De-Inking of Waste Paper by the Floatation Method

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Importance of the raw material

The percentage contribution of pulp manufactured from waste paper is about a third of the total pulp produced in most of the western countries and Japan. For example, for the year 1960 :

in West Germany	36%
in United States	34%
in England	30%
in Japan	34%

These statistics reveal the growing importance of this commodity as a paper making raw material. In India in the year 1963, the total waste paper recovered was about 700,000 tons or a recovery rate of 14%. This percentage is bound to increase as at present efforts are being made on a nation-wide scale to systematise and organise procurement and supply of this material. A very interesting and detailed report of the growing importance of this subject has been published by Podder.

Historical

The first attempts to make new paper out of waste paper were made in China as early as in 1600 A. D. A number of other contributions followed, in 1695 by Balthasar in Denmark, in 1774 by Claproth in Germany and in 1849 by Rogers in United States. The first pilot plant for regenerating paper pulp from old books and records was installed in Wisconsin in the year 1931. This subject has developd fast after World War II and more so in the last five to seven years both in the United States as well as in West Germany.

Theory of De-inking

The term 'de-inking' signifies the treatment of waste paper to separate the printing ink from the fibres and make it in a form suitable for the manufacture of paper. The de-inking process consists of defibering the waste paper (printed newspapers, magazines, records, etc) mechanically, together with water, heat and chemicals, generally alkali to saponify, dissolve or emulsify the printing ink and binder. The separated pigment is then diluted and finally removed by washing out or floating the stock. The choice of chemicals and the process depends mostly upon the type of waste paper and the composition of the printing ink and many a time on the end-use of the regenerated stock. Strachen[2] and Bragdon[3] carried out investigations to find the effect of alkali on fibres and summarised their observations as follows :—

1. Neutralization of the alum in paper and further penetration of the alkali into the cellulose ;

2. Saponification of the natural resin and sizing materials thereby separating the ink particles from the fibres.

Bragg[4] observes the de-inking process from the standpoint of the printing ink, which after all should be ultimately removed from the surface of the fibres. He divided the types of ink particles into three groups :

1. Ink manufactured from **saponifiable** oils ;

2. Ink manufactured from **unsaponifiable** oils ;

3. Special printing inks which are extremely resistant to de-inking.

This group of inks are generally manufactured from synthetic resins and organic solvents.

Wells[5] observes that for de-inking, six additives are necessary :

1. An alkali to saponify the printing-ink binder ;

2. A washing material e. g., a sodium soap of a fatty acid, sulfonated oil and fat-alchohol as well as complex phosphates ;

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3. A dispersing agent e. g., sulfonated products to separate the pigments adhering to the fibres and agglomerate the particles ; also to emulsify the mineral oil or wax in the stock ;

4. A softener to dissolve synthetic resins, if present ;

5. A medium for selective absorption of the pigment after separation from the fibres and to prevent re-adhesion to the fibres. e. g., loading materials like china clay serve this purpose. This is one of the chief reasons why in a de-inking process generally, certain percentage of magazine paper is added to incorporate fillers into the suspension and thereby achieve a better end-whiteness of the stock.

6. Chemicals like sodium pyrophosphate or sodium hexametaphosphate to prevent the formation of calcium or magnesium soaps and also to dissolve the salts of these metals formed with hard water.

The chemicals that are normally used to separate the ink particles from the surface of the fibres are sodium peroxide and sodium silicate for paper from mechanical pulps and sodium hydroxide for waste paper containing a large proportion of chemical pulps. It is not advisable to use sodium hydroxide in the case of mechanical pulp as there is a risk of yellowing of the stock after treatment.

The non-fibrous portion of waste paper can be anything from 1—50% by weight of the paper and the percentage depends upon the sort of waste paper. The main constituents of this portion are :

1. Fillers like titanium dioxide, china clay, soap stone etc.,

2. Resin, rosin and wax emulsions ;

3. Alum ;

4. Starches and gums ;

5. Coating materials which contain fillers, starch, casein and other proteins, latexes and other synthetic coating formulations ;

6. Printing dyes ;

7. Polymers like polyvinyl acetate, polyvinyl chloride, nitrocellulose, cellulose acetate, polyethylene etc., and,

8. Binders which are heat-melting like polystyrene.

The quantity of printing dye as given by O'Donoghue[6] is approximately 1.5-2% by weight on waste paper in the case of newsprint, 0.5-1% in the case of old books and 1-7% in the case of magazines which are printed in multi-colour. The thickness of the ink film is generally 1.5-2.0 (Bragg[4]).

The de-inking process and fundamentals of floatation

The de-inking process may be fundamentally divided into two parts :

1. Sorting and preparing the waste paper together with the separation of ink particles from the surface of the fibres.

2. Removal of the separated ink particles from the fibre suspension by floatation.

Floatation is a method of separation of a solid from a suspension containing generally two or more solids. It ordinarily depends upon the affinity of the particles that are to be floated to water, i. e., if these particles are hydrochilic or hydrophobic in character. The hydrophobic particles adhere to the air bubles and are taken over to the surface of the suspension as foam, whereas the hydrophilic fibres remain inside. It is evident that the removal of these particles from the bulk of the suspension depends upon physical, physico-chemical and chemical properties of the system. The physical properties to be considered are particle size, size of air bubles, consistency of stock and its temperature. Physico-chemical properties like the intensity of charge on the ink particles, and dielectric constant of the medium play a significant role in the floatation process. Chemical properties like the pH of the suspension, affinity of water to the particles floated and the nature of the chemical additive added to produce and stabilize the foam are also of considerable importance.

The technique of floatation depends mostly on the floatation machine. There are vacuum floatation machines, high pressure air-cells and cells with mixed feed of air and suspension. The last mentioned seems to be the best of the three types.

The Floatation Plant

The first floatation plant for converting waste paper into pulp suitable for manufacturing paper was established in U. S. A., in the year 1952. Jelks [7] has given complete details of the plant using Denver cells in **Paper Trade Journal** of February 1952. This plant was modified with time, but essentially the working is the same.

In Europe, the firm Voith Gmbh, Heidenheim, started working on this plant in 1956 and introduced a lot of modifications in the original Denver Cells and are now able to manufacture large scale plants upto 50 tons/day. A scheme of the De-inking plant (Voith) is given in Fig. 1.

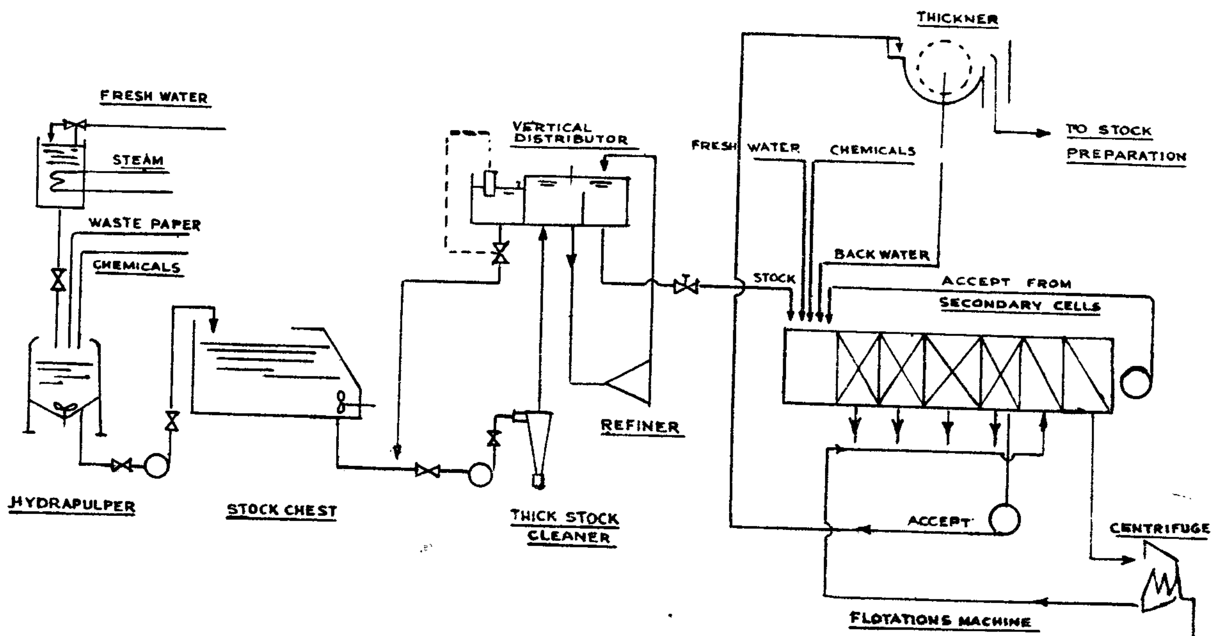

Fig. 1. Scheme of a De-inking Plant (voith)

Fig. 1.

Waste paper charge is taken in a hydropulper along with the chemicals at room temperature of slightly elevated temperature (between 40°-60°0) and a consistency of 5-7%. After charging all the chemicals and paper, the stock is pulped for about 15-20 minutes. Then it is let out into a stock-chest. From the chest the stock is pumped to a vertical distributor through a thick-stock cleaner (which removes the paper clips, thick clumps of undissolved paper, heavy metal particles etc.). From this vertical distributor the stock is passed through refiners to completely disintegrate the stock and then this stock is passed through the floatation cells.

The Floatation Cells

The floatation cells are rectangular cells with a vertical propeller to mix the stock and at the front with an overflow chost for the flow of the stock from one cell to the other. A schematic diagram of the floatation machine is shown in Fig. 2. The inflow of the stock into the cell is from below and along with the stock the propeller at the bottom sucks air so that a mixture of stock and air flow into the cell and by thorough mixing, aided by the foam is produced and floats to the surface. There is a horizontal rubber paddle at the top which removes the foam continuously. The light ink particles are carried out by the foam to the surface and thus removed from the stock by the rubber paddle. Thus while flowing from one cell to the other, the stock is progressively cleaner and free of ink particles. The effect of the size of the ink particles also plays an important role in floatation and is shown diagramatically in Fig. 3. It depicts the distribution of the particle size as is present in the suspension before and after floatation. It

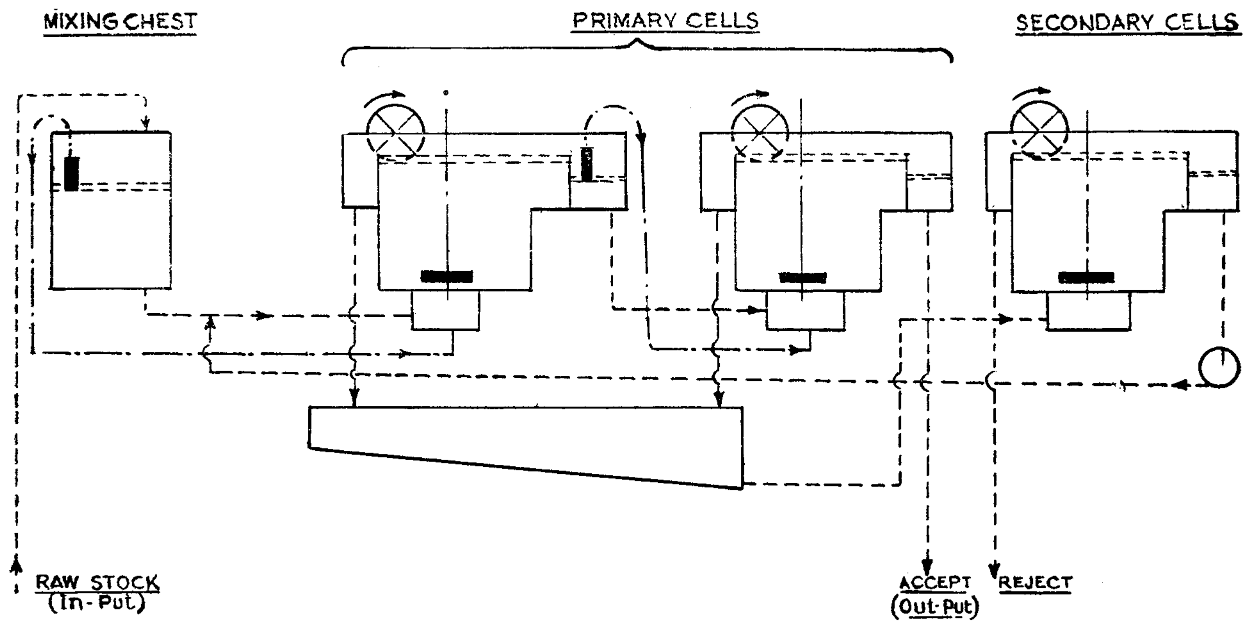

Fig. 2. Scheme of a Voith Flotation Plant.

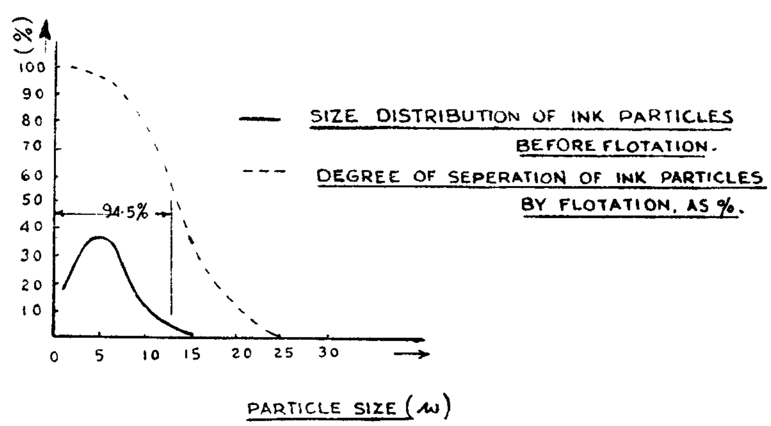

Fig. 3. Influence of particle size on flotation.

is seen from the figure that the particles between 2 and 10 are completely removed by floatation whereas particles of size over 25 are completely left in the suspension. An optical investigation has revealed that particles of size less than 2 are also completely left in suspension.

The size and number of floatation cells generally depend upon the daily production. For example, in a 50 ton-day plant there are two floatation streets. Each street consists of one mixing cell, where the thick stock from refiners is diluted with back-water to about 1% consistency; and then it is passed through 11 primary cells. The stock coming out of the 11th cell is taken as "accept" and this passes through a vibration screen to further clean the stock and is thickened by rotating thickeners to a consistency of 4-6%. This is the finished stock.

The foam with the ink particles, continuously removed by the rubber paddle is led through two secondary cells and the black foam that is removed from the surface of these cells is rejected directly or after centrifuging and thickening to nearly 40% consistency. The stock from these secondary cells flows back to the mixing cell and repeats the whole circle.

Results:

Given below in Table—1 are the results of de-inking of different types of waste paper by floatation. The values are the actual figures obtained in one mill in Europe 8.

(Table—1.)

Waste Paper Composition	Whiteness in % * Before Flotation	After Flotation
100 % Newsprint	47.0	58.0
50 % Newsprint 50 % Magazine	45.1	59.0
65 % Magazine 35 % Printed Cuttings (wood free)	45.8	64.5
100 % wood-free books	59.3	75.0
70 % wood-free books 30 % ,, ,, printed cutting	63.0	80.5

*measured on a Zeiss—Elrepho tester with Filter R 46.

The measurements of whiteness of pulp sheets was conducted on a Zeiss-Elrepho Tester with Filter R 46. The higher whiteness in the case of magazine paper to newsprint is clearly seen from the above table. Table—2 presents the strength properties of the finished stock after floatation. From the above two tables, it can be seen that the pulp obtained by the above process is satisfactory both in whiteness as well as in strenght.

TABLE—2.

Strength properties of the finished de-inked stock*

Property		Waste Paper I 100% Newsprint.	Waste Paper II 70% Books 30% printed cuttings. (both wood-free).
Freeness	oSR	67.0	38.0
Ash	%	5.2	2.8
Density	kg/dm3	0.504	0.575
Breaking Length	m	2710	3560
Elongation	%	2.4	2.8
Bursting strength	kg/cm^2	1.47	1.98
Double folds		12	51
Tear Strength	Cmg/cm	112	120

*Hand-sheets made on Rapid-Kothen machine (German standard) : 95 g/m2 for waste paper I
75 g/m2 for waste paper II

Besides achieving whitenerss and strength of the finished pulp, it is also necessary to observe the fibre losses in the foam that is rejected directly, or centrifuged and rejected.

Table—3 shows the results of the above investigation.

(Table—3.)

I. Reject from Secondary Calls (100% Newsprint)

Consistency	%	..	36.2
Ash	%	..	3.5

II. Rejects after centrifuging the foam

Consistency after de-watering	%	33.3
Ash	%	31.4
Fibre-content of water	mg/1	83.0
Ash	%	29.0

By the regeneration of pulp from newsprint, the consistency of the foam rejects in the secondary cells is around 3.5% with an ash content of about 36%. After centrifuging and de-watering the foam to 34% solids, the ash content is 31.4% and the fibre-content in the clarified water is only 84 mg/1. Thus the fibre losses through foam are seen to be very small and well within the range of economic working of the plant.

Utilization of the Finished stock.

In Europe and United States, the de-inked pulp is utilized in various ways. This pulp can be mixed with mechanical pulp from soft woods to the extent of about 20-25%. For example, one mill in West Germany producing about 250 tons per day of mechanical pulp from soft woods, is able to take in 50 tons of waste paper pulp and the machine run is absolutely normal and quite unaffected. In fact the strength properties of finished newsprint are increased slightly due to the chemical pulp content in waste paper. This waste paper pulp is being successfully used in other factories both in Europe and United States in the production of cheap writing papers, Magazine paper, Toilette crepe paper wall base paper, Duplex and Triplex boards (as top layer).

Outlook for such a plant in India

The cost of production of de-inked pulp in Europe and other western countries is very much lower than even mechanical pulp from soft woods. The difference is anything between Rs. 100-150 per ton depending upon the working conditions of the mill.

To establish such a plant in India, there are a few major draw-backs which are to be overcome :

(1) Cost of waste paper is comparatively higher in India than the Western countries ;

(2) Organised procurement and constant supply of waste paper. This can be done successfully, once thought is given to the installation of such plants by the Government.

The machinery for the de-inking plant is being supplied by Voith in India through Utkal Machinery Ltd., Kansbahal, Orissa on rupee payment. Detergents for flotation are also being manufactured lately.

Thus it is our considered opinion that this plant shall be of great value and utility to the paper industry in providing a new and cheaper raw material and thus help in stepping up the progress in this direction.

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