Deinking of waste papers containing non-dispersable inks by dry defibering

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ABSTRACT

The waste paper recycle potentiality is affected by many factors of which the age of paper appears to be a dominant factor. With age, not only the strength of paper is reduced, but dispersability of the ink is also hampered. The number of recycles through which the paper must have gone is another factor of concern while recycling waste paper.

Dry defibering has been explored as a technique to overcome some of the problems by way of using waste paper containing non-dispersable inks, fines and fillers etc for making high grade papers It has been found out that papers with heavy printing on coated surface like magazine papers or papers printed by photocopying technique respond well to dry defibering. A good amount of ink, filler, coating material and fines etc. have been dislodged from the fibre/coated surface which could be screened out Ink could be removed as seen in the microscope, from 100-150 specks/view to 20-30 specks/view in xerox paper while, from 150-200 specks/view to 20-40 specks/view in Magazine paper. Ash content, in former paper could be reduced by 70.0% and in latter by 61.5%.

From the fibre length measurement studies, contarary to expectations, no damage or cutting of fibres was found as a result of dry defibering. However, some broken fibres were noticed in the case of old Newsprint finer fractions due to brittle nature of such fibres. The slack sized or uncoated papers like old newsprint (ONP) found to produce dark grey stuff as a result of dry defibering.

Introduction :

The recycle potentiality of waste paper is mainly dependent on the type of ink, printing processes used and the paper to be recycled. As long as, the vehicle of the ink is not getting hard set into the matrix of paper due to drying, aging and or oxidising etc. the conventional deinking processes viz. Washing[1] and Floatation[2] can produce speck free waste paper pulp. But in the quality printing where long life is the requirement, the vehicles are of special types containing constituents which in the dried/aged state turn into a very hard surface and therefore, are not easily dispersed under normal deinking conditions[3]. Hard to disperse printings are also of non-vehicle type inks which are heat fixed after getting carried by an electric field on to the paper. These types of fused inks are very much resistant to chemical attack, photocopy papers can be example of this type.

The main purpose of the present investigation is to explore the possibility of removal of non-dispersable

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printing inks from the paper surface by dry defibering. The other purpose is to fractionate the resultant defibered material into usable fibres free from brittle fines, fillers, pigments and ink particles etc.

Experimental

Materials

Based on different types of ink and paper the following four varieties of waste papers were selected for this investigation.

A. Xerox Paper — Silica coated and printed by electrostatic printing.

B. Magazine Paper — High gloss heavily coated and printed with offset ink.

C. Old Newsprint — Chem. pulp/Ground wood pulp mixture, slack sized and printed with offset ink.

D. Computer Print out — Ordinary writing printing paper printed with Kores Computer inked ribbon.

Methods :

Dry Defibering :

Each grade of waste paper was defibered in air dry condition in CONDUX MILL V4 type of D 6451 Wolfgang bei Hanau (Germany). The mill consists of two rough surfaced stones, one being stationary and the other moving at 832 r.p.m.

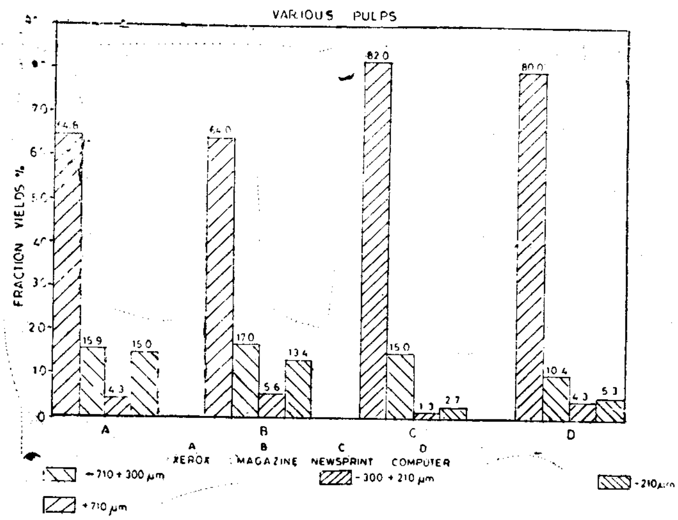
Fractionation

The defibered material was fractionated on an automatic seive shaker for 1 hr. The shaker imparted rotating as well as shaking motion to have maximum size separation. Following four fractions were selected for analysis.

Sample No.	B.S.S. Seive No.	Size (μm)
1	+22	+720
2	−22	−720
	+52	+300
3	−52	−300
	+70	+210
4	−70	−210

The yield of each fraction was calculated on the basis of oven dry defibered material. The results are given in Fig. 1.

FIG 1 DRY DEFIBERING YEILDS FOR



Wet Defibering :

For comparison each grade of waste paper was wet defibered after soaking in distilled water for 24 hrs. in a laboratory disintegrator for 10 mts. @2500 revolutions/mt, consistency was adjusted to 5.0%.

Brightness Pad Formation

1.0 gm. of dry defibered fraction, conditioned at 65% RH and 25°C for 24 hrs. was disintegrated with 1 litre of distilled water in laboratory disintegrator for 10 mts. @ 2500 rev./mt. Fiber mat was formed on Whatman filter paper No. GF/F. This paper retained the finest particles down to 0.7 μm and therefore was used for pad formation. In order to have uniform deposition of material and give support to the filter paper, 10 cm dia glass silica disc G4 funnel was used as filtering container instead of conventional Buchner funnel. The water was removed with the help of vacuum pump. The filterate in all the cases was nearly as clear as pure distilled water. The pulp sheets were air dried in shade in order to avoid the affect of sunlight.

Brightness value of paper is also effected by grammage, bulk and surface smoothness. These properties were kept as constant as practicable by taking constant conditioned pulp and calendering the pulp sheets under identical conditions of moisture and pressure.

Testing

Waste papers and pulp sheets were tested, after conditioning, for grammage, bulk, smoothness[9] and ash[10] etc. per TAPPI testing procedure. The test results are given in Table-1.

The brightness[11] of the samples was also tested in accordance with Tappi testing method procedure. The results are given in Fig. 2,3,4 and 5.

TABLE-I

Characteristics of pulp sheets and Waste Paper

Waste Paper Type	Fraction	Substance g/m²	Bulk cm³/gm	Smoothness (Secs.)	Ash %
A	Paper (Undefibered)	81.0	1.11	45-60	21.0
	Wet defibered	127.5	1.25	73-87	—
	Dry defibered				
	1	126.8	1.69	98-120	6.3
	2	127.2	1.63	89-107	7.3
	3	127.6	1.61	65-74	8.7
	4	127.3	1.58	—	35.7
B	Paper (Undefibered)	113.0	1.39	55-73	16.9
	Wet defibered	127.2	1.44	68-83	—
	Dry Defibered				
	1	127.4	1.76	105-128	6.5
	2	126.8	1.72	95-115	7.4
	3	127.1	1.69	70-84	8.0
	4	126.9	1.65	—	31.0
C	Paper (Undefibered)	54.0	1.61	95-130	3.5
	Wet defibered	127.0	1.75	117-145	—
	Dry defibered				
	1	126.8	2.20	145-160	2.9
	2	127.4	2.00	—	3.1
	3	127.1	1.97	—	3.1
	4	126.8	1.90	65-77	3.8
D	Paper (Undefibered)	56.0	1.33	70-87	5.0
	Wet defibered	126.7	1.48	85-100	—
	Dry defibered				
	1	127.4	1.72	93-108	4.3
	2	127.8	1.69	87-105	4.5
	3	127.2	1.63	76-90	4.7
	4	126.9	1.60	70-80	6.2

FIG. 2 BRIGHTNESS OF PULP SHEETS FROM XEROX WASTE PAPER

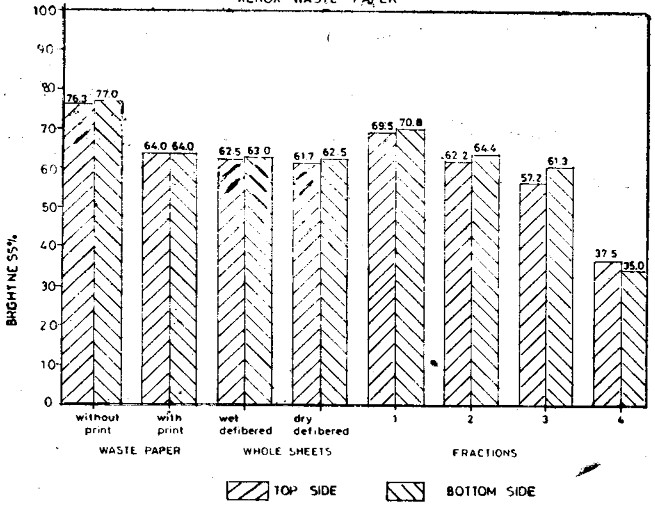


FIG. 3. BRIGHTNESS OF PULP SHEETS FROM MAGAZINE WASTE PAPER

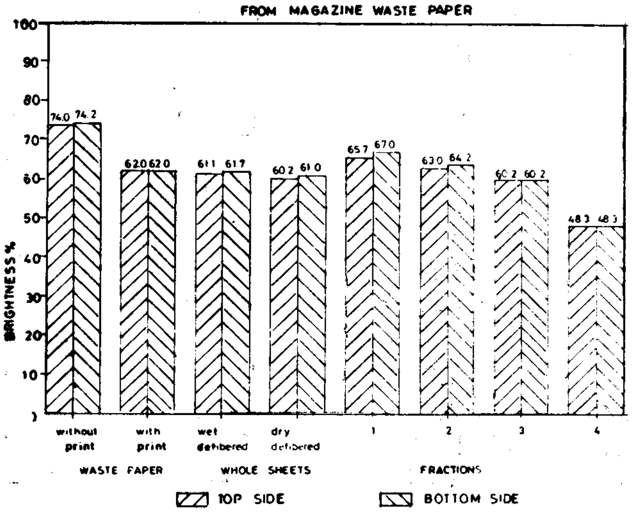


FIG. 4. BRIGHTNESS OF PULP SHEET FROM OLD NEWS PRINT

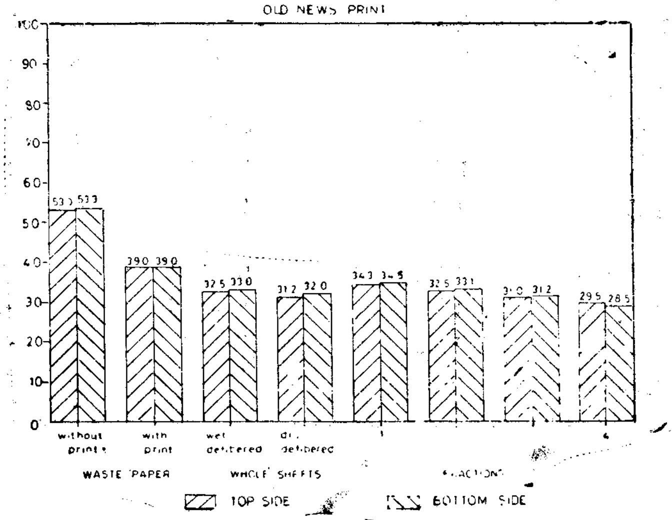
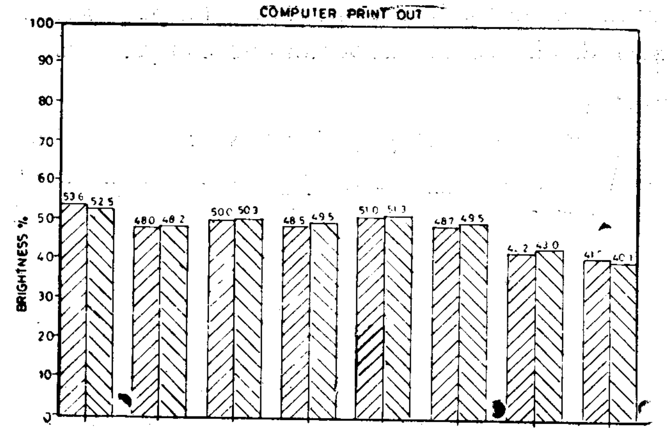


FIG. 5. BRIGHTNESS OF PULP SHEETS FROM COMPUTER PRINT OUT



Plain and Microscopical Photography

The brightness sheets of fractions 1 and 4 of all the four grades were photographed directly and under microscope with 40X magnification. The photographs taken directly were tested for brightness value as before. The results are given in Table-II. The ink particles, fibers, fines and filler particles as seen under microscope are shown in Fig. 6. Manual counting of ink particles under microscope was made. The range of numbers and sizes etc. of ink particles are given in Table-III.

TABLE-II

Brightness of Photographs taken Directly

Waste paper type	Fraction	% Brightness
A	1	62.5
	4	47.0
B	1	54.5
	4	39 0
C	1	36.0*
	4	41.0*
D	1	42.8
	4	33 7

*Reverse trend is due to more roughness of frection 1 than fraction 4 as evident from smoothness values (Table—1). Therefore photograph of C_1 showed less brigtness value than that of C_4

Fibre characteristics

A small portion of each brightness sheet was thoroughly defibered in a test tube and tested for fibre length after making slides under microscope. The maximum, minimum and average fibre lengths are reported in Table-IV.

Fig-6. MICROSCOPIC PHOTOGRAPHS

W	Wet defibered Whole pulp	A—Xerox
1	+720 μm Fraction	B—Magazine
4	—210 μm Fraction	C—Newsprint
		D—Computer

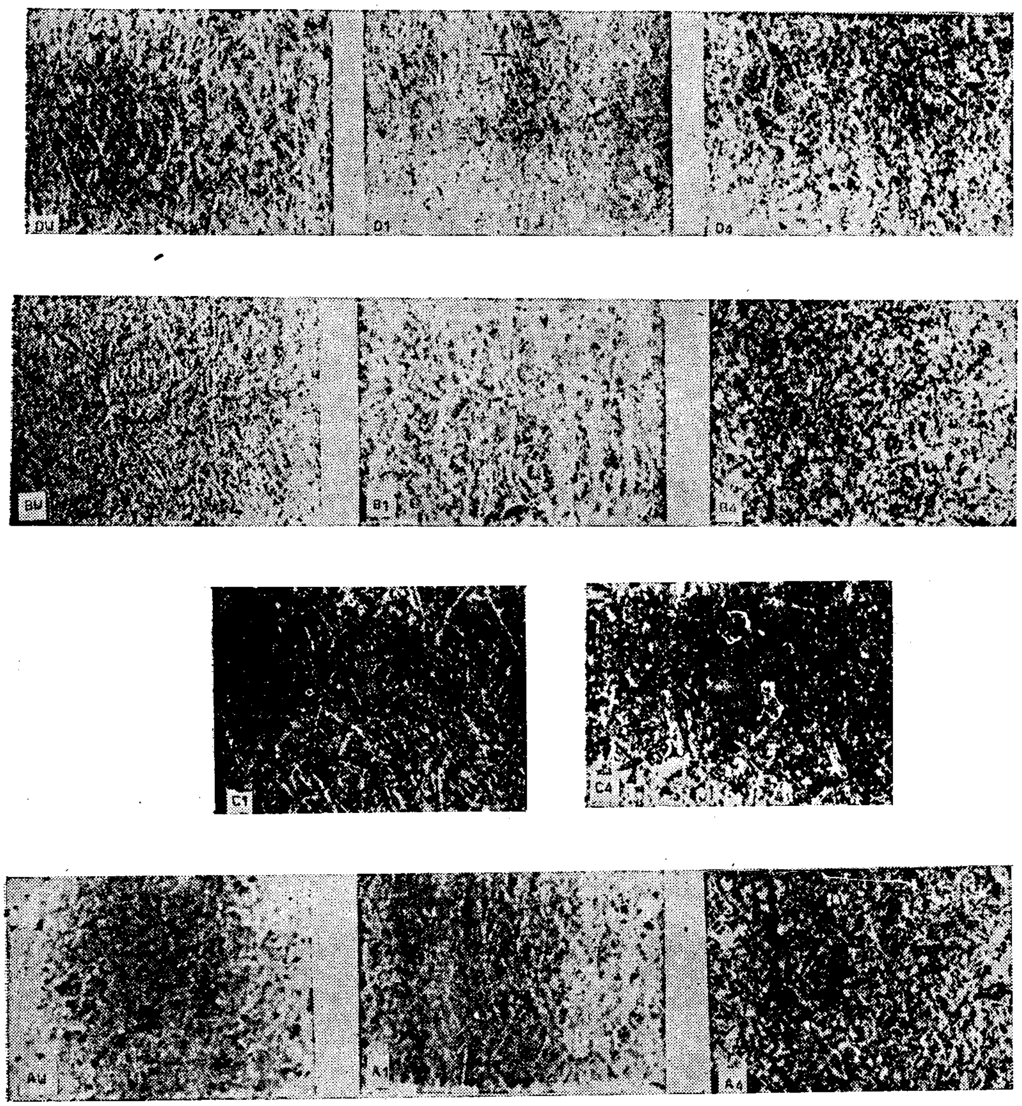


TABLE-III

Particle size and number of ink particles/view in various pulp sheets

Waste Paper type	Fraction	Numeer of ink particles/ view	Particle size Below 10 μm (%)	Above 10 μm (%)	Max. μm
A	Wet defibered	100-150	15	85	85
	Dry defibered				
	1	20-30	25	75	45
	2	30-50	15	85	30
	3	40-60	20	80	50
	4	150-200	50	50	80
B	Wet defibered	150-200	50	50	80
	Dry defibered				
	1	20-40	85	15	15
	2	10-20	50	50	15
	3	15-20	60	40	15
	4	250-350	70	30	80
C	Wet defibered	—	—	—	—
	Dry defibered				
	1	4-5	100	0	10
	2	—			
	3	—			
	4	40-60	65	35	35
D	Wet defibered	10-20	50	50	20
	Dry defibered				
	1	5-10	80	20	40
	2	—			
	3	—			
	4	10-20	75	25	30

TABLE—IV

Fiber lengths of different fractions as found in pulp sheets

Waste Paper type	Fraction	Fiber lengths. mm. Max.	Min	Average
A	Wet defibered	3.33	0.58	1.48
	Dry defibered			
	1	3.30	0.53	1.52
	2	1.67	0.33	0.94
	3	1.25	0.30	0.72
	4	1.25	0.20	0.56
B	Wet defibered	3.70	0.65	1.60
	Dry defibered			
	1	3.60	0.55	1.54
	2	1.73	0.37	1.00
	3	1.28	0.28	0.70
	4	1.25	0.25	0.55
C	Wet defibered	3 30	0.50	1.29
	Dry defibered			
	1	3.50	0.37	1.27
	2	1 42	0.25	0.73
	3	0 91	0.15	0.45
	4	0.67	0.10	0.25
D	Wet defibered	3.40	0.62	1.45
	Dry defibered			
	1	3.50	0 60	1.49
	2	1.70	0.32	0.90
	3	1.24	0.30	0.72
	4	1.25	0.20	0.50

Results and discussion

Brightness results (Fig. 2, Fig. 3 and Fig. 4) show that an appreciable removal of ink particles have taken place in the case of xerox, Magazine and Computer papers. However, Fig. 5 shows that only a negligible amount of ink is removed in case of Old News Print. The differences in brightness values taken as average of top and bottom side of brightness sheet between fraction 1 (+710 μm) and fraction 4 (—200 μm) for xerox, Magazine, Old News Print and Computer Print Out are 33 4. 28.0, 5.5 and 10.6 respectively.

The reason for this variation of brightness difference values between 1 and 4 fraction is attributed to both the nature of paper and the type of ink. For example old news print which basically is unsized bulky paper has ink deeply embeded into the matrix. This paper, therefore, produced a more or less uniform grey coloured mass giving only 5.5 points brightness difference between fraction 1 and fraction 4. Next, Computer print out paper being a normal writing printing paper and sized normally, offers some resistance to ink particles in going deep inside the body of paper. Computer print out, therefore, showed a medium difference of 10·6 brightness points between fraction 1 and 4. In the case of Magazine paper the ink mostly is remained on the coating and on dry defibering therefore gets separated along with fines, fillers etc. This is evident from 28.0 brightness points difference between fraction 1 and 4. Similarly, xerox ink which fundamentally is a thermosetting ink is expected to be brittle and so under mechanical shear force breaks into fine powder. This explains the 33.4 brightness points difference between fraction 1 and 4 in the case of xerox paper.

The brightness of filter paper before and after sheet formation was measured. The difference in brightness before and after increased in the ascending order of fractions 1 to 4 and also in the sequence C>D>B>A. The average reduction of brightness of filter paper in case of fraction 1 of A & B papers was found to be 10-15 points. This shows that quite a good amount of fine ink and fibrils are adhering even with the longest fraction. Contrary to the findings of McKinney(8) in all the cases except the fractions 4, the brightness of bottom side of the pulp sheets was found to be more by 1-3 points as compared to corresponding top side. This possibly be because the fine ink particles and fines comes out of bottom side of the sheet and get absorbed into the filter paper. As a result the brightness of filter paper was reduced by 15-25 points.

As can be seen from the microphotographs (Fig 6) of pulp sheets A & B having 40X magnification that fraction 1 is having much less ink and filler particles than the fraction 4, confirming thereby the effective deinking by dry defibering. However, inspite of bottom side brightness being higher than top side, the average number of ink particles/view was found to be more (20-40 specks/view, bottom side to 10-20 speaks/view, top side) in the case of former. This shows that a good amount of ink particles of different sizes are loosely adhering even with fraction 1. These particles can possibly be removed either by flotation, washing or centricleaning etc. depending upon the nature of ink.

As regards the filler removal by dry defibering this is very much evident from Table-I, particularly in the case of Xerox paper and Magazine paper in whose case ash content of fraction 4 is 35.7% and 31.0% respectively. Quantitatively speaking 77.3% filler was removed in Xerox paper while 69.8% in the case of Magazine paper taking base paper ash as 2 0%. It is because of this, as shown in Fig. 1 that fractions 4 of Xerox and Magazine paper are 15.0% and 13.4% as against 2.7% and 5.3% that of Old news print and Computer print out respectively. The filler and coating material removal is also confirmed by the microphotographs, where filler and coating particles can be seen clearly in fractions 4 where as, it can rarely be seen in the fractions 1. The filler and coating particles are visible even in the microphotograph of wet defibered sheet made from Magazine paper for comparison which further confirms filler and coating removal by dry defibering.

In contrary to expected risk of damage to fibers due to dry defibering, it can be seen from the test results of fibre lengths (Table-IV) none of the paper type suffered any cutting or damage of fibres. However, quite a good number of broken ground wood fibres could be seen in the fraction 4 of Old News Print. This cutting was negligible as the fraction 4 amounted to only 2.7% (fig. 1). Groundwood fibres have broken down probably because of their more brittle nature compared to chemical pulp fibres.

Conclusion

i. Dry defibering on screening can be helpful in detaching and partial removal of non-dispersable inks like heat set resin containing offset inks on heavily coated paper like magazine papers and thermosetting inks used in photostatic copies like Xerox. Dry defibering though to a lesser extent, can be suitable to well sized uncoated papers for example computer print out etc.

ii. The filler and other coating materials which become brittle with age can also be removed to the extent of 60-70%. This shall be useful in the case of heavily coated and loaded papers like magazine papers.

iii. Dry defibering is not useful for uncoated and slack sized papers in which the ink is absorbed into the fibre matrix e.g. old news print and more so printed with inks containing no heat set resins. On the other hand such papers should not be even wet defibered under high shear as grey colouration shall be imparted to fibers which is very difficult to remove by any known deinking or bleaching technique.

iv. An overall brightness drop of 6—8 points has been noticed even with papers like Xerox and Magazine papers which were found suitable by this technique compairing unprinted brightness of waste papers to brightness of fraction No.1.

V. A significant increase in bulk (Table 1) as result of drydefibering can make the technique useful for utilising waste papers like Magazine and photocopy papers for the production of high bulk papers like toilet and absorbing tissues, filter papers and pads of industrial use etc.

vi. Unusable fibers (aged and weak fibers) have been crushed to powder which are visible under microscope and thus dry defibering is expected to increase the overall strength properties of recycled paper. This shall probably be more prominent if the waste paper is overaged or recycled over four or five times.

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