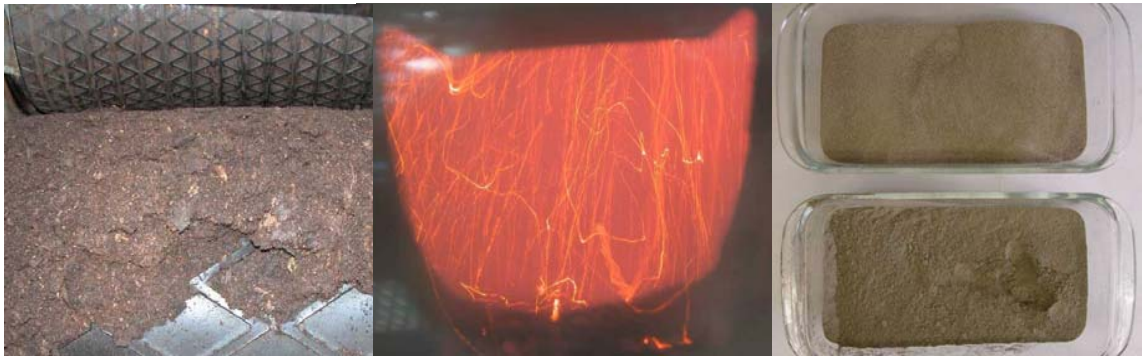

ENERGY AND NUTRIENT RECOVERY FROM COMBUSTION OF SWINE SOLIDS AND TURKEY LITTER

Tom Miles and Bert Bock

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Project Participants

- Cape Fear Resource Conservation and Development, Inc., North Carolina
- BEST Solutions, LLC. (Smithfield Foods, Inc.)
- Tennessee Valley Authority Public Power Institute (BR Bock, Consulting)
- T R Miles, Technical Consultants, Inc.
- Energy Products of Idaho

Objectives

- Combust swine solids and turkey litter with acceptable operation and environmental performance
  - Continuous operation
  - Low emissions
- Recover nutrients (P, K) for export or sale to feed and fertilizer markets.
- Demonstrate non-subsidized method of nutrient management

Background

- Mixed success with commercial systems for burning manures
  - Agglomeration, fouling, corrosion in fluidized beds
  - Slag in secondary combustors of gasifiers
  - Fouling in spreader stoker convection passes
  - Excess carbon in ash
- Good emissions and ash quality from pilot fluidized bed combustion of poultry litter
  - Enriched P recovery in boiler ash
  - Enriched K recovery in baghouse ash
  - Clean ash, good carbon burnout

BEST System

(Biomass Energy Sustainable Technology)

- On-farm, two-stage solid-liquid separation of the swine manure
- Transporting swine solids to a centralized fluidized bed combustor
- Mix poultry litter with the swine solids to provide a sufficiently dry feedstock
- Combust mixture of swine solids and poultry litter
- Use the heat from the combustor for direct drying or to produce process steam and/or electricity
- Exporting the nutrient rich ash to existing fertilizer granulation plants and incorporation of the ash into existing fertilizer products

Project Steps

- Locate combustion facility
- Prepare and transport swine solids, turkey litter
- Test fuels minimum 15 days 24/7
- Monitor operation and emissions
- Post test ash processing (granulation) for fertilizer
- Post test feeding trials for value added nutrient utilization (separate project)

Combustion Facility Requirements

- Fluidized Bed
- Capacity to generate 40 tons of ash
- Ash and flyash recovery
- Proven scale-up parameters
- Emissions monitoring
- Commercial interest in supplying a system

SO_X Emission Control

--Fuel Ca forms $CaSO_4$ deposited with ash

--Added lime (CaO), if required

Prevention of Ash Fusion due to K, Na, Cl

--Uniform air & fuel dist.

--Low temperatures

--Added lime (CaO), if required

Complete C Burnout

--Bed mixing and fuel/ash abrasion

--Excess air vs. starved air for gasification

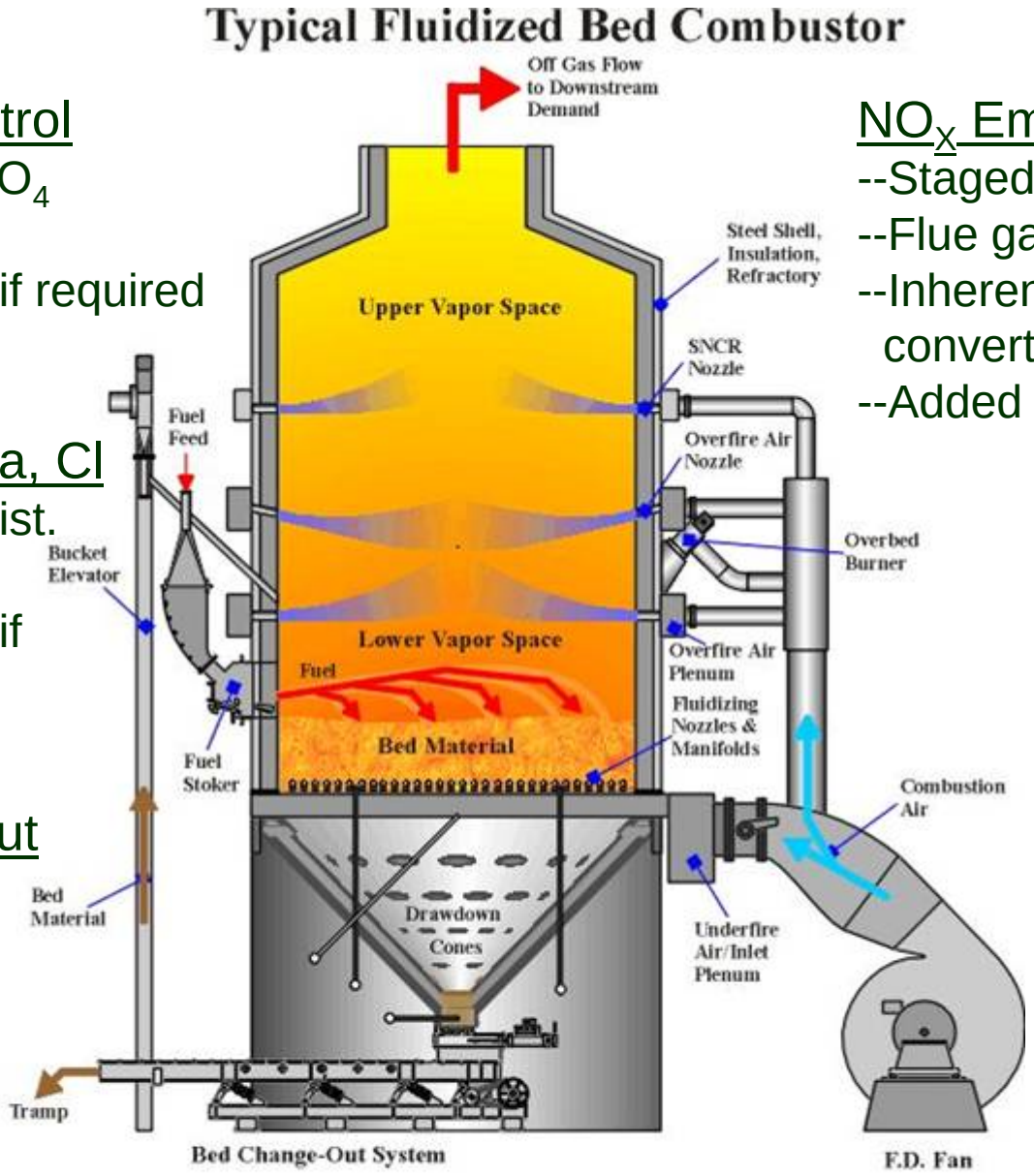
NO_X Emission Control

--Staged combustion

--Flue gas recirculation

--Inherent fuel NH_3 converts NO_X to N_2

--Added NH_3, if required



Courtesy Energy Products of Idaho

Energy Products of Idaho Pilot Facility

- 900 kW (3 MMBtuh)
- Freeboard 7.9m (25 ft)
- Bed area 0.8 m2 (8.5 ft2)
- Bed Media silica sand 600-800 µm
- 7 sets of OFA w/ FGR or NH3 injection
- Preheat to 427°C (900° F)
- Aux freeboard burner
- Periodic ash clean/removal
- Analyzers: SO2, NO/NOx, O2, CO

SWINE SOLIDS BEING SEPARATED IN NORTH CAROLINA


LOADING TURKEY LITTER
IN NORTH CAROLINA


SWINE SOLIDS


50% SWINE SOLIDS-
50% TURKEY LITTER

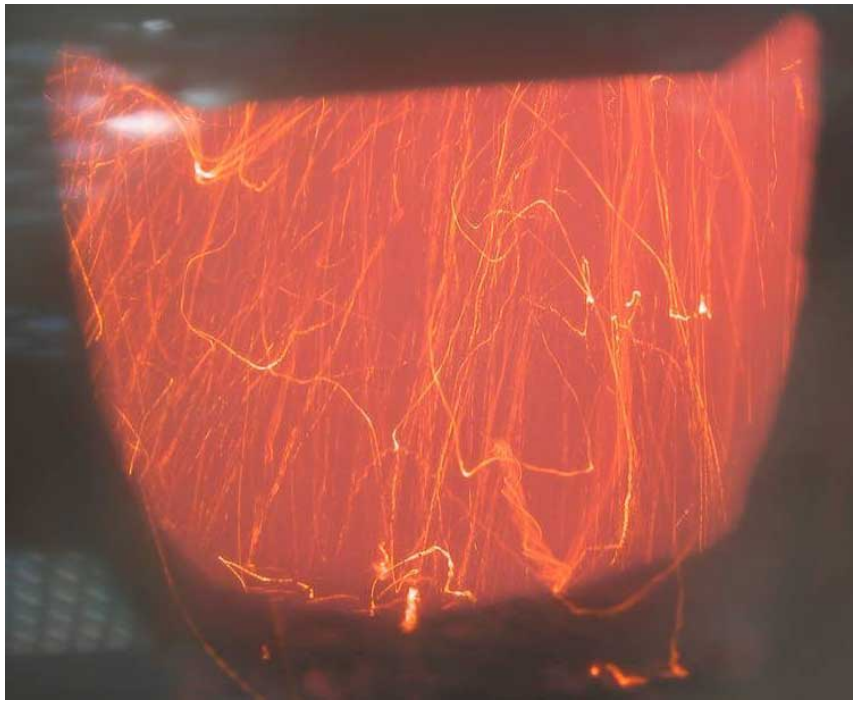
LITTER AND MANURE SOLIDS VARY IN FUEL QUALITY

	Poultry Litter	Turkey Litter	Swine Solids
Carbon, dry wt %	39.50	33.77	51.30
Hydrogen, dry wt %	4.30	3.55	6.08
Nitrogen, dry wt %	3.90	0.62	1.83
Sulfur, dry wt %	0.80	0.62	0.28
Ash, dry wt %	22.90	38.63	5.94
Chlorine, dry wt %	1.28	0.39	.07
Oxygen, dry wt %	27.30	20.01	34.57
Moisture, % (as delivered)	20-35	30 (32-46)	58.41 (66.5-71.6)
Dry HHV, MJ/kg	15.3	11.8	19.3
LHV, MJ/kg as fired	8.4-9.3	4.8-6.7	3.4-4.4

Fuels Qualities Determine Combustion Conditions

	Turkey Litter	75% TL 25% SS	67%TL 33% SS	50%TL 50% SS	Swine Solids
Source MC % NC	30%				58%
Delivered MC % ID	32%-49%	36% to 45%	40% to 46%	48% to 55%	67 to 72%
Ash, dry % (as fired)	38.6 (22)	31.6 (18)	27.1 (15.4)	26.7 (14.1)	5.9 (2)
Ca:S	4.95:1	6.23:1	4.52:1	3.89:1	3.6:1
LHV, MJ/kg	4.8-6.7	5.7-7.0	6.1-6.9	5.2-6.2	4.4-4.7

High Moisture and Ash Require Controlled Combustion Conditions



- Air preheat
- Staged Combustion
- Properly placed OFA and FGR
- Extended residence time
- Controlled temperature in refractory vessel
- 6% O2 and 871 °C (1600 ° F) to maintain low CO

Typical Combustion and Emissions

Vapor temp	760 °C max 982 °C (1400 °F to 1800 °F)
Min Bed temp	704 °C to 760 °C (1300 ° F to 1400 °F)
O2	6%-12%
CO	25 ppm dv
NOX w/FGR	10-50 ppm
SOx	0- 25 ppm

Operation

- No fuel feeding problems
- Free flowing media and bottom ash
- Temperature excursions (982 °C/1800 °F) caused fouling of cyclone and “convection” pass
- Refractory walls accumulated sintered deposits
- Some agglomeration on fluidizing nozzles

Boiler Separates Ash Constituents

- Cyclone ash is coarse and enriched in phosphorous

- Baghouse ash is fine and enriched in potassium

PREPARING ASH FOR FERTILIZER

Ash From Combustion

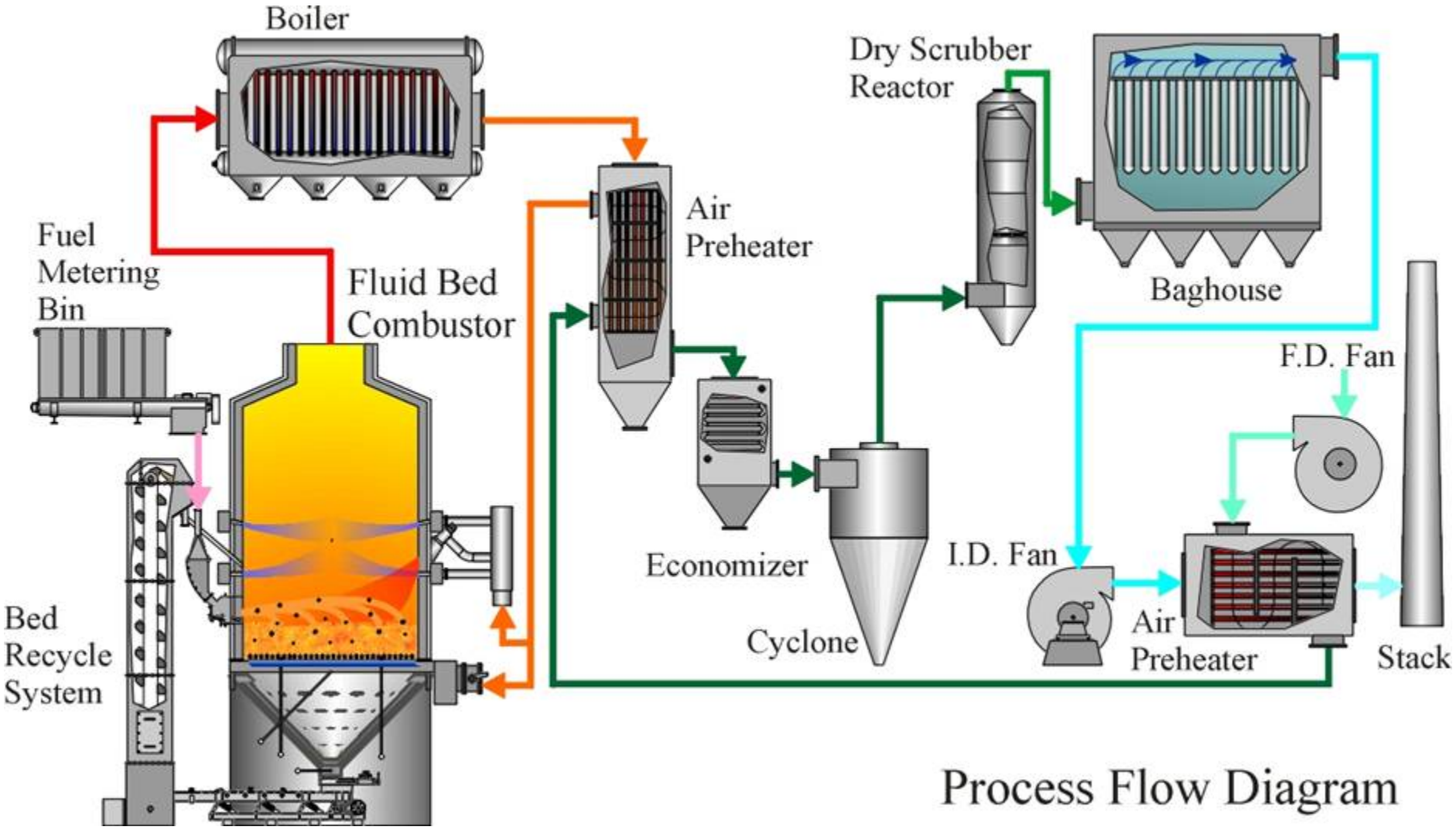
Granulation

Granulated Ash

Conclusions

- BEST fuel preparation and handling successful
- Prevent wetting of fuel in storage
- No bed agglomeration
- Fouling controlled with freeboard temperature
- Good NOx and SOx control
- Fluidized bed can produce valuable carbon free ash

Elements of a Commercial FB System for Energy and Nutrient Recovery



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Next Steps

- Feasibility studies for host energy consumers in swine and poultry production areas
- Feeding trials to verify nutrient utilization
- Demonstrations and commercial plant

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- Mike Murphy, Energy Products of Idaho www.energyproducts.com

T R Miles Technical Consultants, Inc
1470 SW Woodward Way, Portland, OR 97225 USA
1 (503) 292-0107 1 (503) 292-2919 (fax) tmiles@trmiles.com
www.trmiles.com