



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

*industrial technologies program*

# U.S Department of Energy Mining Industry of the Future

## Round II Projects



## industrial technologies program

### CastCon Process for Mining Applications

- **Principal Investigator:** X. Huang, R. Gertsch (co-PI) and J. Y. Hwang (co-PI), Michigan Technological University
- **NETL Project Manager:** Mike Mosser
- **Partners:**
  - The Robbins Group
  - Superior Bit Co.
  - Advanced Ceramics, Inc.
- **Total Project Cost:** **\$483K**
  - DOE Share: \$ 234K
  - Participant Share: \$ 249K
- **Project Period:** 42 months
- **Project Start Date:** 19 Dec. 2000

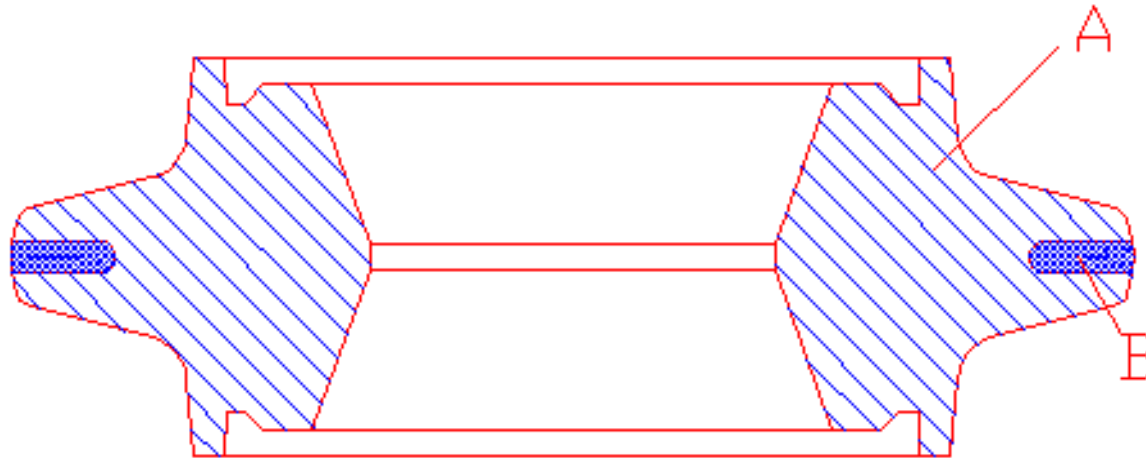


## Project Objectives

- Develop an effective means for producing rock drill bits and rock disc cutters that last longer, increase energy efficiency and penetration rate, and lower overall production cost
- Double the useful life of the vital components, increasing the energy efficiency from 10% to 30% per ton of rock fragmented and reducing total operation costs from 10% to 30%.



## Photo Library



The disc cutter body material (A) surrounding a hard material insert (B) will be HIPped in one step by the CastCon process.



## Milestones and Status

### Major Milestones Planned to Date/Status

<u>Planned Milestone</u>	<u>Scheduled</u>	<u>Completed</u>
– Begin initial process design	April 01	April 01
– Prototype unit lab test completed	Dec. 01	Dec. 02
– Prototype unit tested in mine	Dec. 03	Continuing
– Complete data analysis & unit design modifications	June 03	Dec. 03



## Key Accomplishments

- **Progress to Date Highlights**

Ten full size 6.5” disc cutters have been produced. Five of them contain WC inserts and the others are made of H13 tool steel powder only for comparison purposes. One disc cutter with WC inserts was machined to final dimensions.



## industrial technologies program

### Comminution Circuit Optimization

- Principal Investigator: **S. K. Kawatra, Michigan Technological University**
- NETL Project Manager: **Mike Mosser**
- Partners:
  - Badger Mining Corp.
  - Cleveland Cliffs Iron Co.
  - Derrick, Inc.
  - PERI
- Total Project Cost: \$1,054K
  - DOE Share: \$ 449K
  - Participant Share: \$ 605K
- Project Period: 48 months (1 year extension)
- Project Start Date: 12 Dec. 2000



## Project Objectives

- Use comminution modeling to study methods for optimizing the product size distribution
- Determine methods to minimize generation of excessively fine material by modeling alternative circuit arrangements
- Determine whether new technologies, such as high-pressure roll crushing, can be used to alter particle breakage behavior



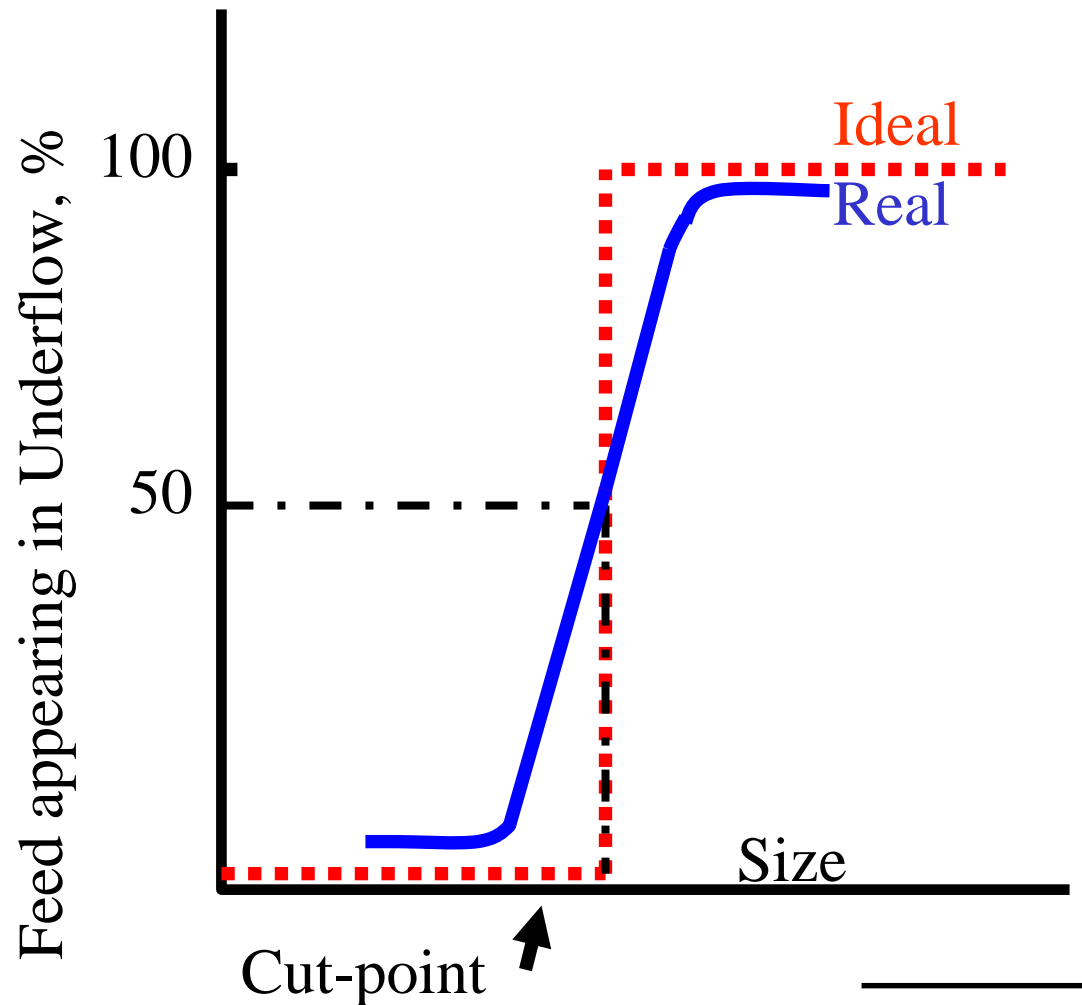


## Preventing Overgrinding

- In-plant sampling and hydrocyclone modeling has determined that the major source of overgrinding is the “fish-hook” behavior of the hydrocyclones, where particles that are already sufficiently ground are returned to the mills for further grinding rather than being removed.
- The use of a 2-stage hydrocyclone was examined as a possible method for reducing the effects of hydrocyclone “fish-hook” behavior.
- Mathematical models of the circuit were used to simulate the behavior of 2-stage hydrocyclones, in combination with a pebble mill model



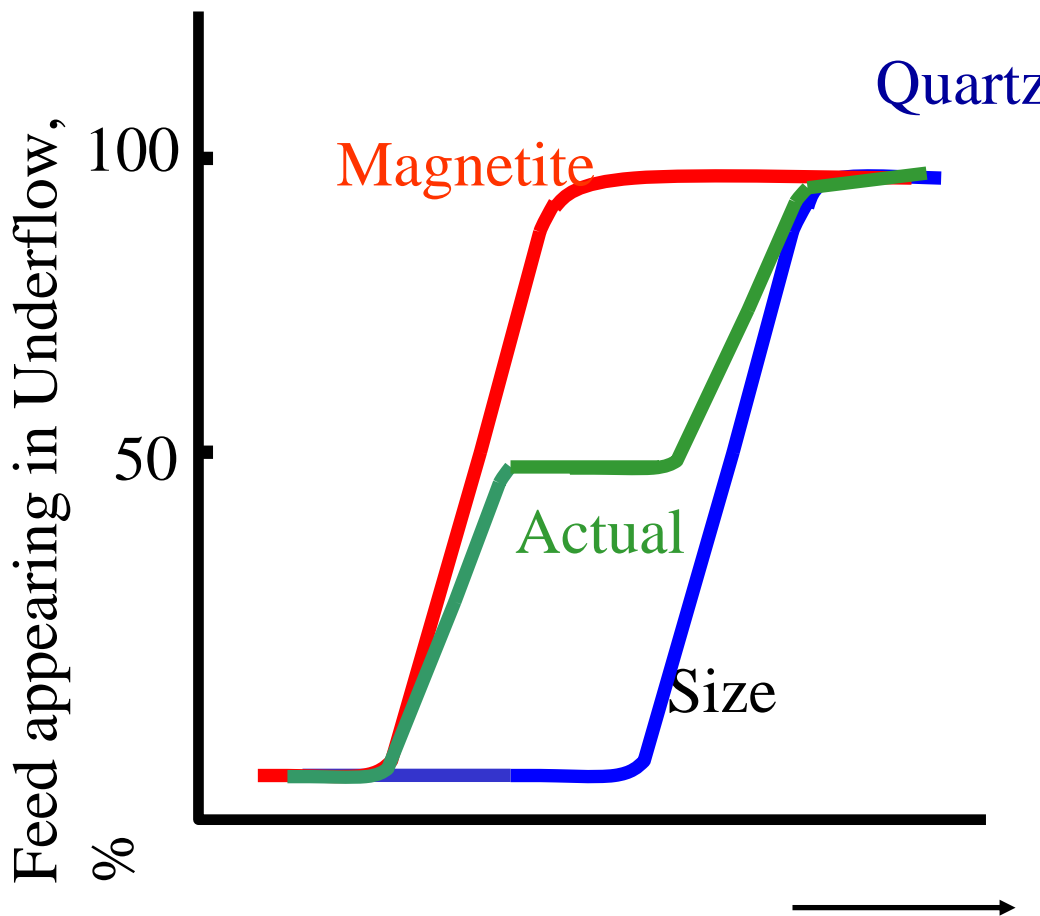
## Partition Curve



Partition curve for a cyclone is drawn by plotting the percentage of the feed reporting to the underflow, against the particle size



## Fish Hook



The “fish-hook” is due to the different behavior of high-density valuable minerals and low-density gangue in hydrocyclones.



## Pebble Mill Modeling

- In order to study the effect of hydrocyclone “fish-hook” behavior on comminution efficiency, models are needed for both the hydrocyclone, and the associated pebble mill
- Hydrocyclone model already developed, pebble mill model needed.
- The pebble mills modeled had the following characteristics:

– Number of mills in parallel		1
– Mill diameter inside shell (m)	4	
– Length/diameter ratio	2.1	
– Fraction of critical speed	0.8785	
– Mill discharge	Overflow	
– Filling of the mill (%)	43	
– Reference size for the wear function (mm)	15.875	
– Wear coefficient (0=surface, 1=volume)	0	
– Wear rate of pebbles (1/h)		3.45



## Pebble Mill Function Parameters

**Selection Function**

$$S_i = S_1^E e^{a_1 \ln\left(\frac{d_i}{d_{i(ref)}}\right) + a_2 \left(\ln\left(\frac{d_i}{d_{i(ref)}}\right)\right)^2}$$

**Where**

- $S_i$  is the fraction of particles in size fraction  $i$  that are broken
- $d_i$  is the geometric mean particle diameter of size fraction  $i$
- $d_{i(ref)}$  is the reference particle size class
- Selection function parameters-constants obtained from fitted data
 

– $S_1^E$	0.75
– $a_1$	-1.5
– $a_2$	-0.5

**Breakage Function**

$$B_{ij} = \phi \left(\frac{x_{i-1}}{x_j}\right)^\gamma + (1 - \phi) \left(\frac{x_{i-1}}{x_j}\right)^\beta$$

**Where**

- $B_{ij}$  is the fraction of the mass of broken particles from size fraction  $i$  that reports to size fraction  $j$
- $x_i$  is the top size limit of size fraction  $i$
- Breakage function parameters-constants obtained from fitted data
 

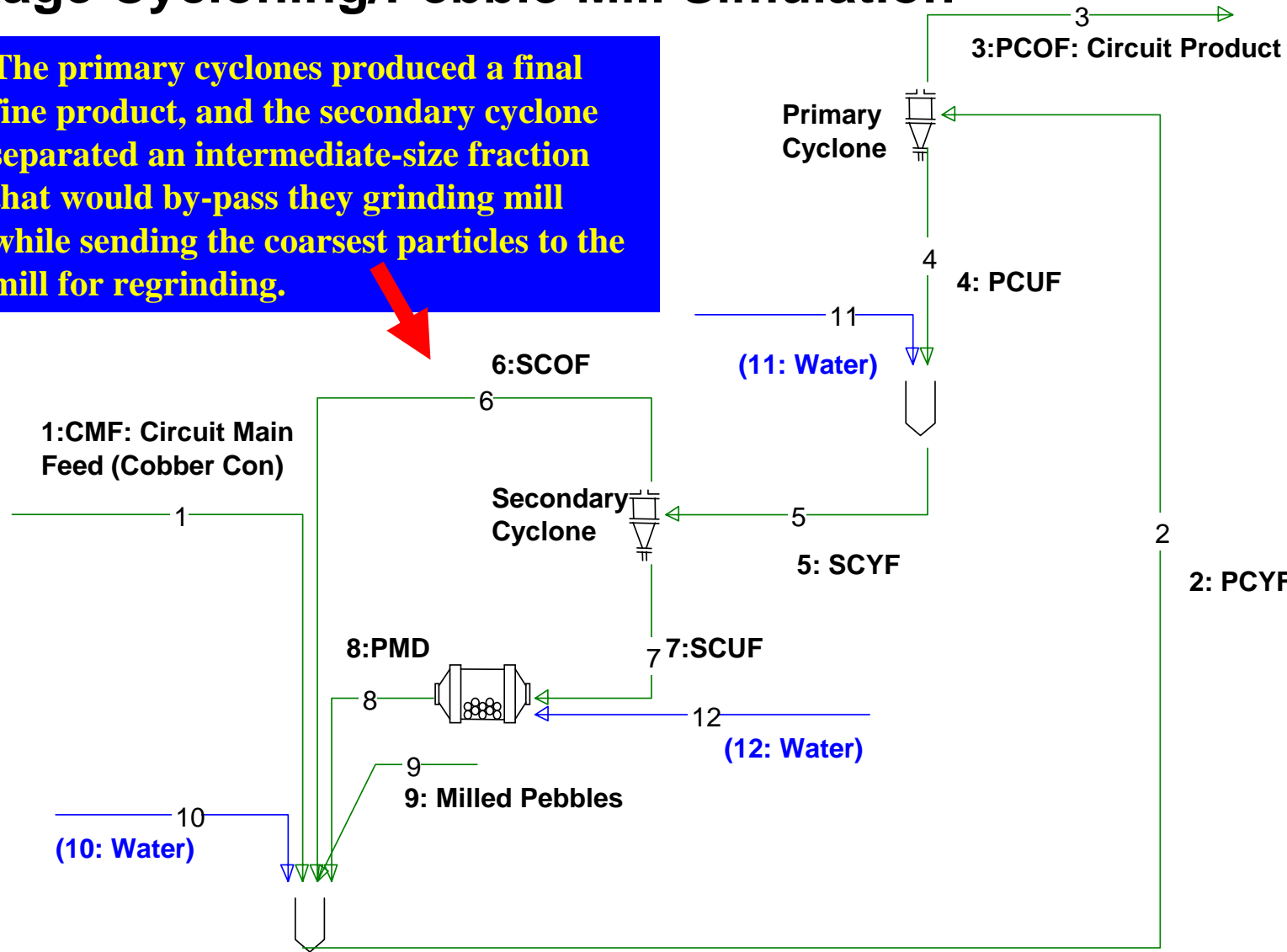
– $\phi$	0.096
– $\beta$	3.93
– $\gamma$	0.608

**Pebble Mill Model**



# 2-stage Cycloning/Pebble Mill Simulation

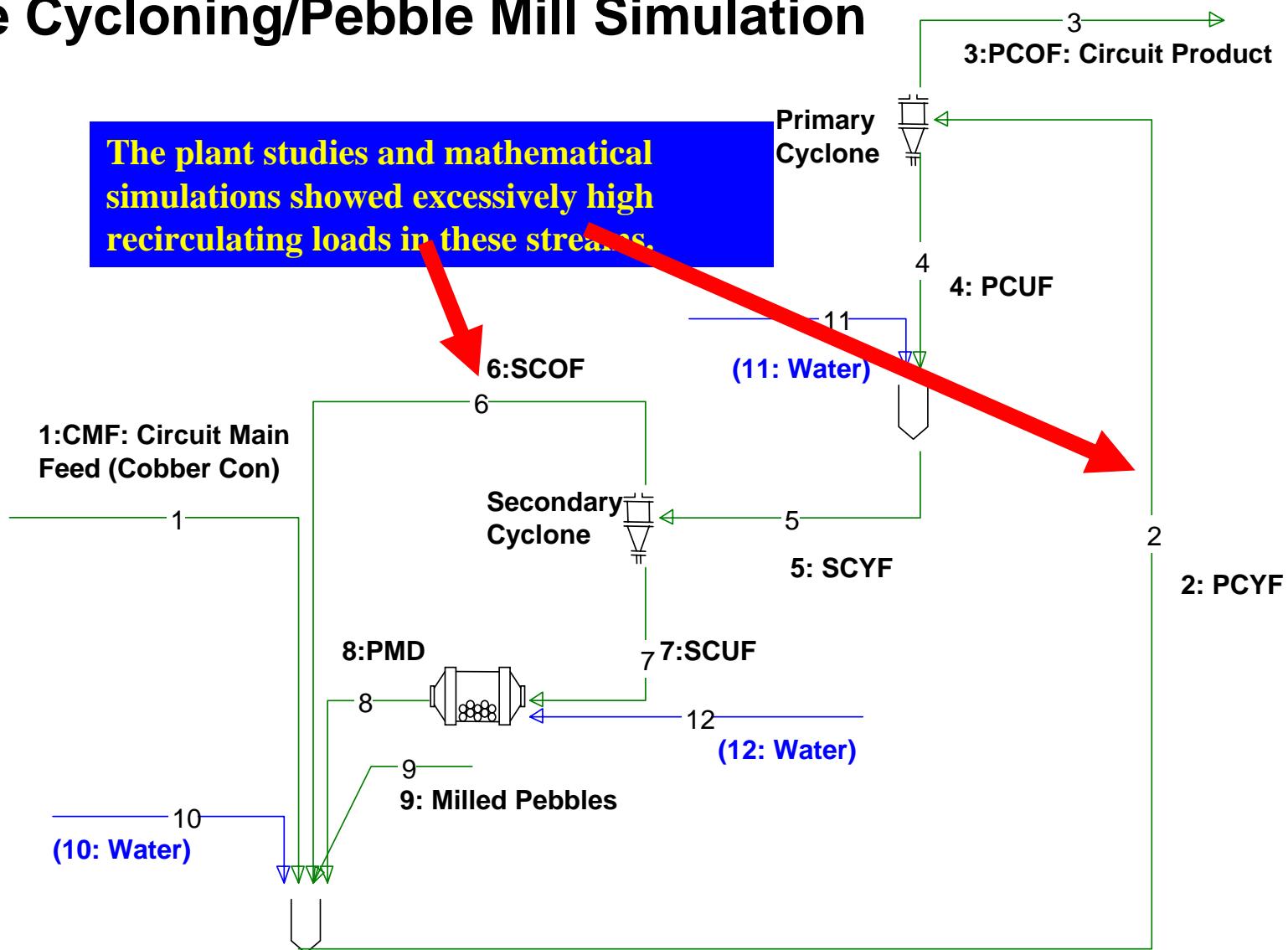
The primary cyclones produced a final fine product, and the secondary cyclone separated an intermediate-size fraction that would by-pass they grinding mill while sending the coarsest particles to the mill for regrinding.





# 2-stage Cycloning/Pebble Mill Simulation

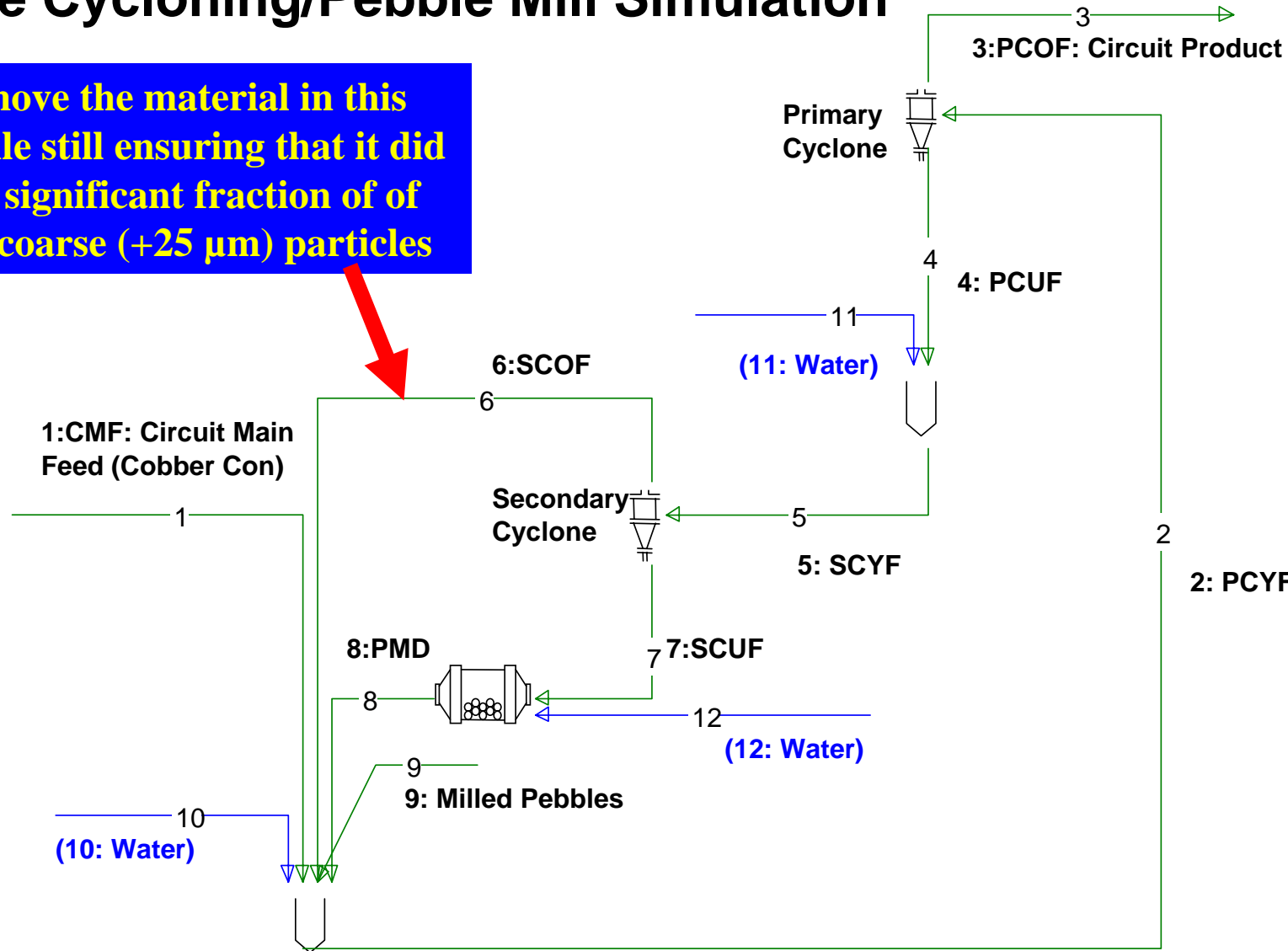
The plant studies and mathematical simulations showed excessively high recirculating loads in these streams.





# 2-stage Cycloning/Pebble Mill Simulation

Need to remove the material in this stream, while still ensuring that it did not contain significant fraction of excessively coarse (+25  $\mu\text{m}$ ) particles



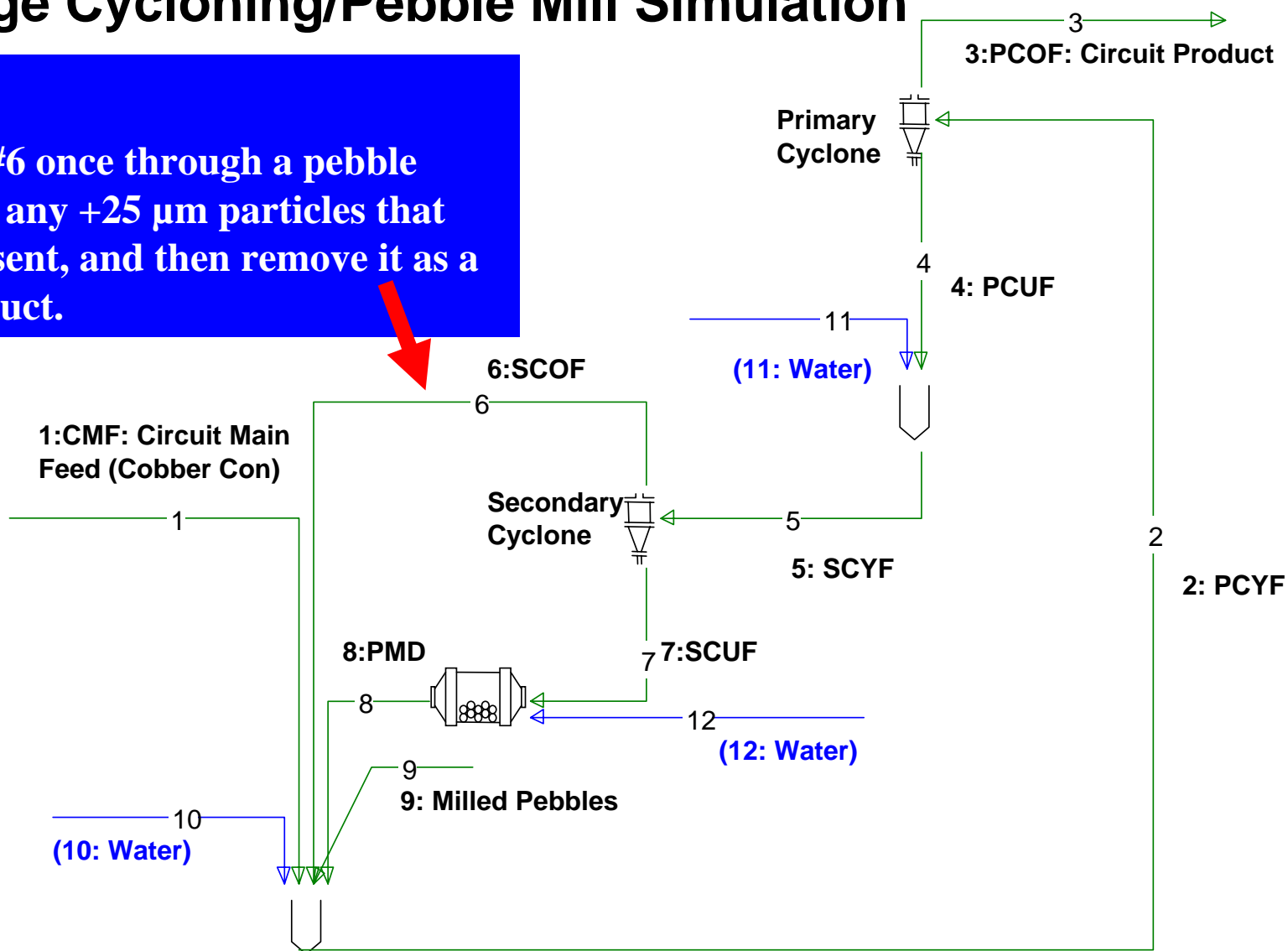




# 2-stage Cycloning/Pebble Mill Simulation

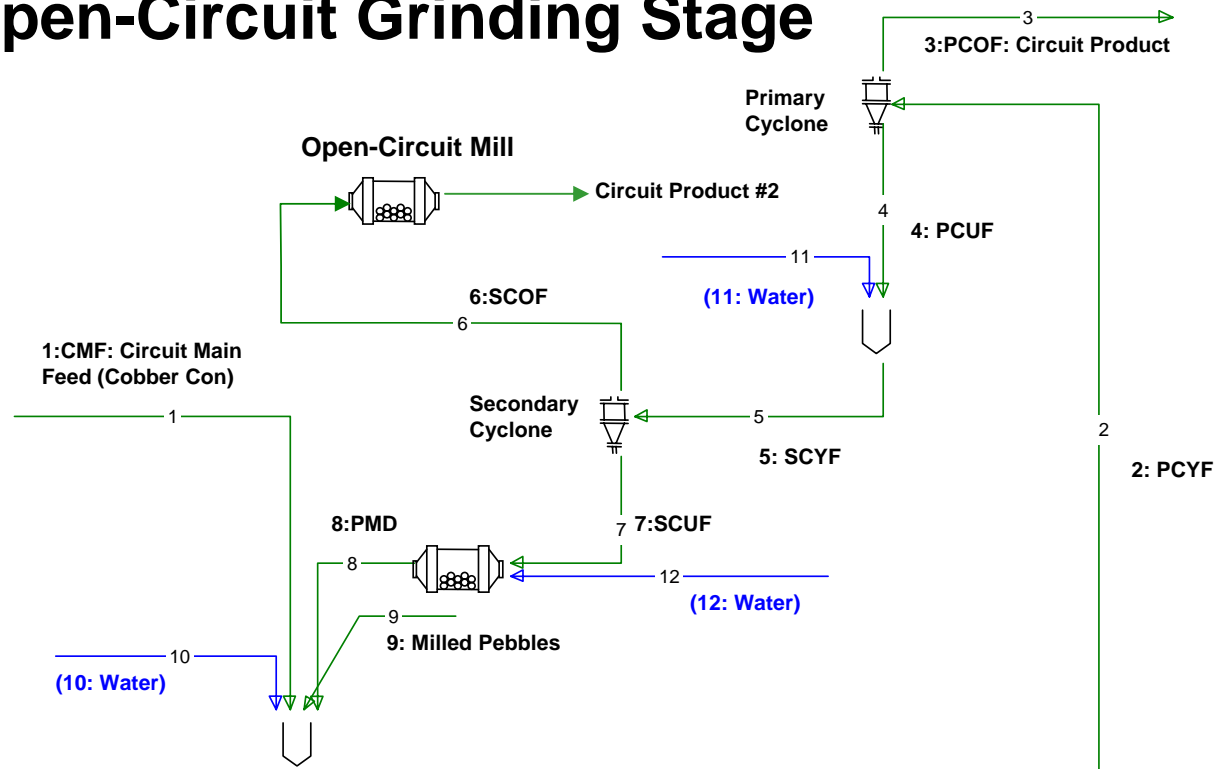
## Approach:

Pass stream #6 once through a pebble mill, to grind any +25  $\mu\text{m}$  particles that might be present, and then remove it as a finished product.





## 2-stage Cycloning/Pebble Mill Simulation with Open-Circuit Grinding Stage



- In this series of simulations, the circuit was modeled with stream #6 diverted to an open-circuit grinding mill, and then removed as a finished product. This prevented the particles in this stream from building up in a recirculating load
- The size distribution used in the simulation of the open-circuit mill was determined from plant samples collected during the previous full-scale trials of 2-stage cycloning.

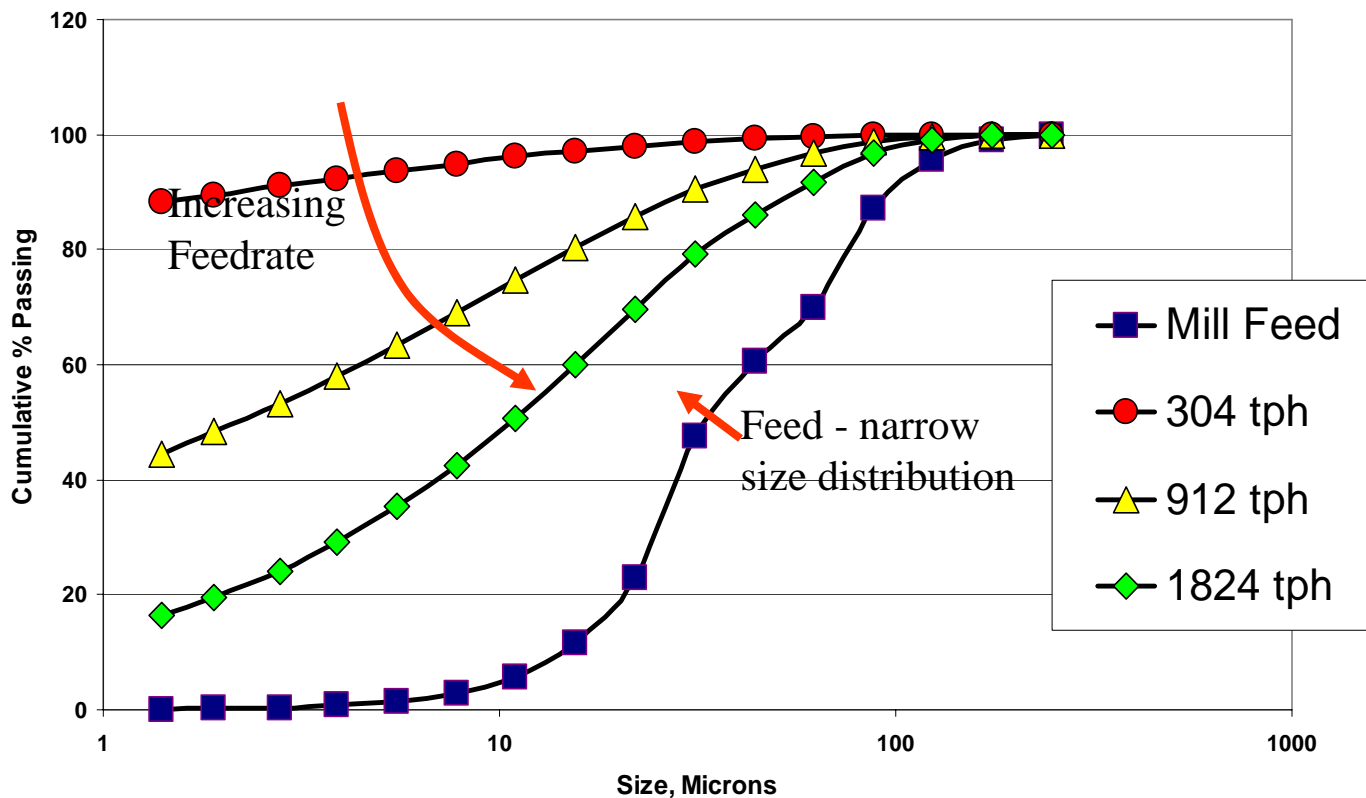


## Mill Feed

- Initial simulation was only of the open-circuit mill, to determine how it would behave with the product from the two-stage cycloning.
- “Mill Feed” is the size distribution of the intermediate-size particles that were removed by the second stage hydrocyclone . This was a narrow size distribution, consisting primarily of particles between  $10\ \mu\text{m}$  and  $100\ \mu\text{m}$ .

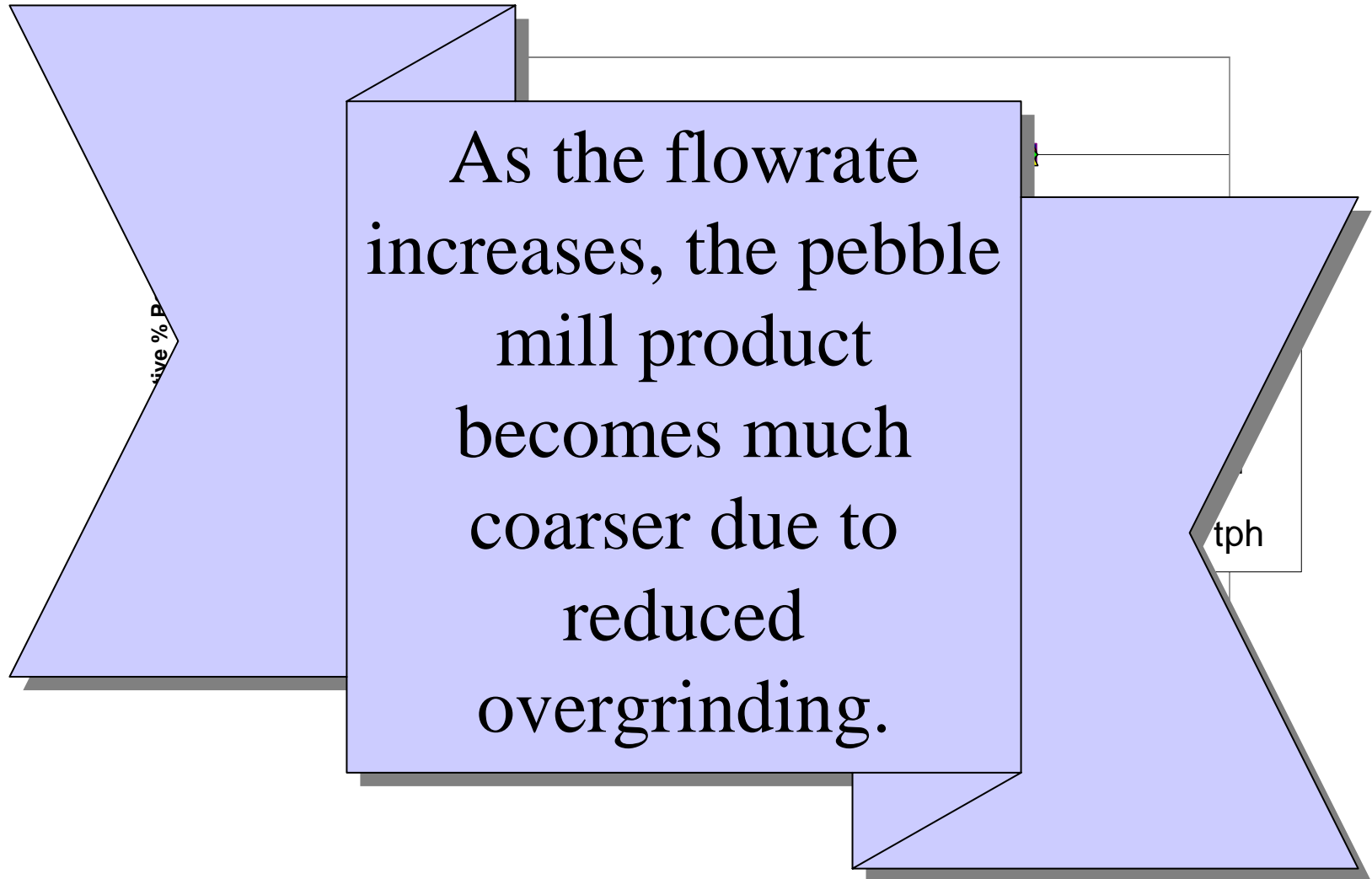


# Simulation Results for Open-Circuit Grinding of 2-stage Cyclone Intermediate Size Product (Stream #6)





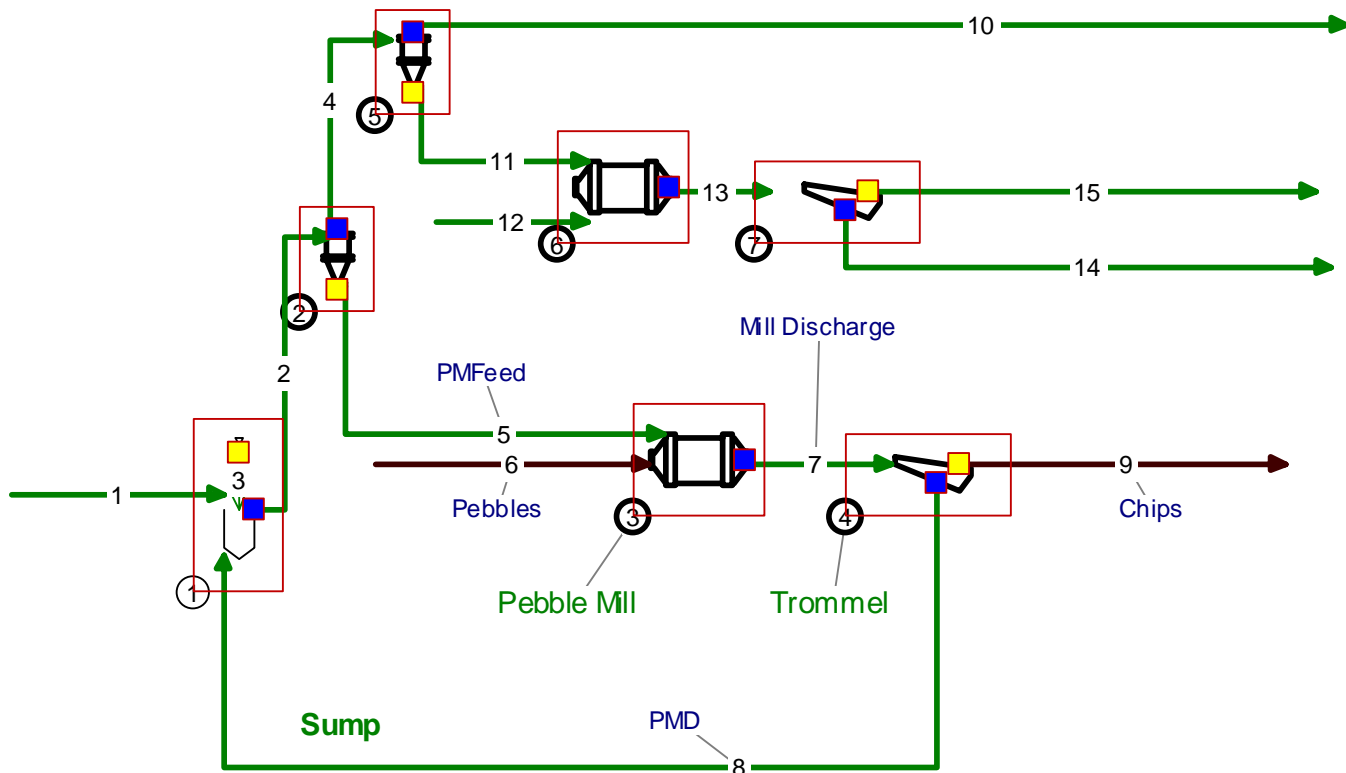
## Simulation Results for Open-Circuit Grinding of 2-stage Cyclone Intermediate Size Product (Stream #6)





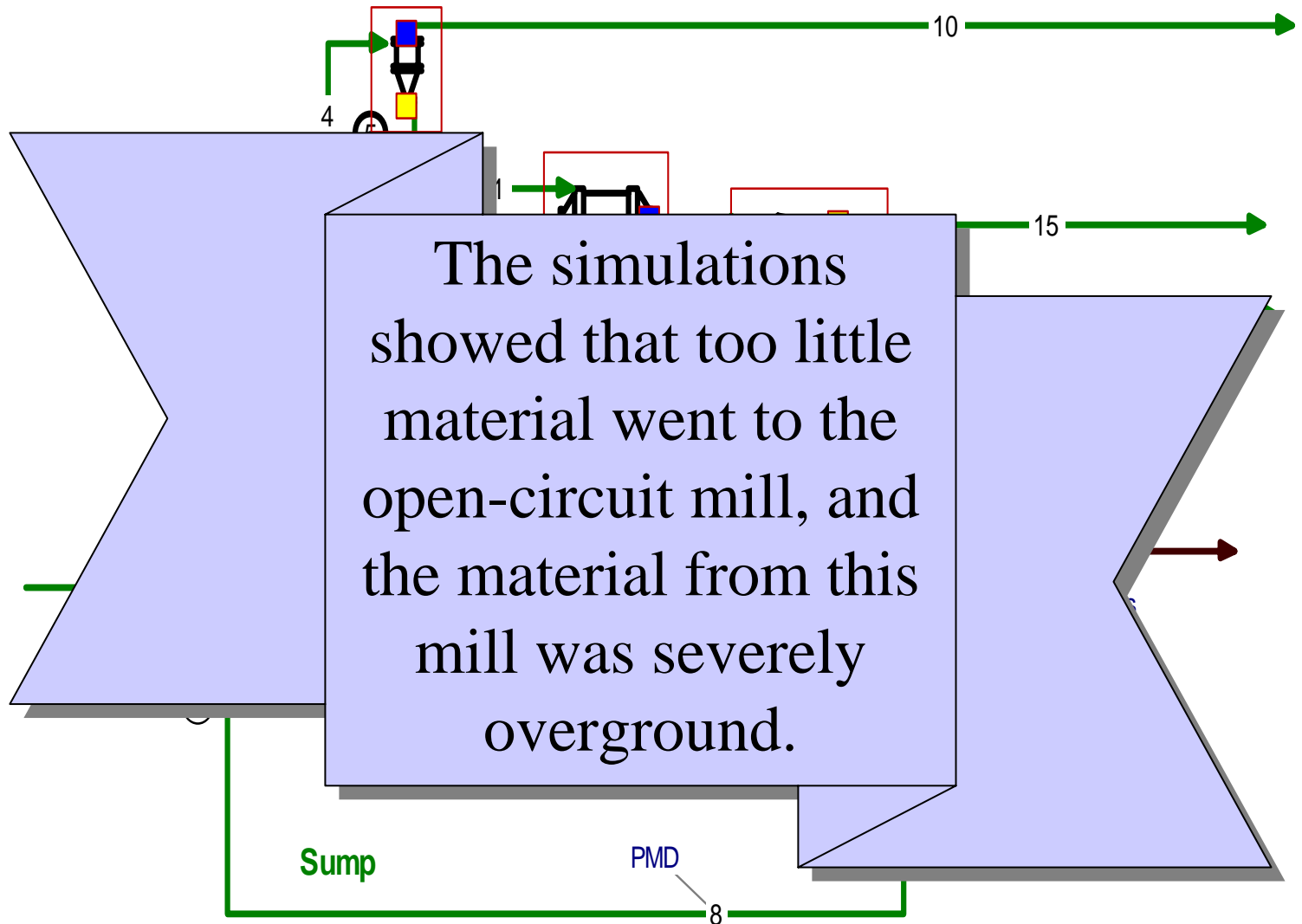
## Circuit Configuration Modeled

- Incorporation of the open-circuit mill with the closed circuit mill and 2-stage cyclones.
- This configuration provides feeds to both mills at a sufficiently high percentage solids for proper mill operation.





## Circuit Configuration Modeled





## Adjustment of Feedrates

- Original number of equipment units present in the plant:
  - Four 26-inch cyclones
  - Fourteen 15-inch cyclones
  - Two pebble mills (one closed-circuit, one open-circuit)
- Feedrate to the simulated circuit, and the number of cyclones, were both increased so that more material could be diverted to the open-circuit mill.



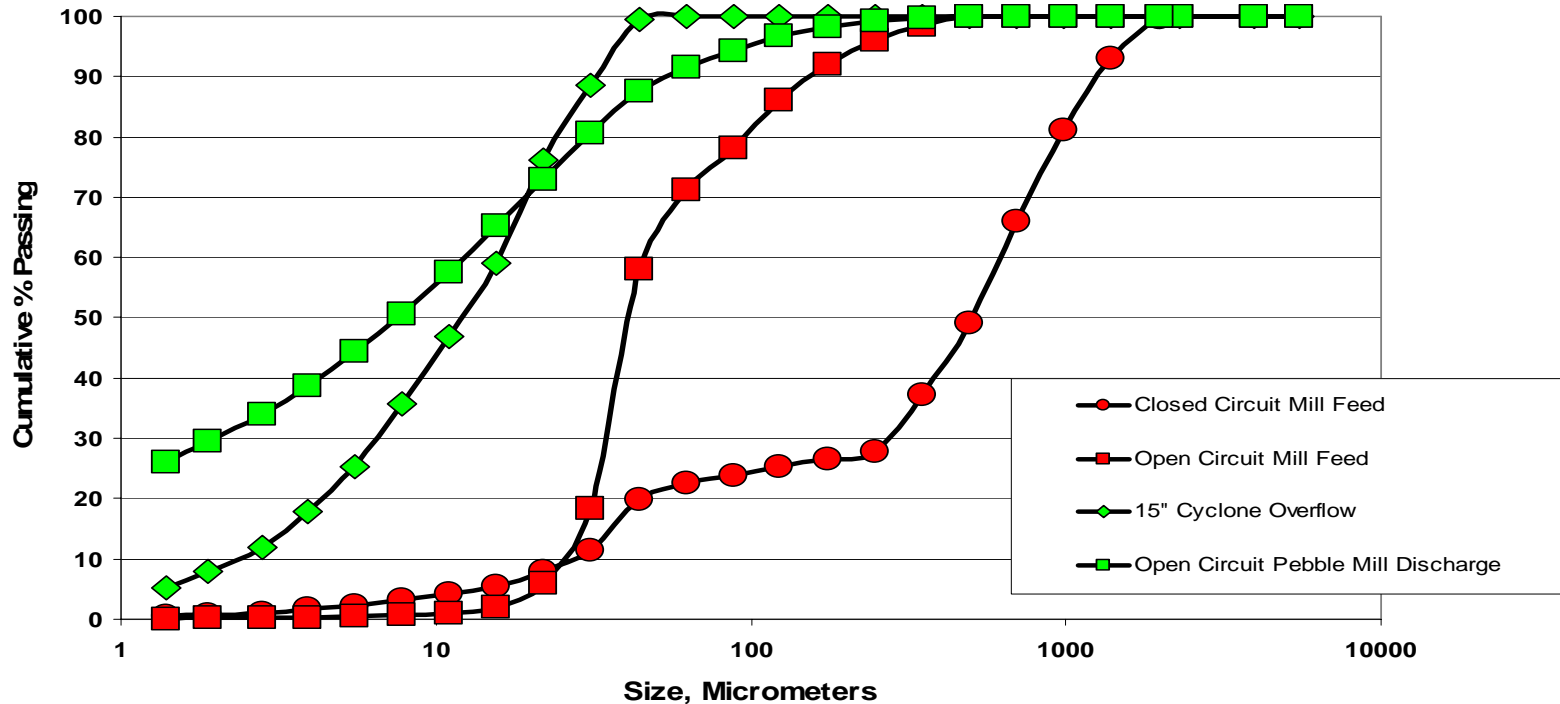


## Adjustment of Feedrates

- Original number of equipment units present in the plant:
  - Four 26-inch cyclones
  - Fourteen 15-inch cyclones
  - Two pebble mills (one closed-circuit, one open-circuit)
- In this configuration, simulations showed that too little material went to the open-circuit mill, and the material from this mill was severely overground.
- Feedrate to the simulated circuit, and the number of cyclones, were both increased so that more material could be diverted to the open-circuit mill.



# Simulation Results for Combined Open/Closed Circuit Grinding



➡ Open circuit mill product is predicted by the simulation to be a broader size distribution than the 15-inch hydrocyclone overflow, but the two products are quite similar. The approach appears to be promising, and further simulations are underway to determine how best to implement the results in the plant.



## Conclusions to Date from the Simulations

- In order to address the overgrinding caused by the “fish-hook” behavior of the hydrocyclones, it is necessary to remove the intermediate-sized magnetite that the hydrocyclones otherwise preferentially return to the grinding mills.
- Open-circuit grinding of a narrow size fraction from the pebble mill feed is a potential solution to overgrinding:
  - Either very high flowrates, or a smaller pebble mill, is needed to keep the open-circuit mill from severely overgrinding the feed.
  - The model predicts that open-circuit grinding of the narrow size distribution will require very fine grinding to completely break down the coarser locked particles.
  - Data for very fine particles is not yet available for model validation, and so the model may be overestimating the amount of material produced at the finest particle sizes.
  - The needed validation data is currently being obtained from the most recent plant sampling results.



## Milestones and Status

### Major Milestones Planned to Date/Status

#### Planned Milestone

- Hydrocyclone modeling
- In-Plant Experimentation
- Final Validation of Models
- Evaluation of advanced technologies
- Final Report

#### Status

Sept. 03 (Completed)  
Aug. 04  
Aug. 04  
Nov. 04  
Dec. 04

Mathematical model for classification of 2-component mixture validated, using controlled experiments with mixed-density materials processed in a laboratory hydrocyclone.

Modeling of the fine screen proposed for use in the plant will begin in the coming quarter.

Planning is proceeding for in-plant testing of a significant circuit modification which simulation work has indicated will significantly improve circuit efficiency and throughput.



## Milestones and Status

- Key Decision Points Remaining

<i>Decision Point</i>	<i>Scheduled Date</i>	<i>Is it a go/no-go decision?</i>
Advanced Technology Evaluation	08/2004	N



## Key Accomplishments

- Progress to Date Highlights
  - Model has predicted a method for altering grinding circuits to improve throughput and energy efficiency, by allowing grinding load to be shifted within the circuit as ore characteristics change.
  - Overgrinding has been conclusively demonstrated to be resulting from the “fish-hook” performance of the hydrocyclones, which causes liberated high-density particles to be recirculated to the grinding mill rather than being removed from the circuit
  - Circuit model is being used to examine the benefits of combined open/closed circuit mill operation in combination with 2-stage cycloning, to reduce or eliminate the overgrinding caused by the “fish-hook” behavior.



# Project Recognition

- T. E. Davis, T. C. Eisele, G. Rajala, S. K. Kawatra, T. P. Weldum, and H. J. Walqui, “Shifting of Grinding Power Load in Comminution Circuits”, Presented at the 2004 SME Annual Meeting, Denver, Colorado, Feb. 22-26
- T. C. Eisele, S. K. Kawatra, “Simulations of 2-Stage Cycloning with Open Circuit Pebble Mill Grinding”, Presented to industrial personnel at Michigan Tech. University, Dec. 22, 2003
- T. C. Eisele, H. J. Walqui, S. K. Kawatra, “Equation to Predict Throughput at Empire IV”, Presented at Empire Mining Co., Palmer, MI, May 24, 2003
- T. C. Eisele, H. J. Walqui, S. K. Kawatra, “Model for Projecting Comminution Circuit Throughput”, Presented at Michigan Tech. University, March 27, 2003
- T. C. Eisele, H. J. Walqui, S. K. Kawatra, “Increasing Comminution Circuit Throughput at Empire”, Presented at Empire Coal Co., Palmer, MI, Dec. 5, 2002
- T. C. Eisele, H. J. Walqui, S. K. Kawatra, “Progress of Comminution Studies at Empire”, Presented at Michigan Tech. University, Sept. 25, 2002
- H. J. Walqui, Mathematical Modeling of Coal Pulverizers using Population Balance Models, M.S. Thesis, Michigan Technological University, August, 2001
- Walqui, H.J., Kawatra, S.K., Eisele, T.C., “Development of Mathematical Models for Coal Pulverizers”, Application of Computers and Operations Research in the Mineral Industry - Proceedings of the 30th International Symposium, Edited by Sukumar Bandopadhyay, Published by the Society for Mining, Metallurgy and Exploration, Inc. Chapter 10 Process Control and Optimization, pp 503 – 510.
- H. J. Walqui, T. C. Eisele, and S. K. Kawatra, “Development of Mathematical Models for Coal Pulverization”, Presented at the SME Annual Meeting, Phoenix, AZ, Feb. 25-27, 2002.
- H.J. Walqui, S.K. Kawatra, “Modelamiento Matemático de Circuitos de Comminución”, Presented at Infomina 2002, Lima, Perú, September 17-20.



## Good News!

- Preparations are underway to test model predictions in a full-scale plant, to confirm that the grinding efficiency and throughput can be increased based on the modeling results.
- Feasibility tests have shown that the planned circuit modification is practical, and plant trials are being prepared.
- The circuit models are proving to be suitable for evaluating a range of circuit modifications that have the potential to reduce or eliminate overgrinding of liberated high-density minerals.





## Commercialization Outlook

- One of the industrial partners is preparing to make use of an improved throughput projection model developed in this project, and to evaluate a circuit modification that is predicted to increase throughput and improve energy efficiency. These results are therefore at the beginning of commercialization
- Commercialization will continue with adoption of the developed techniques by the industrial co-sponsors immediately after the project is completed.
- Results will be disseminated to industry through short courses and publications in the technical literature.



## industrial technologies program

# Computerized Roof Bolt System

- **Principal Investigator:** Syd Peng, West Virginia University
- **NETL Project Manager:** Mike Mosser
- **Partners:** CONSOL Inc., Commercial Stone Co. Inc., Ohio Valley Coal Co., J.H. Fletcher & Co., Newmont Mining Co., Riverton Coal Production Inc.
- **Total Project Cost:** \$1,352,338
  - DOE Share: \$563,504
  - Participant Share: \$788,834
- **Project Period:** 36 months
- **Project Start Date:** Dec. 18, 2000
  - No-cost time extension to 12/31/04



## Project Objectives

- Development of a computerized method to evaluate the roof geology and stability in real-time during roof bolting operations
- Roof bolt system design requirements will be developed. The real time evaluation of roof geology and stability conditions as well as design requirements for roof bolting systems will reduce roof falls
- The results will be used to develop a computer program that will work with the bolter for real time production of the mechanical properties, structures of roof strata and design requirements for roof bolt systems



## Milestones and Status

### Major Milestones Planned to Date/Status

<i>Planned Milestone</i>	<i>Scheduled</i>	<i>Completed</i>
Development of operator control technology	09/01/01	completed
Laboratory and underground testing	12/31/01	95% completed
Drilling parameter data analysis and correlation	10/01/03	85% completed
Software development for mapping of roof conditions.	10/01/03	90% Completed
Computer modeling to investigate the mechanisms	10/01/03	100% completed
Development of computerized bolting design system	10/01/03	80% completed



## Key Accomplishments

- **Project Highlights**

- Development of the systematic and mechanics-based approach for interpreting the drilling parameters is continuing.
- A method to use torque to thrust ratio as indicator of relative rock hardness and to identify the fractures and voids
- More field and laboratory tests are planned to



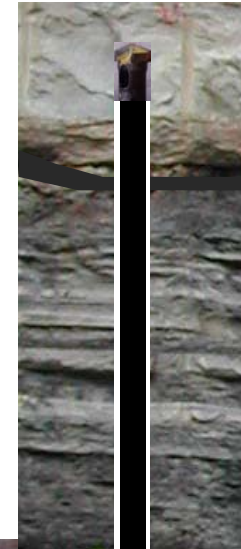
## Key Accomplishments

- **Project Highlights (cont'd)**
  - The development of a real-time roof geology mapping and bolt design program is well under way. This program is currently able to
    - Provide a number of ways to incorporate AutoCAD mine map into the mapping program and to show the interpretation results for easy comprehension.
    - Using the roof geology information, the suitability of the current roof bolting design will be assessed.
  - A special version of the geology mapping program for roof bolters in limestone mine has been developed and is in field testing stage



# Roof Bolting - Computerized Roof Bolt Design System

Development of a computerized method to evaluate the roof geology and stability in real-time during roof bolting operations.



**Sandstone**

**Crack**

**Laminated Shale**

**Shale**



**Drill Control Unit**



**Underground Testing**





## Roof Bolting - Computerized Roof Bolt Design System



The special version of *Mine Roof Geology Information System* (MRGIS) developed from this research is in field testing





## Project Recognition

- **Following technical papers have been presented at SME 2004 Annual Meeting held at Denver, CO, Feb. 23 – 25, 2004**
  - **“Roof Bolter Drilling Parameters as a Tool for Strata Prediction”**
  - **“Void Prediction in Mine Roof Geology Information System (MRGIS)”**
  - **“A Mechanical Approach to Estimate Roof Strata Strength from Bolting Drilling Parameters”**



## Good News!

1. Development of a systematic approach for estimating rock strengths is continuing.
2. It seems that the ratio of torque and thrust can be used as an indicator for relative rock hardness
3. Two methods for identifying voids have been developed and both worked very well
4. Development of roof geological mapping software is about 90% completed. This MRGIS provides a platform for incorporating the data interpretation methods developed and to display the interpretation results in engineer-friendly ways
5. A special version of the geology mapping program for a limestone mine has been developed and is in field testing stage



## industrial technologies program

### Dense Media Cyclone Optimization

- **Principal Investigator:** Gerald Luttrell, Virginia Polytechnic Institute & State University
- **NETL Project Manager:** Mike Mosser
- **Partners:**
  - Massey Coal Services
  - Partition Enterprises
  - Precision Testing Laboratories
- **Total Project Cost:** \$318,880
  - DOE Share: \$153,858
  - Participant Share: \$165,022
- **Project Period:** 36 months (closed)
- **Project Start Date:** December 14, 2000



## Project Objective

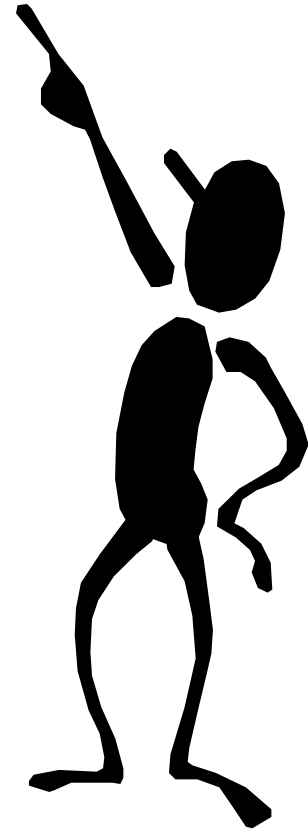
- ❑ To develop engineering tools to improve HMC performance.
- ❑ These include:
  - Low cost density tracers to rapidly assess HMC efficiency (used by plant engineers)
  - Process models to predict influence of operating and design variables (used by plant designers)
  - Model-based expert system to provide a user-friendly interface for troubleshooting HMC problems (used by equipment operators)





## Milestones and Status

- Task 1: Baseline Assessment **completed** using density tracers and sampling campaigns.
- Task 2: Circuit Modifications **completed**, including plant upgrades and new O&M practices.
- Task 3: Follow-Up Assessments **completed** on a monthly basis to track process improvements.
- Task 4: Sample Analyses **completed** for all samples from monthly and detailed test programs.
- Task 5: Data Analysis/Simulation **completed** for all plant sites using spreadsheet simulator.
- Task 6: HMC Expert System **completed** for plant training and trouble-shooting.
- Task 7: Concept Assessment is **being finalized** (final report and cost-sharing documents).





## Key Accomplishments (1)

- ❑ Project demonstrated that **Density Tracers** can rapidly assess HMC performance.
- ❑ Tracers added to HMC feed and collected by personnel on drain-and-rinse screens.
- ❑ Tracers make it possible to identify/correct problems that cause losses of clean coal or misplacement of rock into the final product.

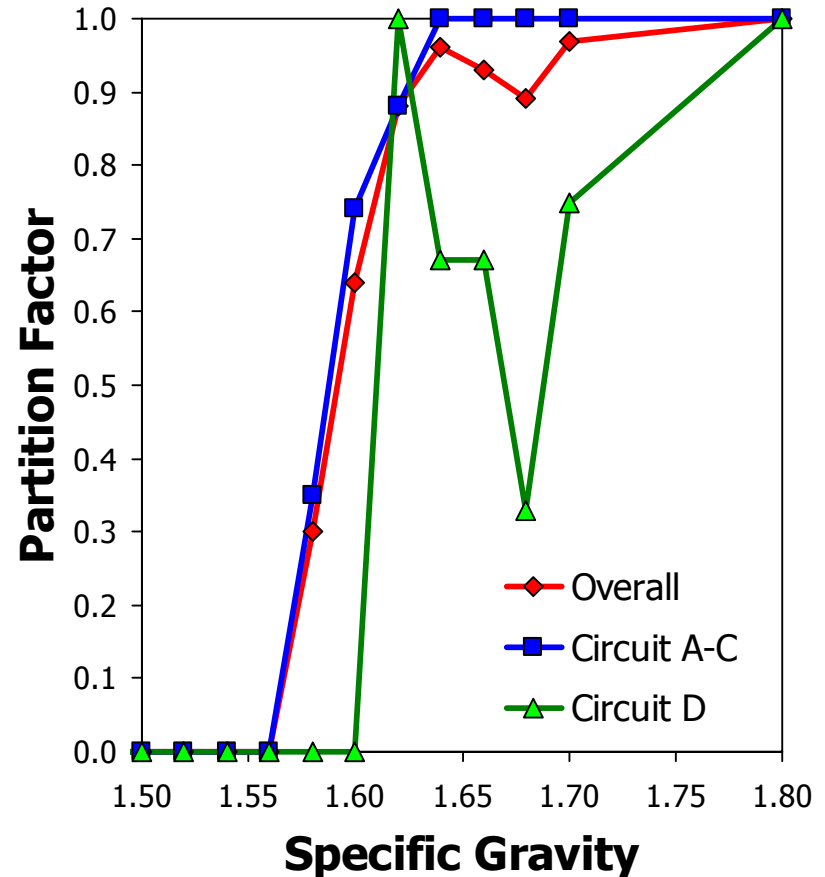




## Key Accomplishments (1)

- ❑ Example of partition curves for a four unit bank of HMCs at a KY coal plant.
- ❑ Tracers clearly demonstrate that Circuit D was performing badly.
- ❑ Clean coal tonnage increase of 36.5 tph by correcting HMC problems and optimizing cutpoints.

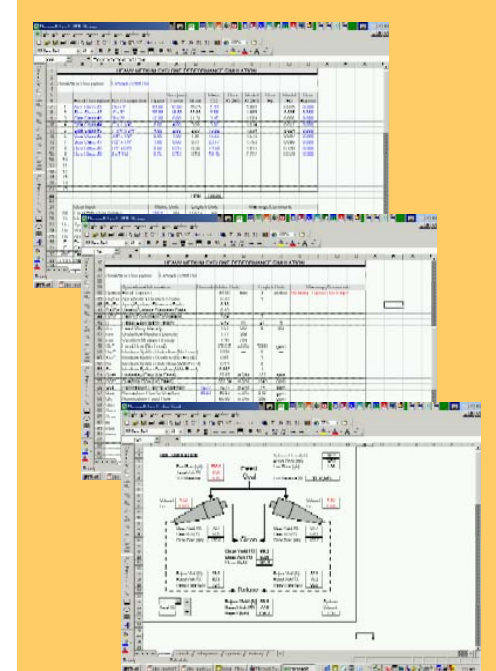
### Four Parallel HMCs





## Key Accomplishments (2)

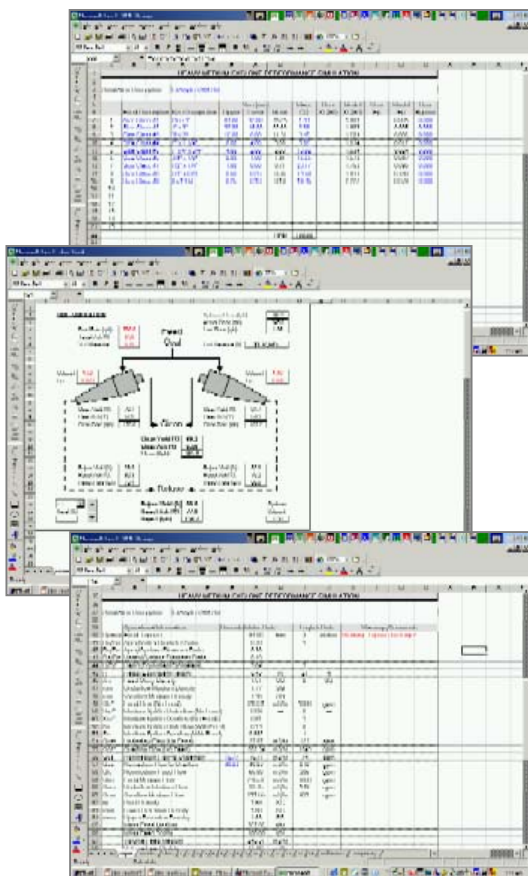
- ❑ Project made it possible to develop a spreadsheet-based **HMC Simulator**.
- ❑ Simulator developed using an operator-friendly spreadsheet format (Microsoft Excel).
- ❑ Copies of the simulator are currently being used/evaluated by company personnel.
  - Massey Energy
  - Alpha Natural Resources
  - TECO Mining Company



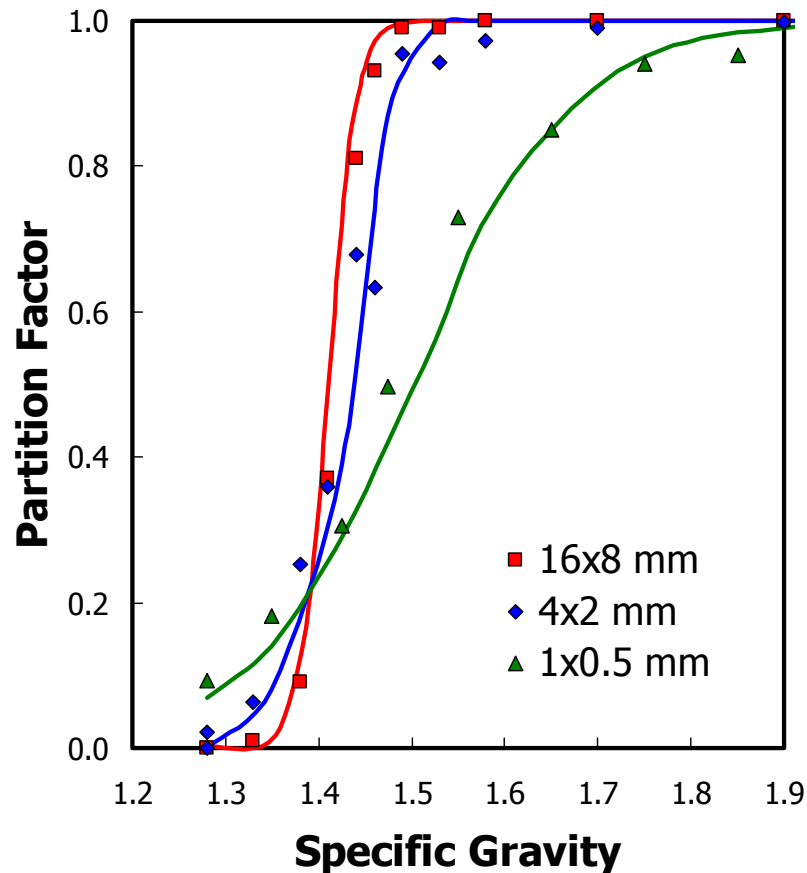




## Key Accomplishments (2)



Sample input/output for the simulation program.



Comparison of experimental data and simulator predictions.



## Key Accomplishments (3)

- ❑ Project data used to construct a **Expert System** for HMC troubleshooting.
- ❑ Expert system features include:
  - Menu-Driven Navigation
  - Overview of Industrial Circuits
  - HMC Operating Guidelines
  - HMC Maintenance Guidelines
  - Plant/Circuit Testing Protocols
  - Trouble-Shooting Guide
  - Reference Materials
- ❑ Expert System to be distributed via CD's and project web page.

**Main Menu**

- Introduction
- Industrial Circuits
- Operating Guidelines
- Maintenance Guidelines
- Efficiency Testing
- Trouble-Shooting
- Reference Materials

*Heavy Medium Cyclones*

**Marcy Scale Calibration**

**WATER CALIBRATION**  
Dead 1.00 DG When Filled With Clean Water

**MARCY CALIBRATION**  
Dead 1.60 DG When Empty and 1.60 Kg Standard Weight Added

*Heavy Medium Cyclones*

**Floats Overload**

❑ **Problem:**

- flow of media may be insufficient to carry all of the low-density particles out the vortex finder
- some low-density particles report to refuse

❑ **Correction:**

- increase pressure
- reduce apex diameter
- reduce raw feed rate
- install HMCs with more volumetric capacity

**Floats Overload**

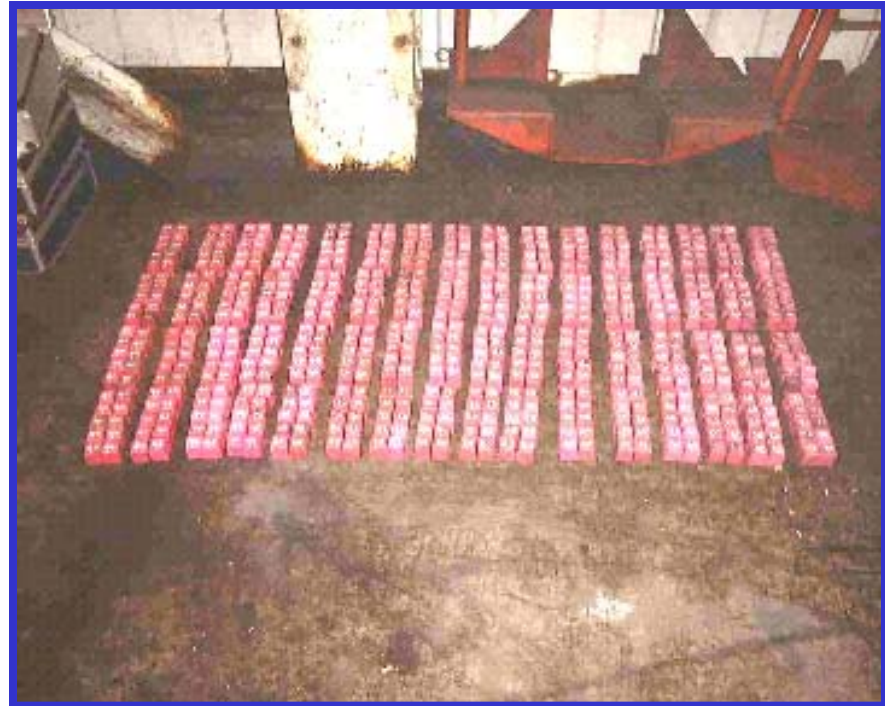
*Heavy Medium Cyclones*



## Photo Library



Shane Bomar (graduate student) and Chris Wood (Partition Enterprises) preparing for plant sampling and density tracer testing.



Density tracers (32 mm cubes) sorted into groups of 20 each (1.32 to 2.50 SG) just prior to being introduced into the cyclone feed stream.



## Photo Library



A bank of parallel coarse coal heavy media cyclones that were sampled in detail and evaluated using the density tracers .



An installation of twin parallel coarse coal heavy media cyclones that were sampled in detail and evaluated using the density tracers .



## Photo Library



Computer-based interface used to monitor and control the heavy media bath and heavy media cyclone circuits at one of the four project test sites.



Photograph showing the internal condition of one of the heavy media cyclones (ceramic lined) that was inspected by the project team during the first phase of the in-plant test program.





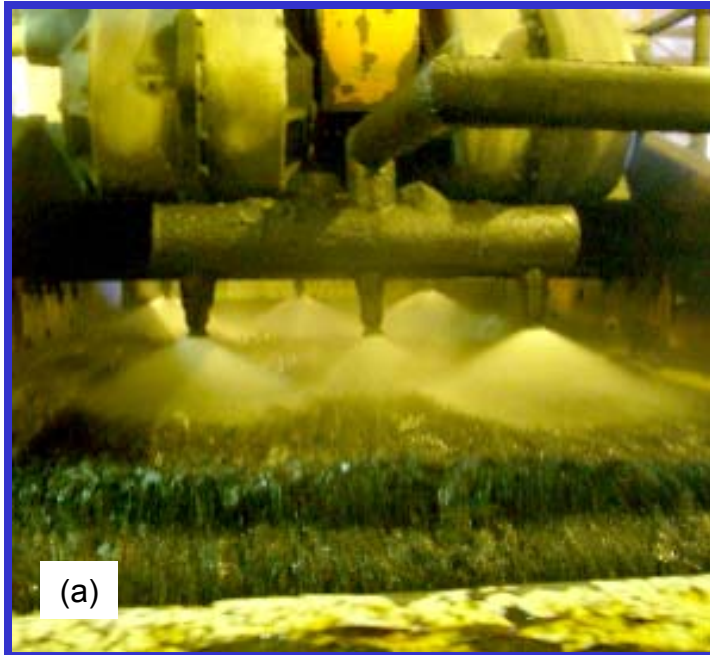
## Photo Library



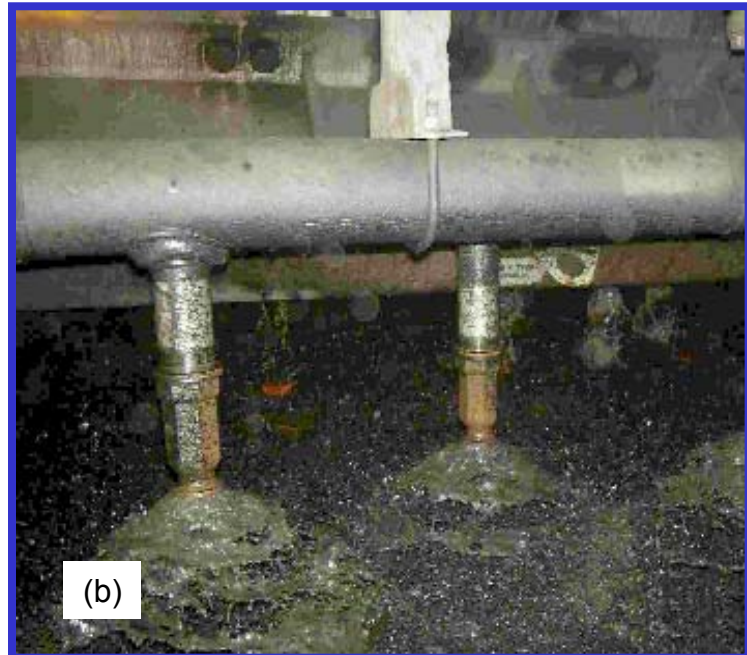
Improperly designed feed distributions can result in unequal solids loadings and result in poor heavy media cyclone performance. Density traces were used in this project to identify such problems at several of the test sites. Photographs show (a) an overhead distributor and (b) and up-flow distributor used to feed twin parallel heavy media cyclones.



## Photo Library



(a)



(b)

Inadequate water pressure on water sprays used for drain-and-rinse screens can result in poor rinsing of media (ultrafine magnetite) from the clean coal and refuse products from heavy media cyclone circuits. Poor rinsing will increase media consumption and adversely impact circuit stability/control. The photographs show (a) effective rinsing and (b) inadequate rinsing at two of the project test sites. Guidelines for proper operation of water sprays have been developed as part of this project.



## Project Recognition

- Technical Publications/Presentations
  - Luttrell, G.H., Bomar, T.S., and Wood, C.J., 2002. "Optimization of Heavy Media Cyclone Circuits," Proceedings, **SME Annual Conference & Exhibit**, Phoenix, Arizona, February 25-27, 2002, Preprint No. 02-128, 7 pp.
  - Luttrell, G.H., Bomar\*, T.S., Wood, C.J., and Bethell, P.J., 2002. "Operating Guidelines for Heavy Media Cyclone Circuits," Proceedings, **19th Annual Coal Preparation Exhibition & Conference**, Lexington, Kentucky, April 30-May 2, 2002, pp. 117-124.
  - Luttrell, G.H., Barbee, C.J., Wood, C.J., and Bethell, P.J., 2002. "An Industrial Evaluation of Heavy Medium Cyclone Circuits," Proceedings, **19th Annual International Pittsburgh Coal Conference**, Pittsburgh, Pennsylvania, September 23-27, 2002, Session 22 – Coal Production and Preparation I, Preprint No. 22-1, 10 pp.
  - Luttrell, G.H., Barbee, C.J., Wood, C.J., and Bethell, P.J., 2003. "Operating Guidelines for Heavy-Media Cyclone Circuits," **Coal Age Magazine**, Vol. 108, No. 4, April 2003, pp. 30-34.
  - Luttrell, G.H., Wood, C.W., and Bethell, P.J., 2004. "Simulation of Heavy Medium Cyclone Performance," Proceedings, **SME Annual Conference & Exhibit**, Denver, Colorado, February 24-25, 2004, 6 pp.
  - "Coal Preparation," **Annual Alabama Mining Institute Meeting**, Regional Chapter of SME, September 5-6, University of Alabama, Tuscaloosa, AL, (Presentation Only).





## Project Recognition

- Workshop/Training Sessions (**Page 1 of 2**)
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, February 9, 2001, **18 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, March 9, 2001, **11 attendees.**
  - "Introduction to Coal Preparation," One-Day Short Course, Sponsored by Coal Prep 2001 Exhibition & Conference, Lexington, KY, April 30, 2001, **66 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, TECO Coal Company, Dunbar, KY, June 12, 2001, **14 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, July 6, 2001, **10 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, August 17, 2001, **8 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, February 1, 2002, **7 attendees.**



## Project Recognition

- Workshop/Training Sessions (**Page 2 of 2**)
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, February 15, 2002, **13 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, March 1, 2002, **14 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Charleston, WV, March 22, 2002, **13 attendees.**
  - "O&M Standards for Heavy Media Cyclones," Half-Day Workshop, Massey Coal Services, Chapmanville, WV, July 10, 2002, **14 attendees.**
  - "Heavy Medium Cyclones," Half-Day Workshop, Coastal Coal Company, Kingwood, WV, planned for October 23, 2002, **12 attendees.**
  - "O&M Guidelines for Heavy Medium Cyclone Circuits," Half-Day Workshop, Alpha Natural Resources, Abingdon, VA, December 10, 2003, **19 attendees.**



## Commercialization

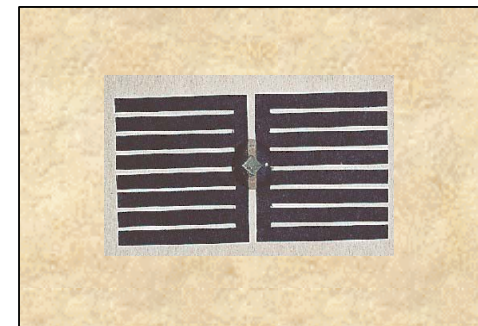
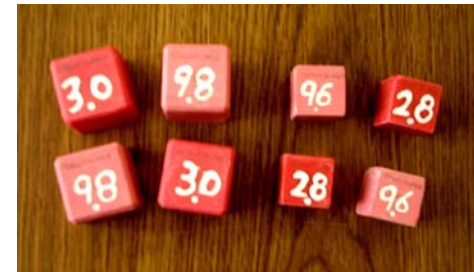
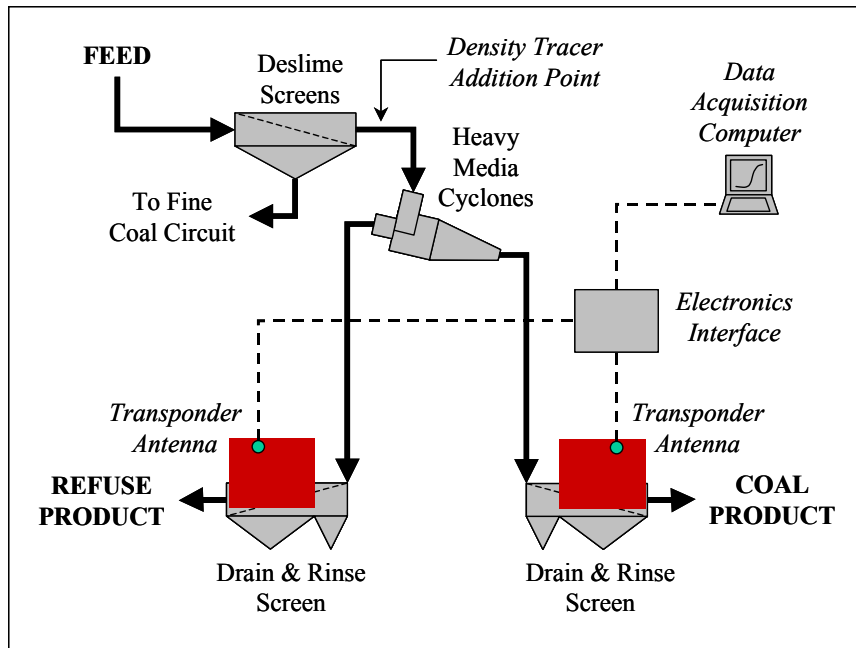
- ❑ Tracer services now offered by Precision Testing Laboratories of Beckley, WV.
- ❑ Tracers recently used at industrial sites:
  - Turris Coal
  - Sapphire Coal
  - Arch Coal
- ❑ Project data used to obtain spin-off project involving electronic tracers that can be remotely detected.





# Commercialization

- ❑ Project data used to develop new spin-off project.
  - Involves development of “electronic transponder” tracers that can be automatically detected with minimal personnel.
  - Funded by DOE CAST initiative.





## Project Status

- ❑ Technical activities successfully completed.
- ❑ Expenditures well within budget allocations.
- ❑ Project closeout underway.
  - Editing/Submission of Final Project Report
  - Securing Required Cost-Sharing Documentation





U.S. Department of Energy  
Energy Efficiency and Renewable Energy

## *industrial technologies program*

# Development of Novel Dewatering Aids for Minerals and Coal Fines

**Principal Investigator:** R.-H. Yoon, Minerals and Coal Technologies, Inc.

**NETL Project Managers:** Morgan Mosser and Joe Renk

**Partners:**

- Beard Technology
- Boliden Minerals, AB
- Nalco

**Total Project Cost:** \$624K

DOE Share: \$312K

Participant Share: \$312K

**Project Period:** 33 months

**Project Start Date:** 15 March 2001



## Project Objectives

- To develop novel chemicals that can facilitate the removal of water using conventional mechanical dewatering devices:
  - Vacuum filters
  - Pressure filters



## Milestones and Status

### Major Milestones Planned to Date/Status

<u>Planned Milestones</u>	<u>Scheduled</u>	<u>% Completed</u>
Task 1: Surface Chemistry Control	12/03	100
1. Reagent Development for Minerals	09/03	100
2. Surface Tension & Contact angle	06/03	100
3. Reagent synthesis	06/03	100
4. Auxiliary reagents	04/03	100
5. Reagent Blends	09/03	100
6. Conditioning	12/03	100
7. Mode of Addition	08/03	100
Task 2: Capillary Radius Control	12/03	100
<u>Key Decision Points Remaining</u>		
- Final report in preparation		





## Key Accomplishments

- **Commercialization**
  - Garpenberg Mine, New Boliden, in Sweden has been using MCT's dewatering aids for the past two years.
  - Another base-metal mine is Urope is planning to use MCT's dewatering aids.
  - Straford Mine, Gluchester Coal, in Australia is using MCT's reagents commercially, as reported in the World Mining Magazine, December, 2003.
  - Nalco has conducted plant trials successfully in many countries.
- Draft final technical reports has been prepared, and is currently under process of being edited within MCT.
- It is anticipated that another dewatering patent will soon be approved and issued.



## Stradford Mine (Application of MCT reagents)





## *industrial technologies program*

# Fibrous Monolith Wear Resistant Components for the Mining Industry

- **Principal Investigator:** Mike Fulcher, Advanced Ceramics Research, Inc. Tucson, AZ
- **NETL Project Manager:** Morgan Mosser
- **Partners:** Advanced Ceramics Manufacturing; Kyocera Corporation; Phelps Dodge Sierrita; Phelps Dodge Bagdad; The University of Arizona; Krebs Engineering; University of California Santa Barbara; Inco LTD.
- **Total Project Cost:** **\$5,442,399**
  - DOE Share: \$2,696,005
  - Participant Share: \$2,746,394
  - **Project Period: 36 months**
- **Project Start Date: 22 Feb. 2001**



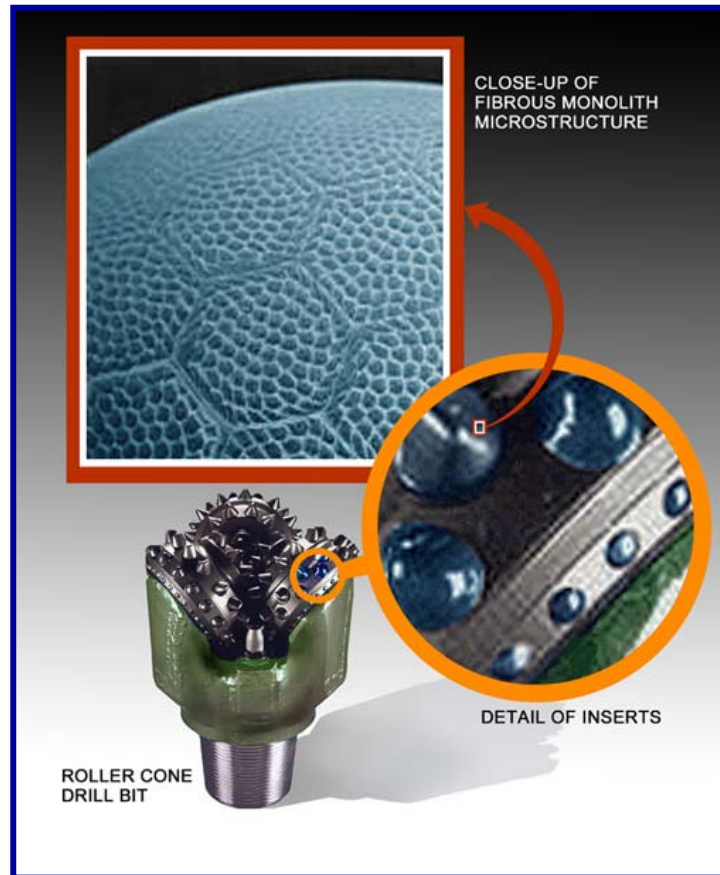
## Project Objectives

- To develop advanced materials for wear resistant components using our patented fibrous monolith processing technology and overcome the cost/performance barrier traditionally associated with advanced materials. The developed components will show a significant increase in wear life while remaining cost competitive with current wear resistant components. The targeted components include mining drill bit inserts, point-attack tools, dozer teeth, and hydro-cyclone apex cones.



# Photo Library

## Fibrous Monolith Coatings for Mining Drill Bit Inserts



ROLLER CONE  
DRILL BIT

CLOSE-UP OF  
FIBROUS MONOLITH  
MICROSTRUCTURE

DETAIL OF INSERTS





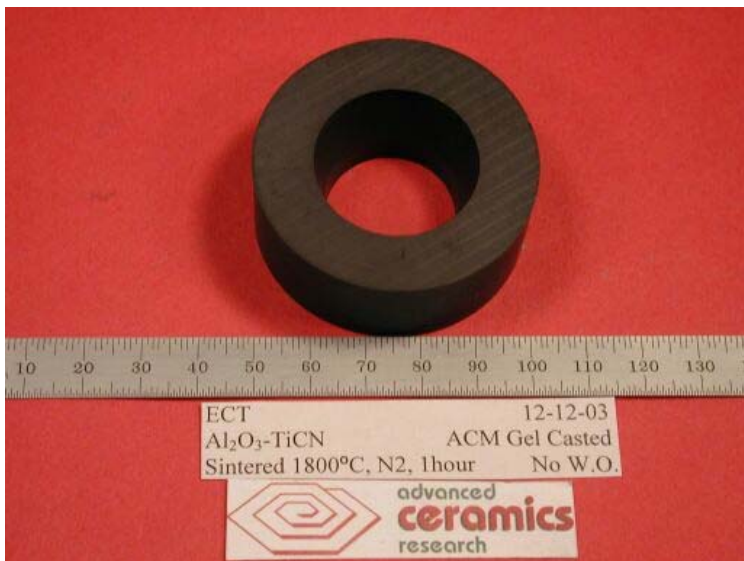
## Photo Library



WC-3%Co/WC-25%Co Fibrous Monolith bucket lip insert installed and tested with the assistance of The Robbins Group. The image at the left shows the FM insert after use and a comparison to the other lips installed at the same time. The bucket lip was installed on a large diameter tunnel boring machine (TBM) being used to bore subway tunnels in Sidney, Australia.



## Crosscutting Technology



Follow-up gelcasted extrusion dies were again tested at a central Michigan brass extrusion house. The gel casted dies did not perform to the same standard seen with the FM die provided for testing previously.



# Milestones and Status

## Major Milestones Planned to Date/Status

<u>Planned Milestone</u>	<u>Scheduled</u>	<u>Completed</u>
– Project Management Plan	2/22/01	2/22/01
– Complete drill bit material trade study	4/17/01	7/6/01
– Complete cyclone apex cone trade study	4/17/02	4/1/03
– Complete electro-winning material trade study	7/15/02	7/15/02
– Complete point attack tool trade study	3/21/03	12/15/01
– Complete drill bit insert lab testing	12/31/02	Ongoing
– Complete dozer blade insert lab testing	12/31/02	Cancelled
– Complete cyclone apex cone lab testing	12/31/02	Cancelled





# Milestones and Status

## Major Milestones Planned to Date/Status

<u><i>Planned Milestone</i></u>	<u><i>Scheduled</i></u>	<u><i>Completed</i></u>
– Complete electro-winning anode lab. testing	9/15/02	6/30/03
– Complete point attack tool lab testing	7/21/03	Ongoing
– Complete electro-winning anode field testing	9/30/02	Cancelled
– Complete drill bit insert field testing	10/31/03	Ongoing
– Complete cyclone apex cone field testing	7/31/03	Cancelled
– Complete dozer blade insert lab testing	10/31/03	Cancelled
– Complete point attack tool field testing	12/31/03	Ongoing
– Deliver Report of Termination/Complete Report	2/20/04	



## Milestones and Status

### – Result of Point Attack Tool Laboratory Testing

- Based on laboratory wear testing of the insert material, it is expected that the WC-Co(3%)/WC-Co(25%) FM material will demonstrate similar improvement in the point attack tool application.



## Milestones and Status

### – Result of Roof Bit Insert Field Test

- Initial field test of bucket lip inserts complete! Insert outperformed the existing material it in which it was embedded. Limitation was the depth to which the insert could be embedded.



## Milestones and Status

- **Key Decision Points Remaining (cont'd)**
  - **Result of Point Attack Tool Field Test**
    - Was the field test successful in demonstrating increased wear life and damage tolerance in the point attack tool application?



<b><i>Decision Point</i></b>	<b><i>Scheduled Date</i></b>	<b><i>Is it a go/no-go decision?</i></b>
<b><i>Results of drill bit insert material trade study</i></b>	<b><i>April/2001 Completed June 2001</i></b>	<b><i>Go</i></b>
<b><i>Results of apex cone material trade study</i></b>	<b><i>April 2002 Complete April 2003</i></b>	<b><i>No-Go</i></b>
<b><i>Results of electro-winning anode material trade study</i></b>	<b><i>7/15/02 Completed July 2003</i></b>	<b><i>No-Go</i></b>
<b><i>Results of point attack tool material trade study</i></b>	<b><i>3/21/2003 Completed December 2001</i></b>	<b><i>Go</i></b>
<b><i>Results of drill bit insert lab. testing</i></b>	<b><i>12/31/02 Ongoing</i></b>	<b><i>Go</i></b>



<b><i>Decision Point</i></b>	<b><i>Scheduled Date</i></b>	<b><i>Is it a go/no-go decision?</i></b>
<b><i>Results of dozer blade insert lab. testing</i></b>	<b><i>12/31/02 Ongoing</i></b>	<b><i>Go</i></b>
<b><i>Results of apex cone lab. testing</i></b>	<b><i>12/31/02</i></b>	<b><i>No-Go</i></b>
<b><i>Results of electro-winning anode lab. testing</i></b>	<b><i>7/11/03</i></b>	<b><i>No-Go</i></b>
<b><i>Results of point attack tool lab. testing</i></b>	<b><i>7/21/03</i></b>	<b><i>Go</i></b>
<b><i>Results of drill bit insert field testing</i></b>	<b><i>7/11/03</i></b>	<b><i>Go</i></b>



<b><i>Decision Point</i></b>	<b><i>Scheduled Date</i></b>	<b><i>Is it a go/no-go decision?</i></b>
<b><i>Results of cyclone apex cone field testing</i></b>	<b><i>10/31/03</i></b>	<b><i>No-Go</i></b>
<b><i>Results of dozer blade insert field testing</i></b>	<b><i>10/31/03</i></b>	<b><i>No-Go</i></b>
<b><i>Results of point attack tool field testing</i></b>	<b><i>12/31/03</i></b>	<b><i>Go/No-Go</i></b>



## Key Accomplishments

- **Gel casted extrusion die inserts field tested with Master Craft Extrusion Tools and Metal Extruders. Did not match the performance seen with the FM tools.**
- **Bucket lip inserts fabricated, installed and tested in tunnel boring machine in Sydney, Australia. Success seen in improvement of wear over standard bucket lip material.**





## Good News!

- Bucket lip tested in tunnel boring machine bucket lip improved the wear of the bucket lip. Improvements suggested by The Robbins Group will be incorporated if additional bucket lip can be obtained for insert placement.



## Commercialization Outlook

### •Kyocera



- Kyocera cost share estimated \$2,000,000.00(US) to date.
- Potential market development \$5,000,000./year
- Licensed to develop FM applications
- Developing FM CBD bits, diamond coatings and machine tool applications



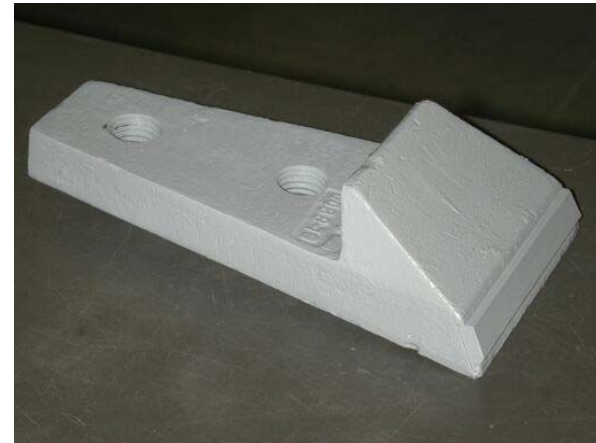
## Commercialization Outlook



- Extrusion die inserts to be sold to Extruded Metal, Belding, MI for brass extrusion. Extruded Metal control 12% of extruded brass market in the US.



## Commercialization Outlook



- Bucket lip insert performed well in application. The Robbins Group (TRG) suggested improvements in the insert placement. TRG will be approached about additional testing.



## industrial technologies program

### Horizon Sensor

- **Report Period Start Date:** January 2004
- **Report Period End Date:** March 2003
- **Principal Investigator/Author:** Larry G. Stolarczyk, Sc.D.
- **Project Period:** 36 months
- **Project Start Date:** 20 December 2000
- **Report Issue Date:** 13 April 2004
- **DOE Award No.:** DE-FC26-01NT41050
- **Name of Submitting Organization:** Stolar Research Corporation
- **Address:** 848 Clayton Highway  
Raton, NM 87740
- **NETL Project Manager:** Mike Mosser
- **Total Project Cost:** \$1,817,506.00
  - DOE Share: \$857,217.00
  - Participant Share: \$960,289.00



## Abstract

Real-time horizon sensing on continuous mining machines is becoming an industry tool. Installation and testing of production-grade Horizon Sensor (HS) systems continued this quarter at Monterey Coal Company (ExxonMobil), Mountain Coal Company West Elk Mine (Arch), and Ohio Valley Coal Company (OVC). Monitoring of system function, user experience, and mining benefits is ongoing. All horizon sensor components have finished MSHA (U.S.) and IEC (International) certification.



## Project Objectives

To demonstrate the feasibility of real-time stress measurement, bit loading, and horizon sensing on a longwall shearer, boring machine, continuous miner, and loading bucket



## Experimental Timeline

### *Milestones and Status*

Major Milestones Planned to Date/Status

#### Planned Milestone

<u>Complete</u>	<u>Date – %</u>
– Completed Certification (U.S. and Australia)	Sept. 02 – 100%
– Dual Frequency Capability HS	Nov. 02 – 100%
– Accelerometer Triggering	Feb. 03 – 100%
– Clean Coal Technology Program (Illinois)	Feb. 03 – 100%
– U.S. Production Miners (6 Total)	Mar. 03 – 100%
– U.S. Longwall Shearers (3 Total)	Mar. 03 – 100%
– Clean Coal Technology Program (Ohio)	Mar. 03 – 100%
– HS- HW (highwall HS system) product launched	June 03 – 100%
– HS-HP (head positioning) product launched	June 03 – 100%
– LED Remote Display for Improved Visibility	Pending
– OLED Hand-held Display for Operator	Pending





## Technical Status

- The total tonnage, shifts, and operational hours are being documented for all current HS-equipped machines
- There are no outstanding engineering tasks left to “optimize” the performance of the system
- Some improvements are being made for user concerns and ease of maintenance in particular the display is being simplified and a hand-held remote is under design and approval
- The first power-generator-equipped long wall shearer system is performing well at Robinson Run
- Production and sales of the HP system is gaining momentum
- Discussions with Joy Machinery are underway to facilitate a working agreement for HS Factory Installation and agile mining projects
- “Forward-looking” capabilities are being developed that will allow the HS (HS-Radar) to detect anomalies in the coal seam ahead of mining, such as dikes, faults, and abandoned mine workings. The HS-Radar prototype is being tested using a salt wall to simulate 25 feet of unmined coal seam



## Commercialization

### Commercial Lease Programs 2001 - 2003

- Sasol Fuel: HS-CM Joy HM31 (Status: Removed)
- Consol Energy: HS-CM Joy 14CM15 (Status: Removed)
- TwentyMile Coal: HS-CM Joy 12CM12 (Status: Current)
- Oxbow Mining Company: HS-CM Joy 12CM12 (Status: Idle)
- FMC Trona: HS-BM Marietta Bore Miner (Status: Idle)
- Deserado Mine: HS-LW Joy 7LS Shearer (Status: Idle)



## Commercialization

### Commercial Lease Programs 2003 - Present

- Monterey Coal Company: HS-HP Joy 12CM12 (Status: Current)
- West Elk Mine: HS-CM Joy 12CM12 (Status: Current)
- Massey Energy: HS-HW Superior SHM (Status: Current)
- Monterey Coal Company: HS-HP Joy 12CM12 (Status: Current)
- Sufco Mining Company: HS-HS Joy 12CM12 (Status: Current)
- Consol Energy: HS-LW Joy 7LS Shearer (Status: Current)
- Consol Energy: HS-CM ABM-14 (Status: Pending)



## Commercialization

### HS-LW Impact and Benefit Study

- HS-LW has demonstrated its capability to detect the coal seam horizon on 4 different longwall panels (western, midwest, and eastern coal seams)
- Detection of the coal horizon has enables mining engineers to plan selective mining to reduce waste including sulfur, ash and possibly trace metals
- The production data analyzed shows that reject or dilution can be reduced and in one example a 14 percent improvement was achieved, or a 4-point reduction of waste
- Selective mining also improved or increased the volume of ROM and clean coal; mining advancement per day greatly improved as more time is focused on cutting coal and not rock
- Stolar estimates that on average these improvements translate into an economic benefit exceeding \$1 per ton



## Project Recognition

- “The Smart World of Mining,” *World Coal* magazine, May 2001
- “Breakthrough Technology,” *World Coal* magazine, May 2002
- “A Clearer Image,” *World Coal* magazine, December 2002
- “Sensing the future,” *World Coal* magazine, May 2003
- Numerous trade show and exhibition demonstrations of HS products and simulations
- Recipient of the R&D 100 Award for breakthrough technologies from *R&D* magazine



## industrial technologies program

### A Real-Time Coal Content/Ore Grade Sensor

- **Principal Investigator:** Rand Swanson, Resonon, Inc. and Tom Moon, Montana Tech
- **NETL Project Manager:** Joseph Renk
- **Partners:** Montana Tech of the University of Montana; Stillwater Mining Co.; Montana Board of Research Commercialization Technology
- **Additional Contributions:** Barretts Minerals, Inc. (Talc); MSU TechLink (Outreach and grants)
- **Total Project Cost:** \$717K
  - DOE Share: \$ 358K
  - Participant Share: \$ 359K
- **Project Period:** 36 months+ 6 months of no cost extension
- **Project Start Date:** 21 June 2001
- **Project End Date:** 31 December, 2004





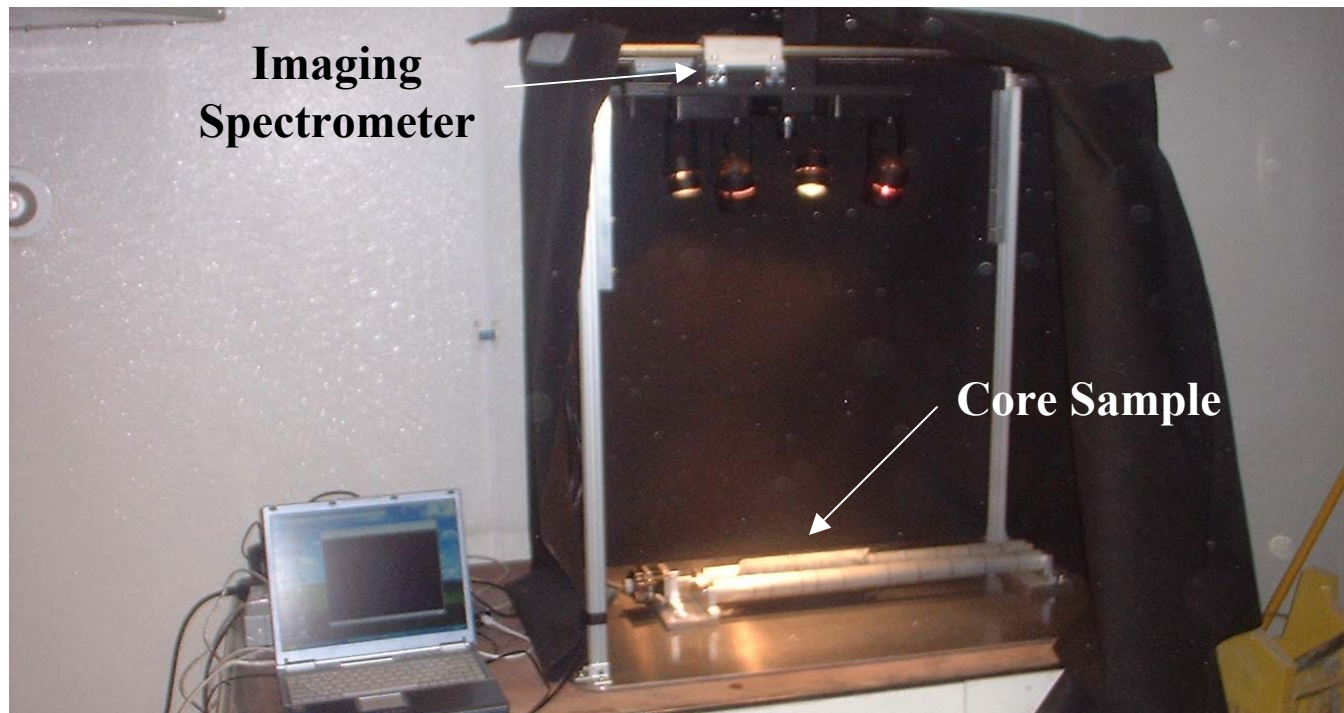
## Project Objective

- The primary Year-3 objective is to install our machine vision system in a working mine. This is being done at the Stillwater Pt/Pd mine in south-central Montana.
- Additional objectives include the development of high-speed image processing algorithms and identifying other applications.



## Progress This Quarter

**Installation Progress:** A table-top system has been installed in the Stillwater Mine's core room. This system will be used to quantitatively determine the relationship between visible sulfides in core samples and assay results.

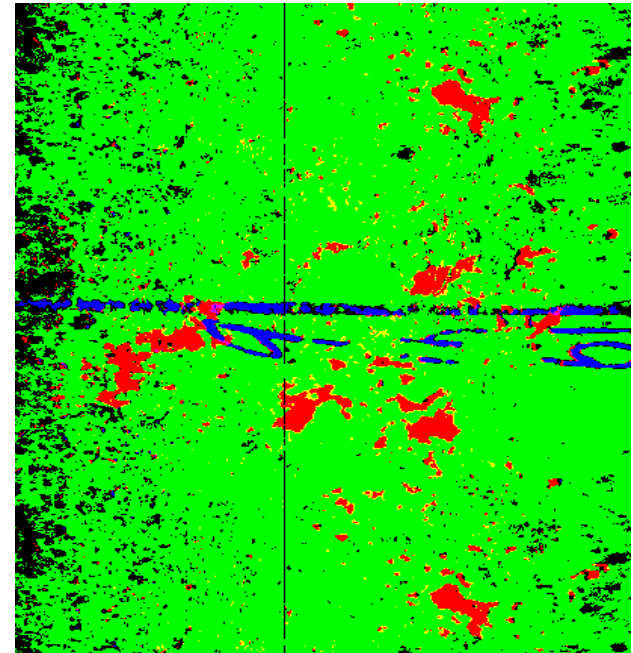
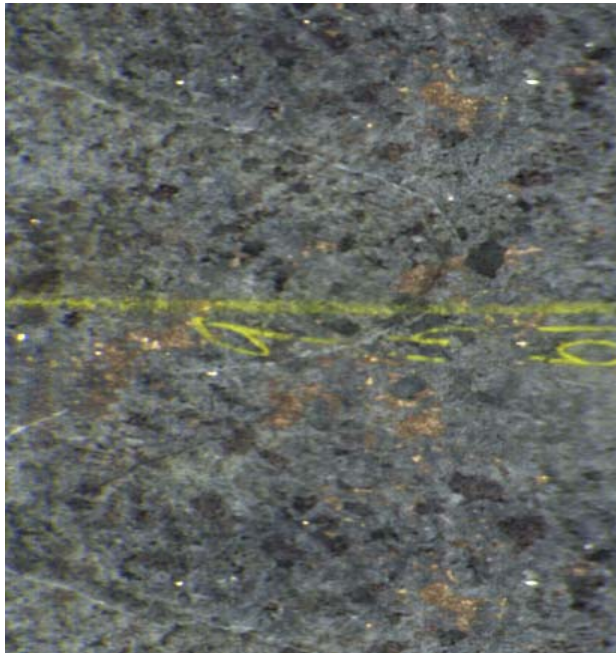






## Progress This Quarter

**Algorithm Progress:** A first-generation Spectral Angle Mapper (SAM) program has been written to identify sulfides in the core samples. The left image below shows a section of core with gold-colored sulfides. The false-colored right image shows sulfides in red.





## Milestones and Status

Year 3 Tasks and Summaries:

### Task 1: System Assembly

**Summary:** The system has been assembled and has been installed. Additional work may be required to obtain optimal lighting. Repair work was also required on the bearings of the core roller.

### Task 2: Algorithm Development

**Summary:** A first-generation high-speed classification algorithm has been written and tested. Additional work may be required to for better accuracy. More work will be done to obtain spectral libraries as well.



## Milestones and Status

Year 2 Tasks and Status:

### Task 3: Installation

**Summary:** The system has been installed and the lighting has been adjusted for the first set of experiments.

### Task 4: Monitoring

**Summary:** Initial measurements have been made, but year-long monitoring is required to determine how well the system functions over time, to establish a maintenance schedule, and to collect a database sufficiently large to determine how well the approach works.

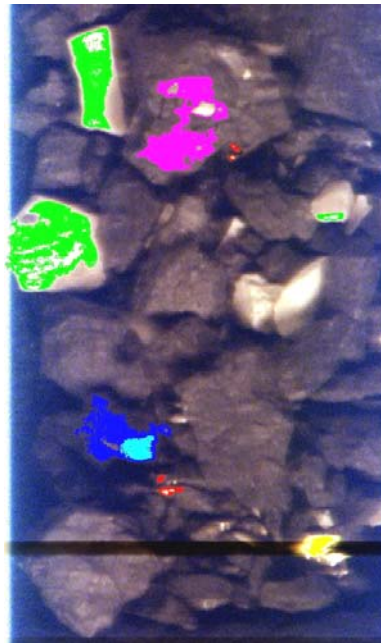


## Images: Ongoing work on coal

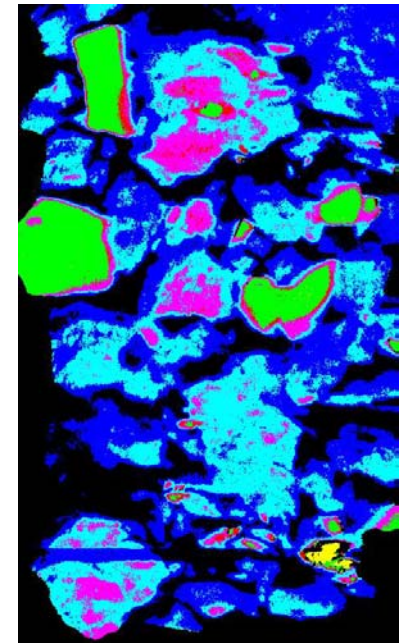
A graduate student at Montana Tech has been using “region of interest” techniques to identify shale and pyrite in coal samples. Taking multiple measurements, he found that the percentage of these materials determined from hyperspectral data is matching coal-analyzer results within a few percent. Some images and a classification map are shown.



Coal, Shale,  
and Pyrite



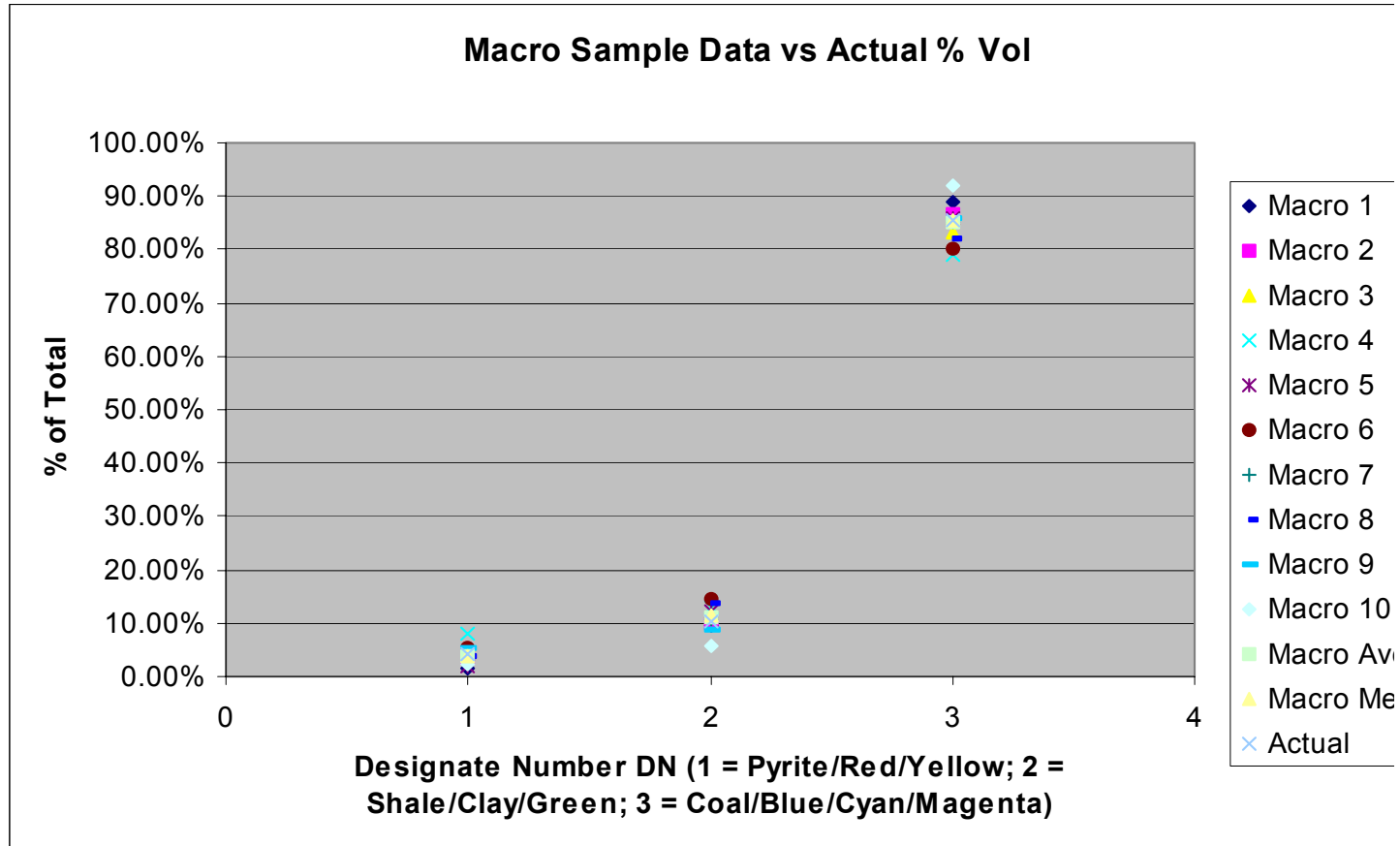
Picked Regions



Classifications



## Images: Results from the coal experiments



Ten measurements of coal, pyrite, and shale were taken using hyperspectral imaging. The results indicate reasonable accuracy is obtained even though only the surface of the samples are imaged.



## Good News!

- Resonon has been selected as a winner for a new SBIR Phase I award from the Air Force to develop a novel imaging spectrometer. Some of this work will benefit the ore-grading system.
- Two new orders for imaging spectrometers are in place, largely due to advances made during this effort.





## industrial technologies program

# Wireless Mine - Wide Telecommunications Technology

- **Principal Investigator:** Steve Meiksin - Transtek
- **NETL Project Manager:** Morgan Mosser
- **Partners:** University of Pittsburgh, Victor Products USA, National Institute for Occupational Safety and Health, CONSOL Inc., Gateway Commerce Center, Ben Franklin Partnership
- **Total Project Cost:** \$1,075,800
  - DOE Share: \$400,000
  - Participant Share: \$675,800
- **Project Period:** 36 months
- **Project Start Date:** Feb. 7, 2001



## Project Objectives

- Development of two-way, real-time, wireless communications system for use in underground mines. This technology will lower the cost of mining by increasing productivity as well as increasing the safety of miners





## Transtek's Remote Interface



A comprehensive wireless mining communications system that will allow two-way communications among underground personnel and between underground and surface personnel will be designed and tested



## Milestones and Status

### Major Milestones Planned to Date/Status

#### Planned Milestones

#### Scheduled

#### Completed

– Develop in-mine voice capability	12/01	12/01
– Expand the through-the-earth voice technology	12/01	12/01
– Develop the digital data transmission capability	12/02	12/02
– Develop tracking sensors and beacons	12/03	12/03
– Test the wireless telecommunications system	12/03	12/03



# Key Accomplishments

## Project Highlights

- A surface-mount electronic circuit to pre-process voice signal before injections into the power line for the in-mine communications system was designed and fabricated onto a printed circuit
- A continuously self-adjusting signal transmission mechanism for through the earth communications was conceptualized and designed. This mechanism will ensure peak quality voice and data transmission at all times
- Excessive interference in overlapping areas was eliminated



## Key Accomplishments

### Project Highlights (cont'd)

- An evaluation of technologies lead to the decision to use adaptive spread spectrum synchronization and modulation to interface the in-mine system with power lines
- A special purpose advanced technology filter to reject noise for through the earth communication was designed and implemented successfully
- Signal compression in preparation for multi-channel communication through power lines was successfully completed
- Noise-free through the earth voice communication was demonstrated



## Key Accomplishments

### Project Highlights (cont'd)

- The through-the-earth wireless voice communications lab prototype was finalized and repackaged to construct a commercial/industrial demonstration prototype. Features were added to the system to make a two-way conversation possible using three different man/machine interfaces. This accommodates potential users' preferences depending on their particular environments.



## Key Accomplishments

### Project Highlights (cont'd)

- Arrangements were made with NIOSH to install our through-the-earth and in-mine wireless communications system in NIOSH's Lake Lynn underground mine for evaluation and demonstration to potential users. The two systems will be linked to allow persons inside the mine to communicate with two-way radios with other persons anywhere in the mine as well as with persons on the surface. Representatives of CONSOL and other companies will be invited early in 2002 to see the system in operation



## Key Accomplishments

### Project Highlights (cont'd)

- Our subsystem for voice compression was combined with the adaptive spread spectrum synchronization and modulation subsystem for interfacing with power lines
- Using this combination with compression by a factor of 12, compressed voice was transmitted through a power line, expanded at the receiving end, and received with high clarity
- Transtek's communication system was installed in NIOSH's Lake Lynn mine for use in rescuer training scheduled for April 2002
- Point-to-point data communication was added to the in-mine system
- The USPTO issued Transtek a patent for its in-mine technology
- A "SPEED" - -Shutdown Prevention through Early Error Detection – circuit was added to the in-mine system to facilitate system installation and initial adjustments



## Key Accomplishments

### Project Highlights (cont'd)

- Data transmission was added to the through-the-earth and the in-mine systems.
- A feature was added to the in-mine system that allows to dial a particular person rather than alerting everybody at once.
- Transtek sold additional systems bringing the total number of underground mine installations to five.
- Transtek expanded sales from Western Pennsylvania to the Midwest.
- Transtek installed an in-mine wireless communications system in a sand mine in Wisconsin.





## Key Accomplishments

- NIOSH introduced Transtek's ResQCom system, at the 2003 National Mine Rescue, First Aid, Bench and Preshift Contest held September 15 to 19 in Louisville, Kentucky.
- NIOSH purchased Transtek's ResQCom system and included it in the rescue team training program held at the Lake Lynn Laboratory on October 21, 2003
- Additional purchases of Transtek's in-mine communications system, one in Tennessee and one in Pennsylvania are in the negotiations stages.



## Milestones and Status

### Key Decision Points Remaining

<b>Decision Point</b>	<b>Scheduled Date</b>	<b>Go/no go</b>
<b>Complete voice communication capability</b>	<b>12/01</b>	<b>Completed</b>
<b>Develop digital communication capability</b>	<b>12/02</b>	<b>Completed</b>
<b>Develop tracking sensors and beacons</b>	<b>12/03</b>	<b>Completed</b>



## Good News!

- A continuously self-adjusting signal transmission mechanism for through the earth communications was conceptualized and designed. Excessive interference in overlapping areas was eliminated
- A special purpose advanced technology filter that was designed and implemented into prototype equipment has proven to make possible noise-free through the earth voice communication



## Good News!

- A commercial through-the-earth wireless voice communications prototype was built and will be installed in NIOSH's Lake Lynn underground mine for testing and demonstration in early 2002. The system will be linked with Transtek's in-mine wireless communications system allowing persons in the mine to talk to other persons anywhere in the mine as well as to persons on the surface.
- Transtek's wireless communication system was installed in NIOSH's Lake Lynn mine for use in rescuers' training scheduled for April 2002.



## **Good News!**

- **Transtek received favorable critic for its system from attendees at the mining training program at NIOSH's Lake Lynn mine in April 2002. A report will be issued by NIOSH.**
- **Transtek was issued a U.S. patent for its in-mine System.**
- **Transtek received inquiries for the use of its in-mine system in aboveground, other than mining, applications in addition to mining applications.**
- **Transtek has sold and installed five wireless communication systems in underground mines.**
- **Transtek expanded sales from Pennsylvania to the Midwest**



## Good News!

- Transtek receives repeat orders from from customers: an indication of customer satisfaction.
- A spin-off product resulting from this project, is a system, named ResQCom, developed specifically for rescue teams.
- The ResQCom system is used by NIOSH in the training programs it offers to mining rescue teams.



## Good News!

- Transtek receives favorable comments from customers. A representative comment is: “We are seeing improved productivity as a direct result of the ComCell system.”



## Project Recognition

- A press release introducing our cat-5 ComCell wireless in-mine communications system appeared in several mining journals. The press release also introduces the Through-the-Earth (TTE) wireless communications system as being under development.
- Transtek's system was highlighted in a feature article titled "Making the Connection" published in the March 2001 issue of the Engineering & Mining Journal (E&MJ).
- Transtek's systems were included in a paper presented by Ronald S. Conti of NIOSH at The Northwest Mining Association's 107th Annual Meeting, Dec 3-7, 2001.
- Transtek was issued a U.S. patent for its in-mine system.





## Project Recognition

- Australian “INTERNATIONAL LONGWALL NEWS” published on September 17, 2003 an article under the title “Transtek eye up coal communications”.
- Australian “INTERNATIONAL LONGWALL NEWS” published on December 19, 2003 an article under the title “ New lifeline technology to save lives” introducing the ResQCom system.
- The COAL AGE American magazine scheduled to include an article describing the ResQCom system in their January 2004 issue.
- The COAL AGE magazine published an article under the title “New communication system for mine rescue” describing Transtek’s ResQCom system in its February 2004 issue.



## Commercialization Outlook

- Transtek is partnered with Victor Products USA for marketing and selling Transtek's present products. Transtek plans to expand this relationship to include the new products that are now under development.
- Transtek added a sales/marketing person to its team.
- The voice communication capability will be brought to market early in 2002.

The data communication capability including environmental and production sensor monitoring and control will be brought to market in 2003.

- Tracking people and equipment will be brought to market in 2004.



## Commercialization Outlook

- Transtek is exploring marketing contacts in China.
- Transtek is exploring application of its system to aboveground environments in addition to mining environments.
- Transtek has sold and installed five wireless communication systems in underground mines.
- Transtek expanded sales from Western Pennsylvania to the Midwest.
- Transtek has an in-mine wireless communications system installed in a Wisconsin Sand Mine.



## Commercialization Outlook

- Negotiations for two additional installations of the ComCell in-mine system, one in Tennessee and one in Pennsylvania are in progress.
- Transtek received a repeat order to extend the ComCell system for the Fairmount Minerals sand mine in Wisconsin to expand coverage area as they continue mining operations.

Transtek received a repeat order to extend the second channel coverage for the Iron Mountain mine in Pennsylvania.



## Commercialization Outlook

- Transtek sold to NIOSH a ResQCom system designed for rescue teams.