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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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APPROPRIATE TECHNOLOGY FOR THE MANUFACTURE OF PULP AND PAPER PRODUCTS

THE SEARCH FOR APPROPRIATE TECHNOLOGY FOR THE UNITED KINGDOM PAPER AND BOARD INDUSTRY

Background Paper

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THE SEARCH FOR APPROPRIATE TECHNOLOGY FOR THE UNITED KINGDOM PAPER AND BOARD INDUSTRY

by

D. Attwood
UNIDO consultant

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The Search for Appropriate Technology for the United Kingdom Paper and Board Industry

Summary

Paper and board are internationally traded products, and most national industries have similar characteristics and problems. In recent years world market conditions have been unfavourable, and the UK paper and board industry has faced severe problems. This paper describes the structure of the current UK paper and board industry and sets this in the context of the common market (EEC) and world scene. The problems in finding indigenous raw materials are described and the role wastepaper plays as a raw material is discussed. The problems caused by the size new pulp mills have to be, to be viable, is examined, especially in the context of building new straw pulping plants which could integrate with existing paper and board mills.

Introduction

The per capita consumption of paper says something about the civilisation of a country. Certainly the spread of literacy was directly related to the availability of cheap printing papers although now in the developed countries the effects of packaging papers is probably the overriding factor in setting the per capita consumption.

A literate consumer orientated society is therefore, likely to be a high consumer of paper. Indeed the per capita consumption in 1976 in the USA was 245.5Kg and for the countries of the Common Market (EEC) was 113.1 Kg. Some observers find this discrepancy surprising because the EEC represents as does the USA, a large consumption and production area which, historically, developed in much the same way as the EEC.

On the other hand the per capita consumption of paper in such countries as Turkey-13kg, India-2.1kg, and Bangladesh-0.63kg is still very low. FAO forecasts that paper consumption in the ASEAN countries, (Indonesia, Malaysia, the Philippines, Singapore and Thailand) is likely to double by 1985 and could be five times more in the year 2000 than in 1974.

Paper making was known to the Chinese many years ago being introduced into Europe in about the 12th century. However, it was the introduction of the Fourdrinier machine in about 1800 and the production of cheap pulps from 1840 to 1860 which led to the explosion of paper making and the consequent increase in consumption. At the time this occurred the UK was ideally placed to take the lead since it was in the throes of its industrial revolution and so was well placed to take the lead in the mass production of paper and it had an expanding population who were eager for news and education.

The new cheap papers were of course, made from wood fibres and yet the UK has no forests to speak of and therefore, might be regarded as singularly inappropriate to have a paper industry. It is a cliche these days to say that mass produced papers should be made in the forest and that quality papers should be made close to the customer. These questions never arose at the time the UK started to build its paper industry and even in 1950 the UK was a major producer of both newsprint on the one hand and fine papers on the other.

In more recent times countries with forest resources have been keen to sell their products with the highest possible added value. Countries that once were prepared to sell pulp wood wished to sell pulp and countries selling pulp wished to sell paper. The sum total of these effects has been to put up the price of pulp worldwide, or at least it has been a contributory factor.

The UK has thus had to seek other sources of raw material and in common with many European countries has turned to wastepaper which it now sees as a major source of indigenous raw material. This is, as it were, an example of the UK's use of appropriate technology. Other indigenous raw materials have been investigated in depth, notably straw and short rotation coppice hardwoods. Wastepaper is an accepted fact as table 1 shows. The logistics of dealing with straw, an annual crop, has yet to be solved and whether short rotation timber will ever be viable has yet to be proved.

TABLE 1 Uk Consumption and Production

	IN TONNES - 1977
Consumption of paper and board	7
Production	4
Imports	3
Wastepaper consumption	2.1

(Wastepaper consumption as a % of total based on FAO definitions = 47%)

To set the scene for the current UK industry structure it is only necessary to categorise the paper machines into size as in table 2.

TABLE 2*

1977 Production of Paper & Board	Mill in each category		% of total UK products
	no	% of total	
Less than 1000 tonnes	2	1.4	under 1%
1001 5000 tonnes	30	21.3	2.1
5001 10000 tonnes	25	17.7	4.7
10001 25000 tonnes	35	24.8	14.6
25001 50000 tonnes	30	21.3	26.6
50001 100000 tonnes	9	6.4	14.6
100001 tonnes and over	10	7.1	37.4
TOTAL	141	100.0	100.0%

* Source BPBIF

This is the most uptodate situation and mirrors closely the structure of other EEC countries. The past 20 years has seen a consistent reduction in the number of papermachines operating in Europe as well as a steady increase in the size of production units until about 1970. The only new machines to be installed in recent years have been in the tissue sector, elsewhere small machines have been closed and machines rebuilt to produce higher quality grades, on, for example, news machines.

The situation is then that there are nearly 150 mills operated by 110 companies of which 6 produce over half the volume manufactured. Products are very varied and there are several distinct sub sectors whose performance and outlook differ widely.

The paper and board industry is noted for being cyclical. Whilst Table 1 shows the consumption figures for 1977 between 1963 and 1974, consumption of paper and board in the UK rose from 5.6 million tonnes pa, the annual average rate of increase being 2.7 per cent pa. It then dropped to 6.1 million tonnes in 1975, rising to 7 million tonnes in 1976 and 1977. As in other countries, growth in consumption of paper and board has been closely linked with growth of the national economy, and growth of the UK economy and hence of paper consumption has for many years, been less than that of other developed nations.

Between 1963 and 1974 UK production of paper and board rose from 4.1 million tonnes pa to 4.6 million tonnes pa, the average annual growth rate being 0.6 per cent pa.

Output dropped to 3.6 million tonnes in 1975 but recovered to 4.1 million tonnes in 1976 and 1977. Mention was made earlier of the cyclical nature of the paper and board industry - year to year variations over the business cycle since 1963 have been 70% greater for paper and board than for manufacturing output as a whole.

Imports rose between 1963 and 1974 from 1.6 million tonnes pa (representing 29% of consumption) to 3.8 million tonnes (just under 44% of consumption). In 1975 they dropped to 2.6 million tonnes but rose again to 3.0 million tonnes in 1976 and 3.2 million tonnes in 1977, when imports accounted for 45% of UK consumption.

The overriding political reason for the decline of the UK's paper and board industry was the lowering of the tariff barriers when the UK joined EFTA and from 1967 onwards faced duty-free competition from Finland, Sweden, Norway and Austria. Producers in these countries enjoyed the advantage of being able to make paper from slush pulp in integrated mills and in some cases got their electricity from hydro-electric schemes and of course, had the benefit of considerable natural resources in the way of timber.

The Nature of Wastepaper

Papermaking originally relied on the rag merchants for supply of its fibrous materials. After an interim period in which wood pulp provided the bulk of the raw material, economic necessity is forcing UK manufacturers to rely much more heavily on wastepaper and so wastepaper merchants are now an extremely important link in the supply chain. Waste was always a prime raw material for cardboard and cartonboard. It is now chiefly used also for the manufacture of substitute flutings and liners for case making. Its use is growing in UK manufactured newsprint where a typical virgin fibre furnish might be 20% semi-bleached kraft and 80% groundwood a more modern furnish containing de-inked news and magazine waste would be 15% semi-bleached kraft and 85% news and pams.

Another grade where waste is becoming more popular is tissue. Soft high quality white tissue is customarily produced from say 30% bleached softwood, 40% bleached hardwood and 30% bleached groundwood.

Well selected and relatively contrary free wastepaper can be incorporated into this furnish. Ideally, this would be white wood free waste consisting of computer print out paper, white forms, converters waste, etc. The material should contain very little printing and have an ash content of say, less than 8%. Contraries in the waste should be typically wire staples, clips and small amounts of plastic. The whole of the bleached hardwood and some of the bleached groundwood can be replaced.

Lower quality tissues (using virgin fibres) would contain up to 60% groundwood. For this lower quality coloured grade well selected grades of unprinted newsprint and magazine papers, converters trimmings and possibly high quality boxboard waste could be utilized. Again the material needs to be relatively print free and have an ash content of less than 8%. Contraries would be similar to the first grade.

The wastepaper processing system to handle both these types of waste for soft tissue manufacture would be relatively simple. It would consist of a wastepaper pulper fitted with a junk trap but no ragger followed by high density cleaning and centrifugal separation. Further high consistency screening would be carried out and the rejects from the equipment would be treated on vibrating screens.

There are two weaknesses to the use of waste as just described. First of all the quality of the waste has to be maintained so that the simple processing system remains adequate. Secondly, the quality of the product dictates that the waste be both bright enough and soft enough. Thus very little ink should be present and the ash content should be very low.

An alternative and one being actively considered in the UK at the moment is to use a more extensive processing system. The waste could then be relatively unsorted, with any degree of printing and high ash content. This would enable the use of a much broader range of wastepaper types with a consequent slackening of parameters.

It is very early days yet in this field of development but with 5 million tonnes of paper "lost" each year in the system it must be possible to increase utilization by a further million tonnes from 2 to 3 million tonnes per annum.

All the higher grades of paper have been taken up and so the next million tonnes can only be of the lower qualities. It seems likely therefore, that more extensive processing will be seen in the future and de-inked stocks used in high quality paper making.

Other Sources of Raw Material

It is known that something like 4 million tonnes of straw are wasted each year in the UK (some experts put this figure as 7 million - a very careful assessment of the situation has shown that, in a bad harvest year at least a million tonnes are available).

This would seem therefore, to be an ideal source of raw material, even allowing for its slowness as a pulp and the low yield of conventional cooking. However, without even considering the technical problems there are very real impediments to the introduction of a new pulp mill in the UK quite apart from the logistical problems of collecting straw during a six week harvesting period to provide a 52 week supply.

A generally held consensus is that the smallest viable pulp mill is of about 250000 t/annum. To achieve profitability it might be thought that this should be integrated with a paper mill of appropriate size. Single pulp papers, which are manufactured on the basis of a single grade of pulp from a given wood, do not exist (excepting Kraftliner). Some papers require 60 or 70% of a single pulp combined with other pulps. This means that a pulp mill with a 250,000 t/year capacity should be integrated with a paper mill with a capacity in excess of 325000 t/year. Moreover it is unlikely that straw could be used in a higher proportional than 40% and 30% would be more likely. An integrated operation would thus be more likely to require paper making capacities of 800000 t/year. This is self evidently not on so that the requirements are either -

1) the mill must produce market pulp

or 2) research aimed at constructing very small pulp mills in the 50 to 100 tonnes/day range is necessary.

Research into Small Pulp Mills

There is really only one major constraint to a small pulping plant and that is the question of recovery. Briefly, the problem is that a recovery boiler plus associated equipment for a conventional process would cost £2.5 million for the smallest conceivable mill. It is possible to scale down the actual pulping unit so that a 50 nett tonnes/day pulp mill including pulping, screening, washing and bleaching could be built for say £3 million, but this would then require the additional expenditure of £2.5 million for the recovery system. Regrettably, there is no way a conventional recovery system could be installed in a small pulping unit even up to 150 tonnes/day and justify the investment.

The requirement is for a very simple system of pulping and bleaching to be developed using low cost equipment and a chemical treatment, which requires the very minimum of recovery. This means either -

a) the chemical is so cheap that it can be discarded

or b) it can be recycled very simply

The object of any chemical pulping process is to release the cellulose fibres contained in the original raw material from the lignaceous 'binding' materials. The latter materials are then washed out of the fibrous mass with, hopefully, the very minimum of papermaking material. In the production of sulphate pulp for example, the fibre source (usually wood chips) is cooked, or 'digested' in a liquor consisting of a mixture of caustic soda and sodium sulphide, the latter being obtained as a reduction product of sodium sulphate which is added at one stage of the recovery cycle.

Where pulps are bleached this is usually performed by a sequence of chlorination and caustic stages when the chlorine is in the following forms:

i) Gaseous chlorine

ii) Sodium Hypochlorite

iii) Chlorine Dioxide

One can almost regard the bleaching process as a continuation of pulping in which the remaining lignin compounds still in the pulp are converted into water or alkali soluble forms and washed away.

The preparation of bleached straw pulp may also be carried out by the traditional processes although one or two problems can occur. These are:

i) Straw is less dense than wood and does not easily pack in the digester

ii) The straw nodes usually resist attack by the cooking liquor and can lead to quite high losses at the screening stage.

iii) Straw is very 'wet' and does not part with water very easily. It is therefore, more difficult than wood to wash and requires rather more water than the latter per tonne which in turn leads to weaker black liquor going to the evaporation stage.

iv) The silica which is always found associated with straw, either in the plant 'skeleton' or as dust adhering to the stem (usually both), is dissolved by the cooking liquor and then precipitates out in the evaporator. This produces a very hard scale which in turn reduces the efficiency of the operation. Silica glass can also form in the recovery furnace, usually on the pre-heater tubes or superheater.

v) The calorific value of straw black liquor is lower than that from wood and it is also more viscous. There can be a problem producing a final liquor which will burn and, at the same time, flow through the furnace inlet nozzles.

Nevertheless, straw is successfully pulped in very many countries.

The Pira report, 'A Survey of Straw Pulping in Great Britain', lists over 40 distinct processes for treating straw. Some have never been commercially exploited and others are in use commercially in producing straw pulp in many parts of the world. Some of the more interesting processes are summarised in the following table.

TABLE 3

Possible Pulping Processes for Straw

Main Cooking Chemicals	Process, Patent,etc.	Comments
Sodium Hydroxide	SODA Process	Carried out commercially in many countries. Full chemical recovery is possible if suitable precautions are taken.
Sodium Hydroxide plus Sodium Sulphide (Mixture)	SULPHATE (or KRAFT) Process	Calarasi (Romania) produces 50,000 tonnes of bleached straw pulp per annum by this method. Full chemical recovery possible with conventional equipment.
Sodium Hydroxide (or Sodium Hydroxide plus Sodium Sulphide)	SCHOLLER PERCOLATION Process	There seems to be no commercial plant in existence (possibly because of numerous storage tanks involved)
Sodium Hydroxide plus Chlorine (2 stages)	CELDECOR-POMILIO Process	Chemical recovery is uneconomic and the process would be unsuitable for the UK.
Sodium Hydroxide	The H F Process	Commercial plant exists in Denmark producing unbleached pulp only. Twin screw digester of interest and is merely a soda process using special equipment.
Sodium Hydroxide plus Sodium Chlorite (Separate Stages)	SODA/CHLORITE Process	The use of a chlorine compound could make chemical recovery extremely difficult. A variation on the soda process followed by chlorine bleaching.

TABLE 3

Possible Pulping Processes for Straw (continued)

Main Cooking Chemicals	Process, Patent, etc.	Comments
Sodium Hydroxide	WARZECHA, STOLTING & SCHMINKE Patent	This uses a fluidised bed technique but does not appear to be commercially exploited.
Sodium Sulphite plus Sodium Hydroxide or Sodium Carbonate (Mixture)	MONO-or NEUTRAL SULPHITE Process	Chemical recovery doubtful unless some of the recent processes developed for wood can be applied to straw. Commercial plants exist (Palas Mill, Romania 25000 tonnes/annum-no recovery)
Ammonium Sulphite	1 NAVARRE Patent 2 KUWABATA Patent 3 Work of SATO and SHIMODA	The value of this treatment will largely depend upon whether there is a demand for the fertiliser by-products and/or the cost of chemical recovery
Nitric Acid	NITROCELL Process	Low effluent outflow claimed together with useful by-products. Special engineering required to cope with nitric acid
Sodium Hydroxide plus Oxygen (2 stages)	HOPES Process	The use of oxygen is very interesting although 'oxygen pulping' has not gained very much popularity despite the claims for it. Oxygen in combination with other alkalis has been investigated by many workers.
Ammonium Hydroxide	THILLAIMUTHU Patent (and others)	Ammonia has the attraction of simple recovery by steam stripping and could make a small pulping unit commercially viable. It is also worth further study in combination with oxygen.

The research work is yet to be completed, but ammonia oxygen seems promising as does the "Universal Pulping" concept. In the latter system the pulping process has been chosen on the requirements of a black liquor which instead of being recovered in the normal manner can be modified to be given added value, i.e. as partial starch replacement and sizing agents in low grade papers.

The Future

Although not touched on in this paper, it is an obvious requirement for the UK to increase her productive woods and forests. The target at the moment is to encourage an increased planting rate so that 25% of UK pulpwood consumption can be achieved by the year 2000.

In wastepaper the need is to increase the recovery rate and the industry is attempting to make sure that the collection of wastepaper by merchants and local authorities is increased. In addition, research is to be encouraged directed at increasing the availability and optimising the utilisation of existing and new raw material sources indigenous to the UK, including wastepaper.

The use of non fibrous raw materials particularly clay and precipitated calcium carbonate loading (noticeably cheaper than wood fibre and readily available in the UK) should be maximized. There are several potential processes which will enable their content to be increased and the techniques involved need to be more widely disseminated and adopted.

Whilst not minimizing the problems of productivity, water utilization, energy and transport costs, the overriding problems the UK is seeking to solve are those of raw material availability. The lesson for a developing country seeking to build up its paper industry is to concentrate on the raw material and to give first priority to the appropriate forestry, or other fibrous resources.

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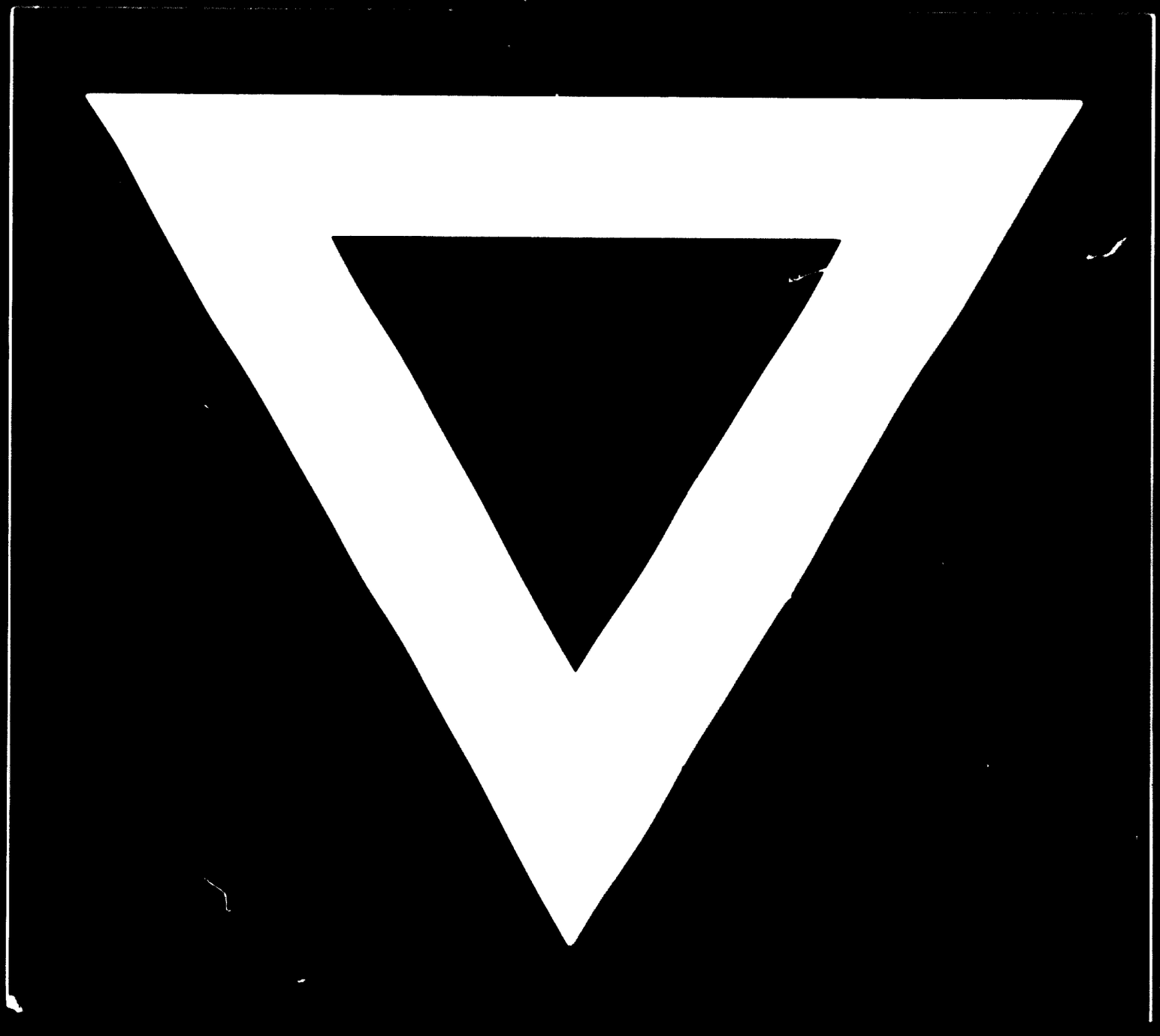

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