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LOW WASTE TECHNOLOGY IN PULP AND PAPER INDUSTRIES

Hans Norrström

IVL-Consulting Ltd
Box 21060
S-100 31 STOCKHOLM
Sweden

Abstract
The waste of fibre raw material and process chemicals from the pulp and paper industry can with modern technology be reduced to very low values. The residual discharge to air and water can with present treatment methods be reduced to comply with stringent environmental requirements.

Manufacture of procucts based on a high share of mechanical or chemimechanical pulp requires large amounts of electric energy of which only a small portion can be recovered in the form of low energy steam. When producing strong, chemical pulps for packaging papers the dissolved wood substance can be used to generate steam. Mills of this type can be made self-sufficient with regard to heat energy and also generate a main part of the electric energy required for the processes.

The major conclusion is that the pulp and paper industry already today is low waste and resource conserving. To further improve this position the following problem areas should be subject to study; reduced bleach plant effluents, low energy defibration and low energy external treatment.

Paper products - low waste technology

Corrugated containers, paper cups, facial tissue, diapers, newspapers and copy papers are examples of products provided for us by the pulp and paper industry. This industry thrives and survives as long as it can deliver these products cheaper and of better quality than any other branch of industry.

The question is now to what extent the pulp and paper industry can be regarded as low waste industry. The answer to this question is sought by analyzing two main products of the industry - newsprint and kraftliner. The analysis will indicate what processes are low waste and also areas where further work is necessary to improve the efficiency of the processes.

In such an analysis it is necessary to put the end result - the product -in focus. The market, i.e. the sum of the needs of individuals, requests certain functions. It is then the industry's task to produce these functions (products) as cheap and efficiently as possible. Ideally this should mean with as low wastage as possible.

A given function (product) can usually be obtained by several different processes. A cup for instance can be made from paper, plastic, metal, wood, clay etc. Which one of a number of alternate processes represent the lowest wastage and use of primary resources is one important area of study.

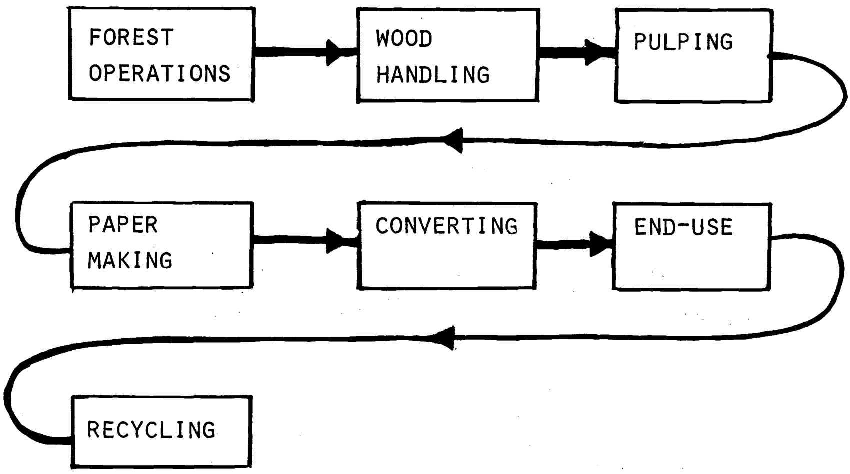
Another way to proceed is to study in detail a given process and its possible modifications to save resources. The two types of study have some major problems in common e.g.

- the product obtained by a different process or by a modified process may not have the same characteristics as the original one and might not be received in the same way by the market

- changes of a very different nature have to be compared and evaluated e.g. to save energy versus to save a raw material or to reduce a discharge to air but to increase the discharge to water.

Low waste studies on a product should take into account all phases of the products life from raw material extraction to recycling or destruction after final use. A schematic life cycle for a paper product is shown in Fig. 1. For all steps the energy demand, the raw material consumption, the losses, the capital required and the manpower needed must be calculated in order to obtain a complete and correct evaluation.

Fig. 1 The various steps in the life cycle of a paper product.



In the present analysis, however, emphasis will be put on the pulping and papermaking operations. As an introduction the cost structure for Swedish newsprint as delivered in Europe is given in Table 1 (Ref. 1). A dominating part of the total cost is the capital costs (for the pulp and paper mill) and the cost for wood raw material.

TABLE 1. Cost structure for newsprint from Sweden when consumed in Europe

Item	%
Capital	39
Wood raw material	24
Energy	12
Manpower	7
Miscellaneous	9
Transports	9

The numbers are from 1978 and since then we have had a dramatic increase in energy prices. The energy share should therefore today be closer to or above 15 %. It is notable that the transports from the millsite to a port in Europe account for almost 10 % of the selling price. The transports of wood and of chemicals etc are included in items "Wood raw material" and "Miscellaneous".

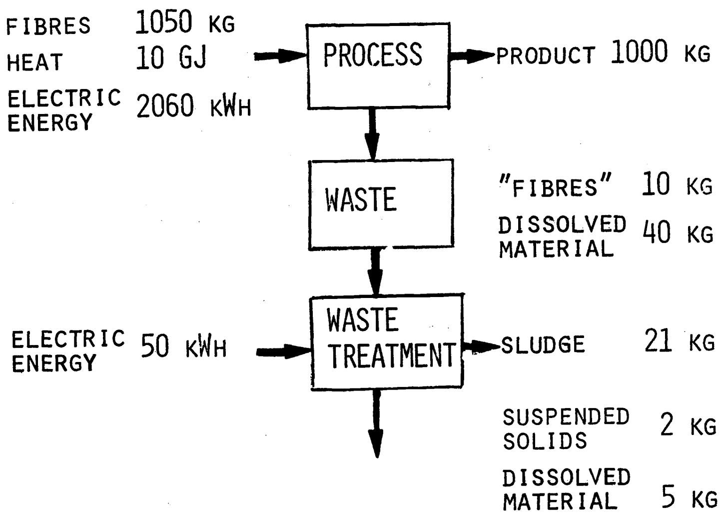
Newsprint manufacture

When making newsprint from mechanical pulp only e.g. TMP the fibre yield is usually above 95 % (Fig. 2). Only a small amount - of the order of 10 kg per tonne product - of fibres leave the process. The main part of this loss is in the form of fibre fragments which are removed in sedimentation basins.

Part of the wood raw material is dissolved in the process. The dissolved substance consists of low molecular carbohydrates, lignin fragments and extractives. There is today no commercial technology available to recover and utilize this material. It gives the raw waste stream a BOD_7-value of 15-20 kg/tonne product which can be reduced by biological treatment or chemical flocculation.

The final effluent then contains 2-8 kg BOD_7/tonne depending on treatment method and efficiency required. A sludge also results with accompanying costs for its destruction or deposition. The energy requirement for the external treatment is low (Ref. 2) compared to that required for the process but represents a significant cost.

Fig. 2 Generalized process scheme for newsprint showing major inputs of raw material and energy. Main product and waste streams are indicated. All numbers refer to 1 tonne bd. product.



A mean value for the heat energy required in a Swedish newsprint mill in 1973 was 10.6 GJ per tonne (Ref. 3) of which the major part was used directly in the process for heating and drying purposes (Table 2). About 15 % was used to generate back pressure power. Most of the energy originated from oil (8 GJ).

TABLE 2. Heat balance for 1 tonne newsprint (in GJ).

Heat	Source	1973	Best possible	
			A	B
Generated	Bark	1.2	1.5	1.5
	Oil	8.0	3.0	0.4
	Liquor	1.4	-	-
	TMP steam	-	0.1	2.0
Consumed	Process	9.1	3.6	3.6
	Back pressure	1.5	1.0	0.3
Total		10.6	4.6	3.9

A study has been made by the Swedish pulp and paper association on possible energy saving measures (Ref. 3). In a new mill the total heat energy demand can be reduced to 4.6 (mill A) and 3.9 GJ/tonne (mill B). In mill A TMP steam is used to preheat the chips entering the refiner and to generate hot water. Mill B transforms the TMP-steam for use in the paper dryer.

Mill B thus only requires 0.4 GJ per tonne in the form of external fuel (corresponding to 11 liters of oil) but generates back pressure power from 0.3 GJ only (75 kWh/tonne). The power generated in mill A is 270 kWh/tonne out of a total requirement of 2000 kWh/tonne.

Considerable efforts are being devoted to find less energy intensive processes to defibrate wood. So far no breakthrough has been achieved but several promising developments e.g. pressure grinding are under way. In the meantime an increasing share of recycled fibres is introduced into the newsprint (Table 3).

TABLE 3. Electric energy demand for 1 tonne newsprint (in kWh) as a function of the amount of recycled fibres in the sheet.

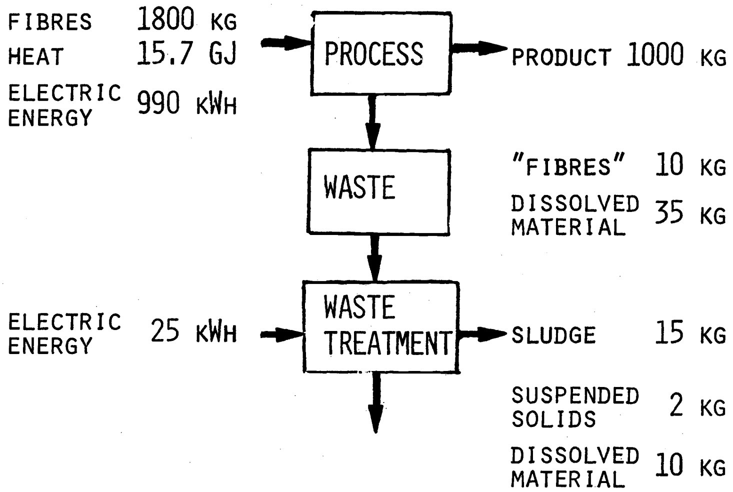
	Recycled fibres, %		
	0	25	100
TMP	1550	1160	-
Recycled	-	125	500
Paper machine and misc.	450	450	450
Total	2000	1735	950

At least 1500 kWh are required to produce one tonne of thermomechanical pulp. To prepare the same amount of recycled fibres in a form suitable for newsprint 500 kWh are used. It can be assumed that as a rule 25 % recycled fibres can be used in a newsprint furnish reducing the electric energy demand by almost 15 %. There are newsprint mills using up to 100 % recycled fibres, however.

Kraftliner manufacture

Kraftliner i.e. the top layer on corrugated board has been chosen as the example of packaging papers (Fig. 3). It is made by sulphate pulping with a yield of about 55 %. The dissolved wood substance is recovered to about 98 % and burnt to generate process steam. The process chemicals, mainly NaOH and Na_2S, are also recovered (97 %) and regenerated.

Fig. 3 Generalized process scheme for kraftliner showing major flows of raw material, product, wastes and energy. All numbers refer to 1 tonne bd. products.



The direct, aqueous discharge from a normal mill is of the order 10 kg fibres and 35 kg dissolved material per tonne product. The corresponding BOD load is about 10 kg/tonne.

By external treatment using e.g. an aerated lagoon followed by chemical flocculation the amount of suspended material can be brought down to 2 kg and the BOD to 1-2 kg/tonne. A mixed fibre-biological-chemical sludge of 15 kg/tonne is also formed.

System closure and process modifications is another way to obtain low discharges to water. One kraftliner mill in Sweden, Obbola Linerboard, has successfully developed this concept. A total amount of 20 kg process chemicals and dissolved wood substance corresponding to about 6 kg BOD_7 per tonne leaves the process. The fibre discharge is around 1 kg per tonne product. This result has been achieved without any external treatment facilities.

As was previously mentioned the process chemicals are efficiently recovered and reused (Fig. 4). The total loss of sodium compounds in this example corresponds to 6.5 kg Na/tonne. The main part is made up by the washing loss and the accidental spills. Almost half of the sulphur loss is in the form of SO_2 with stack gases. The remainder is evenly distributed on washing losses, sulphur compounds in the condensates, spills and particulates in the stack gas.

The 1973 mill (Ref. 3) had a heat balance of 15.7 GJ per tonne product (Table 4). The majority of this was generated from internal fuels. By various energy saving measures it seems possible to reduce the process heat demand by about 35 %. It also judged possible to increase the amount of bark used for heat generation. This means that the future mills A and B run without external fuels.

Fig. 4 Mass balance for sodium and sulphur (in kg per tonne product) for a kraftliner mill.

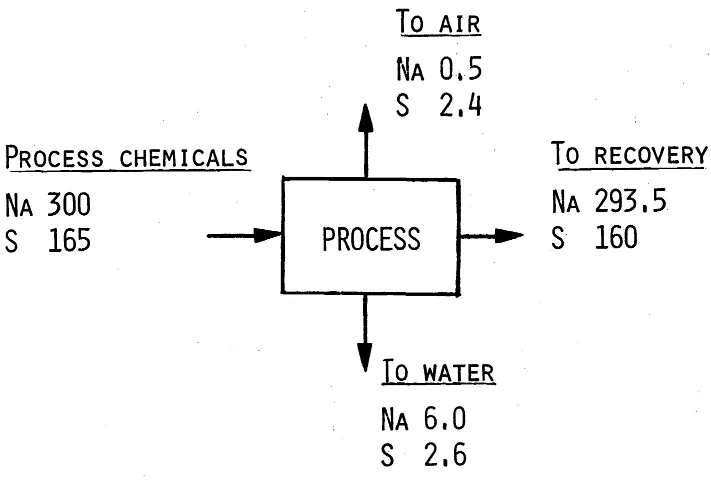


TABLE 4. Heat balance for 1 tonne kraftliner (in GJ).

Heat	Source	1973	Best possible A	Best possible B
Generated	Black liquor	11.2	11.3	11.3
	Bark	0.8	2.6	2.6
	Oil	3.7	0	0
Consumed	Process	14.7	9.5	9.5
	Back pressure	1.1	2.1	2.1
	Condensing	0	0	2.3
	Surplus steam	0	2.3	0
Total		16.7	13.9	13.9

Mill A uses 2.1 GJ for backpressure power generation and has a 2.3 GJ surplus of steam for external use in e.g. district heating, other industries etc. Mill B uses the surplus steam for condensing power generation.

The total demand for electric energy was 1973 990 kWh/tonne (Table 5). It is estimated that a mill built today with energy saving measures can be run with 770 kWh/tonne. Mill A has to buy 230 kWh/tonne and mill B is almost selfsufficient with respect to electric energy.

TABLE 5. Electric energy balance for 1 tonne kraftliner (in kWh)

	1973	Best possible A	Best possible B
Total demand	990	770	770
Back pressure	280	540	540
Condensing	0	0	215
External	710	230	15

Products competing with paper

A printing paper and a packaging paper have now been analyzed. The next step is to identify the competing products and to study them from a low waste angle.

Paper as a medium for information transmission competes primarily with various electronic systems. The manufacture of computers and microprocessors is a low waste industry with small, if any, environmental impact. The information exchange using such devices requires only little energy and other resources.

The important question is how much of the present market for information transmission and display presently held by paper will be captured by electronic systems. It should not be overlooked, however, that the electronic systems also generate uses for papers. This corner of the market is very complex and at present it will be left with the self-evident statement that it is necessary for the paper industry to closely follow the development.

The rôle of paper in the market for transportation of goods seems more straightforward. The main competitors are metals, glass and polymers. All these materials contain a high share of energy and will thus tend to increase in price with the oil.

Garbage sacks of paper and polythene with a volume of 160 l have been compared (Ref. 4) with respect to the use of oil (Table 6). To make one tonne of polythene sacks 1150 kg oil is used in the raw material and 1250 in the processing (in addition to almost 2500 kWh electric energy).

TABLE 6. Energy content of 1 tonne of garbage sacks of paper and plastics.

	Paper	Polyethene
Raw material		
MJ	42200	-
kg oil	-	1150
Production		
electricity, kWh	1600	2450
heat, kg oil	320	1250
Total as oil	320	2400
Recoverable	290	890

The same amount of paper sacks requires only 320 kg oil and 1600 kWh. These numbers can be further reduced by applying energy saving technology. If this case is valid also for other types of containers for goods it means that paper is competitive in this market segment and that it has a possibility to improve its position in the future.

Conclusions

Newsprint and other papers based on a high share of mechanical or thermomechanical pulp are low waste with respect to fibre raw material. The main residual discharge is to water and this can with present treatment methods be reduced to comply with stringent environmental requirements. The mills can also be designed so as to require only small amounts of external fuels.

The defibration process, however, uses electric energy in the range 1200 to 1800 kWh per tonne product which makes this category of papers vulnerable to rising energy costs. Many of the functions of printing papers can be accomplished by electronic systems while at the same time such systems require paper for hard copies.

In the first place less energy intensive defibration methods should be sought. Secondly more effective ways to remove or use the organic substance in the effluent should be investigated.

When producing strong papers for packaging purposes part of the wood material is dissolved. By using the dissolved material to generate steam those mills can be made self-sufficient with respect to heat and also generate a main part of the electric energy required for the process. Efficient recovery of process chemicals and low waste from the wood raw material make the discharges very low. Competing materials for packaging purposes are all energy intensive. This gives paper a promising position when energy prices rise.

So far bleached chemical pulps for high quality printing and packaging papers has not been dealt with. Bleaching of chemical pulps gives rise to a residual discharge which cannot be reduced efficiently with presently available technology.

Reduced bleach plant effluents, low energy defibration, low energy external treatment and an aggressive product development are in my opinion the most important areas for study in a promising future for the low waste pulp and paper industry.

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