High Yield Pulping Especially of Hardwoods

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INCREASED DEMAND FOR PULP AND PAPER

Paper and paper board are very essential for both the cultural and economic development. Newsprint and other printing and writing papers are needed for information, for education and in business life; wrapping papers, paper board and corrugated board are essential for the distribution of consumer goods etc; speciality papers are required for a variety of industrial purposes. All over the world the need for paper increases. At present the total world consumption of pulp and paper increases approximately 5% annually **Fig. 1.** In India the approximate annual increase is now about 7 - 8%. The relative proportion of different papers is different in India, Europe and USA, with a higher proportion of cultural paper production in India **Table I.**

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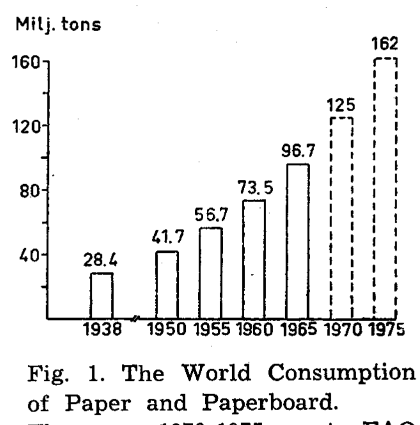

Fig. 1. The World Consumption of Paper and Paperboard.
The years 1970-1975 acc to FAO

Wood is of course by far the most predominant raw material for paper. A few decades ago almost only softwoods were used. However, there has been and is still going on a marked shift towards more use of hardwoods. In 1954,

Table I: Consumption of Different Papers—(1957) Percentages

	Newsprint	Printing Writing	other paper	paper board
India	20	41	16	23
West Europe	21	20	24	25
USA	20	16	23	41

in the USA the average content of long-fibred chemical pulp in the total amount of paper and board consumed was less than 44%. Also in India more hardwood pulps will be used **Table II.** The global supply of softwoods is limited, whereas hardwoods are relatively abundant. It has been estimated that during the 1980's all economically available softwood forests in the world (except USSR) will be exploited, assuming sustained yield. It is thus natural that in the future the additional pulp and paper production will be based mainly on hardwoods. In Japan, for instance, the projected increase in production will almost entirelv be based on imported hardwoods.

Table II: Estimated Pulp Consumption in South Asia
(FAO 1962)
Percentages

	1965	1975
Long fiber chemical pulp	44	29.5
Short fiber chemical pulp	11.5	18.5
Semichemical pulp	9	12.5
Groundwood pulp	22.5	24.5
Waste paper	13	15

In the 1940's and even 1950's hardwood chemical pulps were generally regarded as inferior to softwood chemical pulps for paper production. Traditionally the short fibres from hardwoods were loked upon as less useful for paper than the long fibres from softwoods. Through research and expeerience a re-evaluation has taken place. In Scandinavia, for example, birch sulphate pulp is now regarded as a very desirable constituent in many types of paper, especially printing and writing papers.

Moreover hardwood has turned out to be a very suitable raw material for high yield pulps, for semi-chemical pulps. It is interesting, especially with the aim of this symposium as a background, to study the development in different countries of the production of semichemical pulps, which generally are NSSC hardwood pulps.

The first country to start commercial semichemical pulping was USA. The first mill started in 1926, with a production of 12,000 tons in 1927. 40 years later, in 1967, the total annual US semichemical production was 3.3 mil. tons. **TABLE III** shows when some different countries started their production of semichemical pulps. This kind of pulp is thus rather "young", except in USA and Italy, less than 20 years old. It might of some interest to know the total pulp production in a country during the same year as semichemical production started. In order to make a better comparison for India I have excluded the USA, Sweden, Finland, and Japan. For the other eleven listed countries the total pulp production of all grades of pulp was as an average 470,000 tons/year. when semichemical production started. This is less than the current Indian pulp production, indicating that semichemical pulping ought to start here, which also is the case.

Table III: Production of Semichemical Pulps

Country	Production begins in year	Production 1967 1000 short tons
USA	1926	3273
Italy	1946	154
Finland	1951	225
France	1951	128
Japan	1953	426
Australia	1956	96
Brazil	1956	87
New Zealand	1956	7
Sweden	1957	180
Norway	1960	82
Argentina	1961	57
Denmark	1962	15
Yugoslavia	1962	34
Turkey	1963	3
Germany	1965	48
India	1969	—

NOMENCLATURE AND DEFINITIONS

In the literature the term "high yield" can be found to denote certain chemical pulps as well as semichemical. In principle wood fibres can be separated by two means,chemical pulping or mechanical pulping. Chemical pulping is a process where the lignin in the middlelamella between the fibers has been dissolved to such an extent that at least about 90 % of the fibers can be separated by a rather simple mechanical agitation, the rest being the screenings. This occurs at or below the so called "point of fiber liberation". Above this point, which for most wood species and pulping processes occurs at a yield of about 55 to 60 %, semichemical pulps are obtained. This means that a chemical treatment must be followed by fiberizing in a refiner or other elaborate equipment for mechanical fiberizing. This definition of semichemical pulps includes thus also high yield sulphite and high yield sulphate pulps.

In commercial chemical pulping it is inconvenient to carry out the pulping to a yield very close to the point of fiber liberation because variations in chip thickness or between cooks or within a cook will easily give high screenings. With conventional pulping equipment softwood pulp yields above 55 % for sulphite and above 50 % for kraft are therefore rare. There has, however, been a development towards higher yields, and the first stage is then to install refiners to take care of the increased amount of screenings. Such a process would still not be semichemical, but rather high yield chemical. At still higher yields, when the whole stock has to be passed through refiners, the process is semichemical. In my opinion, the term high yield chemical pulps can also include chemical pulps obtained in special processes giving an unusual high yield at the point of fiber liberation such as 2-stage sulphite, bisulphite and polysulphide pulping.

WHAT ARE THE INCENTIVES FOR HIGH YIELD PULPING?

A self-evident prerequisite is of course that there is a demand for high yield pulps or tha a demand can be developed. This demand very seldom comes from companies other than the manufacturing one itself. In other words, semichemical pulps are very seldom market pulps, but used in an integrated mill or within the company. Especially the international trade of semichemical pulps is insignificant. For instance the total import and export of semichemical pulp in the USA was in 1967 only 0.7% of the total domestic production of semichemical pulp.

High yield chemical pulps on the other hand can well be market pulps. A further prerequisite is naturally the economic demand for proper earnings.

An analysis of the reasons why pulp and paper companies in different countries and with different production types have taken up production of high yield or semichemical pulps wil show different incentives :

1) A **demand exists** for a pulp with such specifications that a semichemical pulp will best fulfil them. As an example, fluting paper in corrugated board as a packaging material can be mentioned. Stiffness is one of the most characteristic properties of this type of paper and this can best be achieved by using semichemical pulp as a raw material. Neither chemical pulps nor mechanical pulps are as suited for this as semichemical pulps. In other cases chemical pulps are unnecessarily high grade and expensive, whereas mechanical may not fulfil the quality requirements. The use of high yield pulps in newsprint is an example of this case.

2) A **high wood cost** is a strong incentive to find uses for high yield pulps where lower yield pulps generally are used. The high wood cost problem must, however, be solved by total economic optimization i.e. the total value of the different products made of the wood should be maximal. If, for instance, byproducts with high value could be made of the lignin and hemicelluloses dissolved in chemical pulping, this should be an important economic complement in making chemical pulps. However, so far no general solution to this problem has been found. In some cases such byproducts as vanillin, lignosulfonic acid salt as detergents, DMSO (dimethyl sulphoxide) etc., are produced, but it is no general solution since the world demand of those products are limited. The highest value of lignin can often be achieved by leaving it in the pulp, as in semichemical pulps. The problem is that the presence of the lignin in these pulps, together with secondary effects, diminishes the value of the cellulose in the pulp. As usual, the the problem is one of optimization of the whole system, including waste liquor treatment and pollution control.

The high cost can also have the effect that the industry switches to other less expensive species. The use of hard wood as raw material in pulping has sometimes been stimulated by its lower cost compared to softwood, at least in the first place.

3) A third incentive is **lack of wood.** That this situation will lead to an exploration of possibilities to go to higher yields is natural, provided that there is a demand for more pulp and paper, for which the high yield pulping can be used.

4) A problem in the developing countries is generally a very pronounced **lack of capital** for investment in factories, mills etc. The necessary capital is much less for a semichemical neutral sulphite pulp mill than for a sulphate mill of the same production capacity. This is especially evident for small mills, as demonstrated in **Fig. 2.**

The cost for the semichemical mills has been calculated both with and without recovery of che-

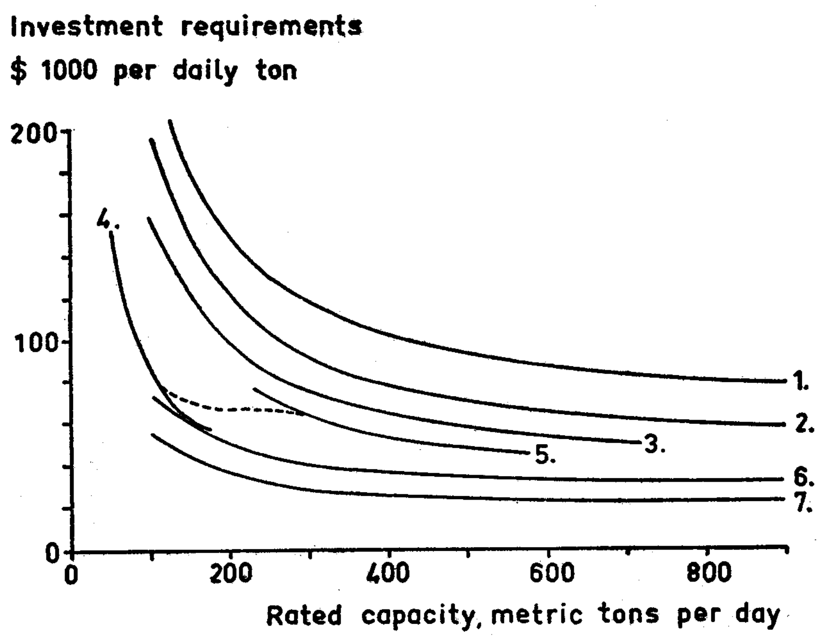

Fig.2. Investment Requirements for Pulp Mills as Function of Mill size (1967).

1. Bleached sulfate (pine), AD-pulp.
2. Unbleached „ „ „
3. Unbleached magnefite (spruce), slush pulp.
4. NSSC, without recovery (birch), „ „
5. NSSC, with „ „ „ „
6. Groundwood (spruce), 50 percent moisture.
7. Groundwood „ slush pulp.

micals. No chemical recovery generally implies water pollution problems. The cost of a recovery plant is a substantial part of the total cost of a mill. It is interesting to note, that where procurement of capital is a severe problem, a groundwood pulp mill for newsprint seem to be most interesting.

The importance of the four points mentioned can, of course, be quite different going from one case to another. There are also other positive factors not mentioned.

NEGATIVE FACTORS

Counteracting negative factors exist almost always, and unfortunately also in case of high yield pulping.

The most important one is the adverse effect on a number of quality properties, which a change towards higher yield brings with it. The strength properties, such as tensile strength (breaking length) burst strength, tear resistance and folding properties generally decrease when the yield is increased above a certain point which often occurs in the upper part of the chemical pulp yield range. Also the wet web strength generally decreases.

The importance of the strength properties has very often been overemphasized in the literature, and also in the trade of pulp. Not only the strength properties but also other pulp and paper properties have quite often been pushed too far by the competition on the market to levels above what is really needed in view of the demands on the end products. Nevertheless, the strength properties are important in many cases. Their real importance must, therefore, be carefully examined in each case.

Another property which has prevented the use of high yield and semichemical pulps for different types of paper is the brightness and brightness stablity. I am thinking of high yield sulphite and NSSC-pulps. Although they can be brightened with peroxide and hydrosulphite, the same brightness as that of fully bleached pulps cannot be achieved economically. Also the brightness reversion is usually very pronounced both under the influence of light and heat. Much effort has been made to make the lignin in semichemical pulps bright and stable bright, so far, without enough success.

The lignin in a semichemical pulp can of course be removed in a conventional three stage chlorine-alkaline extraction—hypochlorite bleach sequence. However, at the same time the major part of the increased yield is lost. Such a pulp can be bleached to high brightness, but to high cost of chemicals.

The cost of most systems for recovery of chemicals and for burning of the dissolved organic substance must be regarded as a disadvantage. Both the capital cost for equipment and running costs calculated per weight of processed substance are high because the concentrations of both organic and inorganic substance in the spent liquors are low, compared to the spent liquors from chemical pulping. Where there is a nearby-located sulphate mill of proper size relative to the semichemical mill, cross recovery of chemical will often be a convenient solution to the problem.

COMMON TYPES OF SEMICHEMICAL AND HIGH YIELD CHEMICAL PULPS

By far the most common type is hardwood neutral sulphite semichemical pulp for production of fluting paper for the inner layer in corrugated board, for boxes and other packaging materials. Another type which is produced in big quantities is (high yield) softwood kraft pulp used in the bottom layer of linerboard which goes together with the fluting paper in corrugated board. Also large quantities of high yield softwood sulphite pulp for newsprint are made. Some of the first mentioned semichemical hardwood neutral sulphite pulp is also used as part of the newsprint furnish. The same type of pulp after having been fully bleached is sometimes used in printing papers and also in greaseproof papers.

The US Statistics for 1963 give the uses and produced quantities of semichemical pulps listed in **TABLE IV.** High yield chemical pulps can be made both by modifications of the sulphite process and by a modified sulphate process. There are two different sulphite modifiifications. One way is two stage sulphite pulping with sodium base, at least in the first stage, with a pH in this stage of at least 8. This type of cook will give a pulp with increased content of hemicellulose and also higher yield at the point of fiber liberation. After bleaching, this pulp is used for printing papers but can also be used for greaseproof papers.

Table IV: Consumption of Semichemical Pulp in USA 1963

	1000 Short tons
Paper	
Coated Printing and Converting paper	31
Book Paper, Uncoated	49
Fine Paper	134
Special industrial paper	4
Board	
Container Board	1996
Bending Board	26
Nonbending Board	28
Hardboard and Insulating Board	245
Others ,Newsprint, Groundwood paper, Coarse paper, etc.)	158
Total	2681

The second type is bisulphite pulping at pH 4 which will give a strong unbleached pulp with higher than usual yield at the point of fiber liberation, well suited for newsprint. Both these sulphite cooking methods are. however, better suited for softwoods than hardwoods.

Kraft pulping with polysulphide gives a pulp with better yields than conventional kraft pulping using sulphide. This effect is more pronounced using softwoods than hard woods. The pulp can be used for the same paper types as conventional kraft pulp.

VIEWPOINTS ON RAW MATERIAL, PROCESSES AND PRODUCTS

The quality of the end products depends to a great extent on the properties of the wood as well as on the type of process and process variables. Also there is a dependence between the raw material and the processes.

The evaluation of a raw material or the optimization of process variables must be based on a consideration of the desired quality and the total cost of the end product as well as on the processability of the raw material from the start to the end product. The quality of the end product produced is of great importance. But, unfortunately, it is often very difficult to make a proper evaluation of the end product, for instance the quality of corrugated board. Various methods may very well classify different boards in different relative orders. But which one is the best one? And after all, will any one of them reflect the behaviour of the corrugated board in a box, or rather the behaviour of the box itself under different types of stresses under different conditions? In most cases intermediate products and end products are evaluated using standard test methods, the real significance of which can be questioned. Evaluation according to standard methods may thus involve an uncertainty, which sometimes may classify a material incorrectly. I want to stress this, as it might be of importance to remember it in certain cases. However, it must be pointed out at the same time, that many test methods have been worked out based on long experience and careful evaluation. The results obtained using these test methods must therefore generally be regarded relevant and basically correct.

Raw Materials

The physical properties of the individual fibers differ very much between wood species. These properties. such as the fiber length, the fiber width. and the width of the lumen have a most significant influence on the paper properties. The individual fiber strength, the fiber flexibility and the ability to form fiber to fiber bonds are all factors depending on fiber dimensions and fiber structures which constitute the strength properties of the paper or board.

Such strength properties are generally of more importance for papers than boards. For boards other quality factors such as bending properties and stiffness are usually more important.

The hardwood fibers are all very short compared to softwood fibers. The importance of fiber length has often been overemphasized, especially in connection with tensile and burst strength. However, for obtaining good tear resistance a longer fiber length seems to be necessary. The rather low tear strength of paper made from harwood with an average fiber length of about 1 mm. is probably mainly due to the short fiber length. Generally speaking, however, the fiber wall thickness relative to the fiber diameter is the most important fiber property relative to paper properties such as strength, bulk and opacity. The fiber wall thickness will influence the fiber stiffness and the ability of the fiber to collapse to a ribbon after beating and drying giving good fiber conformability. Collapsed fibers will tend to give a paper with more transparency, lower bulk, higher tensile, and lower tear strength. However, most hardwood fibers do not collapse. They will, therefore, tend to give a bulky, opaque paper with low tensile strength. Further, short fibers improve the sheet formation giving a more homogenous sheet. Also the surface smoothness is improved.

The bending properties of board are generally better the less the content of short fibers, at least in the surface of the board. On the other hand hardwood fibers contribute to the stiffness of the board. There is, however, a wide difference between different hardwoods in this respect.

The physical properties of the wood have also a bearing on the pulping process. Firstly, there is the matter of penetrability of the cooking liquor. The porous system differs between species. Especially, it should be investigated among hardwoods, if a given species can form tyloses. The tyloses can give serious penetration problems. Secondly, there is the question of how much void volume there is in the wood, which can be filled with cooking liquor. The higher the specific gravity of the wood (measured on dry wood), the less amount of liquor can penetrate per volume of wood. At the same time, unfortunately, the larger amount of total dry substance and lignin need more cooking chemicals per volume of wood. Thus the higher the specific gravity, the more cartfully the cook has to be carried out. Especially vapour phase cooking can be difficult to carry out on high specific species.

Processes

Any pulping process can give a semichemical pulp. It is only necessary to interrupt the pulping at a proper yield level and continued with mechanical defiberation.

There are, however, a number of factors which will influence the choice of pulping method. The most important are the type of raw material available and the characteristics of the pulp desired. But the problem is not only technical. The overall economy of the project will ultimately decide what process should be used. It is impossible to go into all details here. A few remarks wil, however, be made.

Semichemical Pulping Process

The totally dominating semichemical pulping process for hardwoods is the neutral sulphite pulping (NSSC) using sodium sulphite. commonly buffered with sodium carbonate. In the middle of the 1920's it was realized, mainly through work at the Forest Products Laboratory at Madison, Wis.. USA, that the neutral sulphite pulping was especially well suited for hardwoods because of the lower lignin content and probably also because the hardwood lignin is more concentrated to the middle lamella. Softwoods are more resistant to this type of pulping. The hardwood pulp yield is generally between 65 and 85 %. The pulps contain 10 - 15 % lignin. Because of the neutral cooking conditions, a large quantity of the hemicelluloses is not dissolved, but kept in the pulp. The neutral sulphite semichemical process yields hardwood pulps which frequently are stronger than chemical pulp from the same wood. They are always stronger than acid sulphite semichemical pulps. Above about 65 % yield the neutral sulphite chemical process can give pulps which are stronger than after sulphate semichemical pulping. Several kraft semichemical pulps mills have therefore changed over to neutral sulphite pulping in cases where hardwoods were the raw material.

The lignin dissolution is slower during a neutral sulphite cook than in both more acidic cooks, such as bisulphite or bisulphite-sulphite, and in more alkaline cooks. The hemicellulose removal is, however, relatively still more slow. Thus the NSSC-hardwood pulps are relatively rich in hemicelluloses. As a consequence they are relatively easily beaten, compared to semichemical sulphate pulps. After fully bleaching they are also easily beaten to high grade greaseproof papers.

Neutral sulphite cooks can well be made also without the buffering carbonate addition, or, the composition of the cooking acid can correspond to a mixture of sulphite and bisulphite. This will result in brighter pulps, shorter cooking time or lower cooking temperature, and lower consumption of chemicals. Even pure bisulphite semichemical pulping of hardwoods can be made. The stiffness, CMT-value, is in this case usually lower than after NSSC-pulping. A considerable advantage in bisulphite pulping is, however, the possibility to use magnesium base. This will make recovery of chemicals rather simple and solve the water pollution problems. Also ammonium base can be used. This will, however, give a somewhat darker pulp.

NSSC hardwood pulps are to a limited amount used as part of the furnish for newsprint. It is sometimes necessary to bleach this kind of pulp with peroxides or hydrosulphite in order to brighten the pulp without any substantial loss of substance.

Another type of NSSC hardwood pulp is fully bleached removing the lignin. These high bright pulps are very well suited for making high grade printing or writing paper as well as glassine paper.

Sulphate Pulping

The sulphate semichemical process is nowadays mostly used for softwoods. The pulp goes into the bottom layer of linerboard with a top layer of chemical kraft pulp. Semichemical sulphate pulps are rather dark coloured and also rather difficult to beat.

The point of fiber liberation occurs rather distinctly in sulphate pulping of hardwoods, at least Swedish birch. Above about 53 % pulp yield the amount of screenings increases very quickly. However, it has been found at the Central Laboratory of the Swedish Cellulose Industry (CCL), that birch high yield sulphate pulps up to about 57 % yield have after refining the same strength properties as chemical birch sulphate pulps with yields of about 51 - 52 %. Moreover, these high yield pulps were easily refined.

Rydholm mentions in his book "Pulping Processes" that for linerboard, hardwoods can be used only to a limited extent about 25% and hardwood kraft is then preferred to neutral sulphite because of the higher burst strength.

A modification of the usual sulphate cooking process can give an increased yield both of chemical, high yield chemical and semichemical pulps.

Using polysulphides instead of sulphide in sulphate pulping can on softwood give a yield increase of 6 - 12% calculated on the wood and compared at the same Kappa-number. The situation is similar when hardwoods are used. In this case the increase is somewhat lower. This big increase depends mainly on a retention of hemicelluloses, glucomannan and/or xylan.

Sulphite Pulping

Ordinary acid sulphite cooking acid with calcium-base as well as other bases such as sodium, magnesium, and ammonium can be used in semichemical pulping. Compared to sulphate cooking, where installations for recovery of chemical are necessary from an economical as well as pollution point of view, the sulphite cooking is cheap, especially with calcium base. Where recovery of chemicals is necessary in order to avoid water pollution, magnesium base will offer a rather simple and low cost solution.

There is a substantial amount of high yield acid sulphite pulp produced commercially, mainly for part of the furnish for newspaper. Unfortunately, however, this seem to be of limited interest in connection with this meeting, since softwood is used almost exclusively. Many, but not all, hardwoods can be pulped, but as hardwood semichemical pulps have better properties after neutral sulphite pulping than acid sulphite cooking the former method is preferred.

As mentioned before there are some modifications of the sulphite process which wil give higher yield than the common acid sulphite process.

Two-stage sulphite pulping with the first stage in the pH-range of 8-10 and the second stage acid as in ordinary acid sulphite pulping will give pulp yields 6-8 % higher (calculated on the wood) than ordinary sulphite pulping. The comparison is made at equal Kappa-number. Also in the high yield range the process will give substantially higher yields. However, this big increase occurs only with softwoods. Hardwoods will give much less, about 2-3% increase. For this reason, this process is of minor importance for hardwoods, especially as the sulphate process will give about the same yield. Furthermore, since sodium base must be used in the first stage, and preferably ought to be used also in the second, the base should be recovered, which means a rather complicated and expensive system.

Bisulphite pulping at pH 4 gives on softwood a higher yield at the point of fiber liberation than common acid sulphite pulping, about 63 % yield instead of about 57 %. The same increase will not occur with hardwoods, where the point of fiber liberation also is lower.

Products

Already comments have been made regarding paper and board products and their quality. Further to this I would like to add the following and I am now partly quoting Professor Steenberg from a paper entitled 'Short fibered pulp in papermaking" which he presenttd in a UNESCO/FAO Symposium in Beirut 1962.

Paper can be divided into two main groups, namely paper for cultural use and paper for packaging use. The remainder is used for household purposes like sanitary tissues and for industrial purposes like electric insulation papers.

Cultural papers are made from bright pulps. The required brightness is sometimes obtained without resorting to bleaching as in the case of the ground wood pulp from coniferous species, of sulphite pulps, or neutral sulphite semichemical hardwood pulps. Frequently the pulps are bleached however either by use of chlorine compounds or peroxide.

Short fiber pulps are obviously of considerable use in this case, especially since high strength is not important and short fiber pulps are inferior in strength. An advantage of short fiber pulps in cultural paper is the ability of these fibers to give a uniform distribution in the pulp suspension when forming the sheet on the wire. Good and uniform sheet formation is of utmost importance for the printing properties of a paper.

The limiting factor in the use of short fibred stock for printing papers has frequently been the low strength of the wet network forming a moist sheet in the wet end of the paper machine. Recent advances in paper making have made these advantages, can be realised only with first class machinery of latest design. It is under these conditions possible to produce a number of printing paper grades from short fiber pulps entirely, or as a part of the furnish.

One of the most important properties of printing papers is opacity. Generally speaking, short fiber pulps contribute more to this property than long fiber pulps. For printing papers it is very important to know the development of opacity as well as strength with beating. This is especially important with pulp from short fiber sources and especially those used by unconventional pulping processes.

Quantitively the largest amount of cultural papers are used for newspaper and magazines Such papers are made of groundwood from coniferous species as the main ingredient. There is no material known which will give higher capacity than groundwood. Further the printing properties of groundwood sheets are superior in letter press printing. For other printing papers a large amount of, for instance, short fiber bleached pulps can be and will be used. Some grades are made only from short fibered pulps.

Writing paper requires some special properties of paper, for example, good erasing properties, folding endurance etc., which may be difficult to obtain without a considerable amount of long fibered pulp. The use of surface sizing with different products has increased the possibility to use a larger proportion of short fibered pulp also in papers of this type.

Packaging papers on the other hand can be divided into flexible and rigid paper. The flexible ones include wrapping papers, bags, and sacks, and the rigid ones include paper boards of various types for boxes.

Flexible paper packaging requires increasingly higher standards of strength of the papers. Practically all these papers have to show high tear resistance. This can be achieved only by long fibered pulps, and especially long fibered pulps made up of fibers all with thick cell walls. Thus the smaller the package the less important this property becomes in grocery bags of small type it is possible to use at least partly short fibered pulps, and glassine wrappers for sugar lumps etc. can be made from only short fibered raw material.

In the field of rigid paper packaging, the picture is again different. Smal size paper packages normally do not meet large transport hazards. The main strength property to consider for such boxes is rigidity. The main property, stiffness, is determined by the thickness of the paper and the modulus of elasticity, that of the surface layers being most important. In order to use as low a quantity of material as possible in building up the wall, the material should have high bulk.

The best results are obtained when the surface layer is made of strong pulps and the interior of the board is made of bulky fibers which do not have a high bonding power. The core of many paper boards is made up of waste paper but groundwood pulp is also widely used. Short fiber high yield pulps can also be used for this purpose. Because most boards have to have high bending resistance for boxmaking it is necessary to have strong and extensible pulps in the surface layer. This normally requires long fiber pulps, although short fiber pulps can be used to some extent. Short fiber pulps enter this field in important percentages only if the composite board has a basis weight above around 200 g/m^2.

For larger size paper boxes transport hazards are important and at least the surface layers must contain long fiber pulp with excellent mechanical properties. The large boxes are most often made of corrugating board. Such boxes are made up of two liner boards glued to a fluting paper.

Fluting paper must have high stiffness, other strength properties being of little importance. Semichemical neutral sulphite papers from short fibered raw materials seem to be extremely useful as fluting paper.

The outer layer liner is often of higher quality than the inner liner, which is protected from rubbing, rain etc. Mostly this layer is built up of softwood fibres but 20-30% of high quality NSSC hardwood pulp might be mixed in. In low quality liners short fiber pulps might be a greater part of the furnish.

When boxes are used for export goods, it should be remembered, that international trade rtquires international standards.

Export packages have to be able to stand up to the transport hazards in other countries, or the products will be damaged and the goodwill will be lost. Also in many cases for a locally used printing paper, printing presses and printing inks of common type have to be used, which require national standards of the paper quality.

As a conclusion I want to emphasize that the high stiffness, which is an inherent property of most tropical hardwoods, is a strong negative factor, when these hardwoods shall be used for different types of paper. The stiffness is a draw back, which must be overcome. The lower yield in pulping the less stiff will the fibers be. Mechanical treatment, beating, will also lower the stiffness. For semichemical pulps this seem to be the only available method. By research and experience perhaps methods will be found which can make the stiff tropical hardwood fibers more apt for paper-making.

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what he has destroyed. This will be expensive and will require individual, communal, national

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amount of sugars, resins, etc. The treatments for utilization have general similarity.

TREE AND PLANT UTILIZATION

The larger softwood or conifer trees (pine, fir, spruce, hemlock,

fully destroyed by burning.

In warmer climates, bagasse from sugar cane is also being utilized for pulp production instead of fuel. Straw, grasses and canes are being employed for fibre con-