The Forest & Wood

Forest is the name for a considerable stretch of terrain covered with trees. Scientifically, however, it has a greater meaning than a simple collection of trees, as it is a question of a real vegetal society in which each individual fights of space, light and food, influencing its neighbours, in many ways. In the midst of this society, there are also epiphytic plants, bushes, grasses, mosses and other plants. The virgin forest represents the serenity of natural forces: it is balanced nature. Within it, trees of all ages and sizes live together, more or less mixed.

Like an independent being, the tree grows, reproduces and dies to make away for others. The annual growth of the whole is the same as its decrease by degeneration. However, it is only with difficulty that the forest escapes from the devastating effects of the elements. Sometimes there are hurricanes, which leave their mark on the mass of trees; other times there are fires, caused by lightning in some corner of the forest and which spread and devastate whole areas, and finally, of course, there are insects which attack and decimate the arboreal hosts. Nature repairs such devastation and repopulates the clearings with new individuals, which, although sometimes of different composition, finally take on character and irregular form of their predecessors.

With man comes a new agent of destruction for the forest. His methods of exploitation in recently discovered regions are brutal, as he only seeks to satisfy immediate needs, without a thought for the conservation of the forest. He is frequently guilty of causing fires, which seems to worry him very little. In any case, the vegetation gradually grows back if any seeds remain, and its development will not have been disturbed by the fire. However, the flames often continue their destruction.

In damp regions, the trees grow in dense masses which not even the sun manages to penetrate. In semi-arid areas, the vegetation is sparser, so that in many cases, the crowns of the trees do not even touch.

We can distinguish the following as types of characteristic forests or several categories of forest:

1) Tropical forest, also called virgin forest; its vegetation is perpetually

green and the trees often grow to a height of 40 or 50 metres, among which there are a lot of lianas and epiphytes.

2) The monsoon forest, characteristic of South East Asia with thick but intermittent vegetation, for when the dry season comes, it stops growing and the leaves fall.
3) The summer forest, native to mild climates, if it consists of a single type, it is normally known by that name, e.g., pine woods, oak or chestnut groves, etc. The leaves fall in winter.
4) Scrub or undergrowth is found in the area immediately below, in warm countries. In this type, bushes and xerophilous ligneous bushes predominate with deep roots and coriaceous leaves, like broom and thyme. This type of forest is also known as scrub and the land appears more or less covered by undergrowth bushes, beneath which a layer of hummus is formed, a vitally important material in the preservation of the ground, as it frees it from the catastrophic effects of erosion.

Humidity and atmospheric temperature conditions are of primordial importance for the forest's existence. The lack of humidity is responsible for the wide unwooded interior expanses in every continent, while low temperatures prevent the development of forests in septentrional latitude or at great altitude. Areas of high humidity have an almost uninterrupted covering of forest: here, clearings only appear due to adverse ground conditions or the action of destructive agents, such as fire, wind, or insects.

Different climate conditions and areas produce arboreal species which differ in size, wood, form, type, quantity and products. Where temperature and humidity conditions are more favourable, there will be a greater variety of species. Conversely, there will be fewer in the mountains and high latitudes. Conifers predominate in cold climates and semi-arid regions. Around the equator, and in sufficiently damp places, the number of species increases and the conifers decrease or completely disappear. In large, mild zones, the forests are made up of types of wood and conifers, with a predomination of one or the other depending on the local condition. In the tropics, and wherever there is heavy rain, the hard and leafy varieties develop differently and profusely.

Forests render countless services to man, directly or indirectly. Directly, they provide him with fundamental raw materials for the development of his existence: fruit, wood, coal, cellulose, alcohol, acetone, resins, essences, tannin, colourings, starches, waxes, cork, etc.

And, indirectly, they serve as indispensable regulators of the necessary climatic conditions for the development of agriculture and even for

Wood: Organoleptic and Physical Properties

Wood is, without doubt, one of the most noble and useful raw materials given to us by nature, without which man would never have reached the high level of progress and well-being which he enjoys at the moment. At first it was vital material to make the first tools, houses and boats to cross and sail on the rivers. Then, wood was used to make the majority of objects and useful tools on which humanity relied for centuries to make progress and develop its own life. Part of wood technology has survived under the work of craftsmen, retained by a few, but most of it has been irremediably lost, replaced by other materials and methods, fruits of man's industrial revolution. In spite of everything, it would be wrong to treat this material lightly.

Wood has the unappreciable, not to say unique, value of being the only natural which man is able to continually renew. Oil will be used up one day, coal and other mines will be exhausted. But a well-cared for forest, or sometimes even uncared for, will go on producing wood indefinitely. Nowadays, wood retains a prominent place in the world economy, as much for the high figures of its annual production (2500 million cubic meters) as in the different international markets, given the existing appreciation of its qualities and physio-chemical properties, and also mechanics which make it, for the time being, irreplacable.

Organoleptic Characteristics

As for the organoleptic characteristics, we find the following:

1) Colour 2) Lustre (natural shine) 3) Translucidity 4) Smell

Intense or accentuated colour is more normal in hardwoods and conversely, the colours white and pale ivory are usually found in softwoods. The colour of healthy woods can be uniform or varied. At first, the sapwood and heartwood have a similar tone and are almost the same in the early and late zones or areas, as for example in the birch and the boxwood. Wood of varied colours are those which have different sapwood and heartwood, like the lime and plum trees. The colours of the heartwood can range from white to black, there are a lot of yellows and duns; with a few reddish tones and even fewer greys and greens.

Woods are very lustrous in their radial section, much less so in the tangential section, and almost not at all in the front. The lustre can have different degrees, satinized, shiny, silky, metallic, iridescent and pearly. The lustre can be increased and intensified with suitable polishing and varnishing.

Translucidity is a characteristic which increases with percentage of resinous materials and also with the proximity to the sapwood. This is much more translucid than the heartwood specially if it is damp, so the species with the highest water content are more translucid than those without.

The smells are caused by the evaporation slowly produced by the resins and essential oils contained in the wood. Normally, a good smell indicates healthy wood, and an unpleasant smell is a symptom of a negative change. In hot regions, there are more perfumed woods than in mild areas. The intensity of the smell is directly related to the durability. The smell in strongest in recently cut wood, and lessens with time. The smell is not a very usual characteristic in wood, however there are some with a specific smell which help to identify them. One such is sandal wood, which has a very characteristic sweetish perfume.

Physical Properties

As for the physical properties of wood, the most outstanding are the following:

1) Hygroscopicity
2) Retractability
3) Density
4) Homogeneity
5) Plasticity
6) Hardness
7) Fissility
8) Durability
9) Conductibility
10) Porosity

Wood is a hygroscopic material and absorbs or releases humidity depending on its environment. The variations in its water level bring about the variation weight as well as in volume. When it loses water, there is a reduction in the dimensions and retractability, a change of shape, a deformation or curving, and often cracking. Contraction or retractability, is always greater in young than in old fibres, and in softwoods than hard ones. The density of wood is a very important physical characteristic, although it is necessary to distinguish between absolute and apparent density. The first is constant, as a question of the weight without the hollows of cellulose and its derivations, and the second, which includes the wood's ducts and pores, is very

Table 3-1. Chemical Composition of Woods (%).

Components	Softwoods	Hardwoods
Holocellulose	59.8-80.9	71.0-89.1
Cellulose	30.1-60.7	31.1-64.4
Polyoses	12.5-29.1	18.0-41.2
Pentosans	4.5-17.5	12.6-32.3
Lignin	21.7-37.0	14.0-34.6
Extractives, hot water	0.2-14.4	0.3-11.0
Extractives, cold water	0.5-10.6	0.2-8.9
Extractives, ether	0.2-8.5	0.1-7.7
Ash	0.02-1.1	0.1-5.4

elimination of one molecule of water, and each glucose molecule added t chain is rotated 180°. This process of repeated, indifinite addition of glu units (monomers) is called polymerization. The empirical formula cellulose is $(C_6H_{10}O_5)n$, where "n" is the degree of polymerization or nu of glucose monomers per cellulose chain. This number in "native" cellu (i.e., cellulose in its natural state) lies on the average between 8000 10,000.

Hemicelluloses are chemically related to cellulose in that both carbohydrates. Carbohydrates are chemical substances composed of car hydrogen, and oxygen, in which the last two elements are present in the s proportions as they are in water. Separation of cellulose and hemicellulos based on their respective solubility in alkali; cellulose is not soluble i 17.5% solution of caustic soda (NaOH), where as hemicelluloses are solu The molecules of hemicelluloses are also chainlike, as in cellulose, but degree of polymerization is much smaller (on the average about 150). Un cellulose, which is exclusively composed of glucose, hemicelluloses incluc variety of monosaccharides. In softwoods these units are mostly mannose 6-carbon sugar, like glucose) and some xylose, whereas in hardwoods they (mostly xylose, a 5-carbon sugar) and little mannose.

Pectic substances are also carbohydrates or related compounds. They prominent in cambial tissues, where they form the membrance that separa the young daughter cells produced by the cambium. According to so reports, pectic substances are absent from older wood (having changed i lignin-like compounds); however, the prevailing opinion is that they present, although in small proportions—they are mainly located in the mid lamella and the primary wall.

All carbohydrates (cellulose, hemicelluloses, and pectic substances) are sometimes called, summarily, holocellulose. On the basis of solubility in 17.5% caustic soda, holocellulose is subdivided into in soluble A-cellulose, which is synonymous to cellulose as used in this text, and the soluble B- and Y-celluloses.

Lignin is the cell-wall component that differentiates wood from other cellulosic materials produced by nature. Lignification, namely deposition of lignin, constitutes the last stage of cell-wall development. Lignin is produced only by living cells. Completion of lignification practically coincides with consumption of the protoplasm and cell death. It is interesting to note that lignin always occurs in association with cellulose, where a cellulose may be found almost pure in nature, (e.g., in cotton).

Lignin is not a carbohydrate; it is predominantly aromatic in nature. However, the type of chemical structure and the reactivity of lignin are not completely known, and its isolation is still a problem. The composition of lignin differs between softwoods (guaiacyl lignin) and hardwoods (syringyl lignin), and also varies especially among different hardwood species.

Wood may contain various inclusions (mainly organic) that are collectively called extraneous materials or extractives. They are not part of the wood substance, but are deposited in cell lumina and cell walls. Extractives are compounds of varying chemical composition, such as gums, fats, resins, sugars, oils, starches, alkaloids, and tannins. The term is based on their possible (at least partial) extraction from wood with cold or hot water or neutral organic solvents, such as alcohol, benzene, acetone, or other. The proportion of extractives varies from less than 1% (e.g., poplar) to more than 10% (e.g., redwood) of the oven-dry weight of wood.

Mechanical Properties of Wood

The mechanical properties of wood are measures of its resistance to exterior forces which tend to deform its mass. The resistance of wood to such forces depends on their magnitude and the manner of loading (tension, compression, shear, bending, etc.). In contrast to metals and other materials of homogeneous structure, wood exhibits different mechanical properties in different growth directions (axial, radial, tangential) and therefore, it is mechanically anisotropic.

In the following, each mechanical property of wood is considered separately and in relation to the influence of various factors.

Strength in Tension. The strength of wood in tension shows considerable differences if loading is axial (parallel to grain) or transverse. Strength in axial tension is much higher–up to 50 times and more. In the transverse direction, the influence of radial or tangential loading is not consistent. The values of strength in axial tension of different temperate woods vary from about 50 to 160 N/mm^2 (50-160 MPa, 7250-23200 psi), whereas in transverse tension the range is 1-7 N/mm^2 (1-7 MPa, 145-1015 psi). In certain tropical woods, axial tensile strength may reach 300 N/mm^2 (300 MPa, 43500 psi).

Strength in Compression. The strength of wood in compression is also different if loads are applied parallel or transverse to the grain. Axial compression strength is higher–up to about 15 times–and varies between 25 and 95 N/mm^2 (25-95 MPa, 3625-13775 psi), whereas transverse values vary between 1 and 20 N/mm^2 (1-20 MPa, 145-2900 psi). It has been observed that in softwoods, tangential compression strength is higher than radial, whereas in hardwoods the situation is opposite. The strength of wood in axial compression is smaller in comparison to metals, but higher in comparison to most other construction materials, such as brick and stone. Also, wood differs from other materials (metals, minerals) because its strength in compression is about half that compared to its strength in tension. The difference is due to the structure of wood. The skeleton of wood is made of cellulose chain molecules which impart very high strength in axial tension. The other constituents (hemicelluloses and lignin) contribute to compression strength, but cellulose also supports compression loads.

Strength in Shear. Shear may exist in longitudinal or transverse plane. Longitudinal shearing stresses are present when wooden members are stressed in bending. The strength of various woods in axial shear varies between 5 and 20 N/mm^2 (5-20 MPa, 725-2900 psi). Strength in transverse shear acting on a cross-section is 3-4 times greater than in axial shear, but this is of no practical importance, since wood fails in axial or rolling shear than in transverse shear. The strength of wood in axial shear has the greatest practical importance. Under the influence of shearing loads, wood usually fails in this manner.

Strength in Bending. Strength in static bending is an important mechanical property, because in most structures wood is subject to loads which cause it to bend. The typical case is of wood as a beam bent under external forces, which act transversely to its access. Under their action three stresses develop: tension, compression, and shear. These stresses are axial. Tension stresses tend to lengthen the wood fibers, compression stresses tend to make them shorter, and shear stresses tend to make the upper part of the beam slide over its lower part.

Cleavage. The resistance of wood to cleavage refers to exterior forces acting in the form of a wedge. Due to its structure, wood has a low axial resistance to cleavage (i.e., it may be easily split). This is an advantage for certain uses (e.g., splitting fuelwood) and a disadvantage for others (e.g., wooden members splitting when nailed or screwed). Different wood species process a different resistance to cleavage.

Toughness. Toughness (or energy in dynamic bending) refers to resistance against sudden loading in contrast to the previous cases, where the loads are static or slowly applied. This property is important for certain wood uses (e.g., tool handles, sport items, boxes and crates, etc.). The energy absorbed by wood is higher with sudden rather than static loads. For example, a beam can support about double the load in the former case. Also, it has been observed that, with sudden loading, the deflection of a beam is about double in comparison to static loading.

Elasticity. From an elasticity point of view, wood has an intermediate position in comparison to other materials. The values of the modulus of elasticity varies between 2500 and 17000 N/mm^2 (2.5-17 GPa, 362500-2465000 psi). Wood has a lower modulus of elasticity than other materials (it bends more under a certain load); however, if weight (density, specific gravity) is taken into consideration, wood is comparable to steel. Modulus of elasticity is different in the three growth directions (i.e., axial, radial, and tangential). The above values apply to the axial direction, whereas transverse values are only 300-600 N/mm^2 (300-600 MPa, 43500-87000 psi). There are no important differences between radial and tangential directions.

Hardness. Hardness is a measure of the resistance of wood to the entrance of foreign bodies in its mass. This resistance if higher-up to about double in the axial direction than sidewise, but the difference between radial and tangential surfaces is seldom important. Hardness is related to the strength of wood in abrasion and scratching with various objects, as well as to the difficulty or ease of working wood with tools and machines. It is an important property for various uses, such as floors, furniture, sport items, pencils, etc. Some woods are relatively soft (poplar, willow, basswood, pine), others have a medium hardness (pine, fir, juniper, walnut), and some are hard (yew, oak, elm, black locust, ash, beech, sycamore, hornbeam, maple, birch, olive). Tropical woods include a range from very soft (balsa) to very hard species.

Transformed Wood & Its By-Products

Independently of the use of wood as a raw material, as we have seen, there are other types of materials on the market which in some cases can be considered transformed wood, and in the others, simply by-products or even in the case of cork, by-products direct from the tree. There are also, many more, as by-products of cellulose, a series of synthetic materials which attempt, often very successfully, to imitate the most beautiful and authentic woods. All of these materials can be divided into the following groups, all with the same objective; to see and touch wood:

Veneered boards with fine cabinetmaking woods, plywood boards with crossed expensive woods, seen with quality woods and sheets in strips with a solid wood heart and other variants.

Wood particle agglomerates, flat-pressed, homogeneous, three-ply, multiple layered etc. Boards and normal and medium density wood fiber agglomerates.

Cork and cork agglomerates with different varieties of granulometry and density.

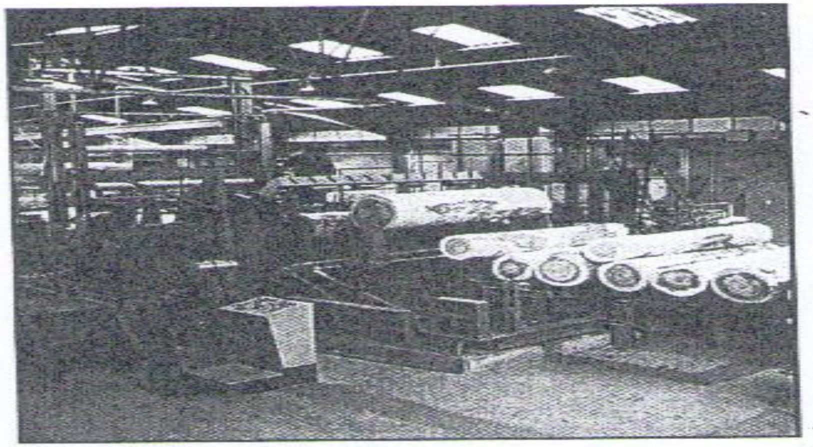
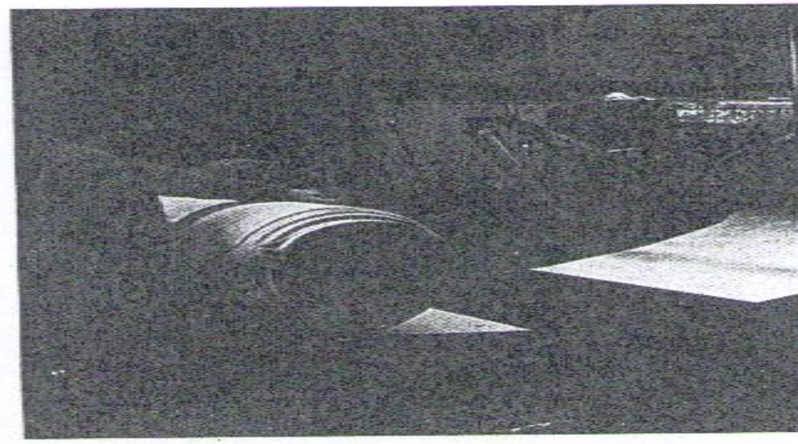
Paper with wood-grained imprint, with and without different types of resin saturation.

Wooden planks of low quality or even particle and fiber agglomerates, with the imprint of high quality woods.

Plastic and stratified laminate planks with base and support of resin impregnated cellulose. Other materials are expanded polyurethane, PVC, polyester, etc.

Veneered Boards

First of all, sheets and sets of sheets must be chosen with a grain or pattern, or attractive floral effects and of which there is a good number of square meters so that the user, in turn, has a sufficient amount to undertake a large production of furniture pieces and doors. The veneer (Figure 8-1) must have a

base, be it of particle agglomerate or other, inferior types of wood, as a center, and by sticking the sheet and posterior pressing the quality wood sheet adheres to one of these bases. The base must be completely dry flat, without imperfections, knots, pits, chips, nail holes or hammer marks. If there is some defect, it has to be covered by suitable pastes and putties in order to create a perfect sanding. If the base has some imperfection or defect after veneering, it will be even more noticeable with lacquer or varnish. The veneer can be affected on one or two faces; if it is only on one face, the work is simpler, and there are not so many problems, partly because it is a question of smaller surfaces as is the case of beams, wainscot, etc. The covering sheet is stuck onto the base wood in such a way that the fibers of both run in the same direction, for in this way, the covering and the base can work together. The veneer of two sides is normally applied to boards with a large surface area, yet, when they are fitted into a framework, they can warp or become deformed in the center. In some cases, the reverse veneer can be more economic, but it must always be of the same thickness as the good side. It must also be remembered that neither in the covering of one side, nor of two, should the sheet be placed with its fibers perpendicular to those of the base board attempting the construction of crossed wood. The thin covering sheets do not have the sufficient strength to prevent the work of the base, and so the covering will move its fibers in the same direction, so that they can contract together.

Particle Agglomerates

Agglomerate wood particleboards (Figure 8-2) were a great discovery when pressing, and the other is by side or extrusion pressing. In the flat pressing system, three different qualities can be obtained:

a) Homogeneous: As the name suggests, the particles are of the same size, both in the center and near the faces. The particles are also parallel to the surface. This type of board is also known as single layer board.

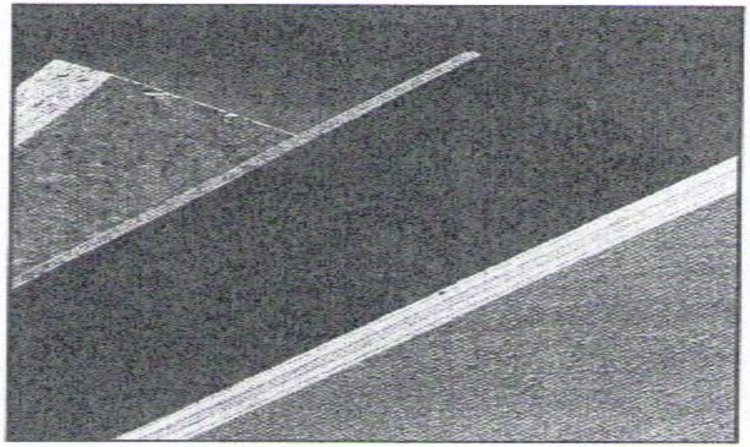
b) Three-ply: In this board, the faces have different sized particles to the center, and, in the cut, the three layers differentiated by size and porosity, can be seen.

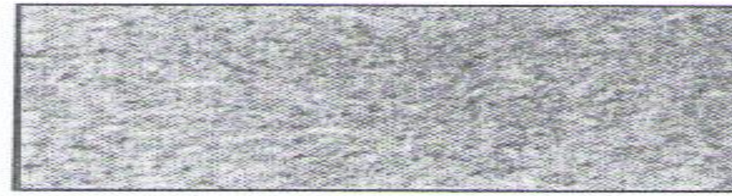
c) Multiple layers: The particles in this type of board are progressively finer from the center to the outer layers, and the difference in size of the particles in the different layers is hardly noticeable.

The qualities of the particle agglomerate board using the side or extrusion press manufacturing system are these:

a) Solid board: The particles are placed perpendicularly to the surface which, in turn, is covered by a sheet to give greater resistance.

b) Board with hollows: Similar to the previous, also with both faces covered by a sheet but in this case there are some lengthwise hollows inside the board. This type is used for insulating and sound proofing as it weighs less than a normal board of the same size.





they appeared on the market, as they heralded an important change in the traditional methods and systems of working wood. For example, they do not have a direction in the grain, unlike any kind of wood. In the board, the cellulose mass is homogeneous and can be worked in any direction with the same facility. In addition to this great difference, there is the variable hardness of the different types of wood, such as the more costly design in those with which cross more or less at right angles, as happens in knotted wood, or roots. In boards of particle agglomerate none of these problems exist, as their quality and hardness can always be the same.

We can summarize the advantages of the use of particle agglomerate boards over wood, in the following points:

a) Large lengths and widths (impossible to obtain in wood), up to almost 8 meters in length and 2 meters in width.
b) Average densities 500/750 kg per cubic meter.
c) Unlike wood it is not vulnerable to mildew, parasites, etc., because its particles are amorphous and are resin-covered.
d) Greater resistance to atmospheric agents and changes of temperature.
e) Equal hardness in all its surface.
f) Absence of joints, defects, deformation and sticking.

Agglomerate boards are panels formed by shavings or wood particles which are stuck with thermosetting and polymerized synthetic resins, under pressure at high temperatures.

There is a great variety of particle agglomerate panels, based on two very different ways of manufacture: one is the obtaining of the boards by flat

b. Initially, there was a similarity to paper manufacture, mechanical or chemical pulping and forming by suspension of fibers in abundant water.
c. Fiberboard manufacture is now an important sector of the wood-using industry, but lags in dynamism of development in comparison to particleboard.
d. Fiberboard is different from particleboard because wood, or other ligno-cellulosic material, is used in the form of fibers instead of particles, and an adhesive is not always needed for bonding.
e. Later, pulping by "explosion" was invented (Masonite process, 1924), and dry mat forming (i.e., forming without water) was introduced.
f. The fibers are held together by the development of hydrogen bond, flow of lignin, interweaving, or addition of a synthetic resin.
g. Manufacturing of fiberboard started at about the beginning of this century, and developed successively in England (1898), the United States (1908), France (1928), Sweden (1929), and other countries.

1	2	3	4	5	6	7

Section Two: Further Reading

More About Transformed Wood & Its By-Products

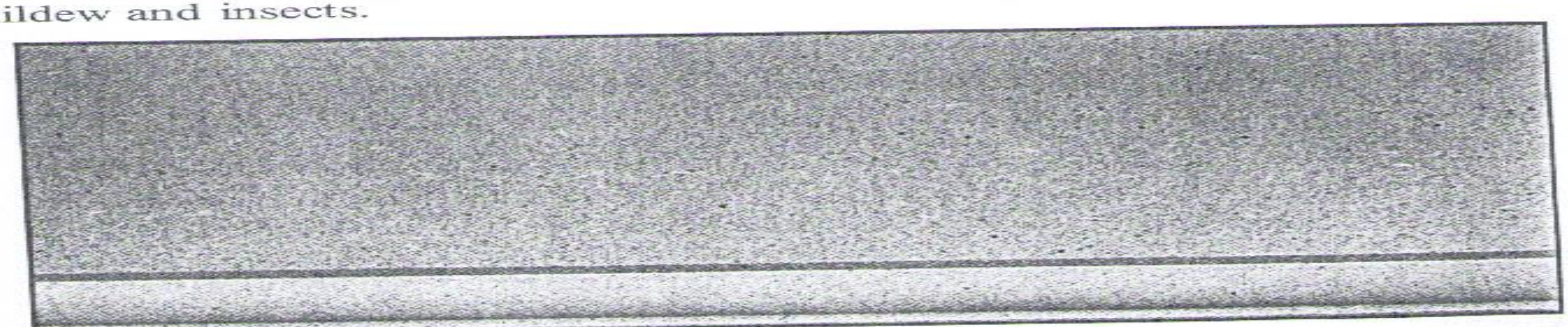
Medium Density Fiberboard

Another very interesting variety is the wood fiber agglomerated board, developed twenty years ago in the United States, and known as the medium density fiberboard or M.D.F. This quality board is considered "reconstructed wood" and can almost be worked like a solid piece of wood. The development of this material was so spectacular in the United States that new factories were quickly set up in Europe. The M.D.F. is a board of wood fibers, joined when dry, using synthetic resins and a high frequency pressing, in this way, achieving a high quality product, which is uniform, strong, compact, stable, smooth on both faces and completely homogeneous in all its thickness. The M.D.F. has some excellent qualities to replace natural woods in some cases. Eliminating its inconveniences although its specific weight is somewhat higher than that of other boards.

Fiberboard

The difference between M.D.F. and the fiberboard previously known as "tablex" is mainly in that **the latter** is formed without the addition of any type of glue. The adhesive properties of cellulose and lignin are enough to form a layer of the conglomerate. This board is extraordinarily damp resistant, it neither chips nor rots and has very good thermal, insulating and sound-proofing qualities. These are several qualities, always with a smooth decorated face and a rough face in the form of mesh. The visible side can imitate different types of wood, using a grain print system. White lacquered fiber-board is the most used of all types, especially in commercial interior decorating and for furniture, above all kitchen furniture. Other qualities with a nonsmooth visible surface and the perforated tablex and tablex with relief or engraved with different decorative effects.

The manufacture of fiberboard (Figure 8-3) begins with the cutting of the wood into trunks or rolls when, because of its dimensions or characteristics, it is not suitable for direct use. With a conveyer belt the board goes to the chipper which converts the wood into reduced chips and sieves select, or eliminate the sizes of chip which are of no use. Then, the suitable chips go on to the shredder in which, as a result of steam and pressure, the cellulose softens at the same time as the oils, resin and lignin contained in the wood. It continues the process to the refiner in constant movement and with a lot of water to avoid sediment. After this phase, additives are added in order to protect the board, making it fireproof and waterproof to protect it from mildew and insects.



The next operation is the formation of the board in a wet state: the fibers are poured with the water into a mould the width of the board. When it is completely full, the elimination of water begins, by suction pumps and also with the pressure exerted by cylinders which press the blanket, eliminating water and leaving a uniform thickness which will later be the fiberboard. Finally the panels go to the measuring and cutting sections where the transversal and longitudinal saws reduce them to standard size. The manufacturing process of particleboard is very similar to that of fiberboard, except in the shredding and humidifying.

Cork and Agglomerates

Cork comes from a tree in the fagaceae family, called oak. The exact variety of this tree is the one with the botanical name "quercus saber". The best quality cork is obtained when the tree is 30-40 years old, and if the bark is removed properly, the tree can produce bark for up to 200 years. The annual production of cork bark can vary from a minimum of 2 kg to a maximum of 20 kg depending on the tree's circumference. Once it is cut into pieces or squares, it is dried and hardened in the open air. Then it is boiled, which improves its characteristics and facilitates the elimination of the surface bark which has been exposed to atmospheric agents. Finally, the surface is measured and refined, and last of all, it is classified. During the whole process the oak loses approximately 50 percent of its original weight.

The most important characteristics of cork are its lightness, elasticity, its impermeability to liquid and gas, its low thermal conductivity and its great capacity as an insulating or soundproofing material. The specific weight of cork, after boiling, varies from 0.10 to 0.22. When submitted to a pressure of 18 kg per square meter, cork is reduced to half its volume. Chemically, cork is composed of the following substances: suberin, cellulose, lignin, cerin, water, and remains of very complex organic acids. The cork panels can be treated with special waxes or acrylic or polyurethane resin varnishes, to offer greater surface protection.

Papers Printed With Wood Grain

The production of paper decorated with imitation wood began some years after the appearance of stratified or laminated plastics. The imitations are very high quality, depending on the number of inks used and the wood which is imitated. These papers can vary greatly in weight and quality and can later be impregnated with resin. Depending on the type of impregnation, once the paper has been pressed onto a particle- or fiberboard, it may not need any type of finishing. The use of aminoformol resins in the impregnation, with hot-plate pressing and obtaining a total polymerization of the resins used, can produce a very high quality paper which can be used in the manufacture of modern economic furniture and decorative board.

Plywood Boards (Printed Agglomerates)

Long before the appearance of decorative imitation wood papers, there was a process called "print", on plywood boards with bad quality wood, or on particle or fiber agglomerate board. This process consists of first printing the board (depending on the base used). After the correct drying and hardening of the applied product, a total sanding takes place to leave the surface completely smooth. Next, a cylinder applies a base, similar in colour to the wood to be imitated. After the complete drying and hardening, each of the colours corresponding to the wood to be imitated is printed the grain printing rollers for each colour must be of a high quality in order to achieve maximum authenticity in the imitation. Finally, with the use of a roller or curtain machine a varnish or lacquer is applied, on the one hand to protect the printing, and on the other hand to give a fitting finish to the board.

Plastic Laminates

The plastic or stratified laminate is manufactured with a support formed by several sheets of "kraff" paper, all impregnated with phenol resin. The chosen decorative paper in turn impregnated with melaminaformal resins, is placed on this base. Finally, a transparent page, also impregnated, is placed on top and pressed at about 200 degrees centigrade in order to achieve the total hardening or polymerization of the whole. A great variety of plastic laminate finishes are manufactured: shiny, glossy, matt, rough or smooth and even recently, even with a quality allowing post-shaping for all types of curves. This perfection of the laminate was a great event in its day especially for the manufacture of office and kitchen furniture.

The most important characteristics of plastic laminates can be summarized as follows: their dimensions are not affected by humidity or temperature. Unlike wood, they do not splinter. They have a high resistance to all types of chemicals and liquids used in the house. They wear very well, and as a result are very useful for covering surfaces such as tables, desks, etc. They stand up to high temperatures without changing. They are easy to clean, not only with liquid detergents, but with organic solvents. They are easily cut

Papermaking

Paper is produced from wood fibers; use of other plant or synthetic fibers is limited. Plant fibers are advantageous because they do not need an adhesive for bonding. Various additives, such as starch, gums, and synthetic polymers, are used to improve adhesion and paper strength. This product was originally made in China (105 A.D.) from bark fibers (mulberry inner bark), hemp residues, and rags. The art was transferred from China to Japan (610 A.D.), Samarkand (Central Asia, 751), Baghdad (793), Spain (1100), and elsewhere. Factories making paper were later established in Italy (1260), Germany (1389), England (1494), and North America (1690).

The invention of typography (Gutenberg Bible, 1445), and of specialized paper machines, together with the use of wood as a raw material, were decisive factors for the development of the production of paper. The use of wood started relatively recently (about 1850); until then, rags (cotton and linen) were the main material. The abundant availability of wood made possible the present huge development of the paper industry, which was previously facing difficult problems of raw material supply. Up to the nineteenth century, paper was made by hand (using a frame screen submerged in a fiber suspension), whereas today machines produce up to 1500 running meters of paper in one minute.

In addition to wood (or other materials), the production of paper requires chemicals for pulping, various additives, and water. Only fir and spruce were used initially, but now almost all wood species–softwoods and hardwoods–can be utilized. Availability in needed quantities and cost are the decisive factors for selection of species. The wood is transported to the factory in round form, or in the form of residues of other wood-using industries (sawmill slabs, veneer residues), or as chips produced from industrial of logging residues. It is sapwood which is more easily pulped (includes few extractives), and contains long fibers in comparison to juvenile wood. In the factory, the wood is stored on the ground or in water. Out-of-door storage of chips presents both advantages (better utilization of the storage ground, lower cost of handling) and disadvantages (risk of fungal attack or fire, loss due to wind). The quality of wood needed to establish a pulp factory depends mainly on the pulping process. The lowest quantity varies from about 60,000 tons per year for mechanical pulping to 500,000 tons for chemical pulping.

Fibers suitable for papermaking may be obtained from other (usually annual) plants, such as wheat, straw, sugar cane residues (bagasse), esparto, bamboo, reeds, flax, and cotton. These sources, except bamboo, have the advantage that their supply is seasonal, and the raw material is bulky, which makes their transportation to long distances uneconomical. Also, their fibers differ from wood fibers with regard to chemical composition and morphology. With the exception of cotton (which contains cellulose in a proportion of about 95%), fibers from other plants contain less cellulose. Fiber morphology is also variable; certain plants (flax, hemp) have long fibers and a high ratio of length to diameter, whereas the fibers of others are short.

Cotton, flax, and hemp fibers (mainly used as rags) produce paper of high strength and low weight—a combination suitable for special uses, such as currency, carbon paper, cigarettes, and large-volume editions (e.g., telephone directories). Esparto fibers produce soft paper with very good printing properties. Straw is used to make paperboard, writing and book paper, and other papers usually by mixing long-fibered, softwood pulp, because otherwise the paper is rigid (difficult to bend and fold), heavy low in strength, and of undesired opacity. Bagasse and bamboo produce paper of satisfactory quality for various uses.

In general, plant fibers have advantages, because their cellulosic skeleton provides self-adhesive ability and strength; disadvantages also exist, however, including heterogeneity of size and shape, change of dimensions with varying moisture content (due to shrinkage and swelling), limited durability (they are attacked by microorganisms, chemicals, and high temperatures), and presence of other substances (lignin, extractives, hemicelluloses), which must be removed, partly or entirely. For these reasons, it would be desirable to replace them with synthetic fibers, but they also have disadvantages: their cost is much higher, and they possess no ability of self-adhesion. Therefore, adhesives should be added. Thus, the use of such fibers (glass, nylon, dacron, etc.), is limited to specialized products.

Several chemicals are used for the production of paper. They are added at various stages of production with the purpose of pulping, bleaching the pulp, and improving fiber adhesion and paper properties. Such additives provide protection from diffusion of solutions, especially ink, in the mass of paper, improvement of printing properties, control of color, reduction of hygroscopicity, etc. The particular chemicals are named in the discussion of production processes.

Paper production requires the consumption of large quantities of water for pulping, treatment of the pulp, and forming the paper sheet. The water is obtained from rivers, lakes, streams, or wells, and its availability is a decisive factor for the site selection of such an industry. Depending on the method of production and type of product, the quantities of needed water vary from about 40,000 to 400,000 $^{l}/_{t}$ of paper. The water should be not only abundant but also of good quality, as salts (calcium, magnesium, etc.), gases (oxygen, carbon dioxide), and foreign matter or dirt have an adverse effect on the machines (clogging, erosion) and generally on production. Discarding the refuse (cooking liquors) creates problems of environmental pollution if paper measures are not taken, but if such refuse is cleaned, most of the water (up to 95%) may be reused.

d. Additives are used to improve bonding of the fibers.
e. This is sought by the addition of synthetic resins (urea-formaldehyde, melamine-formaldehyde, polyamide-type resins, etc.).
f. However, such forces dissolve or are neutralized in water.
g. This property is an advantage for the recycling of paper, although in certain cases the preservation of strength in a wet state is desirable.
h. Starch (modified), natural glues, or synthetic resins are usually added to increase the strength of paper in a dry state.

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Section Two: Further Reading

Production of Paper

Wood is prepared through debarking, chipping, screening, and storage of chips, and is generally similar to fiberboard production. Debarking is an almost general requirement for paper production, because bark differs from wood with regard to cellular structure. Thus, the presence of bark causes a high consumption of chemicals, affects digester capacity, and has adverse effects on the strength and cleanliness of the pulp.

Chipping of wood to particles is mainly applied when pulping with chemicals, in order to facilitate their entrance into the mass of wood. The chips are produced by a revolving disk with knives attached in a radial arrangement. After chipping, the chips are screened to remove fines and unsuitable dimensions. There are various systems for screening, usually perforated and vibrating frames placed one above the other. The openings of the upper screen are such that it retains oversize chips, whereas a lower screen retains suitable chips and allows passage of fines. Large chips are brought back to the chipping machines to be rechipped, and fines are transported to be burned for steam production. Use of uniform chips is necessary in order to ensure a uniform action of chemicals during pulping. The screened chips are transported to storage, either out-of-doors or in closed soils, and then to digesters for pulping.

There are three pulping methods: mechanical, chemical, and chemical-mechanical. The traditional method of mechanical pulping is the groundwood process, where roundwood is ground against a "stone". Logs of spruce and fir are the usual species, but other softwoods (including pines) are also used. The adverse effects of resin are neutralized by additives, such as alum and alkali, in combination with control of the pH of the pulp. Suitable hardwoods are poplar and species of similar structure, including some eucalypts. In general, there is a preference for woods of young age and fast growth, without heartwood. Various mechanical systems are used for grinding, and they differ depending on manner of pressing the logs against the grinding stone (hydraulically, by chains), type of feeding (from one or more inlets, separately or continuously and automatically), and arrangement of parts (revolution of the disk inside water or not, inside a drum, etc.). Mechanical pulp is also produced from wood chips, which are ground in a "disk refiner". Thermomechanical pulping (TMP) is the main process in **this category**. The chips are presteamed and ground under pressure. This is a relatively new method (after 1960), but it is fast-growing in worldwide application.

In chemical pulping, the fibers of wood are separated by dissolving the lignin of the middle lamella. However, delignification also takes place in the secondary wall, which allows the stiff cylindrical fibers to collapse into ribbons that provide greater surface contact for hydrogen bonding. Delignification results from the action of acidic or alkaline chemicals in digesters under high temperature and pressure. Reduction to pulp is accomplished by blowing out the contents of the digester, and usually no other mechanical processing is applied except mild stirring. There are two chemical pulping processes: sulfite (acidic) and alkaline.

Initially, pulping was performed by sulfurous acid (H_2SO_3) and calcium bisulfite $Ca(HSO_3)_2$. This is also done today, but aside from calcium other bases are used such as magnesium $Mg(HSO_3)_2$, sodium ($NaHSO_3$), or ammonium (NH_4HSO_3). Calcium bisulfite successfully pulps softwoods without resin or with low resin content (fir, spruce, hemlock), but it is not suitable for resinous softwoods, such as pines. Also, pulping with this base produces refuse (spent liquors) from which usable pulping chemicals cannot be reclaimed; therefore, it contributes to water pollution (rivers, lakes, sea), where such liquors are discharged.

Alkaline pulping started in the 1850s by use of a soda (sodium hydroxide, NaOH) solution. Soda pulping had a wide industrial application in the past, but it is now almost entirely replaced by the "sulfate" or kraft process, which in addition to soda, utilizes sodium sulfide (Na_2S) as an active pulping chemical. Any wood species may be pulped by the kraft process, but this is especially suitable for resinous woods such as pines. The resin is dissolved, and separated from the pulp as tall oil, which constitutes an important by-product. Aside from pines, other softwoods and hardwoods may be used.

Chemical-mechanical pulping processes apply both chemical treatment and mechanical energy for pulping, and include: semichemical, chemi-mechanical (mechanochemical), and chemiground pulping. Semichemical is the main process; the others are of minor importance. In "semichemical" pulping, defibering is done partly by chemical and partly by mechanical energy, in two successive stages. The chemical and mechanical properties of this pulp are intermediate between mechanical softwood pulp and chemical pulp, but resembles more closely chemical pulp, and its macroscopic appearance is more like that of chemical pulp. "Chemimechanical" (or mechanochemical) is characterized by high yields (85-95%), which are close to the yields of mechanical pulping. Pulp is mainly produced by action of cold soda (sodium hydroxide) on chips. Finally, the "chemiground" process is a variation of mechanical pulping. The wood is used in round form, subjected to the action of neutral sodium sulfite, and mechanically defibered. The method enables production of pulp from hardwoods, which do not produce pulp of good quality by grinding.

The pulp produced by the above methods is subjected to a series of treatments, which include screening and cleaning, thickening, bleaching, beating and refining, coloring, and addition of various chemicals (additives) to improve self-adhesion of the fibers. The purpose of screening and cleaning is to remove wood which has not been pulped (knots, fiber bundles) and foreign matter (sand, soil, dirt, metals, conglomerates of chemicals, etc.). They are removed by screens and cleaners. The principal aim of pulp bleaching is to increase brightness. Beating and refining is a very important stage of pulp preparation for paper production. Pulp intended for other products is not treated in this **manner**. Additives are used to improve certain properties of paper, such as resistance to entrance of liquids, brightness, opacity and surface smoothness, printing properties, color, and strength (in dry condition or after wetting).

The next stage is forming the fibers to a continuous sheet of desired thickness and weight, and then making paper by the removal of excess water by pressure and heat. These processes are carried out by complex machines, which may produce a continuous sheet of paper, 1.5-10 m (5-30 ft) wide, 10-500 g/m^2 in weight, at a speed of up to 1500 m (5000 ft)/min, and in excess of 1000 tons/day.

There are two traditional types of papermaking machines: Fourdrinier and cylinder. They differ in the manner of forming the fiber mat. In the Fourdrinier machine, forming is accomplished on an endless metallic web (wire mesh belt) equipped with many openings. This is made like a table top, and moves at a high speed in a horizontal-longitudinal direction, while at the same time it oscillates sidewise. The cylinder machine is different, mainly, because the fibers are laid on the surface of one or more porous cylindrical structures, the periphery of which is covered by wire mesh.

The paper becomes available for consumption usually after a series of other treatments, such as supplementary smoothing between rolls, splitting and rewinding to produce rolls of the desired size, and cutting to sheets. Other treatments include improvement of properties by coating or impregnation of chemicals, lamination (e.g., to produce a three-layer corrugated paperboard), and finally conversion to various products. All this is done by specialized machines. One of the most important treatments is coating the surface of paper to improve its printing and writing properties and appearance. Coating is applied by mechanical devices, which also smooth the coating material between pressure rolls. Coating materials include kaolin, titanium dioxide, calcium carbonate, and others.

A. Translate the following passage into Persian.

Properties of Pulp & Paper

The properties of pulp and paper vary due to differences in raw materials and production methodologies. For wood (and other plant fibers), cell morphology is a fundamental factor of influence; thus, fiber length, fiber diameter, lumen diameter (diameter of cell cavity), and cell-wall thickness are very important. For example, research has shown that the ratio of lumen diameter to fiber diameter (an expression of the tendency of a fiber to collapse) is strongly related to pulp and paper sheet density. Sheet density, combined with individual fiber strength, relates highly to sheet tensile and bursting strength. In a more complex manner, tear factor is related to sheet density, fiber length, and fiber strength; tear factor at first increases with increasing sheet density, and subsequently decreases at higher sheet densities; fiber length and fiber strength both have a positive influence on tear factor–up to a critical level of sheet density corresponding to the level of bonding between fibers, beyond which fiber rupture prevails as the mechanism of failure. Another study showed that of the morphological characteristics of hardwood fibers, length wall thickness (L/T) ratio, and fibril angle. Parenchyma cells were detrimental to bursting and tensile strength, but vessel elements had no effect on tensile strength.

Pulp is evaluated by chemical and physical tests. Chemical tests include determination of cellulose and noncellulosic (mainly lignin) content, and physical tests measure fiber characteristics and resistance to water flow through the pulp (freeness). Pulp is also evaluated from pulp sheets made in the laboratory. Such sheets are used to determine the following properties: weight per unit of surface, specific volume (Cm^3/g, ft^3/lb), coefficient of light diffusion, tensile strength, stretch, bursting, tearing, folding, zero-span tensile strength, and moisture content.

Paper is produced in virtually thousands of grades and products, which present minor or very important differences. The evaluation is also based on specifications that apply to the following properties: dimensional stability, weight (g/m^2), thickness, density, tensile strength, bursting, tearing, folding, bending, abrasion resistance, porosity, surface texture, optical properties (brightness, color, opacity, gloss), and chemical properties (aging, flammability, acidity). Identification of additives and wood species in pulp or paper is made by use of chemical reagents and microscopes.