

BRIQUETS FROM WOOD WASTE¹

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The art of briquetting is relatively old and widespread in its applications to a great variety of substances. It is applied to the metering of uniform quantities (pills), to consolidation of fine material into convenient units (sugar cubes, coal dust), to densification of bulky material (metal turnings for remelting, peat), and to improvement of physical qualities (powder metallurgy, charcoal). The equipment, technique, and experience of this broad field are available for guidance in wood briquetting, since the consolidation, densification, and improvement of physical qualities desired for utilization of finely divided wood refuse apparently parallel the customary briquetting of metal turnings and of coal dust and other fuel stuffs.

These more or less general briquetting methods have been used in some European countries for many years for sawdust, shavings, extracted bark, and chips. In this country, because of the cheapness of other fuels and the plentiful supply of solid firewood, many similar ventures during the last half century have been financially unsuccessful. As a conservation and stop-loss measure, there remains a strong inducement to convert otherwise waste wood of low value to dense, clean, easily burned briquets. It has been only in the last decade or so that any considerable degree of financial success has attended wood-briquetting efforts (and then only under the most favorable circumstances). This has been primarily due to the use of a radically different method.

It has been found that some granular materials require no added binder because they are self-bonding when briquetted at elevated temperatures. Among these is wood. At temperatures above the minimum plastic temperature (325° F. for wood), the elastic strains set up in the material under briquetting pressure are completely relieved and the particle surfaces come together into intimate contact. Cohesion of the interfaces,

¹This is one of a series of Forest Products Laboratory reports on wood waste utilization.

²Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

interlocking of broomed-out, fibrous parts of the particles, and a possible adhesion of the heat-softened lignin (the natural bonding agent between the wood fibers), all contribute to a binding action that imparts satisfactory strength to briquets after they have cooled under pressure.

Briquetting Machines

This self-bonding feature of wood waste is the basis of the only wood-briquetting process commercially successful in this country at present. Practically all plants based upon this process use one type of machine,³ the "Pres-to-log," made by Wood Briquettes, Inc., Lewiston, Idaho. This machine operates by compressing the waste wood (sawdust, shavings, and other scrap ground to oatmeal size) into a primary compression chamber by means of a feed screw developing a pressure of approximately 3,000 pounds per square inch. At the outlet from this chamber a secondary head cuts the compressed material into a spiral ribbon and forces it into a mold under a local pressure of 25,000 to 30,000 pounds per square inch, the friction at this extreme pressure generating sufficient heat to produce the necessary plasticity for self-bonding. The molds are cylindrical holes 4 inches in diameter spaced at regular intervals in and extending through the rim of a large wheel about 12 inches wide, with the axes of the molds parallel to the axis of the wheel. The bottom of the mold cavity is closed by a hydraulically operated piston, which supplies the necessary resistance during filling and retracts as the mold fills. When the mold is filled, the mold wheel revolves slightly to bring the next mold cavity into line for filling. The mold wheel is water cooled, and the briquets are cooled below their plastic temperature by the time it makes a complete revolution. The cooled briquet is ejected from the mold as the resistance piston enters the mold cavity ahead of it preparatory to its filling.

The 4- by 12-inch briquets produced by this machine are suitable for hand firing but not for mechanical stoking. For stoker briquets, a different type of machine, which is available from the same company, extrudes the self-bonded material through a cluster of eight 1-inch round holes to form continuous rods. As these rods emerge from the extrusion head, they are cut into 1-inch lengths by rotating knives and yield pellets suitable for mechanical stoking.

Extrusion-briquetting is a recent development, and few machines using this principle are in use. A Swiss extrusion machine, the "Glomera,"⁴ for making stoker briquets without binder is also available. It has

³These machines are understood to be available in this country only on a lease-royalty basis. For use abroad, they are sold outright.

⁴Sumner Iron Works, Everett, Wash., has been licensed to produce the Glomera Briquettor and auxiliary equipment in the United States.

two adjustable tubes, about 3-1/2 inches in diameter, through which the material is forced by pistons or rams. The tubes have an adjustable slight taper that provides sufficient resistance to the flow of the material to develop high pressure under the pistons, which causes the loose material to be compacted. The cohesion between successive charges is less than that within each charge, so that the extruded briquet tends to separate easily into disks about 1/4 to 1/2 inch thick. These are more conveniently handled for stoking small fires in cook stoves or shoveling the fuel into a furnace. An automatic head for wrapping of briquets with cellophane is available. Newer models of this machine give greater density and cohesion by precompressing the charges before the pistons force them into the tubes. The horizontally positioned pistons of the Glomera machine are driven by a pulley and compound lever arrangement. In a new German briquet press, the alternate-acting pistons are hydraulically actuated, in a vertical position.

A machine operating on the piston principle was developed about 1949 by Walter W. Letts of Northville, N.Y. Eight or sixteen extrusion tubes produce stoker-size briquets 1-1/8 inches in diameter and several inches long. The pressure face of the piston, or ram, has a dimpled center and scalloped radial grooves, the imprints of which improve the interlocking of successive charges of material, so that there is less tendency for the briquet to break up into small disks. The Sandy Hill Iron and Brass Works, Hudson Falls, N.Y., was the manufacturer of the machine.

A third method for binderless briquetting is used by the California Pellet Mill Co. of San Francisco. In this process, the material is fed into a die cup that has many orifices in its bottom. A roller under heavy pressure revolves over the material on the bottom of the die cup and forces the material through the tapering orifices. Rods of dense material are thus formed that are cut into short lengths by a rotating knife under the die cup.

A production rate of about 2 tons per hour is reported for the pelletizer system. Production with the Glomera machine is 1 ton per hour. One man can tend the machine and pack the product. With the Letts machine, a production of 700 to 1,000 pounds per hour could be expected from an eight-tube machine, with one man supervising four machines. Production with the log-size Pres-to-log machines, more than 120 of which have been installed, is about 1/2 ton per hour, with 1 man tending 2 machines. The stoker-size Pres-to-log machine produces about 20 tons per 24-hour day.

For profitable production, continuous round-the-clock operation is desirable. For efficient use of labor, some installations have been made in pairs or multiples thereof. Since the daily output of a pair of machines is 24 tons, it is apparent that a large and continuous supply of waste must be available. To compete successfully with other fuels, costs must be kept at a minimum. Briquetting machinery, therefore, must be located at the source of waste to eliminate expensive handling of bulky material. Because the large quantities of waste required can be

obtained in the West and because competing fuels are expensive in that region, nearly all of the briquetting plants are located there. One eastern plant, in New Jersey, has a luxury market in New York and other large eastern cities where the cleanliness and convenience of briquets command a premium price for fireplace, restaurant, dining-car, and ship-galley use.

No accurate cost figures on Pres-to-log briquetting are available, but in the West, where this product is sold in bulk, the selling price of stoker briquets, delivered, was \$12 per ton, bulk, or \$13 per ton, sacked, in 1950. A "unit" of 240 log briquets (approximately 1 ton) sold for \$13.35, delivered, or \$12.35 on a cash-and-carry basis. Summer prices were \$1 less to encourage picnic use and early stocking for winter use.

Dry Waste Essential

At present, waste used for briquetting is chiefly from coniferous species. One southern plant is making log-size briquets from oak sawdust. Many types of vegetable material, from alfalfa to bark, have been briquetted successfully, and a study by the Michigan College of Mining and Technology⁵ shows that some northern hardwoods, alone or in mixture with eastern hemlock, can be made into briquets. High-quality briquets can be made from bark alone, but the large volumes of bark required for a briquetting operation usually are available only at plants using wet debarking methods. Extensive drying thus becomes necessary.

To develop the necessary strength and hardness in the briquet, it is essential that waste be used with a moisture content of less than 10 percent, preferably 6 percent. Various types of dryers (such as drums, steam-heated plates, and steam pipes over which the waste is cascaded) may be used to bring the waste to the desired moisture content. A recent drier installation,⁶ the Raymond Flash Dryer, uses a short exposure to hot gases to reduce the moisture content to the desired level. Flash dryers are also made by the Glomera manufacturers.

Charcoal Briquets

The production of charcoal briquets may be accomplished either by preparing the charcoal first and then pressing it, or by preparing wood briquets to be carbonized after forming. During the war, 85 percent of the total production of Pres-to-log briquets was used for charcoal

⁵Hereford Garland. "Possibilities for the Production of Wood Briquette Stoker Fuel in Northern Michigan." Forest Products Research Division, Michigan College of Mining and Technology, Houghton, Mich. June 1950.

⁶The Timberman, 48:4, p. 48. February 1947.

production. Basore⁷ developed a method of making a semicharcoal briquet by preheating sawdust until the distillation of pyroligneous acid ceased, at which point tar distillation began and the sawdust was brownish in color. This partly charred sawdust was then cooled to 212° F. moistened with water, and pressed into molds. Basore and Moore later developed a method⁸ in which the dry sawdust was heated in molds, under no pressure except the weight of the mold piston, until partially carbonized and then placed under a pressure of 350 pounds per square inch until carbonization was complete. The resulting briquets were then further heated to drive off smoke-producing volatiles.

In the Seaman process of distilling finely subdivided wood, the resulting granulated charcoal is mixed with wood tar produced in the distillation process, briquetted, and reheated in a retort. Here the lighter fractions of the tar are driven off and recovered, and the remainder undergoes a coking that binds the charcoal particles firmly together. A very dense briquet results from this process.⁹

Field of Briquet Development

Further developments in briquetting are possible either in the process used or in the type of machinery employed, but prospects for substantial improvement are not encouraging. A small, inexpensive machine and simple process that could convert small quantities of green sawdust to briquets economically would be very useful in salvaging the waste at small sawmills, especially portables, where available waste is not sufficient to warrant the installation of the large-capacity machines now available.

The many processes and machines so far developed have two characteristics that must also be a part of future developments. These are (1) the use of pressure to reduce the bulk and provide hardness for resistance to handling and to improve burning qualities and (2) the provision of some agency to bind the small particles together to form the briquet. Pressures may vary over a wide range that may be as high as 25,000 to 30,000 pounds per square inch, and several types of binding actions are available, some of which have been used with varying success.

Binding agents may be broadly classed as external, such as wrappings of cloth or paper or ties of cord or wire, and internal, in which the

⁷Cleburne A. Basore. "Fuel Briquettes From Southern Pine Sawdust." Bul. 1, Engin. Expt. Sta., Alabama Polytechnic Inst., Auburn, Ala. May 1930.

⁸C. A. Basore and O. C. Moore. "The Production of Lump Charcoal From Pine Sawdust Without a Binder." Bul. 14, Engin. Expt. Sta., Alabama Polytechnic Inst., Auburn, Ala. November 1942.

⁹Mixing tar with charcoal is common practice and not limited to the Seaman process. Under some briquetting conditions, starch-bound briquets are also very dense.

binding agent may be dispersed within the briquet. Internal binders may be subgrouped into "additives," such as glues, cements, wood tar added to charcoal; "extractives" from the briquetted material itself, such as bitumen from soft coal, gums from southern pines, tars from partially carbonized wood; or "self-bonding," a characteristic of plasticized material.

If satisfactory briquets are to be produced economically, binders must meet a number of severe requirements. Overall cost is a primary consideration, in which unit cost of material, relative quantity required, cost of applying, and effect on production must be analyzed. Secondly, the binding agency must produce a briquet of sufficient toughness to withstand exposure and the shocks of transportation, storage, and stoking. Exposure to weather must not cause crumbling or excessive softening, and during combustion the exposure to heat must not cause disintegration and consequent loss of fine pieces through the grates. The binder, preferably, should not cause smoke nor produce gummy deposits. An objectionable odor, during storage or burning, should be avoided, and dust should not form in handling. Added binders should have at least as high a heat value as wood.

Additive binders fall into three classes: inorganic materials (such as cement and silicate of soda), organic materials (tar, pitch, resins, glues), and fiber. Some of these permeate the material to be briquetted; others merely surface-coat it. For wood fuel, cements are objectionable and have not been used because of increased ash, decreased combustibility, and disintegration during burning. Organic binders usually increase the heat value of wood briquets and do not add to their ash content, and briquets made with some of these binders do not soften or disintegrate during combustion. The majority of the binders most suitable from a physical standpoint are too expensive to use in the proportions necessary for good briquetting.

Self-contained extractable binders are available in some types of materials, chiefly the bituminous coals, from which an added nonbinding solvent extracts tarry materials that serve to bind the particles together upon subsequent evaporation of the solvent. Wood has no extractable binders of this class (except the resins of a few species) but has a parallel in the formation of tars in destructive distillation that can be added to charcoal for briquetting binder. The partial carbonization of wood briquets produces a comparable result.

Fibrous binders for briquets have received little study. In briquetting peat, one process is assisted by the hydration of fibers during the grinding, or "mastication," stage of preparing the material. Various types of fibrous material might serve as binding agents, but the cheapest would be hydrated wood fiber. This can be prepared from wood waste by grinding it to a high degree of hydration. The hydrated fiber could then be added in relatively small proportions to the material to be processed into briquets by a wet method combined with air drying for economy.

A new briquet product has recently been introduced that combines sawdust and coal dust, with added chemicals. The mixture is compressed into logs 4 inches in diameter and 24 inches long, and the individual briquets are wrapped in paper for cleanliness in handling.

The combination of wood with other fuel materials, such as coal, peat, and flue dust, or with metal wastes to be reprocessed, may be worthy of exploration. Such combination may be somewhat restricted because of the need for having two or more materials available in sufficient quantity at the same place; on the other hand, situations may exist where the quantity of each material, separately, may be inadequate to operate a briquetting plant but may be fully adequate if two or more materials can be combined.