De-inking Of Waste Paper - Novel Techniques And Methodologies

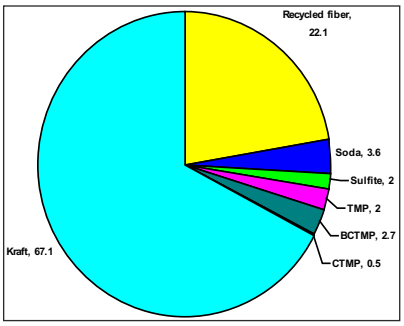
Raje Sameer, and Vivek V.

ABSTRACT

This paper has tried to review the scientific literature as well as some practical case studies which have been done relating to the de-inking processes to develop novel methods for effective de-inking. A special focus has been given to the role of enzymes and surfactants on the de-inking process. The paper also gives an insight into how an enzymatic process and surfactant process of de-inking have developed in the modern paper making industry. At the end of the paper, it is aimed that the reader would be able to identify a suitable chemistry for his de-inking process.

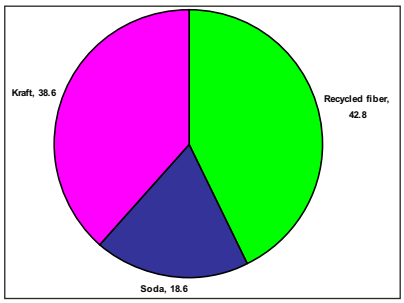
Introduction

It is quite common to see that recovered fibers form a major source of raw materials for the Indian pulp and paper industry. As a raw material for paper manufacturing, in the Asia- Pacific region recycled fiber content of 22.1% and in India about 42.8% is used (Fig.1&2). This stresses a need of novel technology for deinking. Consequently, studies are being conducted globally on the use of enzymes and the role of surfactants and a comparison is being made as to how they vary from the conventional de-inking processes. The traditional chemical de-inking process would ideally generate lot of chemical effluent, as against the action of enzymes which either act on the cellulose or on the ink particle. The use of enzymes additionally causes cellulose hydrolysis on the fiber/ ink



(Fig.1)

Thermax Ltd. 97-E, General block, MIDC, Bhosari, Pune-411026



(Fig.2)

interbonding regions which facilitates ink detachment. Additionally these enzymes can remove small fibrils from the surface of the ink particle thus altering the relative hydrophobicity of the particles, which facilitates their separation in the floatation/ washing step.

General De-inking process

The development of papermaking processes with low environmental impact finds enzymes as suitable option, especially when deinking is considered. In fact, traditional deinking involves the use of large quantities of chemical products, which makes the method expensive and highly environmentally damaging. On the contrary, the biological treatments can favour ink particle detachment from the fibres without discharge of pollutants. According to their specificity, the enzymes can either act directly on the fibres or on the ink film. When cellulases/ hemicellulases are used , the release of ink particles into suspension is generally attributed to the cellulose hydrolysis on the fibre/ink inter-bonding regions, which facilitates ink detachment. Furthermore, these enzymes can remove small fibrils from the surface of the ink particles thus altering the relative hydrophobicity of the particles, which facilitates their separation in the flotation/ washing step. Enzymatic technology has been described as especially advantageous to deink high quality wastepaper, namely mixed office waste (MOW) of which reuse is usually limited by the high content of non-contact inks (toners). Toners are very difficult to remove by the application of current methodologies because they contain thermoplastic binders that polymerize and fuse onto the paper fibres during the high-temperature printing process; when these fibres are chemically treated, the toner particles usually remain as large, flat, rigid particles that separate very poorly from fibres during the fibre/ink separation stages.

It is also known that application of enzymatic deinking causes increase of brightness, increased dirt removal efficiency but can lead to reduced mechanical properties of hand sheets.

In the present work, a comparison is made between the enzymatic and chemical deinking of samples obtained from the disintegration of different non-impact inks prints. The effect of each method on the contaminants removal (ink amount) and on the pulp and paper properties is examined.

Steps in Deinking process

The de-inking process that culminates in the separation of useful pulp for paper production is a five- step process.

Pulping
Ultrasonic treatment
Floatation de-inking
Wash de-inking
Sludge treatment

Surfactant and de-inking process:

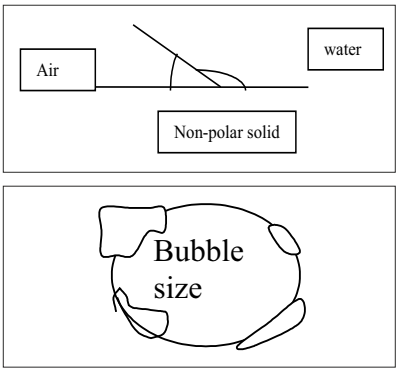
In general surfactants play three roles in flotation de-inking.

1. As a dispersant to separate the ink particles from the fiber surface and prevent the re-deposition of separated particles on fibers during flotation deinking.
2. As a collector to agglomerate small ink particles to large ones and change the surface of the particles from hydrophilic to hydrophobic.

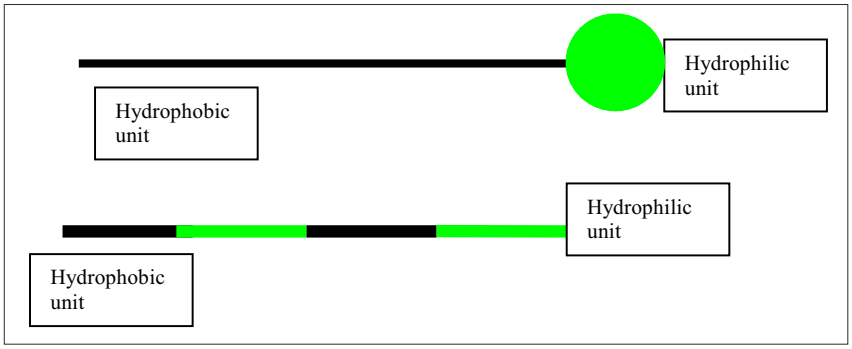
As a frother to generate a foam layer at the top of a floatation cell for ink removal(Fig.3).

The basic surfactants are unique species and have dual characters. They have both hydrophobic and hydrophilic nature portions attached to one molecule itself (Fig.4). Surfactants can be non-ionic, anionic or cationic.

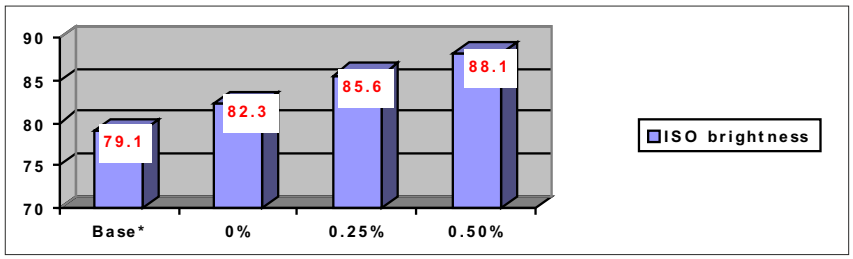
Alkoxylated deinking surfactant formulation (Maxtreat® DI 16)- a proprietary composition of Thermax Ltd., was tried in a plant scale and the use of surfactants in deinking was evaluated. The major source of furnish was wood free paper .Fatty acid soaps, which were earlier used for the conventional deinking process had many disadvantages, especially when the fibre furnish consisted of laser or xerographic toner. Also by experience it was confirmed that if the ink particles are broken down in size, then the removal efficiency of a surfactant based deinking product increases. The following results (Fig.5) were obtained when (Maxtreat® DI 16) was employed on a wood free paper.



(Fig.3)



(Fig.4)



(Fig.5)

Enzyme based deinking done by Thermax Ltd.

Enzymes are being used in recent times in the Paper de inking process. They offer an increased potential for their application as they a number of advantages. Some of the advantages include more environmental friendly operations, selective action, milder process requirements and very importantly low capital investment. Keeping this in view a mill trial was carried out to check the efficiency of the deinking enzyme.

ONP as a raw material furnish was used. Enzymes were added in the blend chest where the raw material was present. pH of the chest was constantly maintained between 5- 7.5. The pulp consistency was 13.8%. H_2O_2 was added at about 1%on OD fiber; while Na_2SiO_3 was added about 2% on the OD fibre and 1% on OD fibre- NaOH was added. After a retention time of 10 min, Maxtreat® DI 25 (a proprietary formulation of Thremax Ltd.), was added in the chest along with the surfactant. The dose was kept between 0.01 0.04% on the OD fibre. A retention time of 20 min. was maintained so as to give enzymes enough time to react wit the substrate. The brightness (ISO) was later checked (Fig. 7)of the pulp obtained in the lab. The enzyme dose and the surfactant dose shown below are 1/1000 of the value. On X-axis are the days of trial run in the mill. It can be seen that during the 5th and the 7th day, when enzyme was not used, the pulp brightness too dropped and it regained after the enzyme addition started.

In order to further evaluate the enzyme, we did a lab analysis with Maxtreat® DI - 25 enzyme at Pulp and Paper Research Institute, Jayakapur for deinking enzymes.

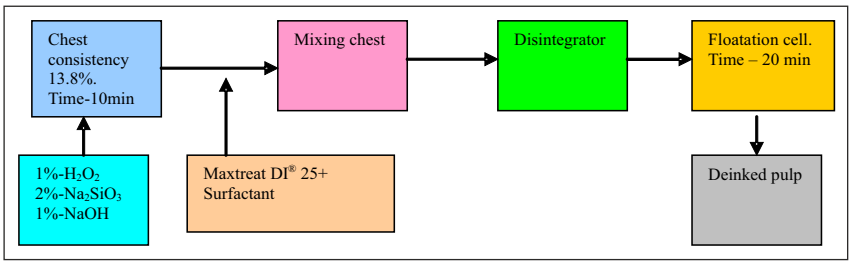
ONP was used as raw material for the lab test and general deinking properties like Brightness (ISO) (Fig. 8), Dirt count(Fig.9), No of ink particles (Fig.10) and ERIC (Effective residual Ink Concentration) was seen. A surfactant was also employed to check and compare the efficiency at the lab scale. Pulp of 12 % consistency was used with a pH of 4.5and temperature of 50^0C, enzyme dosed at 0.04% w/w and surfactant of 0.05% for 10 minutes. The below mentioned tables (Table : 1 -4) are for the ONP:

It was observed that Brightness achieved by Maxtreat® DI -25 was higher than that of the surfactants. Another set of experiments were carried out by PAPRI to check the dirt count (mm^2/m^2) and the number of Ink particles (no/m^2).

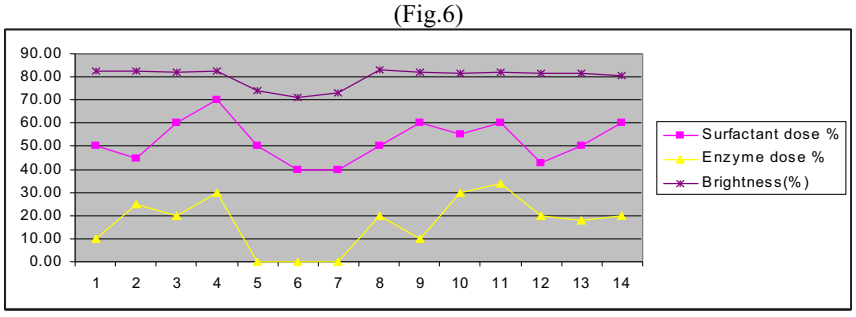
In the above processes it is noted that enzymes have shown the effectiveness as a deinking chemical. As it has been noted in the several researches done earlier, there is a loss of strength which was evaluated here as well to check in the lab test.

One can see from the above results (Table: 4) that there has been no effect on the strength because of enzymes. The ERIC blank values for ONP were

Below is the flowsheet of the Maxtreat® DI 25 addition (Fig.6) sequences in the mill



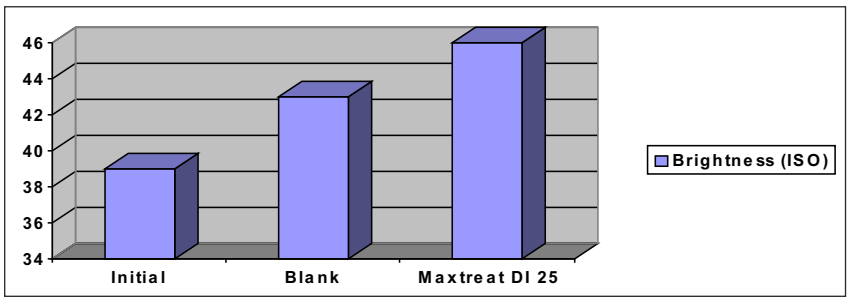
(Fig.6)



(Fig. 7)

Table : 1

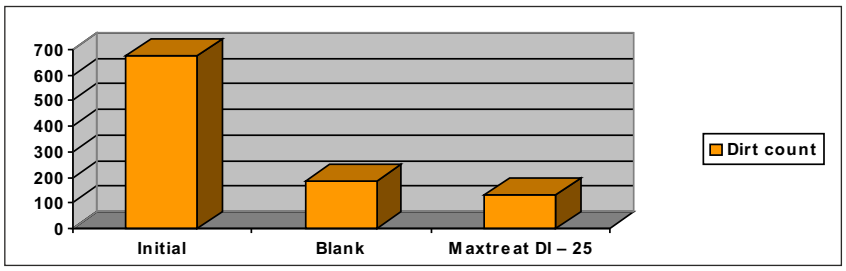
Initial	Blank	Maxtreat® DI 25
37.5	43.3	46



(Fig.8)

Table 2:

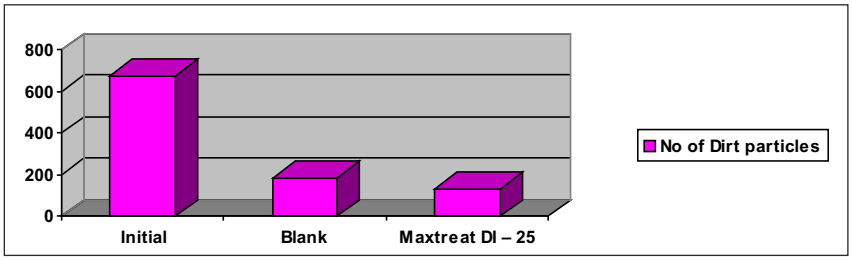
Initial	Blank	Maxtreat DI® – 25
675	185	132



(Fig.9)

Table : 3

Initial	Blank	Maxtreat DI® – 25
675	185	132



(Fig.10)

found to be 39.86, while surfactant and enzyme gave 43.97 and 48.48 respectively. As stated in some research papers that were referred there was an increase in brightness, but the strength property when evaluated did not show any drop.

Where are De-inking technologies leading us?

While existing technologies provide a satisfactory means of deinking the vast majority of printed output, there have been a number of notable print/ink systems that are increasingly causing problems for deinking operations. These include:

Flexo: The deinking of flexo printed papers has been the subject of much research. Modifications and adaptations of conventional deinking processes have been proposed that have enabled small proportions of flexo-based material to be tolerated. Further, ink manufacturers have addressed the issue by seeking to formulate new inks that have at least some improved deinkability for newsprint and other applications.

Digital print: As digital printing technologies become more widespread and the printed output by such methods increases, more of this material will end up in recovered paper collections. The deinkability of such printed material could threaten the efficiency of current systems. It has already been shown that material printed using water-based, pigment-based ink-jet inks, as commonly found in a range of well known office and home based printers, is not deinkable. Worse still, researchers have shown that the presence of around 10% of this material among other recovered papers will ruin the deinkability of the whole batch.

More attention has been paid to the deinking process as a result of a number of factors:

- The increasing reliance on DIP as a raw material
- The continued development of new printing engines and print vehicles: inks, toners, etc.
- The demand for less process waste, and
- Rising customer and end-use expectations.

Consequently, the need for effective and efficient deinking is more important than ever. In particular, there is a need to better understand the fundamentals of the deinking process, so that deinking operations can be better developed and optimized. This would enable paper mills to better deal

with the changing nature of incoming material. Such knowledge would also have the potential to enable the development of inks and printing techniques that minimize deinking problems and maximize the efficiency of deinking technology.

Conclusion

It is seen from the plant trials and the lab trials conducted using enzymes and surfactants, it has become quite evident that a whole lot of selection of proper deinking method depends on the type of fibre and the ink used for printing on it. While surfactant based deinking chemistries have advantage like they can be used in combination of other chemicals as against enzymes which need to be dosed separately and their combined effect with the use of other process chemicals has not been studied in detail. Whilst, enzyme based deinking chemistries offer more environmental friendly approach, reduced capital investment and milder process conditions. It is felt by the authors that use of deinking chemistry has to be studied more in relation to the inks that are being used for printing.

References:

1. Bolanca I & Bloanca Z. "Chemical and Enzymatic Deinking Flotation of digital prints" , 4th International DAAAM conference- Industrial Engineering- Innovation as competitive edge for SME, 29-30th April 2004, Estonia.
2. Yulin Zhao, Yulin Deng, Zhu .J.Y, "Role of surfactants in flotation deinking", Progress in Paper recycling /Vol No. 14, No.1, November 2004.
3. Venugopal Vijaykumar C, "Design of a de-inking process for recycling mixed waste paper".
4. Phatak Puneet, Bharadwaj Nishi K., Singh Ajay K., "Enzymatic de inking of office waste paper: An overview"IPPTA Journal Vol. 22, No.2, Apr-June, 2010 Page 83 88.
5. "India- underdeveloped but potentially strong", Tissue world, Feb-Mar 2011, page 26-29.
6. Hannuksela Tea, Rosencrance Scott, "Deinking Chemistry", Kemira GmBH.
7. Pala H., Mota M., Gama F.M., "Enzymatic versus chemical deinking of non-impact ink printed paper" , Journal of biotechnology , Vol 108, 2004, page 79-89.
8. Milton J.Rosen, "Surfactants and interfacial phenomenon" , 3rd edition, A John and Wiley & Sons , Inc., Publication.