EACP Committee

From: Tim Gunter <timgunter55@yahoo.com>
Sent: Thursday, October 31, 2019 1:18 PM
To: EACP Committee
Subject: EACP - 17 (5) for the 11/5 for the EACP committee meeting
Attachments: Maui Seminar 2019.pptx

Aloha This is the presentation From Dr. Ratner and Hawaii Energy Independence Company for the 11/5 EACP committee meeting EACP - 17 (5)
Any questions call Tim Gunter 633-7089

Aloha Tim Gunter

Biomass Gasification and Waste to Energy Conversion

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Presentation to the Maui County Council
November 05, 2019

About Albert Ratner, PhD

- Joined the faculty at the University of Iowa in 2003
- Associate Professor of Mechanical Engineering
- Author/co-author of 48 scientific journal papers and 46 scientific conference papers
- Fellow of the American Society of Mechanical Engineers (ASME)
- Senior Member of American Institute of Aeronautics and Astronautics (AIAA)
- Executive Committee member for the Central States Section of the Combustion Institute

University of Iowa

Presentation Outline

- Waste Disposal and Energy Generation From a Societal and Historical Perspective
- Overview of Combustion Approaches to Waste Elimination
- Why is This Version of Down-Draft Gasification Appealing?
- Experimental System – Research Gasifier at UI
- Results and Conclusions

Waste Disposal

- Burning, now more politely known as incineration
- Land-filling, still no better than it was 5000 years ago
- Recycling, helpful but can't fix everything
- Using less and Reuse are great, but won't eliminate the problem

From Smithsonian Magazine, Aug. 1 2016

From the Austin Chronicle

From General Kinematics

Energy Generation

- Fossil Fuels output a lot of CO_2
- Wind is great, but intermittent
- Solar panels are good, but take up a lot of space
- Waste-to-Energy is appealing, but is has to be low pollution and not crazy expensive

From Phys.org

From MachineDesign.com

From Nikkei Asian Review

What Path Makes Sense?

- Use less
- From what you use, reuse what you can
- From what you can't reuse, recycle what you can
- From what you can't recycle, extract as much energy as you can (to replace fossil fuel sources) and bury as much carbon as you can to be carbon-neutral or carbon negative

- Make the best use of the resources you have!

Combustion Methods for Waste Disposal

- Combustion-driven incineration
- Plasma-Arc driven incineration
- Pyrolysis into bio-oil
- Gasification with Syngas combustion
  - Up-draft gasification
  - Cross-draft gasification
  - Down-draft gasification

Incineration

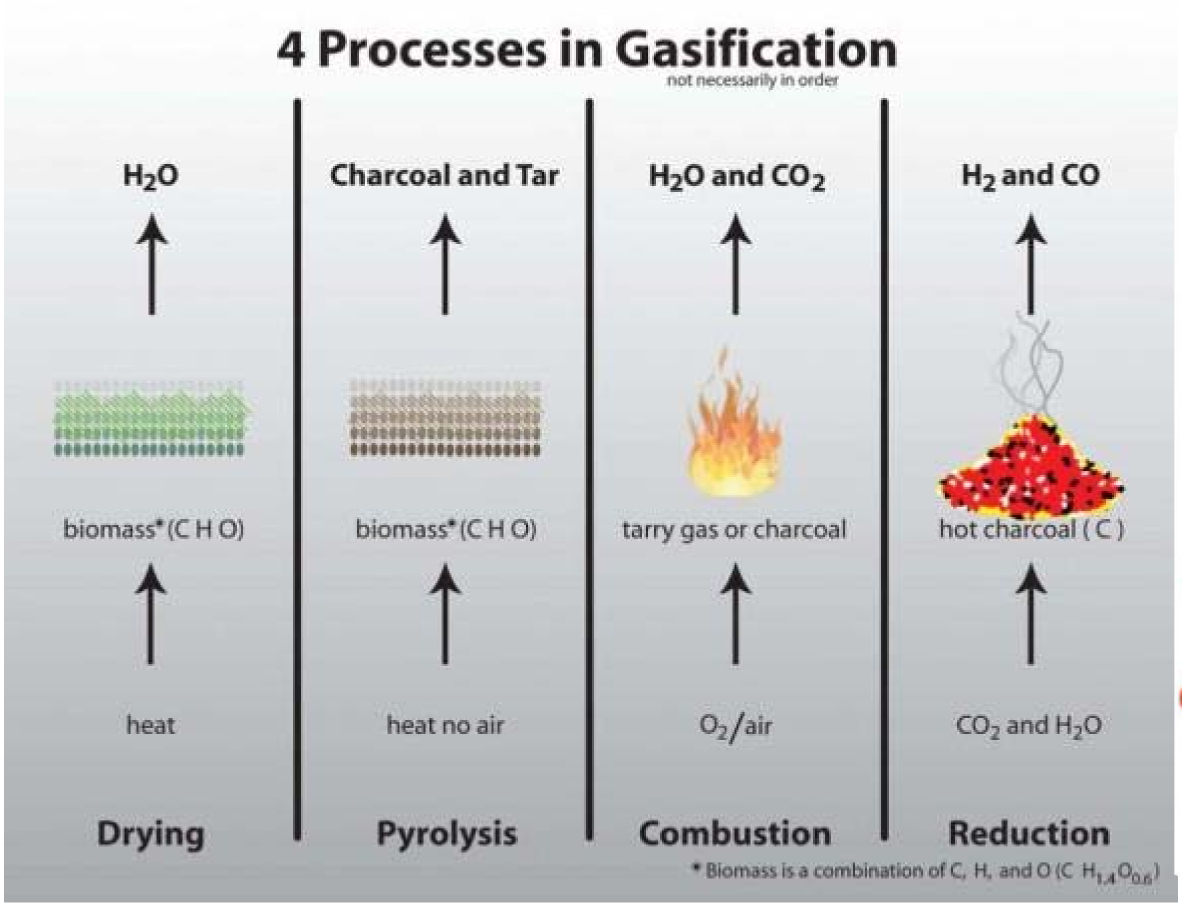
- Common, and well understood
- Expensive to do cleanly
- For example, Sweden recycles half of their MSW and incinerates the other half
- Less CO_2 out put than fossil fuels because ~70% of material is from renewable sources

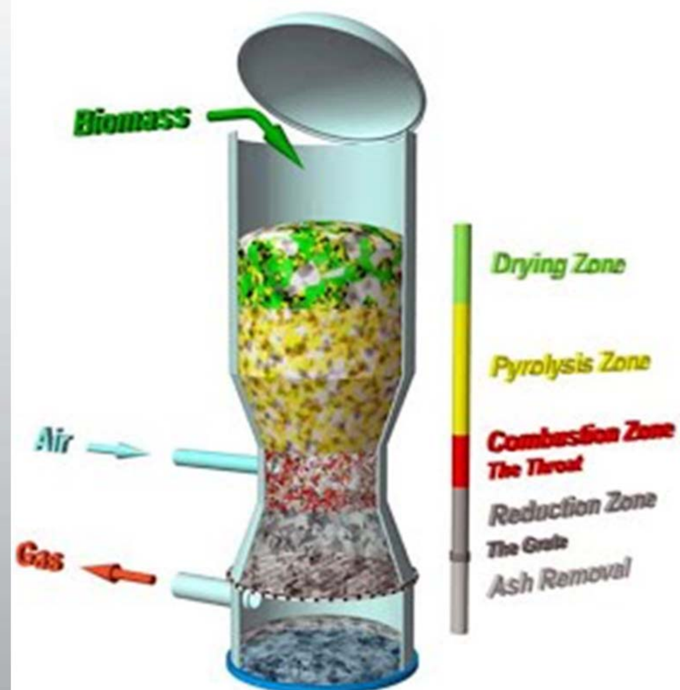
Plasma Arc and Bio-oil

- Plasma Arc is expensive both on a first-cost and energy efficiency basis. Used primarily for medical waste.

- Bio-oil is designed as a general replacement for crude oil
  - Process is not particularly clean
  - There exist many specific thermal, chemical, and biological processes that are better at producing specific chemicals and products from waste stream

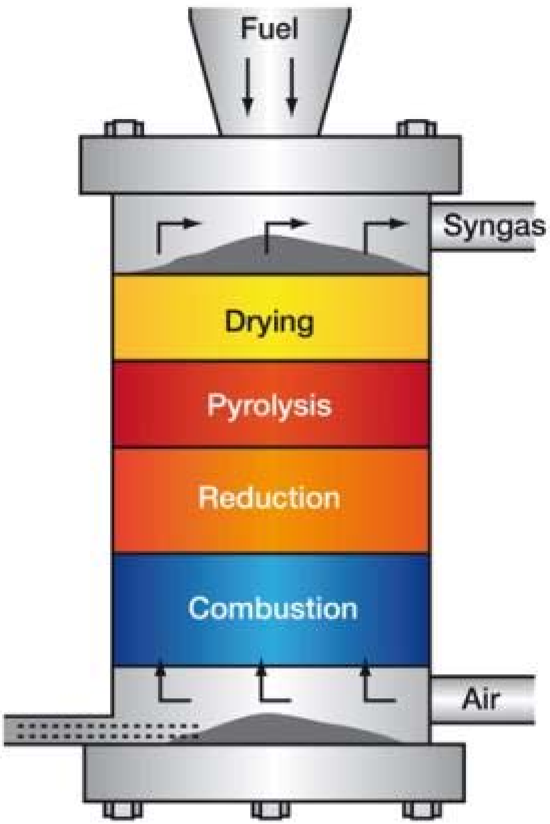
Gasification Processes

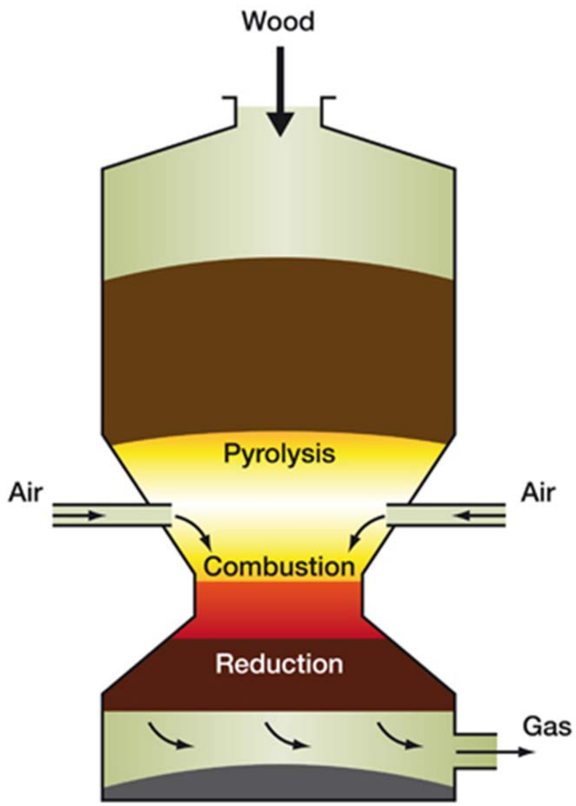


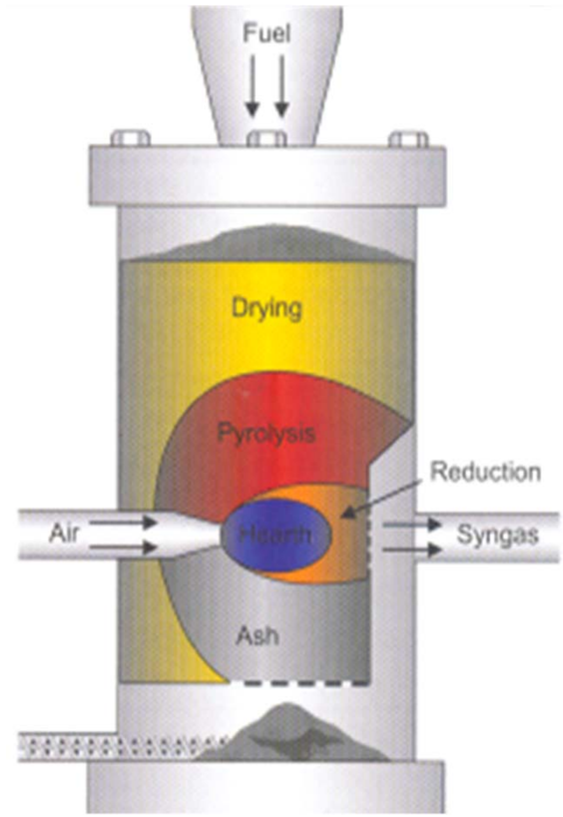


Types of Gasification

Up-draft	Down-draft	Cross-draft





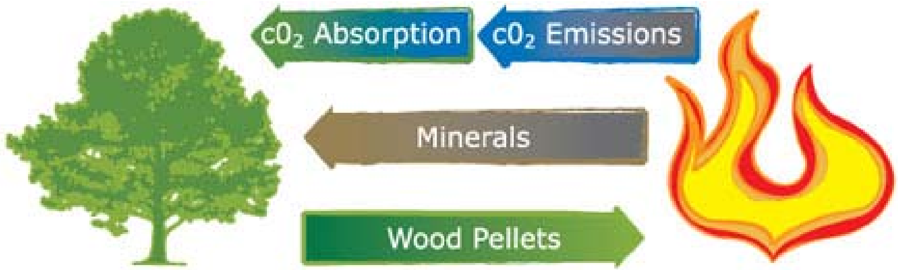


Down-Draft Gasification

- Produces char (biochar) as part of the process at about 20% by mass
- Much cleaner than other processes because the char breaks down organic vapor into simple components such as Hydrogen, CO, and CO_2
- The resulting gas is referred to as Syngas (Synthetic Natural Gas) or Producer Gas
- This clean gas is burned for energy in either an Internal Combustion (IC) engine or in a traditional boiler-steam turbine
- Testing with a range of materials including plastics and sorted trash pellets produced exhaust well within EPA emissions limits

Why Biomass/MSW Gasification?

- Reduce Greenhouse Gas emissions
  - Diesel for electricity generation produces 884 kg CO_2 per MWh
  - Sorted MSW produces 209 kg CO_2 per MWh in a down-draft gasification-based power cycle
- Sorted MSW is approximately 70% renewable material
- Renewable resource
- Reduces landfill waste
- Monetarily competitive



What is New in This Technology?

- Is there new science that makes this technology possible?
  - No. The science is well known and has been around for several decades.
- Is this a secret process that requires confidentiality agreements to see?
  - No. The process is public and has been published in peer-reviewed journals.
- Why wasn't this done decades ago?
  - Ugh…..

Let’s recall 2006….

- Portable phones? Yes
- Cameras? Yes
- Day Planners? Yes

From weebly.com

From amazon.com

From day-timer.com

The University of Iowa

Then Came 2007

- iPhone released in 2007
- All of the specific features existed in either stand-alone devices or previous phones from other manufacturers
- Better integration and usability created a new market and fundamentally transformed society
- No new science

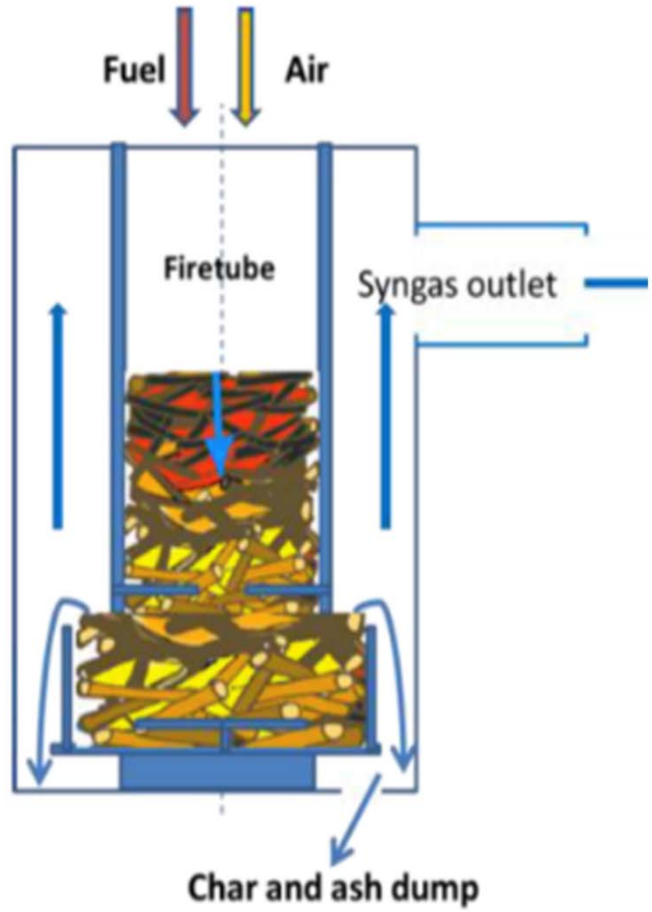
From apple.com

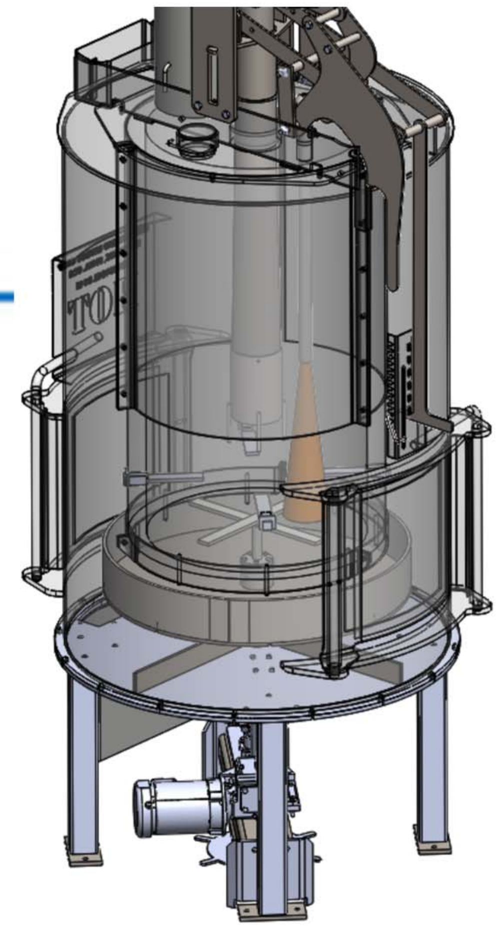
Key Attributes of New Gasifier Design

- Simple, low-cost design
- Produces charcoal (or biochar) and syngas as part of the regular operation
- The hot (up to 1000F) charcoal cleans the syngas and breaks fuel molecules down to simple pieces, mostly CO, CH_4, and H_2
- The syngas can then be cleanly burned for energy
- Ash can be used as a concrete hardener
- Charcoal (biochar) can be added to soil to both improve it and to sequester the carbon

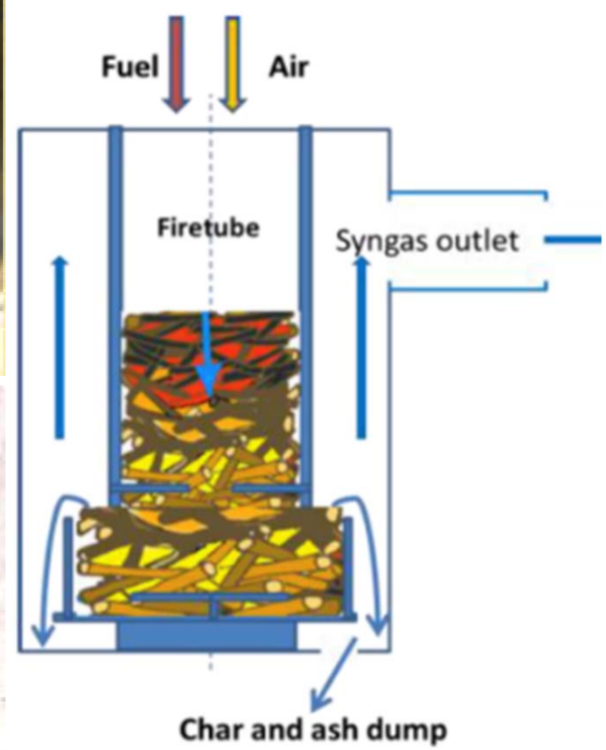
UI and IEC Type of Down-Draft Gasifier

- Air and fuel co-feed from the top
- Continuous movement to agitate the fuel bed
- Char and ash drop out the bottom
- 8" to 10" char bed



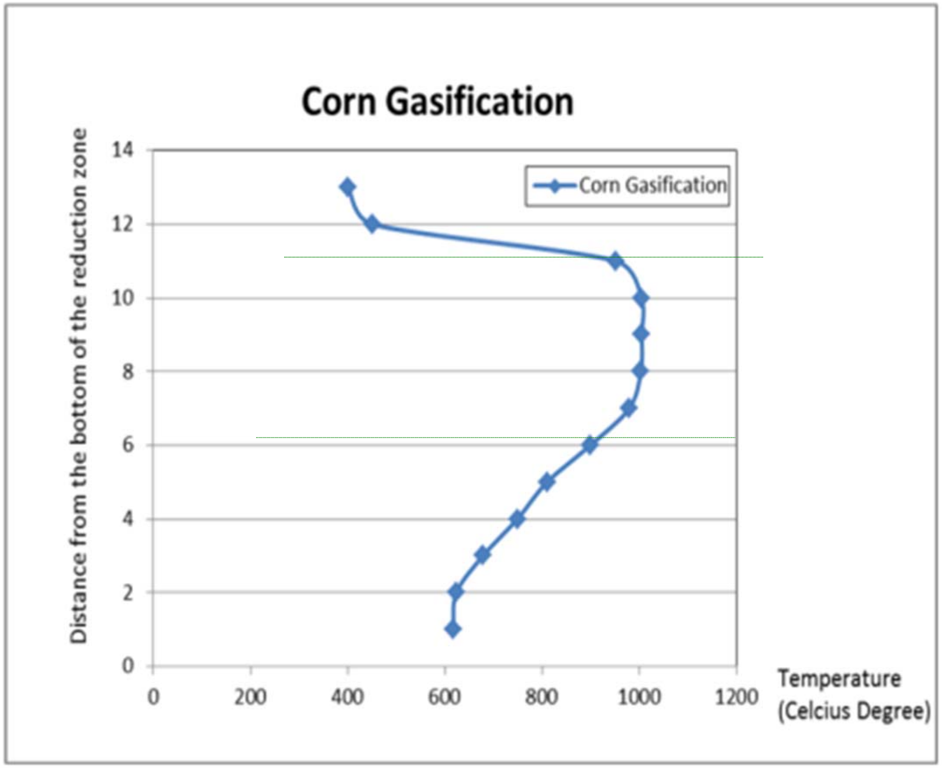


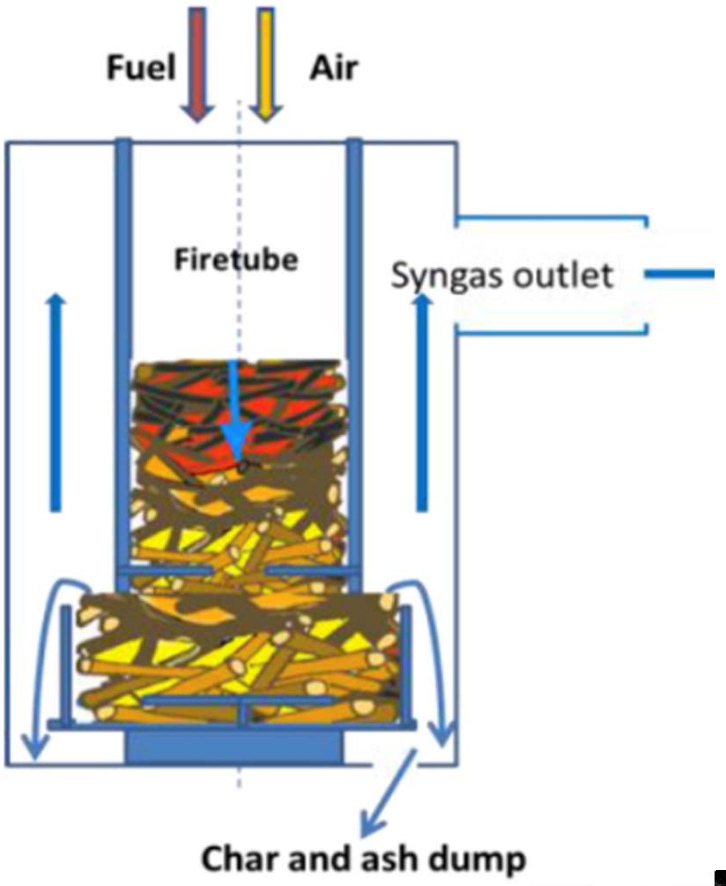
Research Gasifier at the University of Iowa



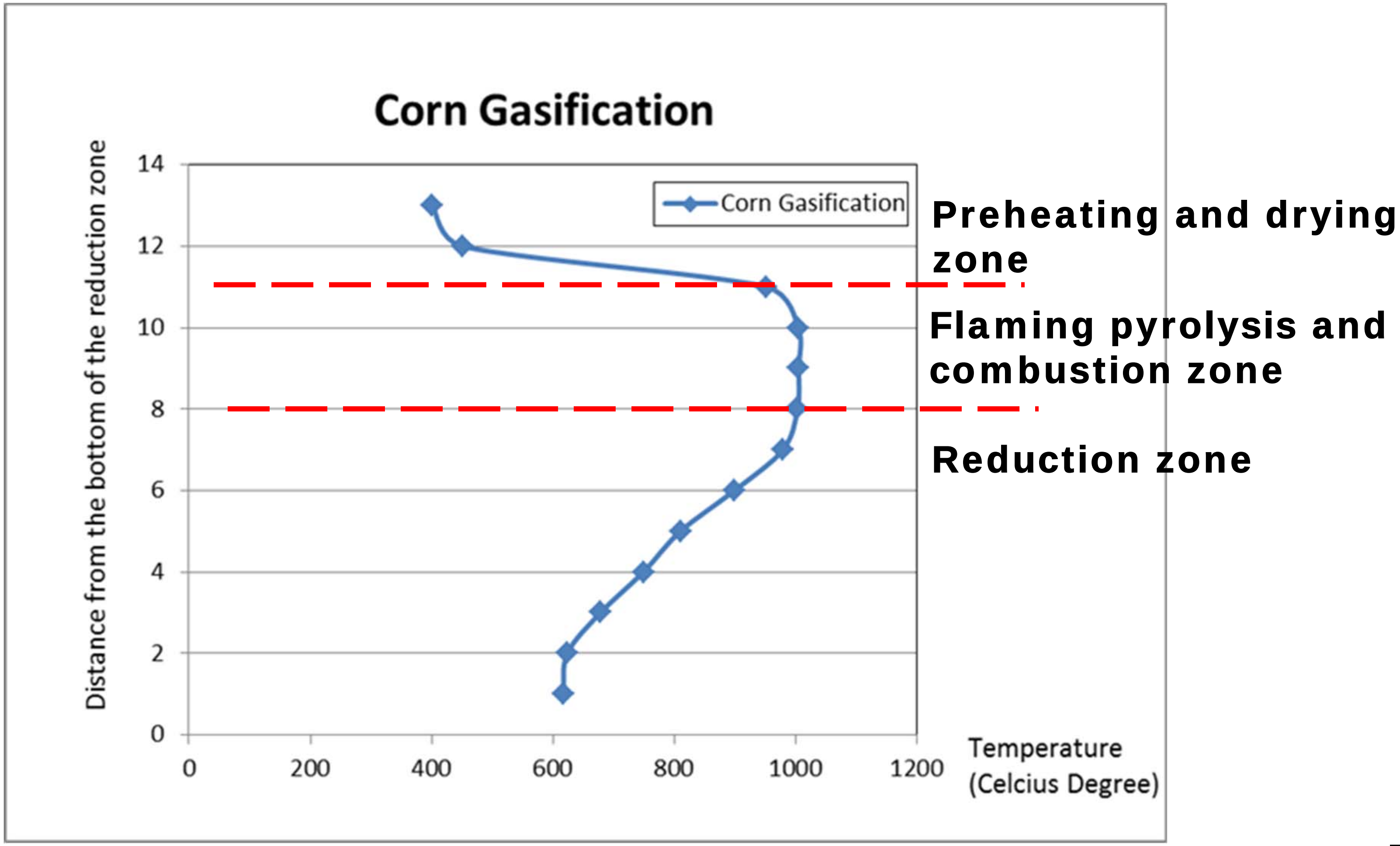
Gasifier Operation

Temperature profile in the gasifier





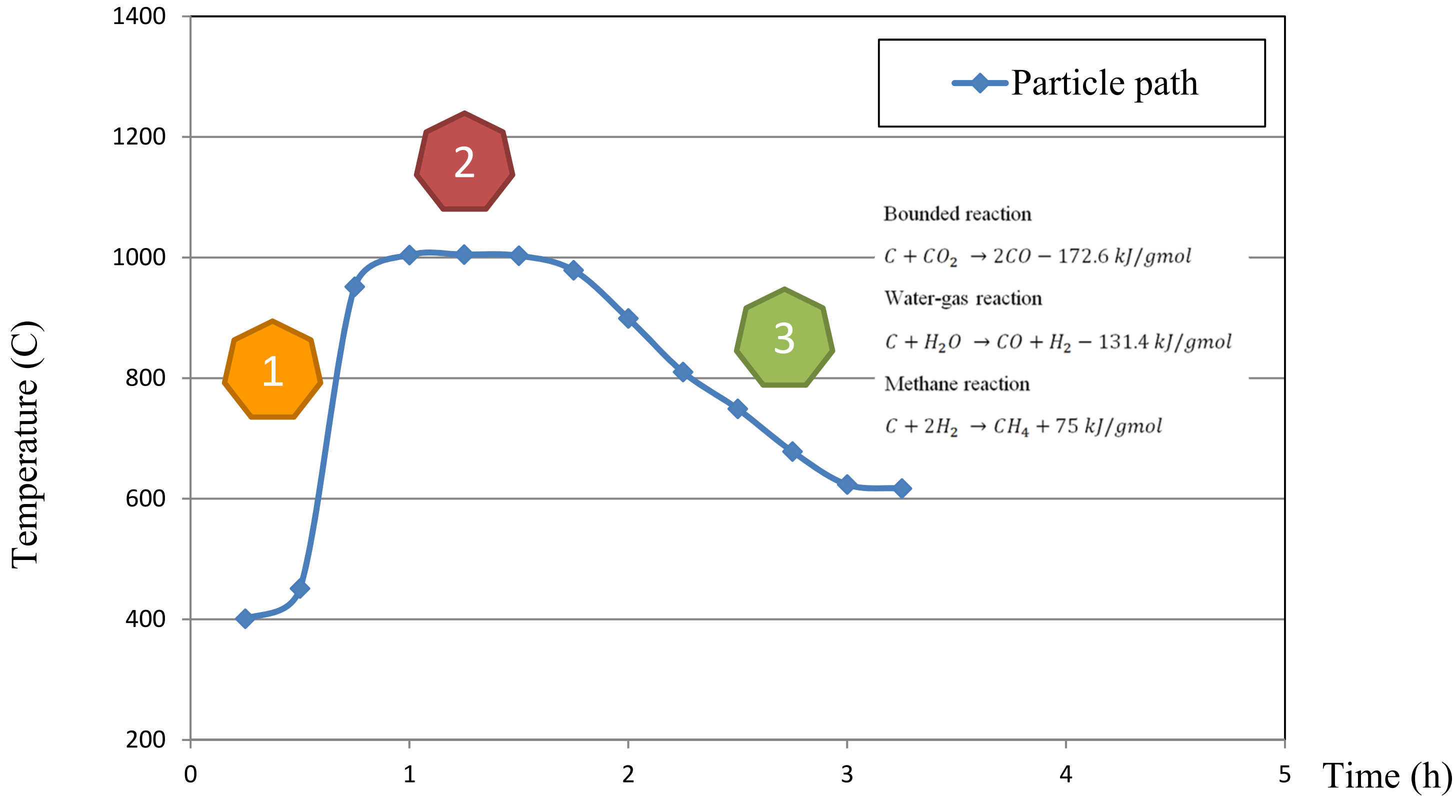
Thermal Profile and Different Zones



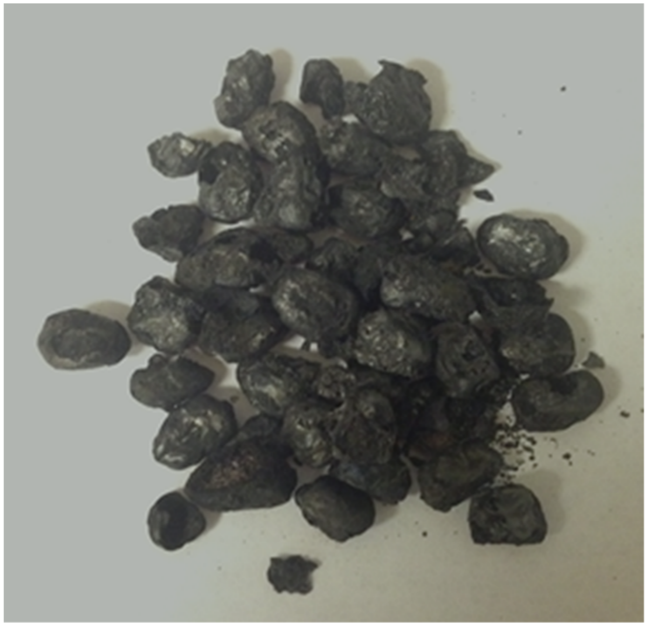
RDF Pellet Characteristics

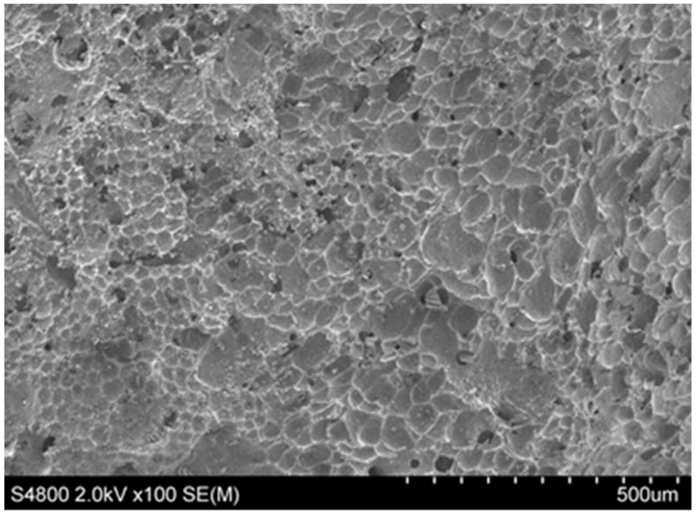
- Pellets were about 30% plastic, 35% cardboard, 35% paper and other cellulose material
- Composition was 63.71% Volatile Matter, 7.53% Fixed Carbon, and 28.71% Ash, with an energy of 8759 BTU/lb
- Post gasification, the material removed was 52.2% Ash and 47.8% Fixed Carbon

Particle Path

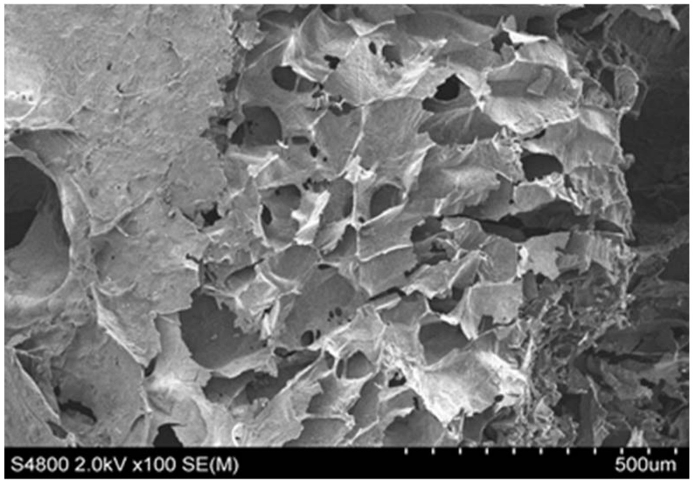


Characterization of Char





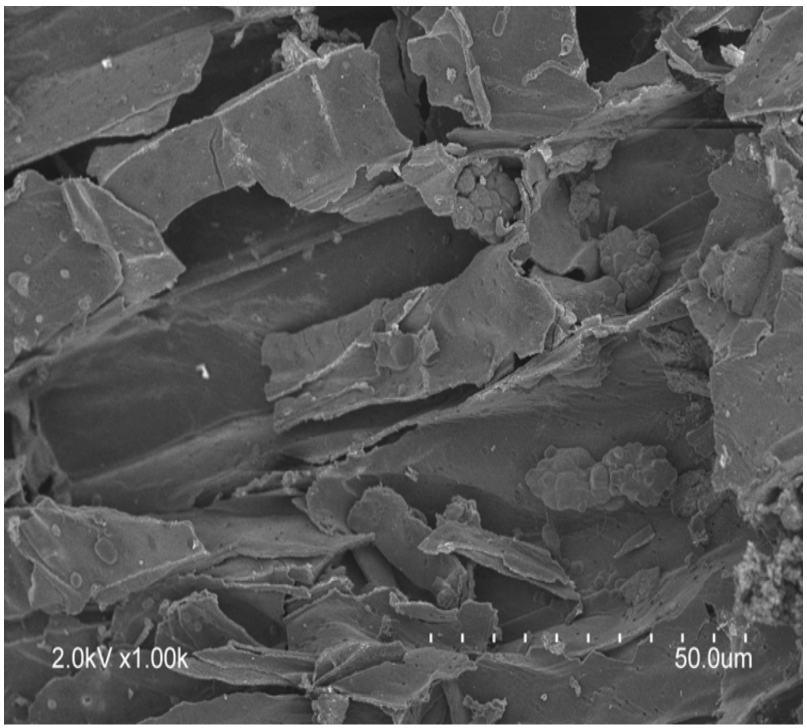
Exterior

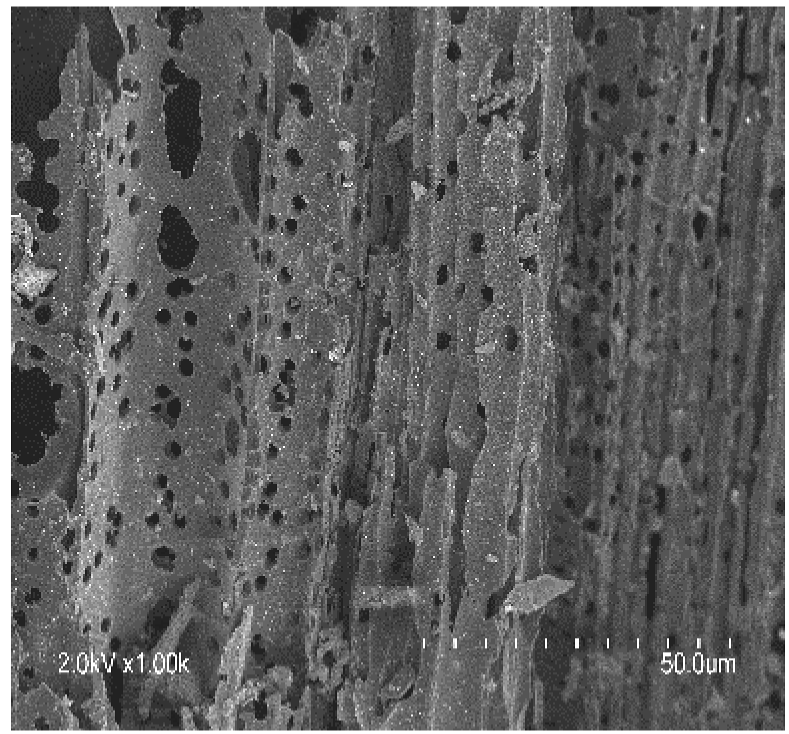


Interior

Biochar Structure

Scanning electron Microscope(SEM) analysis





Higher temperature and residence time leads to increase in the number of pores

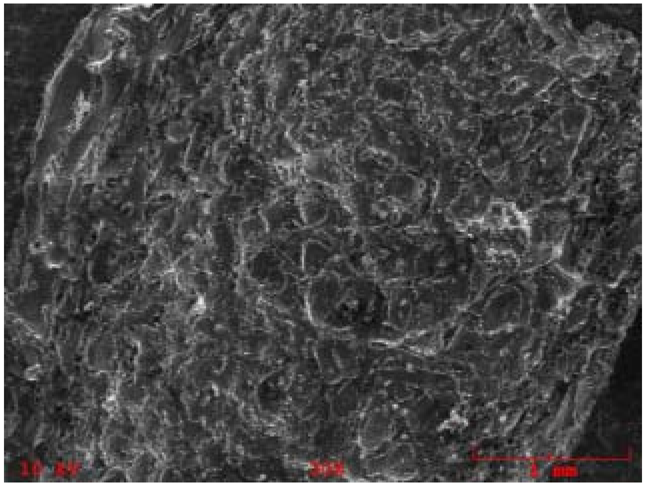
Bio-char Ultimate and Proximate Analysis

	Corn Biochar
% Moisture	6.97
% Volatile Matter	10.16
% Ash	9.3
% Fixed Carbon	**73.56**

	Corn Biochar
% Carbon	66.64
% Hydrogen	3.242
% Nitrogen	2.81
% Sulphur	--

Biochar Mineral Composition

Scanning electron Microscope(SEM) analysis



Elt.	Line	Intensity (c/s)	Atomic %	Conc	Units	Error 2-sig	MDL 3-sig	
C	Ka	12,177.78	82.945	72.704	wt.%	0.020	0.029	
O	Ka	1,047.06	13.085	15.278	wt.%	0.051	0.018	
P	Ka	381.48	1.154	2.607	wt.%	0.027	0.006	
K	Ka	377.16	1.692	4.828	wt.%	0.057	0.010	
Fe	La	111.49	1.124	4.582	wt.%	0.147	0.016	
			100.000	100.000	wt.%			

K and P (nutrients) can be used to replace fertilizers

Biomass Summary and Conclusions

- Using BET analysis, the surface area of the biochar was **32.02 m^2/g for corn in a single stage gasifier** .Increase in surface area is due increase in residence time due to the larger high temperature zone

- Using SEM analyses, a number of pores ranging from 50 to 100 micrometer was obtained.

- Through ultimate and proximate analysis, it was found that the carbon content of the biochar from the single stage gasifier is closer to that of activated carbon.

- The main elements found in the biochar were mostly carbon, phosphorus, potassium and iron.

- Understanding the relationship between the production of syngas, tar and biochar will help in optimization of gasifier systems for various applications.

Thanks for Watching!

Questions?