Method for Biochar Passivation Using Low Percent Oxygen

NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Kristin Smith, Dan Dupuis, Esther Wilcox

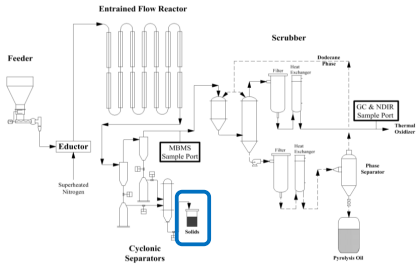
Objective

To develop a method that mitigates hazards for char collection and storage while maintaining char research integrity and improving passivation throughput.

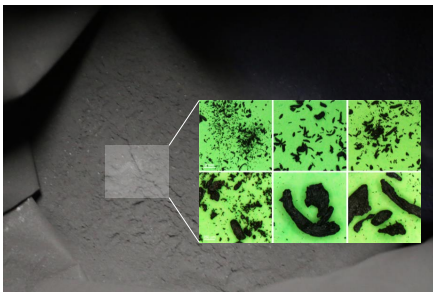
NREL's Thermochemical Pilot Plant

The thermochemical process development unit may be configured for pyrolysis or gasification. The pyrolysis unit operations include: feed transport system; entrained flow reactor; solids removal and collection; and liquid scrubbing, collection, and filtration. Char accumulates in the collection drums at a rate of ~1.5 kg/hr and must be passivated before it is stored or transported[1].

Flow Configuration for Pyrolysis



Thermochemical Byproduct: Biochar



About Char

Composed primarily of carbon with mineral ash. Potential uses as process heat source, soil amendment, or in carbon sequestration. Created in a low-oxygen environment and surface oxide formation upon oxygen exposure generates significant exotherm.

Char Hazards

When exposed to oxygen, has potential to undergo self-heating runaway[2]. Self-insulating, so undetected smoldering has potential to combust nearby materials. Dust static charge buildup and suspension can create a combustible environment.

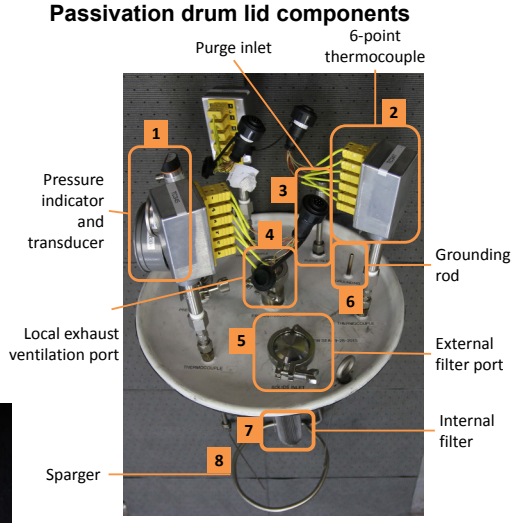
This work was supported by the Department of Energy's Bioenergy Technology Office under Contract no. DE-AC36-08-G028308

Low-Oxygen Char Passivation Method

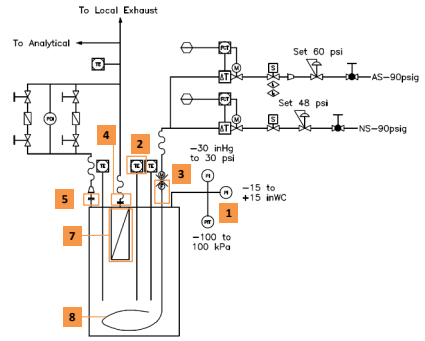
Air and nitrogen mix purges the drum through sparger. Drum monitored with three six-point thermocouples, pressure transducer, and oxygen sensor.

Self-Passivation	Controlled Passivation
Char exposed to room air	Controls introduction of fixed oxygen concentration through drum sparger
Rate ~0.2 kg/hr	Rate ~0.4 kg/hr
No temperature control	Air flow interlocked on high temperature
Complete when max. temp. < 30°C for 30 min	Complete when max temp. < 30°C for 30 min with 5.5 vol% O_2

Passivation drum lid components

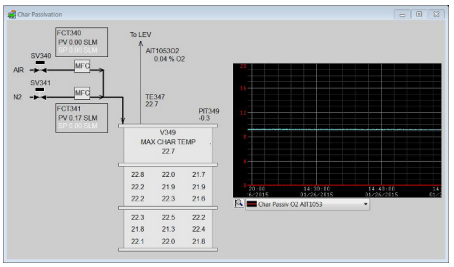


Piping and Instrumentation Diagram



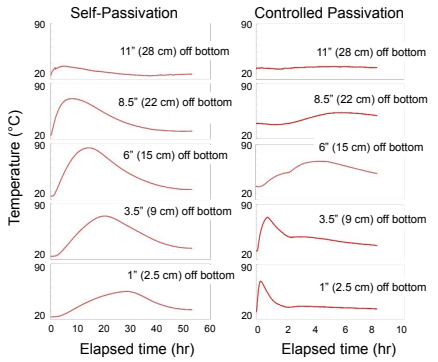
Char Control

Displays current valve positions, mass flow setpoints, oxygen concentration, drum pressure, and temperatures. Chart shows trends for all values. Control system alarms and disables air flow at 55°C max temperature, 15 kPa pressure, or 5.5 vol. % O_2 concentration. Oxygen interlock based on char LOC of 10% with a safety factor of two[3].

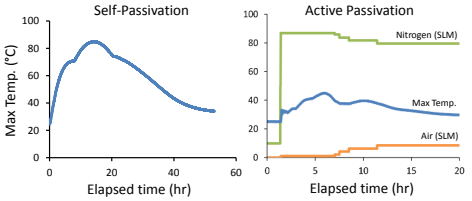


Passivation Results

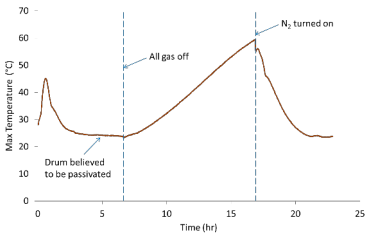
Self-passivation occurs from top of drum, downward whereas controlled method through sparger passivates from bottom, upward.



Duration and maximum temperature lower for controlled method.



High nitrogen flow rate masks passivation exotherm.



Conclusions

Successfully developed method to safely passivate char and maintain research integrity. Design and control features mitigate passivation hazards. Duration and maximum temperature reduced through bottom-up, controlled passivation. High gas flow rates reduce temperature, falsely signaling passivation completion. Current passivation rate about 3 times less than char production rate.

Future Work

- Consider oxygen concentration as passivation criterion instead of temperature.
- Optimize passivation method to increase throughput.
- Automate passivation strategy to make less operator intensive
- Continue to track passivation data to determine feedstock and run condition effects

References

1. Coolidge, Dennis Wayne, and Ernest Peter Esztergar. 1998. "5,711,769."
2. Dzonzi-undi, Junice, Ondrej Masek, and Olusegun Abass. 2014. "Determination of Spontaneous Ignition Behaviour of Biochar Accumulations" 3 (8): 656–61.
3. Hauptmanns, Ulrich. 2015. *Process and Plant Safety*. Berlin, Heidelberg: Springer Berlin Heidelberg: Berlin, Heidelberg. doi:10.1007/978-3-642-40954-7.

Acknowledgements

Dr. Rich Bain, Tim Dunning, Tina Fehringer, Calvin Feik, Katie Gaston, Christopher Golubieski, Ray Hansen, Doug Herrick, Marc Oddo, Matt Oliver, Marc Pomeroy

The information contained in this poster is subject to a government license.

European Biomass Conference & Exhibition
Amsterdam, The Netherlands
June 6-9 2016
NREL/PO-5100-66563