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AN INVESTIGATION INTO STOCK PREPARATION EQUIPMENT

G. H. van DORTH

Introduction

THIS paper is intended to summarise and follow up the papers presented at the Spring Conference of the B.P. and B.M.A. Technical Section in London in 1973 and the Eucepa Symposium in Bratislava in 1976.

In 1968 the Fibre Institute of the Netherlands Organisation for Applied Scientific Research (TNO) initiated, in close co-operation with the Research Association of the Netherlands Paper Industry, a programme to promote the use of waste paper. This programme, which is still in progress, covers—

1. An overall comparison of mills which use clean and/or mixed waste paper.
2. Pulping, deflaking, cleaning, dispersing, de-inking and bleaching.
3. Treatment of sludges.
4. An analysis of raw materials losses.

The studies are based mainly on comparisons of recycling equipments installed in Dutch paper and board mills. Special trials were made using the pilot plants of paper machine manufacturers.

Method of assessment

THE effectiveness of each system studied is evaluated in terms of a rating scale for the visual appearance of handsheets made from the resulting product. This handsheet comparison scale ranks from 1 (very dirty) to 10 (very clean). The rating for appearance before pulping the bales is set at 0. The scale is used for expressing relationships such as 'Power consumption in kWh/t *versus* rating for appearance'. It may be used also to express the improvement in sheet appearance in relation to investment and operating costs.

General observations

NEARLY all the mills studied have about the same configuration of equipment. This consists of one pulper, two deflaking stages and four cleaning

Under the chairmanship of M. I. MacLaurin stages. Mills using mixed waste achieve almost the same stock as far as physical and mechanical properties are concerned, but the rating for appearance may range between about 2 and 5 on the handsheet comparison scale. On the other hand, mills using clean waste grades finish with different stocks, depending upon the quality of the waste paper used. The ratings for appearance in these mills range from about 6 to 9.

The average energy consumption in making pulp from wood is at least 1 000 kWh/t, whereas for secondary pulp this figure ranges between 150 kWh/t, for mixed waste paper, to 400 kWh/t for clean waste.

These figures include the energy used for dispersing and de-inking.

It may be expected that specialised equipment, adapted to the various kinds of waste paper, will promote greater replacement of virgin pulp by secondary pulp in the future.

Pulping

COSTS for pulping are high at about Dfl 10 per tonne for 1 to 2 points increase in the rating for appearance; the rating before pulping of the bales being set at 0.

Deflaking

DEFLAKING costs are relatively low at about Dfl 8 per tonne (using two stages), for 2 to 6 points increase in rating for appearance.

Exactly the same make and type of deflakers give very different effects (and consequently different costs) at different places in the mill.

The configuration between deflakers is important. If two or three are placed in line (they may be separated by other equipments) only the first works satisfactorily both from the technological and economic points of view. However, the effect of two deflakers in line is better than that of two in parallel, based upon the same throughput.

The most effective deflaker is a disperser.

Dispersing

A DISPERSER is identified as a device having a similar action to that of a deflaker or refiner, but which operates at a high consistency, usually in the range 25–35 per cent. Much of the information acquired refers to a specific type of disperser known as a Disperger, but the conclusions are generally valid.

Dispersing costs are relatively high at Dfl 30 per tonne. However, the effect of dispersing upon the rating for appearance is very good and varies between 4 and 8 points increase.

Dispersers overcome the detrimental effect of bitumen, wax and ‘stickies’.

Dispersers vary greatly in their effects upon the dispersing of contaminants and the way in which they change the physical and mechanical properties of the stock. In the main, mechanical dispersing treatment of the stock results in an improvement of the strength properties, but, on the other hand, it has a negative influence upon the dewatering time.

In comparison, thermal dispersing treatment gives a deterioration of the strength properties, although the dewatering is not influenced except, perhaps, for an improvement in some cases.

Cleaning

TOTAL cleaning costs, using four stages, are about Dfl 12 per tonne for an increase in the appearance rating of 1 or 2 points.

Evaluation of cleaners is difficult. Based upon appearance ratings there is hardly any difference in the effectiveness of various groups of cleaners; be they high density or low density hydrocyclones, vibrating screens, pressure screens or other types.

De-inking

FLOTATION or washing types are used. The best system is a combination of both. This arrangement is a very flexible one able to de-ink various kinds of waste papers with different types of printing colours.

Treatment of sludges

AT present very little sludge can be reused. Most of it is dumped.

Clearly the production of sludge should be minimised and this can be done by closing the mill system as far as possible, re-using fibres and employing retention aids.

The remaining fillers and fines are not recovered, but separated from the waste water by flotation and/or sedimentation. A centrifuge, vacuum filter or filter press is used to concentrate this residue.

Material losses

WHEN using waste paper as a raw material, the total material loss may range from 8–20 per cent with an average of about 14 per cent.

This is divided as follows—

Separation of contaminants	1– 5 per cent
Moisture differences between waste paper and product	2– 6 per cent
Sewer losses	4–10 per cent

These figures are true both for mixed and clean waste paper.

The residual sewer losses should be reduced by the established methods of closing systems, fibre recovery and the use of retention aids.

Discussion

Mr M. I. MacLaurin Esoteric theories about hydrogen bonding, for example, are very much our bread and butter at this symposium. We are doing fundamental research. But we must also be concerned with the real world—often the money for our research comes from people who are concerned with mills and with machinery—and make sure our endeavours are directed towards a fairly practical end, even though we may use the methods of fundamental research methods to get there.

Dr R. Oye I would like to ask a question to Dr Eastwood. I was very impressed with PIRA's work which he described on recycling. The state of paper technology seems to be quite similar in the East. In our case the recovery of paper and board is 38–40 per cent; and 0·68 ton, on average, of waste paper is re-utilised to produce 1 ton of paper board. For every 1 ton of newsprint produced, 0·1 ton of recycled fibre is added to the furnish. As Prof. Marton pointed out this morning, there is not too much difficulty in the case of mechanical pulps except for de-inking and screening. However, if we want to increase the cycling ratio from 40–50 per cent, it is necessary to use much more waste paper for making printing or other papers. Have you any ideas how to develop the use of waste paper in printing or other specified papers?

Dr F. G. Eastwood Good quality waste can certainly be incorporated into a pulp furnish for printing papers and I am sure this is being done at the present time. There are two important problems with using this waste which are not caused by strength property defects. Firstly, very small quantities of a contrary, such as latex in the waste paper, can cause difficulties in the final printing process on the press and such contraries can be very difficult to sort out from the waste paper. Secondly, the quantity of waste paper of the quality required for such printing paper is in short supply in the UK. As to your question of developing the merits of recycled fibres on specific papers, we have considered the problem from a different viewpoint; although I thoroughly agree with the importance of your approach. The upgrading work at PIRA

Under the chairmanship of M. I. MacLaurin has been on improving the strength properties of pilot machine recycled semi-bleached kraft, a material of known prehistory, and also on mixed waste, (see paper by Eastwood & Clarke in a recent edition of Paper Technology and Industry), and on news and pamphlets and other material in abundant supply. Only recently have we started to think about how we might introduce our upgrading work to particular grades of paper made in the mill rather than as received from the waste paper merchant.

Mr B. W. Attwood As one who has been involved with secondary fibre over many, many years, I find it most refreshing that at last there is a chance for a fundamental approach to be made. If it is only to stop people repeating experiments carried out many years ago over and over again. I have some criticisms, but I hope these will be constructive. We must understand that it is an extremely complex problem. Suppose you had waste which was entirely from a tissue machine and you recycled it. What sort of material would you get? At the other end of the spectrum, say you had waste which came from a glassine machine and you tried to recycle, what would you get? On top of all this you have the contamination problem. Also a point which I entirely agree with: what really is a handsheet? What are we comparing handsheets with? We still do not know very much about the process and there is a case for taking sheets right the way through a paper machine and having a look at the developments that take place down the machine.

Mr A. T. Luey Dr Graminski, will your technique indicate contaminants that are present from a level of something like 25 parts per million? If you do have stickies present in that quantity, and they tend to agglomerate and you have a rejection.

Graminski The difficulty would be to develop the technique for measurement. I have specifically asked the recycling industry what their problem was with regard to making high grade papers. One of the questions was about dirt in paper which was very small and which can be very detrimental. The reply was 'I'm not interested in measuring it, I want to know how to get it out'. But, if you do have a method for getting it out, I think you want to be sure that you do have it out; and here is where the technique would be helpful. I think in the future we may be able to measure several properties of interest, two of which are coarseness and wet fibre flexibility.

Mr V. B. Balodis Dr Graminski, how do you ensure that the curl of the fibres on the photomicrograph corresponds to the curl of the fibres in the suspension?

Graminski There were fibres taken from a dilute suspension placed on a microscope slide and covered with a cover glass so that the fibres were kept flat. I presume, if you can measure a sufficient number of fibres, then I think you have a pretty good idea of the statistical distribution of the curl of those fibres. In automatic mode it will only take a fraction of a second to carry out such an analysis.

Dr A. de Ruvo In answer to Prof. Marton's earlier comments, you said that there is an influence due to the pulping process—and of course you are right. The largest losses in strength of course we get when using chemical pulps. We have noticed that, in general, for sulphate pulps, there is a decrease in the recovered properties as you decrease the yield. This is a little depressing as this is the strongest pulp we have. However, if you break the cook at about 65 per cent yield and then proceed with the chlorine bleaching, then this trend is counteracted. This work was reported at the Ellenville Conference in 1975. The explanation for this should be found in the structural differences between the selective delignification and the composite removal of components—hemicellulose and lignin—that you get in the ordinary kraft cook. So, if you selectively remove the lignin, that will improve the ability of the fibre wall to reswell.

MacLaurin I was just wondering how many of you here were concerned in the technology or science of recycling and waste paper—I see about four-fifths of the audience,

Dr Caulfield, would you like to comment on the effect of heat cycling on cross-linking?

Dr D. F. Caulfield Our work on cross-linking runs contrary to the concept of recycling of fibres. The work is intended for specific purposes where structural factors are more important than recycling.

MacLaurin So you do not think it has relevance to what we were talking about?

Caulfield It is relevant in the respect that cross-linking will prevent recycling. Unless you can develop a special cross-linked bond that can be hydrolised by some method; that will not hydrolise the rest of the cellulose chain.

Dr J. D. Peel I would like to ask those people who have worked in the field of the importance of fines in recycling. Undoubtedly this is one of the most important features of recycling. The increase in fines on repeated recycling seems to be very large. Why? The energy you put into reslushing is nothing like as much as you put into refining, yet on Prof. Szwarcsztajn's figures the amount went up from 5–25 per cent on repeated recycling.

Prof. E. Szwarcsztajn On recycling the fibres change by hornification and then they are generating more and more fines during repeated cycling. It is a cumulative process for each recycle.

Mr P. Howarth We might be up against a question of definition here. What are fines? If you define fines as what passes through a 200 mesh screen, then in our experiments we do not find this increase in fines. How do you define fines Prof. Szwarcsztajn?

Prof. Szwarcsztajn We separate fines in a Swedish Crill separator. The maximum length of these fines is 0·2 mm.

Dr H. Corte I would support Dr Peel. No matter how you define fines the fact remains that the drainage resistance increases. That is what matters. You cannot run the machine as fast as you can with virgin fibres. So this is a matter of real mill practice, not just one of definition.

Mr Howarth The point has often been made before that we put too much energy into the preparation of waste paper furnish before running it on the machine. That is part of the trouble. We make the recycled pulp too wet.

Prof. G. Duffy (Prepared Contribution)

In 1975 I had the privilege of working with Dr de Ruvo's group at the Swedish Forest Product Research Institute in Stockholm and at that time we developed a method of separating fibres at 3–4 per cent concentration into long, medium and fines fractions. The fractionator is a high speed atomisation device and it works just as well at 1 per cent stock concentration as it does at 4 per cent. We can separate the bark, sand, shives and other fine material. It atomises the suspension using a specially designed atomising unit rotating at 20 000 r.p.m. and we get coarse, fine and medium-fine fractions. Obviously from that we could take the long fibred material, beat those long fibres only and recombine them with other fractions to form a better furnish. This may have some value in the future.

TABLE 1—WASTE PULP FROM SEDIMENTATION TANKS

Feed		*Rejects*	*Total Accepts*	*Accepts 1*	*Accepts 2*
Fibre	615	62 (10·1%)	553 (89·9%)	382	171
Shives	305	187 (61·3%)	118 (38·7%)	60	58
Bark	39	29 (74·3%)	10 (25·7%)	2	8
Ash	41	11 (27·8%)	30 (73·2%)	20	10
TOTAL		289 (28·9%)	711 (71·1%)		
Cellulose	920	249 (27%)	671 (73%)	442 (48%)	229 (25%)
Bark particle (mm)		0·65		0·032	0·079

Also we have used waste sedimentation pulps as shown in Table 1. This is a waste pulp from the sedimentation tanks. You can see from the Feed composition that we had six hundred-odd parts of fibre, three hundred parts of shives and a small quantity of bark and ash. In another case we had over one hundred parts of sand. You can see from the Accepts column that the chamber has several parts for collection (we collected Accepts from positions one and two only) and we recovered five hundred and fifty parts as long fibre, which is nearly 90 per cent. The shives recovery was about one hundred and eighteen parts (about 39 per cent of the shives), but these were very small particles as you can see from the comparative bark analysis at the bottom of the table. The Reject bark size was at 0·65 mm whereas the Accepts bark size is of the order of 0·032 mm so the shives were of that order of size for comparison. Only the fine shives and fine bark were retained in the Accepts. Keep in mind that 90 per cent of the fibres were recovered from the waste from sedimentation tanks which was collected over several days from the different tanks and added together.

TABLE 2—WASTE PULP WITH SAND

			Accepts			
			Total	*Position*		
Feed		*Rejects‡*		*1*	*2*	*3*
Fibre	363	31 (8·5%)	332	42	159	131
Shives	506	283 (55·9%)†	223*	2	39	182
Alum	21	7	14			
Sand	110	105 (95·5%)	5			

* Fine shives (increase in coarseness from positions 1 to 3).
† Coarse shives (90%).
‡ 36% Cellulose (11% fibre), 95% Sand in Rejects.

With the sand case as in Table 2, one hundred and five parts were in the Rejects and only five parts out of the one hundred and ten parts of sand were in the Accepts.

Referring now to Table 3; this is an interesting experiment. We had some waste corrugating board and the liners were peeled manually from the corrugating medium. These were slushed separately and handsheets were formed. Then the waste box material was slurried, dispersed without beating and passed through the fractionator. You can compare, say, the handsheet properties of the liner on the right hand side of the table. Although there is some disparity due to the fact that we did not quite select the correct positions in the collection unit, you can see that there is a fairly good comparison between the properties of the sheets formed from the pulp of the manually separated liner with those of the sheets from the fractionated pulp recovered from the total reslushed boxes. Now, if you compare the corrugating medium you can see again some similarity in the sheet properties. We have gained perhaps in the properties of the corrugating medium over the comparable properties of the liner, but this was the first attempt and it is possible to obtain pulps from the fractionator that agree more closely with the individual liner and corrugating medium.

TABLE 3—FRACTIONATION OF A WASTE CORRUGATED BOARD

	Corrugating medium		*Liner*	
	Manually Separated	*Fractionated*	*Manually Separated*	*Fractionated*
Basis weight (gsm)	114	131	183	182
Density (kgm^{-3})	583	544	583	552
Tensile index (Nmg^{-1})	34·6	40·7	43·5	36·3
Burst index (k Pa m^{2}g^{-1})	1·79	2·30	2·69	2·11
Stretch (%)	2·1	2·2	2·0	1·8
Elastic modules (Nmm^{-2})	2820	2870	3250	2840
Tensile energy absorption index (Jkg^{-1})	502	509	609	470
CMT (N)	130	140	184	159

The atomising unit can therefore be used to screen, clean and fractionate pulps at high stock concentration.

Mr MacLaurin Let me try to sum up what the rest of us thought. Firstly, people working on fibre properties should not confine their attention to virgin fibres. Secondly, there must be some way that fundamental research can help the engineers and technologists to design more cost effective processes.

Thirdly, we need better methods of measurement to characterise the stock. A further problem area is how to remove fine contaminants. How do we get rid of them? Up to 400 kWh/tonne for obtaining a clean product from waste is too high. The future energy policies will demand that we reduce this. We also have to find ways of making strong paper from waste without causing drainage problems. First drying is the most important thing, and for countries who buy in their pulp, is their 'first drying' really their second drying? So, perhaps it would be worthwhile investigating whether it would be more cost effective to pay slightly more for pulp at a higher moisture content. Pulp mills are near the forest, so how about small market pulp mills for recycled fibres near the town? That is not just a technological and engineering problem; there are scientific considerations to be taken into account as well.

It is quite clear that we have tried to do too much in the time, but we would be glad to hear any constructive criticisms you may have. I would like to thank all our panelists and discussion contributors for what they have done today. I would also like to thank our two microphone girls, Julie and Sandra, not only for today but for the whole week.