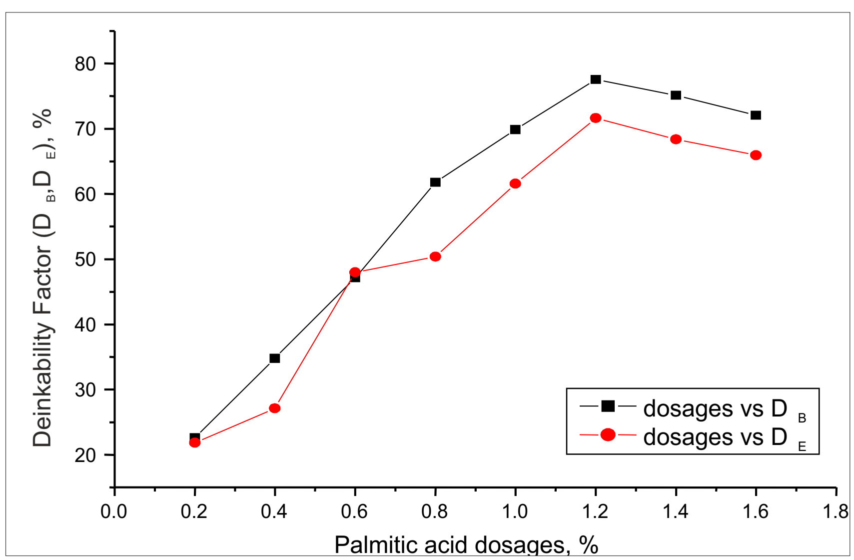

Figure 3: Effect of Palmitic acid Dosages on Deinkability Factor

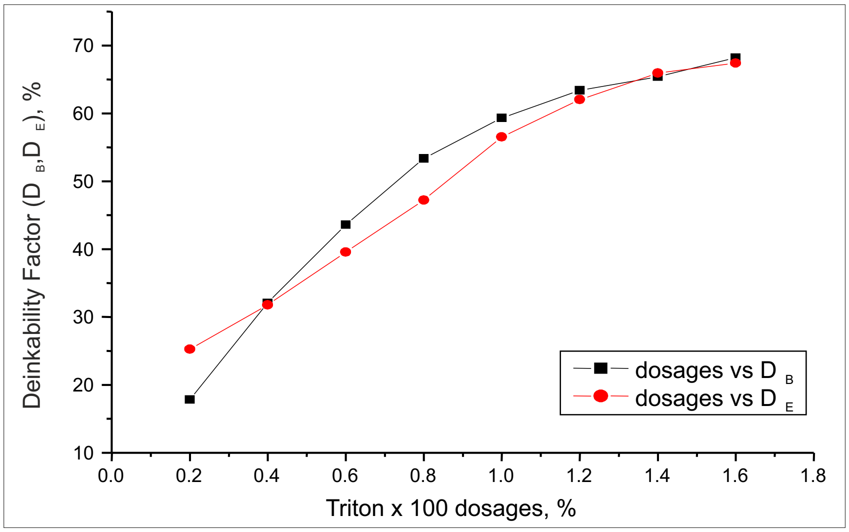

Figure 4: Effect of Triton x 100 dosages on Deinkability Factor

deinkability factor based on ISO brightness and ERIC. Similarly, in this case as the deinkability factors D_B and D_E increases up to 68.21 % and 67.40 % respectively, with the increased dosages of chemical, but no reversal is obtained as in the earlier cases of oleic, palmitic and stearic acids.

2. Effect of Flotation Time variations on Deinkability Factor:

Figure 5 shows the effect of flotation time in terms of deinkability factors, D_B and D_E. In this figure as the flotation time increases, the D_B and D_E increase, consequently the D_B and D_E go on increasing up to 10 minutes to 75.14% and 74.53 %, respectively. After 10 minutes, there is no substantial increase in D_B and D_E. Further time shall only use power with no additional advantage in flotation efficiency.

Figure 6 shows the effect of flotation time in terms of deinkability factors, D_B and D_E. In this figure, as the flotation time increases, the D_B and D_E increase, consequently the D_B and D_E go on increasing up to 10 minutes to 83.41% and 77.50 %, respectively. After 10 minutes, there is no substantial increase in D_B and D_E. Further time shall only use power with no additional advantage in flotation efficiency.

Figure 7 shows the effect of flotation time in terms of deinkability factors, D_B and D_E. In this figure, as the flotation time increases, the D_B and D_E increase, consequently the D_B and D_E go on increasing up to 10 minutes to 73.55 % and 69.68 %, respectively. After 10 minutes, there is no substantial increase in D_B and D_E. Further time shall only use power with no additional advantage in flotation efficiency.

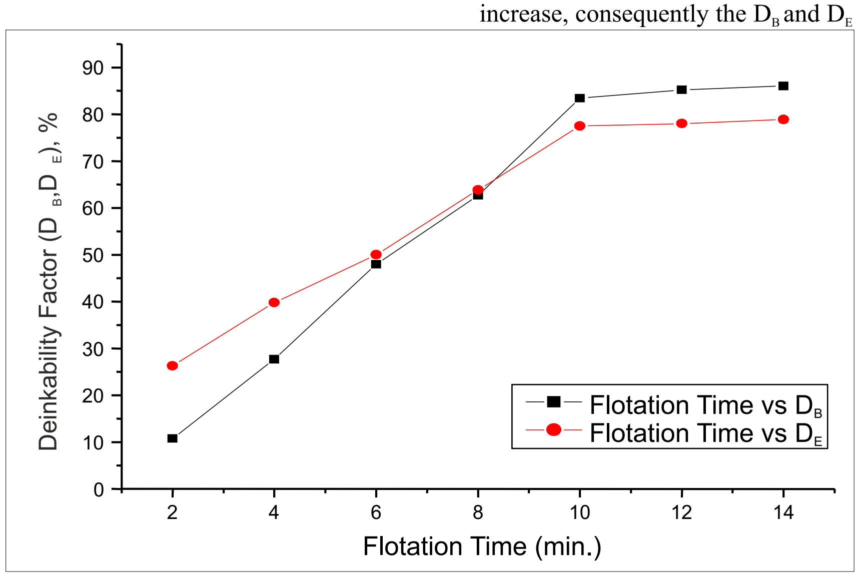

Figure 6: Effect of Flotation Time on Deinkability Factor (for Stearic acid)

Figure 8 shows the effect of flotation time in terms of deinkability factors, D_B and D_E. In this figure, as the flotation time increases, the D_B and D_E increase, consequently the D_B and D_E go on increasing up to 10 minutes to 67.24 % and 67.57 %, respectively. After 10 minutes, there is no substantial increase in D_B and D_E. Further time shall only use power with no additional advantage in flotation efficiency.

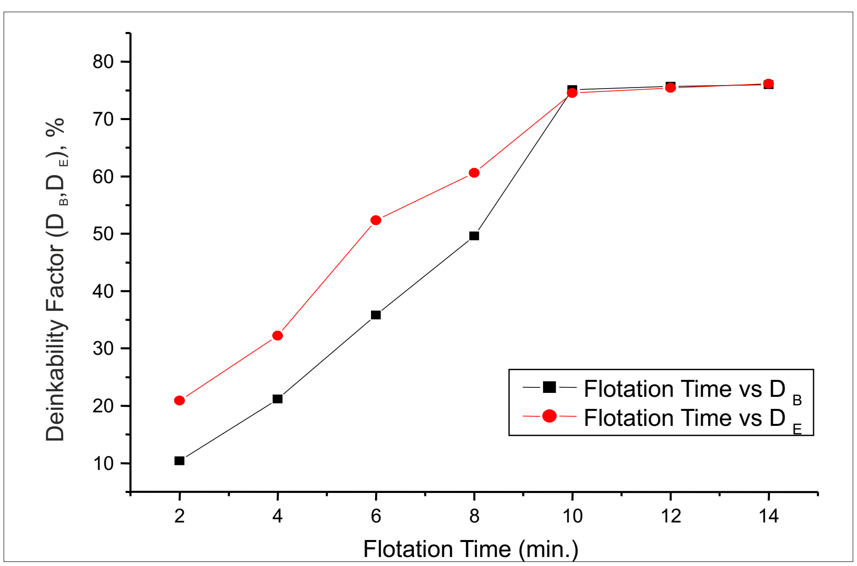

Figure 5: Effect of Flotation Time on Deinkability Factor (for Oleic acid)

agglomerate size increases to a limit where the ink agglomerates remain back in the system, leading to lower deinkability factor. Thus, it is observed that the chemical dosage is critical to the deinking operation. Stearic acid gives best results in comparison to all other active deinking chemicals.

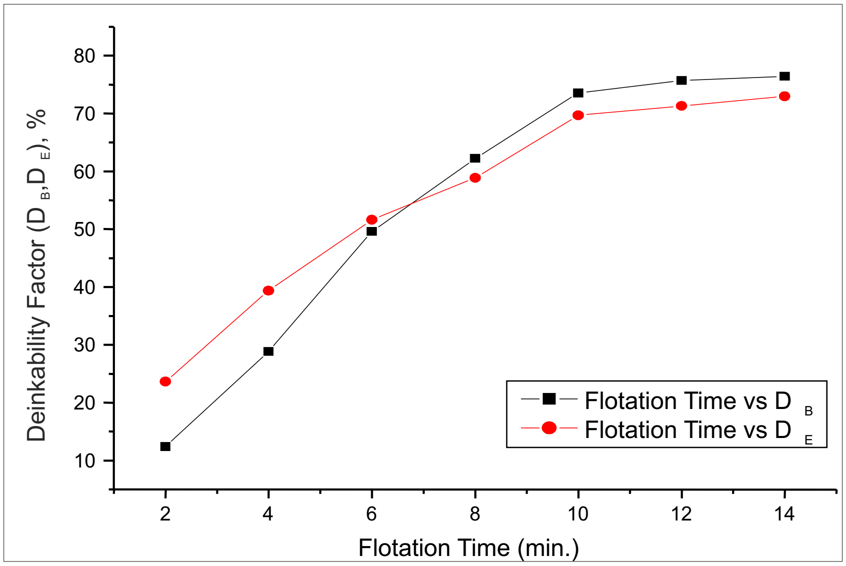

Figure 7: Effect of Flotation Time on Deinkability Factor (for Palmitic acid)

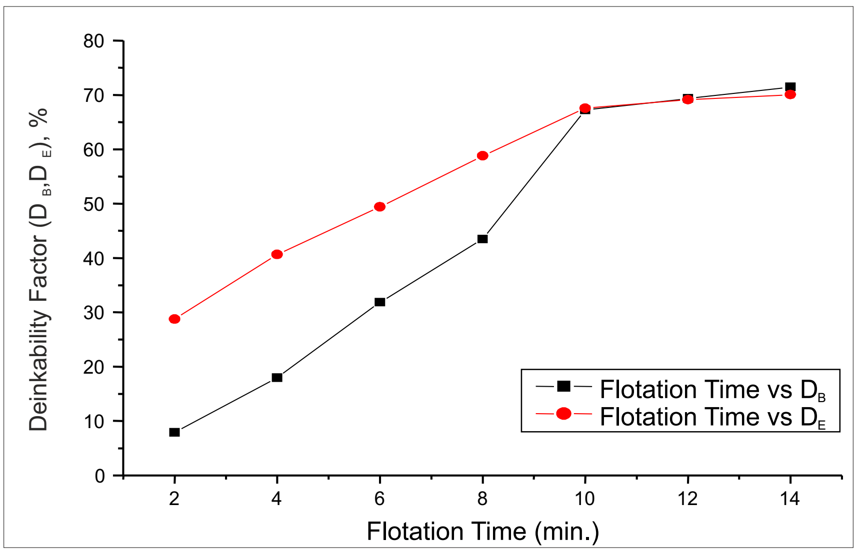

Figure 8: Effect of Flotation Time on Deinkability Factor (for Triton x 100)

Conclusion

In the present work, we have investigated the optimization of process variables (Chemical Dosages and Flotation Time) in the flotation deinking process to observe their effects on Deinkability Factors based on ISO brightness and ERIC values. The main conclusions are as given below:

- From the experimental studies, it is concluded that the amount of ink removal increases with the increase in chemical dosages up to the optimum conditions and then it decreases, as indicated by the Deinkability Factors based on ERIC and ISO Brightness.
- Chemical Dosage of 1.2 % for oleic, palmitic and triton x 100 and chemical dosage of 1.0 % for stearic acid and Flotation Time of 10 minutes have given better results.
- The effects of different active deinking chemicals (Fatty acids/ Surfactants) during pulping operation and flotation deinking operation have been discussed. With the increase in active deinking chemical dosage, the ink agglomerate size increases. Initially for small dosages the size of agglomerate is small which negatively affects the brightness. With the increase of chemical dosages, size of the ink agglomerate increases up to an optimum size. These large agglomerates are more easily removed by flotation. The deinkability factor is highest at this condition. Finally beyond the optimum chemical dosage the

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