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MANUFACTURE OF DISSOLVING PULPS FROM EXOTIC RAW MATERIALS 1/

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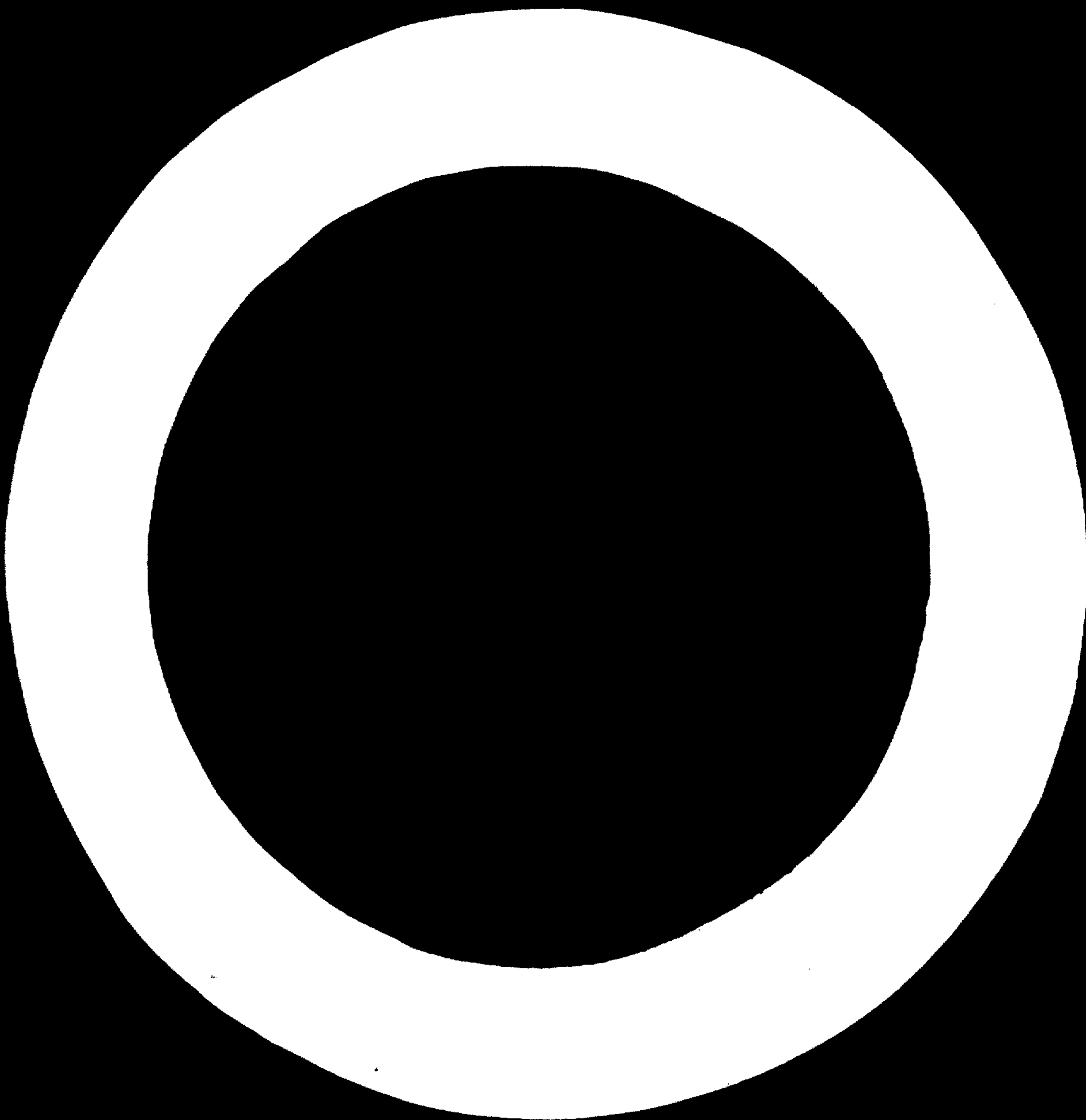

The degree of chemical purity and the chemical reactivity during the production process are the most important properties of dissolving pulps.

The content of pure cellulose, the so called alpha-cellulose, is the determining factor of the chemical purity of the pulp. The degree of chemical purity is also, beside the pure cellulose, determined by the content of the mineral components /ash/, resins and other materials, as for instance low-molecular carbohydrates /hemicelluloses/, contained in the pulp. Aside the above factors, much properties of the pulp as viscosity, brightness and dirt content are of a great importance.

<u>Alphacellulose</u>

The alpha-cellulose content is one of the most important factors of the dissolving pulps quality. Between the alpha-cellulose content and the suitability of the pulp to the processing in viscose rayon exists a close correlation. The alpha-cellulose content in pulps for rayon staple fibres should amount at least to 88%. The refining of pulps /in most cases by extraction with hot alkalies of a part of hemicelluloses/ makes it possible to obtain an alpha-cellulose content above 90%, but it is connected with high losses of pulp yield /about 3% on each 1% of alpha-cellulose content increase above 90%/.

<u>Hemicelluloses</u>

The presence of greater quantities of hemicelluloses in the rayon pulp is undesired, as the low-molecular carbohydrates cause an increase of heterogenity of the processed material and influence in a lesser or greater degree the strength properties of viscose fibers.

Lignin

The presence of lignin in rayon pulps causes the lowering of their reactivity, a decrease of depolymerization during the alkali cellulose ageing. The lignin content in bleached pulps is generally not determined, as the content usually amounts to the fraction of a percent and does not exceed much the limits of an analytical error /the real lignin content in rayon pulps should not exceed 0,2 - 0,3%/.

Mineral components - ash

The mineral components, originating from the starting material as well as from chemicals and process water, are chiefly present in pulps as salts and oxides. These components are not taking a direct part in the reactions connected with rayon fibres manufacturing and their presence can cause a certain number of disturbances and difficulties to the equipment. Especially undesired in rayon pulps is the presence of iron, manganese as well as calcium and silicon compounds.

Iron and manganese exert a catalytic action on the process of the ageing of alkali cellulose, thus making it difficult to standardize this process. Moreover, they can produce coloured /in most cases brown/ compounds, adversely influencing the purity and colour of rayon fibres.

The presence of calcium and silico compounds causes a decrease of viscose filterability indices. The general requirements for rayon pulps stipulate that a mineral component /ash/should not exceed 0,2% and iron content - 20 mg/kg.

Resins and fats

The resinous and fatty components, determined by means of extraction with organic solvents /ether, dichloroethene, alcohol-bensene/ are considered as undesirable in rayon pulps, as they are the cause of viscose turbidity. They also raise difficulties during the filtration process and impart to viscose rayon a yellowish colouring, difficult to remove. The general requirements for rayon pulps allow a resins and fats content not exceeding the value of 0,4% of ether extract.

Brightness

A low grade of pulp brightness is undesired not only because in such a case the obtained fibres are greyish and do not show after dyeing clean and vivid colours. The low brightness gives also evidence of the presence of an excessive amount of incrusting matters /lignin, coloured mineral and organic compounds/ as well as of an insufficient cooking degree. The brightness of rayon pulps amounts generally to about 90%.

Moisture content

The moisture content of pulps is an important, although very often underestimated, technological index. Beside of the indices of the absolute moisture content and moisture uniformity in a whole lot of pulp, the method of pulp drying is also of essential importance. In cases of drastic drying conditions, especially on cylinders of the pulp machine, an irreversible "skinning" of fibres on the web surface occurs, causing an increase of pulp heteregeneity, due to a different reactivity of the fibres on the surface of the sheet and in the middle layers. A non-uniformity of the pulp moisture can also be the cause of non-homogeneous reactivity of the pulp, especially during the mercerisation process.

Reactivity and filterability

The reactivity is a feature depending upon the structure, composition and chemical, physical as well as physico-chemical properties of the pulp. It characterizes the pulp behaviour during defined reactions or even during the separate stage of a reaction. In the pulp industry the concept of pulp reactivity imply first of all the ability to produce uniform, good filtering viscose solutions. It is the reason why the reactivity is in most cases expressed by a definition of filterability indices /velocity, filter clogging constant, amount of viscose filtration residue obtained in standardized conditions / /1/.

2. Potential sources of fibrous raw materials for manufacture of dissolving pulps in developing countries

The use of non-woody fibrous raw materials for pulp production has a great economical importance in the developing countries.

The non-woody fibres constitute at the present moment about 5% of the total world fibrous raw material resources. From this amount 5 million tons annually of fibrous pulps are produced. It is expected that this quantity will rise to about 10 million tons in the year 1975./2/

From the theoretical point of view any plant can be used as raw material for pulp production. Nevertheless the costs of pulp manufacture must be taken into consideration.

The following conditions must be fulfilled if a plant is to be used for pulp production in a technical scale:

- the raw material should be processed entirely, as a sorting by hand or by mechanical means is not feasible in the conditions of industrial production, and the level of its average cellulose content should make the pulping economically advantageous;

- the source of raw material should be in a short distance from the pulp mill or good transport conveniences should connect the area of the raw material growth with the mill, in order to keep the delivery costs as low as possible.

These conditions exclude a great majority of plants as a possible raw material. Only a few species remain, principally the gramineae /grasses/ and soitamineae /reeds, papirus/. They are characterized by a good cellulose yield as well as by a simultaneous grow-th in masses.

In the world scale the most important potential source of non-woody fibrous raw material is the bagasse. This was repeatedly stressed during international conferences. The production of bagasse pulps increased from 100 000 tons in the year 1950 to over 500 000 tons in the year 1967 and will reach presumably about 1 000 000 tons in the year 1975.

Other non-woody fibres used principally are straw, bamboo and reed. Such raw materials as esparto, sabai grass, cotton linters have only, in consideration of their resticted quantities, a secondary importance.

3. Morphological and chemical properties of exotic non-woody fibrous raw materials

Bagasse

The name of bagasse is given to the stems of sugar cane /Saccharum officinatum/ left over after the sugar juice has been pressed. Bagasee is thus a secondary raw material.

In consideration of large widespreading of sugar cane in Asia, America, Africa and Oceania, its great quantitative resources and suitability for pulp production as well as a totally mastered pulping technology, bagasse is the most important potential source of raw material for the pulp and paper industry in the developing countries.

The quantities of bagasse are tightly connected with the quantity of processed sugar cane. It can be admitted that generally for 1 ton of produced sugar 1.2 - 1.3 tons of bagasse are obtained. The worlds resources of bagasse in the years 1960-1970 were estimated to be about 40 000 000 tons of bone dry material annually.

Bagasse released fr^m the sugar factory has a moisture content of about 50%. Its residue of saccharose amounts to 2,0 - 2,5 %, the content of others water-soluble components - to 2,0 - 2,5 %.

Expressed in dry substances the average typical bagasse composition is as follows:

useful fibres	60%
pith	25%
fines and dirt	5%
water-soluble subetances	10%
	100 %

The size of bagasse fibres is not only dependent on the specie and place of growth of the sugar cane, but also on the method of crushing, applied in the sugar factory, as the processing of the cane influences the degree of fibres demage. The average length of bagasse fibres amounts to about 1,5 - 2,0 mm, the dia-meter about 140 microns.

The chemical composition of bagasse is dependent on the specie of sugar cane, on climatical conditions and kind of soil as well as on the period of growth. The typical results of a chemical analysis of separate bagasse parts, after the removal of water-soluble substances, are as follows:

	fibres	pith
content of alpha-cellulose	38 %	34 %
" " pentosans	32 %	32 %
" " lignin	19 %	19 %
" " ash	2 %	5 %

This results show in general a marked similarity of the chemical compositions of the fibrous fraction and the pith, but a higher alpha-cellulose and lower ash content in the fibres can be observed. The content of pentosans is in both fractions high, it is two to four times higher than in softwood. The chemical composition of bagasse stresses its good suitability to pulping.

Bamboo

Bamboo belongs to grasses /Gramineae/. Depending on its kind and growth conditions the bamboo stems can be from one up to 40 m high and of 2 to 30 cm in diameter. The stems are divided every 30 to 50 cm by knots, which constitue 6 to 15% of the total mass. The plant attains the full maturity in 5 to 7 years, but the bamboo exploitation takes place in most cases in 3 - 4 years cycles /3/.

Bamboo growth, in natural stands and plantations, principally in tropical and subtropical regions. Its world resources are estimated to several hundred million tons.

The most important quantities of bamboo are found in India, Pakistan, Burma, on the Philippine Islands, Sumatra and Java, in smaller but still important quantities it is found in China, Japan, Cambodia, Laos, Vietnam, Australia, in some countries of America /principally in Mexico, Argentina and Brazil/ and Africa /Ethiopia, Congo, Kenya/.

It exists about 50 various bamboo species and above 1000 kinds showing marked dissimilarities as regards the size of the plant, its structure, the size of fibres and chemical composition. From the fibrous pulps industry point of view the most important are the species Dendrocalamus strictus /growing in India, Africa and North America/, Bambusa arundinacea /India, Australia, Siam/, Bambusa vulgaris /India, North America, Africa/, Helocanna bambusoides /Pakistan/, Gigantochloa aspera /Philippine Islands/.

The bamboo fibres, which constitue about two third of the mass of its stems in dry condition, are resembling, as regards their size, the softwood fibres. Their length amounts to 1 - 5 mm /on an average about 2,8 mm/, the width to 14 -27 microns /on an average about 20 microns/. The length of vessels is 0,3 - 1,3 mm /on an average 0,8 mm/ and their width 13 - 214 microns /on an average about 110 microns/, the average length of the parenchyma cell is 1 mm and its width 18 microns. Hence the average length of all the bamboo cells is about 2,0 mm and the width about 20 microns. The thickness of cell walls in the majority of used bamboo species amounts to about 7 microns and the lumen diameter to 4 - 7 microns.

The chemical composition of the most representative bamboo species is contained in following ranges of average values:

Cross and Bevan cellulose 57 - 63%, alpha-cellulose 36-41%, lignin 22 - 26%, pentosans 16 - 21%, ash 1,5 - 3,0% /of which 0,5 - 2,0% silica/, alcohol-benzene extract 1,0 - 2,0% /4/. In this chemical composition it attracts notice first of all a high content of hemicellulose easily soluble in dilluted alkalies and an important content of silica.

Rice straw

Rice is the second of importance, after wheat, cereal in the world. It is cultivated in all warm regions of the earth, especially in the developing countries / India, Indonesia, UAR, Madagas-car/. The world production of rice amounts to about 250 million tons/year, and the quantity of rice straw is estimeted to be about 750 million tons /calculating 3 tons of straw for 1 ton of rice/. However, considering the needs of agriculture, the lack of roads and great distances between the farms and the pulp mills as well as to great losses during the harvesting and storage, only 5 to 10% of the theoretically available rice straw can be used for industriel purposes /5/.

The rice straw contains a great portion of contraries such as empty spikes and leaves /about 50%/, knots /about 12%/, remainder of grains /about 0,5%/ as well as fines /about 5,5%/, so that the proper stems represent scarcely 42% by weight /6/. The avera-ge length of bast fibres, characterized by thick walls and principally found in the middle layer of the stem, amounts to about 1,2 mm, their diameter - to 7 - 9 microns. Owing to a large number of parenchyma cells the fibrous pulps obtained from this raw material are characterized by low drainage.

Depending on the region of growth, the rice straw contains 42 to 46% cellulose /25 to 36% alpha-cellulose/, 20 to 28% pentosans, 12 to 14% lignin, 16 to 20% ash /of which 10 to 16% is silica/. The water extract amounts to 14 - 18%, the alcohol-benzene extract to 4 - 6%. /7/

In comparison with chemical composition of other cereal straws, the rice straw has a lower content of cellulose, lignin and pentosans and a higher ash content. This high ash content creates difficulties in the recovery of chemicals.

<u>Reed</u>

Reed is largery widespread in regions of various climatic conditions, but a statement of its total available world amount is lacking. As yet, especially in Rumania, USSR, Chinese People Republic and Korea People Republic the common reed /Phragmites communis/ has found the largest application in papermaking. Great quantities of this reed are growing in the Middle East /it grows on about 100 000 ha in Iraq/, in Africa and South America. The annual growth of reed in Rumania /in the Danube delta/ amounts to 4,7 tons/ha.

The fibres of common reed show a morphological structure similar to the structure of cereal straw fibres. Their length amounts to 0,7 - 3,4 mm /on the average 2 mm/, width - to 8 - 34 microns / on the average 20 microns/.

The chemical composition of the reed is the following: Kürschner cellulose - 49%, alpha-cellulose - 40%, hemicelluloses - 31%, lignin - 21%, ash - 5%.

Several other species of reed, viz.Pragmites Karka /common name Nal/, Eviantus ravenae /Ekra/, Ochlandra travancorica/ Eeta/, as yet not used in a commercial scale, were investigated as to their possibility of application in papermaking. The results have shown their good suitability (8, 9).

Esparto grass

Esparto grass /Lygeum spartum and Stipa tennacissima/, called also alpha grass, grows wild on large areas in North Africa and South Spain. It is found as well in smaller quantities in Mexico. The available resources of this raw material are estimated to about 500 000 tons/year.

The fibres of African esparto grass are characterized by a length from min. 0,4 to max. 1.8 mm /on an average 1.1 mm/ and a diameter of 7 to 14 microns /on an average 8 microns/(10).

The chemical composition of the African esparto grass is the following:

cellulose	50 - 54% /of which 33 - 38% alpha-cellulose/
pentosans	27 - 32%
lignin	17 - 19%
ash	6 - 8 %

The esparto grass is a valuable cellulosic raw material. Esparto pulps are especially suitable for the manufacture of fine printing papers.

A low yield from the esparto fields and the necessity of hand harvesting have an adverse effect on the costs of esparto grass and are restricting its use in the pulp and paper industry.

Sabai grass

Sabai grass /Eulapiopsis binata/ is growing at the foot of The Himalayas. It has the second place of importance as fibrous raw material for the paper industry in India.

The fibre dimensions of Sabai grass are similar to those of bamboo / length on an average 2,1 mm, diameter on an average 9 microns/.

The chemical composition of Sabai grass fibres is as follows /11/:

Cross and Bevan cellulose	54,5%
pentosans	23 - 24 %
lignin	20 - 22 %
ash	6 - 7 %
alcohol benzene extract	4,1 - 4,6 %

The very high ash content makes this raw material unsuitable for the manufacture of viscose pulps.

4. Survey of information about the results of investigations on the use of non-woody raw materials for the manufacture of dissolving pulps

The survey presented in preceding chapters, concerning the region of growth of exotic plants potentially suitable as raw material for dissolving pulps, or morphological properties and chemical composition of these plants has shown that only several of them can be taken into consideration for processing in a commercial scale, viz. bamboo, bagasse and reed.

It must however be clearly stated that the use of these plants for dissolving pulps production is associated with a number of difficulties, resulting from the necessity of complicated handling of the raw material, problems connected with the pulping process control, obtaining of lower pulp yields and from higher costs of production in comparison with pulping of wood.

According to the available informations viscose pulps from non-woody raw materials are produced on a commercial scale in two plants only: at Gwalior /India/ and at Braila /Rumania/. The plant at Gwalior uses bamboo as raw material, in the plant at Braila reed is used for pulping.

Bamboo

For the pulping of bamboo the kraft process is applied in most cases. As yet only in the mill Gwalior Rayons, where for viscose pulp production bamboo from Kozhikode /India, State of Kerala/, sulphate process is used, the prehydrolysis of raw material is applied.

The process of production runs as follow: the chips are prehydrolyzed with sulphuric acid acidified water /H_2SO_4 consumption amounts to 0,5% in proportion to oven dry chips/ at a temperature of 170°C during 3 to 4 hours; after removal of hydrolyzate the chips are washed with hot water and cooked with sulphate liquor at a temperature of 166 - 168°C for about 4 hours. The quantity of added alkalies corresponds to 20% Na_2O based on chips, the sulphidity of liquor amounts to 20%. The pulp is bleached in seven stages. For 1 ton of oven dry pulp 65 kg chlorine, 78 kg NaOH, 4 kg ClO_2 and 3 kg SO_2 is used. The yield of oven dry end product amount to 28% /12/.

The production in The Gwalior Rayons Silk Mfg.Co.Ltd. plant started in the year 1963. The production capacity of the plant is 54.000 tons of pulp yearly. According to the later obtained data this production is somewhat higher and amounts to 58.000 tons /13/.

The possibility of obtaining viscose pulps suitable for viscose rayon manufacture is also shown by the results of a certain number of laboratory investigations.

By pulping the bamboo Dentrocalamus strictus using kraft method with prehydrolysis Karnik obtained pulps showing after bleaching a yield of 26% based on the starting material. The alpha-cellulose content of these pulps amounted to about 90%, pentosans content to 3,5%, ash content was below 0,1% and brightness 84%. /14/.

Results of investigations carried out in Northern Regional Research Laboratory at Peoria, USA /15/ have shown the suitability of bamboo as raw material for high quality dissolving pulps production. When kraft pulping with prehydrolysis by means of HNO_3 /6% solution/ was used, pulps containing 94 - 96% alpha-cellulose, 3 - 5% pentosans, 0.15% ash and showing 85 - 88% brightness were obtained. A comparison of experimentally obtained pulps with pulps produced on an industrial scale has proved that the bamboo pulps correspond to industrial conditions set for viscose pulps or even show higher properties.

<u>Technology of pulp production from bamboo</u>

Owing to the hot and damp atmosphere in which the bamboo is delivered to the plants this raw material is very susceptible to the action of fungi and insects. This circumstance causes direct and indirect losses /lowering of pulp yield/, estimated to 2-5%.

These losses can be markedly reduced by spraying the bamboo with insecticides and fungicides. Good results were also obtained by constant sprying the stored bamboo with water. When the bamboo is stored in water its stemps show a marked resistance to noxious insects and fungi. The optimum moisture content from the point of view of losses during shredding and screening of chips should amount to 25 - 34%. Generally a mixture of green bamboo /moisture content about 45%/ and air dry bamboo /moisture content about 10%/ is used for pulping. The resultant moisture of the mixture amounts in most cases to about 20%.

For the shredding of bamboo Voith, Wigger, KMW and Carthage conventional chippers with 3 to 10 knives and an output of 1 to 4,5 tons/hour are used. Owing to considerable content of silica on the outer surface /skin/ of the bamboo stem, the chipper knives are getting dull rapidly and one set of knives is sufficient for chipping 1000 - 2000 tons of this raw material only. Screening of chips and the secondary shredding of the coarse reject are performed in the majority of mills at the same manner, as in the case of chip cutting from wood. The losses during chip preparation amount on an average to 4 - 5%.

In the majority of plants producing pulp from bamboo the pulping, washing and screening of pulps is conducted in the same manner as in plants producing pulps from wood.

For the preliminary pulp screening Jonsson flat vibrating screens with hole diameters od 4 - 8 mm are used. Several plants use also Dunbar screens. For fine screening centrifugal screens /Biffar, Trimbey, Cowan screens/ or pressure screens /Selectifier/ are used. In more modern plants the pulp is additionnally screened in Jonsson-Lindgren screens with rotating and vibrating drums and afterwards cleaned in centricleaners /12/.

The washing of pulp is carried out in counter-current on multistage wash filters Dorr Oliver, Imperial, Kamyr, Voith or Impco. The dillution coefficient of the pulp washed on vacuum filter vary between 3 - 3,5 to 6 - 8.

The black liquor of a dry substance concentration of 15 to 16% are evaporated to 60 - 62% of dry substance on a multiple effect evaporator /generally 5 to 6 stages/. A high silica content in the black liquor /on an average 3,3% based on the total dry substance in the liquor/ causes an increased incrustation, compeling to a frequent mechanical cleaning of the pipes /every 4 - 6 weeks/.

From various types of recovery boilers as most suitable for Indian conditiona the JMW boiler is estimated in consideration of the long periods of uninterrupted work and good performance. In the recovery boilers the high silica content in the liquor and its low calorific value /1340 - 1410 kcal/kg/ cause also numerous exploitation difficulties, which can be overcome by adequate alterations of the boiler.

In most plants the green liquor caustization is carried out in a continuos manner in a Dorr-Oliver installation, which proved itself to be suitable. The use for the caustisation of lime with a low silica content, if possible below 2%, is of a great importance.

<u>Bagasse</u>

Bagasse is not used as yet for the production of viscose pulps production in a commercial scale, but experiments to this purpose were carried out, among other on Taiwan and Cuba.

In the commercial experiment conducted on Taiwan the pulping was carried out by kraft process with steam prehydrolysis, during the bleaching of pulp ClO_2 was used. The obtained pulpe were characterized by an alpha-cellulose content of 94 - 95 %, pentosans content of 4 - 6%, viscosity of 80 - 85 centiposes and brightness of 90 - 93%. Viscose rayon can be obtained from these pulps without difficulty. The bagasse utilization for the production of viscose pulps is limited by its high pentosans content. In the discussion concerning the above experiment it was stressed that the steam hydrolysis before kraft pulping allows an easy removal of pentosans from bagasse. /16/.

Very promising results as regards the quality of viscose pulps from bagasse were obtained during the investigations carried out on Cuba /17. In several research centers laboratory scale studies on production of viscose pulps from bagasse were also made.

Experiments on the use of prehydrolysis in the process of viscose pulps manufacture from bagasse were undertaken among other in India. In these experiments the whole bagasse was used for pulping. After the prehydrolysis /162°C, 2,5 hours, pH 3.4/ the obtained residue /yield 74,7%/ was digested by the soda method. The yields of obtained pulps amounted to 37,5% of the unbleached and to 33 - 34% on the bleached ones. These pulps were characterized by an alpha -cellulose content of 91 - 95%, pentosans content of about 2,5%, ash content of 0,2% and by a brightness about 85% /18/.

In similar experiments when after the hydrolysis the kraft method was used /16% active alkalies, temperature 153°C/ the yield of obtained unbleached pulps amounted to 37,5 - 39,7% and of bleached ones - to 34 - 35%. These pulps were chara-cterized by an alpha -cellulose content 92 - 96%, pentosans content 1,9 - 7,2%, ash content 0,1% and by a brightness of 82 - 96%. /19/.

The results of investigations made by Jayme /20/ on obtaining viscose pulps from bagasse have shown that the kraft pulps have a high pentosans content. A two stage processing - acid hydrolysis followed by kraft pulping - gives very good results regarding the lowering of the pentosans content to the desired level. The content of pentosans in a pulp obtained without prehydrolysis amounts to 18 - 20%, but this content can be lowered to 4 - 6% by means of prehydrolysis. The chemical composition and properties of bleached kraft pulp obtained with application of prehydrolysis is as follows: alpha-cellulose - 93,8%, pentosans - 4,8%, ash - 13%, viscosity 13,7 centipoises, brightness - /G. E./ - 89%.

Reed

The processing of reed into viscose pulp requires before the pulping by alkaline methods, the application of hydrolysis in order to remove the most part of hemicelluloses.

In the plant at Braila /Romania/ kraft pulping with prehydrolysis is applied. The characteristics of obtained pulps are as follows: alpha-cellulose content - 92 - 93%, pentosans - 2,5 - 3%, ash - 0,2 - 0,3%, viscosity - 15 - 25 centipoises. /21/.

The commercial practice has shown that the deciding factor which can make the reed processing profitable is the resolving of the problem of harvesting and handling of this raw material.

The investigations performed on laboratory and pilot scale in United Arab Republic on kraft pulping with prehydrolysis of Egyptian reed /Phragmites communis/ have shown the possibility of obtaining viscose pulps with following characteristics: yield 34,5%, alpha-cellulose content 96,5%, polimerization degree 865, ash content 0,09% and brightness 80%. Experiments have shown that these pulps give viscose and viscose rayon of good quality/22/. In experiments made subsequently with the same raw material the results were also satisfactory /23/.

Studies of several other kinds of reed, thus far not used in a commercial scale, have shown their suitability for viscose pulps production. So for instance from the Ekra reed /Eriantus ravenae/ growing in abundance in India /raw material resources amount to several thousand tons/year/ viscose pulp characterized by about 35% yield and alpha-cellulose content 93% could be obtained. This pulp was estimated as suitable for viscose yarn manufacture /8/.

An other kind of reed - Ochlandra travancorica - /common name Eeta/ was experimentally digested applying kraft method with prehydrolysis. The characteristics of the obtained pulp were as follows: alpha-cellulose content - 96,9%, pentosans content - 4,1%, ash content - 0,11%, brightness - 85%. This pulp was estimated in the German Federal Republic as suitable for viscose rayon manufacture /9/.

The digesting of the Arundo Donax reed by kraft method with prehydrolysis /this reed grows in several regions of India, Birma, North Africa and Europe/ has given pulps of a yield 24,2% after bleaching. The characteristics of these pulps were as follows: alpha-cellulose content - 92,4%, pentosans content - 6,3%, ash content - 0,12% and brightness 82% /24/.

Technical and economical factors concerning pulp mill erecting in developing countries

The cost of a mill erection as well as the production costs in the developing countries are usually markedly higher than in industrialized countries. The involved factors are the costs of organization, raw material transportation, lodgings accomodation for the staff, repair workshops construction, higher expenses for imported chemicals and of an installation for producing the needed chemicals on spot etc.

The comparison of separate elements of the total production costs in a plant localized in an industrialized country /e.g. in Scandinavia/ and in a developing country is shown in the following table:

	Industrialized country	Developing country
Costs of raw material	56%	28%
" " chemicals	5%	7,5%
Manufacture and commercial costs	18%	17 %
Investment costs	21%	40,5%
Expenses for auxiliary items	-	7 %
	100 %	100 %

The above data are clearly showing that an essential part of the production costs in a developing country are the investment costs.

In connection with these high costs calculated on the product unit a great importance takes the choice of a suitable size of the plant to be constructed.

The optimum size of a mill depends on several technical and economical factors, tightly connected together, which are:

1. The cost of equipment for the chosen production process and mills capacity. This cost must be analized from the point of

view of maintenance costs, working life operational costs, reliability of performance.

2. The costs and avaliability of: a/ chemicals, b/fuel, c/ power, d/ water, e/labour, indispensable for any kind of process in a defined geographical region.

3. Cost of raw materials delivered to the mill.

4. Methods and costs of effluents disposal.

5. The quality of the obtained product.

According to European and American criteria small pulp mills do not pay and the use of simple methods permits to obtain low quality products only. The production capacity of a pulp plant should be high enough in order to cut the costs of investments, amortization and of labour and the used production process should make it possible to obtain the product of maximum yield and high quality at minimum consumption of chemicals, steam and power. Yet in the developing countries a trend exists to erect small mills /5 to 30 tons of pulp daily/, where the simplest technological processes are applied /25/.

In the case of pulp production, especially of high quality pulps, this trend is not the right one. In Africa for instance the costs of a pulp mill construction are 1,6 times higher than in Europe. Moreover the costs of power supply, chemicals and specialist wages are so high, that it pays only to produce pulps of a highest quality /26/. This problem is similar in India. If the individual items of the investment costs of a mill producing bleached pulps from bamboo by the sulphate process were divided in three groups - the first comprising the costs connected with pulping /preparation of raw material, pulping, washing, screening, bleaching, drying/, the second - costs of the recovery of chemicals /thickening, black liquor burning, cooking liquor preparation/ and the third - costs of auxiliary services /steam and power generation, water preparation, repair workshops, laboratory, material handling, stores, preparation of chemicals, offices/ - then the percent share of the separate groups in the total costs depending on the mill capacity would be as follows /27/:

Cost group	Production 50	Capacity in tons/day 100	200	300
1	36,5 %	39%	43,4%	46,2%
2	25,2 %	24,6%	23,5%	25,2%
3	38,5 %	36,3	33,1%	28,6%

The above data are clearly showing that the costs of the 2nd an 3rd groups decrease considerably together with the increase of production capacity of the pulp mill.

This lends to a general conclusion that in the developing countries also the mills of a high production capacity are more profitable. This is especially true in the case of dissolving pulp production.

6. Conclusions

The survey of literature data has shown that several non-woody fibrous raw materials can be used with advantage for viscose pulp production. However only very restricted information, concerning the industrial experiments of the use of these raw materials for viscose pulps manufacture are available. An unquestionable need exists therefore to make further investigations on this matter in order to acquire more data, indispensable for commencing the production of viscose pulps in a commercial scale from bagasse, bamboo, esparto and others non-woody exotic raw materials.

The research centers of the Polish pulp and paper industry process certain experience on pulping these materials. It appears that this experience could be helpful in studies concerning the use of these raw materials for the viscose pulps manufacture.

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