Coking/Coal Gasification Using Indiana Coal for the Production of Metallurgical Coke, Liquid Transportation Fuels, and Electric Power

Status Report
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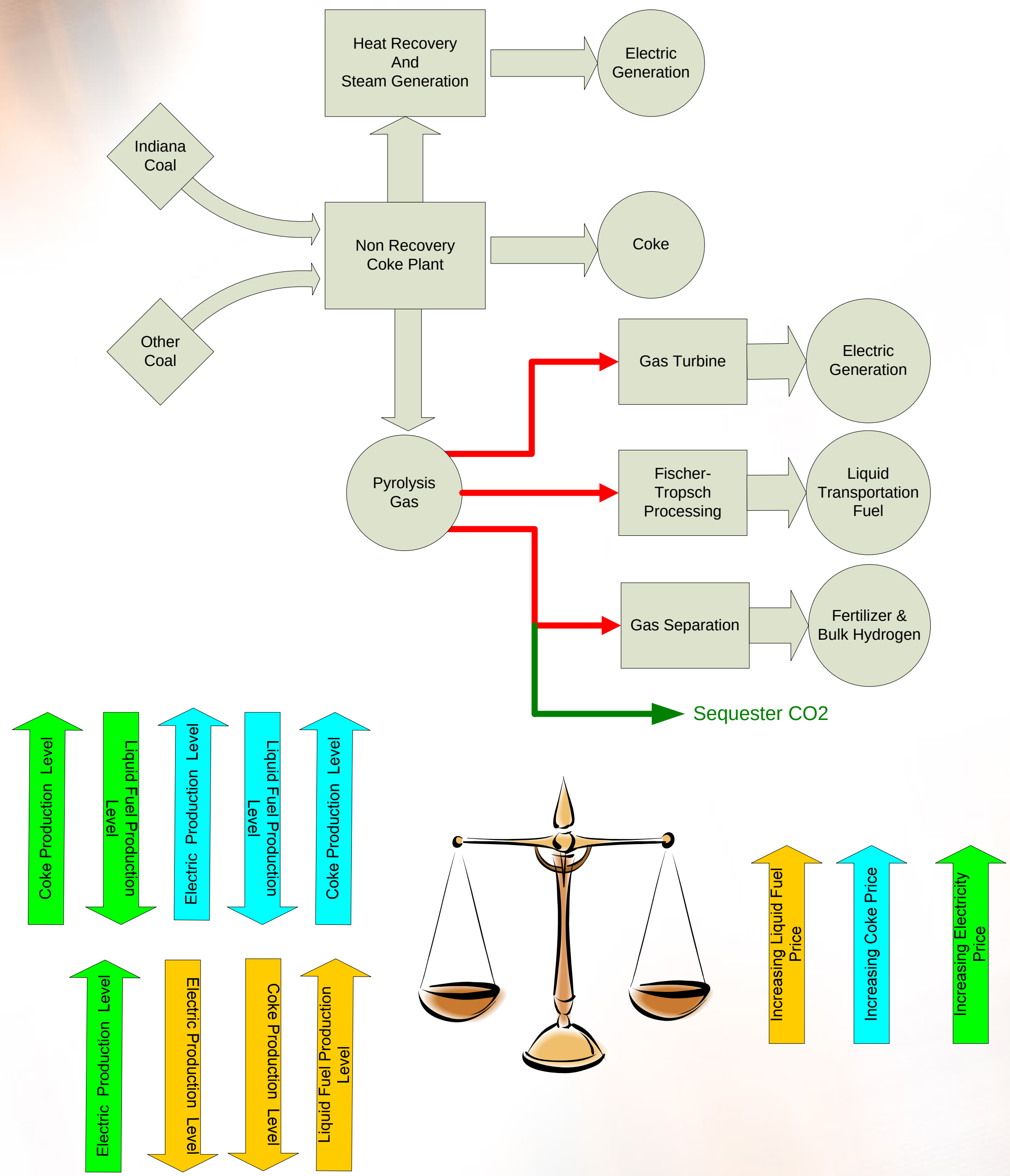
Center for Coal Technology Research

Discovery Park The Energy Center

Research Team

- Robert Kramer (Ph.D.) is Director of the Purdue University Calumet Energy Efficiency and Reliability Center. Dr. Kramer serves as the Principal Investigator. His areas of expertise include energy research, electric system design and operation, engineering, physics, Combined Heat and Power systems, environmental engineering, and project management. He has over 30 years of industrial experience in the energy field, most recently as the Chief Scientist for NiSource.
- Libbie Pelter (Ph.D.), Assistant . Professor, Department of Chemistry and Physics, Purdue University Calumet. Dr. Pelter has a background in surface chemistry and catalysis from the petroleum industry.
- Harvey Abramowitz (Ph.D.), Professor, Department of Mechanical Engineering, Purdue University Calumet. Dr. Abramowitz has had extensive experience in metallurgy and steel making processes in general.
- Hardarshan Valia (Ph.D.), President, Coal Science, Inc. Dr. Valia serves as a team member and consultant to the project. He has extensive experience in the steel industry and specifically in the utilization of coal and the coking process. He also has experience with various production and economic aspects of both the coal and steel industry.
- Chenn Zhou (Ph.D.), Head of Mechanical Engineering Purdue University Calumet. Dr. Zhou is an expert in computational fluid dynamics.

Process Value Streams



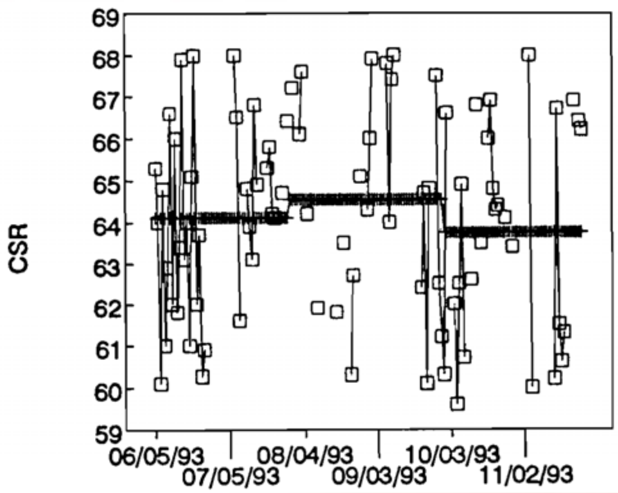
Coke Oven

Coal Blending Is Key to Using Indiana Coal For Coke Production

Table VII: Analytical data for selected Indiana-Illinois coals

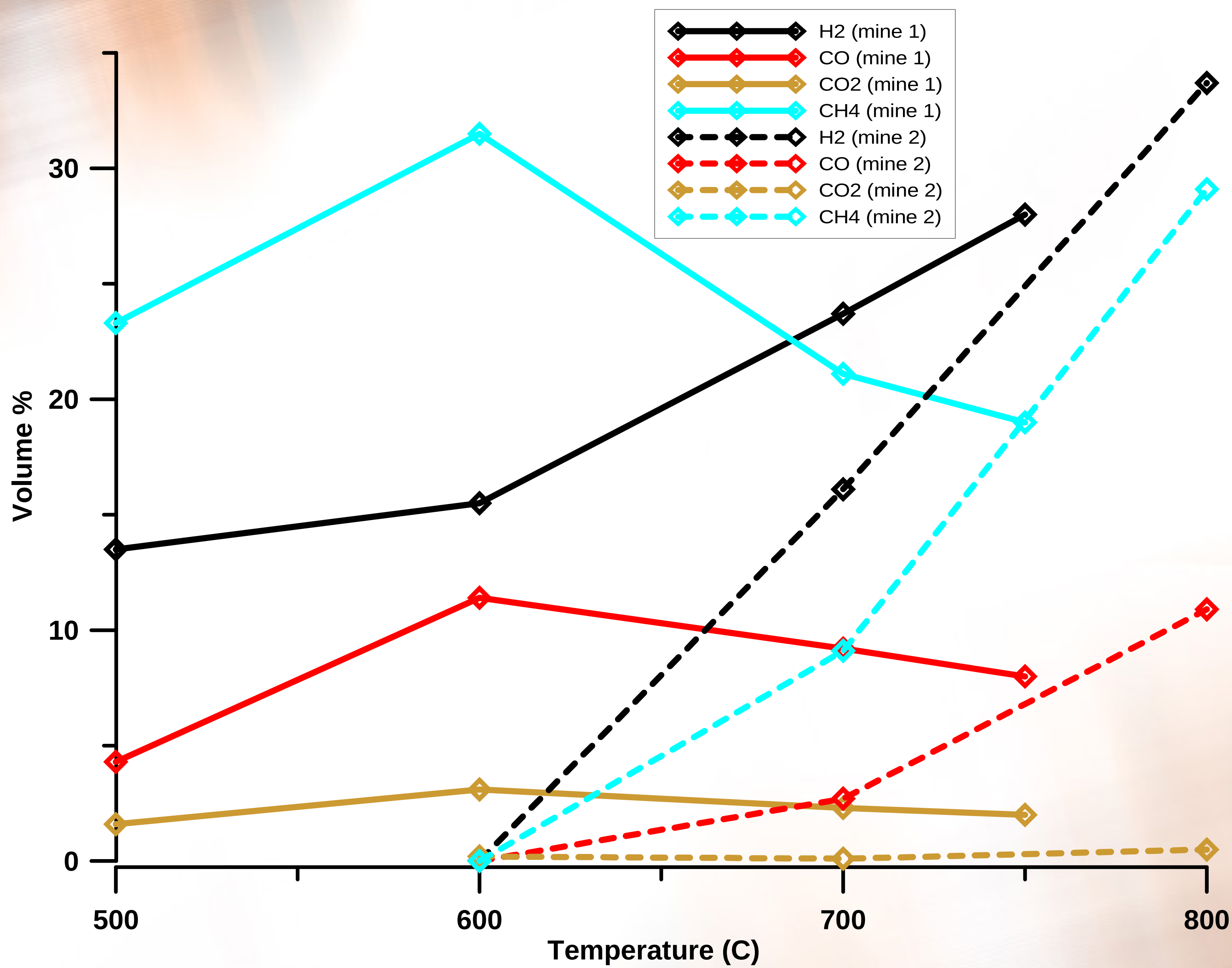
	Coal A	Coal B	Coal C	Coal D	Coal E
Petrography					
T. Inerts(%)	18.91	23.38	22.22	10.82	10.22
O. Inerts(%)	15.03	18.63	19.29	6.21	6.82
Exinite (%)	12.80	8.0	11.40	4.20	4.20
Reflectance(%)	0.56	0.55	0.63	0.58	0.65
Inert Index	0.84	1.11	0.96	0.43	0.37
Rank Index	2.54	2.43	2.57	2.45	2.52
P. Stability	12(33)	4	11(25)	19(33)	25(31)
USSCBI	0.84	1.09	0.97	0.44	0.38
USSSI	2.57	2.49	2.62	2.48	2.54
USS P.Stab.	21	17	24	5.22	4.49
Chemistry					
V.M.(%,db)	37.5	36.3	37.0	36.50	35.80
F.C.(%,db)	55.6	54.9	58.0	55.40	58.40
Ash(%,db)	7.0	8.8	5.0	8.1	5.8
Sulfur(%,db)	0.62	0.75	0.86	0.86	1.04
FSI	1.5	1.0	4.0	2.0	2.0
Alkali Index	0.78	0.85	0.92	1.53	1.33
Phophorus(%)	0.043	0.037	0.005	0.007	0.009
Rheology					
F.Range(Deg.C)	64	52	54	53	41
M.F.(ddpm)	48	30	24	5	3
P. CSR	50(48)	43	42(46)	35(30)	28(27)

Blend of 23% Indiana coal - 37% Eastern High Volatile (EHV) coal - 40% Eastern Medium Volatile (EMV) coal



Source: Use Of Reverts And Non-Coking Coals
In Metallurgical Cofemaking, H.S. Valia and W. Hooper,
1994 Iron Making Conference Proceedings

Initial Indiana Coal Test Results



Coke Oven Gas

- One metric ton of coal typically produces 600-800 kg of blast-furnace coke and 296-358 m^3 of coke oven gas.*
- 2005 forecasts indicate that the US will produce 11,500,000 net tons of coke, but will require 17,000,000 net tons for blast furnace, foundry, and related uses.
  - At present, essentially no Indiana coal is being used for coke production. In 2002, Indiana's steel industry used an estimated 10.7 million tons of coal.
    - 8.1 million tons was used for coke production.
    - Most from West Virginia and Virginia.

*The Making Shaping and Treating of Steel, Association of Iron and Steel Engineers, Herbick & Held, Pittsburgh, 1985.

Economic and Quality Process Optimization

- Develop model that for blending coals in way that maximizes Indiana/Illinois Basin coal percentage (minimizes cost) within constraints
  - Maintain acceptable CSR levels
  - Produce pyrolysis gas streams at various temperatures that have composition suitable for producing Fischer Tropsch liquids, fertilizer, and bulk hydrogen
  - Electricity production
- Use the Model to formulate the design for a multipurpose coking facility that maximizes value for the entire process while meeting operating requirements
- Continue development of new approach to using nut coke in blast furnace operations that maximizes use of Indiana/Illinois Basin coal

Zones of a blast furnace

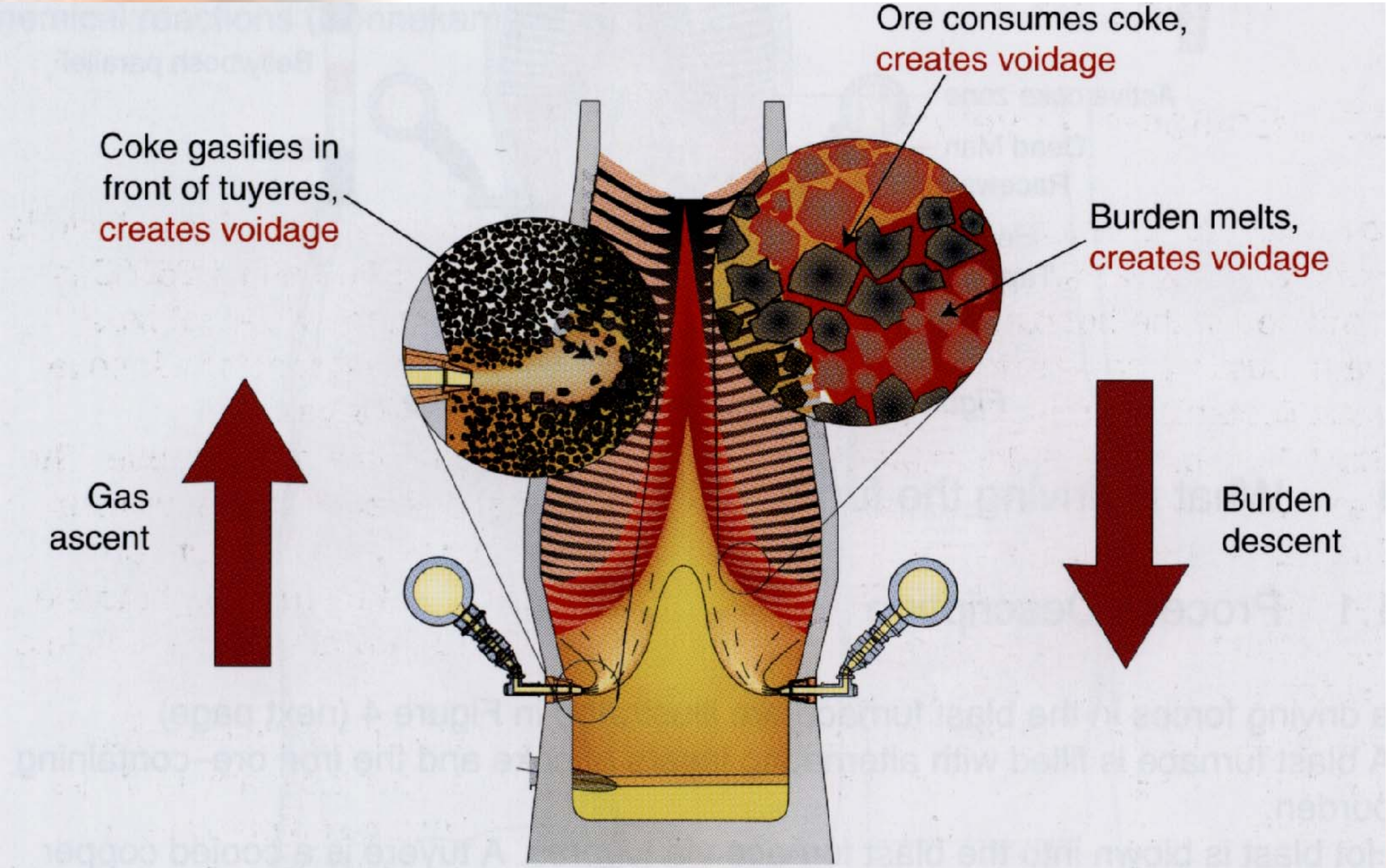
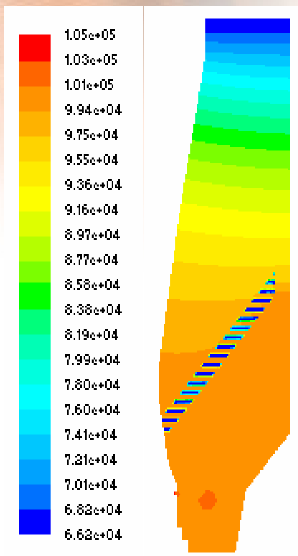


Figure 4: The driving force of a blast furnace: the counter current process creates voidage at the indicated areas causing the burden to descend

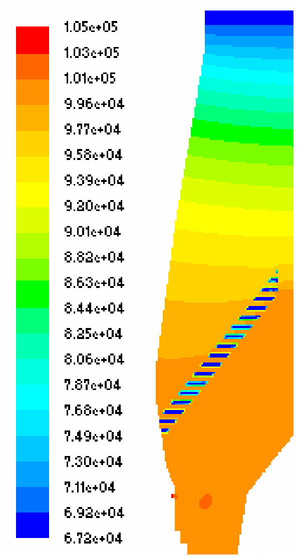
Source: Modern Blast Furnace Ironmaking, Verlag Stahleisen GmbH, 2004

CFD Results

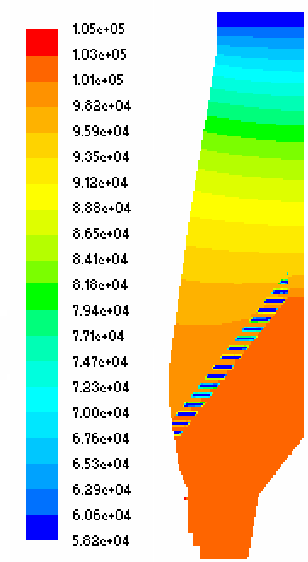
Pressure Drop



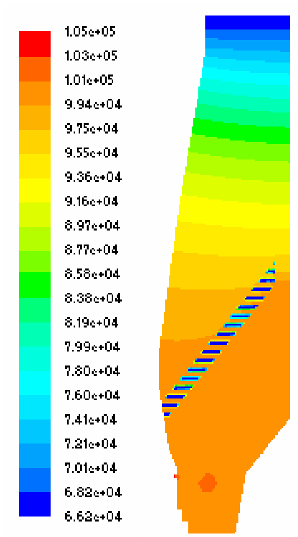
a) Coke porosity = 0.5



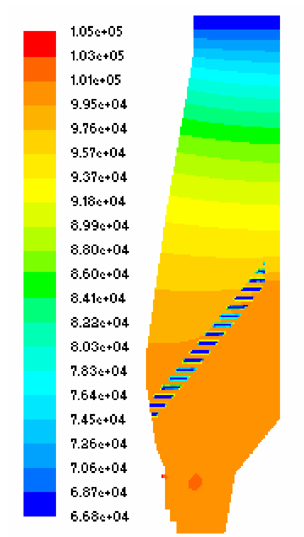
(b) Coke porosity = 0.65



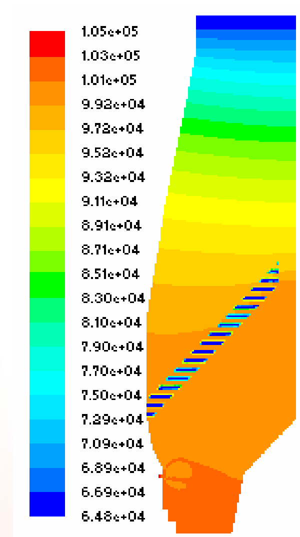
(c) Coke Porosity = 0.3



(d) Coke dia = 0.038m



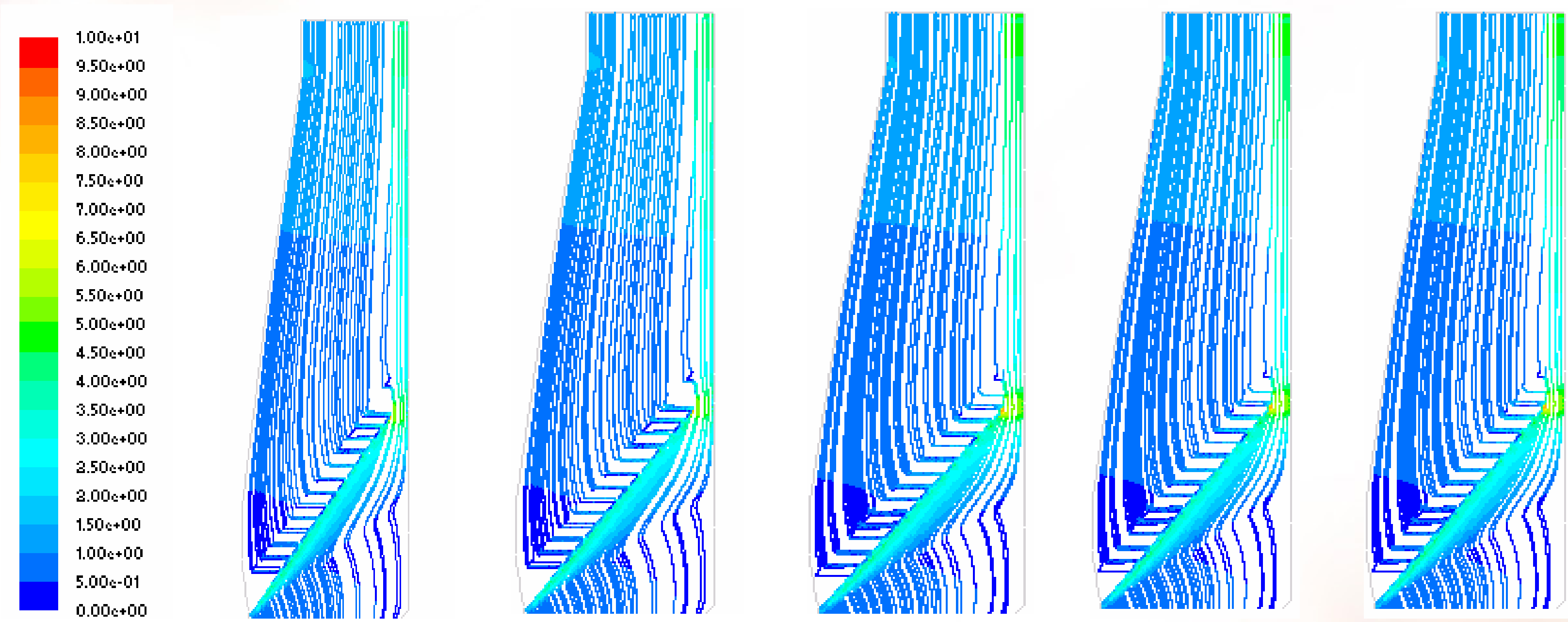
(e) Coke dia = 0.06m



(f) Coke dia = 0.02

CFD Results

Path lines for different coke properties



Porosity – 0.5

Coke dia – 0.038m   Coke dia – 0.02m   Coke dia – 0.06m   Porosity – 0.3   Porosity – 0.65

Initial Test Setup

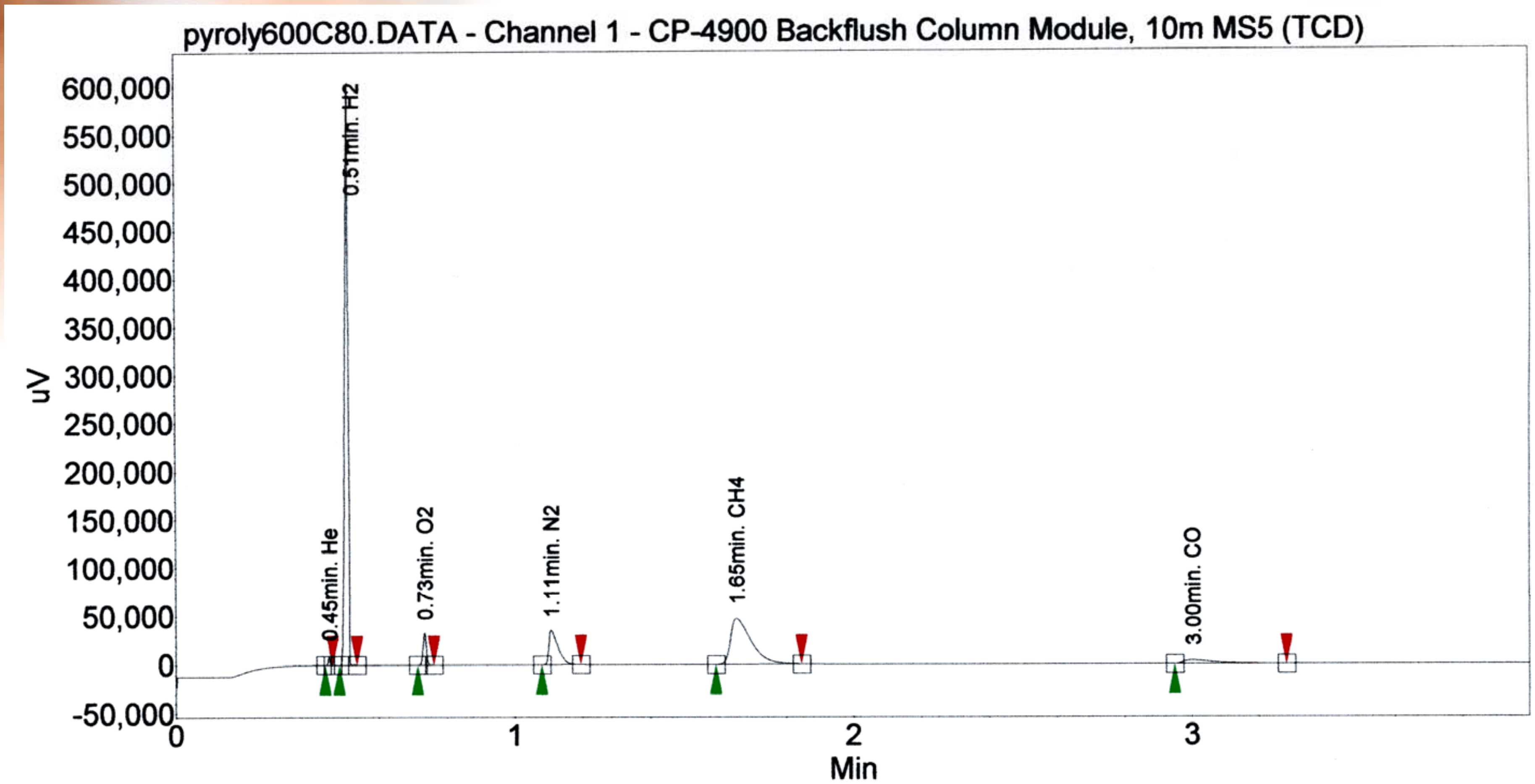
Post Initial Test

New Design

Current GC for Gas Analysis

GC for Next Testing Stage

Pyrolysis Chromatogram



CSL Pilot Oven

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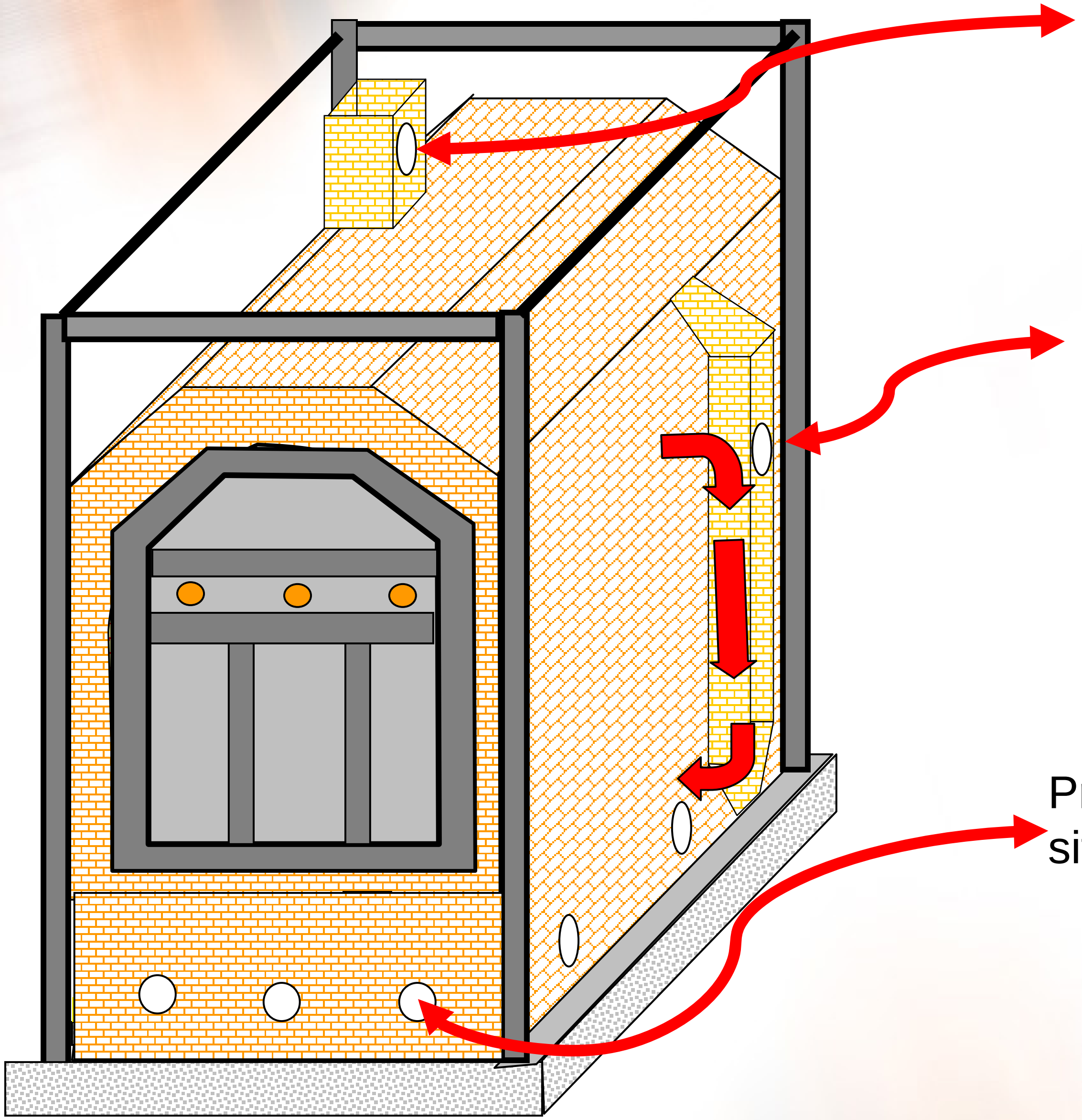
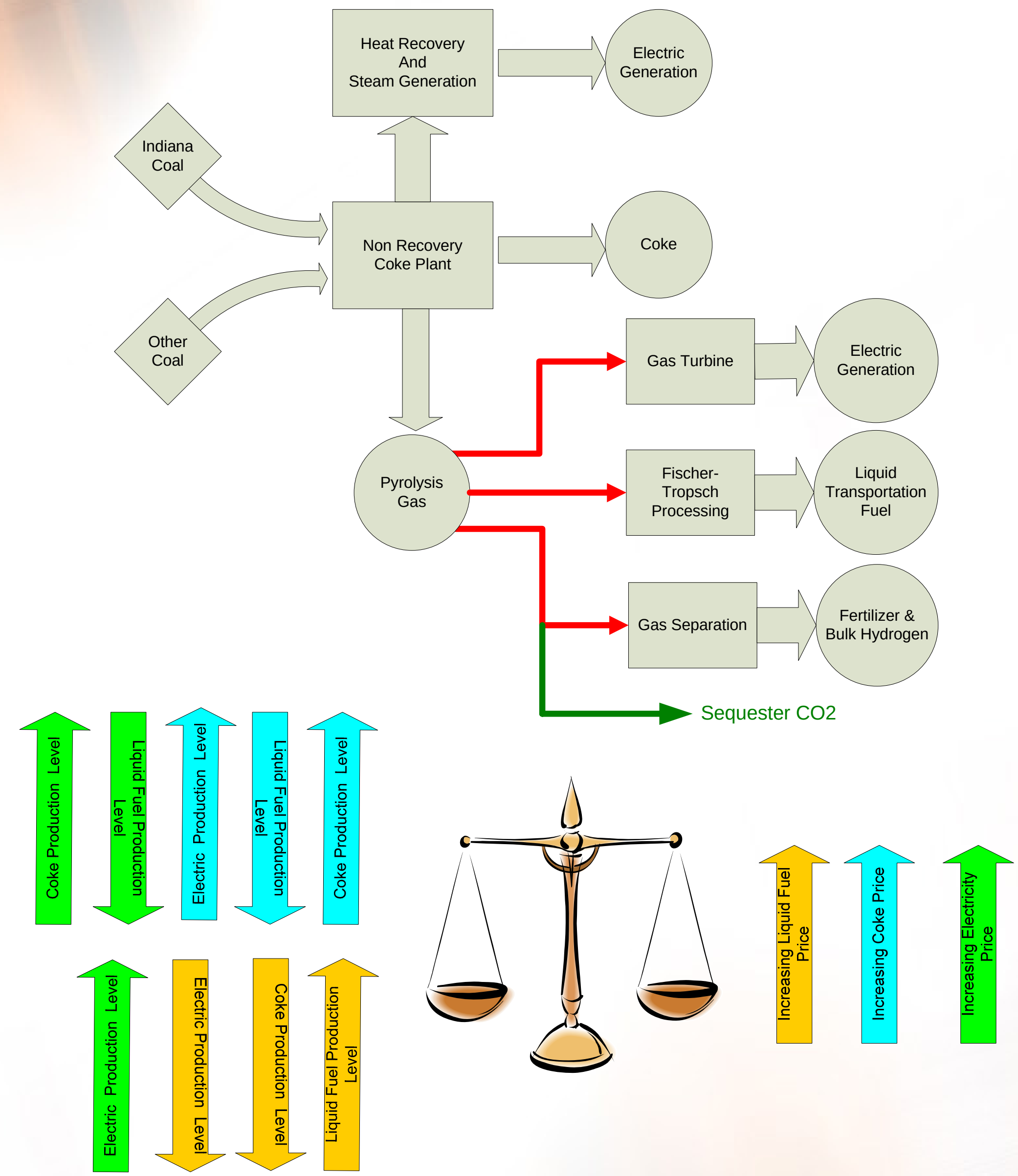


Process Value Streams



Future Work Objectives

- Phase 2 can be started in 2007
- Additional funding required
- Ongoing discussions with potential industrial collaborators
- Develop optimization model for minimizing cost by maximizing Indiana/Illinois Basin coal use, coke properties, and value streams
- Obtain more test data for coal samples
- Start one ton oven testing
- Fischer-Tropsch unit design, construction, and installation
- Fertilizer concept development and testing
- Bulk H concept development and testing
- Consider environmental issues in more detail
- Continue discussions for potential commercialization at mine mouth (or other) multipurpose coke facility

Thank You !

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