Alkaline peroxide mechanical pulping: the pulp of the 1990'S

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RESUMO: Tanto o número de fábricas de CTMP como a sua produçao tem crescido muitíssimo nos anos 80. Cresceu também a complexidade da tecnologia por trás disso. Hoje o projeto para uma fábrica de CTMP assemelha-se a uma fábrica de celulose kraft branqueada, com seus multiestágios de lavagem e sequências de branqueamento. Todos os custos de capital para construir-se uma planta destas, o que tem reduzido o número de possíveis empresas que podem fazer tal investimento. No entanto, existe uma carência de processos de polpa mecânica que possam vir a produzir CTMP de altas propriedades, mas a um significativo capital reduzido e a reduzidos custos operacionais. Um destes processos é o APMP - pasta mecânica peróxido alcalina - tanto para fibra curta como longa, pode-se produzir com propriedades iguais ou superiores se comparadas com CTMP branqueadas. APMP compreende um sistema de impregnaçao de 2 estágios, seguidos por refino atmosférico, e passos de processamento fibroso convencional. A maior vantagem da APMP é que nao há necessidade de branqueamento após o refino, eliminando assim a necessidade de separar a planta de branqueamento

ALKALINE PEROXIDE MECHANICAL PULPING: THE PULP OF THE 1990'S

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ABSTRACT

The manufacture of CTMP has grown dramatically in the 1980's. As the number of mills producing CTMP has grown, so has the complexity of the technology behind it. Today the design for a CTMP mill resembles a bleached kraft mill, with its multi-stage washing and bleaching sequences. All of this processing has increased the capital costs involved in building such a mill, which reduces the number of sites that can afford increased investment.

Therefore, there is a need for a mechanical pulping process that can produce CTMP-like properties, but at significantly reduced capital and operating costs. One such process is the Alkaline Peroxide Mechanical Pulping (APMP) Process. For both hardwoods and softwoods, a fully bleached APMP pulp can be produced with equal or superior pulp properties as compared to bleached CTMP (BCTMP). APMP involves a two-stage impregnation system, followed by atmospheric refining, and conventional fiber process steps. The major advantages of APMP is that no additional bleaching is required after refining, eliminating the need for a separate bleach plant.

INTRODUCTION

The manufacture and use of CTMP has grown dramatically since the first commercial mill began operations ten years ago. It is expected that nearly 1.25 million tonnes per year of Bleached Chemi-Thermo Mechanical Pulp (BCTMP) capacity will be available by the end of 1990 (1). With the increase in production, there has been a growing acceptance of CTMP for a widening range of products. To satisfy the customers needs, each CTMP installation has increased the complexity of their pulping plant to improve product quality and achieve market differentiation.

CTMP was developed when the industry realized that a brigher and somewhat stronger pulp could be produced by applying sodium sulfite to the chip prior to refining (2). While this process was called CTMP, it bears little resemblance to today's CTMP. To enhance pulp properties, the original process was modifed. Screw press impregnators were developed to improve the penetration of chemical into the chips, thereby improving the strength (3). Multi-stage bleach plants were installed to improve the brightness economically. Washing sequences were designed to reduce the resin content and improve both the bleach response and the usage of BCTMP in certain grades. The list of new design features

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continues to grow. As a consequence, today's BCTMP mill has the appearance and cost structure similar to a kraft mill.

Aside from cost, there are other problems with CTMP. As outlined in a recent paper (4), they include:

- high energy requirements
- inability to handle high extractive levels
- increasing levels of effluent loads

There is little hope that the first three problems can be resolved without increasing both the capital and operating costs; therefore, a new direction is necessary.

The momentum of the global effort to make CTMP a practical alternative to kraft had nearly eliminated studies in alternative technologies. One technology that suffered was known as the Cold Soda Process. A patent for a cold soda-type process for non-wood fibers was issued in 1919, and by the early 50's, several laboratories were doing extensive work using caustic to treat the wood chips prior to atmospheric refining (5). The pulp produced had a brightness in the 40's, which meant that bleaching was necessary, which at the time meant a hypo-chloride bleaching stage to reach a 55-60 brightness

In 1960, Jahne and Price reported that significant brightness improvements could be obtained by adding hydrogen peroxide into the primary refiner (6). While refiner mechanical pulping was still in its infancy at this time, the Sprout-Bauer Pilot Plant was already experimenting with a process where chips were impregnated with bleach liquor. However the costs for a high brightness mechanical pulping were too high and there was no demand for that quality of fiber. Over the next 30 years occasional research on chip bleaching was done with some work reported in the literature (7, 8). Only recently has an alkaline/peroxide chip pre-treatment been shown to be an alternative to the conventional sodium sulfite technology (9).

The purpose of this work is to show that the Alkaline Peroxide Mechanical Pulping Process (APMP) can produce a pulp with equal or superior pulp properties compared to either hardwood or softwood BCTMP. The advantages of the APMP system are numerous. The pulp is bleached while refined. Thus, no additional bleach plant is necessary and the cost of building a plant can be reduced by 25% or more. Simple atmospheric refiners can be used, thus eliminating the need for extensive steaming systems. The APMP process can allow the control of the energy consumption by varying the application of caustic. Since the process does not use sulfite, the effluent from the plant will be easier to treat.

PROCESS DESCRIPTION

A block flow sheet for the APMP process is shown in FIGURE 1. As with any high quality mechanical pulp mill, the first operation in an APMP mill is to wash sand, grit, and bark from the wood chips. This is accomplished with a conventional high efficiency chip wash system complete with a wash water cleaning system. The specification for chip size is not as critical for this process since the combination of the high compression ratio of Sprout-Bauer's Impressafiner as well as the

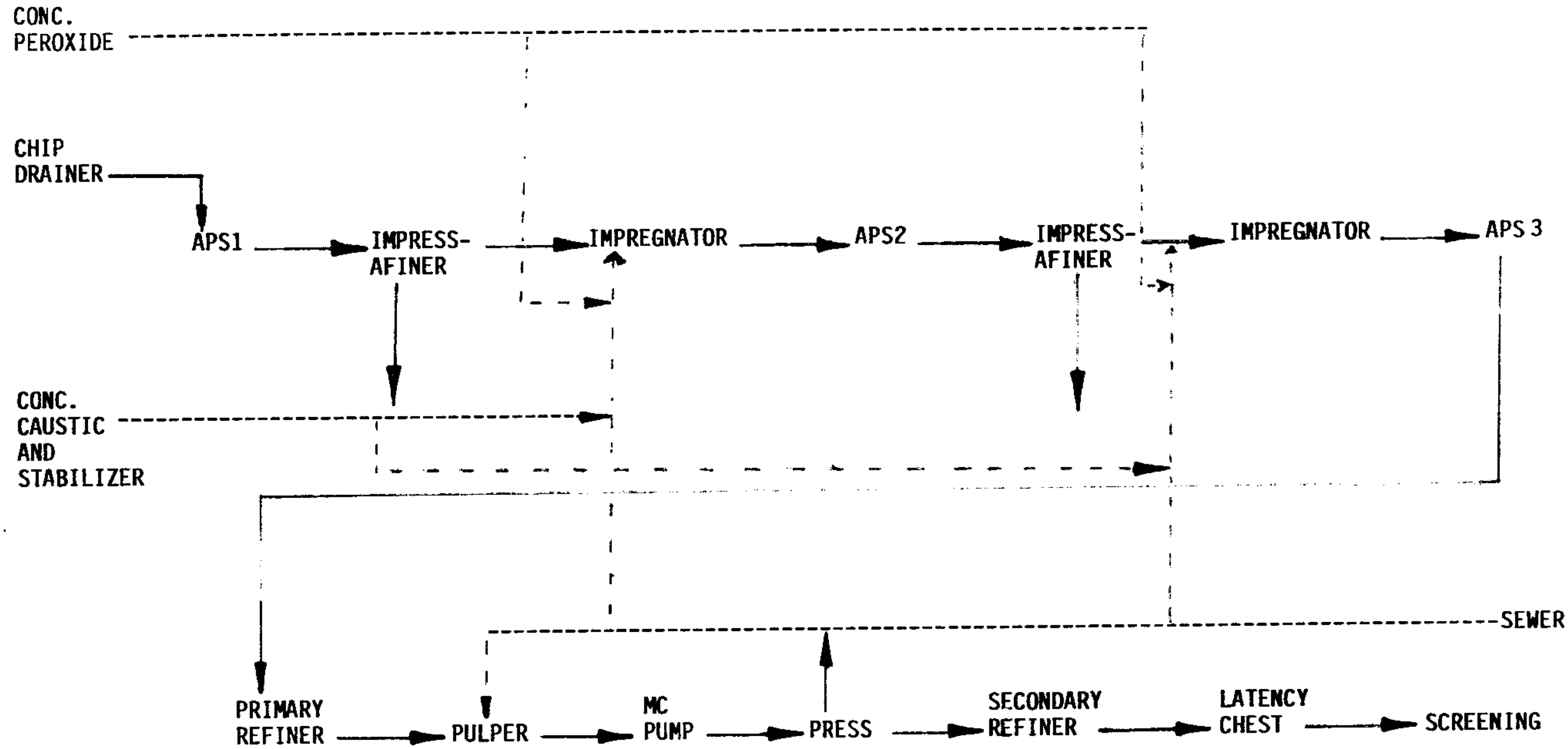

FIGURE 1...APMP PROCESS FLOW

multi-stage impregnation system does not require the screening of over-thick chips.

The chip washer also begins the process of heating the wood chip. This softens up the chip as well as driving the air out of the chip mass. The chips then enter the two stage alkaline peroxide impregnation system, as can be seen in FIGURE 2. The chips are lightly steamed in an atmospheric bin immediately ahead of the Impressafiner in the design of the bin to ensure that the wood is heated uniformly to 70°C. The first stage of impregnation is accomplished with the Impressafiner (FIGURE 3). The Impressafiner is a rugged duty, high-compression screw device that initially squeezes the water and water soluble materials from the steamed chips.

The 4:1 compression ratio and the interrupted flight design of the Impressafiner allows for a more uniform and slightly macerated chip mass to be introduced into the first-stage liquor. The chips are generally pressed to a 60% solids level before contacting the liquor. The consistency after the chemical is added will range from 30% to 35% solids. The first stage liquor consists of a mixture of DTPA and residual caustic and peroxide. This residual chemical comes from the inter-stage washing of the pulp after the primary refiner.

The impregnated chips are allowed to steep in a 10-minute atmospheric bin which is equipped with the usual steaming arrangement to allow uniform temperature control. From here the chips are sent to the second stage of impregnation, where the main pulping and bleaching chemicals are applied. The second-stage impregnation also uses the Impressafiner which squeezes out the chips that have been chelated and alkali extracted, thus reducing the amount of wood constituents that have been identified as inhibitors to bleaching reactions. The effluent from this stage will contain 25% to 35% of the BOD and COD generated by the process.

The second impregnation stage applies the caustic, which is necessary for strength development, and peroxide for bleaching the pulp. The peroxide liquor is stabilized with DTPA, and sodium silicate -- the latter at a low level to minimize any plate scaling problems. From this stage the chips are again allowed to steep for up to 60 minutes in an atmospheric bin. This allows the pulping and bleaching reactions to proceed, but not to completion as it is necessary to maintain a residual through the primary stage of refining. The combination of thorough penetrations of the chemicals, high consistency, and uniform temperature provides the ideal conditions for bleaching. The absence of sulfites, resins, and an atmospherically-heated lignin combines to help to achieve a superior bleach response, as good as the response from a conventional two-stage high efficiency bleach plant.

After reacting, the chips are fed to an atmospheric discharge refiner where 400 to 500 kWh/ADMT are applied at high consistency. The refiner acts like a high speed mixer/reactor completing the pulping and bleaching reactions. Again care must be exercised to either neutralize the residual caustic or maintain a sufficient peroxide charge to prevent darkening of the pulp. To achieve the highest strength and lowest energy consumption, the amount of caustic is increased. The brightness level is controlled by the addition rate of the peroxide. Any combination of chemicals is possible, hence a wide range of pulp types can be produced. Since no bleach plant is required, the time between grade changes is dramatically reduced compared to a conventional CTMP system.

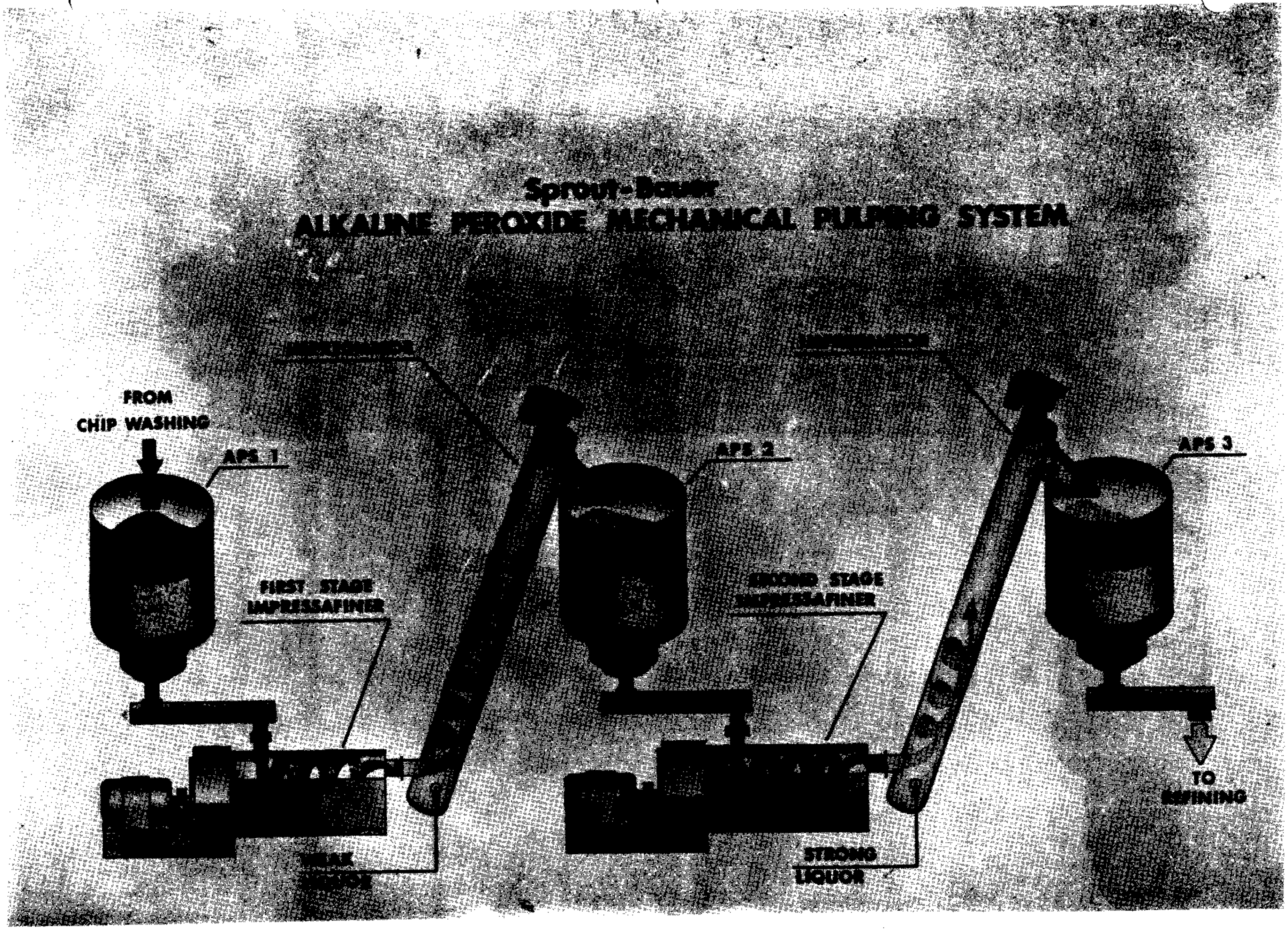
Sprout-Bauer
ALKALINE PEROXIDE MECHANICAL PULPING SYSTEM
FROM
CHIP WASHING
APS 1
APS 2
APS 3
FIRST STAGE
IMPRESSAFINER
SECOND STAGE
IMPRESSAFINER
STRONG
LIQUOR
TO
REFINING

FIGURE 2

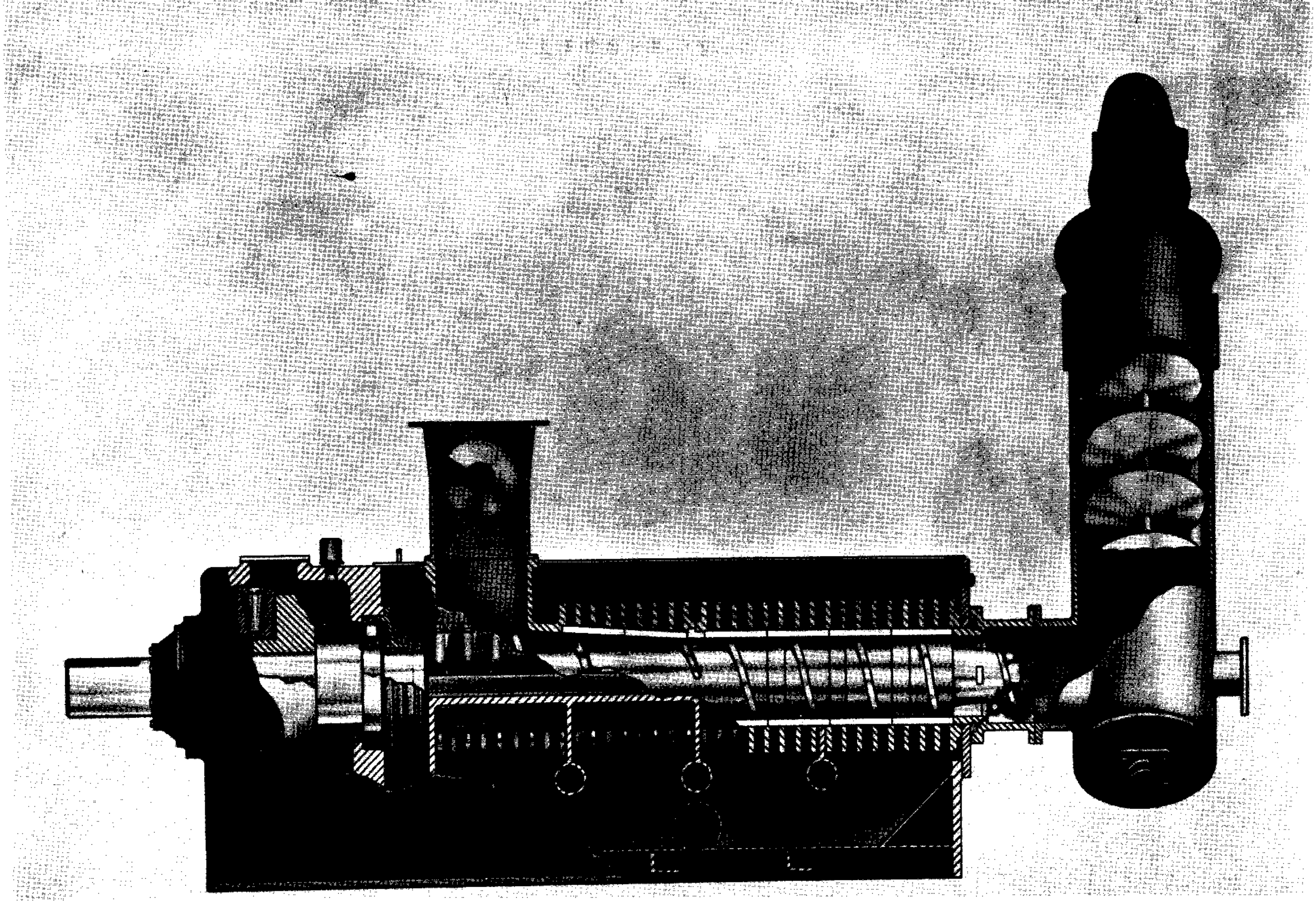

FIGURE 3

This reduces off quality pulp production and improves the operating economics of the mill.

The stock discharges into a chest where the neutralization of the caustic can be completed if desired before washing. A better process flow simply dilutes the stock with both white-water and wash press filtrate to generate a peroxide/caustic residual that can be used in the first stage of impregnation. The stock is pressed in dewatering screw presses to wash the pulp before the high consistency second-stage refiner. The washing is also necessary from a pulp quality standpoint since the high charge of caustic in the pulp can make the refining process more prone to fiber cutting than fiber development. The addition of MC washing will further improve the economics of the process by increasing the concentration of the residual chemicals in the wash water stream. This chemically-rich water can then be used to provide the dilution in the impregnators.

The secondary refiner is sized to apply 800 to 1200 kWh/ADMT to the pulp. From here, the stock goes to a latency chest followed by screening and thickening on a disc filter. The rejects are refined separately. Provision can be made to apply a small amount of alkaline peroxide liquor to the rejects before reifning to improve pulp quality.

RESULTS AND DISCUSSION

ASPEN APMP

Aspen BCTMP has been a very successful grade. It has found application in the printing and writing paper grades because of high brightness, good opacity, and adequate strength. Producing APMP from aspen also results in superior brightness and strength properties, at a fraction of the cost of BCTMP.

A series of trials were conducted at the Sprout-Bauer Pilot Plant using fresh aspen to study the effects of varying the two main process parameters in the APMP process -- the charges of peroxide and caustic. In these trials, first the level of caustic was varied from 2.0% to 7.5% with a fixed peroxide charge. The next set of trials held the caustic charge at a constant level, while the addition rate of the peroxide was varied. In the trials where the caustic charge was varied, a CTMP and a TMP baseline were also made to allow for a full comparison of the alkaline peroxide pulps. The CTMP was bleached since it is known that low density hardwoods can be made significantly stronger during the bleach stage. TABLE I contains the operating variables used in the analysis of the effect of the caustic charge on pulp quality.

PULP	TMP	CTMP	APMP	APMP	APMP
CHEMICAL APPLIED					
% sulfite		1.4			
% caustic		1.8	3.4	5.3	8.1
% peroxide			4.2	4.3	4.3

TABLE I. Aspen pulping conditions

As would be expected, the strength of the pulp from the APMP process is dependent upon the amount of caustic used in the pre-treatment stage of the process. As the amount of caustic increases, so does the bonding strength of the fiber. In addition, there is an increase in the tear strength due to the liberation of more intact fibers. When the APMP fiber is compared to the TMP or CTMP pulps, the advantage of the pre-treatment steps can be easily observed. FIGURE 4 shows that the energy consumption for APMP can be significantly lower than CTMP. The reduction in the energy consumption will depend on the amount of caustic that is applied. While this same effect will occur in a more traditional CTMP system, the amount of caustic that can be applied is limited by the ability of sulfite to prevent the alkaline darkening of the pulp. With peroxide, the brightness will increase to levels typical for a fully bleached BCTMP. This feature of the APMP process allows for significantly reduced energy costs as compared to the CTMP or TMP processes, in some cases, by as much as 30%.

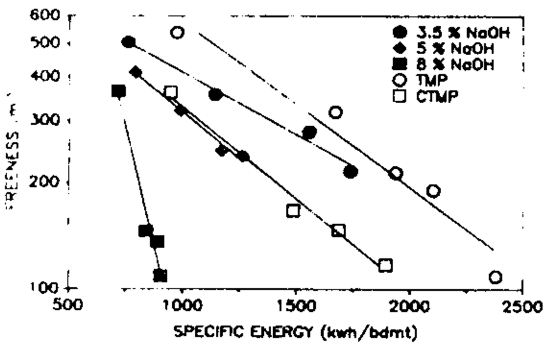

FIGURE 4: ASPEN APMP
EFFECT OF CAUSTIC ON THE
ENERGY CONSUMPTION.

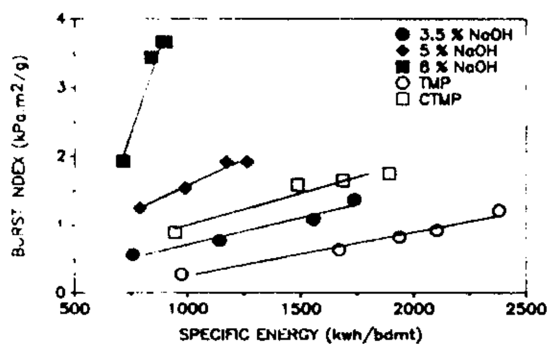

FIGURE 5: ASPEN APMP
EFFECT OF CAUSTIC ON THE
BONDING STRENGTH.

As FIGURES 5 and 6 show, increasing the caustic charge will result in substantial improvements in bonding strength and density. In fact, the levels of strength can be very similar to hardwood kraft, thus an APMP made with 5% to 8% caustic could be used in printing and writing grades.

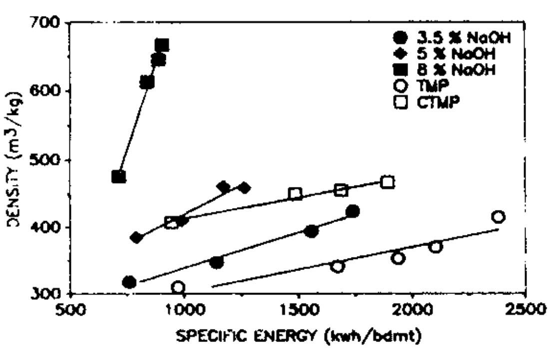

FIGURE 6: ASPEN APMP
EFFECT OF CAUSTIC ON THE
HANDSHEET DENSITY

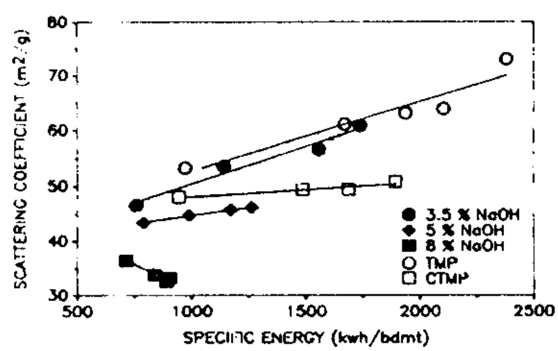

FIGURE 7: ASPEN APMP
EFFECT OF CAUSTIC ON THE
LIGHT SCATTERING COEFICIENT.

The problem with the use of high levels of chemical is usually a loss of opacity. As FIGURE 7 shows, the addition of 3.5% caustic actually results in a rather small loss of scattering surface. As the chemical charge increases, the generation of surface area diminishes with the transition point between a mechanical and chemical pulp occurring at the 5% caustic level. Producing CTMP is seen to start-off with a significantly lower light scattering coefficient, thus bleached, the BCTMP will have a lower opacity.

Finally, the relation of tear and tensile can be seen to be dependent on the amount of chemical applied (FIGURE 8), with the 5% to 8% caustic charges producing more long fiber even as the bonding strength increases. In contrast, once standard CTMP is produced, the tear strength of the pulp will not improve and will, in fact, decrease as the bonding strength is increased during the bleaching sequence.

The brightness of the pulp as it discharges from the secondary refiner will be dependent on the amount of peroxide applied in the impregnation stage. FIGURE 9 shows how the efficiency of brightening reactions in the APMP process is similar to the response expected from a modern high consistency bleaching system. Brightnesses of 84% to 85% with aspen are economically achievable with 3.5% to 4.5% peroxide applied. With the use of recycled peroxide in the impregnators, the actual fresh makeup chemical can be reduced 0.25% to 0.4% peroxide.

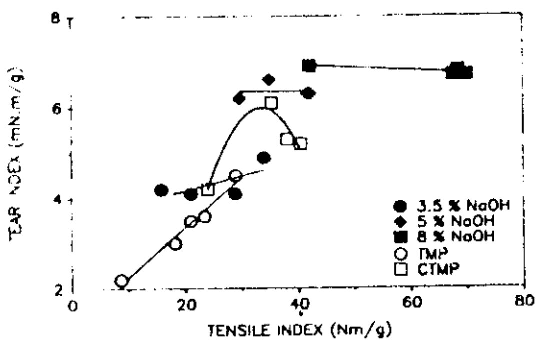

FIGURE 8: ASPEN APMP
TEAR VERSUS TENSILE

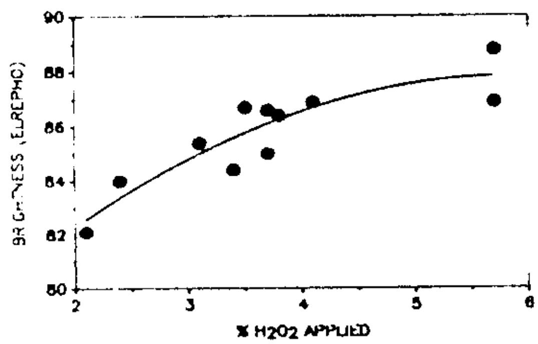

FIGURE 9: ASPEN APMP
BRIGHTENING RESPONSE

To make a final comparison of the APMP process to the BCTMP technology, the impact on CTMP quality during the bleaching sequence must be analyzed. In this experiment, another aspen CTMP was prepared and bleached in a single-stage at 25% consistency after a thorough washing. The bleaching conditions used and the results of the physical tests are shown in TABLE II. In order to compare properly, an aspen APMP was made with the same <u>total</u> peroxide and caustic charge applied as the BCTMP.

Bleaching the aspen CTMP will increase the strength of the pulp substantially due to the 4% of caustic in the bleach liquor, and as the comparison shows in TABLE II, when the same chemical charges are used, the pulp quality will be equivalent. The major difference between APMP and BCTMP is the absence of the bleach plant to achieve a fully bleached pulp. From an operating standpoint, APMP will also be less costly since the use of all of the caustic in the pre-treatment of the chips allows for a reduced energy consumption. In this case, a 35% reduction in the energy requirement was observed for APMP relative to BCTMP.

PULP	BCTMP	APMP
CHEMICAL APPLIED		
% sulfite	1.4	
% caustic	1.8/4.3	5.8
% peroxide	4.0	4.0
ENERGY (kWh/ADMT)	1715	1220
FREENESS	77	77
DENSITY	555	558
BURST INDEX	2.9	3.0
TEAR INDEX	6.3	6.3
TENSILE INDEX	58	60
BRIGHTNESS	82.8	83.5
OPACITY	80	81.8
LIGHT SCATT. COEFFICIENT	39	43

TABLE II. Effect of bleaching aspen CTMP vs. APMP

BLACK SPRUCE APMP

As with aspen, APMP, BCTMP and TMP were produced at the Sprout-Bauer Pilot Plant from black spruce. Standard CTMP from spruce was produced with 1.0% sodium sulfite and APMP from the same wood with 4.7% peroxide and 5.4% caustic. We chose the high level of peroxide in order to allow a comparison of bleached CTMP to the fully bleached APMP. After pulping, the CTMP was bleached in one stage at high consistency with 5% peroxide. The process conditions used to produce and (in the case of CTMP), bleach the pulps. This information is found in TABLE III. TMP was also produced using conventional steaming conditions. All samples of pulp were tested according to TAPPI standards.

PROCESS TYPE	APMP	BCTMP
CHIP PRE-TREATMENT		
% DTPA	0.2	0.2
% sulfite	-	1.0
% peroxide	1 / 3.7	-
% NaOH	3.3 / 2.0	-
% silicate	1 / 1	-
% Epsom salt	0.1 / 0.1	-
PRE-HEATING	45 MINS. @ 70 C	5 MINS. @ 120 C
BLEACHING		
% DTPA	-	0.1
% peroxide	-	5.1
% NaOH	-	4.8
% silicate	-	3.0
% Epsom salt	-	0.1

TABLE III. Pulping and bleaching conditions for black spruce

The pulp testing results are shown in TABLE IV.

PULP	CTMP UNBL	CTMP BL	APMP
BRIGHTNESS	62	80	80
FREENESS	255	245	244
DENSITY	380	445	457
BURST INDEX	2.6	3.4	3.2
TEAR INDEX	10.8	9.9	9.7
TENSILE INDEX	48	57	56
SCATT. COEFFICIENT	52	47	50
SHIVES (0.004")	0.6	0.6	0.1
+28 MESH (%)	50	50	50
-200 MESH (%)	20	20	17
YIELD (%)	92	88	87
ENERGY (kWh/ADMT)	1700	1700	1700

TABLE IV. APMP vs. BCTMP on a fully bleached basis

It can be seen that the APMP produced equivalent strength and brightness properties compared to BCTMP. The APMP has superior light scattering coefficient and shive characteristics at an equal energy input, though. While the amount of sodium sulfite applied can be increased for the BCTMP to improve strength, the amount of sodium hydroxide applied in APMP can also be increased to improve strength. Therefore, a high quality APMP can be produced from black spruce that will be competitive with BCTMP in pulp properties.

ASPEN/BLACK SPRUCE BLENDS

Sine APMP can be used with aspen and black spruce with equal success, it was decided to examine various blends of these species to determine the effect of species mix on the pulp properties. Each furnish had roughly 4% hydrogen peroxide and 5% sodium hydroxide applied in the impregnation system. The pulp testing results are shown in TABLE V.

% ASPEN	100	75	50	25
% SPRUCE	0	25	50	75
CSF	200	200	200	200
ENERGY (kWh/MT)	1200	1250	1600	1760
DENSITY	400	427	449	494
TENSILE INDEX	27.4	31.5	42.7	53.2
TEAR INDEX	3.9	6.0	8.1	10.1
SCATT. COEFFICIENT	55.0	53.6	52.0	49.5
BRIGHTNESS	84.7	83.0	82.2	82.2

TABLE V. Effect of species mix

It is not surprising that as the amount of the spruce increases in the furnish, the strength properties increase and the optical properties decrease. Specific energy requirements also increased with the addition of more spruce. What is somewhat surprising is that the relationship between pulp properties and the percentage of spruce in the furnish is strongly linear. The regression coefficient for many of these properties is ± 0.98 or greater. This suggests that spruce and aspen can be processed together in an APMP system, and that separate lines for each furnish may not be necessary for certain products.

SUMMARY AND CONCLUSIONS

By combining the pulping and bleaching sequences into a single operation, the BCTMP process can be simplified. In the APMP process, chips can be fully bleached and the strength fully developed at the discharge of the secondary refiner, thus eliminating the need for a separate bleaching system. The heart of this development is the ability to achieve perfect impregnation of the chips with the peroxide/caustic liquor by means of the Impressafiner. The Impressafiner is a rugged design screw press that can squeeze out high levels of resins and water soluble materials from the chips. By configuring the chip pre-treatment step in a two-stage sequence, the chips can be stripped of the materials that limit the bleach response of the wood, thus allowing for the production of a fully bleached chip/pulp.

The APMP process has been demonstrated to produce pulp similar in all respects to what is experienced today in BCTMP mills from both hardwoods and softwoods at the same levels of chemical usage. In addition, the use of more caustic on the chips prior to refining reduces the energy consumption required to achieve the desired fiber properties. In some cases, this energy consumption approaches 40%.

BCTMP has gained in acceptance as a first class fiber resource. APMP offers all of the quality of BCTMP at a fraction of the capital and operating cost.

ACKNOWLEDGEMENTS

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