E-Practical cum Teaching Manual

FP2202, 3(2+1)

Wood Products Utilization

B.Sc. (Hons.) Forestry

Prepared by

Dr. Yogesh Y. Sumthane

Dr. Mohammed Nasir

Dr. Kulwant Rai Sharma

Dr. Sanjeev Kumar

DEPARTMENT OF FOREST PRODUCTS

COLLEGE OF FORESTRY

BANDA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BANDA 210001 (UTTAR PRADESH) INDIA

E-Practical cum Teaching Manual

Wood Products Utilization

Year

April, 2023

Publication No: BUAT/ (M)/2023/22

Prepared by

Dr. Yogesh Y. Sumthane

Dr. Mahammed Nasir

Dr. Kulwant Rai Sharma

Dr. Sanjeev Kumar

Published by:

College of Forestry

Banda University of Agriculture and Technology

Banda-210001 (Uttar Pradesh)

Foreward

Wood is the earth's most valuable resource, conforms to the most varied requirement of the human beings, and is widely used raw material. The progress of mankind from the primitive state to the present day technological advancement has always been closely/intimately associated with multifarious role of wood and its products. Man's dependence on wood is of such antiquity that it is the only gift of nature that has been in use since the human beings came in to existence. A range of complex issues affects societal value of wood throughout the world. The availability and cost of wood used for so many applications from housing, furniture to reading materials has come under increasing attention as a result of environmentally driven social and government policies. To some extent, this has led to the use of substitute material.

This e-Practical Cum Teaching Manual on **"Wood Products and Utilization"** has been prepared as a help to undergraduate students of forestry to give information related to the vast uses of wood and wood based industries with the hope that it will prove its worth to meet their needs and motivate them in understanding different aspects of the subject.

I am confident that this basic Teaching cum Practical manual will not only meet the requirements of the students, but will also prove to be useful for researchers, professionals and other interested readers a handy material. I appreciate the efforts of the authors in preparing this manual and hope that it will provide necessary impetus in positive direction.

College of Forestry

Banda University of Agriculture & Technology, Banda , U. P. (210001)

April, 2023

Dr. Kulwant Raj Sharma

Ex- Dean CoF UHF, Nauni, Solan H.P.

PREFACE

Ever since the dawn of civilization wood, the world's most valuable resource has served mankind in multitudinal ways. It is an important structural and more importantly a renewable natural material with high strength per unit weight. In most of the countries, wood is the primary constructional material. In its simplest application, the energy stored in wood is used to produce heat for cocking or for industrial process. Wood is also a major potential feed stock for synthesis of more complex material. Wood can also represent a large volume of waste material generated by industrialized societies. Cellulose and lignin are the two most abundant polymers on the earth. Lignin is practically problematic because of its resistance to degradation and development of method of degradation of this resource in to more readily utilizable material has received extensive study.

Since long time need was being felt to have well compiled information on the teaching and practical aspects of wood products utilization. This teaching cum practical manual on **"Wood Products and Utilization"** cover the different type of wood products and their manufacturing processes from practical point of view and in a systematic manner to cater to the needs of under graduate forestry students.

In developing the material for this manual authors have relied mainly upon the help of literature from several sources which is highly acknowledged. Some of the help came from discussion, field visit and various other sources. Authors extends their gratitude to all those who even in small way helped in preparation of this manual. We would like to record our since thanks to Dr.(Prof.) Narendra Pratap Singh Hon'ble Vice Chancellor, Dr. A.K Mishra Director of Research Banda University of Agriculture & Technology Banda. Dr. A.K Shrivastva Director PMEC, Dr. Sanjeev Kumar Dean Cof, Dr. M. Nasir In-charge FPU. Escaped our attention, authors would be grateful if they are brought to notice.

College of Forestry

Banda University of Agriculture & Technology, Banda, U. P. (210001)

Dr.Yogesh Y. Sumthane

April, 2023

CONTENTS

Technical term used in the Course

Bark – The outer layer of a tree.

Cell- A general term of the anatomical units of plant tissue, including wood fibres, vessel members, and other element of diverse structure and function.

Cambium- The thin layer of productive cell in wood found between the xylem or wood, and phloem, or inner bark, cell reproduction occurs in the cambium.

Compression- A measure of inward-pushing forces as a load is applied to a wood member.

Density- Weight per unit volume. Density of wood is influenced by rate of growth percentage of latewood and in individual pieces, the proportion of the heartwood.

Grain- The visible line in wood that show the natural growth rings of the log.

Heartwood- The inner area of a tree trunk or log that- when the tree was growing – had stopped containing living cell and reserve material such as starch. The heartwood may be darker in color than the outer sapwood though not all species show a clear difference between the two. The heartwood is often more durable than sapwood.

Hardwood- Timber produced from broad-leaved trees.

Latewood- Wood that is added in the letter part of the growing season with in an annual ring. Latewood cells in softwoods are often smaller, denser, and darker in color than early wood cells. Latewood cells in hardwood may be recognized by the difference in volume occupied by vessels (pores)

Pith- The small and soft core of a tree that the wood grows around.

Pits- Pits serve as passage of nutrition communication between neighboring cells.

Rays- A narrow ribbon of cells that conducts and store food in is tree. Rays run across the grain of timber.

Reaction wood- Wood with more or less distinctive anatomical character, formed typically in parts of learning or crooked stem and in branches. In hardwood, this consists of tension wood, and in softwood, compression wood.

Sapwood- The outer area of a tree trunk or log, which in the growing tree contains living cells and reserve material such as starch. Sapwood is generally lighter in color than the inner heartwood, although not all species show a clear difference between the two. The sapwood is more vulnerable to attack.

Softwood- this is usually obtained from pine, fir, source, or larch (mainly conifers). Most structural timber used in the Europe is softwood

Swelling- The expansion of wood fibres due to change of moisture content.

Tension wood- Abnormal wood found in leaning trees of some hardwood species and characterized by the presence of gelatinous fibres and excessive longitudinal shrinkage. Tension wood fibres hold together tenaciously, so that sawed surface usually have projecting fibres and planed surface often are torn or have raised grain. Tension wood may cause warping.

Shrinking- The contraction of wood fibres caused by drying below the fibre saturation point (usually around 25-27% M.C.). Values are expressed as a percentage of the dimension of the wood when green.

Xylem- Commonly referred to as wood, the region of a tree lying between the pith and the cambium.

Laminate- Clear wear layer protects the floor from high abrasion, stains, fading, and wear-through.

Log- The section of a tree can be sawn or used for veneer.

Plywood- An engineered panel, typically composed of an odd number of thin layers of wood veneers, called plies, bonded together with a rigid adhesive and with the grain direction of adjacent layers perpendicular to each other.

Veneer- A thin sheet of wood, rotary cut, sliced, or sawed from a log, bolt or flitch.

Slicing- Process of shearing off the veneer in sheet.

Sander- A wood working tool used to shape or smooth the wood surface by using a gritty surface of varying roughness.

Blending- Mixing all necessary ingredients for making particleboard and fiberboard.

Composite- The collective name of engineered wood-based material or components.

Fiber board- A board generic term inclusive of sheet material of widely varying densities manufacture of refined or partially refined wood fibres. Bonding agents and other material may be added to increase strength, resistance to moisture, fire, or decay, or to improve some other property.

Flake board- A particle panel product composed of flakes.

Chipboard- A paperboard sued for many purposes that may or may not have specification for strength, color, or other characteristics, it is normally made from paper stock with a relatively low density in the thickness of 0.1524 mm and up.

Particleboard- A type of construction in which the wood particle are made or classified into different size and placed into the preprocessed panel configuration to produce a panel with specific properties. Panel that are destined for primarily non structural uses requiring smooth faces are configured with small particle on the interior(core). Panel designed for structural application may have flakes aligned in orthogonal direction in various layers that mimic the structure of plywood. Three – and five layer construction are most common.

Pressing- Process of bonding of different material with the application of adhesive, heat band pressure.

Board- Timber product which is less than 38 mm thick, more than 80 mm wide.

Saw blade- The cutting medium of the saw. Usually from steel.

Sawmill- A place where the log are transferred into limber or other value added product.

Shake- A separation along the grain, the grater part of which occurs between the rings of annual growth. Usually considered to have occurred in the standing tree or during felling.

Stack- Pile of wood ready for air-drying.

Pulp, pulping- Commodity class of soft moist mass of wood fibre used in the manufacture of paper. Pulp is made up by reducing wood chips to fibres, either by grinding them up, or by chemical means, and then turning the fibres into slur

Cross bands- The core veneers that run across the panels at right angles to the face veneers.

Blackboard- Core board, the core of which is made of strips of solid wood more than 7 mm wide but not wider than 30 mm which or may not be glued together.

Bond- Adhesion by means of glue.

Adhesive- A substance capable of holding materials together by surface attachment. It is a general term and includes cements, mucilage and paste as well as glue.

Tracheids- The elongated cells that constitute the greater part of the structure of the softwood (frequently referred to as fibers). Also present in some hardwoods.

Shear strength- Ability to resist internal slipping of one part upon another along the grain.

Compression- A measure of inward-pushing forces as a load is applied to a wood member.

COMPOSITE WOOD

Composite wood is a general term for built up bonded products, consisting either wholly of natural wood or of wood in combination with metals, plastics, etc. Various processes and methods have been developed, most of them in recent years in building larger pieces from relatively small pieces or in treating and modifying wood by means of pressure, heat and chemicals. These developments also help in utilizing waste wood and wood of inferior species.

The following are the forms of composite wood.

1. Plywood
2. Laminated wood
3. Core boards
4. Sandwich boards
5. Fibre boards
6. Particle boards

PLYWOOD

Plywood is a term applied to glued wood construction built of veneers in such a manner that the grain of each veneer is at right angles to that of the adjacent veneer in the assembly. This method is called the cross bonded construction. The most significant advantage is the modification of strength properties to a maximum advantage. The outer plies in a plywood panel are called faces, or face and back and the center ply or plies, the core. The core may consist of veneer, timber, or various combinations of veneer and timber. The different plies may vary as regards number, thickness and kinds of woods. Plywood may consist of any odd number of plies. The simplest structure is of three plies. In panels having more than three plies the layers between the core and the face or "back are called 'cross bands'

The cross banded construction of plywood offers many advantages over the use of solid wood. It possesses dimensional stability, which is lacking in solid wood. Plywood has the strength distributed in both directions. There is little or no tendency to split. As veneers can be cut from big logs at their greatest width. Plywood can be made in big sizes. Water proof

plywood, made with special glues is resistant to the action of water. Plywood can be moulded to various shapes and will retain those shapes more or less indefinitely. In plywood construction, the shrinkage and swelling are approximately equal and substantially less than the radial or tangential changes in solid wood. The tendency of plywood to warp as a result of stresses caused by dimensional changes is eliminated by balanced construction.

LAMINATED WOOD

Laminated wood may be defined as a built up product made of wood layers (called laminate), all laid with their grain parallel and glued or otherwise fastened together. The laminate may vary as to species, number, size, shape and thickness. Glued laminated wood construction or the structural material resulting from glued lamination, is called glulam, the laminate, which may be thin veneers or boards, are seasoned in kilns. They are then cut to uniform width and length. Laminated that are short of length are end-joined and glued to the required length. The laminate are then arranged in the proper order and fed into a glue spreader which spreads the glue uniformly and properly. The glued laminate are thee placed on a form for assembling to the required shape and pressure applied by means of clamps fitted at regular intervals. The amount of pressure required to produce a good joint varies within a wide range.

Parallel grain or laminated construction is used for furniture parts, cores of veneered panels, sports goods, aero plane hangars, auditoriums, exhibition halls, engine houses, garages, churches, green houses, gymnasia, planetariums' theaters, warehouses, etc' Laminated wood is also suitable for diving boards, wood rolls, picker-sticks, flooring, boat and ship timbers, aircraft parts, etc.

CORE BOARDS

A core board is a composite board built up of a core composed of strips of wood of various dimension glued together or otherwise jointed together to form a slab, which is in glued between two or more outer veneers the direction of the grain of the core strips running at right angles to that of the adjacent veneers. It is called batten-board when the size is not more than 25 cm and a laminated-board when each strip of wood has a thickness not more than 7 mm. Core board construction arms at lightness of weight economy in the use of wood, consistent with strength. It also help in the utilization of sawmill waste. Core boards with

fiberboard or hollow materials as cores have been used increasingly. Core board are also covered with outer layer of fiberboard, synthetic resin fibres, metal sheets, sun mica, etc. On account of their low weight, better stability, good acoustic and heat insulation properties core board are used for doors and partitions.

SANDWICH BOARDS

Sandwich board is a general term for built up boards having a core of light material, faced on both sides with a relatively thin layer of material having high strength properties. Sandwich constructions are composites of different material bonded together into a unit, to achieve a combination desirable property which is not attainable with the constituents themselves individually. The two thin facings, called skins, are usually of a strong dense material, since they are the principal load-carrying members of sandwich construction. The core of weaker, light weight material separates and stabilizes the thin facings and carries shearing loads. The entire assembly provides, relatively to its weight, a structural element of high strength and stiffness. The construction is also economical, since the relatively expensive facing material is used only in small quantities and the core materials are inexpensive. The materials the core materials are inexpensive. The materials are positioned in such a way that each is used to its best advantage are positioned in such a way that each is used to its best advantage. Sandwich construction finds application in aircraft components, motor boats, table tops, flush doors, containers, etc.

FIBRE BOARDS

A fiberboard is a sheet of material made from fibres of wood. The wood is first deliberated or pulped and the fibres are then interfiled into a mat and consolidated by pressure and heat. Bonding agents and supplementary materials may be added at the felting stage to improve mechanical properties. Fiberboards are used as core material in core boards and sandwich boards. Such boards are often designated according to the purposes to which they are put e.g., Building board, Insulating board, Wall board etc.

The boards are also classified into three types according to densities e.g., hardboard, semi-hardboard, medium hardboard and soft- hardboard, etc.

Fibre boards are made from agricultural or forest waste materials (lops and tops) in forest falling's, off cuts, rejections in wood conversion, waste veneers etc. Varying conditions of pressure, time and temperature are employed to make different kinds of fiberboards. Synthetic resins, like phenol formaldehyde, are sometime added to the pulp in order to improve the strength and water resistant properties of the board. Wood preservatives can also be introduced into the boards so as to increase their durability. Fibre boards are manufactured for use as panels, insulating and cover material in buildings and for components of cabinets, cupboards and the constructions requiring flat sheets of moderate strength.

PARTICLE BOARDS

Particle board is a board or sheet constituted from fragments of wood and other lignocelluloses materials, bended with organic binders with the help of one or more agents like heat, pressure, humidity, catalyst, etc. The difference between fibre- board and particle board is that in the former the basic particle is essentially pulp made up of individual fibres or small clumps of fibres, while in the latter basic material consists of larger units in the form of chips, flakes, splinters. etc. that exhibit many of the characteristics of the original wood. Particle boards depend entirely on the adhesive additive for their cohesiveness. Particle boards vary much more in appearance and properties than fibre boards. Common types of particle boards are the Flake-board, Chip-board, and Shaving-board according to the material from which the particle board is made, e.g., chips, flakes and shavings.

Particles of waste wood in the form of flakes, shavings, splinter, etc., or chips and particles obtained by converting the raw material in a chipper are usually screened to get particles of more or less uniform size. The oversized particles are the reprocessed and used. Screened particles are then run through a drier to drive off excess moisture. The dried particles are then mixed thoroughly in mechanical mixers with a resin adhesive. The mix is then formed into particle boards, either by flat pressing, in a hot press at a suitable temperature and pressure or by continuous extrusion through two rigidly mounted heated platens; Boards can also be manufactured from bamboos, saw dust and miscellaneous wastes. Particle boards have adequate strength for interior applications in housing or furniture. They are generally not recommended for use in exterior or other exposed conditions because they shrink and swell appreciably.

ADHESIVES USED IN THE MANUFACTURE OF COMPOSITE WOOD

Adhesives

- Adhesive is any substance applied to one surface, or both surfaces, of two separate, of two separate items that binds them together and resists their separation.
- Adhesive may be used interchangeably with glue, cement, mucilage, or paste.
- The use of adhesives offers many advantage over binding techniques such as sewing, mechanical fastening, thermal bonding, etc. these include the ability to different materials together, to distribute stress more efficiently across the joints, the cost effectiveness of an easily mechanized process, an improvement in aesthetic design, and increased design flexibility.

Type of Adhesives

1. **Phenol Formaldehyde**: Phenol Formaldehyde resin are synthetic polymers obtain by the reaction of phenol or substitutes phenol with formaldehyde. Used as the basis for Bakelite, PFs were the first commercial synthetic resins (plastic). They have been widely used for the production of molded products including billiard balls, laboratory countertop, and as coating and adhesives.
   - These are used in manufacture of construction plywood and oriented strand board.
   - Phenolic resins require more time for bonding as compared to other adhesives and have boiled proof bonds which help them to withstand wet condition.

2. **Urea Formaldehyde :** A thermo setting synthetic resin made by condensing urea with formaldehyde and used especially in wood-bonding adhesives, colored molded articles, and for finishes (as of textiles, paper, and metals).
   - It requires less time for bonding, but its bond breaks under wet or moisture condition.

3. **Melamine Formaldehyde:** It is hard, thermo setting plastic material made from melamine and formaldehyde by polymerization.

Melamine formaldehyde is used in plastic laminate, decorate laminates, paper coating, paper treating and overlay materials. Formaldehyde is more tightly bound in MF than it is in urea formaldehyde, reducing emissions.

PF resins are more expensive than PF resins are used in combination with UF resins.

4. **Polymeric methylene –di-isocyanate (PMDI):** It is used as an alternate to PF resins.
   - It is more expensive and can tolerate higher moisture and temperature condition.
   - Its curing rate is higher and only disadvantage is that it cause chemical reaction while using in raw state.
5. **Bio adhesive:** Bio adhesive are natural polymeric materials that arc as adhesives. The term is sometimes used more loosely to describe glue formed synthetically from biological monomers such as sugars, or to mean a synthetic material designed to adhere to biological tissue.

- Organisms may secrete bio adhesives for use in attachment, construction and obstruction, as well in predation and defense.

IMPROVED WOOD

Improved wood is a general term for wood that has been specially treated in various ways to reduce or retard working i.e., (alternate swelling and shrinkage) or to increase its strength. Treatment may involve impregnation with synthetic resins or other materials and/or compression and/or heating and may be applied to solid wood or to veneers that are subsequently bonded together. The treatments have the effect of modifying the properties of the wood in terms of hygroscopicity, working, density and strength etc., and for this reason improved wood is also known as modified wood. Depending on the treatment, improved wood may be classified as follows.

IMPREGNATED WOOD

The term Impregnated Wood' is a collective name for woods impregnated with all possible implement's i.e., wax, paraffin's, resins, oils, etc., with the object of improving dimensional stability and preventing water absorption. The most successful impregnates that have been commercially applied are water soluble, thermosetting, phenol-formaldehyde resin forming systems. Veneers treated with a thermosetting. fibre penetrating resin that is cured without compression and then bonded together are known as impreg. The veneers are soaked in the aqueous, resin forming solution or impregnated with the resin by the vacuum impregnation with or without subsequent pressure. They are allowed to stand under non-drying conditions for a day or two to permit uniform destitution of the solution throughout the wood. The resin containing wood is dried at moderate temperatures to remove the water and then heated to higher temperatures to set the resin. They are then coated with the same or any other resin and air dried. The veneers are then assembled and pressed. Impregnated wood can be used for facing exterior plywood in order to eliminate checking. It can also be used for master patterns such as master shoe-lasts, die models for automobile parts, for acid tanks and components in electrical equipment's etc.

HEAT STABILIZED WOOD

Heat stabilized wood is one in which an appreciable degree of stabilization of dissensions and decay resistance to wood is imparted by a simple heat-treatment, which reduces the hygroscopic city. The treatment consists in passing wood. Beneath the surface of a molten metal or fused salt and thus subjecting it to controlled high temperature from 260-315° C for a few minutes under non oxidizing conditions. The product can be usefully employed for door and window frames in which dimensional stability and decay resistance are important and some strength can be sacrificed.

COMPRESSED WOOD

In this case the wood is compressed without impregnating it with any synthetic resins. Considerable improvement in the properties of wood can be attained by compression. Compressions across the fibre increase the specific gravity of wood and thereby improve its strength properties. Compressed wood can be made either from solid wood or from laminated wood. In practice, pressures varying from 90 to 140 kg per sq. km are applied and materials varying in specific gravity from 12 to 13 are obtained. Compressing woods of a number of species has good strength properties, high resistance to wear and tear and can be used as a substitute for more conventional timbers.

COMPREGNATED WOOD

Compregnated wood is a wood that is both impregnated with synthetic resin and compressed. The timber is converted into veneers and the veneers are compressed together in a pack at a suitable pressure and temperature after impregnating them with phenol-formaldehyde resin. The resin treatment prior to compress size property improves the shear strength of the wood in a plane at right angles to the direction of compression. By suitable choice of wood, thickness of veneer, pressure, temperature and direction for laying the veneers, the properties of the resultant material can be varied and made to suit particular requirements.

The process results in high dimensional stability; shrinkage or swelling with atmospheric changes become negligible. The compression increases the tensile strength, modulus of rupture in bending and modulus of elasticity in direct proportion to its extent. Compregnated wood is

highly resistant to mild acids, alcohols and many other solvents. It takes on a high luster from the press platters and needs no further finishing. It has 10 to 20 times the hardness of normal wood and has increased wear resistance. It has a high heat resistance, satisfactory electrical insulation properties, resistance to decay, termite and weather conditions.

The compregnated wood is an excellent material for aero plane propeller blades. It is suitable for gear wheels, bearings, fish plates, press forms, textile mill accessories, electrical machinery, supporting blocks for refrigerators, etc. Other uses are knife handles, trays, and fan blades, instrument cases, facing material for floors, panels, and furniture.

HEAT STABILIZED COMPRESSED WOOD

This is a compressed wood solid or laminated without impregnation with resin, as both impregnated and compregnated woods are more brittle than the original wood. The wood is made by modifying the compressing conditions so as to cause lignin cementing material between fibres to flow sufficiently to eliminate the internal stresses. Both solid and laminated wood can be made into heat stabilized compressed wood. It can be used in the same way as compregnated wood where high water resistance is not needed.

CHEMICALLY MODIFIED WOOD

Chemically modified wood has been developed to make it less hygroscopic, by use of chemicals, which replace the hydroxyl group in cellulose, simultaneously inducing stability, and decrease in shrinkage and swelling. The chemicals used are acetic anhydride in presence of pyridine as catalyst;] urea, hydroxyl in and sulphuric acid. The wood has specific advantages over ordinary wood.

DESTRUCTIVE DISTILLATION OF WOOD

Destructive distillation is a chemical process that involves heating of unprocessed material to cause them decomposes resulting to the formations of cracks in the relatively bigger molecules. Destructive distillation of wood is basically the decomposition of wood by heating it to tepm-450 550°C in the absence of air.

The products of destructive distillation of wood are:

- Gases such as carbon dioxide, carbon monoxide and methane.
- Liquids
- Solid residue which is charcoal.

The gaseous and liquid products separate out as a mixture of steam and gases and when the mixture is cooled a distillate is obtained. The distillate then separates into pyro ligneous and wood tar. The pyro-ligneous acid is then treated for it to yield acetic acid methanol etc. wood tar undergoes fractional distillation to yield:

- Inhibitors (fraction rich in phenols) used to stabilize oil,
- Benzene which is obtained by the cracking process.
- The solid residue which is charcoal is then used in the production of activated charcoal (used in adsorbing apparatus devices carbon di-sulphide and other substances.
- The products of this process have the following average yield:
- Charcoal 32-38%
- Liquid products 45-50%
- Gaseous products 16.5-18%

Factors affecting the yield of product in the destructive distillation of wood Size and moisture content of wood.

Temperature: high temperatures increases the carbon content of charcoal, increases the yield of tar and gases but decreases the yield of acetic acid and alcohol, lower temperature.

Rate of pyrolysis process: increase rate of the process reduces the yield of charcoal and acetic acid but increases the yield of tar.

Destructive distillation of wood is carried out into two methods:

1. Continuous destructive distillation of wood

2. Batch destructive distillation of wood.

Continuous destructive distillation of wood

In continuous destructive distillation, retorts are included in automated parts for the method.

Process:

Wood informs of round bullets or silver up to 20cm diameter is arranged on a bench and transferred onto a trough conveyor. The billets are moving on rotating cylinders to the cutting disk of the conveyor. The billets are then cut blocks of about 25 cm long. Blocks are transferred to storage silo. A charging bin is filled, as it is positional under the silo, it is then moved to the wood dryer. When level falls to a defined height, in the wood dryer, the loading chamber of the wood is complemented. Wood is then exposed to the action of drying gas at a temperature of 160-180°C. Gas flow is forced by fans installed downstream by drying gas expansion chamber. The expansion chamber receives small pieces of wood formed during drying. Vibration chutes installed at the bottom of each dryer transfer the dried wood to a container car which moves over retort and drops the wood into it when the level falls to a defined height.

Thermal decomposition of wood then starts, which is initiate and d by hot gases of temperature of 250-300°C which flows from the Centre of the retort (tempering zone) and the organic substance of wood gets carbonized. The process also results to production of acetic acid, acetone, methanol, wood tar, oils, and gases. CO3, Co, CHs, higher hydrocarbons, Hz and H20.The partly carbonized wood shrinks, and moves the retort to the tempering zone, here the temperature is 500 550°C, However, the amount of heat generated is too small for maintenance of temperature and for complete gasification.

SACCHARIFICATION OF WOOD

"The hydrolysis of cellulose to glucose and simple oligosaccharides will become a dominant economic factor. Cellulosic byproducts will find increased utilization as raw materials for the production of simple aliphatic chemicals through chemical engineering and biological processes... Looking far into the future we can see that cellulose, the most abundant of all photosynthetic products, will become one of man's most useful raw materials. The supply is replenished by growth while materials stored from past ages are continuously depleted."

Scarification processes

The conversion of cellulosic materials to sugar appears at first glance to be a simple hydrolytic cleavage of glyosidic bonds. As such, one should expect the reaction to be simple, and the capital costs of a factory to be low. In reality, cellulose is unique among the known polysaccharides in its extreme resistance to hydrolysis. The glyosidic bonds themselves are easily broken, but the crystalline organization of the cellulose results in a low accessibility to dilute acid commonly used as a catalyst. As a consequence, the conditions of temperature and acid concentration required to accomplish the reaction in a reasonable time because serious decomposition of the resulting sugars. Faced with these facts, only a few basic alternatives have presented themselves for practical hydrolysis.

1. A simple dilute-acid hydrolysis can be carried out without separation of product as it is formed.

2. A percolation process can be employed in which yields are raised by the expedient of continuously removing the product as it is formed.

3. A concentrated acid process can be used in which the crystalline organization of the cellulose is destroyed, the carbohydrate solubilized, and finally completely hydrolyzed with dilute acid.

Percolation processes

In scarification by percolation processes, wood is put into an acid-resistant pressure vessel and hydrolyzed by dilute acid injected into the top of the vessel and withdrawn through a filter in the bottom. In this way, sugar production and extraction go on simultaneously, and the sugar is separated and cooled as soon as possible to prevent decomposition.

The following advantages and disadvantages of the process:

Advantages

1. High yield of alcohol

2. Recovery of furfural and eventual other byproducts such as acetic acid and ethereal oils 3. Possibility of working with sawdust as well as with chips

Disadvantages

1. High consumption of acid
2. Necessity of solving the problem of placing the large quantities of calcium sulphate

Summary and discussion

Wood scarification is seen to have many facets with many possible combinations of process and product. No comparison of processes is possible without specifying the place where a plant is to be located and the purpose it is to serve. Thus in some locations the production of refined glucose from wood might be an attractive proposition. In the United States, such a process would merely reduce the consumption of corn, a commodity already in surplus supply and selling at a price controlled by the Government. Similarly, chemicals from cellulosic residues might find a ready market in the United States but in underdeveloped areas they would have no value.

PULP AND PAPER

Pulp

Pulp is a crude fibre material produced either mechanically or chemically from fibrous cellulosic raw material that after suitable treatment can be converted into paper, paperboard, pulp molded product, rayon, plastics and other products.

Paper

Paper is a matted or felted sheet of fibres principally of vegetable origin formed in a wire screen from a water suspension or paper is a homogeneous formation of primarily cellulose fibres which are formed in water suspension on the machine wire and bound together by weaving of fibres and by bonding agents.

Generally, the visit is conducted to Paper Mill at Baddi. However, under favourable circumstances the big paper mills at Saharanpur and near Pantnagar are also visited. The detailed study of the following parameters is necessary to understand the functioning of Paper Mill.

SELECTION OF FIBROUS RAW MATERIAL FOR PAPER MAKING

RAW MATERIAL

Sources of raw materials

Cellulosic raw materials utilized for production of pulp, paper and newsprint are categorized as:

1. Forest based raw material including plantation grown wood and bamboo.
2. Agricultural residues (wheat straw, rice straw and bagasse).
3. Recycled fiber (waste paper).
4. Market pulp

- The fibrous raw material for paper making are derived almost exclusively from plants, of which thousands of species ranging from common grasses to the largest trees growing in nature.
- The basic raw material for paper making is cellulose (CsH1oOs)n

Classification of Raw Material

1) Primary Sources: Wood fibres and non-wood fibres are primary fibres or primary sources of raw materials.

a) Wood Fibres

- Softwoods (Gymnosperms e.g. Spruce, Fir, Pine etc. They have larger fibre length)
- Hardwoods (Dicots e.g. Eucalyptus, Poplars, Birch etc.)

b) Non-Wood Fibres

- Naturally growing plants e.g. Bamboos, Grasses etc.
- Crop fibres (grown primarily for their fibre content).
- Bast fibres (Jute, Hemp, Kneaf, Flax etc.)

- Leaf fibres (Sisal, Manila)
- Seed hair fibres (Cotton Fibres and Linters, Cotton Rags and Textile Waste).

Secondary Sources: Secondary fibres or recycled fibres (waste paper) constitute another major source of raw material for paper manufacture.

S.NO.	Type of Paper	Prohibitive Material	Throw outs
1.	Mixed Waste Paper	<20%	<10%
2.	Corrugated Paper (Double lined Kraft outer surfaces and Fluted medium centre)	<1%	<5%
3.	Direct Entry (White Paper having printing also identified as Pulp substitute)	No	<0.5%
4.	Deinking Paper (Paper having printing colour)	<0.25%	No
5.	News	No	<0.25%

Prohibitive material:

Any material that by its presence in the bale in excess of amount allowed, which make. The bale unsuitable or unusable for the grade specified. Any material that may be physically damaging to the equipment.

PROCESS OF PAPER-MAKING

PULPING PROCESSES

Major pulping processes are:

A) Mechanical pulping

B) Chemical pulping

C) Semi chemical pulping

D) Semi mechanical pulping

E) Chemi-mechanical pulping

F) Bio-pulping

Basically there are four main pulping processes

1. Chemical 2.Semi chemical 3.Chemi-mechanical 4.Mechanical

These processes are in order of increasing mechanical energy required to separate the fibers (fiberation) and decreasing reliance on chemical reaction. The chemical methods rely on the effect of chemicals to separate fibers, whereas mechanical pulping relies completely on physical action. The more that chemicals are involved, lower the yield and lignin content since chemical degrades and solubilizes components of the wood, especially lignin and hemicelluloses. Chemical pulping also yields individual fibers that are not cut and give strong papers since the lignin which interferes with hydrogen bonding fibers is largely removed.

A) MECHANICAL PULPING

Mechanical pulp is also known as Ground Wood Pulp and is produced by forcing Crossed wood laterally against a revolving grindstone. Hence, the wood is reduced to fibrous mass, which after screening and subsequent thickening is converted in to pulp. The main use of Mechanical Pulp is in newsprint's and as' a base stock.

Wood used

Softwoods are preferred for the production of ground wood pulp. Hardwoods, unless specially treated, are not as well suited as short fibers produce a weak pulp. Types of Mechanical Pulping:

i) Stone ground wood pulping (SGP)

ii) Refiner Mechanical Pulping (RMP)

ii) Thermo Refiner Mechanical Pulping (TRMP) (Chips pre- steamed at 100 °C more before refining).

iv) Thermo Mechanical Pulping (TMP)

Properties and uses of Mechanical Pulp

- Mechanical pulp (MP) differs from semi chemical and chemical pulps in that it contains practically all the wood substance, including lignin and hemicelluloses.
- Pulp consists of Bundles of fiber fragments than individual Cell Units.
- Mechanical pulp is characterized by low initial strength. It deteriorates rapidly in strength and turns yellow with age. Low strength of MP is' due to LIGNIN which interferes with the Hydrogen bonding between the Fibers when paper is made.
- MP is characterized by high yield, high bulk, high stiffness and low cost. MP is low in brightness, but this property can be considerably improved by special bleaching techniques.
- On the plus side, mechanical pulp is characterized by outstanding printing qualities.
- It is used principally in produces which do not require high strength or are intended to be used a short time.
- The use of MP is mainly confined to non-permanent papers like newsprint.
- Other important uses of ground wood pulps are in papers for cheap books, catalogues, magazines, toilet paper and toweling, low-grade wrapping paper, wallpaper and as an

- Absorbent for explosives in the manufacture of Dynamite.
- MP constitutes 20-25% of World Production and is increasing due to high yield of the process and increasing competition for Fiber Resources.

Yield: The yield of mechanical pulp is 90-95 per cent of the dry weight of wood, as compared 50 per cent or less in chemical processes.

B) CHEMICAL PULPING

Chemical pulping may be defined as the treatment of wood with chemical reagents at high temperature and pressure with little or no mechanical energy utilized to separate wood fibers from each other.

Objectives of Chemical Pulp

To separate wood fibres from each other with minimum mechanical damage; this is accomplished by suitable chemical treatment, which removes the more soluble cementing materials, largely lignin and hemicelluloses leaving behind a fibrous mass (pulp) consisting of more or less cellulose.

CLASSIFICATION OF PAPER

Classification

Paper is classified on the basis of weight per unit area of the sheet and the dividing line is usually a weight of 250 grams per square meter. The different kinds of paper are:

1. Absorbent Paper: High absorbent quality and are spongy, loosely fitted. Fibers should be clean and of good quality. Example: Blotting and filter papers.

2. Airmail Paper: Light weight and opacity is required. They are used for letters and circulars mailed by air.

3. Art Paper: Consists of a base paper made of chemical pulp. They are used for halt tone reproductions of the highest quality.

4. Bible Paper: Made from rag pulp using Titanium Dioxide as filler. These are light weight, opaque, printing paper used in books, bibles and encyclopedias.

5. Bond Paper: Strength, durability and permanence are essential requirements. Its special qualities are obtained by the use of a mixture of rag and chemical pulp Example: Government bonds, Legal documents etc.

6. Book Paper: The better grades are usually made from chemical pulp while cheaper ones are made largely of mechanical pulp. These are used for book, magazines, catalogues etc.

7. **Building Paper:** Made up of old stock consisting of rags, wool, old papers etc. The common examples are Sheathing papers used in house construction and felt papers used either for heat insulation or as a roofing material.

8. Cigarette Paper: Thin and opaque, Calcium Carbonate (CaCOs3) is used as filler. The raw material used in India for cigarette paper is Sun hemp (Crotolariu juncea) Magazines etc

9. Cover Paper : They have folding qualities, permanence of colour, high resistant handling and abrasion. Used for covers of catalogues, pamphlets, booklets magazines etc.

10. Drawing Paper: Must be strong, permanent, white and opaque. It is made from rag pulp or chemical pulp and is well sized.

11. Grease Proof Paper: Paper having few inter connecting pores between the fibres usually done by beating. Papers are transparent and resistant to grease and oils.

12. Imitation Art Paper: Made by adding a large quantity of mineral loading to the pulp in the beater (cheaper quality).

13. Hanging or Wall Paper: Consist of 70 to 90 percent Ground Wood and the remainder unbleached Sulfite Pulp. Used for papering walls and ceilings. 14. Kraft Paper: Comparatively coarse paper particularly noted for its strength. It used as a wrapper or packaging material.

15. Ledger Paper: Usually made from a mixture of rag pulp and chemical.

CATEGORIES OF PAPER BOARDS

Paperboard is a generic term for wide spectrum of board types of differine dens hardness made from wood in a fibrous state. They are made either on a fourdrinier or on one or more cylinder machines. The paperboard consists of several on pulp stock laid down to form a thicker sheet.

Types of Paper-board: The two principal divisions of paper board on the basis of utilization are:

1. Boards for containers: It is a combined type where the outer and the inner layers consist of different pulp stocks.

2. Board for Building and Insulating Uses: Based on their physical characteristics , they may be classified as:

Rigid fiberboards

a) Structural fiberboards

May be homogeneous or laminated. They combine strength with heat and sound insulating properties. They include Building Boards, Tile Board, and Roof Insulating Board etc.

b) Non-structural fibreboards

Often called slab insulation and is made by lamination to form rigid blocks used mostly for cold storage insulation.

Flexible fibre insulation or felt

It is manufactured in the form of blanket and thickness ranges from 1/2 to 2 inches. It is usually covered on one or both sides with paper, fabric or aluminum foil.

Fill insulation

It includes all insulation materials that are supplied in bulk form to be poured into spaces between wall studs, floor and wood joints. The products commonly used as fill insulation are wood fibre, ground and macerated newsprint, sawdust and shavings.

Paper boards are also classified into different categories according to the raw material used, viz.,

Duplex boards: They are two-ply boards made from two different stocks on a cylinder mould machine. The top layer is made up of good quality pulp while the bottom layer from waste paper. Boards are stiff and capable of folding. They are used in the manufacture of packing cartons.

Straw boards: They are cheap paper boards made on crude paper machine from agricultural residues like wheat straw, rice straw which is cookea lime.

Mill boards: These are cheap paper boards made on crude paper man waste paper and are used in road sweeping.

PAPER INDUSTRY OF INDIA

The Indian paper industry accounts for about 37% of the world's production of paper. The estimated turnover of the industry is INR 60,000 crore (USD 8.5 billion approximately) and its contribution to the exchequer is around INR 4,500 crore The industry provides employment to more than 0.5 million people directly and 1.5 million people indirectly.

The Indian Paper mills use a variety of raw material like wood, bamboo, recycled fibre, bagasse, wheat straw, rice husk, etc. In terms of share in total production, approximately 25% are based on wood, 58% on recycled fibre and 17% on agro residues.

The per capita paper consumption in India is at a little over 13 kg IS way behind the global average of 57 kg Paper consumption in India is approximately 15 million tonnes per annun TPA) but is expected to reach 23 5 TPA by 2025 Foretasted demand for paper in 2025 is 23, 5 million tons The futuristic view is that growth in paper consumption would be in multi pies of GDP and hence an increase in consumption by one kg per capita would ear to an increase n demand of 1 million tonnes. The Indian paper industry [is] expanding at a rate of 6- 7 per cent which would drive the growth of the Industry.

Industry Forecast

Paper consumption forecasted to increase by 7.6 %o per year in the coming years.

RAYON INDUSTRY

Rayon is the oldest commercial man made fiber.

- The US Trade Commission defines Rayon as manmade textile Fibers and Filaments composed of Regenerated Cellulose.
- A French chemist, Count hillaire de Bernigaud de Chaardonnet is known as father of Rayon.
- Rayon was developed in France in 1890's and was originally called Artificial Silk.
- In 1924, the term Rayon was officially adopted by the Textile Industry.
- Rayon is one of the most versatile and economical man made fiber available and is also called

"the Laboratory's first gift to the loom".

Definition

According to American Society for testing the term Rayon was adopted (adopted in 1924 in trade) for the class of synthetic filaments and textiles made from cellulosic raw materials.

"Rayon is a generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice and solidifying it in the form of filament".

- Because of the marked difference in chemical and physical properties of the filaments, the more recent trend is to confine the term RAYON to the products Viscose and Cup ammonium processes.
- Viscose method of Rayon Making is relatively inexpensive and of particular Significance in the production of non-woven fabrics.
- The process of making Viscose was discovered by CF Cross and Beven and Beadle in 1892

Rayon fiber characteristics

- Ravon is moisture absorbent (more than cotton), breathable, comfortable to- easily dyed in vivid colors.
- It does not build up static electricity, nor will it pill unless the fabric is short, low twist yarns.
- It is comfortable, soft to the skin with moderate dry strength and abrasion.
- It withstands ironing temperatures slightly less than those of cotton.
- It generally resists insect damage.
- Possesses ability to blend easily with many fibers.
- It has moderate resistance to acids and alkalis.

Different types of Rayon

- High wet modulus rayon (HWM)
- Polynosic rayon
- Specialty rayons
- Flame retardant fibers
- Super-absorbent rayon
- Micro-denier fibers
- Tencel rayon
- Lyocell

8. REFERENCES

Bodig, J. and Jayne, B.A. (1993). Mechanics of Wood and Wood Composites. Krieger Publishing Co., Melbourne, FL.

Boldizar A., Klason C., Kubat J., Näslund P., and Saha P. (1987). Prehydrolyzed cellulose as a reinforcing filler for thermoplastics. Int. J. Polym. Mater. (11):229.

Pizzi, A. and Mittal K.L. (2003). Handbook of Adhesives Technology (2nd ed.). Marcel Dekker, New York. Kollman, F.F. (1975). Principles of Wood Science and Technology: Wood Base Materials Manufacture and Properties. Springer-Verlag, New York.

Maloney, T.M. (1996). The family of wood composite materials. For. Prod. J. 46(2):19–26.

Maloney, T.M. (1993). Modern Particleboard and Dry-Processed Fiberboard Manufacture. Miller-Freeman, Inc., San Francisco, CA.

Marra, G. (1979). Overview of wood as a material. J. Educ. Modules for Mater. Sci. Eng.

1(4):699–710. Schniewind, A.P. (1989). Concise Encyclopedia of Wood and Wood-Based Materials. The MIT Press, Cambridge, MA.

Suchsland, O. and Woodson, G.E. (1986). Fiberboard manufacturing practices in the United States.

FOUQUÉ, H. M. L. R. *French Patent No. 834, 743,* Nov. 30, 1938.

FREDENHAGEN, K., and CADENBACK, *G. Angew. Chem.* 46:113-17 (1933*).*

FRITZWEILER R., and KARSCH, W. Z. *Spiritusind 61(28):207* (1938).

GILBERT, *N.*, HOBBS, I. A., and LEVINE:, J. O. *Ind. Eng. Chem.* 41:1712 (1952*)*

GIORDANI, M. *Chimica e Industria* (Italy) *21:266-72* (1939).

GREAVES, *C. U. S. Dept. Comm Off.* P B 18941.

Kamel S, Ali N, Jahangir K, Shah S M and El-Gendy A A. 2008. Pharmaceutical significance of cellulose: A review. 2(11): 758 778.

Kollmann F F P and Cote W A. 1968. Principles of Wood Science and Technology-I (Solid Wood). Springer-Verlag Berlin Heidlberg. NewYork. 592p.

Lavigne RJ. 1979. Instrumentation Application for Pulp and Paper Industry. Miller Freciman publication. 320p. Moon R J, Martini A., Narin J, Simonsen J and Youngblood J. 2011. Cellulose nanomaterial review: structure properties and nanocompositcs. Sociely of' Chemical Revlew. 40(7): 3941-3994.

SOME IMPORTANT TERM RELATED TO THE PULP AND PAPER

Absorbency: That property or paper, which causes it to take up liquids with which it is in contact.

Active alkali: NaOH and NaS content in sulfate cooking liquor expressed as Na_2O.

Activity: The active alkali content divided by the total alkali content of sulfate cooking liquor, expressed in percent.

Air brush coating: A method of coating paper on one side in which the coating mixture is applied by a metal roller and distributed by a thin, flat jet of air coming from a slot in a metal blade which extends across the machine. The air removes excess of coating and smoothes the surface.

Air dried: The artificial drying of paper by contact with air over skeleton dryers after the paper has been surface sized. Air dry: Refers to moisture free pulp divided by factor 0.9.

Alpha pulp: A specially processed chemical wood pulp of high alpha-cellulose content.

Alum: Aluminum sulfate used for precipitating the rosin size on to the pulp to give water-resistant properties to the paper.

Apparent density: The weight per unit volume of the sheet. It is commonly calculated by dividing the basis weight by the caliper, although it must be recognized that the numerical value thus obtained is dependent on the definition of the ream.

Appearance: The effect on the sense of sight resulting from the observation of the colour, brightness, finish, cleanliness, formation and other visible characteristics of paper or paper boards.

Ash: The inorganic residue obtained by igniting a specimen of pulp, paper, or other cellulosic material in Such a way that the combustible and volatile compounds are removed. The ash content is percentage of such residue based on the weight of the test specimen.

Barking drum: Large rotating cylinder in which pulpwood sticks are tumbled against one

another to remove the bark.

Basis weight: The weight in pounds of a ream (either 480 or 500 sheets) of paper cut to a given size. The standard size ream varies with different grades of paper according to trade practices.

Beater: A large mixer in which the pulp is mixed with the other ingredients of paper.

Beta cellulose: That portion of a pulp or other cellulosic material, which dissolves in an alkaline solution.

Black liquor: Spent liquor from a sulfate digester. It contains dissolved organic wood materials and residual active alkali compounds from the cook. It is the name applied to the liquors recovered from the digesters, up to the point of their incineration in the recovery plant.

Blanks: Boards made either on a cylinder machine or in a multiple ply on a fourdrinier and pasted in to several plies. If uncoated, they are called plain mill blanks; if coated, they are called coated blanks.

Bleach: A chemical used to purify and whiten paper pulps.

Bleaching: The process of purifying and whitening pulp by chemically treating it to alter the coloring matter so that the pulp has a higher brightness.

Blister: A defect arising in paper when dried too suddenly on the drying cylinder or when the felts are not in good condition, leaving air between the felt and the sheet.

Blow: Releasing the pressure and discharging the contents of the digester in to a blow tank.

Blow tank: A tank into which pulp from the digester is blown.

Body stock: The base stock or coating raw stock for plain or decorated-coated papers. Also termed as base paper.

Bogus: A descriptive tem applied to papers and paper boards manufactured principally from old papers, or inferior or low grade stock in imitation of grades using a higher quality of raw materials.

Bond paper: The name bond was originally given to a paper, which was used for printing bonds and stock certificates. t is now used in referring to paper used for letterheads and many printing purposes. Important characteristics are finish, strength, freeness from fuzz, and rigidity.

Bone dry: Refer to moisture free pulp.

Book paper: A class or group of papers having in common physical characteristics that, in general, is more suitable for the graphic arts, exclusive of newsprint. These physical characteristics are varied to meet the requirements of the type of impress employed and the objective use of the article produced.

Boxboard: Paperboard used for fabricating boxes.

Break: A complete tear or rupture of the web of the paper or paperboard during manufacture or some subsequent operation, which utilizes rolls of paper.

Breast roll: A large diameter roll around which the fourdrinier wire passes at the machine head box just at or ahead of the point where the stock is admitted to the wire by the stock inlet.

Brightness: The reflectivity of a sheet of pulp or paper tor blue light measured under standard conditions.

Broke: Paper trimmings or damaged paper as a result of breaks from the paper machine or finishing operations. Usually returned for reprocessing.

Brown stock: Unbleached pulp from a digester. It derives its name from its dark brown appearance.

Bruising: A refining action, which results in internal fibrillation.

Brush coating: The process of applying a semi fluid mixture of the pigment and the binder by means of a revolving cylindrical brush and smoothing the coating so applied by means of a oscillating flat brushes which contact the coated sheet as it is being drawn tightly over a moving rubber apron or a revolving drum.

Brush finish: A coated paper run under stiff brushes after coating and before calendaring to give a high finish.

Brushing: A refining action, which results in external fibrillation.

Bulk: The thickness of a sheet or relative thickness according to basis or substance weight of the sheet.

Burst: The pressure in pounds required to rupture one square inch of paper under stipulated testing procedures.

Bursting strength: Resistance of paper to rupture under pressure, as indicated in pounds per square inch on a burst or pop tester.

Calendaring: Smoothing the surface of paper sheet by applying pressure or friction.

Calendar stack: Steel roles at the dry end of a paper machine, which smooth and level the sheet of paper

Caliper: The thickness of a sheet measured under specified conditions, expressed in thousands of an inch, millimeters, or points.

Cast coating: Coating paper by pressing against a solid surface while the coating is in a highly plastic condition.

Causticizing: Converting green liquor to white liquor.

Causticizing efficiency: A percentage found by dividing NaOH by NaOH+ Na-CO in the caustic zing process, both items being expressed as Na20.

Cellulose fibre: The fibrous material remaining after the non fibrous components of wood have been removed by pulping and bleaching operations.

Chemical consumption: The pounds of NapSO4 added per day, divided by the tons of air-dry pulp produced per day.

Chemical loss: A percentage found by dividing sodium sulfate (expressed as Na20) in new chemical by total alkali to the digester.

Chemical loss in evaporators and furnace: A percentage found by dividing the total alkali to the evaporators, plus sodium sulfate (expressed as Na20) in chemical minus total alkali in the green liquor, by the total alkali to the digester.

Chemical loss in pulp washing: A percentage found by dividing the total alkali to the digesters, minus the total alkali to the evaporators, by the total alkali to the digesters.

Chemical loss in recausticizing and mud washing: A percentage found by dividing the total alkali in the green liquor, minus the total alkali in the white liquor, by the total alkali to the digesters.

Chemical pulp: Pulp obtained by cooking wood with solutions of various chemicals.

Chemical recovery: A percentage found by dividing the total alkali to the digesters, minus the sodium sulfate (expressed as Na,0) in new chemical, by the total alkali to the digester after correcting for any change in the liquor inventory.

Chemiground wood: A process in which a whole or full- sized pulpwood log is cooked with chemicals and steam prior to grinding. The resultant products, after grinding this log, are called chemiground.

Chipboard: A paperboard used for many purposes where strength and quality are not needed. It is relatively of low density and made from waste (usually mixed) papers.

Chipper: Machine with rotating knives which cuts pulpwood logs to chips about 1-inch square and 1/8- inch thick.

Chlorine dioxide: A chemical (CIO) used in pulp bleaching in a solution of water, usually in one or more of the latter stages of a multistage sequence.

Classifier: A device for separating pulp fibre in liquid suspension according to fibre length and particle size by depositing the fractions on known mesh wire cloth for final bone- dry weighing.

Clothing: A term applied to paper machine felts and fourdrinier wires.

Cloudy: A term indicating unevenness or irregular formation in look- through of paper.

Cockling: A rippling effect given to a surface of a sheet of paper which has not been properly dried.

Colour: Dyes added to wood pulp to give the finished product the desired color.

Compressing: A refining action, which results in densification of fibre.

Consistency: The percentage expression of relative weight of dry pulp in a given weight of pulp and water mixture.

Continuous digester: A process vessel for producing chemical pulp continuously.

Cook: The operation of treating any cellulosic raw material with chemicals, usually at elevated pressures and temperatures, for the purpose of removing impurities and producing pulp suitable for paper making.

Core: A tube on which paper is wound for shipment.

Corrugated board: Board after it has passed through a corrugating machine. A roll ordinarily involved in dewatering and picking off, or couching, of newly formed paper web wire on which it was formed and partially dewatered, and in the transfer of the web to the wet from press felt for their dewatering.

Crushing: A refining action resulting in permanent fibre deformation.

Curl: Tendency of a sheet of the paper to coil or roll up at the edges. Caused by changes in weather or faulty drying on the paper machine.

Curling: A refining action, which permanently reduces the radius of curvature of a fibre.

Cutter: A machine which cuts rolls of paper in to pre determined sheet sizes.

Cylinder machine: One of the principle types of paper making machine, characterized by the

use of wire- covered cylinders or moulds on which a web is formed. These cylinders are partially immersed and are rotated in vats, which contain a dilute stock suspension.

Dandy roll: A skeleton cylinder covered with a woven wire cloth, or with an arrangement of fine longitudinal wires, crossed at close intervals produces wave and by heavier circumferential wires. The former structure the latter, the laid paper. The dandy roll is one way of applying watermarks to while wet. It positioned on paper the top of the wire in front of couch roll. Decker: A drum vacuum filter, which is used to thicken pulp for storage and produces white water for reuse in the process.

Deckle: The straps on the wet end of the paper machine which prevents the fibres from overflowing the Sides and which determine the width of web of paper which can be run on any given machine.

Digester: The vessel used to treat pulpwood, straw, rags, or other such cellulosic materials with chemicals to produce pulp.

Digesting: Cooking in a digester.

Dissolving pulp: Special grade of chemical pulp made from wood or cotton linters for use in regenerated ceulose (viscose rayon and cellophane) or cellulose derivatives such as acetate, nitrate, etc.

Doctor: A device for keeping the surface of a roll clean by a scrapping action.

Draw: Then tension applied to the paper between sections of a paper machine, such as the press section or dryer section.

Dregs: Stable solids, which comprise the underflow from clarifiers in the caustic zing process.

Dry end: That part of the paper machine where the paper Is dried.

Dyers: The steam -heated cylinders over which the paper in the web is passed to be dried.

Efective alkali: NaOH+ NaS content in sulfate cooking liquor expressed as Na, O2.

Eimendorf test: A test, which determines the tearing resistance of the paper.

Felt: A woven cloth used to carry the web of paper between the press and dryer rolls on the paper machine

Felt side: The top side of the sheet when it is formed on a wire.

Festoon drying: Air drying paper by washing in a single continuous web, in short festoons, or loops, on travelling poles or slats moving through a drying chamber in which the temperature and humidity are controlled.

Fibre: A unit of paper pulp, which is longer than its diameter.

Fibre axis ratio: Ratio of fibre width to fibre thickness.

Fibre coarseness: Weight per unit length of paper.

Fibre debris: Pieces of wall which have been separated from the body of fibre.

Fibre flexibility: the ability of fibre to bend or deform

Fibrillation: The external disruption of lateral bonds between surfaces layers of a fibre which results in a partial detachment of fibrils or pieces of the outer layers of the fibre and the internal or lateral bonds between adjacent layers with in a fibre.

Fibrils: Thread like elements of a wall of a native cellulose fibre

Filler: A substance added to pulp in paper manufacturing to fill the spaces between wood fibres. Film coating: Application of light pigmented coating to provide a more uniform and smoother surface.

Fine papers: Writing papers which usually possess good pen and ink writing characteristics, such as bond, mimeo, ledger, duplicator, manifold paper.

Fines: Small particles of pulp. Which include fibre debris and small particles.

Finish: A tem used to describe the cutting, counting, sorting, trimming and packing of paper.

Also refers to conditions of its surface. A high finish gives a smooth, hard surface a low finish gives a relatively rough, toothy surface.

Flow-on-coating: Flowing suspension of pigment and adhesive directly on to wet web as it is being formed on the paper making machine.

Folding endurance: A test that measures the number of double folds that can be given to a strip of paper under specified tension, before it will break

Formation: Arrangement of fibres in a sheet of paper.

Fordrinier: The were part of a type of paper making machine where the wet sheet of paper is formed on a wire screen from pulp

Free: Refers to pulp or paper stock, which parts readily with its water, as contrasted to wet or well hydrated stock. Also a sheet of paper which contains no ground wood.

Freeness: The ability of mixture of pulp and water to give up or retain water. The ease or lack of ease with which the mixture or slurry will drain is referred to as freeness or slowness.

Furnish: The list of ingredients, which make up the blend of pulp fibres and additives in the wet end mixture fed to the paper machine.

Fuzz: Fibrous projections on the surface of the sheet of paper caused by excessive suction, insufficient beating, or lack of surface sizing.

Grade: A term applied to a paper and pulp which is ranked (or distinguished from other papers or pulps) on the basis of its use, appearance, quality, manufacturing history, raw materials, performance, or a combination of these factors.

Green liquor: The name applied to liquor made by dissolving the recovered chemicals (smelt) in water and weak liquor preparatory to caustic zing

Ground wood papers: A general term applied to variety of papers made with substantial proportions of mechanical wood pulp together with bleached or unbleached chemical wood pulps (generally sulfite), or a combination of these, and used mainly for printing and converting

process.

Guillotine: An instrument for trimming paper with a downward cutting action similar in operation to the guillotine used in France.

Hard- sized: A type of paper, which has been treated with considerable size to resist moisture penetration.

Head Box: This is a device for maintaining a constant head to a piece of equipment such as a pump, screen, paper machine, etc. The level is maintained by throttling incoming flow or by continuous Overflow tram the box as re circulated item. The first wet end component of a Fourdrinier machine. It distribute the furnish over the moving wire screen.

Hydration: To swell the fibres and then partially break them down in to fibrillate and mucilage or get any process for altering cellulose fibres to increase their ability to absorb water.

Hygroexpansivity:. That property of a material, which causes it to expand, or contract when its moisture content is changed. (as when the relative humidity of the surrounding atmosphere is changed).

Hygroscopic: That property of paper or other substance which makes it prone to absorb water

Imbibition: Sorption of water by fibre without increase in volume.

Indented: A paper or paperboard with raised knobs developed or formed in to the sheet in the primary process

Job lot: Paper produced in excess of an order or small lots of discontinued lines; or paper rejected because of defects or failure to conform to specifications, or paper which although of standard quality at the time of manufacture, has become non standards subsequent to manufacture.

Jordan: A type of refiner whose working element consists of a conical plug rotating in a matching conical shell, the outside of a plug and inside of the shell is furnished with Knives or bars commonly called tackle.

Jumbo roll: A roll of paper with a large diameter, usually over 9 inches.

Kappa number: The permanganate number of a pulp measured under carefully controlled conditions and corrected to be the equivalent of 50 per cent consumption of the permanganate solution in contact with the specimen It gives the degree of delignification of pulps through a wider range than does the permanganate number.

Kinking: A refining action producing fibres containing an abrupt change in the radius of curvature.

Knotters: Special pressure screens separating knots and uncooked wood materials from the blow tank brown stock.

Kraft: The sulfate or alkaline process. It means strength in German.

Kraft pulp: A strong pulp made largely form pine by the sulfate process.

Lap machine: A machine to produce sheets or laps of pulp for storage.

Lignin: The inter fibre bonding material in wood, and it is the material separated from cellulose fibres in the cooking and bleaching process.

Machine direction: The direction of paper parallel to its forward movement on paper machine, the direction at right angles to this is called the cross direction.

Machine dried: The process of drying paper on the paper machine by passing the damp sheet or web over steam heated cylinders or drums.

Machine finish: The finish applied on the paper machine, commonly called MF.

Machine glazed: The finish produced in glaze on the wire side of a sheet as it is passed in contact over a single, large diameter, steam heated cylinder on the Yankee machine. The finish is commonly referred to as M\G.

Machine wire: The continuous, copper meshed wire which is the travelling surface on which the web of paper is formed. It is usually referred to as the wire.

Mercaptan: smelling substances formed in cooking wood by the sulfate process (CaH,SH).

Moisture content: The per cent of moisture found in finished paper. The amount varies according to atmospheric conditions because paper may be either absorb or emit moisture.

Mullen: Mulen or burst is the pounds per square inch of pressure required to rupture the sheet. It is normally reported as point calculated as follows: Bursting ratio. Bursting strength x weight in pounds (500-25x40) ream.

Nip: The point of contact between two rolls, as in a calendar stack

Opacity: The proper of a paper, which prevents show-through of dark printing, etc., on or in contact with the backside of the sheet

Paper board: A thick, stiff type of paper made of wood fibre, straw, or waste paper, or a combination of these maternal. Common kinds are boxes, milk cartons, etc.

Paper clay: A natural white, low- free silica substance with high retention, colour and suspending properties used for filing or coating paper.

Paper machine: The machine on which the fibres and other components of the paper are formed, pressed, dried, calendared, wound on reels, slit in to appropriate widths, and wound in to rolls or cut in to sheets in certain cases

Permanganate number (K number): A measure of the amount of lignin left in the chemical pulp after digestion, determined by laboratory tests on a sample. The more lignin there is in the pulp.

Pigment: An insoluble powder of mineral and inorganic compounds.

Pinholes: Imperfections in paper which appears as minute holes when looking through the sheet, which originates from the foreign particles that are pressed through the sheet.

Pitch: In the paper industry. pitch is the material (largely a mixture of fatty acid and resin acids and unsponifiable organic substances) that can be extracted from wood, mechanical or chemical pulps, by means of organic solvent.

Ply: The separate webs, which make up the sheet formed on a multi cylinder machine. Each cylinder adds one web or ply, which is pressed to the other, the plays adhering firmly upon drying.

Point: A tem used for an impression of thickness of a sheet of paper in one-thousandths of an inch (0001in.)

Pop test: Slang term for bursting test, originating from the popping sound when the paper bursis.

Porosity: A test, which measures the time, required for a given amount of air to flow through a sheet of paper. This test is measure of how closely the fibres are compacted and bonded together. A paper of high Porosity is one that is quite dense and relatively non-porous. This test is made with a densometer.

Pulp: A Crude fibrous material produced either chemically or mechanically from fibrous wood cellulose and used as raw material for paper making.

Pulping: The manufacturing process for transforming pulpwood, rags, and other raw material into pulp which after suitable beating, refining, bleaching, etc. Can be made in to paper or paperboard.

Ratio of active alkali to wood: The ratio of active chemical in the liquor to dry wood charged into the digester. In the sulfate process, the chemical is sodium hydroxide and sodium sulphide.

Rattle: The crisp, crackling sound produced by shaking or crumpling a sheet of paper to indicate its rigidity or stiffness.

Ream: A number of sheets of paper, either 480-500, according to grade.

Refiner: A device, which separates fibres from one another or cuts fibres in shorter lengths by an action in which the pulp passes between the discs centrifugally to the periphery.

Refining: The application of energy to papermaking fibres, which causes changes in their physical characteristics via mechanical and/or hydraulic means.

Refractive: Ability to bend a light from a straight course. Materials differ in refractivity, which is measured as refractive index.

Rigidity: Stiffness, resistance to bending, inflexibility.

Ripple finish: A dimpled or rippled effect given to the surface of paper by means of an embossing roll.

Roll coating: A process in which the coating is applied by rolls and subsequently smoothed by means of reverse rolls contacting the freshly coated surface.

Salt cake: A make up chemical added to black liquor. Chemically it is sodium sulfate (Na»SO).

Save-all: A device, which screens paper fibres from water. Used to save pulp which might otherwise be lost to the sewer.

Screen: A device used to separate undesirable objects from pulp.

Screening: The operation of passing chips over screens to remove sawdust, silvers and oversize chips, or passing pulp or paper stock through a screen to reject coarse fibres, silvers, shives, knots etc.

Screenings: The knots of pulp and foreign matter, which are screened from pulp.

Semichemical pulp: A pulp produced by a mild chemical treatment of the raw material followed by a mechanical diarizing operation.

Shavings: The strips of paper cut from the sheet or roll in trimmer, reminder or cuter.

Shearing: A refining action which results in two contiguous parts of the fibre sliding relative to each other, in a direction parallel to their plane of contact.

Sheet rol: A roll of paper that is to be finished into sheets on finishing room equipment.

Shive : A bundle of incompletely separated fibres, which may appear in the finished sheets as an imperfection.

Shives: Uncooked wood particles, which show up in the finished sheet.

Shortening: A refining action causing a physical separation of a fibre across the axis in to two or more pieces.

Side roll: The roll of paper run in conjunction with a regular run in order to complete the fill of a paper machine.

Size: a water-resistant material, which is added to paper.

Size press: Section of paper machine where surface treatments, such as starch solution, applied to the sheet of paper to give it special qualities.

Skid: A platform, usually wooden, on which sheet paper is packed for shipment.

Slaking: The mixing of green liquor and lime (Ca0) prior to caustic zing reaction.

Slime: An aggregation of heterogeneous material, sometimes having a slippery feel, found at various points within a pulp or paper making system.

Slime spots: Semitransparent spots produced in a paper caused by micro-organisms which have grown in one of the many wet spots around the wet end of the paper machine.

Slitter: A sharp disc, which cuts paper in to predetermined widths.

Slush: A mixture of pulp fibre and water.

Slush pulp: Wood fibres mixed with water so that the material can be pumped.

Smelt: The molten ash formed in the bed of the recovery as a result of burning concentrated black liquor, consisting mainly of Na2CO3 and Na,S which is mixed with weak wash liquor in the dissolving tank to from green liquor.

Smoothness: The texture of the surface of paper also called its finish.

Snowstorm: Describes the appearance of paper with a wild, non-uniform formation.

Soda process: The process of making soda pulp. The principal chemical used in cooking liquor is sodium hydroxide, derived from sodium carbonate or soda ash.

Sorting: The operation of examining sheets of paper, generally on both sides, to remove those that are not saleable as perfect papers.

Specific surface: Surface area of fibres per unit weight of dry fibre (cm-1gm).

Specific volume: Volume of fibres per unit weight of dry fibre (cc/gm).

Spent liquors: Chemical solutions, which have been used in pulp, manufacturing and after treatment, are used again on fresh batches of wood chips.

Splice: The joining of ends of paper to make a continuous roll.

Splitting: A refining action causing a physical separation of a fibre parallel to the axis.

Starch: Material, which is used as a sizing for paper.

Static electricity: Charges of electricity, which may be contained by paper, which has been improperly dried or has sustained excessive pressure in calendaring. It can also exist in properly dried paper. Which has become affected by local atmospheric conditions after shipment.

Stock: Pulp which has been beaten and refined, treated with sizing, color, filler, etc., and which after dilution is ready to be formed into a sheet of paper.

Stretch: The elongation of a strip of paper when subjected to a tensile pull. The term is colloquially but incorrectly used to indicate expansion caused by moisture absorption of a sheet of paper.

Stuff: Paper making material or a low density stock as it is ready for the paper machine.

Suction box: A device at the wet end of the machine located under the paper machine wire, which removes water from the paper web by means of a vacuum pump.

Sulfate: Alkaline process of cooking pulp. More often referred to as the Kraft process. Also, pulp cooked by this process.

Sulfate process: The process of making sulfate pulp; the principal chemical used in the cooking liquor is sodium sulfate (salt cake)

Sulfate: Acid process of cooking pulp. Also the pulp cooked by this process.

Sulfite process: The process of making sulfite pulp; the principal chemical used in the cooking liquor is calcium bisulfate.

$$\frac{Na_2S\ \%}{NaOH+Na_2S}$$

Sulfite pulping: The acid or neutral base pulping process.

Super calendar: A calendar stack used to alter the surface properties and appearance of paper. It is constructed on the same principle as a calendar, except that alternate chilled cast iron and soft rolls are used in the super calendar. The soft rolls are constructed of highly compressed cotton or paper. It is not part of paper machine where the calendar is.

Surface sized: Paper that has been treated with starch or other sizing material at the size press of the paper machine. This term is used interchangeably with the term tub-sized, although tub-size more properly refers to surface sizing applied as a separate operation where the paper is immersed in a tub of sizing (starch or glue), after which it passes between squeeze rolls and is air dried.

Sweetener: Long fibre or virgin pulp added to white water to improve its filtering properties in save-alls.

Tall oil: The mixture of resins, fatty acids, and other substances recovered in the black liquor.
Tensile strength: The force parallel to the plane of the specimen required producing the failure in specimen, given width and length specified conditions of loading.

Text papers: Those grades of printing papers specifically made for use in the manufacture of books.

Tissue paper: A class of papers that are of gauzy texture and fairly transparent.

Titanium dioxide: Filler made from titanium ores which has great pacifying and brightening properties and is of minute particle size.

Total alkali: Alkali present in sulfate cooking liquor. (NaOH+ Na2S +Na2 CO3+ Na2SO3) expressed as Na20.

Translucency: Ability to transmit light without being transparent.

Translucent: A soft cardboard, pasted or non-pasted, made of soda pulp with both sides clay

coated.

Trim: indicates the maximum width of finished paper which can be made on a particular machine.

Trimmer: Machine, which cuts sheets in to final size by the diagonal motion of the cutting blade or knife.

Two-sided: A term applied to paper having large differences in cooler or finish on the wire or felt sides of the same sheet.

Unreduced salt cake: Na2S04 in the green liquor, expressed as Na2so4 in grams per liter.

Untrimmed: Paper cut by the slitters with the grain and rotary cutters across the grain on a sheeting machine.

Watermark: A translucent marking made on paper while it is still wet for purposes of identification of paper.

Waviness: A warping effect occurring along the edges of paper, particularly across the grain of the paper, exposed to an excess of atmospheric moisture.

Weakwash: Overflow wash water from the lime mud washer. Recycled into the recausticizing process.

Web: A continuous sheet of paper forming or having been formed and finished on a paper machine.

Well-closed: A term describing a closely formed or uniform distribution of fibres in a sheet of paper.

Wet end: The beginning of the paper machine, comprising the head box, wire, and press section.

Wet strength: The tensile strength of paper if it is wetted after manufacture. Wet strength is

increased by adding certain synthetic resins to the finish.

Wetting: An action which increases water physically sobbed by fibres.

White liquor: The name applied to liquors which are made by caustic zing green liquors and are ready for use in the digester.

White water: Filtrate from the paper machine wet end containing short fibres (fines) and fillers.

Wild: Irregular sheet formation.

Wire: The moving "screen" at the wet end of the paper machine where the sheet is formed.

Wire mark: The impression left in a web of paper by wire of a fourdrinier Machine.

Wire side: The surface of a sheet of paper, which was next to, the wire when formed.

Yankee Machine: A type paper machine employing a single drier of large circumference with a highly polished surface.

Yield: The ratio of dry output to dry input wood, expressed in percent.

Assignments

Q.1. Draw the exact procedure of plywood making

Q.2. Draw the exact procedure of manufacturing of particle board

Q.3. Enlist different types of plywood

Q.4. Differentiate between seasoned and non seasoned wood

Q.5. Write a report on

A. Visit to saw mill to study veneering and different kind of sawing

B. Visit to handicraft manufacturing unit

C. Visit to wood distillation unit

D. Visit to nearby industrial plantation

E. Visit to various wood based industries

1. **Plywood industry**
2. **Packing industry**
3. **Match based industry**
4. **Furniture industry**
5. **Saw mill industry**