

ONTARIO POWER GENERATION

Torrefaction Treatment Process

October 27, 2010



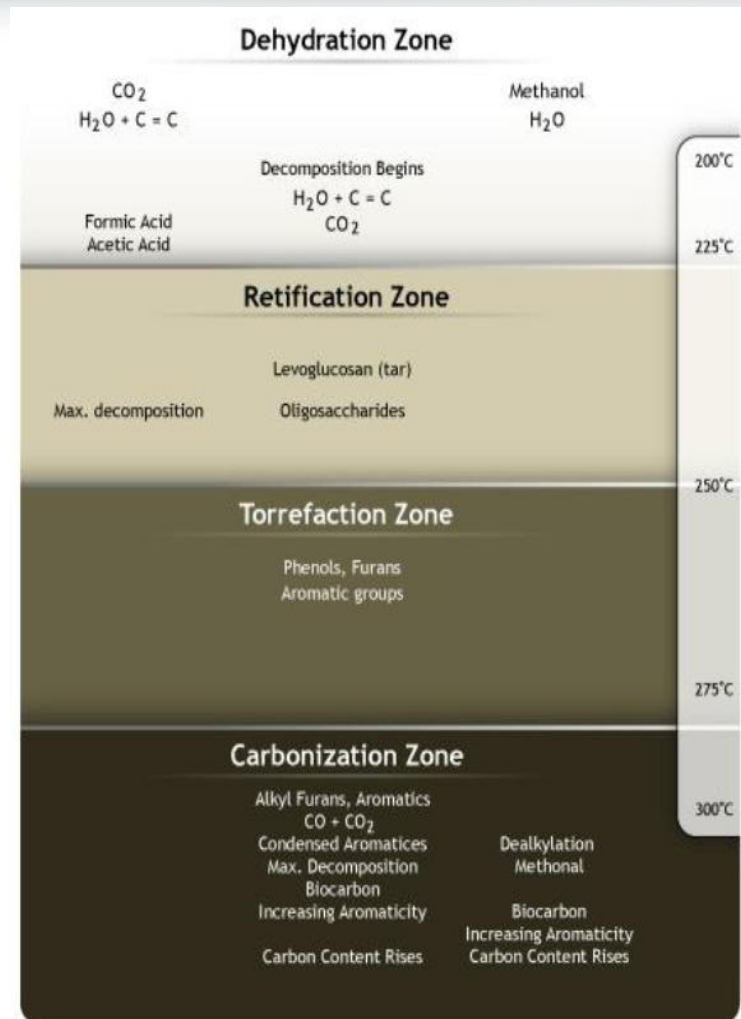


Torrefaction Process

- Used for a Significant Period of Time on “plant material” by the Lumber Industry in pressure treatment and by the Coffee Industry for roasting coffee beans
- Layman’s Definition: True torrefaction is a thermo-chemical treatment of raw wood/agricultural products at between 200-280°C. It is carried out under atmospheric conditions and in the absence of oxygen. During the process, the water contained in the raw product as well as superfluous volatiles are removed, and the biopolymers (cellulose, hemicelluloses and lignin) partly decompose giving off various types of volatiles. The final torrefied product is the remaining solid, dry blackened material.



Process Temperature Zones





Why Torrefaction?

Benefits of Torrefied Biomass (Ag and Wood)

- No off-gassing (CO, CO₂, and CH₄)
- No Biological Decomposition Issues (i.e. no moulds and others)
- Calorific Value similar to coal (i.e. higher than PRB)
- Dramatically reduced Dusting
- Low Moisture Content
- Non-Hygroscopic (doesn't attract moisture from surrounding atmosphere)
- Hydrophobic (minimal moisture absorption when it gets wet)
- No Smoking during Combustion
- Uniformity of Product
- Flame Stability during Combustion



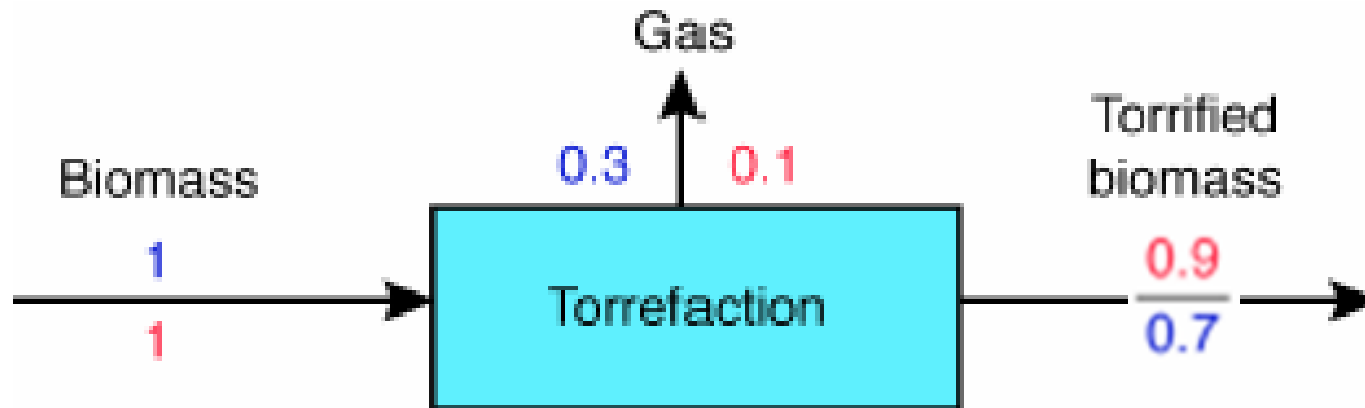
Beneficiation

- “Beneficiation” covers a number of potential technologies:
 - Torrefaction
 - Steam Explosion Pulping
 - Microwave
 - Carbonization
- The underlying objective of these technologies is to produce a product that behaves more like coal:
 - No active biological material
 - Higher calorific value & greater grindability
 - Lower volatile content & lower dust potential
 - Hydrophobic in nature



Benefits of Beneficiation

- Fuel is better suited to OPG's existing assets since it behaves more like coal:
 - Fewer capital modifications would be required
 - Greater confidence in the technical capability of the assets
- Increased production and flexibility:
 - Greater calorific value = greater production potential
 - Ability to inventory large quantities
- Reduced H&S risks associated with the fuel:
 - Lower Explosivity values
 - No Moulds or Off-gassing, etc.



Energy densification (E/kg)

$$1 \frac{0.9}{0.7} = 1.3$$

Mass

Energy



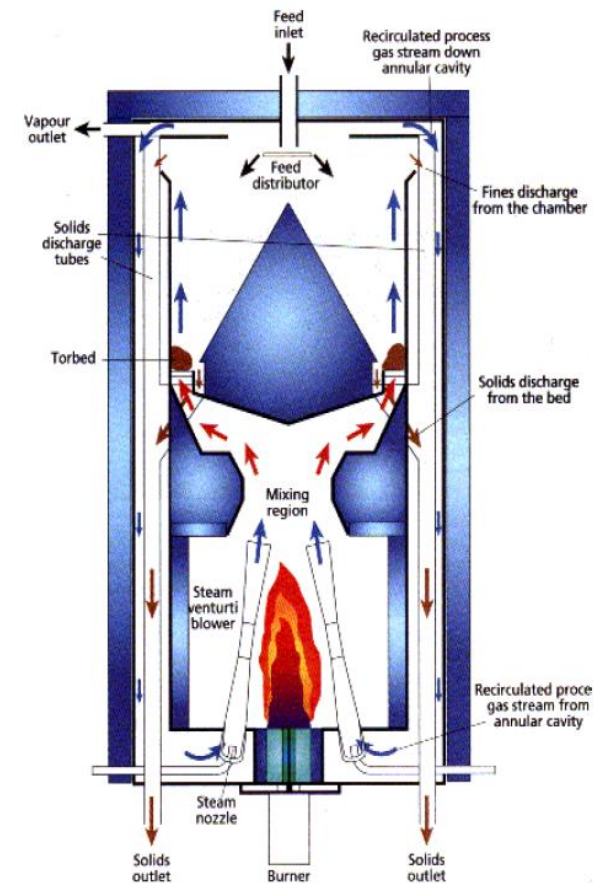
Torrefaction Reactor Technologies

- Six Main Technologies
 - Rotary Drying Drum (Rotary Kiln)
 - Screw Conveyor
 - Multiple Hearth Furnance (Herreshoff Oven)
 - Torbed Flash (Toroidal Flow)
 - Compact Moving Bed
 - Belt Dryer



Torbed Reactor

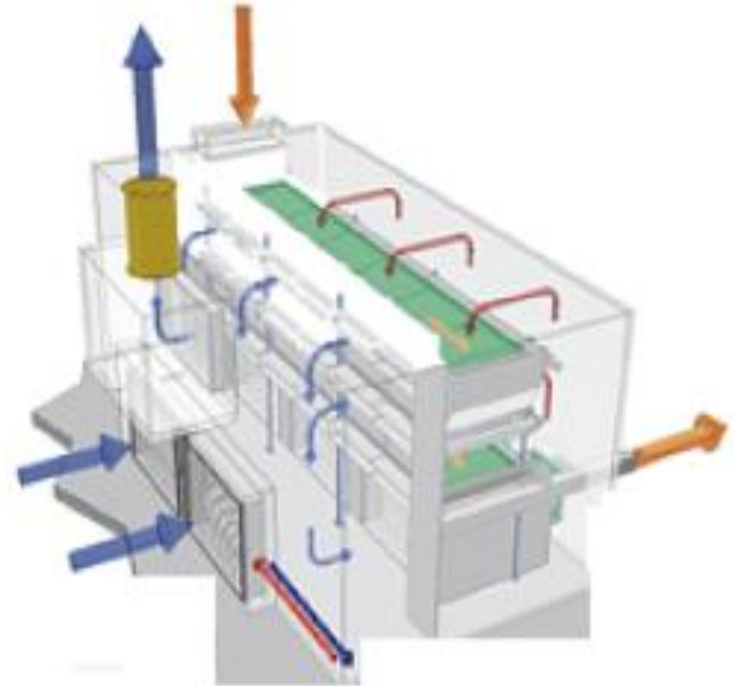
- Principle of the reactor is based on a torodial flow of the bed, created by injecting a fluidization medium with high velocity (50 to 80 m/s) through stationary angled “blades”.
- It is a “flash” reactor technology which requires 90 seconds to 5 minutes of material residence time, at temperatures up to 280 °C.
- Production throughput is high due to the nature of the technology. However, there is the risk of carbonization of product and process tar formation due to the high temperatures.





Belt Reactor

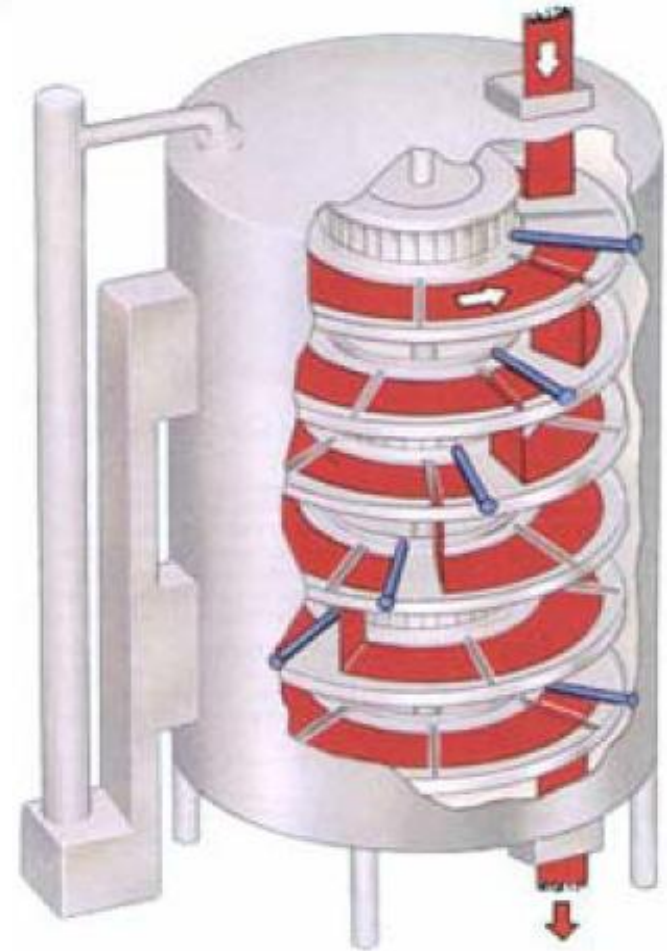
- Simple, proven technology (mechanical aspects)
- Biomass is transported through the reactor with a belt. This method ensures all biomass particles have the same residence time.
- Up-scaling ability is limited, based on the size of the belt. Maximum size is believed to be 5 t/h, or 35,000 t/a per unit.





Wyssmont Dryer

- Already in use by a number of industries as the torrefaction reactor.
- During torrefaction, the dryer is air locked and superheated steam & nitrogen are used in the re-circulating atmosphere.
- They are easily scaleable since the dryers are manufactured in all sizes between 4 & 35 feet in diameter.



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