



Eco-Friendly Production of Paper Products

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Abstract: As we know that paper is more than an industrial and commercial commodity. This production of the handmade paper can be categorized into an cost effective, eco- friendly, profitable, energy and resource saving technique. This process of making paper involves the operations of pulping, web formation, sheet pressing and the moisture removal which finally undergoes finishing with coloring agents and calendaring. The chemicals in this process are very few namely Sodium Hydroxide, Starch, Rosin alum. So, it causes very little amounts of pollution. Thus it leads us to an eco-friendly society. This was the most required thing for us now. As these handmade paper industries are the small scale industries it includes less investment with a good amounts of profits. Some of the problems faced by the large scale paper mills are overcome by methods like: Raw materials- Here in these processes of making paper the raw materials used are mostly the textile waste, Gunnies, Banana stem which are abundantly available to us; Chemical requirement- very few chemicals are used in the small scale handmade paper mills as already discussed above. So, high capital investment to buy these chemicals is not needed; Plant and Equipment- The machinery required in these paper mills are very less except for Beating and compressing. So, the capital investment on the machinery is also less. It does occupy very less space and also saves plant area.

Keywords: cotton cloth, pulping, sodium hydroxide, starch, rosin alum, textile waste, gunnies, banana stem.

Introduction

Paper is more than an industrial and commercial commodity. The welfare of a nation cannot be achieved without rise in the consumption of all kinds of cultural and industrial qualities of paper. Paper is essential for liquidation of illiteracy. It is the most essential means of communicating thoughts of the peoples of developing better understanding between them. If papers is not available in sufficient quantities we can say that the modern democracy will be seriously hampered[1-3]. Also that we cannot safeguard our human rights like, the right to education, the right to culture, the right to information. Paper is also used as a packaging material. As we know packing and wrapping is an index of standard of living. It is the fact that for any increase in the national income, there will be a proportionate increase in the paper consumption. In industrially developed countries, the production of paper is much more significant.

1.1. History of paper:

The word paper comes from a 'reedy plant papyrus' which is a form of writing material made from the water reed in ancient Egypt. Writing paper first appeared between 2500-2000 B.C, made from a tall reed called papyrus which grows along the Nile River[3-4]. Strips from the reed were glued together with starch and this sheet is superior to calf and goatskin parchments, clay bricks, waked boards, etc. The Chinese invented good processes for paper manufactured from bamboo and cotton about 105 A.D and continued to make good paper by hand today. The first invention of true paper was by "Tsailun", Chinese minister of agriculture, which was

originally made of fishing nets and rags. Also, the conventional paper made from wood pulp was designed by him. Rag paper was manufactured by the southern Europe near the end of 14th century. The America's first paper mill was the Rittenhouse paper mill by Alex Buntin[5-6] in the year 1690. This was the first mechanical pulp mill in north America in the valley field.

1.2. Definition of paper:

“A material made of cellulose pulp derived mainly from wood or rags or certain grasses. Paper is made of pulped cellulose fibres like wood, cotton or flax.”

2. Indian Paper Industry

Paper Industry is a low investment and high labor intensive industry. It uses only waste raw materials and the durability of the paper is long with exclusive look and unique character. The paper is available in a saga of rich varieties, designs, shapes and colors [7-8]. The paper industry has an important social role to play for the country. Use of Paper is considered as an index of cultural growth. Key social objectives of the Government like eradicating illiteracy, making primary education compulsory, extra cultural activities etc. are very much related to the paper industry. In India the most popular paper industries are well established in Assam, Manipur, Arunachal Pradesh and Nagaland. The major production areas of paper are Japan, Thai, Nepal, China, Taiwan, French, Italian and Bhutan. They are among the most popular paper industries establishing a niche on the platform of a variety of papers. Paper industry produces a variety of paper and paper products. The Indian handmade mainly by using waste materials such as cotton rags, tailor cuttings, hoisery cuttings and small quantities of waste paper. Certain materials are blended with them for mottling effects and to produce special varieties of paper. Availability of raw materials and existing infrastructural facilities offer good scope for development of special varieties of handmade paper in the North East. It also has an added advantage to earn from world market. Due to increased literacy, industrialization, modernization and development by 2000 AD, the per capita consumption of paper in India may increase from the existing level of 3 kg to 4.5 kg. The demand for paper is expected to increase from existing 21 lakh tones (1991-92) to 37.9 lakh tones by 2000 AD, while supply will reach only 27.7 lakh tones. The handmade paper and its allied products offer a vast marketing scope in both inside and outside the country. Imports of paper and paper products were growing over the years. However, it has increased during 2001-02 after a fall in 2000-01. Actual import was 2.71 lakh tones in 1998-99, 2.02 lakh tones in 1999-00, 1.39 lakh tones in 2000-01, 1.67 lakh tones in 2001-02 and 1.23 lakh tones upto November, 2002. About 1,40,000 tones of paper was exported in 2000-01.

2.1. Purpose:

The paper industry of India is faced with numerous difficulties, some of which are described in detail below:

1. Shortage of Fibrous Raw Materials:

The lack of forest resources requires long range planning for development of improved bamboo harvesting, utilization of bagasse, eucalyptus and reed grass plus more effective collection and reuse of waste paper.

2. High Prices and Shortage of Chemicals:

Shortage of sulphur, salt cake and chlorine with corresponding high place the Indian paper industry at a great disadvantage in attempting to export paper products to augment the foreign exchange position. This forces a great deal more attention on chemical recovery methods.

3. Procurement of Plant and Equipment:

Pulping equipment is relatively simple and is being built in India.

- Paper-making Industry is quite elaborate and expensive so indigenous manufacture has not yet been successfully attempted.
- Once Indian Engineers have mastered all phases of design and construction of continuous high speed processing plants from raw materials to final paper products, the industry should be in a firm position to move ahead.

At present almost all the large paper making Industries in our country are manufacturing Kraft paper besides writing and printing other varieties of paper. The production of Kraft paper by 2005 is estimated at about 6lakh tons per annum. Its demand in the country is raising at the rate of 5%per annum. Even though this Kraft paper was the most used paper. It was using a lot of chemicals and was just leading us too closer to the polluted environment. This process also consumes a lot of energy, machinery, capital during investment, resources, e.t.c. Whereas coming to the paper from a Hand Made Industry we see very less chemicals mostly sodium hydroxide, starch and alums and also that the machinery requirement is very less when compared to the conventional paper making, energy consumption is also very less. It almost causes no pollution with good varieties of paper products. We can also say these industries as the profitable industries which leads us to an eco-friendly society.

3. Raw Materials

3.1. Prerequisites:

The requisites for any cellulose raw material for the pulp and paper industry

- Ample supply
- Available to the pulp mill throughout the entire year.
- Should not deteriorate on storage.
- High yield of quality fiber.
- Capable of being collected and stored in a small area and transported, if necessary, at low cost.
- Cost of conversion to the paper must be low.
- Quality of the paper is competitive.
- Must not have a higher priority use.

India has critical procurement problems to use wood resource, so it is spread over a number of sources.

3.2. Basic Raw Materials:

Some of the raw materials used in the paper industry are:

1. Soft woods: these include coniferous and non coniferous woods.
2. Grasses and reeds: these include lemon, panni, ulla, siru, munji, etc. others are sabai grass, bamboo, etc.
3. Straws: these are based on the rice, wheat, bagasse, barley, reeds, etc.
4. Cotton linters.
5. Hard woods: like acacia, lemon, gum, Mysore gum, eucalyptus, pines, patula, paper mulberry and rubber plant wood.
6. Kenaf- and Mesta etc.

3.3. Availability of raw material:

One of the major problems facing the paper industry is the availability of sufficient raw material. The total geographical area of the country is 326 million hectares. Of this, 46% of the land is under agriculture, 24 percent under forests, only 58 million hectares is actually exploitable, rest being unapproachable due to lack of communications. India's consumption of industrial wood is mainly used for the production of paper. If we see now the population was drastically increasing. So we need wood for many purposes like Shelter and furniture. As the population is increasing we need to provide them with good education. So in order to increase the literacy rate and for the industrial development of any country i.e. for good communication paper production is needed. So, to meet the demand we have the search for the other source of raw materials.

3.4. Raw materials used normally for both the processes:

3.4.1. Fibrous Raw Materials:

Paper pulp: ground wood, bleached and unbleached sulfite and sulfate, semi chemical pulps.

Reuse pulp: paper products, such as newspaper and paperboard, are re-pulped and mixed with new pulp for paper mill feedstock. The source accounts for 4-6% of fibrous starting materials. So reuse of waste paper is needed.

Cellulose pulp: straw, linen, cotton and rags.

Specialty pulp: inorganic fibers such as asbestos and glass.

3.4.2. Non-fibrous raw materials:

As we know the paper industry is a good customer of chemical industry. In addition to the chemicals used in producing the pulp, a large variety of materials for fillers, sizing and coatings are required. We can also define the paper as “the matted or felted sheets of fibres, cellulose and generally formed on a fibre wire screen from a water suspension.”

3.5. Characteristics of an ideal fibre:

The idea fibre for high grade paper should be

1. long.
2. High in cellulose content.
3. low in lignin content.

The trees from which bamboo are obtained are species is plentiful. Bamboo is an ideal raw material, but production is not in such a way to meet the production requirements which was just increasing. Other resources are like bagasse, hard wood must be developed and good quality paper pulp was made by blending with the bamboo fibers.

4. Types Of Paper Products

Based on the requirements or from the characteristics of the paper, we classify the paper products.

Wrapping paper: bag paper, grease-proof.

Tissue paper: cigarette, carbon, toilet paper, towel, napkin papers.

Writing paper: bond weight, linen papers

Ground wood printing papers: heavier, less flexible, laminated paper stock.

In 1980, the production of paper and paperboard in the United States was about 59.7 million tons. The consumption of newsprint alone was estimated at 10.1 million tonnes and 61000 tons of wood pulp was produced. The United States consumes half of the world's paper products.

5. Manufacture of Pulp or Main Pulping Methods

1. Semi chemical or NSSC pulping.
2. Mechanical and thermo mechanical pulping.
3. Chemical pulping.
4. Solvent pulping.
5. Secondary fibre pulping.
6. Rag pulping.
7. Dissolving pulp.

5.1. Semi chemical or NSSC pulping:

NSSC: Neutral sulphite semi-chemical pulping.

Here substantially less chemicals are used than that in the chemical pulping. The yield of pulp obtained from a given wood is much higher. Such pulping are mostly use on liner board and corrugating paper. Yields of pulp are about 65-80% which makes Better use of wood. Hence continous and batch digesters are both used. But the quality and bleachbility are poorer. Here the high yields obtained reduce the stream pollution problems. Here mainly mild cooking is done which weakens the binding material between the fibres, and then mechanical separation is done. The usual cooking medium is sodium sulphate Buffered with sodium carbonate. Other pulping agents like Kraft green liquor can also be used at elevated temperatures.

5.2. Mechanical and thermo chemical pulping:

Here no chemical treatment is done for wood. Spruce and balsam are the chief wood employed. Here

fibres are torn from the debarked logs. Water is provided to remove the heat of friction and to carry away the dislodged fibres. The freed fibres are dropped into a container called stock sewer and passed along to a silver screen. The fine material is then sent to the stock pit where coarser particles are separated, then to refiner and finally returned to screens. The fines are concentrated in the thickeners and mechanical pulp is obtained. Here as the water overflow contains 15-20% of the original fibres recycling is done to the stock sewers. Here timely supply of the fresh water should be there to reduce the temperature levels. After straining the valuable fibres the water is sent to waste. Here the only chemical change that occurs is the slight hydration of cellulose due its long contact with warm water. Mechanical pulp is rarely used for any process. Mechanical pulp mixed with a small amount of chemical pulp is used to add strength and colour. The product from this pulping is newsprint, cheap manila, wall, tissue, wrapping papers. Thermo chemical pulping is more advantageous because elevated temperatures soften the lignin and make mechanical pulping less difficult. The wood is steamed around 975 kpa and refining is carried out at 170 degree centigrade. The fibre obtained was coated with lignin and is highly suitable for fibreboard but it makes poor paper.

5.3. Chemical pulping:

Here raw material is separated from the non-cellulosic ingredients by reaching the chemicals. Then the fibres are separated by the mild mechanical action and also that here the mechanical pulping. Because, here most of the lignin present in the raw material is solubilised by the action of the chemicals, here the pulp is easy to bleach. The yield of this process is around 40% on dry raw material.

5.4. Solvent pulping:

Here the solvents we use are ethanol, phenol and other delignifying solvents that contain no sulphur should be used. The holopulping process involves chlorine dioxide as the pulping agent. We can also use straight oxygen and nitric acid as pulping agent. Anthraquinone in small and quantity can also be used as a catalyst in pulping process to speed up them.

5.5. Secondary fiber pulping:

Over 20% of us paper now comes from the repulping of recycled paper. Many grades of paper can be produced. Batch processes are mostly opted here. Here the recycled paper is replaced with the water cleaned of objectionable dirt and contaminants, drained with alkali, washed, cooked lightly with alkali, bleached, screened and then handled like any other pulp. Secondary fibre is worth about 5 times its value as the waste paper. The largest single use is in the manufacture of multi-ply cylinder board. Here several sheets formed on a cylinder machine are combined to give a heavy paper. The outside layers may be virgin stock with the inside ones the secondary fibre. Mainly 6 grades are specially recognised: Clipboard, mill board, folding box, folding box board, combination manila board, container board and set-up board.

5.6. Rag pulping:

The oldest material used for making paper is cotton; it is still used for the finest grades. This cotton will be in the form of rags or cotton linters. Old rags make pulp useful for only felts, so clippings from the textile manufacturing plant and clothing manufacturing plants are the major sources of raw materials. Here rayon is most suitable. Mixed fibres are undesirable. Dyes can be removed with the strong reducing agents. Rags must be chopped and cooked to remove sizing materials and then treatment in horizontal rotary cookers is done about 2 to 10 hours at around 300 kpa. Firstly the rags are usually chipped into short lengths needed for paper making before cooking. The equipment is not more modernised and also that the business is quite small. Paper made from rags has a much longer storage life than that made from wood fibre.

5.7. Dissolving pulp:

Pure alpha is used here. It contains very less amounts of lignin but the supply is not sufficient to meet the demand. Dissolving pulp is made by post treatment of high quality sulphite pulp with sodium hydroxide or from pre-hydrolyzed sulphate pulp. Such purified cellulose commands a premium price.

Cellulose:

Cellulose is a polysaccharide used in the chemical industries in the form of chemical cellulose used for the preparation of fibres and plastics. It is obtained largely from refined wood pulp. The $(C_6H_{10}O_5)_x$. this cellulose is insoluble in water, dilute acid and alkali and ordinary organic solvents.

6. Production of Bag Paper

The raw material used for this production includes the cotton waste from the textile industries.

Steps involved during the production of bag paper are:

1. **Dusting:** initially preliminary dusting of the raw materials done to remove the fine dirt particles.
2. **Chopping:** This chopping is done with the help of a beater. Chopping is nothing but the preliminary size reduction of the fibrous raw material.

Definition of Beating:

- Expansion of mechanical work on fibers to develop fibrillation and cutting is known as beating.
- Coming to the importance of fibrillation and cutting, fibrillation develops the strength characteristics of paper. Cutting regulates the length of fibers and influences the bursting strength and formation of sheet.
- During the chopping process, we add some amounts of hydrogen peroxide for regulating the blocking of fibers in between knives.



Fig. I. Beater

- Every beater contains “beater knives” all round its periphery. The thickness and setting of beater knives plays an important role in controlling the fiber characteristic.
 1. Sharp blades placed close together give more cutting and very little fibrillation. The paper made under these conditions has relatively poor strength but higher bulk, opacity and absorbency.
 2. Blunt blades placed together give neither cutting nor fibrillation but hydration. The paper made under such conditions is dense hard and has high bursting strength.
- Consistency in beaters plays a very important role.

Beaters do have some disadvantages:

1. Extremely high power consumption due to large roll used for circulation of pump.
2. Low beating capacity.
3. Require large space.
4. Non-uniform beating of pulp due to channeling.

During beating, the pulp should be slurred with water to 0.5 to 0.75 % fiber content. This beating of pulp for too many times leads to the more cutting of the fibers which was not required for us, as this avoids or reduces the interlocking tendency of the fibers.

3. Digestion:

Digestion is of two types:

1. Cold digestion
2. Hot digestion

- After beating the slurred matter or the pulp is transferred to the digestion tank, where we add resin, caustic and alum powder. Hot digestion includes the boiling of these ingredients with fibers and
- Cold digestion is merely the dissolution of these fibers and the ingredients according to the requirement. Normal period of time which we choose for cold digestion is 24 hours whereas for the hot digestion, it is around 6 to 7 hours.
- Here as we use the pure cotton waste as the raw material, there is no need to add the caustic amounts.

4. Wet web formation:

- These pulped fibers are then transferred into the tank which contains $3/4^{\text{th}}$ of water. These fibers are then shaken and placed into water on a mesh so that the paper interlocking of the fibers taking place. Then this web is transferred on to nylon net so that the attaching of the web to the net does not take place.



Fig.II. Web Formation



Fig. III. Placing of Net

5. Pressing the wet sheet:

Here the compression is done with the help of hydraulic cylinders. Then the squeezing operation is done and the paper obtained from the process still contains about 60-65% of moisture content.



Fig. IV. Hydraulic Compressor

5. Drying:

- For the further removal of the moisture within the sheet, the operation which we follow is atmospheric drying. But we can also choose some of the techniques like passing the wet sheet through the heated rolls.
- During summer, the time required for drying is 7 to 8 hours (drying is needed). During the rainy season and winter season, drying goes on to 24 hours or more.

6. Calendaring:

This is done in order to give smooth finishing to the paper. At a time 15 to 20 papers are sent at a time into the calendaring machine. Normally, papers are rolled for 3 to 4 times for the smooth lining of the fibers. Further calendaring also does not cause any disadvantages to the paper.

7. Sizing:

It is the most needed operation for most of the paper products because; it imparts water resistance to the paper. Here to make this bag paper, we add starch for the better water resistance. We can also the reagents, polymers and plastics like ethylene in the paper boards for this sizing operation.

8. Colouring operations:

These colouring agents are mostly used the papers made from the jute fibers. As this is the bag paper here, we add colour according to the requirement. After applying this colouring agent, again the process of drying is carried out for 12 hours during summer and 24 hours in rainy and winter seasons.

9. Finishing:

This finishing operation is done according to the requirement of the order. For the raw materials like gunnies (jute fiber), we add some bleaching powder for the removal of the colour during the pulping operation i.e. beating. Sometimes, we can also add the computer paper for the proper pulping.

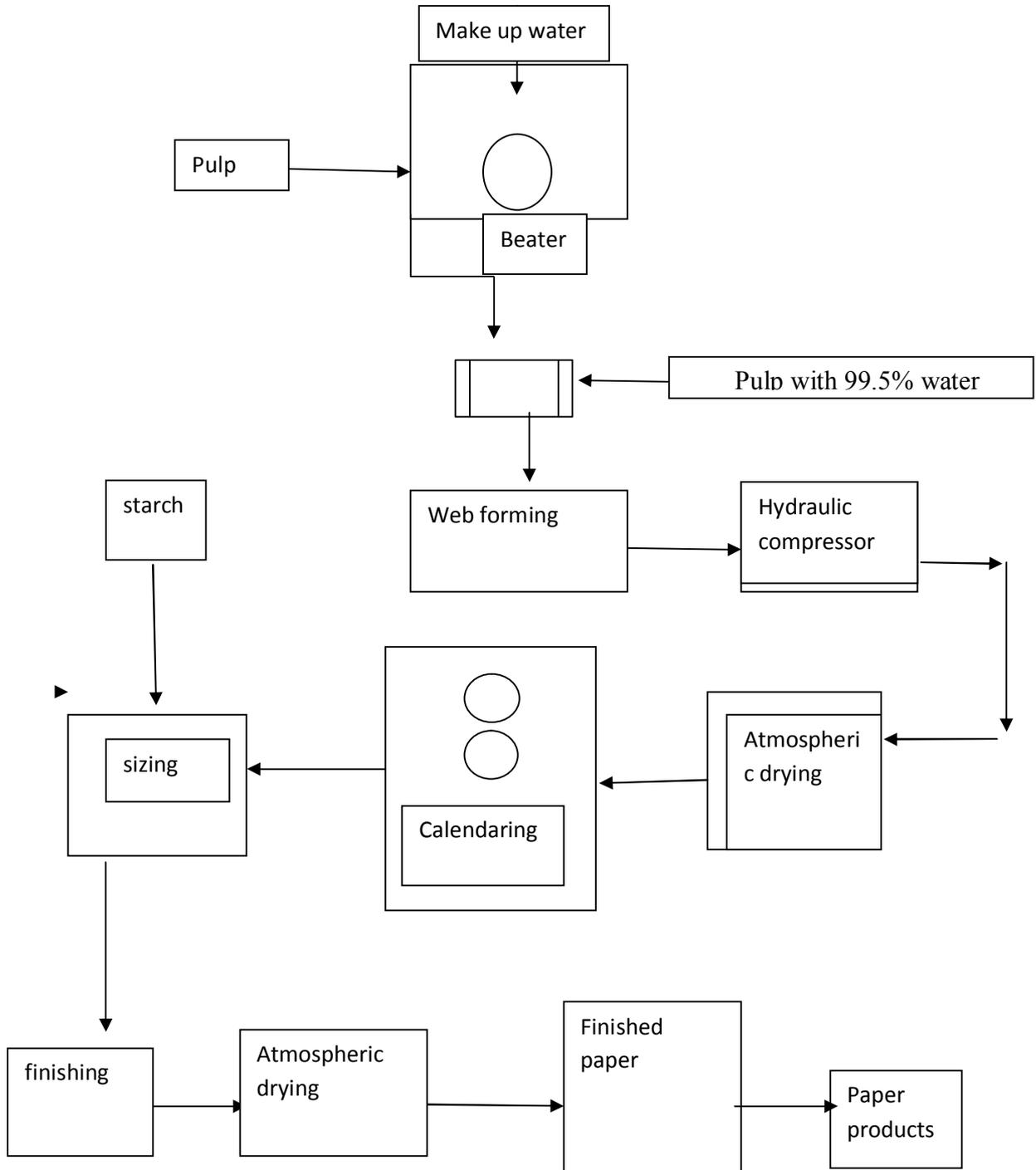
- If we see, the strength of the paper increases with G.S.M (grams per square meter). With the decrease in the G.S.M, the cost of the paper increases. 1 Kg of cotton pulp of 240 GSM produces 7 papers; for 130GSM, about 11 papers are produced and for 90 GSM, 17 papers are produced.

7. Recycled Paper

The recovery of the waste paper is traditional in the paper and paperboard industry. The importance of utilization of waste paper should not be underestimated because this commodity furnishes about 30% of all

fibrous raw materials consumed in paper and paperboard mills in USA, Europe and Japan. We can say that the rate of recovery of the waste paper will gradually increase to 35% even in the lower producing countries.

8. Typical Flow Sheet Common for all the Production Processes



9. Conclusion

In the present society, environmental pollution is a serious problem which we need to consider as it is causing some serious disasters to our nature so this present technology of paper making through wood etc...leads us to get more closer to the polluted society. We all know that paper industry was the major polluting industry among all the production based industries. Not only that the paper industry consumes more number of chemicals, machinery, land and energy when compared to the other industries. But this technology

of handmade paper was very efficient in production and makes an optimum utilization of resources, energy and all other requirements. So, presence of large no of small scale handmade paper mills other than the conventional paper making from the Kraft process, which uses a lot of chemicals like sulphur which was a harmful pollutant, Salt cake, etc... which leads us to a pollutant free society with a good production.

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