

# Briquettes

# The Other Densified Fuel

By Giordano Checchi

**L**e us start from the definition of “Standard” given by the Merriam Webster’s Dictionary: “*something set up and established by authority as a rule for the measure of quantity, weight, extent, value, or quality*”

On June 1, 2011, The Pellet Fuels Institute (PFI) issued the “Standard Specification for Residential/Commercial Densified Fuel.” It takes reading no more than 50 words of Article 1 of the “standard” to understand that, according to PFI, there is only one densified fuel in the world, and that is pellets. PFI equates densified fuel to pellets.

The ubiquitous pellet however is not the only densified fuel. Compressed natural gas and LPG (liquid petroleum gas) are densified fuels, not a biomass, not carbon neutral, but are undeniably densified fuels. And so is compressed biogas. It would take a lot of twisting to include biogas in the PFI “standard.”

But the purpose of this article is to say a few words in favor of another densified fuel, quite similar to pellets and perhaps even better. Briquettes and pucks made of wood, cardboard, paper, agrifibers, or other natural biomasses are a densified fuel. The charcoal briquette we all use to grill our burgers and sausages is another densified fuel. The log made of wax and wood dust we throw in the fireplace is another densified fuel.

A review of the different methods used to manufacture densified fuels from biomasses allows us to classify these methods into three basic techniques:

- Extrusion

- Hydraulic compression
- Mechanical compression

Each technique uses different types of equipment. Extrusion is the forcing of the biomass through a narrow passage (a die). Hydraulic compression is the confinement by means of pressure of a large amount of biomass into a small space (also called a die). Mechanical compression is the confinement of biomass into a shape or the reduction of the volume of the biomass by means of a dynamic impact.

## Pellets

Pellets are made by mechanical extrusion on equipment utilizing a technology derived from equipment originally designed to manufacture animal feedstock, fertilizers, plastics and more. The same equipment, called a pellet mill, adapted to the specific requirements of wood and other biomasses, is used in the mass production of fuel pellets. A pellet mill is a sophisticated piece of equipment, and it works by feeding the prepared biomass into a die with hundreds of extrusion ports. Rollers rotating inside the die forcibly push the biomass through the ports to make the pellets. Single pellet mill presses have capacities that vary from 600 lbs. per hour up to 8 tons per hour.

The biomass needs to be accurately prepared. It must be first cleaned from dirt, soil, stones and metals. This step is of the utmost





Pucks ready for shipping

importance to avoid the premature wear of the vital components of the pellet mill. It must then be dried to a moisture content of 10-13%, and eventually ground to a uniform refined size by means of hammermills. Also the finest dust of the biomass must be removed to avoid that the pellets will not break apart during handling, packaging and transportation.

The process to manufacture pellets requires operating within relatively strict parameters; it is not a forgiving process. The equipment requires a large amount of maintenance, expensive both in terms of replacement items and in terms of downtime.

## Briquettes And Pucks

Fuel briquettes are much older than fuel pellets. Their origin goes back to the time when people needed to improve the burning efficiency of cheap fuels such as peat and coal dust. These loose materials, compressed and shaped into a briquette, would burn better and longer because air would be free to feed the flame occupying the space in between the briquettes. Briquettes can be made of many diverse raw materials and on many different types of equipment. Briquettes have different shapes, densities and characteristics.

When speaking of "briquettes," most people immediately think of the charcoal briquettes used for outdoor grilling. These are made of charcoal derived from virgin wood coming from forestry operations, sawmills, and the like. The charcoal is then blended with a binder (starch) in a moist condition, given a shape using high speed mechanical briquetters, and eventually dried to the point the briquette retains its shape and it can be packaged for consumption.

Another form of briquette is the "fuel log." Made by extrusion, these logs are made of sawdust or other combustible biomass, refined to a small size then blended with a waxy binder. The blended mass is extruded through large dies into a continuous log, eventually cut to length and packaged for consumption.

Lastly are the briquettes that are made of 100% biomass, without the addition of any type of binder. These



Pucks split into quarters by the briquetting press

briquettes are made by compression at extremely high pressures in hydraulic or in mechanical briquetting machines. Temperature also is a factor in the formation of a solid briquette. With briquettes made of wood fibers the binder that keeps the briquette together is lignin, a naturally occurring biopolymer that keeps the wood cellulosic cells together in nature. The relatively high temperatures developed by the compression process contribute to the "melting" of the lignin. The temperature helps the broken chains of the lignin to re-polymerize hence binding the wood particles together.

Hydraulically operated briquetting machines are available in many different shapes and sizes, with output capacities that vary from 100 lbs. per hour for the small ones to more than 1 ton per hour. Compression pressures can go from 10,000 psi to 25,000 psi. Essentially there are two categories of hydraulic machines:

- Small, light duty machines mostly used to manufacture fuel briquettes for own use in small companies that generate biomass waste;
- Heavy duty, industrial type machines, used to manufacture fuel briquettes for the consumer market, or for the generation of space heat or energy.

Both types use the same compression principle. The compression process is relatively slow, with a transient from a fast initial reduction of volume at low pressure to a longer compression phase during which the pressure reaches its peak. Each compression cycle takes from 10 to 25 seconds, depending on the amount of material loaded at each cycle, and the density of the briquette needed. A low amount of material, combined with a long cycle time and the highest pressure will produce the highest density, and therefore the best quality briquette. The manufacture of a high quality briquette penalizes the output capacity of the system, and vice versa.

Mechanical briquetting machines are of several different types. We have briefly mentioned those that produce charcoal briquettes. There are two types of mechanical briquetting machines that manufacture briquettes made of 100% biomass, with no addition of binders.

- Screw extrusion briquetters: The biomass is compressed by a conical screw in a matching conical housing,

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or by a diminishing pitch screw in a matching cylindrical housing. The screw compresses the biomass into a constantly reducing space until it reaches the desired compression. At the end of the screw, the biomass is forced through an extrusion die. When the material exits the die it is in a shape of a continuous briquette, briefly left to cool, before being cut into desired lengths. The final density of the briquette is normally from low to medium. The output capacity of these briquetters is normally low, maximum 800-1000 lbs. per hour.

b) Ram type machines: These are heavy duty machines that compress the biomass by means of a ram impacting on a small amount of material at a very high speed into a die that has the shape of a mild cone. The ram strikes the material at rates between 220 and 260 strokes per minute, therefore the compression is done in less than two-tenths of a second. The newly compressed material moves the forming briquette out of the die into a tight adjustable bushing that creates enough backpressure to allow the compression. The ram is driven by a crankshaft or by an eccentric system moved by major flywheels. The compression with these machines reaches pressures of 36,000 psi, the highest pressure of any other densification system. The drive system is very efficient and 98% of the energy from the main motor is used in the compression. This energy turns entirely into heat, raising the temperature of the compressed biomass and contributing to a strong binding. Ram type machines offer output capacities that start at 400 lbs. per hour, all the way up to 5 tons per hour.

Mechanical ram type machines are the most efficient and the least expensive system to manufacture biomass densified fuel, both in terms of cost of the investment and operational cost. These machines can manufacture high quality briquettes for the consumer market, or short pucks for the commercial, industrial and energy markets, which are easier to transport and handle than regular briquettes. When used to generate thermal energy, briquettes and pucks offer the highest ROI of any other densified fuel based on the same type of biomass.

### Biomasses Used

Briquettes and pucks are made using one of the most forgiving methods to make densified fuel, therefore, accepting a long list of biomasses for densification. While briquettes are made mostly for the consumer market, nicely shaped and ready for the fireplace or the warming stove, pucks are short disks of densified fuel that are generally handled in bulk. In this form pucks can be shipped over long distances, by truck, by rail or by sea. Pucks are



Heating plant in Sankt Nikolaus, Ultental, in Südtirol

characterized by the very high density and the slow burning speed typical of briquettes, with the additional advantage that the burning speed can be adjusted by controlling the puck's length. Pucks are the ideal densified fuel for small, medium and large boilers, regardless of whether used to generate heat for space heating, process heat, or to generate power in a power station.

A very large variety of combustible biomasses can be used in manufacturing briquettes and pucks, with the only requirements being that the biomass shall have a moisture content between 8% and 12%, and the particles shall have a size not exceeding 5/8 in. (16 mm) for best results. The particles do not need to be uniform in size, and can vary from batch to batch. This is a partial list of proven biomasses used to manufacture briquettes:

- wood dust, sawdust, wood chips, virgin wood, recycled wood, demolition wood;
- different agrifibers like wheat straw, rice straw, hay, energy grasses (miscanthus, elephant grass, switchgrass), seed husks, corn cobs, corn stover, energy cane, sugar cane bagasse;
- cotton shrubs, grapevine clippings, fruit tree clippings, coffee shrubs;
- olive pits, peanut shells, and all other types of nut shells;
- tobacco waste, used coffee grinds, dried tomato vines;
- recycled paper, cardboard, spent bank notes;
- MSW (Municipal Solid Waste);
- dried animal droppings, dried sludge from waste water treatment plants.

The above materials can be used in any combination, with the list becoming longer every day.

The preparation of the biomass for briquette densification varies depending on the finished product that is being made. But the aim is always the elimination of contaminants such as metals, stones, sand and dirt, the reduction of the particle size to less than 1/2 in.-3/4 in., and the reduction of the moisture content to 10% +/-2%.

### Target Markets

All potential markets for briquettes or pucks made of densified biomass have the generation of heat in common; heat that can be used for space heating, or to generate process heat, or to generate energy. These are some of the markets that can be targeted by industries that manufacture briquettes or pucks:

- a) Residential (consumer) market. Recreational, outdoor cooking, camping. These are seasonal markets that require an organized and specialized distribution network.

## briquettes & pucks

b) Space heating of commercial, institutional and public buildings, large stores, shopping centers. This is also seasonal, but the distribution can rely on existing fuel distribution channels.

c) Remote heating, a solution widely used in Europe (and in New York City), where heat can be sold in winter to residences, commercial and institutional buildings by delivering it directly to the point of usage. Used in relatively small communities and in some large cities, it has the advantage of commuting from heat generation in the cold season to power generation for the rest of the year. The centralized heat and power station allows for an efficient use of the equipment compared to many small independently run utilization points. The drawback is the large investment required for the distribution network.

d) Process heating, normally non-seasonal, used to satisfy the need of heat of many different industrial manufacturing processes. This market can be internal or external to the densification of the biomass. Internal process heat generation applies to sawmills, board and plywood mills, wood products manufacturers. Examples of external markets for process heat are cement factories, the drywall panel industry, quicklime factories, and an infinite number of chemical and food processing industries.

e) Generation of other fuels and electrical power. This is a non-seasonal market targeting gasifiers and medium size thermal power plants. The shipment by road, by rail or by river or sea vessels of large quantities of pucks to these potential users is simple and cost effective. It feeds the growing demand for green energy. The United Kingdom, Netherlands, and Euro-

pian Nordic countries already have a large number of these power plants in operation.

### Costs And Revenues

Costs and revenues vary depending on the application, the market, the size of the operation, and the number of days and hours worked in a year. The interesting part is the cost of running a briquetting plant. Because of the efficiency and the relative simplicity of the equipment, the operating costs are very low. In particular the cost of maintenance is limited to the cost of replacing inexpensive wear items and the cost of lubricants. The downtime required for maintenance is in the range of a few hours per year, less than 10 hours per year per machine in the worst case scenario, i.e. with plants working 24/7.

Assuming a briquetting machine working 300 days/year, two shifts of eight hours per day, these are the approximate costs one can expect:

|  | small<br>machine     | medium<br>machine | large<br>machine |
|--|----------------------|-------------------|------------------|
| Output,<br>ton per hr.                   | 0.5                  | 1.0               | 2.4              |
| Direct cost,<br>\$ per ton               | 7.80                 | 5.90              | 5.40             |
| Total cost,<br>\$ per ton <sup>(1)</sup> | 51.00 <sup>(2)</sup> | 38.00             | 21.00            |

(\*) The above cost includes:

- All direct operating costs: energy, wear parts, consumables (lubricants).
- Equipment depreciation based on a three year payback, or equivalent leasing cost.
- Direct manpower to operate the briquetting line.

(\*) The cost refers to a single shift per day operation, more typical of a small machine. A small machine used on two shifts would actu-

ally show a higher cost per ton due to the negative impact of a higher cost of labor.

The above numbers do not include:

- The cost of the raw material ready for briquetting, sized and dried.
- The cost of the space required by the operation.

These costs vary substantially, based on the availability of the raw material, whether it is a waste or not, and based on the location, the cost of the space may change dramatically.

From the above numbers it is evident that small machines are more suited for local markets with a low cost of distribution of the densified fuel or to generate fuel for own use, either space heating of process heat. Medium machines are ideal to manufacture briquettes for the consumer market, or for own internal use. Large machines and plants using several machines in parallel are ideal to manufacture pucks for energy use.

While potential investors still need to prepare detailed plans to determine whether making briquettes or pucks are an alternative way to produce densified fuel, this is certainly one very attractive alternative. Limited investments, large output capacities, low cost of operation are all factors worth investigating. ☺

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