



CONTINUOUS CARBONIZATION BY STEAM PYROLYSIS OF ANNUALLY RENEWABLE BIOMASS
PRODUCES BIOCHAR

Allison Talley, Biochemist
Enginuity Worldwide LLC
651 Commerce Road
Mexico, MO 65265
allison@enginuityww.com

Introduction



- Engenuity Worldwide located in Mexico, Missouri
- What we do
- Our facility



Rotary Compression Dryer

e



Rotary Compression Dryer, Reflux Condenser, and Aftercooler



The Enginuity Process



- Consists of a Rotary Compression Dryer (RCD), a Reflux Condenser, and an Aftercooler
- The Rotary Compression Dryer (RCD) uses the Second Law of Thermodynamics via compression and friction to produce heat
- No external heat source is required
- Continuous process may be carried to char in under 5 minutes
- Condenser and Aftercooler currently recaptures and condenses volatiles

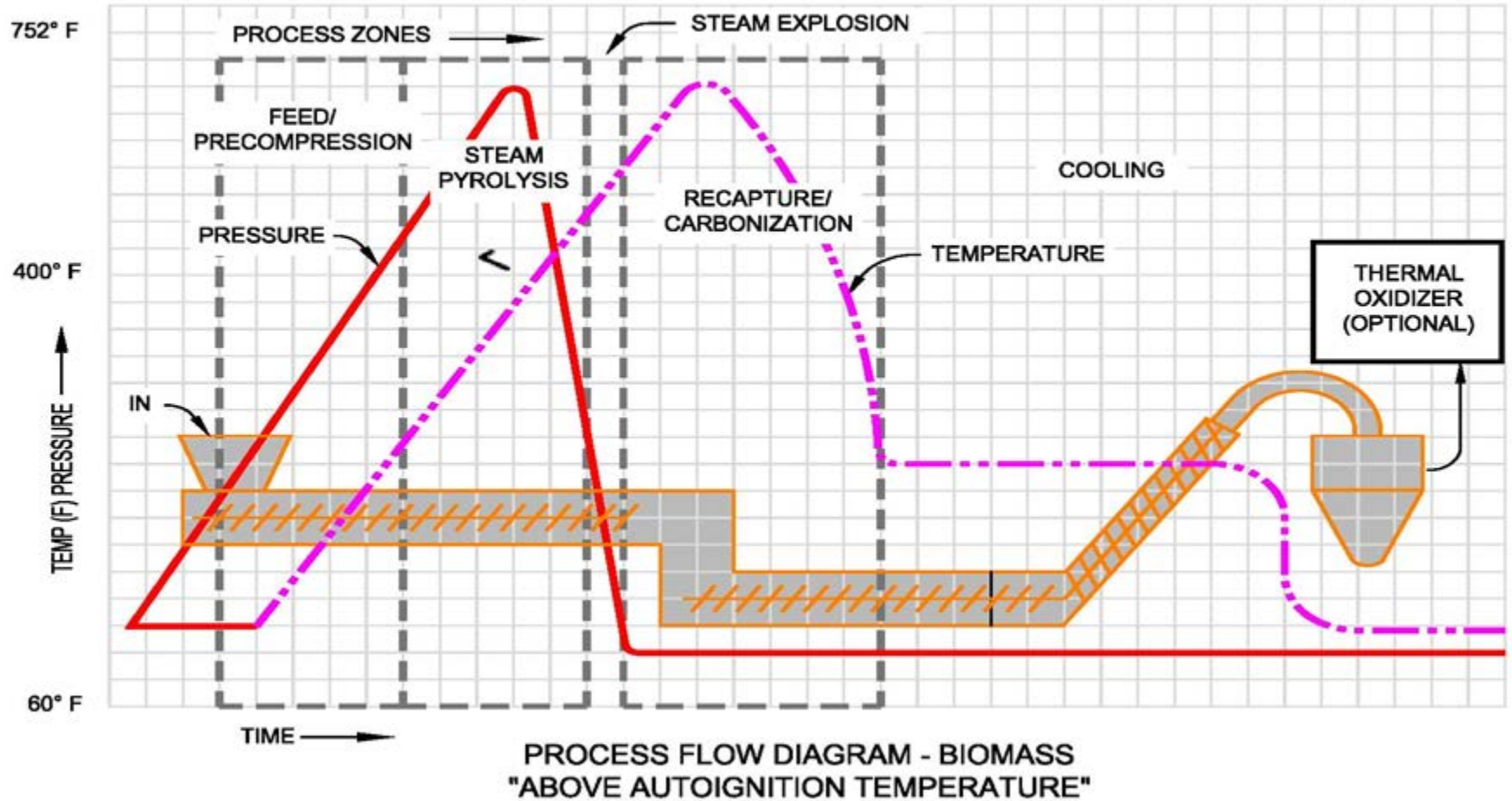
The Enginuity Process

- Start with agricultural residues and wood wastes
- Biomass is subject to the distinct but overlapping phases:
 - Compression
 - Steam Pyrolysis
 - Steam Explosion
 - Recapturing/Carbonization
 - Cooling
- Biocoal may be densified
- Product currently engineered for co-combustion in existing coal fired plants



Before treatment (L) and After (R): Corn Stover

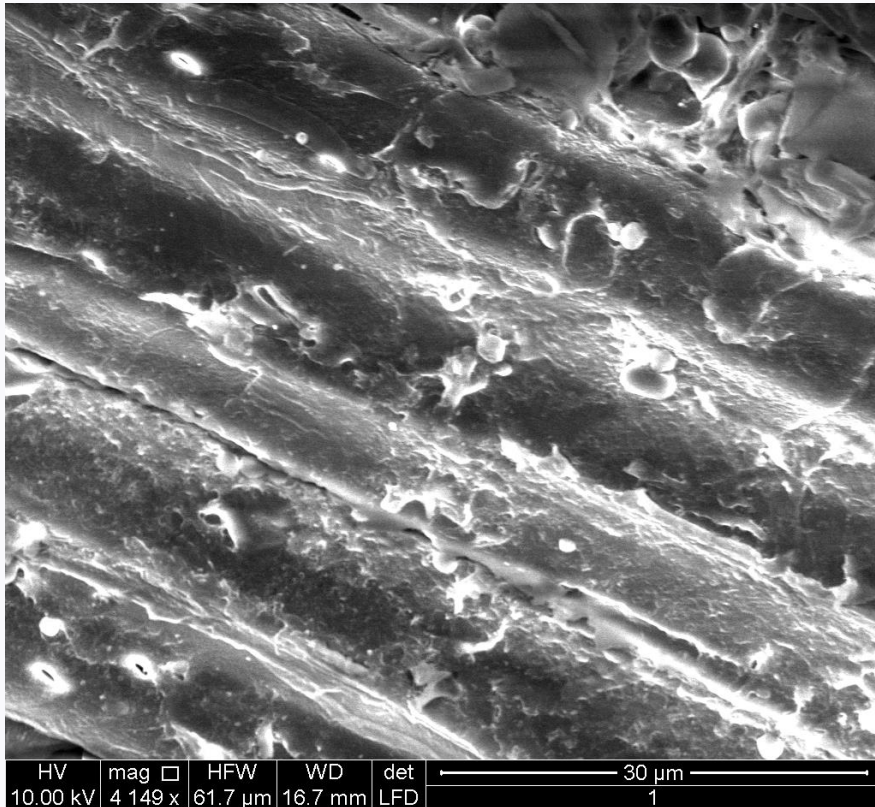
Process Flow for Biocoal



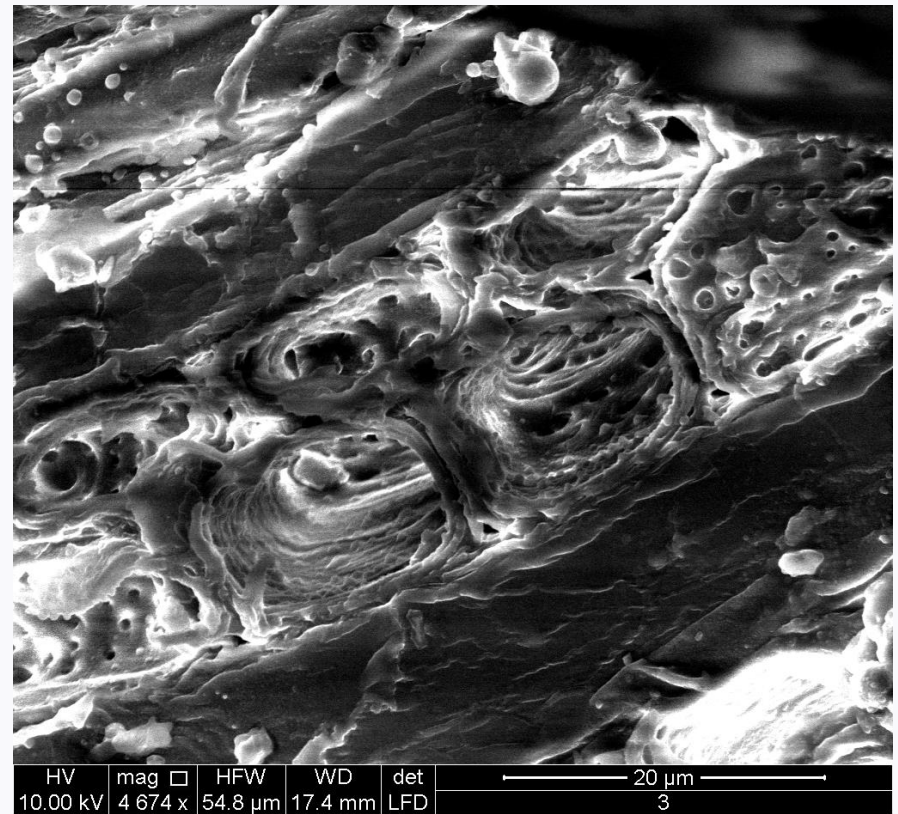
SEM Imaging



Untreated Sawdust at 4149x mag



Sawdust char at 4674x mag



Analytical Work



- Used mercury intrusion porosimetry to determine porosity and intrusion volume
- Uses non-wetting liquid to surround sample in pressure-controlled environment
- Pressure increases and mercury is forced into pores
- Pore diameter and intrusion volume determined based on pressure and time needed

Analytical Work



Sample ID	Biomass	Treatment	Median Pore Diameter (um)	% Change
2014STV001	Stover	Untreated	24.2181	-
Retainer 0012013	Stover	"Dark" Roasted	111.9039	362

Figure 1: Data obtained from a third party testing facility regarding untreated stover and BioCoal created using 6 inch dryer and aftercooler/reflux condenser technologies

Analytical Data

- Enginuity biocoal has very high fixed carbon yield
- Fixed carbon content of biocoal was found to be very similar to coal
- Biocoal has decreased volatile matter and sulfur content
- Biocoal is acidic in nature
- The nature of the machinery allows for capture and condensation of wood vinegar



Enginuity Biocoal undensified

Characteristics of BioCoal

	Raw Corn Stover	Corn Stover Processed in RCD	Raw Wood Waste	Wood Waste Processed in RCD
Moisture (wt.%)	10.53	6.46	32.57	3.97
Volatile Matter (wt.%)	73.85	48.59	80.59	57.79
Fixed Carbon (wt.%)	19.08	37.21	17.92	38.92
Sulfur (wt.%)	0.131	0.067	0.013	0.009
Bulk Density (lbs/ft³) (before densification)	11	30	25	38
Particle Size (in)	0.5	<0.039	0.5-1.0	<0.05
Carbon (wt.%)	43.93	51.5	49.6	60.72
Hydrogen (wt.%)	5.32	4.46	5.85	4.91
Nitrogen (wt.%)	1.18	1.4	0.2	0.37
Oxygen (wt.%)	38.65	25.57	42.83	30.7

Data obtained from external party regarding Engenuity biocoal processed from corn stover and oak sawdust

Advantages of Process



- Continuous Process
- Utilizes any agricultural residue or wood waste
- No special equipment required for change of feedstock
- Energy efficient
- Simple, elegant design, only a prime mover is necessary to spin a shaft
- Requires no external heat source to char material
- Plug and play setup: No special permitting or foundation requirements
- Time efficient: LESS THAN 5 MINUTES TO BIOCOAL

Rotary Compression Dryer

e





For more information visit our website

<http://www.engenuityww.com/>

Or contact

Allison Talley, Biochemist
Engenuity Worldwide LLC
651 Commerce Road
Mexico, MO 65265
allison@engenuityww.com