EERC Technology… Putting Research into Practice

Lignite Fuel Enhancement via Allair Jig Technology

The Pittsburgh Coal Conference

Jason D. Laumb

September 15, 2005

Outline of Presentation

- Project description/equipment
- Background on modeling and advanced analytical
  - Computer-controlled scanning electron microscopy (CCSEM)
  - Chemical fractionation
  - Predictive Coal Quality Effects Screening Tool (PCQUEST^{SM})
- Analytical/modeling results
- Conclusions
- Future directions
- Acknowledgments

EERC
Energy & Environmental Research Center®

Project Description/Equipment

- A 5-ton/hr all-air jig was constructed by allmineral.
- Coal from three separate mines was processed in the jig.
  - Falkirk Mine (North Dakota lignite)
  - Coteau Mine (North Dakota lignite)
  - Red Hills Mine (Mississippi lignite)
- Mass balances were conducted around the jig and samples submitted for advanced analysis and modeling calculations.

EERC
Energy & Environmental Research Center®

Equipment

EERC
Energy & Environmental Research Center®

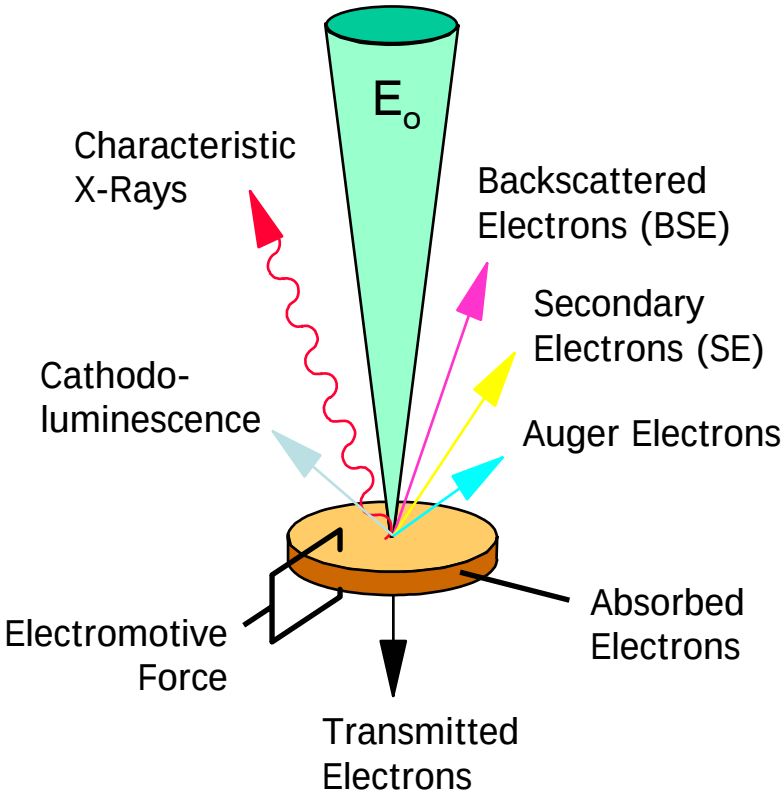
CCSEM

- CCSEM
  - Provides size, composition, and abundance of mineral grains in coal
  - Extremely valuable information needed to predict ash deposition/behavior

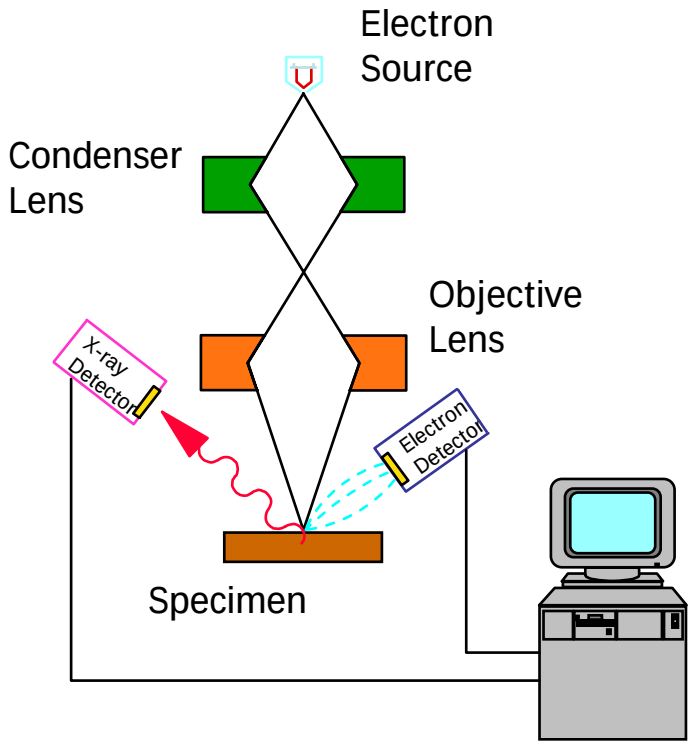
EERC
Energy & Environmental Research Center®

Scanning Electron Microscopy

Beam–Specimen Interaction



Electron Optics



EERC
Energy & Environmental Research Center®

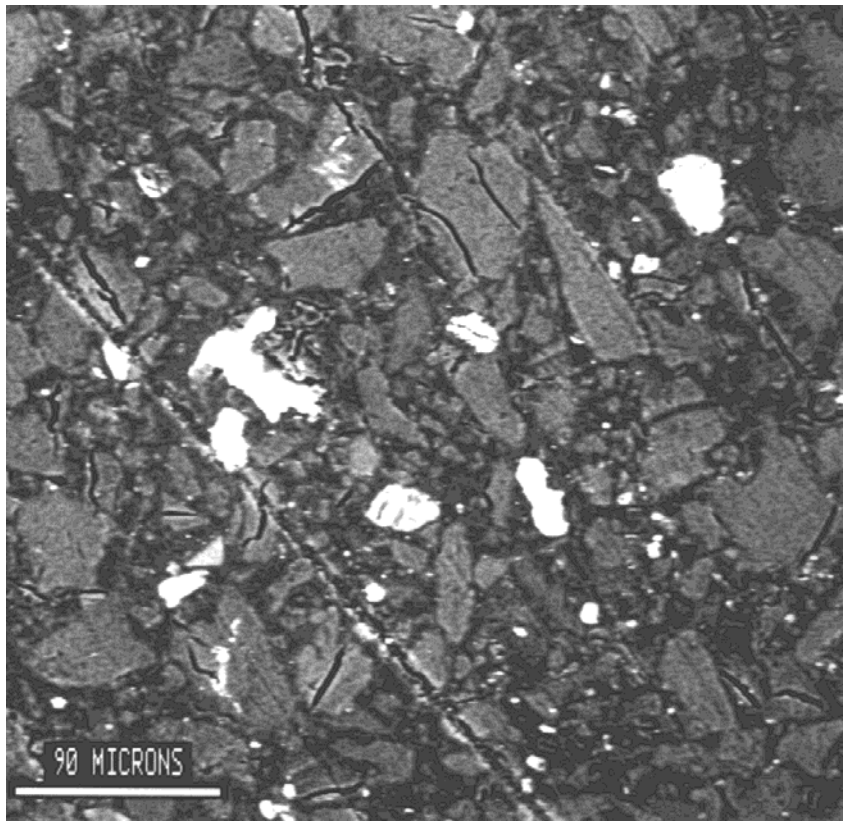
Computer-Controlled Scanning Electron Microscopy

- Scans coal sample in backscattered electron imaging.
- Bright areas that represent minerals are located.
- Each mineral is sized by measuring eight diameters of the particle.
- The composition of the particle is recorded from the x-rays emitted.
- All of the data are manipulated using the Partchar computer code.

EERC
Energy & Environmental Research Center®

Inorganic Minerals in Coal

- Backscattered electron image.
- Mineral grains show up bright and can be located based on gray scales.
- Chemical composition is determined.



EERC
Energy & Environmental Research Center®

PCQUEST

- Eight empirical indices are computed by PCQUEST, including low-temperature fouling, high-temperature fouling, slagging, slag tapping, stack-plume opacity, boiler erosion, coal grindability, and sootblowing effectiveness.
- PCQUEST uses inputs from CCSEM, standard coal analysis, chemical fractionation, and boiler parameters.

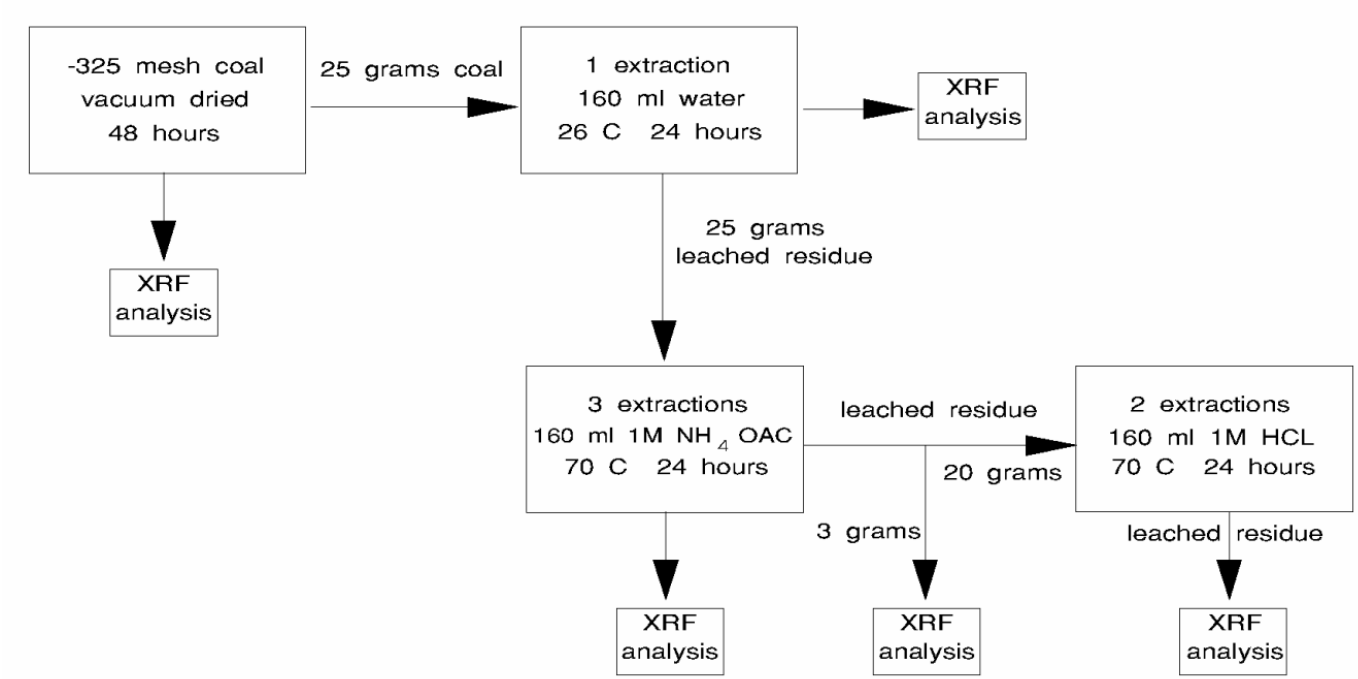
EERC
Energy & Environmental Research Center®

Chemical Fractionation

- Chemical fractionation – determines the amount of organically dispersed elements in the coal by three extractions
  - Water extraction – removes water-soluble cations
  - Ammonium acetate extraction – removes ion-exchangeable cations
  - Acid extraction – removes coordination complexes within the organic structure of the coal, as well as acid-soluble minerals such as carbonates, oxides, and sulfates

EERC
Energy & Environmental Research Center®

Chemical Fractionation (cont.)



EERC
Energy & Environmental Research Center®

CCSEM Results

- Mineral % reduced from 13.4% to 7.9%
- Quartz reduced slightly
- Pyrite-like minerals most significantly reduced 12.5% to 6.7%
- Some clay material slightly concentrated as a result of removal of pyrite and other material.

	Lignite 1 Feed	Lignite 1 Clean
Mineral % (coal basis)	13.4	7.9
Quartz	20.8	19.5
Iron Oxide	1.7	1.1
Kaolinite	7.0	7.1
Montmorillonite	4.9	3.4
K Al-Silicate	10.1	15.6
Fe A1-Silicate	6.7	5.1
Ca Al-Silicate	2.2	1.3
Mixed Al-Silica	3.4	3.7
Pyrite	0.3	0.2
Pyrrhotite	12.2	6.5
Si-Rich	3.8	5.6
Unclassified	20.5	23.2

Bulk Ash Composition

	Lignite 1 Feed	Lignite 1 Clean	Lignite 2 Feed	Lignite 2 Clean	Lignite 3 Feed	Lignite 3 Clean
SiO_2	43.50	44.30	54.50	52.75	51.08	52.72
Al_2O_3	17.00	17.30	16.30	16.15	17.07	17.69
Fe_2O_3	6.42	5.26	7.66	6.66	7.90	6.99
TiO_2	0.70	0.69	0.60	0.60	0.59	0.63
P_2O_5	0.15	0.14	0.13	0.14	0.14	0.13
CaO	17.10	17.50	10.20	11.81	14.85	13.86
MgO	6.63	6.64	3.64	4.04	4.47	4.36
Na_2O	7.32	7.03	4.47	5.50	1.81	1.38
K_2O	1.20	1.20	2.49	2.35	2.08	2.24

EERC
Energy & Environmental Research Center®

Chemical Fractionation Results

	Lignite 2 Feed	Lignite 2 Clean	Lignite 2 Feed Water Leached	Lignite 2 Clean Water Leached	Lignite 2 Feed NH_4OAc	Lignite 2 Clean NH_4OAc	Lignite 2 Feed HCl	Lignite 2 Clean HCl
SiO_2	54.50	52.75	47.80	52.76	61.81	61.33	71.50	71.96
Al_2O_3	16.30	16.15	13.89	15.62	18.27	18.45	17.13	17.33
Fe_2O_3	7.66	6.66	8.65	6.91	8.44	7.70	4.40	3.74
TiO_2	0.60	0.60	0.60	0.60	0.67	0.70	0.83	0.89
P_2O_5	0.13	0.14	0.16	0.14	0.15	0.15	0.01	0.01
CaO	10.20	11.81	17.21	12.99	4.30	5.37	0.56	0.52
MgO	3.64	4.04	4.93	4.38	2.36	2.45	1.21	1.20
Na_2O	4.47	5.50	5.27	4.54	1.04	1.00	1.02	1.01
K_2O	2.49	2.35	1.50	2.04	2.95	2.85	3.34	3.34

EERC
Energy & Environmental Research Center®

Proximate/Ultimate Results

	Lignite 1 Feed	Lignite 1 Clean	Lignite 2 Feed	Lignite 2 Clean
Moisture	30.2	30.8	32.6	32.3
Volatile Matter	32.03	32.45	31.93	31.42
Fixed Carbon	23.43	25.82	24.3	25.52
Ash	14.35	10.93	11.18	10.76
Hydrogen	5.91	6.09	6.29	6.36
Carbon	36.21	37.82	36.62	36.93
Nitrogen	0.73	0.77	0.73	0.73
Sulfur	0.77	0.56	0.74	0.62
Oxygen	42.04	43.83	44.44	44.59
Ash	14.35	10.93	11.18	10.76
BTU	5781	6170	6045	6223

PCQUEST Modeling Results

	Lignite 1 Feed	Lignite 1 Clean	Lignite 2 Feed	Lignite 2 Clean
GRINDABILITY	37	33	34	32
LOW-TEMP FOULING	9	12	9	7
HIGH-TEMP FOULING	20	20	22	22
SLAGGING	55	52	40	41
SOOTBLOWING	5	5	5	5
TUBE EROSION	15	25	8	5
OPACITY	25	31	37	50

EERC
Energy & Environmental Research Center®

General Observations

- Carbon recovery varied from 70% to 94%.
- Mercury removal as high as 62%, very coal specific.
- Process can be sensitive to moisture (rain).

EERC
Energy & Environmental Research Center®

Conclusions

- The air-jigging process can turn coal that was once unusable into a salable product.
- The air jig is most effective at removing pyrite and heavier minerals.
- PCQUEST modeling shows essentially no negative effects on fouling/slagging.

EERC
Energy & Environmental Research Center®

Future Directions

- Complete Vista modeling on results obtained to date.
- Form consortium to better understand the Hg removal seen in this project.

EERC
Energy & Environmental Research Center®

Acknowledgments

- Dick Snoby – allmineral Llc
- Rich Weinstein – The Falkirk Mining Company
- Richard Read – U.S. DOE NETL
- Red Hills Mine
- Coteau Mine
- Great River Energy
- North Dakota Industrial Commission

EERC
Energy & Environmental Research Center®

Contact Information

- **Energy & Environmental Research Center**
- University of North Dakota
- 15 North 23rd Street
- PO Box 9018
- Grand Forks, North Dakota 58202-9018

- World Wide Web: **www.undeerc.org**
- Telephone No. (701) 777-5114
- Fax No. (701) 777-5181

- **Jason D. Laumb**

EERC
Energy & Environmental Research Center®