

20. PAPER AND PULP

Learning outcomes

The students should be able to:

- List out the raw materials, sources of raw materials
- Describe the stages in the production of paper.
- Give a flow-sheet diagram for paper production.
- Describe the quality of the paper.

Introduction

- In today's world, paper is an essential material for human beings, which is used for newsprint, books, copies, packaging, tissue, paperboard, and construction.
- Paper is defined as a thick or pressed mass of fibers, a sheet usually cellulosic material generally formed on a fine wire screen from a water suspension.
- Pulp is the commercial cellulose derived from materials like wood, bamboo, bagasse etc., used for the production of paper

Raw materials

The raw materials for paper are the pulp, which can be classified into two types;

a. Fibrous raw materials:

- Paper pulp: Groundwood, bleached and unbleached pulp, semi-chemical pulp.
- Reuse pulp: paper products, newspaper, paperbound.
- Cellulose pulp: straw, linen, and cotton.
- Specialty pulp: Inorganic fibers such as asbestos and glass.

b. Non-fibrous raw materials:

Such raw materials include the chemicals used for filtering, sizing, and coating paper, as well as pulping and bleaching.

- Inorganic raw materials: clay, Talc, TiO_2 , ZnS , CaCO_3 , alums, sulphur, lime, NaOH , soda ash, H_2O_2 , Cl_2 , $\text{Mg}(\text{OH})_2$, etc.
- Organic raw materials: Rosin, starch, wax, glycerol, dyes, etc.

1. Differentiate between fibrous and non-fibrous raw materials for the paper production. 2
2. Mention the raw materials required for making paper. 2

Sources of raw materials

The raw materials used for the paper industry are;

- Softwood: coniferous and non-coniferous wood
- Grasses and reeds (tall plants with hollow stems): lemon, *siru*, *panni*, bamboo, bagasse, hemp, etc.
- Straws: rice, wheat, barley, etc.
- Hardwoods: Eucalyptus, Pinus, mulberry, rubber plant wood, etc.
- Waste paper

Stages in the production of paper

A detailed description of the stages in paper production is given below;

1. Converting wood into pulp (pulping)

- The commercial cellulose used for the production of paper which is derived from materials like wood, bamboo, bagasse etc. is called pulp.
- It can be prepared by mechanical or chemical methods.
- The process of making pulp from raw materials is called pulping.
- Pulping can be carried out in the following ways;

a. Mechanical pulping:

In this process, the wood is collected, and the bark is removed. It involves mainly grinding and abrading action on wood to produce pulp. For this, revolving grindstones are used in which bolts of wood are pressed. The grindstones are silicon carbide or aluminium oxide grits in a vitrified clay binder. In recent developments, pressure is also used in the grinder, and temperature is controlled. The characteristics of the pulp can be varied by changing the stone surface pattern, stone speed, the pressure of the wood log against the stone, and the temperature of the pulp.

Mechanical pulp is of low strength than chemical pulp. Therefore, such pulps are only used for relatively impermanent papers such as newsprint, catalogues, magazines and paperboard. Such pulp has excellent printing qualities because of high bulk, smoothness and good ink absorption.

b. Chemical pulping

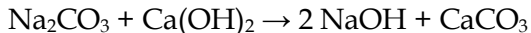
The main objective of chemical pulping is to solubilize and remove lignin from wood.

Here, the cellulose is separated from lignin by using chemical reagents. The chemical process is of two types;

i. The Kraft (Sulphate) process:

In this process, a mixture of NaOH and Na₂S is mixed as active chemicals. The wood is then digested first in a large pressure vessel called the digester. 10 atms pressure and 170-175 °C temperature is maintained for 2-3 hours. After cooking in a continuous digester, the pulp is washed in a countercurrent rotary vacuum washer system. During the process, the conditions are maintained so that lignins are hydrolysed (removed), and cellulose is hydrolysed. The separated liquor is dark and is called dark liquor. It is concentrated to 60 to 65% solid in evaporators. In this stage, liquor is burnt in the recovery furnace to allow the burning of lignin and carbohydrate degradation products. The inorganic portions are collected on the bottom of the furnace as molten smelt of Na₂CO₃ and Na₂S. Na₂SO₄ is added as

makeup and is reduced to Na_2S by carbon. After reacting with water, green liquor is obtained, which is reacted with slaked lime.



The CaCO_3 is filtered off and removed, and the pulp is collected for drying and used for bleaching.

ii. Sulphite process

- In the sulphite process, the lignin of wood is removed by reacting with bisulfite (HSO_3^-) ion under acidic conditions and forms lingo sulphonates, which are soluble in water.
- At first, cooking liquor is prepared by burning sulphur to SO_2 and absorption of it in the water reacting it with a proper base of sodium, magnesium, or ammonia.
- The liquor is sodium, magnesium, or ammonium bisulfite, which is soluble at pH 4.5.
- Wood is cooked for 4-5 hours with bisulfite in batch digesters at 140-150 °C.
- White colour pulp is produced after drying.
- White grade papers, book papers, and sanitary papers are formed from this type of pulp.

c. Semi-chemical pulping

- In this process, the chips of wood are treated with mild chemicals such as dilute sulphite, sulphate, caustic soda, etc.
- The wood is softened to separate fibres mechanically.
- Such a process produces pulp of a specific and higher quality than mechanical pulping.
- The yield of pulp is less but of higher quality.

d. Solvent pulping

- This process was first developed by Keinnert in 1930 and is based on 50% ethanol.
- In this process, wood chips are treated with an aqueous solvent mixture and cooked for several hours at an elevated temperature.

- Initially, formic and acetic acids are released, then hydrolysis of lignin and hemicellulose occurs.
- Catalysts like HCl, CH₃COOH, HCOOH CaCl₂, MgSO₄ etc. can be used for better delignification.
- Cellulose pulp is filtered and the solvent is recovered by distillation.

1. What are the differences between the sulphate and sulphite pulping process? **2**

2. Bleaching and finishing operation of pulp:

The main purpose of bleaching pulp is to remove the remaining pulp and other coloured degradation products. The bleaching process mainly includes three stages;

- a. Chlorination: Chlorine is used for chlorination.
- b. Alkaline extraction: Sodium hydroxide is used for this.
- c. Oxidative process: sodium or calcium hypochlorite, chlorine dioxide or hydrogen peroxide are used.

Then, the pulp is washed in each stage to remove solubilized impurities.

The more steps, the higher the pulp quality.

If the pulp is to be carried over long distances, water removal is necessary, which can be achieved by hydraulic pressing at 200-300 atm, vacuum flash drying, and extraction into noodles or pellets.

3. What is the basic purpose of bleaching pulp? Mention any four bleaching agents. **3**
4. Why is bleaching of pulp necessary during paper production? How is it done? **2**

3. Paper-making process

Paper is defined as a thick mass or pressed mass of fibres, a sheet of cellulosic material, generally formed on a fine wire screen from a water suspension. The paper-making process mainly involves the following steps;

- a. Preparation of fibre suspension: In this step, pulps are mixed with water to make a slurry by using mechanical disintegrators which contain a rotating drum with knife attachments. Such an operation is called beating and refining. Many fillers like [China clay](#), calcium carbonate, [titanium dioxide](#), and [talc](#) are added to the slurry to increase the brightness, flexibility, opacity, softness and weight of the paper. Sizing and colouring agents like synthetic dyes or water-insoluble pigments are also added before processing. In this way, fibre suspension is prepared.
- b. Formation of paper: The conversion of fibre suspension into paper involves three major steps;
 - i. Forming a wet web: In this step, the wet web(wet sheet) is prepared by running 99.5% water fibre slurry into a moving belt of wire clothes at a speed of 50 m/minute for fine paper and 500 m/minute for newsprint paper. By using gravity, water is drained. The screen has a sidewise shaking motion to give better interlocking of fibres on a mat. The water is collected as white matter and reused for the recovery of fibre.
 - ii. Pressing a wet web: The wet paper sheet containing 80% water is passed to a felt roll to the press section where water is removed by mild pressure. The amount of water is reduced to 60-65%.
 - iii. Drying the sheet: The sheet obtained from the press section has sufficient strength to carry its weight. It is then passed through smoothing rolls. Then, it is passed through steam-heated metal cylinders where heat and moisture are removed. The paper board is directly dried. In the last drying roll, about 5-6% H₂O remains. It is then passed through pressure rolls to produce smooth well finished paper. It is wound in rolls and cut, coated and packaged.

Flow-sheet diagram for paper production

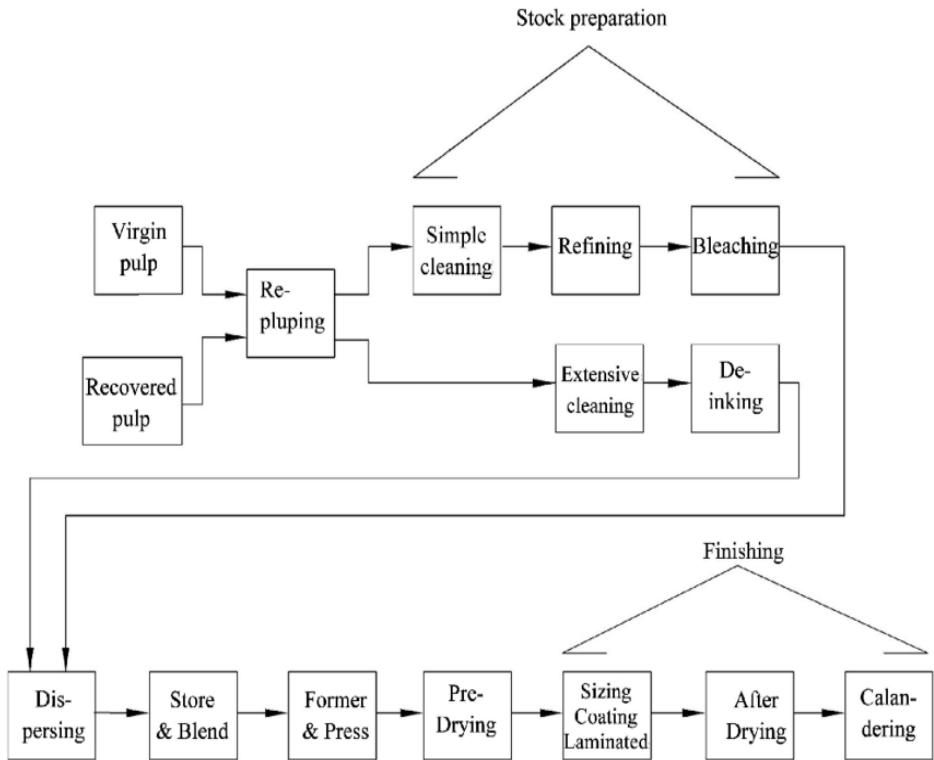


Fig: Schematic diagram of the paper-making process

5. Draw the flow sheet diagram for paper production.

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Quality of paper:

The quality of the paper depends on the nature of the raw materials, the nature of the pulp and the paper formation process. The finishing and converting process also determines the quality of the paper. The quality of the paper can be improved by a surface treatment solution of starch and it can be applied during the drying process to improve surface bonding.

Based on requirements, characteristics and uses, papers are classified as;

- a. Wrapping paper: for bags, grease paper.
 - b. Tissue paper: for cigarettes, carbon, toilet paper, towel, and napkin paper.
 - c. Book paper: coated and uncoated paper, lithograph offset, textbook paper.
 - d. Writing paper: bond weight and linen papers.
 - e. Ground wood printing paper: catalogues, newsprint paper, posters, wallpapers.
 - f. Paper board: heavier, less flexible laminated paper.
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1. Removal of which of the following leads to higher fibre-fibre bonding strength in the paper?
 - a.
 - b. Softwood b. hardwood c. lignin d. pulp
 2. Which of the following is not a fibrous raw material for paper?
 - a. Pulp b. asbestos c. waste paper d. clay
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6. Differentiate between paper and pulp. 2
 7. Write the scope of the paper and pulp industry in Nepal. 4
 8. Write a short note on the pulp and paper industry in Nepal. 4
 9. What is meant by Lokta paper? Write its one use. 2

*****This is not a complete note. It is just to guide you. It is recommended to study the prescribed textbooks along with this material. *****