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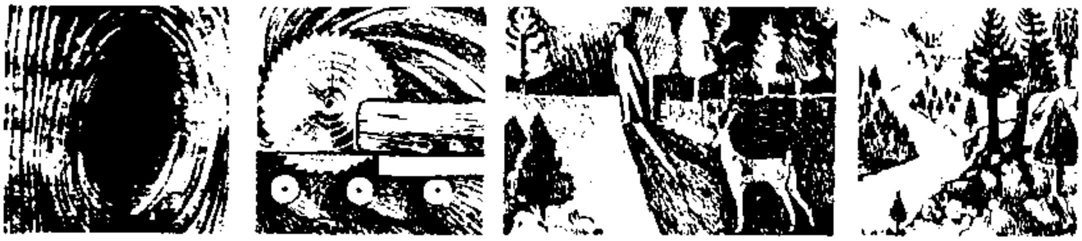
Wood Densification



WHAT IS WOOD DENSIFICATION?

Wood densification is the process of taking wood by-products (manufacturing residues) such as slabs, chips, or sawdust and processing them into uniform sized particles so they can be compressed into a fuelwood product. When wood wastes are densified, not only is a potential environmental hazard being eliminated, but a high Btu, clean burning fuel source is being created. Densified wood in a log form will burn on the average, three times longer than dry cordwood. A densified fuel log will generally have a moisture content of between 6 and 10 percent with the average at about 8 percent. Some other desirable characteristics of densified wood fuels include: a low ash content of around 2 percent, lack of creosote formation, and a Btu rating of around 8000, making it competitive with some types of coal. Handling, transportation, and feeding of combustion systems are also improved when utilizing densified wood products.

Densified wood products come in a variety of shapes and sizes for use as a fuel source, including:

1. Logs - cylindrical shaped, with a diameter of 2 to 4 inches and a length of 12 to 16 inches. A 12-inch log will weigh approximately 5 pounds.

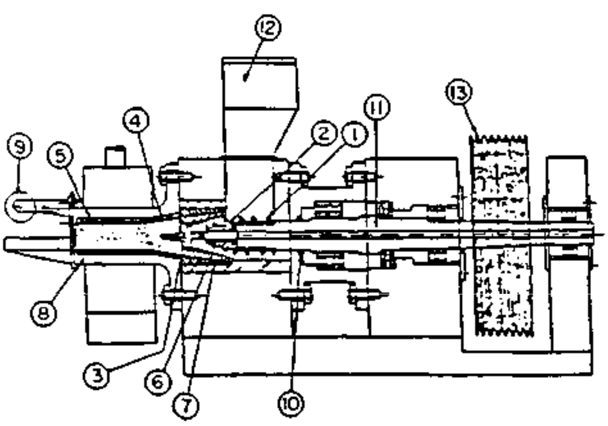
2. Pellets - small cylinders about 1/2 to 1-1/2 inches in diameter and about 1 to 2 inches long.

3. Briquettes - generally disk shaped and produced from the same type of machines as logs. Therefore, diameter is 2 to 4 inches and length is about 1 to 2 inches.

Logs are generally produced for residential markets as fireplace and wood stove fuels. Popularity of logs, in part, is due to the fact that they are clean burning, easy to handle, and burn longer than traditional cordwood. Logs are also used occasionally in small industries as fuel for boilers. Pellets are used more in commercial applications for industrial boilers where ease of handling and burning characteristics offer a competitive alternative to coal. However, with the newer types of boilers capable of using raw sawdust, the need for pellets will decrease. Furthermore, pellets require a high capital investment, high output, and large markets to be profitable. Briquettes have not been as popular as pellets but can be used as a fuel source for both residential and industrial applications. Because of the market flexibility of briquettes, this type of product could enhance the economic feasibility for densified fuelwood manufacturers.

HOW ARE DENSIFIED FUEL LOGS PRODUCED?

Two different types of equipment are available for manufacturing densified fuels: a screw-type extruder and a compacting ram. In the screw-type machine a large screw forces the raw material through a die at a pressure of around 20,000 psi, processing approximately 2000 lbs of dry sawdust per hour. The temperature created through this process is above 400 degrees Fahrenheit. At this temperature, lignin, the natural bonding agent in wood, undergoes a softening process, inducing a certain degree of bonding among particles. However, bonding within the log is probably due as much to the strength derived from intertwined particles as to the lignin bonding.



(1) Main Screw
(2) Front Screw
(3) Forming Head
(4) Taper Sleeve
(5) Cylinder Sleeve
(6) Kikugata
(7) Kikugata Case
(8) Cylinder
(9) Roll Cutter
(10) Front Roll Seal
(11) Shaft
(12) Hopper
(13) V-Pulley

Fig. 1 Screw-Type Extruder

The compacting ram operates like a large piston which compacts the material at around 8500 psi as it is forced through a die. The log formed by this process consists of a series of disks that are bonded together primarily by the mechanical interaction of particles and has very little to do with lignin bonding. The resulting logs are not as dense as the screw-type logs nor are they as durable. The compacting ram is capable of utilizing approximately 4000 lbs of dry sawdust per hour.

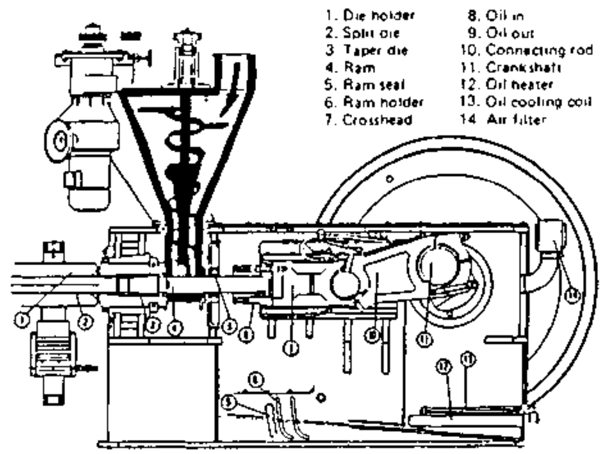


Fig. 2 Compacting Ram

Briquettes can be produced by either type of machine. However, the ram machine is more readily capable of producing briquettes since the disks produced at each stroke of the piston can be easily separated into briquettes. This can be accomplished by a punch or a saw which separates the log at the weak point between disks. A saw is generally the best alternative for cutting logs or briquettes produced on screw-type equipment.

PREPARATION OF THE RAW MATERIAL

For production of densified fuelwood to be successful, the raw material must be properly prepared and of uniform size. Wood particles must be 1/4 inch or smaller and cannot have a moisture content in excess of 10 percent. Above 10 percent, moisture adversely affects the system, slowing down production and causing wear on the internal parts. Material larger than 1/4 inch should first be processed through a hammermill in order to achieve the necessary size and uniformity. Larger material like slabs, edgings or end-trim may have to be processed through a chipper or hog prior to hammermilling. All systems should have a metal detection device to insure that processing equipment is not damaged by foreign objects.

Green (wet) sawdust must be dried prior to densification. Most driers are powered by natural gas, although some recent dryers are equipped to burn sawdust. The dryer has a large heating unit that blows hot air through the drying unit. Hot air mixes with the sawdust as it falls from the side of the rotating dryer. Once dried, the sawdust is generally placed into a dry storage bin and fed into a metering bin as needed. The metering bin feeds the extruder(s) or compacting ram(s) premeasured volumes of sawdust as needed.

POST - DENSIFICATION PROCESSING

Once the densified log product has been formed in either the screw-type or compacting ram-type machine it enters the cooling stage. The cooling process is a very important step, because the logs are still fragile after leaving the densifying process and must have time to cool in order to maximize lignin bonding efficiency. The lignin in the wood will bond more securely as it cools in its new shape.

The ram-type log exits the densification equipment as one continuous log. After traveling about 100 to 150 feet in the cooling line, logs are then cut. This distance is required not only to let the log cool, but to provide added back pressure to the ram to help increase the density of the log being manufactured.

The screw-type machine does not need a long cooling line to generate back pressure since the process is designed to produce a very dense log. The logs are cut to length immediately after leaving the extruder. The logs are about 400 degrees Fahrenheit at this time and need to be cooled either on a straight line conveyor (about 100 feet is sufficient) or cycled through a spiral conveyor or cooling tower which has fans that circulate air for cooling.

Packaging fuel logs or briquettes is often a very labor and/or capital intensive operation. The most cost effective means of packaging logs is in groups of 3 or 6. The most common types of packaging include:

1) Cardboard boxes that hold 3 to 6 logs. More than 6 logs can pose a problem in lifting.

2) Trays covered with a heavy layer of plastic. Each tray is then passed through a shrink tunnel. Shrink wrapping yields a very durable package, plus the added benefit is that the consumer can see the product they are buying. In addition, this type of packaging is generally more cost effective than boxes.

The most effective way of packaging briquettes is bagging. Typical bag weights are 25 and 50 pounds. Briquettes are simply conveyed to a bagging machine (a hopper with manually controlled feeder) where the bags are filled and then passed through a machine that seals the bag.

Transportation of the packaging material to the processing plant is also an important consideration. Empty trays can be shipped in a ratio of about two to every one box shipped.

After filling the boxes or trays they are generally stacked on pallets and each pallet is shrink wrapped in plastic to insure that the logs are kept free of moisture while in storage or shipment. The shrink wrapping of pallets also helps keep the load stable, permitting the higher stacking of pallets without danger of damaging the product.

PLANT LAYOUT

A key factor in determining plant size is the condition of the raw material being utilized. With green (wet) sawdust a drying system is necessary, which will require a plant size of at least 100 feet by 100 feet. The machinery that will need to be under roof in this type of system includes: a portion of the belting for transporting the raw material into the plant, the metal detector, a hammermill (a chipper or hog may also be required to break down large pieces for the hammermill), wet storage bin, metering bin, dryer, dry storage bin, screw conveyor from the dry storage bin to the extruders, cooling line, packaging equipment, and inventory storage for the palletized product. Moving the sawdust through the different stages of the process will require blowers, which must also be under roof.

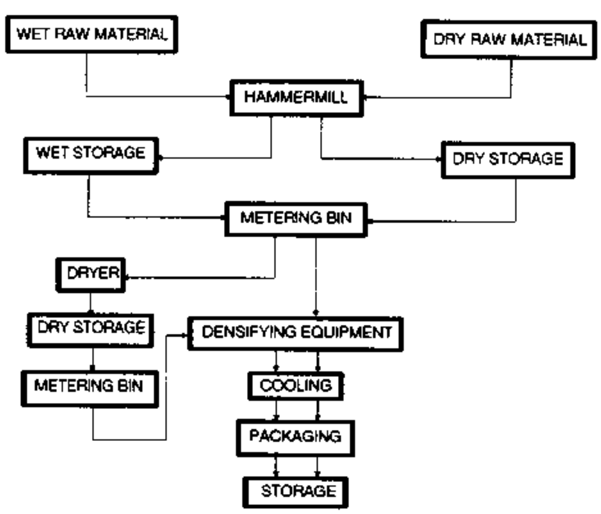


Fig. 3 Flow Diagram for Wet and Dry Materials

When the raw material being utilized is already dry, the space requirements of the plant can be reduced substantially. In this case, the wet storage bin, the metering bin for the dryer, the dryer, and associated blower systems could be eliminated.

CAPITAL COSTS

Capital costs of a densified woodfuels plant will depend on the production capabilities desired and whether the raw material is green (wet) or dry. Capital costs can be divided into two areas: the initial cost of equipment and the initial cost for the structure to house the equipment and the final product.

The densifying equipment will cost approximately $70,000 for the capability to produce 2000 pounds an hour of finished product. The cost differential between the screw-type machine versus the ram-type is negligible when examining the capital cost in units of productivity per hour.

Drying costs can differ depending on the style and the size of the dryer. A rotating gas fueled dryer will cost approximately $160,000 with the heating unit. This is the most commonly used dryer in the wood densifying business. An impact drying system has the capabilities of reducing the wood, like a hammermill, as well as drying it. The impact dryer can handle large quantities of sawdust, is of heavy design, and costs approximately $550,000.

Hammermills and the conveying systems for a densified fuel wood plant would cost approximately $20,000 each, while the metering bin has a price of approximately $30,000. Storage bins vary in cost depending on the size and shape required and for that reason many storage bins are fabricated. A fabricating operation charges $3.25 to $5.00

per pound to manufacture an item such as a bin. The price varies due to the complexity of the design or the type of metal that has to be used.

Packaging equipment has an approximate cost of $50,000 for an automated system. This will take the logs and box them or put them into trays and shrink wrap them. The cost of automated packaging equipment will reduce labor costs and may make the machine well worth the investment.

OPERATING COSTS

Operating costs include utilities, fuel costs for machinery, labor, repair and maintenance of equipment, packaging supplies, transportation, and raw material expense. While these costs will vary with type of raw material and level of production, some rough estimates can be made.

A plant utilizing three extruders is capable of 6000 pounds of logs per hour. If the plant operates 16 hours a day, four days per week, 1,140,500 pounds of logs will be produced in one month. In one month the plant described would use approximately 59,000 kwh of electricity. If the raw material has to be dried the dryer would use approximately 20,500 therms per month of natural gas in the same plant. Maintenance cost of approximately $5000 a month can be expected from wear and tear on the moving parts of the system including bearings, augers, dies, and other parts. The major portion of this cost will be born by the extruder or ram, since this equipment has the most mechanical stress of any others in the system.

Labor requirements to operate the above plant would be 6 to 9 employees. This would include one person to feed the system from raw material storage, one to supervise the drying operation, one or two persons to operate the densification equipment and the remainder to handle packaging and inventory storage. A plant manager would be necessary under this type of operation. However, for a plant using dry sawdust, ram-type densification equipment and bagging briquettes, the labor requirements would be 3 to 4 employees, including a plant manager.

The cost of packaging supplies varies depending on the type of packaging required. Boxes in general will cost 10 to 15 cents more per container than trays with a heavy shrink wrap. New types of shrink wraps will allow a tray to easily hold the weight of 3 to 6 logs. Also, transportation of empty trays and shrink wrapping requires much less space when shipping, reducing costs even further.

Raw material costs will vary with the accessibility and availability. Ideally, a densification facility would be located in an area of abundant raw material supplies. The ideal densified fuelwood plant for wet sawdust would be a part of or adjacent to an already existing sawmill, where the handling costs of the raw material would be greatly reduced. For dry sawdust the ideal location would be near a secondary manufacturer of wood products such as a dimension mill, flooring mill, millwork manufacturer, etc.

OUTLOOK FOR DENSIFIED FUELWOOD PRODUCTS IN WEST VIRGINIA

Fortunately, West Virginia is located within 500 miles of 50 percent of the U.S. population. The key to success of densified wood products is the effort and finances that will be allocated to the marketing of the product within this heavily populated area. At this time, the authors are aware of only one densified log producer on the East coast, which indicates that a significant opportunity exists for the production and marketing of densified fuelwood products.

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