Abstract
Technologies involved in chemical mechanical pulping of hardwoods have undergone some significant developments for the last decade. This paper gives a review on those developments, with main focus on the latest technology, P-RC APMP process. This latest technology itself has been developed into different options for different raw materials and for different applications. The fundamental concept behind the technology, however, has remained the same, that is, alternation of alkali peroxide chemical treatment and refining. It typically has four process steps, in an order of “alkali peroxide treatment + refining + alkali peroxide treatment + refining”. By alternating the alkali peroxide treatment and refining, a best synergy may be achieved between the two. Different variations based this basic concept, together with their applications in different industrial situations and results from commercial operations are presented and discussed in this paper. P-RC APMP is capable of converting eucalyptus woods into a wide range of pulp grades for different applications. Results from commercial operation were in general consistent with results published earlier from pilot trial investigations. As process effluent treatment has become a more and more important issue in the industry, different effluent treatment methods have also been developed in the industry. Among them, mechanical vapor recompression, (MVR), technology has been successful in recent commercial applications, and is briefly introduced in the paper. In recent years, eucalyptus woods have played more and more important role in hardwood chemical mechanical pulps, and the trend is likely to continue for years to come.

Keywords: eucalyptus; hardwoods; pulping process; CMP; P-RC APMP; BCTMP; pulp utilizations.

Introduction
High yield chemical mechanical pulp production from hardwoods has seen steady increase for the last decade. Some of the reasons behind this trend are

- This type of pulping line can be as small as 50-100t/d, or as large as 1000t/d, and has relatively lower capital/investment cost;
- It has relatively higher pulp yield (normally 85% or higher);
- The pulping process is very flexible, and can produce a wide range of pulp properties between pure mechanical pulp and pure chemical pulp;
- Hardwood chemical mechanical pulps provide pulp properties superior or unique to others for certain paper and paperboard applications;
- There are also synergies between chemical mechanical pulp and chemical pulps from hardwoods;
- Process technology involved in chemical mechanical pulping has improved and become more efficient.

This increase in hardwood chemical mechanical pulp production or usage, however, did not come without any challenges. To the contrary, there have been, and still are, many challenges in chemical mechanical pulping of hardwoods, such as

- Large variations in raw materials
  - Different species
  - Different wood conditions
  - Different parts of trees
- Different products from changes in market
  - Different paper grades
  - Different board grades
- Different process requirement or conditions
  - Different process chemical and water qualities
  - Environmental issues with effluent treatment
Continuous demand for low capital and low operational cost

These challenges are also a driving force for technology development of the pulping process. In the early part of the last decade, the main process technologies used in chemical mechanical pulping of hardwoods were conventional BCTMP, which uses alkali sulfite chemicals in chip pretreatment and followed by refining and post bleaching, and P-RC APMP, which uses alkali peroxide chemicals in chip pretreatment and between refining stages. Since then, there have been more installations using P-RC APMP process concept than the conventional BCTMP. More recently, even some of the people who used to promote and sale the conventional BCTMP are now promoting P-RC APMP concept, although using different names. Figure 1 illustrates different basic process steps and sequence involved in P-RC APMP and conventional BCTMP.

Figure 1. Comparison of Two Different Process Concepts

Development Of P-RC APMP Process Concept

Since P-RC APMP concept was first introduced in 1999[1], the technology has undergone some important developments for different raw materials, different pulp grades and different economic situations [2-5], although the fundamental concept remains the same: alkali peroxide (AP) pretreatment, followed by refining, and then AP chemical treatment again on the pulp before another or final refining stage. The alkali peroxide pretreatment is to soften and bleach the chips, and to help the primary refining. The interstage AP chemical treatment is where most of the chemical reactions take place for chemical-related pulp property development, such as brightness and fiber bonding properties. The refining after the interstage treatment is to control the freeness and other pulp properties to meet the final targets. By alternating the AP chemical treatment and the refining, the AP chemical helps refining use less energy and the refining helps the AP chemical distribution/reactions, an optimized synergy, therefore, can be achieved between the two. Based on this fundamental concept, development of P-RC APMP technology in recent years has been variations in each key process steps. For the AP pretreatment, it can be one, or two, or even three stages of impregnation, depending how difficult the raw material is for refining and for pulp property development. For the primary refining, it can be atmospheric or pressurized, although the latter has been the most popular choice now. For the interstage AP treatment, (or bleaching as more commonly called), it can be one high consistency (HC) stage or a combination of medium consistency (MC) and HC, or even HC and HC, depending on the extent to which the AP treatment is required, and on balance of operation cost versus investment cost. For the refining after the interstage chemical treatment, it can be either HC refining, (HCR), or low consistency refining, (LCR), or even medium consistency refining, (MCR). For the HCR, it can be either pressurized or atmospheric.

Figures 2 presents a process flow sheet from the first commercial installation of P-RC APMP at Yueyang Paper mill, which started up in 2003 [6]. It has 2-stage impregnation for chip pretreatment, followed by a pressurized primary refiner and then a HC retention tower for interstage AP chemical treatment. AP chemicals for the interstage treatment can be added either before or after the primary refiner. After the interstage AP treatment, the pulp is washed and then refined using another pressurized refiner. The secondary refined pulp is then kept in a latency chest to remove any potential latency, followed by LCR, pressurized screening and reject refining system, before thickened at disc filter and then MC storage tank. Because the system was designed for difficult poplar wood like Italian poplar and for large variation of pulp quality targets for different paper machines or products, some safety margins were applied in both its chip pretreatment capacity and refining capacity.
After the success of Yueyang P-RC APMP system, a more simplified design was developed for hardwoods that are relatively easy to process. In this case, one stage impregnation system was used for AP pretreatment, and an atmospheric refiner was used for secondary refining. An example of this kind of design is presented in Figure 3.

To further reduce energy consumption, after extensive pilot plant and commercial investigation[3,7], LCR was introduced at the secondary refining position for some of P-RC APMP commercial systems. Figure 4 shows an example of this option, where a single stage AP chemical pretreatment was also used. This design is particularly suitable for paperboard grade and for the wood furnish that is relatively easy to handle. A very obvious advantage of this design is its low investment/installation cost, and low energy consumption, compared to HCR at the secondary position.

In a situation where the wood is difficult for the AP chemical pretreatment, and the refining energy consumption is important to be kept low, a 2-stage impregnation system can be combined with LCR at the
secondary refining position. An example of this is Sun Paper’s second P-RC APMP line, which was installed and successfully started up in 2009 [8]. Figure 5 shows an example of process flow sheet for this situation.

Figure 4. Example of 1-Stage Impregnation with LCR at Secondary Position

Figure 5. Example of 2-Stage Impregnation with LCR at Secondary Position

When a very high brightness target, (85% ISO or higher), is required for the final pulp, and the wood is difficult to bleach, 2-stage peroxide bleaching system can be used in the interstage. The first stage of the two can be either MC or HC, but the second stage is normally HC. This system improves the AP chemical consumption and has potential to reach higher “brightness ceiling”. Example of this is shown in Figure 6.

Trends In Chemical Mechanical Pulping Of Hardwoods

Due to the general global economic situation and development trend, more and more of investments and new projects in pulp and paper industry have moved to Asia, particular China, and South America. Along with this trend has been a shift of hardwood raw material base from traditional northern hardwoods, like poplar/aspen and birch, to more and more tropical hardwoods like eucalyptus and acacia. Those tropical hardwoods typically have shorter mature-age (faster growing rate) and higher density than their northern counterparts. Consequently, they are relatively cheaper to grow and give higher yield per a given land and per year. On the other hand, those tropical hardwoods are mostly darker and more difficult to process in chemical mechanical pulping. This trend is one of the reasons why different variations of P-RC APMP technology have been developed, as discussed above.
Another trend in the industry has been on pulp application side. As printing media has been facing, and continue to face, tougher and tougher competition from electronic media, more and more hardwood chemical mechanical pulps have found their applications in paperboard production than printing and writing (P/W) grades. This shift between paperboard and P/W grades happens not only in developed countries in North America and Europe, but countries in Asia as well. In China, there have been more projects for paperboard grade than P/W grade in recent years. Higher bulk from chemical mechanical pulp, compared against chemical pulp from the same hardwood, is also a factor to this trend.

As environment issues are gaining more and more public and political attention worldwide, like any other industry, regulations on effluent discharge in pulp and paper industry will only become more and more restrictive. In dealing with this situation, there are a number of technologies available for chemical mechanical pulping industry. One of them is zero water effluent system that concentrates and evaporates the effluent.
and recovers clean water back to the system. This may be more expensive than some of conventional methods, but eliminates all problems associate with water effluent, since it does not discharge any water effluent out from the mill site. There are also several different variations in conventional effluent treatment to reduce the effluent COD/BOD to acceptable levels. They consist typically of primary, (mostly anaerobic), secondary, and tertiary stages. For a pulp mill that already has a kraft pulping system, there is, however, a relatively cost effective and easy method to handle the effluent: using mechanical vapor recompression (MVR) system to evaporate and concentrate the effluent and then send the concentrated liquor to the recovery system at the kraft pulping line. Successful installation and operation of such system have been reported from China [9] and Brazil [10]. Figure 7 shows an example of MVR system. It typically can concentrate effluent from 1.5% to 15% solid.

All the above trends strongly influence, if not dictate, the trend of hardwood mechanical pulping technology development. For this, the pulping process development has been and will continue to be on

- more flexible in handling different wood sources and in producing different pulp grades
- more efficient in water usage (more efficient washing)
- less operational cost (energy and chemicals)

Figure 8. Comparison of Eucalyptus Pulps from Different Pulping Processes

![Figure 8. Comparison of Eucalyptus Pulps from Different Pulping Processes](image)

Figure 9. Comparison of Eucalyptus P-RC APMP and Other HWD BCTMP Pulps

![Figure 9. Comparison of Eucalyptus P-RC APMP and Other HWD BCTMP Pulps](image)
Eucalyptus P-RC APMP Pulps

Chemical mechanical pulping of eucalyptus woods have been investigated for many years, and there have been a number of publications from different research groups worldwide. More recent report on P-RC APMP pulps from different eucalyptus woods in South America was presented in 4th ICEP in Chile, 2009 [11]. P-RC APMP pulps from the eucalyptus woods in general have better pulp intrinsic properties, (higher bulk at the same tensile), than their kraft pulps, and BCTMP pulps from northern hardwoods like aspen and maple, as shown in Figures 8 and 9. Among the eucalyptus species investigated, e. siligna and e. grandis were the best. Figure 10 compares results from lab (pilot trials done at Andritz pilot plant) and commercial mill operations. As can be seen, the lab results reported earlier are consistent with results from mill operations.

Figure 10. Comparison of Eucalyptus APMP Pulps from Pilot Trials and Mill Operation

Because P-RC APMP process is very flexible, it can produce, from eucalyptus woods, a number of different pulp grades for applications in different paper, paperboard and tissue products. As have been reported previously [11], the eucalyptus pulps have better overall properties than both aspen BCTMP for printing/writing grades, and maple BCTMP for board grades. After many years of development, eucalyptus chemical mechanical pulps have now been used in various commercial applications, including paper board, tissue and printing/writing papers. Their commercial projects and capacity has increased significantly in recent years. Two largest eucalyptus chemical mechanical pulp lines had just been successfully started up in China late last year, with a capacity of more than 750t/d on each line. They were both designed based on P-RC APMP technology.

Summary

Under basic P-RC APMP concept, (AP pretreatment → refining → AP treatment → Refining), a number of different system designs have been developed to meet challenges in the industry and for different commercial or economic situations. Most of those designs are already proven in commercial operations. As the industry moves towards more diversified hardwood resources, wider range of paper/paperboard products and tougher effluent regulation, the pulping process development will also have to be in the direction of being more flexible and more efficient. With fast growth rate (high wood yield) and superior pulp properties, eucalyptus woods will play more and more important role in chemical mechanical pulp industry, as has already been evidenced by significant increase in their commercial installations and capacity in recent years.

References


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