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WOOD RESIDUES IN COMPRESSION-MOLDED AND EXTRUDED PRODUCTS

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Summary

Compression-molded products are made from a variety of modified wood forms ranging from pulped or whole wood fibers to granular wood-resin combinations.

Binders and resins used in molded articles made from wood residue depend on the intended use of the products and cover a range of thermoplastic and thermosetting binders.

Methods of lay-up or formation of the materials, as well as the technique of molding, vary with the size and shape of the wood residue and the type of product manufactured.

With some types of board products, it is possible to postform or mold them into simple curvatures and mild compound curvatures.

Introduction

The increased use of wood residues by industry has been stimulated by a need for more complete utilization of wood. The concept of an inexhaustible timber supply that was prevalent years ago has been replaced by realistic timber management programs throughout most of the United States. This new outlook regarding our wood resources, together with the rising cost of manufacturing lumber, has prompted many woodworking industries to find some profitable use for their wood residue.

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The residue consists largely of edgings, slabs, trimmings, and shavings which for years have simply been burned or dumped, posing a waste-disposal problem. The problem has been greatly reduced in many of the wood-using industries by using the wood residue as the raw material in the manufacture of interfelted fiber hardboards, resin-bonded particle boards, or molded and extruded products.

The board products made from pulp fibers and from wood-residue particles include such familiar items as hardboards made by the so-called wet-formed and dry-formed process, insulation boards, and resin-bonded particle boards. These products are discussed in Forest Products Laboratory Report No. 1666-21, entitled "Board Materials from Wood Waste."

The utilization of wood residues in compression-molded and extruded products will be discussed in this report.

Molded Wood Fiber Products

Woodpulp fibers are ordinarily made by techniques similar to those used in making paper; that is, the wood is converted to pulp by a chemical or mechanical process. The pulp is dispersed in water, then the molded article is formed from a water suspension of fiber. A more detailed discussion of these techniques is not necessary here, since complete details are available in the literature of the pulp and paper industry.

Articles made in this manner are low in resin content but may incorporate small amounts of rosin size or wax. Picnic plates, pie plates, flower pots, woodpulp sewer pipe (asphalt impregnated), heavy walled grease containers, typewriter cases, and luggage are examples of molded pulp products.

Wastepaper to which has been added about 1 percent of papermaker's rosin or wax size is used in making florists' vases, toys, egg flats, and egg cartons.²

An interesting application of the use of whole wood fiber by a large West Coast company is the manufacture of wood-fiber preforms. The preforms are sold to manufacturers who do the final molding. For relatively simple designs, sheet or blanket preforms are molded into the final product. Where more complex shapes are being made, wood-fiber preforms that have been pre-shaped to the general form of the finished product are used. The resin

²Nonplastic Molded Pulp Products. U. S. Forest Products Laboratory Report No. 1964. 1953.

content of wood-fiber preforms can be varied to meet the needs of the end product.

More recently there has been considerable development of fiber manufacture for molding by the damp or semidry process. The wood is converted to pulp fibers by some high-yield pulping method, which is sometimes a continuous process. Then the fibers are carried in an air suspension and deposited as a mat or blanket which is pressed or molded. Usually a small amount of resin is needed to give strength to the product. This method lends itself to the molding of many useful products. Examples of items that could be made from the wood-fiber preforms include such products as chair seats, toilet seats, furniture components, doors, window frames, tool handles, television cabinets, croquet balls, trays, bowls, etc.

The Forest Products Laboratory has made experimental moldings of wood fibers blended with a high percentage of synthetic resin.³ The fibers were molded into cup-shaped items that, when tested, were significantly stronger in tension, flexure, and impact than moldings made from general-purpose molding powders.⁴ The tests indicated that kraft pulp containing 35 percent by weight of phenolic resin gave optimum strength properties to the products.

The Laboratory has also developed and tested a slotted oil-filter element molded from a slurry of pulp fibers and 35 percent phenolic resin. The slotting was made in the element to increase its surface area.

Moldings of Resin-Bonded Wood Particles

Resin-bonded wood particle products depend primarily on resin for bonding strength, since particles alone, unlike fibers, develop little or no bond when consolidated under pressure.

Products made of resin-bonded wood particles differ from plastics made of wood flour and resin in the amount of resin used. The plastics require a high percentage of resin to bind the wood flour together and to give the product strength. In general, plastics may be considered as high-resin content items in which wood flour is used as a resin filler or extender.

³Pulp-Reinforced Plastics. U. S. Forest Products Laboratory Report No. 1461. 1945.

⁴Physical Strength Properties of Molded Fiber-Resin Preformed Materials. Modern Plastics. February 1945.

The availability of new thermosetting resins and the ever present wood-residue problem have encouraged the development of compression-molded and extruded wood-residue products. These products may vary in shape and thickness from thin, curved panels to thick, extruded rods.

In general, wood particles, resin binder, moisture, heat, and pressure are required for the manufacture of compression-molded or extruded articles. The process will generally consist of:

- (1) Hogging, grinding, hammer milling, or machining the wood residue to the desired size.
- (2) Drying the particles to uniform, predetermined moisture content.
- (3) Adding controlled amounts of resin by spray or other means and blending it with wood particles.
- (4) Pressing or extruding under carefully controlled heat and pressure.
- (5) Cooling and trimming the product and equalizing its moisture content.

Probably the three most critical variables in the manufacturing operation are particle size or shape, resin content, and moisture content before pressing. The end use of the product governs the degree or measure of control required for each variable.

Most processors maintain close control over the size of the particles going into their products. Shapes and sizes of the particles may vary from modified or unmodified sawdust used as resin extenders in moldings that have a high percentage of resin, or millwork shavings used in decorative panels with low resin content, to specially prepared particles for some special purpose.

Many of these products are made with a particular end use in mind and not as an all-purpose product, such as lumber or plywood. Hence, the combination of particle and resin should be selected to fit the conditions under which the final product will be used.

Resin content must be watched very closely, for this governs strength, water resistance, and cost. Decreasing the particle size permits finer molding details and improves surface smoothness, but such particles will require more resin because of their increased surface area per particle volume. Large particles or flakes give a pleasing effect to panel surfaces and require less resin because of their small surface per particle volume.

In general, the greater the ratio of surface area to volume, the larger the resin content required for the same strength.

The two most popular types of resin for use in compression-molded and extruded products are phenol formaldehyde and urea formaldehyde. Both types can be used in liquid or powder form. Probably the most distinct advantage the phenolic resins have over the ureas is moisture resistance at high temperatures. Ureas, on the other hand, cost less, do not darken the product, and cure rapidly. Where water resistance is important, however, as for exterior use, phenolic resins are recommended. Generally, curing times for either type of resin are dependent on temperature of the press, amount of hardener, and degree of acidity of the mixture.

Moisture content of the aggregate during pressing or extrusion helps govern the ease of plastic flow in the aggregate. Excessive moisture, however, increases press time and may result in blowouts or blistering at high temperatures. Moisture content may range from 4 percent for high-pressure molding to 12 percent for low-pressure molding.

Products manufactured by the general processes outlined above can be varied in appearance, weight, and strength by varying particle size, resin content, moisture content, curing pressure, or curing temperature. These manufacturing variables are usually adjusted or modified to suit the products for a specific end use. Examples of some of these products are curved seat backs and toilet seats. Extruded articles are stable in thickness and can be made in a variety of shapes and sizes.

The extruding machines take wood-residue material prepared in the manner outlined above and force the mass through a heated die. By adjusting the space between dies, the desired thickness is extruded and such items as boards, moldings, rods, paper-roll plugs, etc., can be made. By timing the ram force and adjusting the heat, the resin cure is accomplished when the extrusion emerges. This is a continuous process.

Extrusion equipment is also used to produce log-shaped fuel from particles of wood residue.⁵ No binder is required in this product because of the high consolidating pressures used. By this method, a continuous, extruded fuel log is produced and cut to length as it leaves the machinery. Because of the small amount of ash and smoke produced, logs made from granulated wood are used as fuel in dining cars, restaurants, ship galleys, and homes.

⁵Briquets from Wood Waste. U. S. Forest Products Laboratory Report No. 1666-13. 1953.

Methods of Reducing Resin Content

As the resins are the most expensive material used in many of these products, many manufacturers and others are trying some unique methods of reducing costs by resin substitution or modification.

One method of lowering resin consumption in molded products is to substitute certain percentages of lignin for the resin. This is similar to the use of lignin as an extender for phenolic resin in laminated paper products now successfully practiced in Canada, where the paper mills use alkaline lignin obtained from spent pulp-mill liquors, which are available in large quantities. Under heat and pressure, the alkaline lignin flows and forms a hard bonding substance. Thus, the lignin can be considered a bonding agent itself.

When used as an extender for molded products⁶ in which a high resin content is necessary, soda-type lignin can be substituted for 75 percent of the resin without much sacrifice of physical properties, although, of course, dark-colored products result.

Wood-hydrolysis lignin does not flow as well during molding as the alkaline-type lignin, nor is it readily available at present.

A method of utilizing lignin as a bonding agent without adding further binder was developed in Switzerland. A chemical added to wood residue activates the lignin, making it flow and bind the particles when heat and pressure are applied. A similar process is being experimentally investigated in this country, and compression-molded products produced by the "lignin activator" process are claimed to possess good strength properties.

The Australian Forestry Commission has developed a method of producing molding powders and building boards utilizing only the natural resin-producing substances in wood.⁷ One percent of formaldehyde added to the tannin-rich wood residue causes a reaction under heat and pressure which is said to result in a resin formation that binds the wood particles into a strong unit. Only 1 of the 3 classified types of tannins will produce this reaction, and Australia is rich in woods containing it. This type of tannin must be present in amounts of 10 percent or better to produce a molded product of satisfactory strength.

⁶Pulp-Reinforced Plastics. U. S. Forest Products Laboratory Report No. 1461. 1945.

⁷The Preparation of Molding Powders and Building Boards from Tannin-containing Materials. New South Wales Forestry Commission, Subproject C6-3.

Postforming

In conclusion, some discussion of postforming or shape molding of board products should be included under the general subject of compression molding.

Very little has been done on postforming resin-bonded particle boards because of their poor deformation properties. With such boards, it is much easier and less costly in the long run to curve or mold the product in the initial pressing of the raw materials, since the small, resin-coated particles readily lend themselves to loading, forming, and molding.

Unlike boards made from resin-bonded particles, plywood and hardboard can be postformed into simple curvatures and mild compound curvatures. Postforming plywood and hardboard to compound curvatures depends on the ability of the material to deform through compression or shear.⁸ Conventional hardboard has this ability, and it also has plastic properties when heated that are advantageous in postforming. The resins used in particle boards are usually thermosetting, however, and the boards remain rigid after they have once been cured. Plywood or hardboard 1/4 inch or less in thickness can be bent to simple curvatures in heated-mandrel bending machines or by pressing the boards between heated dies. Plywood and hardboard may also be curved by making sawcuts on the back side of the boards, then a curved block or veneer strip is glued to the inside of the curve to add strength after the board is bent.

⁸Bent Wood Members. U. S. Forest Products Laboratory Report No. 1903-3. 1951.