Eco-Link

Linking Social, Economic, and Ecological Issues

Technology in the Mills

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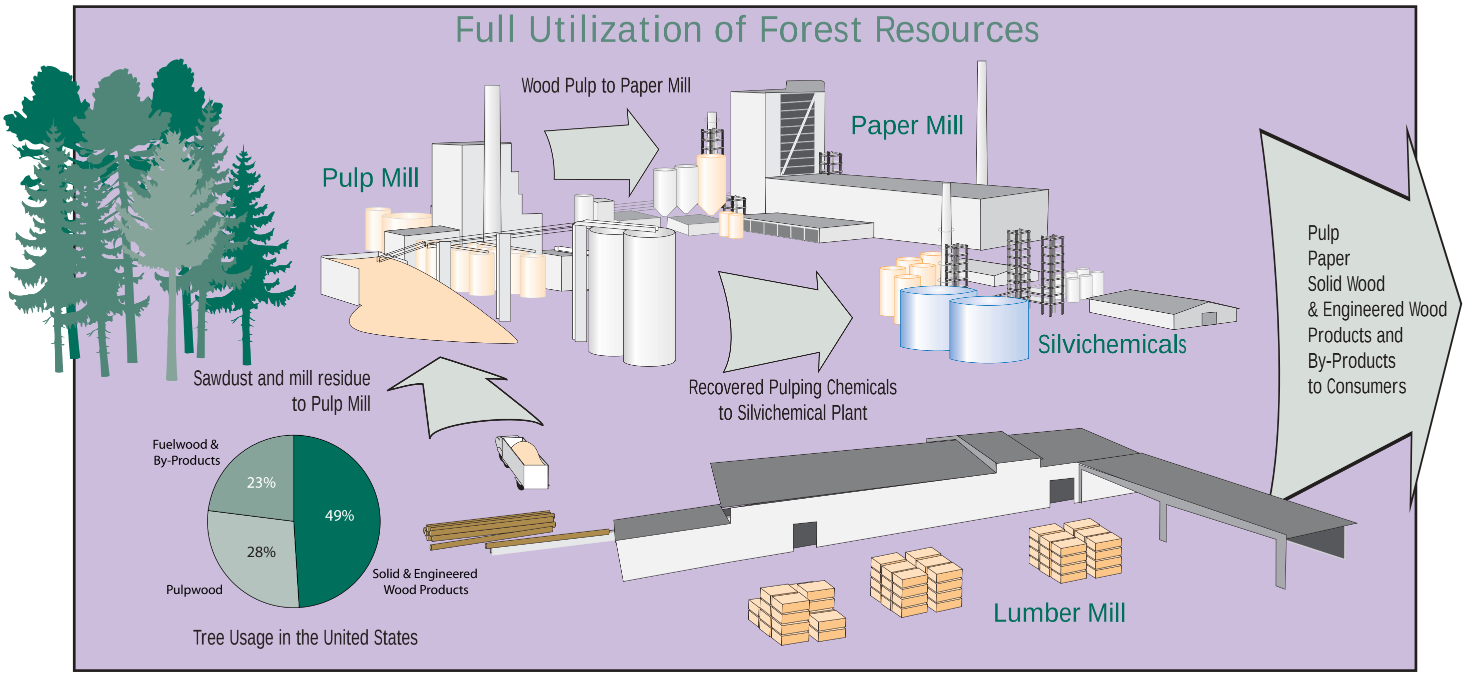
Wood fiber recovery rates have nearly doubled since World War II. This means that almost twice as much wood is recovered from each log for conversion to finished products. Using computers to increase fiber recovery is now commonplace in mills, and the result is that much of what was burned in tepee burners 20 years ago is now made into something we use. Engineered wood products have allowed us to use smaller and lower quality trees, and pieces of wood that would have been burned in the past. This technology is not only increasing recovery and extending the forest resource, it's keeping solid waste out of landfills and it's reducing air and water pollution. It's also allowing us to recycle and to pressure-treat, extending the life of wood in use. Old technology can be a curse, but modern technology employed by the Forest Products Industry is a salvation.

Too many people still see the forest products industry as low-tech, only interested in making a profit at the expense of the environment. In reality, the industry is very proactive in applying technology to help increase efficiency while reducing environmental impact. Many factors have accelerated the industry's transition to a high-tech industry on the cutting edge of information technology. The forest products industry must operate under increasing competition, both domestically and internationally, as well as more stringent regulations limiting access to raw materials and regulating environmental impact. There is also a limited labor pool to draw from, so automation is not only productive but critical.

As resources become scarce, competition increases, and alternative materials continue to target markets historically dominated by wood, manufacturers of wood products must improve their production processes to stay competitive. Increased efficiency, increased yield, and improved information exchange through application of technology will become issues of growing importance throughout the industry.



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Sawmill Technology

Thanks to the application of modern technology, sawmills are able to greatly increase their productivity returns from decades ago. In the mid-1920s only 40% of a log was converted into primary product of manufacture (lumber, for example). In addition, 23% of the log of 70 years ago ended up as sawdust. Nowadays technology can enable 70% or more conversion efficiencies at U.S. sawmills. Automated material handling systems, computer-controlled monitoring systems involving scanning technology, thinner saw blades, and years of research involving the cellular properties of different wood species have all contributed significantly to the industry's ability to compete in rapidly developing world markets. Besides making economic sense, these improvements have been driven by an increased demand for wood products as well as environmental constraints on timber harvesting and a shift to smaller logs from the forest.

Scanning Technology

Scanning technology enables wood manufacturers to get the most volume and value from each log processed. First introduced to the softwood lumber industry in the 1970s, scanning technology has been adopted in hardwood lumber production and secondary manufacturing of wood products. Scanning systems are now being used in automated chop saw operations, quality control systems, and other wood optimizing systems.

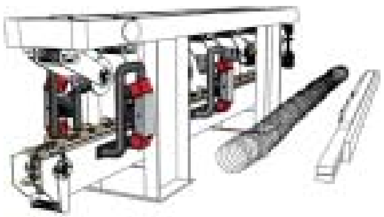


Illustration of in-line scanners (red) imaging a log and modeling board output.

In an optimized sawmill, sensors collect data about logs and boards in-line. The collected information is fed into a computer which then determines the most profitable way to saw the log based on current market prices and on the manufacturing cost of each piece of lumber. The handling systems can then be adjusted to follow the prescription of the computer.

Current research and product development projects are focusing in the area of defect detection scanning systems. These systems are designed to distinguish clear wood from defects such as knots, wane, and decay. Information generated can be used to saw lumber for optimum yield, better match lumber to specific products, or assign grades to lumber.

Automated scanning systems could allow grading accuracy at modern production speeds. Grading machines are supervised by many agencies approved under the American Lumber Standard (ALS) or under the regulations of the American National Standards Institute for laminating lumber under ANSI/AITC A190.1.

Laser Scanning

Laser scanning is fast becoming an essential part of optimization systems that are making mills more productive. Laser scanning works by emitting laser pulses towards the log or boards to be measured. These pulses are reflected and the elapsed time between the emitted and returning signals is measured, generating a three-dimensional model on a computer. Laser scanning can measure the volume on logs entering the mill which helps calculate optimized cutting. Once the logs have been broken down, laser scanning is used on the resulting boards to locate such aspects as wane, voids, and shape.

Other Scanning

Camera scanning collects visual (cosmetic) data about boards which can be interpreted by computers. Color and black and white camera scanning technology can be implemented in color sorting and matching in processes such as cabinet door panel production, as well as in the identification of mineral streaks, surface knots, and pith.

X-ray scanning technology can be used to detect internal defects such as internal knots, internal voids, and honeycomb.. Other scanning technologies exist which detect and utilize differences in wood cell structure to identify defects in lumber.

Automated Handling Systems

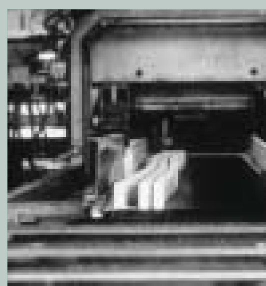
Automated handling systems help assure that mills are mechanically capable of optimizing material handling. Many processing decisions need to be made very quickly for each log and board that goes through the mill. At the same time, a tightening market and limited availability of trees have made it harder to return a profit. Technology such as automated gang ripsaws and optimizing cutup saws have become important components in handling materials speedily and offering processing options to meet demand.

Larger mills are investing in automated equipment at the front end of their process to handle incoming material variation, increase capacity, and improve yield. Essentially, the more cutting options available in-line, the easier it is to adapt to ever-changing market demands. Multi-blade saws known as gang ripsaws have an efficiency advantage over single blade straight line saws. By automating the gang ripsaw, mills can increase yield with improved throughput.

Automated gang rip systems come in a variety of configurations. Some have fixed arbors that incorporate lasers to guide sawyers. Others have fixed arbors with automated in-feed fences to direct lumber to the optimum combination on the line and some setups include all movable blades. Combined with scanning systems and software that simulates various cutting options, these handling systems can help operators determine and execute optimum break down—minimizing waste and maximizing value of the resulting boards

Curve Saw Technology

Curve sawing is a method available to increase yield from curved logs. Curve sawing produces straight lumber with less



wane by following the natural curve of the tree. This contrasts with straight sawing, where a log is fed straight into the saw gang allowing only the center boards of a curved log to be recovered. Curve sawing allows maximum recovery of a log by following its contour. Two methods of curve sawing are 'form following' and 'skew and translate.'

Form following, mechanically following the form of a cant, has been around for more than 50 years with roots in Scandinavia. It remains popular today due to the ability to follow the natural form of a cant and the low degrade this method produces. Even curved lumber is known to become straight on the green chain with this method.

Skew and translate follows an electronically defined path by pivoting the arbor and shifting the saws laterally against the incoming wood. It is used to process two-sided cants with round sides and is absolutely dependant on electronic controls.

One disadvantage to curve saw systems is that they require some adjustment in materials handling. The most likely beneficiaries of curve sawing systems are softwood, random length mills (as opposed to stud length), running at a relatively high production level.

Photo courtesy of Phil Steele, Mississippi State University.

Engineered Wood Products

Engineered wood products are another way to effectively and efficiently utilize smaller, faster growing trees and lower grade trees that wouldn't normally be used to make excellent products. Engineered wood represents the culmination of centuries of forestry (and wood-working) knowledge, modern technology, and efficient use of our natural resources to meet increasing demand. They alleviate the burden on old growth by providing an alternative for large timbers. In addition, engineered wood products are carving out new niches for the forest products industry.

Engineered wood describes wood products that are engineered for construction applications. They evolved with improvements in lamination technology, development of adhesives, and improvement in lumber and veneer drying processes. Glued engineered wood products are manufactured by bonding together wood strands, veneers, lumber, or other forms of wood fiber to produce a larger composite material. The process of making engineered wood products homogenizes the raw material, eliminating defects and weak points, or at least spreading and mitigating their impact. These products are environmentally sensitive, strong, cost-effective, easy to use, and their predictable qualities lead to less rework.

Engineered wood products are being developed for both structural (load-bearing) and industrial applications. Structural engineered wood products are classified into four general groups: Structural Wood Panels which include plywood and oriented strand board (OSB); Glued Laminated Timber (glulam); Structural Composite Lumber comprised of laminated veneer lumber (LVL) and parallel strand lumber (PSL); and Wood I-joists.

Engineered Wood Products such as Particleboard and Medium Density Fiberboard (MDF) have industrial applications. These applications include uses in furniture, floors, roofs, heavy duty shipping containers, and concrete forms in bridge and highway construction work. These products are proven to be excellent substitutes for solid wood in many applications.

Environmental Technology

Technology is being applied to make mills environmentally friendly. The manufacturing process in pulp and paper mills utilizes significant resources; specifically water, heat, and electricity. In addition, pulp and paper production requires many chemicals that pose a risk to air and water. The industry realized the hazard of these factors and has applied modern technology to make their processes friendlier to the environment.

Pulp and paper mills have made significant investments in pollution control technologies and processes. Chemical recovery and recycling systems in the chemical pulping process significantly reduce pollutant outputs while providing substantial economic return due to recovery of process chemicals. Chemical recovery is necessary for the basic economic viability of the kraft process. Due to the large volumes of water used in pulp and paper processes, virtually all U.S. mills have primary and secondary wastewater treatment systems installed to remove particulate and biochemical oxygen demand (BOD) produced in the manufacturing processes. According to the U.S. Environmental Protection Agency (EPA), all kraft pulp mills worldwide have chemical recovery systems in place. Some sulfite mills, however, still do not have recovery systems in place. Scrubber system particulate "baghouses" or electrostatic precipitators (ESPs) are often mill air pollution control components.

E-tubes

Wet Electrostatic Precipitators (E-Tubes) remove dirt and dust from exhaust gases by saturating the gas stream with water which then passes through a magnetic field where dirt and dust are removed. This filters out dirt and dust to protect the thermal oxidation equipment downstream that will remove hydrocarbons from gas emissions. The visible air emissions from a pulp and paper mill are typically water vapor.

Thermal Oxidization

Thermal oxidation is an efficient, safe, reliable, and accepted method for maintaining air quality. In order to comply with the cluster rule, pulp mills have needed a method of destroying the non-condensible gases (NCG) that are the result of the pulping process. All thermal oxidation methods operate under the same principle—heating the NCG with a sufficient amount of oxygen to convert fumes containing hydrocarbons to water vapor and carbon dioxide. Modern oxidizers maximize efficiency by recovering heat from other mill processes.

Regenerative thermal oxidizers (RTO) is a method that recovers heat from other processes in the mill (at up to 85-90% efficiency) for the thermal oxidization thus requiring less auxiliary fuel. A gas burner brings the preheated emissions up to an incineration temperature between 788° and 871°C (1450° and 1600°F) in a combustion chamber with sufficient gas residence time to complete the combustion.

Regenerative catalytic oxidizers (RCO) function similar to RTOs, except that the heat recovery beds in RCOs contain catalytic media. The catalyst accelerates the rate of volatile organic compound (VOC) oxidation and allows for VOC destruction at lower temperatures than in an RTO, typically 316° to 538°C (600° to 1000°F), which reduces auxiliary fuel usage.

Thermal catalytic oxidizers (TCOs) are a combination of an RTO and RCO. The TCO operates at a temperature of around 480°C (900°F) and contains catalytic media. However, the heat recovery canisters and fans on the TCO are sized large enough so that the TCO can be operated like an RTO (with non-catalytic ceramic media) if catalyst replacement costs become overly expensive.

EPA Cluster Rule for Pulp and Paper

The U.S. Environmental Protection Agency (EPA) issued joint air and water standards under the authority given to them in the Clean Air Act and the Clean Water Act. The combined air and water "cluster rule" for the pulp and paper industry protects human health and the environment by reducing toxic pollutant releases to the air and water.

The technology standards in the rule cut toxic air pollutant emissions by almost 60 percent from 1997 levels and virtually eliminated all dioxin discharged from pulp, paper, and paperboard mills into rivers and other surface waters. The rule also provides individual mills with incentives to adopt Advanced Pollution Control Technologies that will lead to further reductions in toxic pollutant discharges beyond the water discharge limits set in the rule.

Since 1990, the EPA confirms a 70 percent decrease in dioxin advisories downstream of pulp and paper mills. This is credited to the virtual elimination of dioxin discharges due to complete substitution of chlorine dioxide for chlorine gas in the first stage of chemical pulp bleaching—so called Elemental Chlorine-Free (ECF). Out of 2,618 total waterbody advisories in the U.S. only 11 are downstream of bleached chemical pulp and paper mills—less than one-half of one percent of the total.

Thanks to environmental technology, most of the exhaust from mills is just water vapor.

Pulp and Paper Technology

Modern papermaking is one of the most capital-intensive industries in the nation, investing over $100,000 in equipment support for each employee. Americans, in the year 2000, used an average of 718 pounds of paper per person. The United States is the world's leading producer and consumer of forest products, accounting for about one-quarter of the world's production and almost 30 percent of the world's consumption. [AF&PA] A major concern of the industry is maintaining environmental quality.

Typically, trees used for papermaking are specifically grown and harvested from scientifically managed timberlands. To meet tomorrow's demand, forest products companies and private landowners plant millions of new seedlings every day. Trees harvested for papermaking are cut into prescribed lengths, measured in cords and transported from the forests to the paper mill's woodyard. Companies benefit economically, by combining pulp and paper facilities.

Pulp


Wood Chips used in pulping.

The modern pulping process is remarkably efficient at producing raw materials for papermaking. There are three forms of pulping: chemical, mechanical and recycled. Approximately 85% of the pulp produced in the United States is manufactured with the chemical kraft pulping process, which uses chemicals, heat, and pressure to break the bonds holding wood cells together and make the wood fibers available for papermaking. Fibers are less likely to be damaged using the kraft process than in other pulping processes.

Chemical pulping was done in the past in large batch digesters (tanks which processed only a single charge of wood chips at a time.) The chips were mixed with the appropriate chemicals (white liquor) and cooked at around 150°C and about 1.0 MPa pressure. The resulting pulp slurry and cooking liquor were then separated and the delignified pulp further defibered, washed, and screened for use.

Advances on this technique include the development of continuous digesters, where fresh chips and cooking liquor are regularly added to the batch. This process permits good control as rates of chemical and fresh chip addition are carefully managed and cooking liquor temperature is also controlled by circulation into and out of the digester via heat exchangers.

The digesting liquid, which at the end of the process contains lignin, polysaccharides and other sugars and resin acids, is usually recycled to recover as much of the digestion chemical as possible. Without chemical recovery, the pulping process would be uneconomical.

Paper History

The use of wood pulp for papermaking is a relatively new innovation. From its invention in AD 150 in China until the mid-nineteenth century, most paper was produced from rags made of cotton, hemp, grass, and other fiber sources. It wasn't until 1866, when American Benjamin Tilghman invented the sulfite pulping process that wood became a viable source for paper fiber. The processing of wood pulp and the subsequent development of paper making mills meant that paper could be made widely available for public use.

Today's paper fiber comes principally from two sources, wood and recovered paper. Approximately 40 percent of today's paper fiber comes from harvested hardwood and softwood logs or pulpwood. The efficient recovery of waste wood from manufacturing processes and forest residues currently provides another 24 percent of the industry's raw material. Recovered paper is another important source of paper fiber. Thanks to curbside recycling programs in many communities, we recover over 45% of all paper used in America for recycling and reuse.

The chemical recovery process takes place in a process recovery (PR) boiler, or recovery boiler which produces enough heat to gasify lignin and other volatile constituents of the black liquor. The energy derived from this process produces enough steam (and in some cases electricity) to supply about 50 percent of the typical U.S. pulp and paper mills' energy needs. Additional energy is often recovered from the combustion of bark and other wood residuals. Residual chemicals collect at the bottom of the furnace as smelt which can then be converted back into the white liquor used for pulp digestion.

Other chemicals used for silvichemical by-products are recovered during the recovery process, including turpentine, obtained by flashing steam bearing volatile chemicals from the digester and condensing them. Tall oil is recovered from the condensed black cooking liquor, and the soap skimmed from the surface of the cooking liquor contains other resin acids. The success of all recovery operations is dependent on the scale of the operation.

Pulp and paper mills are not always integrated, and while pulp mills produce more energy than they need, paper mills require large quantities of steam to run their dryers. Kraft pulp mills are energy self-sufficient, and often generate excess steam and electricity which can be used by an associated paper mill or sold to neighboring industries or communities.


Rolls of finished paperboard.

Papermaking

The introduction and development of process control systems in recent decades has been important to papermaking. Computerized sensors and state-of-the-art control equipment monitor each stage of the papermaking process. These controls allow mills to improve the quality of the paper produced by the continuous measurement and control of various parameters such as basis weight, brightness, caliper, color, moisture and opacity.

Control room at a pulp and paper mill.

Paper machine in a modern paper mill.

Recycling

A full 45% of all the paper Americans used in 1999 was recovered for recycling. That's over 47 million tons of newspapers, boxes, office paper, magazines, cereal and cracker boxes, paper bags, and many other products used every day.

Recycled paper is often made into the same grade of paper that it was originally. For example, most newspapers are made into new newspapers, corrugated cardboard boxes are made into new boxes, brown paper bags into new bags, and office paper into new office paper. Mixed papers can be made into a variety of paper products including cereal boxes, newspapers, and paper towels. Of the paper recovered in the U.S., 81% is recycled into new products by American paper mills. About 16% is exported to foreign markets for recycling, and the rest is used domestically for products such as insulation, molded packaging, hydromulch, compost, and kitty litter.

Recycled fiber being broken down in a pulp/paper mill.

BioPower - Biomass Gasification

The forest products industry is one of the country's most energy-intensive. But the forest and paper industry produces more than 41% of the nation's self-generated electricity through cogeneration. It also far outpaces all other manufacturing industries by generating nearly 85% of that on site electricity from renewable resources—burning wood chips, sawdust, and other by-products of production.

Power plant at a pulp/paper mill uses mill waste for energy.

Chemical pulping requires significant quantities of energy, mostly for process heat, but uses less electrical energy than mechanical processes. However, many modern kraft pulp mills are totally self-sufficient in energy, with combustion of residues and waste products meeting all heat and electrical energy needs.

The industry's next goal is to add biomass gasification to its energy portfolio. These wood-based fuels are ideal because they can generate power cleanly and efficiently, at a comparatively low cost. Moreover, renewable biomass fuels are considered carbon-neutral in relation to greenhouse gas emissions when combusted.

Gasification converts pulping extractives like black liquor and other forms of biomass into combustible gases that can be efficiently burned like natural gas. Gasifiers heat the biomass to convert it into a gas that can be used in high efficient power systems, such as combustion turbines or fuel cells. Advantages include improved waste management, reduced chemical consumption, and improved power production. The favorable heat-to-power ratio of gasification will meet the needs for both power and heat without the purchase of electricity. Gasification systems can improve energy efficiency, environmental performance, and waste management.

With more than 7,000 megawatts (MW) of installed capacity, biomass is the second-most utilized renewable power generation resource in the U.S.

Pulp & Paper By-Products

Paper producers are capable of recycling and reusing all the solid waste produced from papermaking. The digesting liquid, which at the end of the process contains lignin, polysaccharides and other sugars, resin acids and so on, is recycled to recover as much of the digestion chemical as possible. Waste fibers and sawdust are effective as compost, creating the potential for 100 percent recycling and reuse of these materials. Bark, boiler ash, and other solid by-products, when mixed with manufactured composted topsoil, make prime soil conditioners. This reuse of materials creates value-added products while helping meet two environmental objectives: reusing and recycling.

Thanks to advances in fiber research and chemical engineering, we are able to make extensive use of all parts of harvested trees. The success of all recovery operations is dependent on scale since the economics of extraction are often quite marginal. These "silvichemicals" from trees are used today in thousands of products important to people. The best part about silvichemicals is that we will never run out of them, because trees—unlike coal and petroleum sources of chemicals—are endlessly renewable.

Chemical Recovery

Tall oil and turpentine are two versatile products recovered from the paper pulping process. Once recovered, they can be separated into constituent forms that have numerous uses.

Tall oil is recovered from the condensed black cooking liquor. Once recovered, tall oil can be distilled into fatty acids and resins for applications in; asphalt & paving, coatings & paints, concrete, refinery co-products, mining, and textiles. Other typical applications include soaps, detergents, emulsifiers, rubber processing, epoxy additives, printing inks, plasticizers, metalworking, oil field chemicals, and ore flotation.

Common products containing turpentine-based chemicals

Turpentine, which can be obtained from the resinous sap of pine trees *(Pinus)* by steam distillation, is produced by flashing steam-bearing volatile chemicals from the pulp digester and condensing them. Turpentine can further be fractionated into alpha- and beta-pinene which are key components in synthesizing numerous common flavor and fragrance products such as; gum, toothpaste, detergents and shampoos.

Cellulose and synthetic polymers

Wood cellulose is a versatile product with other uses in many common products, besides paper. By mixing cellulose with other chemicals, scientists have developed various synthetic polymers. Over 1.5 billion pounds of cellulose are used annually in the U.S. to produce chemicals, plastics, food additives, fibers, and textiles. [U.S. DOE/OIT 2001]

Cellulose fiber filler is the principal component of wood flour and melamine resins. It is used primarily in plastics materials which are capable of being formed or "molded" into products using heat and/or pressure such as; dinnerware, electrical receptacles and parts, toys, handles for cooking utensils, and camera cases and much more.

Another polymer, Ethyl cellulose is obtained from the treatment of wood pulp with alkali and is used in making tool handles, photographic film and football helmets.

Spools of acetate filament yarn.

Cellulose Acetate filament is one example of a widely used cellulose polymer. Acetate filament yarns have good uniformity and performance plus excellent comfort and aesthetics making it useful for textile products such as clothing, drapes and rugs.

Other By-products

Several other pulp and paper by-products have useful applications. Torula yeast is a high-protein product made from wood sugars as a by-product of the pulping process in paper making. Type S Torula is used in baby food and cereals. Type F Torula is used in feed supplements for cattle, fish and chickens.

Lignosulfonates from spent sulphite pulping liquor are used in cleaning compounds, insecticides, cement, ceramics, fertilizers, oil well drilling muds, cosmetics, gummed tape and certain pharmaceuticals (Aidomet and Aidoril for hypertension and L-Dopa for Parkinson's disease are examples.)

Bark is used as fuel in mills and is also a source of chemicals, resins, waxes, vitamins, plywood adhesives, plastic fillers, lacquers, and mulches.

Sawdust being stored for use at a pulp/paper mill.

Glossary of Terms

Arbor
An axle or spindle that supports cutting tools that spin or rotate.

Black liquor
Spent liquor produced in the digester from the chip cooking process which is sent to the recovery process to be reconstituted into cooking chemicals.

Cant
A large slab cut from a log at the headsaw, usually having one or more rounded edges, and destined for further processing by other saws.

Chemical Pulping
A process using a chemical solution to dissolve lignin from fiber.

Green Chain
A moving chain or belt on which lumber is transported from saws in the mill.

Hardwood
Short-fibered wood obtained from deciduous trees, which is used to produce pulp with high standards of opacity, brightness, smoothness and density.

Integrated Mill
A mill that makes its own pulp from which it then produces paper.

Kerf
The width of a saw cut. This portion of a log is lost as waste when it is sawn for lumber although the residue can be used as fuel or for other purposes. The size of a kerf is dependent on saw thickness, saw type, sharpness, and other factors. Kerf is one of the most guarded statistics within the industry.

Kraft Pulping
A popular chemical pulping process involving the cooking of wood chips in a solution of sodium hydroxide and sodium sulfide. It produces pulp with high strength and can be used for a wide variety of wood species.

Optimizer
Any of various pieces of sawmill equipment designed to maximize the yield from a log or cant by using scanners, linear positioning, and computers to determine the best way to saw, edge, or trim the wood. Among types are; small log, edger, rip saw, trimmer, and headrig carriage optimizers.

Overrun
The volume of lumber actually obtained from a log in excess of the estimated volume of the log based on log scale. With today's technology, overruns of two or greater are common.

Softwood
Wood obtained from evergreen, cone-bearing tree species. Softwood pulp has long fibers that give paper strength and good runnability in the paper machine.

Scanner
A device used to determine the dimensional aspects of logs, lumber, or veneer prior to any one of the steps in the manufacturing process. Scanners feed information to computers, which determine how best to use the material in the next step of production.

Wane
Bark, or the lack of wood from any cause, on the edge or corner of a piece of lumber.

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More Info

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APA - The Engineered Wood Association,
http://www.apawood.org/

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