



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

WASTE TO ENERGY CONVERSION

DENSIFICATION OF SOLIDS-2

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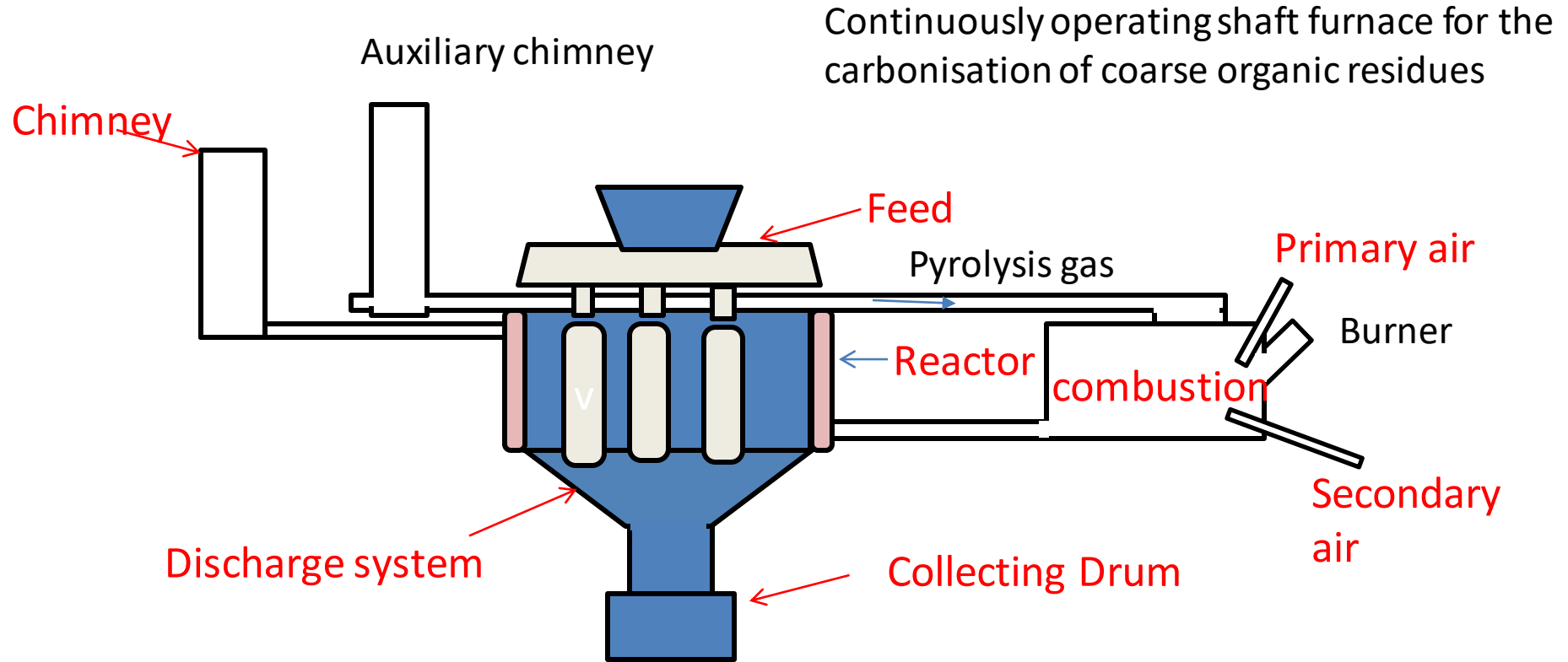
Carbonization reactors

Type of material	Reactor type
Coarse material of medium size (coconut and groundnut shells, tree bark, etc.)	continuously working shaft furnaces
Fine material	rotary kilns or stationary vessel equipped with a stirring device (for example a screw feed)

The vessels are usually heated externally using natural gas, liquid fuel or the off-gas of the carbonisation process itself.



Carbonization reactors



Briquette Characteristics

Briquette Characteristics

Briquette handling characteristics

Bulk density, friability, resistance to humidity etc.,
(the product should not crumble and disintegrate when handled, stored and transported, is mainly a function of the quality of the densification process for a given raw material).

Fuel characteristics

Heating value, size and shape etc.,
(the properties of the raw material and the shape and density of the individual briquette).

The distinction is not always clear and sometimes they interfere with each other. For example, improving the handling characteristics by making a more dense briquette often has a detrimental effect on its combustion behaviour

Density

Most processes are capable of producing briquettes with densities above 1 000 kg/m³, i.e. the individual briquettes will sink in water.

The upper limit for the density is set by the physical density of each raw material which, for ligneous material, is about 1 500 kg/m³.

The density of individual pieces is termed apparent density.

High pressure processes such as mechanical piston presses, pellet presses and some screw extruders, make briquettes in the 1 200 - 1 400 kg/m³ density range.

Hydraulic piston presses make less dense briquettes, sometimes below 1 000 kg/m³.



Density

Materials	Volume Before Briquetting (cm ³)	Bulk Density before Briquetting (g/cm ³)	Volume after briquetting (cm ³)	Bulk density after briquetting (g/cm ³)
Rice husk &cassava Peel gel	100.53	1.67	67.86	0.72
Peel Groundnut shell/Cassava Peel gel	100.53	1.67	76.66	0.81
Maize cob/banana peel	100.53	1.67	65.35	0.69
Sugarcane baggase/banana peel	100.53	1.67	62.83	0.63

Mean Values of the Physical Parameters of materials and their Briquettes

Source : [http://www.iosrjen.org/Papers/vol3_issue1%20\(part-4\)/H03143642.pdf](http://www.iosrjen.org/Papers/vol3_issue1%20(part-4)/H03143642.pdf)



Friability

- This is a measurement of the briquette's resistance to mechanical action that can affect them during handling and transportation.
- Tests can be done either in a rotating drum or by repeatedly dropping samples from a specified height. In both methods, the samples are screened (20 mm sieve) and the fraction retained is used as an index of a briquette's friability (CRA 1987).
- Friability index of 0 indicates that the briquettes are disintegrated entirely after a certain time, which clearly indicates an inadequate briquette quality.
- Generally briquettes produced by mechanical piston-presses and screw-presses are hard enough to be transported by lorry for considerable distances without degradation.



Resistance to humidity

Inherent binders (lignin) and most externally added binders are water soluble.

Briquettes and pellets have to be stored under cover and they do have a limited lifetime under humid conditions.

The dense, hard-surfaced briquettes produced in mechanical piston presses and screw presses with heated dies have enough resistance to humidity to withstand the rainy season in India, Thailand and Brazil provided they are covered.

The resistance to humidity is traditionally tested in immersion tests, i.e. the briquettes are dunked in water and the elongation or swelling of the briquettes is recorded. Sometimes the time elapsed until the briquette has completely disintegrated



Resistance to humidity

In other tests, briquettes are subjected to humid air for extended periods and their swelling is recorded. After a period of 21 days in an atmosphere of 20° C and 95% humidity, an elongation of less than 30% is said to be acceptable and less than 20% would be ideal (CRA 1987).



Heating value

Heating value can be calculated experimentally through Bomb calorimeter

Empirical relations can also be used to determine heating value. Some examples are

$$\text{HHV} = 2.326 (147.6 C + 144 V)$$

Where C is the percentage fixed carbon and V is the percentage volatile matter
(Bailey et al.1982)

$$\text{HHV} = 20.0 \times (1 - A - M) \text{ MJ/kg } (\text{http://www.fao.org/docrep/t0275e/T0275E00.htm})$$

where A is the ash content and M is the moisture content of the actual fuel.

Applications of briquettes

Briquetted fuel can be used by the industrial, commercial and household sectors. It is ideally suited for use in the following areas:

a.	Boilers	(sugar mills, paper mills, chemical plants, dyeing houses, food processing units, oil extraction units, vanaspati units etc.) using fuel for steam generation and heating.
b.	Forges and Foundries	For metal heating and melting.
c.	Brick kilns and Ceramic Units For firing of furnaces.	
d.	Residential Heating	For winter heating in cold areas and in restaurants, canteens etc.
e.	<u>Biomass Gasifier</u>	The gas can be used in Biomass Gasifiers to generate power, /replace oil in furnaces, ovens etc.



Applications of briquettes

Burning equipment

- Open or semi-open cooking stoves which use wood or charcoal in households or small commercial operations;
- Enclosed stoves or furnaces, based upon wood or coal, used in industry or commerce for heating water or raising steam;
- Kilns of various kinds for brick or ceramic making normally burning wood.



Manual briquette machine

Parts are:

- Base plate
- Ejection piston
- Pr. Transmission rod
- Briquette die
- Hydraulic jack



<http://www.bioline.org.br/pdf?ja12035>

When a manual briquetting machine is designed to produce twenty (20) briquettes at a time. Total area on which pressure act = number of mould die x cross sectional area of die

$$= 20 \times \frac{\pi}{4} d^2$$

Where d = diameter of moulding die = 28mm = 0.028m, number of mould die=20, $\pi=3.142$

$$Total Area = 20 \times \frac{3.142}{4} \times 0.028^2 = 0.0123m^2$$

Manual briquette machine

Mass of one pressure transmission rod used = 450grams.

Number of pressure transmission rods = 20.

Total mass of 20 transmission rods = $450 \times 20 = 9000 \text{ g} = 9 \text{ kg}$.

Mass of ejection piston = 100g.

Total mass of 20 ejection piston = $100 \times 20 = 2000 \text{ g} = 2 \text{ kg}$

Mass of the base plate = 4.5kg

Maximum mass of one wet briquette sample = 50g

Thus, Total mass of briquette samples = number of briquette sample x mass of one sample = $20 \times 50 = 1000 \text{ g} = 1 \text{ kg}$



Manual briquette machine

Total mass to be lifted by hydraulic jack is = total mass of transmission rod + mass of base plate + total mass of ejection piston + total mass of briquette samples

$$= 9 \text{ kg} + 2 \text{ kg} + 4.5 \text{ kg} + 1 \text{ kg} = 16.5 \text{ kg}$$

Assume g (acceleration due to gravity) = 9.81

$$\text{Weight to be lifted} = 16.5 \times 9.81 = 161.87 \text{ N}$$



Manual briquette machine

A 10 tonnes(10,0000N) hydraulic jack was used to lift the machine components and compress the briquettes. The compaction force can be calculated using the pressure. Pressure read from the pressure gauge connected to hydraulic jack (Compaction Pressure)=17.5KN/ m² (Ihenyen,2010). The machine has 20 molds.

Let F_c = Compaction Force, and P_c = Compaction Pressure and A_c = Total Compacted Area.

$$Pressure = \frac{Force}{Area}$$

Where A_c = Number of Briquette produced at a time x cross sectional Area of briquette sample

$$\text{Thus, } A_c = 20x \frac{\pi}{4} d^2$$

Where d = diameter of briquette sample = 28mm = 0.028m, π = 3.142

$$A_c = 20x \frac{3.142}{4} x 0.028^2 = 0.0123m^2 \quad F_c = 17.5 x 0.0123 = 0.2153KN = 215.3N$$



Thanks...

