Update on Gasification: Plasma-Arc

Daniel Ripes
Corporate Finance Manager & Business Development
PEAT International, Inc.
www.peat.com
Introduction

- Extreme heat generated breaks down waste to form synthesis gas (H<sub>2</sub> & CO) and slag
- Heat required generated by plasma and not via combustion of all or part of the waste

Equations:

- \[ C \text{ (fuel)} + O_2 \rightarrow CO_2 + \text{Heat (Exothermic)} \]
- \[ C + H_2O \text{ (steam)} \rightarrow CO + H_2 \text{ (Exothermic)} \]
- \[ C + CO_2 \rightarrow 2CO \text{ (Endothermic)} \]

At higher temps, endothermic reactions favored

Some inject (supplemental fuels) petroleum coke

Option promoted most widely for larger scale applications as syngas can be used to offset energy costs
Plasma Generating Devices

- Industrial Thermal Plasma Technology
  - R.F. & Microwave
  - Induction
  - Arc Furnaces
  - Plasma Torches
    - Direct Current
    - Alternating Current
      - Convertible
      - Transferred
      - Non-Transferred
Waste Applications

- Plasma Pyrolysis
  - O$_2$ either absent or at low concentrations
  - Rarely used by itself, usually followed by gasification or combustion
  - Often interchangeable with gasification
  - Some convert tars in secondary cracking reactor
  - Other designs have reactions all occurring in same reactor

- Plasma Vitrification
  - Process of forming glass
  - Melt inorganics which absorb various metals in chemical bond
  - Two types
    - Normal melting within plasma reactor
    - Stand-alone processes using plasma torches
  - Goal of either to create inert matrix and reduce metals to mixtures/alloys

- Plasma Gasification
  - Designed to optimize waste to syngas
  - Oxygen starved conditions
  - Reducing environment: H$_2$S and N$_2$ rather than NOx and SO$_2$
  - Halogens converted to HCl and HF
  - Endothermic and Exothermic reactions
Commercial Stage

• More than 150 companies market pyrolysis or gasification systems (~25 involved with plasma)
• Hazwaste systems: at least 5 countries
  • Enviroarc (assisted gasification – Norway)
  • Europlasma (vitrification – France/Japan)
  • InEnTec (pyrolysis/gasification – US)
  • MHI (vitrification – Japan)
  • MSE (combustion – US)
  • PEAT (pyrolysis/gasification – US/China/Taiwan)
  • Phoenix Solutions (vitrification – Japan)
  • Pyrogenesis (combustion – Canada/US)
  • ReTech (combustion – US/Japan)
  • Tetronics/APP (vitrification/gasification – US/Europe)
  • Westinghouse Plasma/AlterNRG (gasification – Japan/India/UK)
Recent Developments

• AlterNRG – Tees Valley England - 50 MW from 65,000 nm3/hr of syngas (est. 2014), 100 TPD & 40 TPD China projects in production (biomass and flyash)
• Plasco – Ottawa, Canada - 450 TPD MSW-to-electricity project (est. 2016) (two financing extensions rec’d)
• PyroGenesis – Europe – 10 TPD (est. 2014/15), 2\textsuperscript{nd} aircraft system project pending
• InEnTec – Oregon - 25 TPD Gasification char-to-electricity with WM (installed 2012)
• PEAT: 1 TPD system in China, MedWaste (2013)
## Commercialization Hurdles

<table>
<thead>
<tr>
<th>Claim</th>
<th>Viewpoint</th>
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<tbody>
<tr>
<td>Process wider range of feedstocks</td>
<td>• Already implemented in various installations</td>
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<tr>
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<td>• Low calorific values/inorganics</td>
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<tr>
<td>Smaller physical footprint</td>
<td>• No moving grates/less gas volumes</td>
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<td>• Large scale may require # of reactors</td>
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<td>Smaller environmental footprint</td>
<td>• Higher thermal destruction, in some secondary/cracking needed</td>
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<td>• Dioxins minimized/other residues require handling</td>
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<td>End-products w/ no residual waste</td>
<td>• Slag re-use demonstrated</td>
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<td>• Energy balances vary by feedstock</td>
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Conclusion & Summary

• Plasma gaining recognition among stakeholders
• Technology viewed through various lenses
• Many claimed advantages yet to be proven on a full scale commercial basis
• More developed track record needed to alleviate marketplace concerns
• With more data from new installations (next 2-3 years), a clearer picture shall become available
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PEAT International, Inc.
www.peat.com

Tel: 847.559.8567
Fax: 847.291.3704
E Mail: dripes@peat.com