The different technologies used to produce biomass briquettes and pucks

Making densified biomass fuels

There are three basic methods used to manufacture densified fuels from biomass materials. These are extrusion, hydraulic compression and mechanical compression. All methods rely on the same basic technologies of permanently reducing the air space between the particles of the biomass, transforming loose particles into a dense, solid block.

Extrusion

Extrusion is the forcing of the biomass through a narrow passage (a die). This method of densification produces pellets, fuel logs and briquettes.

Briquettes made by extrusion are normally made of wood sawdust or wood waste. The wood particles are fed to a hopper and then into a screw forcing the material through a die. The screw can be conical, therefore the reduction of volume is due to the progressive reduction in the diameter of the screw, or it can be cylindrical but with a progressive reduction of the pitch forming the helix of the screw.

With both techniques the material is progressively forced into a smaller space until, at the end of the screw, it is forced through an extrusion die. When the material exits the die it is in the shape of a continuous briquette and left to cool before being cut into desired lengths and made ready for packaging.

The efficiency of this process is low, as large amounts of energy are used (and lost) to overcome friction (material against the casing and the auger) rather than in the compression of the material itself.

The moisture content of the biomass must be between 8 and 12%

Extrusion works well with certain species of wood and no so well with others unless lubricants, such as palm oil, or binders are added.

Hydraulic briquetting presses

Hydraulic compression is the confinement by means of pressure of a large amount of biomass into a small space (also called a die). Hydraulically operated briquetting machines are available in different shapes and sizes, with varying output usually lower than 1 tonne per hour. Compression pressures range from 700 to 1,750 Atm. There are two categories of hydraulic machines:

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

The compression process for both these types 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 between 10 and 25 seconds, depending on the amount of material loaded at each cycle and the required density of the finished briquette. 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. However, since the cycle time does not change a lot with the amount of material loaded at each cycle, the manufacture of a high quality briquette penalises the output capacity of the system.

Mechanical briquetting presses

Mechanical compression is the low pressure confinement of the biomass into a shape, or the reduction of the volume of the biomass by means of forcing the biomass into a progressively narrower space (medium pressure), or the reduction of volume by means of a dynamic impact and extremely high pressure on small amounts of biomass.

Mechanical briquetting machines are designed to manufacture briquettes comprising 100% biomass, with no addition of binders. These are heavy duty machines that compress the biomass by means of a ram impacting on a small amount of material at a high speed into a die that has the shape of a mild cone. The die is open at the opposite end and the newly compressed material moves forward into a tight adjustable bushing that positively creates enough backpressure to allow the compression by the ram.

The compression pressure in these machines reaches the level of 2500 kg/cm^2, the highest pressure of any other biomass densification system. The drive system is efficient, with 98% of the energy from the main motor used in the compression. The energy of compaction, due to the friction

Briquetting plants have very low operating costs

between the biomass particles and fibres, turns entirely into heat, raising the temperature of the compressed biomass.

Lignin acts as the binder that keeps the briquette together. The high temperature 'melts' the lignin when the material is under the highest pressure, restoring the broken chains of the lignin and helping it to re-polymerise, therefore binding the fibres and particles together. The temperature of the briquette must then be lowered to allow the lignin to harden and solidify. The best mechanical briquetters include a system to cool the compression head.

When the briquette exits the compression head its temperature is low enough to stabilise it. It takes a few more minutes for the briquette to cool down to a temperature where it becomes solid and fully stable and this is why these machines have a long straight cooling channel starting at the compression head and running all the way to the point where the briquette is chopped or sawn to the desired length.

Briquettes and pucks

Pucks are short disks of densified material. Due to their size, pucks are generally handled in bulk as they are easier to transport and handle compared to regular briquettes. They can be shipped over long distances by truck, rail or sea. Pucks are characterised by the high density and the slow burning speed typical of briquettes, with the additional advantage that burning speed can be adjusted by controlling the puck's length.

Both briquettes and pucks can be manufactured using a wide variety of combustible biomasses, with the only requirements being that the biomass must have moisture content between 8 and 12%, and the particle size must not exceed 16mm for best results.

When used to generate thermal energy, briquettes and pucks offer the highest return on investment than any other densified fuel based on the same type of biomass.

Costs and revenues

Costs and revenues vary depending on the application, the cost of the raw material, the amount of preparation necessary, the market, the size and location 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 in which high efficiency mechanical briquetting presses are installed.

Due to the efficiency and the relative simplicity of the equipment, the operating costs are very low. In particular, the cost of maintenance is limited to replacing inexpensive wear items and the cost of lubricants. The downtime required for maintenance is in the range of a few hours annually.

Assuming a briquetting machine working 300 days/year, two shifts of eight hours per day, approximate costs could be as below:

	Small machine	Medium machine	Large machine
Output, tonne/hr	0.5	1.0	2.4
Energy and maintenance cost, €/tonne	6-8	5-6	4
Total cost, €/tonne (1)	35-40	25-30	15-20

From these numbers in the table 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, while 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 is an alternative way to produce densified fuel, this is certainly one very attractive option. Limited investments, large output capacities and low cost of operation are all factors worth further investigation.

Notes:

1 This 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 (considered at western countries labor cost).

The 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.

For more information:
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Biomasses

BIOMASS MATERIALS suitable to make briquettes and pucks include:
- Wood dust, sawdust, woodchips, virgin wood, recycled wood, demolition wood
- Agrifibers like wheat straw, rice straw, hay, energy grasses (miscanthus, elephant grass, switchgrass), seed husks, corn cobs, corn stover, energy cane, sugarcane 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
- Municipal solid waste
- Dried animal droppings and dried sludge from waste water treatment plants.

The preparation of the biomass for briquette densification varies depending on the material and the finished product that is being made. But the aim is always to eliminate contaminants such as metals, stones, sand and dirt, reduce particle size to less than 15-20 mm, and reduce the moisture content to 10% +/-2%.