# A Comparative Investigation on Alkaline Peroxide Mechanical Pulp of Poplar Fast-Growing Clones and a Native Species

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## ABSTRACT

The conventional pulping processes in Iran were reviewed in this paper. On account of forest resources restriction, a considerable extent of non-harvestable hardwood forests, the possibility of accessable non-wood resources and Poplar fast-growing species for using in pulp and paper industry was investigate. The cultivated area and abundance of each mentioned raw material (Wheat Straw, Sugarcane Bagasse, Poplars ) were specified and the quality of their produced papers were compared in strength and opacity properties. Spruce species data was used for experiments comparisons. Regarding to environmental pollutions, low yield, inflexibility in wood and non-wood species resulted from the existent conventional processes of paper manufacturing, APMP is recommended due to high quality paper, desirable opacity properties, high yield and also the usage for all the raw materials.

## 1. A GLANCE ON PULP AND PAPER INDUSTRY IN IRAN

From the viewpoint of paper production volume and consumption, Iran is considered as a paper products importer in form of writing and printing, newsprint and corrugating medium. The general policies of government were oriented toward reducing the country 's dependence to paper imports, decreasing of currency transfer to outside of border, providing of technology transfer and correct regeneration and utilization of forests and to accomplish this task several research centers have been established titled "Center for Natural Resources Faculty", "Forestry Faculty" and etc. In the other hand, some international contracts were adjusted for transferring of this industry. The followings have had a considerable role in paper products import to Iran.

### IRAN WOOD AND PAPER INDUSTRY (CHUKA)

Iran Wood and Paper Complex is located in Gilan province in the north west of Rasht in the vicinity of forests and Caspian Sea. The original mill was founded in 1973 in the area of 100 hectares and in 1978 the trial start-up was initiated. The nominal capacity of the integrated pulp and paper mill is 374 tons of liner or 474 tons of fluting pulp, and also 500 of liner, fluting and board, or 385 tons of wrapping paper. The pulp stock consists of 80% local hardwoods and 20% purchased softwoods. Sulfate processes (Kraft) is used for manufacturing of pulp.

### PARS PAPER MANUFACTURING FACTORIES

Pars factory is located in Khorasan province in Hafttapeh. In 1975 the trial start-up was initiated the nominal capacity of paper mill is 75000 tons writing and printing paper. The pulp stock consists of one of the non-wood plants so-called Bagasses (Sugarcane residue). Soda process is used for the manufacturing of pulp.

### MAZANDARAN WOOD AND PAPER INDUSTRY

MWPI is located in Mazandaran province in the vicinity of Sari. The nominal capacity of this factory is 52000 tons newsprint paper annually (276 tons per day) and 38000 tons writing and printing paper (241 tons per day). As designed the pulp stock consists of Hornbeam and Toska harvested from Mazandaran forests. Two separate manufacturing lines have been adjusted in this plant called "CMP" for production of writing and printing paper and "NSSC" for newsprint paper production. The paper machines are "Twin-Wire" and "Fourdriner", respectively.

### KAGHAZ GHARB FACTORY

KGF is located in Kermanshah province in Kermanshah town. This factory is now under construction but the estimated start-up of the plant is in the late 2002. The nominal capacity of the unit is 50000 tons writing and printing paper. Considering the sort of process, Poplars have been adopted as the best raw materials. APMP is used to prepare the product.

### MARAGHE PULP AND PAPER FACTORY

MPPF is located in east Azarbayejan province in Mraghe city. This factory is now under construction but the estimated start-up of the plant is in the early 2003. The

nominal capacity of the plant is 50000 tons writing and printing paper. The pulp stock is manufactured from poplars and APMP is used to provide the product.

### SMALL-SCALE PAPER MANUFACTURING PLANTS

In 1997, 36 small-scale plants of Soda process were established in all over the country. The considerable amount of raw material used in the process was Wheat Straw from which the produced pulp could be only used in form of combination with other fibers. Some few plants are now working with secondary fibers. As a whole, on account of low quality of products, old and weak technology, lack of specialty and few numbers play a minor role in fulfilling the demand of society.

## 2. GLANCE ON PAPER PRODUCTION PROCESSES

### SODA

This method is classified in completely chemical processes. The main chemical material in Soda is NaOH, which is lignin degradation agent and convert it into small molecules.

Nowadays, this is most popular process for paper production from non-wood fibers in Iran. The pulp yield of this process is 45-55%. The produced pulp from this process for Spruce have 20.0 and 23.3% brightness in 48.2 and 57.8% yields, respectively. Burst index, breaking length, tear index for each yield are 82 and 90; 9.85 and 11.2 km; 99 and 111 mN2m/g, respectively. Due to the process system and the quality of produced liquor, recovery of chemicals is not completely feasible. Considering the above data, the advantages and disadvantages of this pulping method are as follow:

1-High strength paper
2-Flexibility of the process for wood and non-wood species
3-Tree bark tolerance

Disadvantages:

1-Lack of technology in chemicals recovery and since the high BOD and COD of factory effluent and wastewater
2-Low brightness of pulp
3-High capital investment in spite of simple process
4-Low yield

### SULFATE (KRAFT)

Soda promoted process in which Sodium Sulfide (Na2s) is used along with NaoH. The yield is 40-50%. The produced pulp from this process for Spruce have 18.6 and 28.7% brightness in 55.1 and 44.7% yields, respectively. Burst index, breaking length, and tear index for each yield are 103 and 112; 12.4 and 12.9; 100 and 117, respectively.

The advantages are:

1-requirement of complex bleaching processes due to pulp low brightness
2-Undesirable and bad odor of sulfur in cooking liquor
3-High BOD and COD of factory effluent

### NEUREAL SULFITE SEMICHEMICAL

A semi-chemical process using Sodium Sulfite cooking specially used for hardwoods. The yield is 65-80%. The produced pulp from this process for Spruce have 51.8 and 50.3% brightness in 79.2 and 79.7 yields, respectively. Burst index, breaking length, tear index for each yield are 65 and 92; 9.8 and 12.5 km; 61 and 68.

Advantages:

1-High yield
2-Production of suitable pulp for corrugating medium
3-Suitable for treatment of short fiber hardwoods
4-An acceptable strength of produced paper

Disadvantages:

1-Wasting a great deal of chemicals in factory wastewater
2-High environmental pollutions
3-A complex recovery system in comparison with Kraft

### SEMI-MECHANICAL PROCESSES

#### a-CMP

This process is classified in semi- mechanical processes. In this pulping method, chips are pretreated with Sodium Sulfite or Sodium Hydroxide. The minimal yield of this process is 85%. CTMP is also comparable to CMP in two refining stages but the first refining stage is experimented in 100 °c under pressure. The strength of semi-mechanical papers fell down between mechanical papers such as SGW and chemical papers such as KRAFT. Brightness, burst index, tear index of Spruce are 60%, 2.3 kpam2/g, and 9 mNm2/g, respectively.

#### b-APMP

Regarding the problems of traditional pulping processes such as low yield pulps, high capital investment, environmental impacts, restricted flexibility in pulp property development and also the limited raw materials resources, new pulping methods have been suggested to overcome the mentioned barriers. In terms of process design and post pulping bleachability, only CTMP and APMP are suitable. The APMP process was first introduced at the 1989 International Mechanical Pulping Conference. Since then, a number of studies have been reported from the Andritz Pilot Plant on characteristics of this process and how it compares to CTMP and pre-bleached CTMP, and its application to various raw materials.

APMP pulp mills have been successfully started up at Malette, Quebec, and at Yalujiang Paper Mill, Dandong, People's of Republic China. These mills have demonstrated a high flexibility in processing different types of wood on a commercial scale. They have also demonstrated that the energy consumption is likely to be lower than that of other processes and that the pulp quality is likely to be higher.

Generally, APMP is used most favorably for two special areas in high-yield pulping. One area involves high brightness pulp grades when peroxide bleaching is necessary. The other involves a specific hardwood species for which caustic pretreatment is needed to

reduce energy consumption and, more importantly, to obtain acceptable pulp strength.
In the area of achieving high brightness with peroxide bleaching a certain amount of sodium hydroxide has to applied. In the APMP process, both sodium hydroxide (NaOH) and hydrogen peroxide (H2O2) are applied prior to refining. Not only does the sodium hydroxide function as a necessary component of bleaching reagents, but it also softens the fiber. As a result, the refining energy is reduced, and the pulp is improved by having greater strength and lower shives content.
In this way, the chemical potential of sodium hydroxide is realized more fully, and the long fiber content is better preserved. In some cases, especially for hardwoods, bleaching with alkaline peroxide after pulping is completed does improve strength properties. However, the gain is generally less than that observed from the same bleaching treatment prior to refining. There are several advantages to using the APMP process. One is that the chips are bleached instead of the pulp. Pulp often suffers from darkening reactions caused by the thermal and refining processes (TMP, CTMP) and from darkening reactions caused by alkali in conventional alkaline CTMP. Another advantage is that the darkening reactions can be minimized throughout the refining process when the ratio of NaOH to H2O2 is properly adjusted.
The brightness, burst index, and tear index of produced pulp from this process are 64.7%, 2.5 kpam2/g, and 102 mNm2 /g, respectively.
Advantages:
1-High yield
2-Desirable opacity and brightness of pulp for writing and printing usages
3-High flexibility
4-Low capital investment
Disadvantages:
In comparison with all the conventional processes used for paper manufacturing in the world, APMP contains minimum disadvantages and maximum advantages.

The objective of this review is to investigate the potential of the existence Iranian raw materials resources for Chemical Mechanical Pulping. The abundant resources to be considered in this survey are Straw, Bagasse, and Poplars. It should be noted that two high capacity factories are under construction in Kermanshah and West Azarbayjan provinces.

## 3. GLANCE ON IRAN 'S RAW MATERIALS FOR PAPERMAKING

### STRAW

**Straw (*Triticum spp)***

Wheat exceeds in acreage and production every other grain crop (including rice, maize, etc.) and is, therefore, the most important cereal grain crop of the world. The wheat acreage in 1986 on a world wide basis was estimated to be 230 million ha, giving a production of 520 million tones with an average of above 22 quintals of grain per ha.
Wheat Straw has been used for pulp and paper production for a long time and remains one of the major raw materials in many developing countries. To date, almost all of the commercial straw pulping processes are based on chemical pulping technology. However, the Silica content of the fibers is a serious problem, because the Silica makes it difficult to recover the pulping materials. In 1996, the total area of wheat cultivation has been estimated 6807258 hec in which the Khorasan province has taken the first rank. The harvested straw has been estimated 5316175 ton from which several purposes have been obtained. The possibility of developing a wheat straw APMP process to produce bleachable pulps for printing-grade papers have been developed by Dr. George Pan who his experiments have been summarized as follow.

**Experimental procedures**

The cut wheat straw was washed with hot water in the presence or absence of DTPA. Chemical impragnation was conducted in polyethylene bags, with approximately 10 g of wheat straw used in each trial.
The concentration of hydrogen peroxide was determined iodometrically. A 91 cm Atmospheric Double Disc Refiner was used for refining. Handsheets were prepared by TAPPI method T-218.

**Results**

There was a linear correlation between the tensile and handsheet density and the correlation was independent of the chemical charges and the refining energies. At a given density, straw APMP had a higher tensile index, by about 10 N.m/g tensile index, or breaking length of more than 6 km, was reached from the straw APMP pulp.
The results from the present investigation have shown that the straw pulps have:

1) A better tensile/density or bulk/tensile property than Aspen APMP pulps;
2) Strenght properties comparable to, or better than most hardwood market BCTMP pulps
3) Significantly higher light scattering than Aspen APMP pulps;
4) A similar intrinsic light scattering property as kenaf APMP pulps, but a better tensile/density property.

Straw may be easily APMP-bleached to 70% ISO or higher brightness without post-bleaching. Comparison Aspen APMP or market BCTMP pulps suggest that the straw APMP has a good potential for applications such as printing/writing, tissue and paperboard grades.

### BAGASSE (SACCHARUM)

The first mechanical process used for Bagasse was along with mechanical refining and hydrolysis in 3 atmospheric pressure in 10% caustic soda following washing and bleaching processes. In this method 6 kg Bagasse was

utilized for production of 1 kg pulp. After that time, the mechanical processes for Bagasse specially CTMP and APMP are still developing.

| Characteristics | Bagasse containing pith (%) | Bagasse without pith (%) |
|---|---|---|
| Celloluse | 49.6 | 54.2 |
| Pentozan | 23.2 | 23.0 |
| Lignin | 20.2 | 21.4 |
| Ash | 4.3 | 0.7 |
| Fiber Content | 67.2 | 84 |
| Brightness | 46 | 48 |
| Solubility in Benzen | 2.5 | 1.6 |

Nowadays, 800 ha of Khozestan provice aresuitable for sugercane cultivation which result in 3 million annual pulp production.

Table1. Anuual collectable yields of various non-wood plant fibrous raw materials

| Raw material | Collectable raw material (ton/ha) | Bleached pulp production (ton/ha) |
|---|---|---|
| Wheat Straw | 2.2-3 | 0.7-1 |
| Bagasse | 5-12.4 | 1.7-4.2 |
| Rice Straw | 1.4-2 | 0.4-0.6 |
| Barly Straw | 1.4-1.5 | 0.4-0.5 |
| Oat Straw | 1.4-1.5 | 0.4-0.5 |
| Rye Straw | 2.5-3.5 | 0.8-1 |

Table2. Total production of various non-woody plant fiber source

| Raw material | Total available potential in the world (ton) |
|---|---|
| Wheat Straw | 570000000 |
| Rice Straw | 320000000 |
| Oat Straw | 60000000 |
| Barley Straw | 150000000 |
| Rye Straw | 40000000 |
| Bagasse | 75000000 |