A Study on Production of Pulp from Ground Nut Shells

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Abstract— In recent years, with the growing shortage of wood from the forest, the search for alternative fibre producing plant material has been initiated in many countries of the world. The generation of fast growing high biomass yielding plant is thought to be one of the solutions to meet the shortage of cellulosic material. However, certain agricultural plants producing higher biomass are found to be suitable substitute for certain fibre based industries. Among them groundnut shells may serve partly as an alternative resource. In this project we produced pulp from waste groundnut shells using Kraft's process and Soda process, and also analyse the both process based on their yield and energy consumption.

Keywords: Ground nut Shell, Cellulosic material, Kraft's process, Soda process, Pulp.

1 INTRODUCTION

Paper is a thin material produced by pressing together moist fibers,typically cellulose pulpderived from wood, rag s or grasses, and drying them into flexible sheets. Paper is a versatile material with many uses. While the most common is for writing and printing upon, it is also widely used as a packaging material, in many cleaning products, in a number of industrial and construction processes, and even as a food ingredient – particularly in Asian cultures. Paper, and the pulp papermaking process, was said to be developed in China during the early 2nd century AD, possibly as early as the year 105 A.D., by the Han court eunuch Cai Lun, although the earliest archaeological fragments of paper derive from the 2nd century BC in China.

From then on paper is used as the major source of communication in the form of writing letters, keeping records of valuable information like books, entertaining people in the form of novels and spreading information about the daily happenings in the form of news papers, which is the major revolution in communication that ever happened in the history of mankind.

With various technologies available for production of paper, made itself use full in lots of applications. It not only has role in communication but also to large extent in packing materials (low grade paper), which is reason for selection of this project.

In view of this, several attempts were made in recent years to develop paper from agricultural wastes. This project involves not only the production of paper but the basic raw material for paper production that is pulp from groundnut shells (abundantly available on earth). The reason behind the selection of groundnut shells as raw material is, after the nuts are removed, the shells will be wasted. Tons of groundnut shells are thrown away annually.

2 PULPING

Pulping is the process of production of Pulp using wood material which is a lignocelluloses fibrous material. It is prepared by chemically or mechanically separating cellulose fibres from wood, fibre crops or waste paper.

2.1 Raw Materials

Generally, woods are two types. Hard woods and Soft woods. Wood from conifers (e.g. pine) is called softwood, and the wood from dicotyledons (usually broad-leaved trees, e.g. oak) is called hardwood. Hard woods are not necessarily hard, and softwoods are not necessarily soft. The well-known balsa (a hardwood) is actually softer than any commercial softwood. Conversely, some soft woods (e.g. yew) are harder than many hardwoods.

These woods contain basically three materials in them. They are:

- 1. Cellulose
- 2. Hemi cellulose
- 3. Lignin, and
- 4. Pectin

The cellulose present in wood is mostly in the form of fibres. The cellulose fibres are obtained as pulp after pulping process. Cellulose fibre is a long chain of single monomer $C_6H_{10}O_5$.

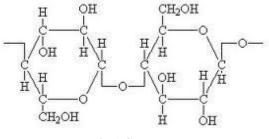


Fig.1 Cellulose

2.2 Methods of Pulping

Many processes came into existence for production of pulp from wood materials in past 2 decades. These methods work different because of the feed they take in, based on the quality of pulp obtained after the process and also based on their efficiencies.

Preparation for Pulping

Wood chipping is the act and industry of chipping wood for pulp, but also for other processed wood products and mulch. Only the heartwood and sapwood are useful for making pulp. Bark contains relatively few useful fibres and is removed and used as fuel to provide steam for use in the pulp mill. Most pulping processes require that the wood be chipped and screened to provide uniform sized chips.

2.2.1. Mechanical pulping:

Manufactured grindstones with embedded silicon carbide or aluminium oxide can be used to grind small wood logs called "bolts" to make stone pulp (SGW). If the wood is steamed prior to grinding it is known as pressure ground wood pulp (PGW). Most modern mills use chips rather than logs and ridged metal discs called refiner plates instead of grindstones. If the chips are just ground up with the plates, the pulp is called refiner mechanical pulp (RMP) and if the chips are steamed while being refined the pulp is called thermo mechanical pulp (TMP). Steam treatment significantly reduces the total energy needed to make the pulp and decreases the damage (cutting) to fibres. Mechanical pulps are used for products that require less strength, such as news print paperboards.

2.3.2. Thermo mechanical pulping:

Thermo mechanical pulp is pulp produced by processing wood chips using heat and a mechanical refining movement. It is a two stage process where the logs are first stripped of their bark and converted into small chips. These chips have a moisture content of around 25-30% and a mechanical force is applied to the wood chips in a crushing or grinding action which generates heat and water vapour and softens the lignin thus separating the individual fibres. The pulp is then screened and cleaned; any clumps of fibre are reprocessed. This process gives a high yield of fibre from the timber (around 95%) and as the lignin has not been removed, the fibres are hard and rigid.

2.3.3. Chemical pulping:

Chemical pulp is produced by combining wood chips and chemicals in large vessels known as digesters where heat and the chemicals break down the lignin, which binds the cellulose fibres together, without seriously degrading the cellulose fibres. Chemical pulp is used for materials that need to be stronger or combined with mechanical pulps to give product different characteristics.

3 MATERIALS AND CHEMICALS

3.1 Why Ground nut Shell?

Groundnut botanically known as Arachishypogeae belongs to leguminous family. It is the fourth largest oil seed produced in world and India is the second largest producer of groundnut after china. A complete seed of groundnut is called as pod and outer layer of groundnut is called shell.

Almost every part of groundnut is of commercial value. Groundnut seeds are nutritionally rich due to the presence of oil, protein, minerals, vitamins etc. As a result, it is often described as 'Poor man's Badam'. There is versatility with respect to the groundnut seed consumption, since it is consumed in raw or roasted or salted or sweetened states in Indian food preparations. Groundnut is also of value as rotation crop. As it is the plant, it improves soil nutrients, due to the presence of atmospheric nitrogen fixing bacteria in its root nodules while the dry plant parts are used as fodder. Thus, all parts of groundnut plant are fully useful.

Groundnut shell has great potential for commercial use. Groundnut shell is used as a fuel, filler in cattle feed, hard particleboard, cork substitute, activated carbon, etc. De-hulled groundnut husk is used in production of hard boards.

The groundnut shell fibres possess good physical strength properties. The higher pentosan content together with gums and mucilage in the sheath of certain species of groundnut plant may be a suitable source for producing paper. Although, reports are available on utilization of groundnut shell fibre for textile, pulp and paper making, but no reports are available developments of paper using groundnut shell fibre.

Species	Cellulose (wt%)	Hemicellulose (wt%)	Lignin (wt%)	Ash (wt%)
Pine (softwood)	40-45	25-30	26-34	
Maple (hardwood)	45-50	22-30	22-30	
Banana	63-64	19	5	
Coir	32-43	0.15-0.25	40-45	
Sisal	63-64	12	10-14	,
Jute	61-71.5	12-20.4	11.8-13	2
Kenaf	31-39	21.5	15-19	
Hemp	70.2-74.4	17.9-22.4	3.7-5.7	
Bagasse	40-46	24.5-29	12.5-20	1.5-2.4
Groundnut shell	35.7	18.7	30.2	5.9
Rice husk	31.3	24.3	14.3	23.5
Pineapple	81		12.7	

Fig 2 Groundnut Shell Fibre Properties

3.2 Chemicals

3.2.1 Sodium carbonate

Sodium carbonate, Na_2CO_3 is a sodium salt of carbonic acid. It most commonly occurs as a crystalline heptahydrate, which readily effloresces to form a white powder, the monohydrate. Sodium carbonate is domestically well known for its everyday use as a water softener. It can be extracted from the ashes of many plants. It is synthetically produced in large quantities from salt (sodium chloride) and limestone in a process known as the Solvay process.

3.2.2 Sodium Hydroxide

Sodium hydroxide, also known as lye or caustic soda, has the molecular formula NaOH and is highly caustic metallic base. It is a white solid available in pellets, flakes, granules, and as a 50% saturated solution.

Sodium hydroxide is soluble in water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon dioxide in air.

Sodium hydroxide is used in many industries, mostly as a strong chemical base inthemanufactureof pulp and paper, texti les, drinkingwater, soap sand detergents and as a drain cleaner. Worldwide production in 2004 was approximately 60 million tonnes, while demand was 51 million tonnes. Although molten sodium hydroxide possesses properties similar to those of the other forms, its high temperature comparatively limits its applications.

3.2.3 Sodium Sulphide

Sodium sulphide is the chemical compound with the formula Na₂S, or more commonly its hydrate Na₂S·9H₂O. Both are colourless water-soluble salts that give strongly alkaline solutions. When exposed to moist air, Na₂S and its hydrates emit hydrogen sulphide, which smells like rotten eggs. Some commercial samples are specified as Na₂S·xH₂O, where a weight percentage of Na2S is specified. Commonly available grades have around 60% Na₂S by weight, which means that x is around 3. Such technical grades of sodium sulphide have a yellow appearance owing to the presence of polysulphides. These grades of sodium sulphide are marketed as 'sodium sulphide flakes'. Although the solid is yellow, solutions of it are colourless.

4 EXPERIMENTAL PROCEDURE FOR PRODUCATION OF PULP (LAB SCALE)

4.1 Preparation of raw material

Initially Groundnut Shells are taken and washed several times with water to remove dust and soil particles present on it.Later it is cut into long pieces. They are crushed to remove water content and later dried at 80°C for about 30 minutes to further reduce the water content.

4.2 Kraft's Pulping

For cooking liquor to be prepared chemicals must be taken in right proportions so that effective cooking would happen. Kraft pulping consists of following chemicals-NaOH, Na_2SO_4 , and Na_2CO_3 . These three chemicals must combine to give total of 12.5% by weight solution.

In this 12.5% of solution, according to Kraft's pulping solids analysis says-

-58.6% is NaOH, -27.1% is Na₂SO₄, and -14.3% is Na₂CO₃

If we take basis as 1000 ml solution of cooking liquor, then 12.5% by weight gives 125grams which is the total weight of all three chemicals required. Compositions of solids are given by wt%. If we calculate the individual weight of chemicals required, they would give the following.

NaOH weight= $0.586 \times 125 = 73.25$ grams. Na₂SO₄ weight= $0.271 \times 125 = 33.875$ grams. Na₂CO₃ weight= $0.143 \times 125 = 17.875$ grams.

Digesting: Once the cooking liquor is prepared 400ml of it is taken separately in a 100ml beaker to which 5 grams of raw material (dried banana stem) is added and the level is marked. The reason for marking the level is described below.

Industrially, steam is used for heating purpose. There are two reasons for selecting steam as heating source:

- 1. Firstly, it would serve as the heating medium for the digester.
- 2. Secondly, once the steam exchanges heat with the cooking liquor and the raw material the water present in the cooking liquor evaporates due to increase in temperature difference. Then the initial concentration of the cooking liquor is not maintained which would result in weak cooking. So, if steam is used, it condenses into the cooking liquor after exchanging heat, there by maintaining the concentration of the cooking liquor.

Here, we do not use steam as heating source. If heat is continuously supplied the water present in the cooking liquor evaporates there by initial concentration of the cooking liquor is varied. To bring back the concentration to initial we add water up to the marked level in the beaker. This is taken care of throughout the process of digesting.

The heat is supplied by means of hot plate for about 4hr 30min at a temperature of 90°C. At the same time stirring is done continuously throughout the process.

In the process of digestion the strong basic cooking liquor and the action of heat combine and help breaking the bonds in lignin molecules. The broken lignin molecules dissolve in cooking liquor there by turning it into dark brown color called as Black liquor and cellulose remaining unaltered is present in the cooking medium as brown stock along with the traces of lignin.

4.3 Soda Pulping

In this process, 20% by weight solution of NaOH is required as cooking liquor.If we take 1000ml as basis 20% by weight gives 200grams of NaOH. These 200 grams of NaOH is dissolved in water and makeup to 1000ml to give required concentration of cooking liquor.Once the cooking liquor is prepared, 5 grams of raw material is taken in 400ml of cooking liquor in 1000ml beaker and the level is marked.The reason for the marking the level is already described above in Kraft's process. The same reason applies here too. And water must be added continuously to maintain the initial concentration of the cooking liquor and this process must be repeated entire boiling time.

IJSER © 2016 http://www.ijser.org Next, It is heated to about 90° C (boiling) for 4hr 30min with continuous stirring. But the heat is not enough as the cooking liquor is weak basic compared to Kraft process. So, it is heated for one more hour to increase the effectiveness of heat and cooking liquor in breaking the lignin molecules and dissolving in the cooking liquor.



Fig 3 Cooking

4.3 Filtration and washing of pulp

After digesting, brown stock and black liquor are formed. Brown stock contains pulp (cellulose and hemi-cellulose) and small amounts of lignin (reason for brown color).And the black liquor contains the dissolved lignin and cooking chemicals that are unconverted and can be recovered. The mixture filtered using cloth to obtain black liquor as waste that contains cooking chemicals that can be recovered. One time filtration doesn't remove the lignin traces completely. So, once the filtration is done it is again washed with water to let lignin and chemicals associated with the brown stock to dissolve in it. And, this mixture is again filtered with the cloth and this process is repeated.

It is washed several times with 1000ml of water to reduce the lignin content (about 5 times).Finally, the obtained product from the filtration must be in such a way that lignin traces must be less in amounts.

4.4 Bleaching

Once filtration and washing is completed the washed pulp is dissolved in 200ml of water to which 5grams bleaching powder is added to completely remove the brown color to obtain white paper grade pulp.



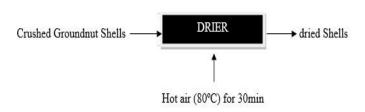
Fig 4 Bleaching 4.5 Drying

Drying is done to find the yield in both the processes. To find the yield entire water in the bleached pulp must be removed. To remove entire water content in the bleached pulp, it is dried at a temperature of 100°C for one hour in hot air oven.

5 OVERALL VIEW OF THE PROCESS

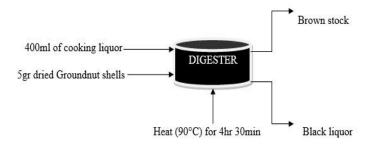
5.1 Drying

Groundnut shells after washing with water is crushed and sent into drier.



5.1 Digesting

5 grams of dried Groundnut shells are taken into beaker along with 400ml of cooking liquor and boiled for 4hr 30min at 90°C. Later brown stock and black liquor formed which are separated.



The above is the main process involved in the pulping. Once the digesting is completed brown stock is washed with water and bleached. Black liquor is sent to chemical recovery section.

6 RESULTS AND DISCUSSIONS

Firstly, describing about the heat required for digesting, Kraft process required only 4hr 30min for breaking lignin molecules. But soda process required more heat for digestion and yet could not obtain effective digestion as groundnut shell material is still present as it is in the beginning on the water cooking liquor surface.

Secondly, Kraft's process consists of strong cooking liquor which can break the lignin more effectively. Where as soda process consist of weak cooking liquor. Because of this reason we can find the traces lignin is more in Soda process than Kraft process.



Fig 5 Washed Pulp in both Kraft's & Soda Process

Product obtained after washing with water is compared in both the processes. The pulp obtained in Kraft process in less dark in colour than pulp obtained in soda process. The reason for this is, pulp obtained in Kraft process contain less lignin content in it due to strong basic nature of the solution which break the lignin effectively. Soda process involves weak basic cooking liquor that acts weak in breaking lignin bonds. At the same pulp obtained after bleaching is also compared. The pulp obtained after bleaching is observed and found that Kraft pulp is whiter in colour compared to soda process, as bleaching agent required breaking the traces of lignin is more in soda process than Kraft process.

S.No	Process	Groundnut shells taken (grams)	Pulp Produced (grams)
1	Kraft's Process	5	1.735
2	Soda Process	5	1.273

7 CONCLUSION

After experimenting and observing the entire process of operation, there are certain conclusions made and listed below. They are:

1. Though Soda process require only one chemical but in large amounts to effectively break the lignin bonds. Kraft process requires fewer amounts of different chemicals and also helps in complete lignin molecule breakage. From this we can conclude that Kraft process is more advantageous.

2. In terms of heat requirement Kraft process is more advantage, because the cooking liquor is able to break and dissolve the lignin in it. Soda process is supplied with heat for one hour more and still the cooking liquor could not effectively digest the lignin.

3. Pulp obtained after washing is added with bleaching agent. The amount of bleaching agent required is more in Soda process when compared to Kraft process. So, the pulp obtained in Kraft process can be used for high grade paper production. Pulp obtained by Soda process can be used for low grade paper production. But the discussion here is about the packing paper, so, the pulp must be entirely lignin free, because it acts as an impurity and may vary the conditions of the packed material. By this we can conclude that Kraft process is safer.

4. Finally, coming to the yield from the observations Kraft process gave more pulp for fixed amount of raw material when compared with Soda process. So, Kraft process is more advantageous.

From the above observations we conclude that Kraft Process is safer and more efficient based on yield.

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8 **REFERENCES**

[1]. procedure to determine pentosan content present in various soft and hard woods by using hydrochloric acid and furfural, Johansson.

[2]. production of paper from Groundnut shell, T Goswami, Dipul Kalita* & P G Rao [1], North East Institute of Science and Technology (CSIR).

[3]. improvement of paper properties, Yuan-Shing Perng and Eugene I-Chen Wang.

[4]. cellulose content in both hard woods and soft woods, Sunday Albert Lawal and Benjamin Iyenagbe Ugheoke[5], Department of Mechanical Engineering, Federal University of Technology, Nigeria.

[5]. Shrieves chemical process industries.

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