Update on Gasification: Plasma-Arc

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Introduction

- Extreme heat generated breaks down waste to form synthesis gas (H_2 & CO) and slag
- Heat required generated by plasma and not via combustion of all or part of the waste

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Equations:

$C \text{ (fuel)} + O_2 \rightarrow CO_2 + \text{Heat (Exothermic)}$

$C + H_2O \text{ (steam)} \rightarrow CO + H_2 \text{ (Exothermic)}$

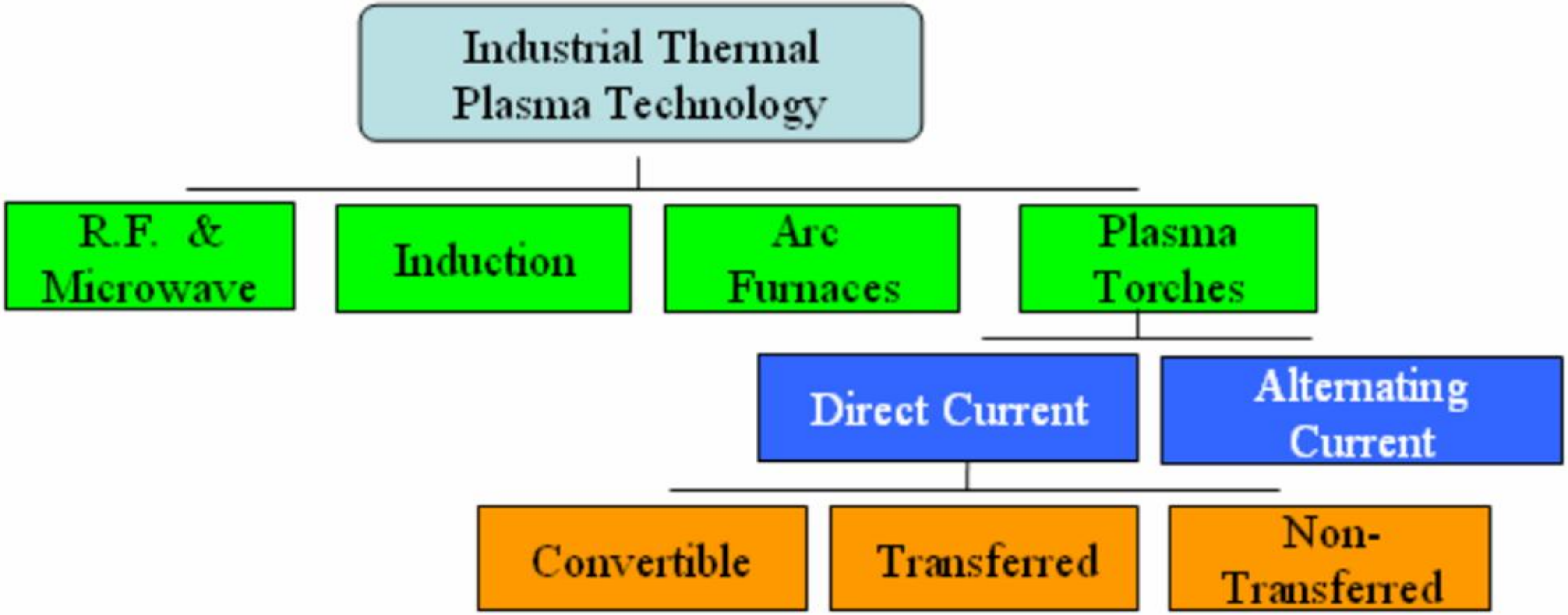
$C + CO_2 \rightarrow 2CO \text{ (Endothermic)}$

At higher temps, endothermic reactions favored

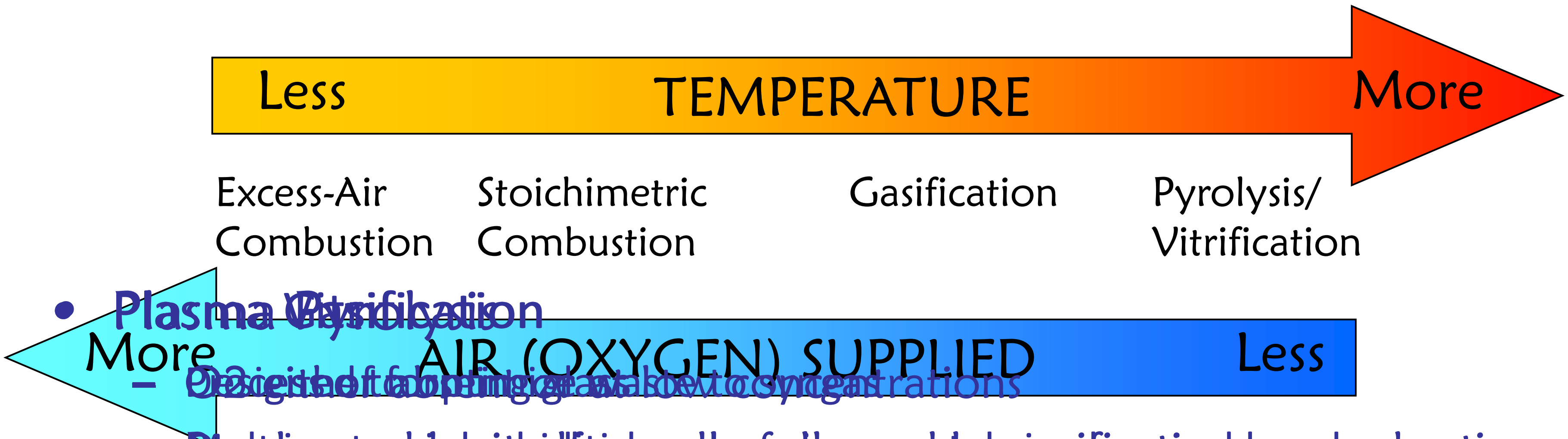
Some inject (supplemental fuels) petroleum coke

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

Plasma Generating Devices



Waste Applications



- Plasma Vitrification
  - Rarely used by itself, usually followed by gasification or combustion
  - Reducing environment: H_2 and N_2 rather than NOx and SO_2
    - Some melting within plasma cracking reactor
    - Standalone process or ... in same reactor
  - Halogens converted to HCl and HF
  - Endothermic and Exothermic reactions
  - Goal of either to create inert matrix and reduce metals to mixtures/alloys

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)
- Pyrogensis – Europe – 10 TPD (est. 2014/15), 2nd 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

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

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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