Recent Advances in Pulping Technology Relevant to the Indian Pulp & Paper Industry

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ABSTRACT

The paper highlights certain recent developments of pulping techniques currently in practice on worldwide basis. It gives a critical View of Soda-Anthraquinone (AQ), Soda-Oxygen and Extended delignification kraft pulping processes. It deals with the NACO process, which can be the most suitable process of chemical pulping for bagasse, straw and other agricultural residues. Recent developments in adopting principles of displacement impregnation, cooking, washing and bleaching have also been indicated with a view to reduce the overall energy requirements.

High yield pulps using the chemi-mechanical pulping process, as adopted in the newsprint plant at Kerala by HPC, appears to be suitable for making pulp from hardwoods to suit the requirements of printing grades of paper.

Although the pulp and paper industry is more than 100 years old, the developments in the field of pulp and paper making have been gradual. During the last few decades, the pulp and paper making has developed gradually into an exact science. Systematic and elaborate research activities in the field of fibre chemistry, morphology, developments in technology and engineering for more efficient systems and equipment have been continuous. New knowledge on morphology and structure of fibres, chemical reactions of carbo-hydrates and lignins during pulping and bleaching has led to several technological innovations in the field of pulping.

There are several pulping processes starting from chemical, chemi - mechanical to purely mechanical pulping systems. the spectrum of fibrous raw materials which was in the past limited to wood has also widened from wood to non-wood and other synthetic fibrous raw materials. On a worldwide basis, chemical pulping provides about 66% of paper grade pulp, of which nearly 88% is kraft pulp and the rest 12% sulphite pulp.

The alkaline chemical pulping process still remains the bulk of chemical pulping. Although there are several modifications of the alkaline pulping processes, sulphur still remains the most indispensable ingredient in the major pulping processes. Environment aspects are today forcing the pulping industry to devise pulping alternatives which are revolutionary in nature. Since sulphur and chlorine compounds are more harmful to the acquatic life and are malodorous, efforts are being made to find out sulphur-free and chlorine-free pulping and bleaching methods.

In recent years there are three trends in development of pulping and bleaching processes The first is the elimination or the minimisation of the use of sulphur containing pulping techniques and of chlorine containing bleaching techniques. The second development is the production of pulps at a higher yield with acceptable optical and mechanical properties by mechanical, thermo-mechanical or chemical treatment or by combination of any of the above. The third development is in the area of energy conservation in the entire pulping process which covers areas of pulping, screening, cleaning, bleaching and pollution abatement. The first has been initiated by the demand of pollution abatement regulations imposed on the pulp and paper industry, the second by the shortage of raw materials existing today or experienced in the near future, and the third by the ever increasing cost of energy in view of worldwide energy situation.

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Effluents in a kraft pulp mill originate mainly from pulping and bleaching sections. Kraft pulp mill is made to approach effluent-free operation. Kraft pulping is still the pre-dominant pulping method not only in India, but also in the world. The existing shortages of forest raw materials and higher procurement cost of all fibrous raw materials are compelling the pulp industry to look for production of pulps at higher yields with acceptable optical and mechanical properties.

KRAFT PULPING

Kraft pulping gives a low yield. Yield improvement can be made either by limiting the degree of delignification or devising new methods of selective delignification techniques both in pulping and bleaching. The methods of improvement of pulp yield can be best grouped into :

1) Choice of variables in the conventional pulping methods for achieving highest yield.
2) Modifications or variations of the conventional pulping methods in order to improve the carbohydrate stabilisation.
3) Pulping methods using new chemicals for pulping and bleaching either as additive or as secondary chemicals.

The variables effecting the sulphate pulping are the chip dimensions. Time temperature relationship, the chemicals charged and the sulphyidity levels.

CHIP DIMENSION

Chemical pulping is a complex of topo-chemical reactions and the dimensions of the chips are an important variable to influence the rate of pulping reactions. The chips must be exposed to the chemicals completely so that delignification can proceed fully.

In kraft cooking, the impregnation of the cooking liquor into the chips is most essential. In chip impregnation two different phenomena play part. One is the penetration (flow of liquor) and the other is the diffusion (movement of chemicals). Penetration is dependent on pressure gradient and is relatively quick, while diffusion is dependent on concentration gradient and is slow. While the chip capillarity determines the penetration, the chip porosity determines the diffusion. In dry chip, penetration is predominant, while diffusion is predominant in wet wood. Most of the chemicals transported by penetration into the chip are consumed for neutralising the carbo-hydrate degrading products. Table 1 shows the distribution of alkali consumed by various reactions in bamboo cooking.

TABLE—1

Distribution of Alkali consumed by various reactions in bamboo pulping.

	%Na_2O on Chips
A. For neutralisation of acetic acid formed	1.0
B. For Hemi-cellulose reactions	8-10
C. For lignin dissolution	4-5

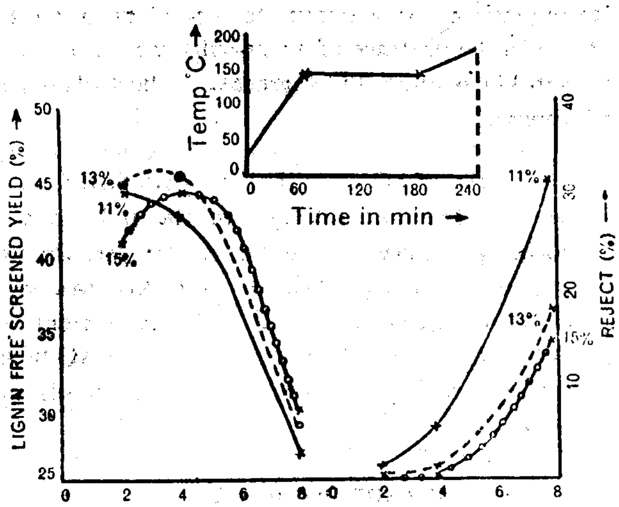
15% Na_2O used on O.D. chips

This takes place at the beginning of the cook at lower temperature. Chemicals required for delignification are predominantly transported by diffusion. Delignification starts before the chips are impregnated. Delignification occurs in those parts of the chips where chemicals are present.

Chemicals are transported with least resistance through the shortest distance or the smallest dimension of the chip, which is the thickness of the chip. Hence, thickness determines the concentration gradient and hence the delignification of the chip. Figure 1 shows the influence of chip thickness on the rejects and the screenings and the screened pulp yield. It is observed that thinner the chips, higher the screened yield upto a certain thickness below which the yield decreases again Under cooking conditions studied chip thickness of bamboo chips below about 3 mm have detrimental effect on the yield[1].

Many mills have adopted segregation of chips on the basis of thickness and this is done with disc screens specially designed for thickness screening although these are more expensive than the conventional screening systems.

Thick chips removed in screening (over-size) can be reduced in thickness by shredding in disc refiners or in special chip slicers. Chip destructuring by passing the chips between parallel cylindrical rolls to produce longitudinal fissures so as to facilitate penetration of the pulping chemicals is particularly suitable for tropical hardwoods.



Effect of chips thickness on the amount of reject and screening and pulp yield of bamboo.

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FIG 1

In the so called MM (Mosca & Moscon) process developed in Argentina, wood flakes of very small thickness (0.3 – 0.5 mm) are pulped in a vapour phase digester at atmospheric pressure with a liquor temperature of 70°C and without liquor circulation. The wood logs are cut into small flakes by means of drum flakes and dried to have uniform moisture content of around 4–10% before being pulped. The Authors claim that the pulp yield is higher and the strength properties are similar to the normal pulps made from wood chips[2]. The pulping equipments are simpler and less expensive.

POLY–SULPHIDE PULPING

For obtaining higher yield of kraft pulp, poly–sulphide pulping has been quite useful. In the Mead (MOXY) process, for making poly–sulphide liquor, white liquor is oxidised with air over a fixed catalyst bed before being fed to the digester. The poly–sulphide oxidises the end groups of the carbo–hydrates mainly Glucomannan and Xylan and stabilises the carbo–hydrates and increases the pulp yield.

The increase in pulp yield is more with softwood than with hardwoods. Stabilisation of glucomannans is responsible for yield increase wioth softwood, while the yield increase with hardwood is due to stabilsiation of xylans[3],[4]. Poly pulps have bleaching and refining properties simiar to sulphite pulp and have strength characteristics similar to sulphate pulps. Higher Hemicellulose content of poly-pulps protects the cellulose in the oxygen bleaching and hence gives a higher viscosity of bleached pulp compared to a kraft pulp[5].

Paper chomotographic study of bamboo poly-saccharides shows that Xylan constitutes 24-25% of the total sugars (Table 2). Laboratory experiments with bamboo chips by poly–sulphide cooking indicated an yield increase of 3% on O.D. chips[1]. Poly sulphide pulping has not found wide acceptability because of sulphur pollution and recent trend towards non-sulphur pulping techniques.

TABLE—2

Composition of Polysaccharides in Bamboo

Sugars	% on Hollo-cellulose
Glucan	63.9%
Xylan	23.9%
Araban	2.0%
Galactan	1.1%
Mannan	0.5%

SODA-AQ PULPING

It is a well known fact that hydrogen sulphide (HS) promotes alkaline digestion of pulp. To get a desired Kappa number, one needs severe conditions of pulping (longer cooking time) in soda pulping in comparison of kraft pulping. The resultant pulp quality is however poor in strength and pulp yield is lower.

An addition to sodium salt of Anthraquinone – 2 – Sulfonic Acid (AMS) increases the delignification rate in soda cooking and gives higher screened yield after a given cooking time. Anthraquinone (AQ) and AQ derivatives with Alkyl substituents (2 - Methyl - Anthraquinone) are superior to AMS as additives.

The advantages of soda- AQ pulping are :

1) The rate of delignification during soda cooking with AQ is much higher. For example,

To get a pulp with a Kappa number

of 80 cooking time required in Soda Cooking	...90 minutes
Cooking time required in Soda+AQ cooking (0.5%)	...30 minutes

AQ catalyses the delignification during the whole cooking.

2) The shorter reaction time needed to reach a given Kappa number with soda AQ pulping means an increase in the pulp yield at a given Kappa number. Thus, for example ;

To get a pulp with a Kappa number of 40 one gets the following yield :

Soda pulping	... 45 2%
Soda + AQ (0.25%)	... 50%
Soda + AQ (0.5%)	... 51.3%

3) Dissolution of carbo-hydrates occurs at a lower rate with soda + AQ pulping. Slower dissolution of carbo-hydrates suggests that the peeling reactions (endwise degradation of reducing sugar and groups and cleavage of cellulose and hemicellulose) are supressed in presence of AQ.

4) Selectivity, as measured by the viscosity at a given Kappa number, is improved in soda + AQ pulping Higher is the selectivity at higher percentage of AQ.

5) In contrast with oxygen delignification, soda + AQ pulping is insensitive to metallic compounds.

Disadvantages

1) Viscosity of pulp is lower in soda + AQ pulping.

2) Soda + AQ pulps have a lower tearing resistance at a given tensile index.

The main disadvantage of the soda + AQ pulps, in comparison to the kraft pulps, is the lower tearing resistance at a given tensile index. The lower tearing strength is due to the lower fibre strength. It appears that in the absence of sodium hydrosulphide, the AQ degrades the cellulose. In the kraft-AQ pulps, the weakening effect of the AQ is not noticed. It may be that the AQ is reduced by sodium sulphide to form Anthra-Hydroquinone and poly-sulphide. Oxidative degradation of the polysaccharides by AQ is prevented and the delignification is increased and also polysaccharides are stabilised against alkaline degradation by the poly-sulphide[6]. Therefore in the soda-AQ pulps, the AQ while increasing the delignification process is also reponsible for damage to the fidres to a certain extent. In the presence of hydro-sulphide, as in the case of kraft-AQ pulping, the degradative effect of AQ does not appear.[7]

3) High cost of AQ is still the main factor why it has not been used widely in the pulp industry. Although its use in Japan is popular, the total number of mills worldwide using AQ process was about 40 in the year 1982[8]. At its present cost ($4/Kg), it is still uneconomical to use AQ to save raw materials (chemicals, energy and fibrous materials.

LOW KAPPA KRAFT PULPING

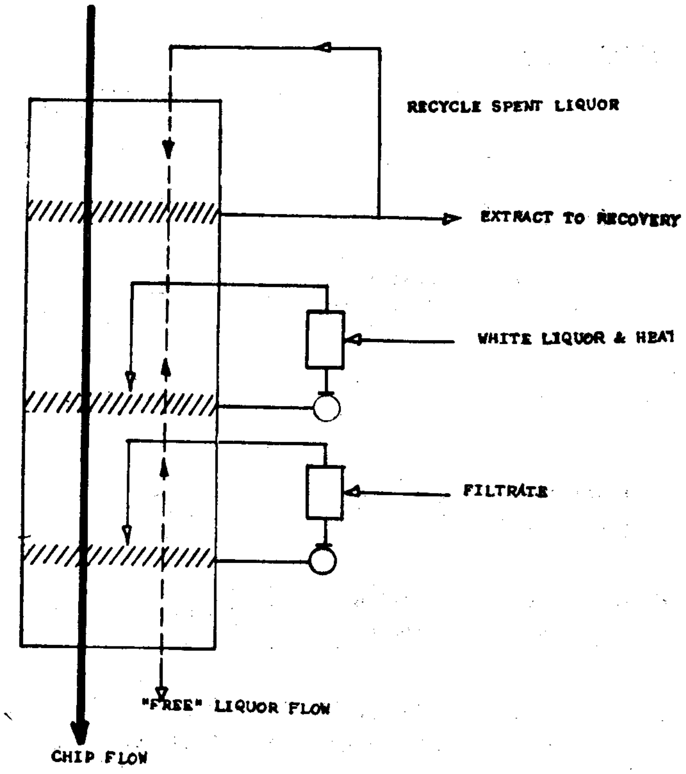
In kraft pulping, bleachable pulp is normally cooked to a kappa number of 30–35, while for making liner board pulp, it is customary to cook the pulp to a kappa number of 75–100.

In the conventional kraft pulping process, delignification to more than 95% of the lignin is not economically attractive. Higher delignification results in a loss of both yield and pulp strength. Also lignin selectivity decreases rapidly in the final stage of cooking.

Cooking beyond the Kappa number range of 30-35 for bleachable pulp by extension of the cooking time is undesirable because this result in a rapid loss in yield, a reduction in the pulp viscosity and strength and a reduction in tne digester capacity.

EXTENDED DELIGNIFICATION

By modifying the kraft cooking system, one can obtain a pulp with a Kappa number in the range of 10–15. The principal objective is to lower the lignin content of the pulp entering the bleach plant and thereby lower the bleaching cost and reduce the bleach plant effluent. By lowering the Kappa number to 10—15 by extended delignification, the B O.D., C.O.D. and colour of the conventional bleach plant effluent can be reduced by 65%, besides, the bleaching can be carried out by using chlorine dioxide as the main bleaching chemical. As we know, chlorine dioxide is more specific as a bleaching chemical like chlorine and hypo-chlorite. Besides, the extended delignification in the cooking stage has the benefit of bringing more of the organic matter into the energy producing black liquor in the recovery system.



COUNTERCURRENT COOKING

FIG. 2

Extended delignification can be carried out by modified kraft pulping in which the cooking liquor composition is changed, by kraft oxygen pulping, by kraft-AQ pulping or by a combination of these.

EXTENDED DELIGNIFICATION IN KRAFT COOKING BY CHANGING THE ALKALI PROFILE DURING COOKING

A normal bleachable pulp has a Kappa number of 30—35. By prolonged delignification in a normal kraft cook, one decreases the pulp viscosity. It has been observed that the concentration of lignin in the cooking liquor determines the delignification rate[9]. By reducing the *lignin concentration*[10] in the cooking liquor, one can improve the delignification rate or the selectivity as measured by the Viscosity-Kappa number relationship. Similarly, the selectivity of lignin dissolution can be improved by *higher sulphidity* as well as the time gradient of the sulphidity during the cook and also of the *hydroxide concentration*. It has been found that higher the sulphide concentration at the beginning of the cook, better is the selectivity. Therefore, if the first part of the cook has a liquor with high concentration of sulphide and followed by liquor with a lower concentration of Sulphide in the later part of the cook, one can get a better selective delignification.

Similarly, lower the concentration of the hydroxide at the beginning of the kraft cook, better is the selectivity. In a normal kraft cook. the hydroxide concetration is at its maximum in the beginning of the cook. This is contrary to what is desirable from the point of view of selectivity. Thus, one can have a liquor containing only a part of the total alkali to be at charged at the beginning of the cook.

In a new system developed by Swedish Forest Products Research Institute & Royal Institute of Technology[11], the liquor has a high sulphide concentration at the beginning of the cook. The concentration of hydroxide at the beginning of the cook is also low (30—50% of the total alkali charged). In a continuous digester the liquor is drawn co-currently with the chips. Somewhere, further down the digester during the cook more alkali is added and drawn counter-currently to the chips. This is implemented by withdrawing the black liquor at a point when the full cooking temperature is reached. The alkali addition is so balanced as to avoid low concentration of the effective alkali. Finally, additional alkali is charged at the end of the cook and drawn counter-currently to the chips. A digester operated in this way can give a pulp of very low Kappa number. With this new cooking techniques, the reduction of BOD load/tone of pulp is quite low (reduction of 40% can be achieved). If one combines this extended delignification with oxygen deliginification, the pollution is further reduced by about 70%. This can be achieved in a Kamyr Continuous Digester.

A diagram of a Kamyr partial counter current continuous digester illustrates the principle. Fig 2 illustrates the principle of counter current cooking and Fig. 3 gives steps of carrying out the above idea.

Point A—Upper Heating Zone

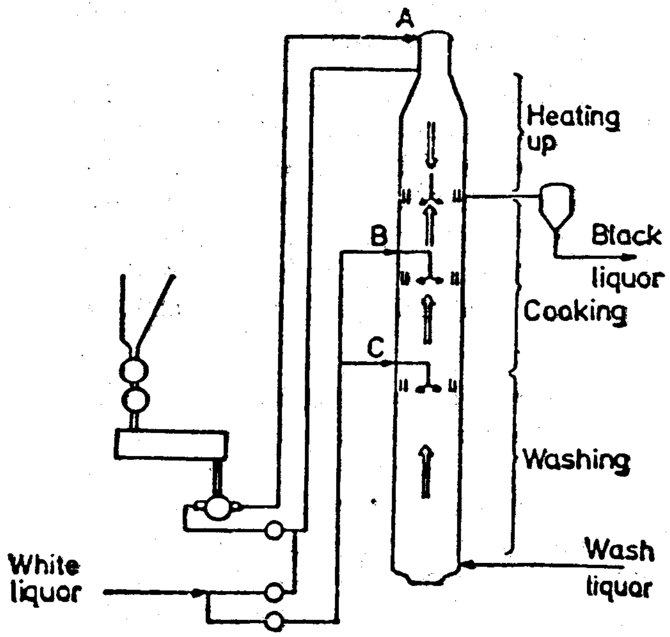
A major part of total alkali (50%) is added. Co-current flow of chips and liquor.

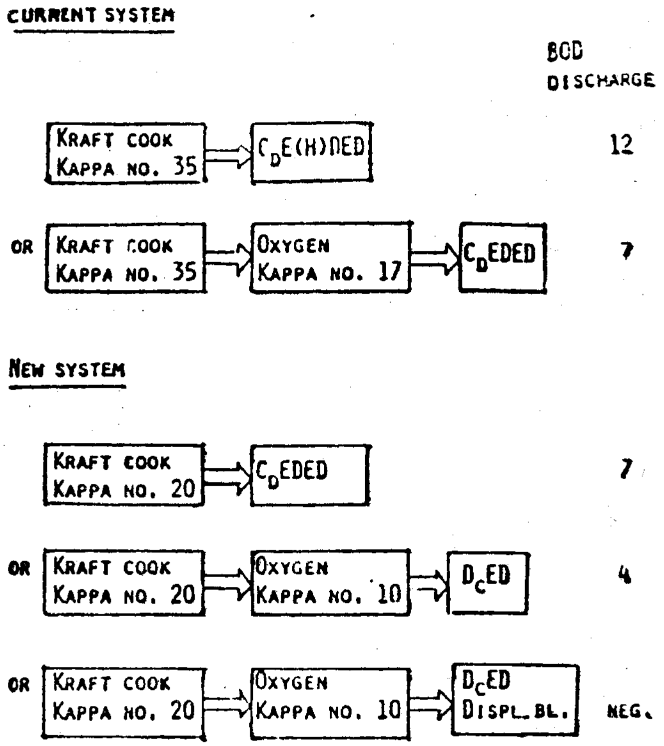
Point B - Upper Cooking Zone

A minor part of alkali (25%) is added. Counter-current flow of chips and liquor.

Point C—Lower Cooking Zone

Rest of alkali (25%) is added here. Counter-current flow of cooked chips and liquor.





Comparison of various systems for delignification of standard bleached kraft pulp.

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Fig 3

Point D—Washing Zone

Wash liquor as usual. Counter-current flow.

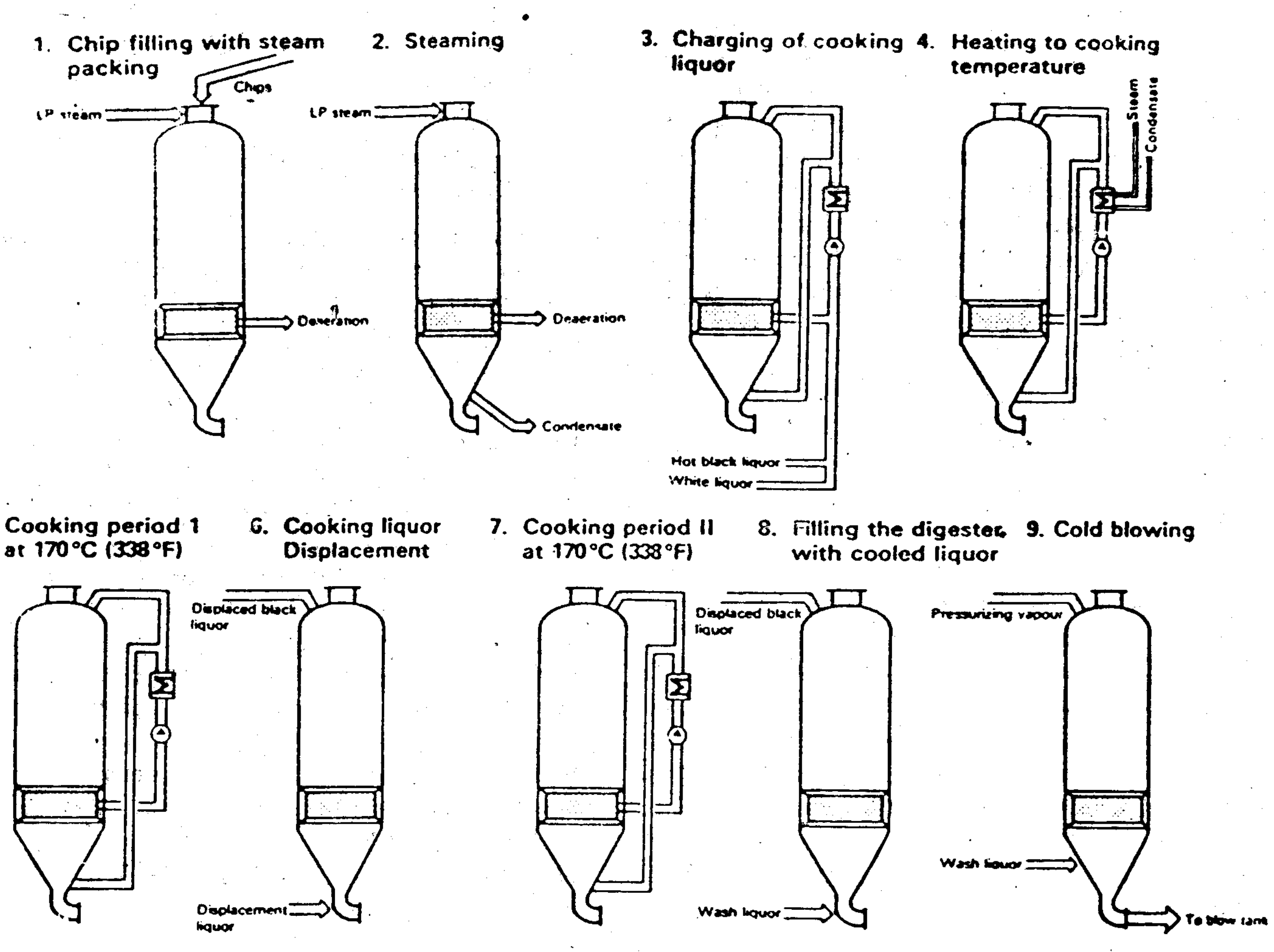
It is also possible to carry out the extended delignification kraft pulping in a modified batch digester system. In the batch cooking system, this is achieved by displacing the cooking liquor at a certain stage with liquor of lower lignin content. So the cook is in two stages with displacement in between. By charging a part of the total alkali charged during this displacement the alkali concentration is levelled out throughout the cook.

A System which has been adopted in the ASSI KARLSBORG, Sweden (developed by Sunds Defibrator) has the following sequences :

1 Chip filling
2 Pre-steating
3 Liquor charging
4 Heating up period
5 Pressure period – 1
6 Cooking liquor displacement
7 Pressure cooking—2
8 Cold blowing

A flow diagram giving the various sequences and the flow sheet of the ASSI KARLSBORG is given in Figure—4.

It is reported that the total steam consumption has been decreased by 20-25% and Kappa number reduced from the normal values of 30-32 to around 25 with



Cooking sequence, ASSI Karlsborg.

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FIG. 4

the same pulp strength. By introducing the cold blowing system at the end of the cook, there is no risk of over cooking.

Traditionally most of the post cooking delignification takes place in the chlorination stage of bleaching. A major part of the lignin can also be removed by oxygen delignification and taken to the recovery in the brown stock washing, hence chorination can become less intensive. This results in lower pollution loads as we' as savings in bleaching chemicals. Another importa fact is that delignification can be made to proceed ve close to completion in the chlorination and alkali sta if the alkali stage is combined with oxygen. The fin bleaching then will be purely for increasing the brig tness and removal of impurities which can be done a single stage chlorine–dioxide bleaching for fu bleached pulp.

KRAFT-OXYGEN PULPING

Oxygen has been used initially as a bleaching agent primarily to reduce the BOD from the bleaching effluent. Oxygen is also being used as a secondary delignification agent in soda and kraft pulping. This process is called *extended oxygen delignification* (EOD). In EOD pulping oxygen is used to reduce the lignin content of kraft pulp with Kappa number (35-70) and bring it to a bleachable level (Kappa number 30-35). The advantages of oxygen delignification as a second stage in kraft-oxygen pulping are :

1 Higher yield of pulp
2 Lesser load on the pulp mill recovery system
3 Lower bleaching chemical requirements
4 Shorter bleaching sequence
5 Lower alkali usage
6 Slightly improved pulp strength, and
7 Lower effluent load

For example, in the conventional kraft pulping system when the Kappa number of pulp is rednced from 60 to 30, there is a yield loss of about 10%. In EOD, the yield loss can be 5% under similar conditions. Similarly, bringing down the Kappa number from 60 to 30 in the conventional kraft pulping, the chemical consumption NaOH is about 6.5% on wood while in EOD it is only 3%. EOD needs higher doses of alkali and oxygen and involves higher generation of temperature than oxygen bleaching.

Oxygen delignification has been applied on the mill scale for the last 15 years. The medium consistency technology is nowadays commonly used in oxygen delignification. Oxygen delignification in presence of alkali is usually carried out in a pressurised reactor.

ALKALI-OXYGEN PULPING
NACO PROCESS

NACO process which has been developed by Sunds Defibrator, Sweden and IPZS (INSTITUTO POLIGRAFICO ZECCA dello Stato), Italy, is basically a process which uses oxygen and ozone in the delignification and bleaching stages. Sodium carbonate is the alkali which is used for pulping along with oxygen. NACO uses ozones in bleaching with recycling of oxygen from the mixture of oxygen and ozone gases. It is a sulphur-free and chlorine-free bleaching system and therefore the pollution loads are minimum. Figure 5 shows the basic block diagram. The pre-treatment or the depithing system is a wet system where the raw material (straw-bagasse, waste paper etc.) is mixed with water and some caustic soda in an ordinary open pulper to remove the waxes and other impurities. The raw material is then separated from sand and stones in a cyclone separater while the finer impurities are separated later on a washing and dewatering screw. The final raw material is dewatered over a DKP-press where nearly 50% silica is removed and the loss of material is of the order of 12–13%[12].

THE NACO PROCESS
Block Diagram

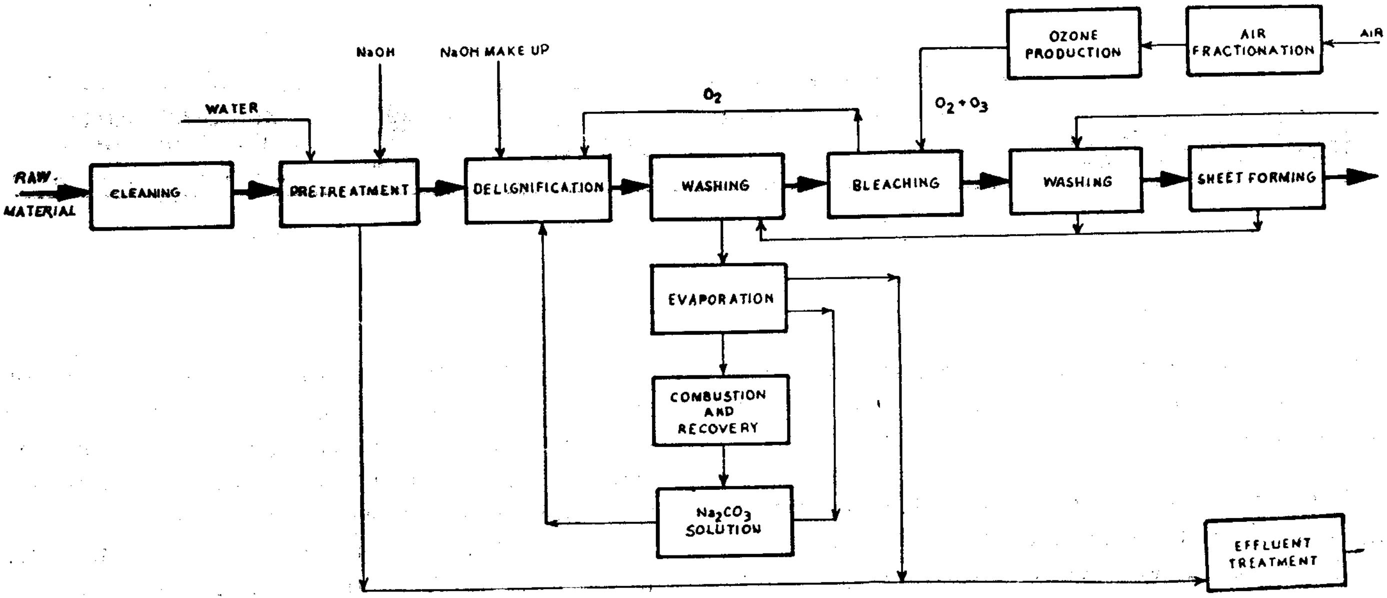


FIG. 5

The raw material is passed through a refiner where the knees are destroyed by having a close disc clearance (2 mm). The material is than pumped into a pressurised turbo-pulper and reactor system where the pressure is 6 bar and the temperature is 135°C. The total retention time in the reactor is 25-30 minutes. Figure-6 gives the flow sheet of NACO process to be adopted at Foggia Mill, Italy.

Ozone can be made from oxygen or air. The ozone content made from oxygeu is at 6–7% while the maximum ozone concentration is 4%, if it is made from air. The electrical consumption for producing ozone from oxygen is 11 KWH/T ozone. The total power consumption for the system is of the order of 240 KWH/hr. per tonne of B.D. pulp. The bleached yield of pulp is of the order of 50-60% on the pretreated straw basis. The brightness of the bleached pulp is about 70% Elphero. This system will be very suitable for fibres like straw, bagasse and other grasses. Since the final brightness cannot be higher than 70% ISO without further bleaching with peroxide, it will be very suitable for making chemical pulp used for manufacture of newsprint whose brightness is limited to 55–60%. Bleaching with hypo–chlorite can also be made in the NACO process in mills where pollution regulations are less stringent and financial considerations do not permit costlier bleaching chemical like ozone and peroxide.

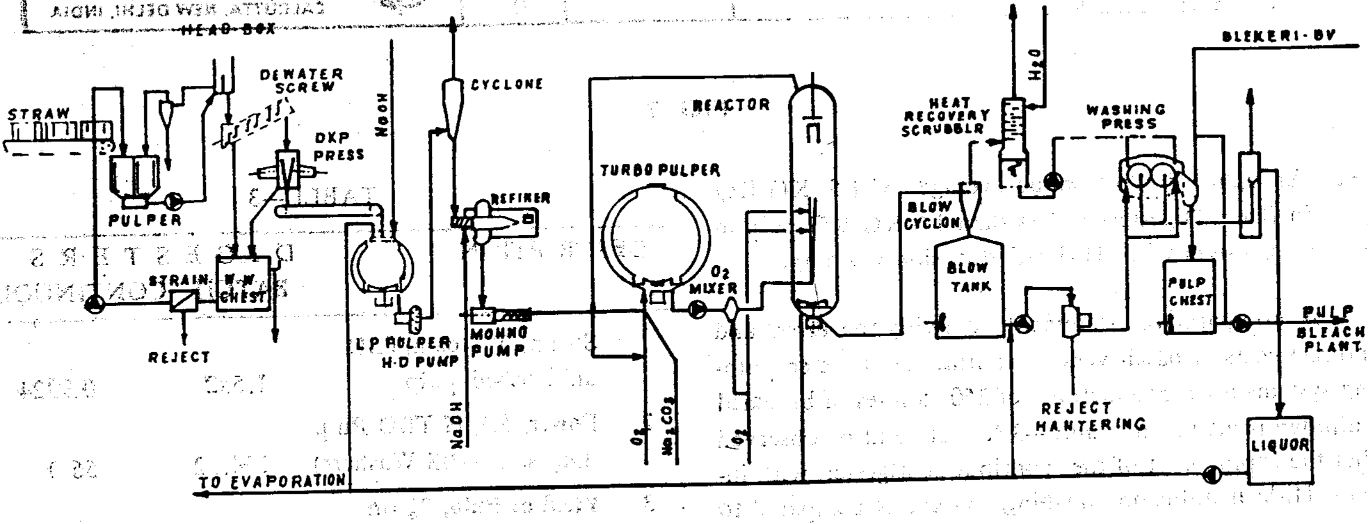
It has been reported that NACO pulping process is much cheaper both in the overall capital cost as well as operating cost. A comparison shown in Figure–7 indicates the differences in the cost of raw mateials, energy, capital cost aud other items[14].

ENERGY CONSIDERATION IN PULPING

In view of the high cost of energy a lot of attention has been paid to the energy requirement of the pulping processes. Here the technologists and engineers of the equipment designers have played a vital role in bringing down the energy requirements.

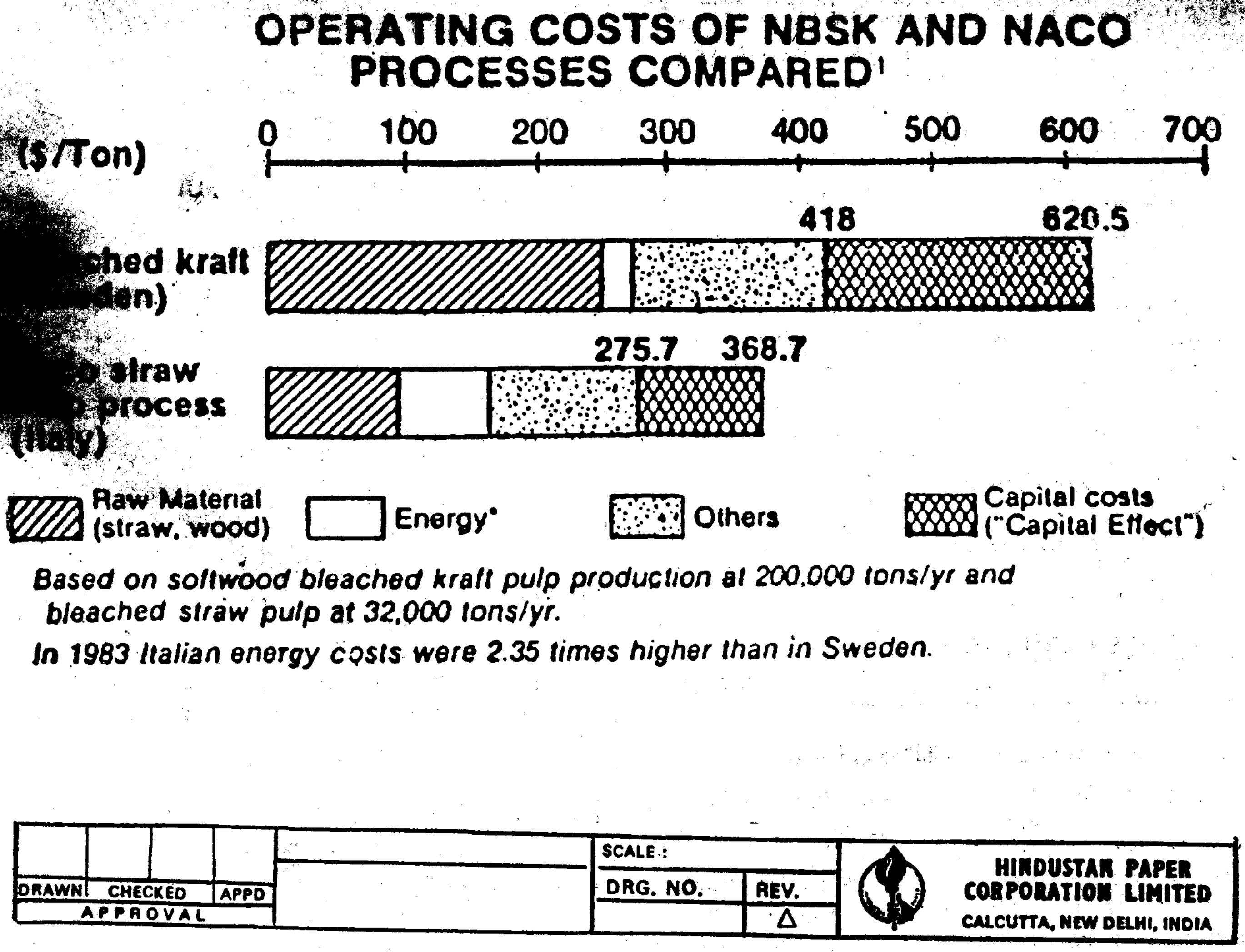
Steam consumption in cooking is gradually reducing. In addition to the various process advantages, such as more uniform heating, longer impregnation time and cold blowing of pulp, the switch-over from Batch to Continuous digester has paved the way for more efficient use of thermal energy, resulting in appreciable reduction of steam consumption in cooking.

In a commonly used continuous digester of the "Kamyr Type" with 'Hi-heat' washing, the flow of chips and white liquor is cocurrent while the washing of pulp is carried out with wash liquor using the counter-current principle. Thus, liquor flow is concurrent in impregnation and cooking zone and counter-current in washing zone. Steam consumption in cooking has



FLOW SHEET THE NACO PULPING SYSTEM

FIG. 6



Based on softwood bleached kraft pulp production at 200,000 tons/yr and bleached straw pulp at 32,000 tons/yr.

In 1983 Italian energy costs were 2.35 times higher than in Sweden.

FIG. 7

been brought down from an average of 1.5 KG/KG pulp in Batch Digesters to less than 1.0 KG/KG pulp in Kamyr digesters with 'Hi-heat' diffusion washing.

A comparative statement showing the direct and indirect costs of batch versus continuous digester pulping systems for a production of 350 tonnes of bleached pulp/day is given in Table—3[15]. It will be observed that the capital cost of the continuous digester with in-built Hi-heat diffusion washing system as compared to the batch digester with brown stock washing system of same capacity is considerably higher. However, the savings by way of power steam and power consumption would over-weigh higher depreciation and interest charges.

TABLE—3

	DESCRIPTION	DIGESTERS	
		BATCH	CONTINUOUS
1	Steam, T Steam/TBD unbleached pulp	1.582	0.9924
2	**Power,** KWH/TBD Pulp (Digesters+BS Washers)	154.92	56.0
3	**Yield of Pulp,** % on BD chips	45.6	46 0
4	**Alkali Consumption for pulping** % Na_2O on BD Cihps	18.0	16.275

DESCRIPTION		CONTINUOUS DIGESTER (Rs. in Lakhs/year)
DIRECT COST		
1	Savings in Steam (Rs. 45/T steam)	32.925
2	Savings in Power (30 P/KWH)	36 825
3	Savings in Bamboo	4.56
4	Savings in cooking chemicals	1.49
5	Savings in Evaporation	8.43
6	Savings in Man-power	0.62
	Total	84.85
INDIRECT COST		
1	Savings in Depreciation and interest	7.38
2	Maintenance, Insurance, etc.	2.38
	Total	9.76
NET SAVINGS FROM DIRECT & INDIRECT COST		Rs. 75.19 lakhs

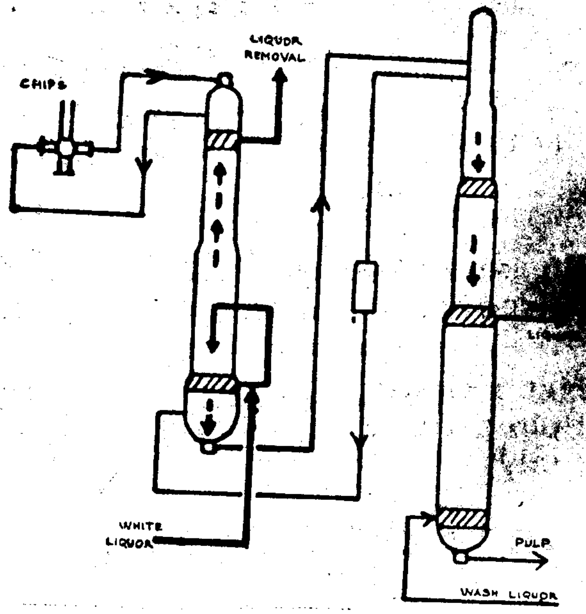
NOTE : **Cost of Equipment including erection**

Batch Digester	Rs. 599.666 lakhs
Continuous Digester	Rs 683 858 lakhs

Efforts have been made to further reduce the steam consumption by extending the principle of counter-current mass and heat transfer to cooking and impregnation zones.

In continuous counter-current impregnation, the cooking chemicals are injected directly in the upper cooking circulation and a portion of the extraction is taken from the make-up flow at the top of the digester. the top extraction is set to give a upflow in the impregnation zones. Computers have assisted in accurate control of flows. The counter-current flow of heat and chemical transfer results in reduced use of chemicals, more concentrated cooking liquor thereby reducing the cooking temperature with resultant steam savings. By counter-current impregnation, cooking and washing and by pre-heating the cooking liquor with Flash steam coming out of the digester, the consumption of steam can be as low as 0.35 Kg/Kg pulp[16].

Figure 8 & 9 illustrate the system of counter-current impregnation in a KAMYR digester.



CONTINUOUS DIGESTER WITH COUNTER CURRENT IMPREGNATION

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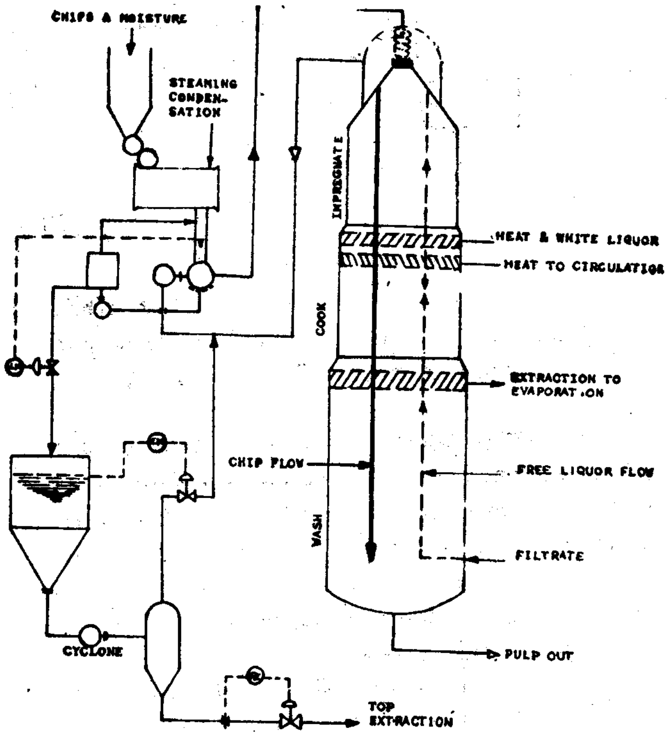
FIG. 8



DISPLACEMENT IMPREGNATION

FIG. 9

Efforts have been made to make use of the well known principle of impregnation, heat recovery and cold blow in batch digesters in recent years. The Rader and the ASSI systems are a few examples. The figures 10 & 11 illustrate the above system.

HIGH YIELD PULPING

The pulp industry is based on the use of fibres as such or liberation of fibres of its woody constituents. There are two ways of fiberising, namely :

i) Mechanical and

ii) Chemical

In the chemical process the middle lamella is chemically dissolved to such an extent as to liberate the fibres without mechanical treatment. The drawbacks of the Chemical Pulping System are the low yield (40 to 50% of wood). To make the pulp less expensive, several high yield pulping methods have been in use. Inspite of several Carbohydrate preserving pulping methods, the yield of pulp has not been more than 55 to 60% of the wood.

The yield of pulp can be partially increased either by mechanical pulping methods or semi-chemical pulping methods. Various grades of bleached pulps are made by stone grinding as well as by grinding the

Typical batch digester System Rader displacement heating.

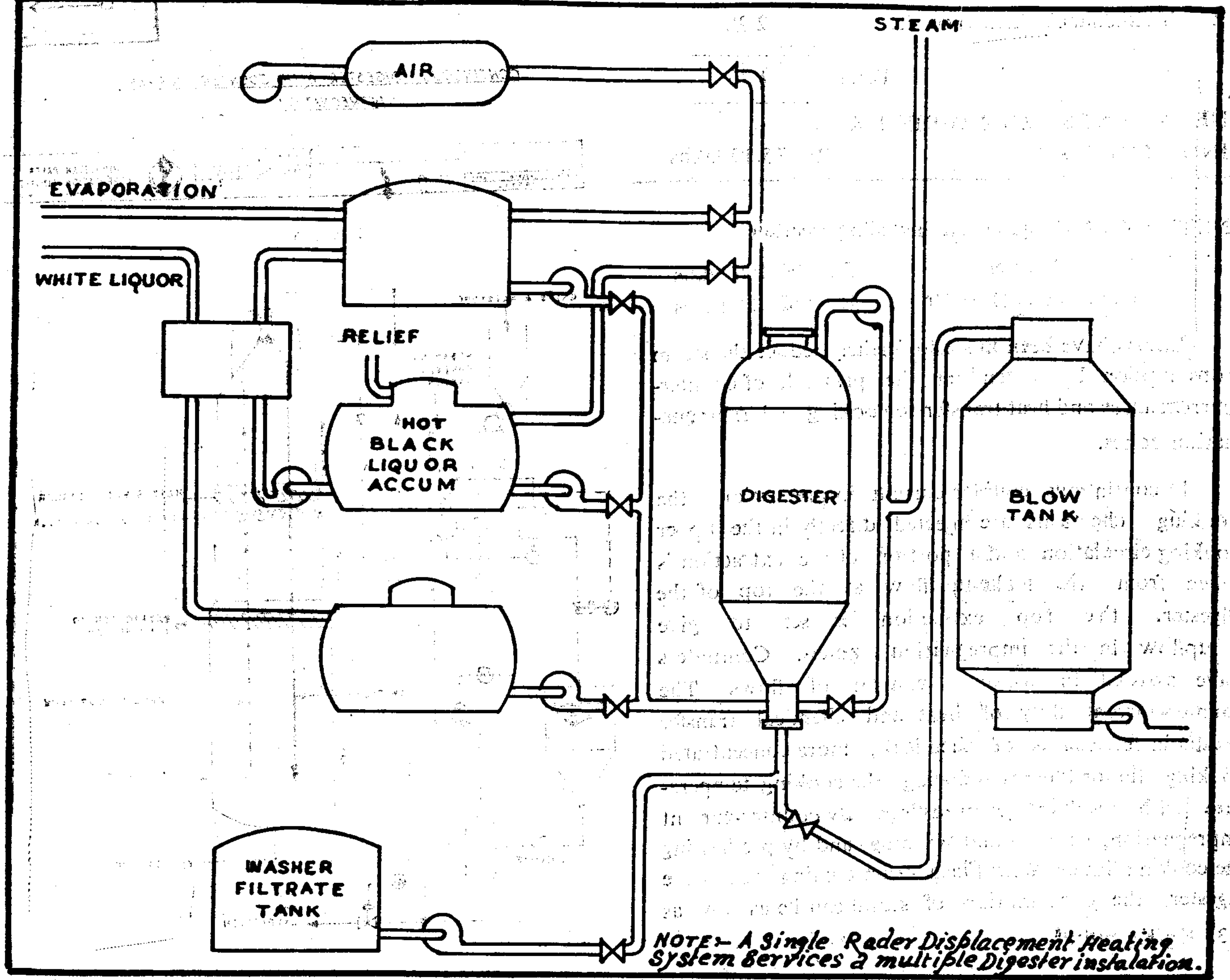
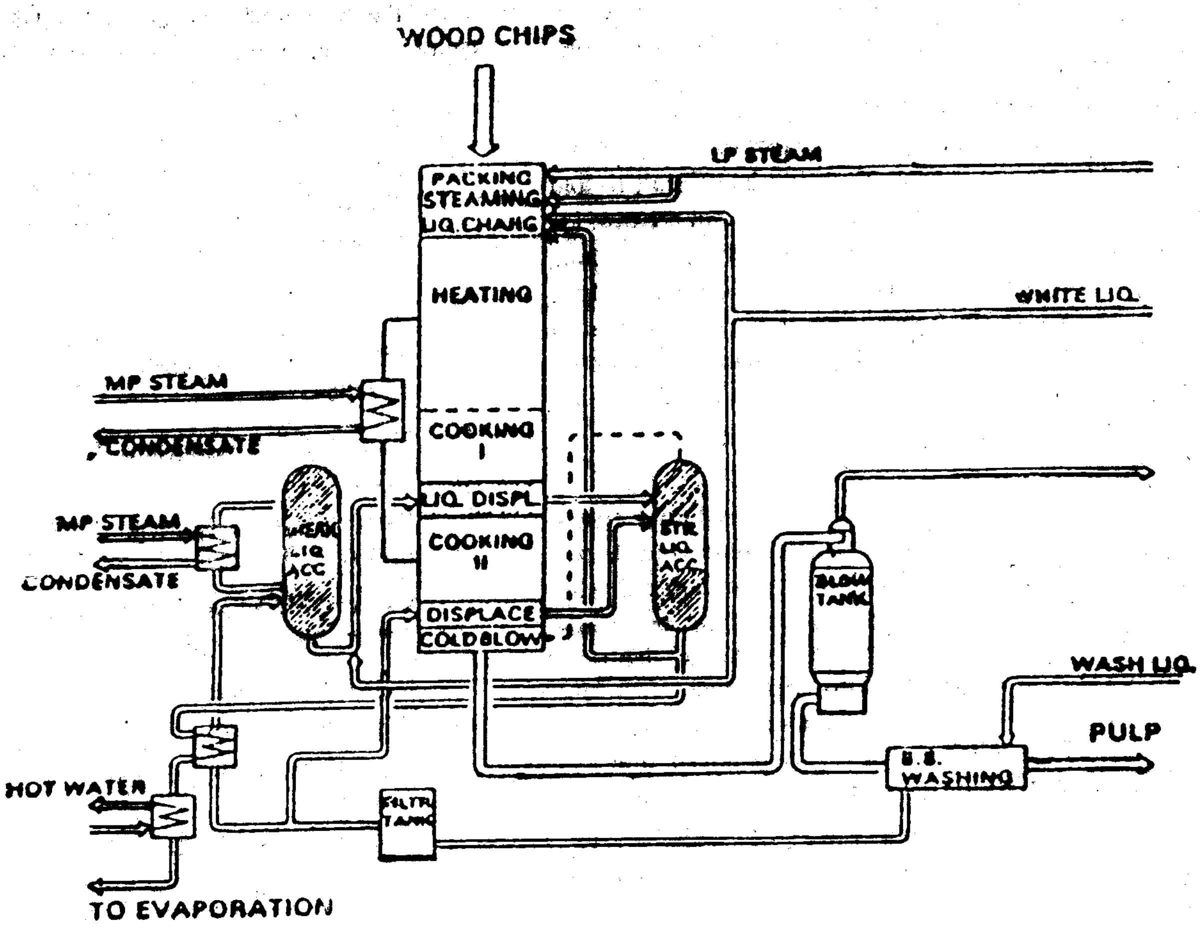


FIG. 10



Flow sheet, cooking system, ASSI Karlsborg..

FIG. 11

partially steamed or chemically treated chips under the influence of temperature and pressure. This has given rise to TMP Pulping Processes. The pulp is bleached by the surface bleaching agents These bleached pulps have a yield of 85 to 90% on wood. The CTMP Process imparts improved strength properties to the pulp at higher levels of yield and brightness compared to any chemical pulping methods. Now-a-days bleached grade of TMP and CTMP pulps are used not only for newsprint making but also for grades like cheap printing paper, tissue paper, drapiers, wall paper, etc. Use of high yield pulps has reduced not only the cost of pulp but also the environmental abatement problems.

In order to produce high yield pulps that are stronger than the pulps available today and to produce these pulps at lower levels of energy consumption, the pulps should have the characteristics of chemical pulps without dissolving the lignins and should have high percentage of long flexible fibres with high bonding ability. This means that wood should be soft chemical penetration to permit the separation of fibres without damage For low energy consumption, the fibres should be easily separated and the mechanical energy should be effectively utilised for internal fibrillation. The energy absorption in wood during the refining is proportional to the stiffness of wood and its internal friction. Most efficient energy utilisation occurs at high levels of internal friction. As wood is a visco-elastic material, the stiffness and the internal friction values depend on the temperature and the loading frequency, in addition to the composition of the wood, the presence of plasticizing agents and other ionic particles.

It has been found that Sodium Hydroxide has a softening effect on the wood. If the chips are pre-treated, pre-heated and defibered at 100°C, the strength properties of fibres will depend on the Alkali charged- Sodium Sulphite does not soften the wood, it merely increases the brightness levels of the pulp and hence it is preferable to use a maximum of Sodium Hydroxide and Sodium Sulphite as the pre-impregnation chemicals for high yield pulping. Probably, it will be difficult to find a substitute for a combination of Sodium Hydroxide and Sodium Sulphite in high yield pulping for a long time to come. HPC (Hindustan Paper Corporation Ltd) has succeeded in manufacturing a chemi mechanical pulp (CMP) whose optical and mechanical properties can be varied to suit the requirements of printing grades of paper.

The main constituents of wood are cellulose, hemicellulose and lignin. While the cellulose and hemicellulose are hydrophilic, lignin is hydrophobic In the conventional pulping methods the cellulose and hemicellulose are separated from the hydrophobic lignin to allow the water to penetrate into fibre structure. In the process of removal of lignin, not only the lignin but also some of the Carbohydrates are removed and the result is a low yield of pulp. If the lignin can be made hydrophilic, unbleached pulp can have a higher yield and yet possess the physical properties good enough for making paper.

The brightness of unbleached pulp is dependent on the pulping chemical. For a given pulping chemical, the brightness depends on the degree of de-lignification. This is probably because the colouring matters in the wood are closely linked with the lignin of the raw material. By bleaching we destroy the chromophores of the colouring matters as well as the lignin. Can the chromophoric centres of the colouring matters be destroyed without lignin removal ? If this can be done one could probably get a brighter pulp even at an extremely high yield comparable to that of mechanical pulp. The end of this century will definitely see such a technology being used on commercial scale.

REFERENCES

1. Panda A, IPPTA, 41 (2) (1969)
   Paper presented at IPPTA Seminar. Madras (1969)
2. Reitter, F J, PPI, 53 (6) (1974)
3. Kleppe, P J & Kringstad K, Norsk Shogind (1) 13 (1964)
4. Kleppe, P J & Kringstad, K, Norsk Skogind (11) 428 (1963).
5. Samuelson O & Sjoberg, TAPPI, 62 (12): 47-50 (1979).
6. Gugnin, M. Y, Malkov Y. A. & Nepnin Y. N, ABIPC 54:9671 (1983)
7. Irvine, G. M. & Nelson P. J., Appita, 39 (4) : 292 (1986)
8. Macleod J. M., Pulp Paper, 56 (11): 98-100 (1982)
9. Lundgren A, Dessertation, Royal Institute of Technology, Stockholm (1977).
10. Norden, S, STFI, B-335 (1975).
11. Hartler, N. Svens paptid, 15:484 (1978).
12. Franzen, T, UNIDO Seminar, Bangkok, Dec. (1985).
14. PPI, (1) 49 (1984).
15. Panda A, paper presented in UNIDO Seminar, New Delhi (1984)
16. Mc Kenna, E & Prough B, Tappi, 60 (5): 183 (1977)