

An Evolutionary History of Oriented Strandboard (OSB)

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Abstract

To improve wood utilization efficiency, oriented strandboard (OSB) was developed; 80% of the wood removed from the forest can now be processed into marketable products. This manuscript describes the history of developing this most profitable wood product, OSB, and the early FPL contribution in development.

Keywords: OSB, oriented strandboard, wood utilization, utilization efficiency, logging, wood waste

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An Evolutionary History of Oriented Strandboard (OSB)

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Historically, logging and wood processing residues have offered a utilization challenge for those involved in the harvesting and manufacture of wood products. Logging operations typically left stumps, tapered log butts, tree tops, and limbs for forest fires to remove or to compost into bedding for destructive forest insects. Even after the delivery of logs to a sawmill or plywood plant, residue materials have represented up to 60% of the log volumes delivered. Thus, commercial efforts have attempted to utilize as much of these residue volumes as possible with production of charcoal, poultry bedding, and heating fuels. Forest fires, tepee burners, and burn piles, however, have often provided a quick answer for getting rid of the surplus accumulations of forest and processing residues. Today, with the increased use of logging residues and wood chips for production of OSB panels, about 80% of the wood volume removed from the forest is now processed into marketable products (Haynes 2003) and tepee burners no longer exist for getting rid of processing residues.

The pathway to OSB production appears to have started in the 1920s with production of hardboards from pulp mats that were produced from wood chips. This was the beginning for producing composite panel products from wood residue types of materials. Following hardboard production and skipping the pulping step for producing hardboards, the utilization of waste materials was increased in the United States in the 1940s by the production of nonstructural and appearance grades of particleboards. Even as a nonstructural product, the particleboard made in the United States was new compared with plywood. But with the decline in the availability of timber suitable for plywood production in the 1970s, the development of technologies for production of structural types of particleboards quickly became a top priority for wood products research. Technological advancements were made, and along with these advancements came changes in the terminology used to describe the unique nature of each evolutionary step forward in product development, from particleboard, to NOVOPLY, to waferboard, to PLYSTRAN, to flakeboard, and finally to the oriented strandboard or OSB panels we speak of today.

Noteworthy Facts about OSB Panels

1. OSB products set records for new product market adoptions in North America by moving production and consumption from 751 million square feet in the 1980s to 7.6 billion square feet by 1990 (OSBGuide 2014).
2. OSB panels have been essentially a problem-free new commodity wood product. Perhaps no other new wood product has ever been so problem free as OSB composite panels.
3. The significant reduction in production binder requirements, from approximately 7% by panel weight to approximately 2.5% through changes in binder formulations and use of steam injection techniques, allows OSB to be an economic champion in the structural panel markets. In contrast, binders in some early forms of particleboards represented up to 40% of the product's weight.

Nonstructural Particleboards

Nonstructural particleboards are used for non-loadbearing, or nonstructural uses like decorative paneling, underlayments, and sidings.

The first industrial production of particleboard is believed to have occurred in 1941 in Bremen, Germany, using phenolic binders and spruce particles (Moslemi 1974). Later, Max Himmelheber of Baiersbronn in the Black Forest of Germany, who made particleboards in the 1930s, obtained a patent on January 27, 1951, thereby being considered the inventor of the class of products termed particleboards. Himmelheber's company later licensed the particleboard manufacturing technology to over 80 manufacturers throughout the world.

In the early 1950s TECO (Timber Engineering Company, Cottage Grove, Wisconsin) manufactured particleboard for the first time in the United States at its laboratory under the direction of Dr. Nicholas V. Poletika in Washington, D.C. TECO had a multiplaten hot press, and made mats for homogeneous type particleboards.

Additionally, there are many nonstructural types of particleboard products that have helped to develop the technologies that have led the way to the development of today's structural loadbearing particleboards, such as the following.

Hardboard

Hardboard, also called high-density fiberboard, resulted in the early 1920s when improved methods of compressing wet wood pulp at high temperatures produced a higher density product. Tempered hardboard is hardboard that has been coated with a thin film of linseed oil and then baked.

Medium-Density Fiberboard

Medium-density fiberboard (MDF) was first manufactured commercially in 1965. It is an engineered wood product formed by breaking down hardwood or softwood residuals into wood fibers, often in a defibrator, combining it with wax and a resin binder, and forming panels by applying high temperature and pressure. In most cases, the board has a density 25% to 50% higher than solid wood (Moslemi 1974).

Mende Pressboard

Mende pressboard, sometimes called thin particleboard, has been commercially manufactured in the United States since 1972. All plants for producing this board have equipment designed for continuous sheet production.

Structural Particleboards

These are commodity wooden panels rated for dead and live loadings for specified spans of support and durations of loading.

NOVOPLY

This product was the first particleboard commercially sold that could be considered a structurally rated particleboard. NOVOPLY was a three-layered particleboard first produced in Switzerland in 1946 and later in the United States by the U.S. Plywood and Georgia-Pacific Corporations (U.S. Trademark Registration, #0542445, 1950, NOVOPLY).

Waferboard

This product is made from flakes called wafers. These were short ~1.5-in. long by approximately 0.0045 in. thick pieces that somewhat nest together for bonding. It was patented by Armin Elmendorf in 1965. Waferboard has acceptable strength properties but falls short for stiffness properties, which can cause serious user complaints. The development of this structural particleboard began in 1949 in a research laboratory of the Pack River Lumber Company at the firm's Sandpoint, Idaho, location. It is thought James d'A Clark invented the first waferboard manufacturing process when he was trying to develop an attractive, decorative wall panel for nonstructural uses (Bengston and others 1988). Waferboard production uses soft or low-density hardwoods rather than

scarce softwood species. Aspen, the most common species for waferboard production, has a transcontinental distribution through North America.

In 1978, five waferboard plants were operational in Canada and one in the United States (Blandin Paper Company, Grand Rapids, Minnesota).

PLYSTRAN Plywood

This plywood is a ½-in.-thick three-ply hybrid sheathing product with a veneer face and back and a core of narrow veneer strips oriented in parallel for a cross-banding core, thereby free of any core voids. This was a white fir (*Abies grandis*) structural sheathing product developed by Potlatch Forests, Inc. (PFI) of Lewiston, Idaho, and certified by TECO for structural sheathing applications. The only production of this product was from PFI's plywood plant in Lewiston, Idaho, beginning in the late 1960s and extending on into the late 1980s. Public records of research projects conducted jointly between Potlatch Forests, Inc., and Washington State University (WSU) document their research on the development of electrostatic wood strand orientation techniques in 1974 to advance the mechanical methods being used. The electrostatic technology was later adopted for production of oriented strandboard, or OSB panels.

Flakeboard

Flakeboard is made from flakes thinner and longer than those used for waferboard. Flakeboard flakes were specified to be at least 3 in. long and approximately 0.0015 in. thick, allowing for the flakes to lap over one another. Forest Service and university collaborative research was conducted in reference to the utilization of a variety of softwoods and low-density hardwoods found in different regions of the United States. In June 6–8, 1978, the Forest Products Laboratory sponsored a symposium in Kansas City, Missouri, to present the technical and economic findings of the Forest Service's flakeboard research. Three years after the Kansas City symposium, 19 new flakeboard plants were operating and after 5 years, 25 plants were operating with the random-oriented flakeboard production shifting into the form of a three-layered oriented strandboard to be sold as oriented strandboard, or OSB.

Oriented Strandboard

OSB is the culminating product in the development of structural particleboards. It is a three-layered flakeboard panel crossbanded by a core of oriented flakes at a right angle to the orientations of the face and back layers of flakes. OSB became a leading commercial competitor for structural sheathing markets in the 1980s, and correspondingly a major contributor to improved forest management practices by way of utilizing what were heretofore considered to be overwhelming volumes of logging and manufacturing residues.

In summary, OSB was conceptually invented and patented by Armin Elmendorf in 1965 as waferboard. Thus, the

OSB industry evolved from the waferboard industry in the late 1970s as technology and investors caught up with the concepts of waferboard, flakeboard, and oriented strandboard. It took about three decades and many researchers to investigate and assess the effects of strand size, the raw materials that could be used, the three-layer structure, the different methods of strand alignment, and the effects of the alignment itself on the strength of OSB to develop the manufacturing specifications and codes that have allowed OSB panels to become the major wood products commodity that it is today.

Epilogue

The first industrial production of particleboard is believed to have occurred in 1941 in Bremen, Germany, using phenolic binders and spruce particles (Moslemi 1974). Max Himmelheber of Baiersbronn in the Black Forest, Germany, is considered the inventor of the class of products termed particleboard. His company later licensed over 80 manufacturers throughout the world.

Toward the end of the 1930s, Fred Fahrni of Switzerland worked systematically on three-layer particleboards. Later he received an honorary doctorate from the Federal Technical University (ETH, Zürich) for his accomplishments. In 1946, the first mass industrial production of three-layer structural boards in the world was accomplished with the start-up of the NOVOPAN factory in Klingnau, Switzerland. Later production and distribution of the product in the United States was handled by U.S. Plywood Corporation and Georgia-Pacific Corporation with the brand name NOVOPLY.

In the early 1950s, TECO manufactured particleboard for the first time in the United States at its laboratory under the direction of Dr. Nicholas V. Poletika in Washington, D.C. TECO had a multi-platen hot press and made mats for homogeneous-type particleboards.

TECO began its work with structural panels through establishing the technical suitability of using white fir (*Abies grandis*) that was prevalent in Idaho and Montana for C-D grade 3-ply ½-in. plywood. TECO functioning as a testing laboratory also certified laminated beams from inland Douglas-fir and hemlock in its initial work as a certifying agency.

TECO was able to advance particleboard technology further with information gained from a study of practices in Europe. In 1955, with the support of 25 companies, TECO Vice President Carl A. Rishell conducted a study on European practices. Generally the investigating team specialized in searching out data on small productive pulping processes, as well as hardboard and particleboard and mechanical waste utilization processes.

The team started with a five-day visit at the Hannover Industrial Fair where the members met principal industrialists from Germany and some other European countries. They

found that the German particleboard industry had advanced far beyond the latest applied technologies in the United States. In 1955, German products were, in general, far superior to those the United States was producing (Rishell 1958).

The team also found that the technology in Switzerland was comparable to that operating in Germany. They did not find much new information in France, Belgium, Holland, and Denmark. In Sweden and Norway, the particleboard industry had not yet taken a foothold, but hardboard processes developed rapidly. Equipment and machinery was also in a high state of development in Europe. An improvement in feedstock development came with the continuous feed disk flaker that was manufactured in Germany.

The 1955 survey was so successful that the team provided information for a report that contained almost 400 pages and the clients requested another investigation. Another trip was conducted in 1956, but this time the survey was asked to specialize in particleboard. The 1956 tour included Finland, but not the Low Countries, France, and Austria. Activity in Finland was found to be similar to that in Norway and Sweden.

TECO went on to become an independent testing and certification agency and pioneered in getting structural products accepted in building codes. TECO cooperated closely with its industry supporters, especially hardwood lumber manufacturers in the East and Potlatch Forests, Inc., in the West. PFI's specialty products salespeople led successful technology transfer efforts through the 1960s and 1970s by interfacing with building code officials throughout the country by way of their technology trained sales staff that included Al Marshall, Bruce Curtis, Larry Hanson, Bob Walton, Dick Peyran, and Bud Filler.

The Forest Service's Close Timber Utilization Committee was organized in the early 1970s to consider opportunities for utilizing more of the residues from forest harvesting operations. Considering the history of particleboards in general and the success of NOVOPLY as an engineered particleboard product, the Close Timber Utilization Committee considered such products to offer promising uses for many types of forest and processing residues. Subsequently, the Forest Service Structural Flakeboard Task Force was organized. Together, these committees were effective in getting cooperation among different Forest Service, academic, and industry laboratories to establish particleboard research programs.

At the same time, in the 1970s the Forest Service Close Timber Utilization Committee and the Forest Service Structural Flakeboard Task Force had been advocating that more efforts needed to be aimed at cleaning up forest residues. And too, Forest Service Economists encouraged the development of structural particleboard as a way to offset what resource specialists identified as a diminishing supply of timber for supplying veneer grade logs to satisfy the needs

of the construction industries. Accordingly, strong research efforts were aimed at utilizing standing and down forest residues. R.A. Arola, project leader of a Forest Service engineering research project at Houghton, Michigan, demonstrated that significant amounts of thinnings could be recovered economically by a completely mechanized system with improvement of residual stand quality and growth (Arola 1978). At Missoula, Montana, David P. Lowery and John R. Host began new research to improve chipping (Lowery and Host 1978). At Pineville, Louisiana, Peter Koch concentrated on two large research efforts to acquire residual wood for structural flakeboard plants, the shaping-lathe headrig, and the mobile chipper (Koch 1978).

Other efforts were aimed at developing more effective manufacturing parameters. Eddie W. Price and William F. Lehmann investigated flaking alternatives for wood species of different densities used in boards produced at different compression ratios. Overall, use of disk and lathe flakers yielded boards with higher bending strength and modulus of elasticity for initial test conditions (50% relative humidity) and after accelerated aging. Internal bond strength of boards made of ring-cut flakes was the highest. Despite their internal bond strengths, boards made from ring-cut and drum-cut flakes were less stable after being subjected to environmental conditioning than boards made from lathe-cut and disk-cut flakes (Price and Lehmann 1978).

The Forest Products Laboratory developed an idealized concept of the form forest residues should take to process them more effectively. This led to definition of particles of elongated dimensions in the fiber direction—approximately 2-1/2 to 3 in. long with a nominal cross-section of 1 in. by 1 in. or less. These particles were termed fingerlings that would then be ring flaked to a thickness of approximately 0.012 to 0.02 in. The long thin fingerlings were deemed best for making aligned flake or randomly oriented flake fiberboard. However, the failure of conventional chippers to be able to consistently produce flakes with fingerling geometry required that other means of making fingerlings be developed.

Roger Arola and John R. Erickson patented a machine with a very novel spiral screw type cutterhead mounted on a rotary shaft to make fingerlings. Moreover, it was capable of being operated at a landing in the forest so that forest residues did not need to be transported uneconomically in bulk form. The inventors called this device a spiral- or helical-head chipper. It became available for non-exclusive licensing from the U.S. Government (Erickson 1976).

R.L. Geimer and E.W. Price studied flake geometry, flake quality, flake alignment, average density, density gradients, layer thicknesses, and resin content for determining final manufacturing details for structural flakeboards made from western softwoods and southern hardwoods. A three-layer board was recommended for both types of wood. Long, thin

flakes enhanced bending properties, while thick core flakes maximized internal bond strengths (Geimer and Price 1978).

Chung-Yun Hse in the USDA Forest Service laboratory at Pineville, Louisiana, studied the effect of a resin formulation for gluing flakeboard of mixed southern hardwoods. To produce a flakeboard of acceptably low density a phenolic alloy of phenol-formaldehyde resin and polyisocyanate was selected (Hse 1978).

To gain acceptance of new types of structural grades of flakeboard, Andrew J. Baker and Robert H. Gillespie demonstrated long-term structural service life. Life expectancy of phenolic-bonded flakeboard was simulated using accelerated aging and its response was compared satisfactorily with exterior-type plywood and solid lumber (Baker and Gillespie 1978).

To demonstrate boards produced using optimum specifications developed by research, J. Dobbin McNatt evaluated 4-by 8-foot panels from Douglas-fir forest residues. For use of wall sheathing, the panels exceeded accepted standards and they met requirements of the Uniform Building Code for roofs and floors. Under fire exposure, the panels had a Class B flame spread rating and exceeded fire endurance requirements for exterior walls of one- and two-family dwellings (McNatt 1978).

Thus particleboard and related panel products, other than hardboard, that were mainly unknown and not thought of before the 1930s have come to the forefront since. When people, especially the Forest Service Close Timber Utilization Committee, and later the Forest Service Structural Flakeboard Task Force, began to think of product outlets for forest residues, particleboard naturally came to mind. Harvesting and utilization of chips, flakes, and smaller particles, from what we now term biomass, became the object of focused research within the Forest Service and among university and industry cooperators.

The collective results from research were sufficiently promising to encourage a combined presentation of research results along with the basic economic factors that would be required to justify private investment in the construction of facilities to produce structural flakeboard panels. Thus, In June 6–8, 1978, the Forest Products Laboratory sponsored a groundbreaking symposium in Kansas City, Missouri, to present the technical findings of the Forest Service’s “flakeboard” research results in such techno-economic terms that would facilitate further feasibility assessments by potential investors. The symposium was convened by the Forest Service’s Structural Flakeboard Task Force that was appointed by Chief John R. McGuire in 1973. The meeting was titled “Structural Flakeboard from Forest Residues” with the collective set of presentations published as a Washington, D.C., Forest Service Technical Report (USDA 1978).

This symposium was perhaps a groundbreaking event because it was the first time the Forest Service had ever

presented a Forest Service wide program of research collectively in the context of techno-economic considerations. The economic considerations included regional estimation of construction and operating costs for three different sizes of facilities and estimates of the annual amounts of forest and processing residues by species that could be expected to be available to supply such facilities. As for the production facilities, Peter Vajda, an internationally renowned civil engineer, presented detailed information for constructing flakeboard production facilities with three different capacities for production outputs. In this context, the symposium presented research findings and reports from 10 Forest Service wood-processing scientists and 10 Forest Service economists located in seven different regions of the United States. The preliminary feasibility assessments addressed 16 different sites in different parts of the United States.

As one of the speakers at the meeting, Peter Vajda, stated, “The definition of a ‘structural flakeboard’ or the physical properties required for a board product to be deemed ‘structural’ are somewhat vague at present. What we do know is that in a structural-grade product we would like to optimize strength, stiffness, and dimensional stability (especially linear expansion) properties and assure that these properties are retained over a long period of time and under varying temperature and humidity conditions. We also know that boards made from ‘flakes’ have basically a higher modulus of rupture, a higher modulus of elasticity, and a lower linear expansion than boards made from ‘random-type particles’ such as shavings, sawdust, or hammermilled chips. Furthermore, strength retention after duration of load under varying temperature and humidity conditions, or, indeed, exposure to weather requires the use of an exterior-grade binder (phenolic or other).”

Vajda also mentioned that Potlatch Forests, Inc., manufactured oriented strandwood in a pilot plant located in Lewiston, Idaho. The development at PFI stemmed from their market experience with the core voids that occurred in 3-ply ½-in. sheathing plywood because of the size of knot holes and other defects allowed for core veneers. Voids in the core veneers created hidden spots where workmen carrying loads could step and dangerously break through. Thus, oriented strands were formed into core mats to replace the low grade core veneers for cross banding. The product was sold in the early 1970s under the name of PLYSTRAN (Vajda 1978).

However, oriented strandboard had its beginnings around the same time Clark initiated research on waferboard when Armin Elmendorf started to work on mechanically orienting strands of wood to produce stronger particleboard (1950s). Research was later undertaken at the Forest Products Laboratory (Geimer 1976) and by scientists at Washington State University who conducted research on flake orientation (Bengston and others 1988), including flake orientation through fields of electricity. Others who worked on flake orientation included Peter Koch at the Forest Service Pineville,

Louisiana, location. For the early PLYSTRAN product (late 1960s), researchers at Potlatch Forests worked closely with John Talbott at Washington State University. Dr. Herbert B. McKean at PFI led a productive research staff that was responsible for many innovative engineered products that became established in building construction.

Public records of research projects conducted jointly between Potlatch Forests, Inc., and Washington State University (WSU) document their research on the development of wood strand orientation techniques in 1974. Both Washington State University and PFI were key long-term participants in keeping advancements in particleboard manufacture to the forefront. Year after year a composites (particleboard) symposium attended by leading industrialists and researchers in the field was held at WSU. Dr. George Marra began the symposia and Thomas M. Maloney became his strong successor. The 48th International Wood Composites Symposium sponsored by WSU and APA was held in Pullman, Washington, April 30–May 1, 2014, as The Engineered Wood Association meeting. John Talbott was the leading researcher at WSU and did pioneering work in aligning lignocellulosic particles in an electrical field. Thomas Maloney was also the author of the book *Modern Particleboard and Dry Process Fiberboard Manufacturing*.

When Max Himmelheber first started implementing his ideas for particleboard manufacture in the 1930s, the product yield from harvested trees in Germany was only about 40%. Today, with increased use of wood chips and sawdust, logging residues have been reduced to less than 10%, with little to no processing residues to dispose of (Haynes 2003).

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