Coal Preparation

“A Discussion on Conventional and Advanced Technology”

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Coal Preparation

• PRESENTATION OUTLINE
  – What is “Coal Preparation”?
  – Introduction and Background
  – Why use “Coal Preparation”?
  – How is “Coal Preparation” Engineered?
  – Conventional Technologies
  – Advanced Technologies
  – Applications
  – Closing Comments
What Is Coal Preparation?

• Coal preparation is the removal of undesirable material from the Run-of-Mine (ROM) coal by employing separation processes which are able to differentiate between the physical and surface properties of the coal and the impurities. Through coal preparation, a uniform product is achieved.
Washability Study

• The selection of the logical separation process is based upon a laboratory study of the ROM called a washability study.
  – Size Distribution
  – Yield Curve
  – Cumulative Float Curve
  – Cumulative Sink Curve
  – Partition (Tromp curve)
Why Coal Preparation?

• Remove extraneous, non-combustible material
  – Ash reduction
    – lower particulates
    – reduced ash handling at power station
  – Sulfur reduction (lower SO$_x$ emissions)
  – Carbon and NO$_x$ Emissions Reduction

• Reduced transportation costs per unit of heat

• Guarantee consistent heat value
  – Improved plant efficiency
Customer Requirements (Commercial Motivation)

- The purpose of these developments and others has been to economically improve the quality of coal to make it suitable for a specific purpose.
  - About 80% of the US production is used in electricity generation
  - The properties and the quantities of the impurities in coal are of major importance in the design and operation of steam generating equipment.
  - The steam coal users, mostly utilities, require optimum calorific value, consistent grindability, minimal moisture and ash variability.
Energy and Coal

- **BTU/lb (kilo-calories/kg) in coal**
  - (1 BTU/lb = 0.556 Kcal/kg)
  - Lignite 4500 (2500) – 7000 (3890)
    - High moisture (25%) with ash
  - Low Grade Bituminous 5000 (2780) – 9000 (5000)
    - High ash (+20%) with moisture (10%)
  - Thermal Bituminous 8000 (4450) – 12000 (6675)
    - Medium ash (10-12%) with moisture (9%)
  - High Grade Bituminous +12000 (+7000)
    - Low ash (<7%) with low moisture (<8%)
Effects of Ash on Heat Value

Empirical Formula for Indian Coals

Gross Calorific Value in Kcal/kg = 85.6 x (100-1.1A – M) – 60M

A = Ash content, wt%    M = equilibrated moisture content, wt%

- 40% ash, 10% M  GCV = 3338 kcal/kg (6000 Btu)
- 30% ash, 10% M  GCV = 4280 kcal/kg (7700 Btu)

1 ton 40% = 0.78 tons 30%
Coal to Electricity

“Heat Rate”

• The average heat rate is approximately 10,000 Btu (2,520 kcal) per kilowatt-hour generated. This number will vary depending upon the type of boiler, heat exchangers, auxiliary power consumption etc. but the efficiency of most plants in operation today is between 30 – 35%.

• By providing a higher concentration of heat in the fuel (lower ash and moisture content), the associated costs of transportation, handling, crushing, pulverizing and residual waste (flyash) disposal in the electricity generation are reduced because fewer weight units per kilo-watt hour generation will be required.
Does Coal Washing Help GHG Emissions Reduction?
(presented March 10, 2000 by S. Padmanaban, USAID/India at CPI 2000 New Delhi)

- Typical Emissions using raw coal (42%) in a standard Indian coal fired power plant.
  - Carbon Dioxide – 1.11 kilograms carbon dioxide per kilo watt hour of commercial power
- Typical Emissions using washed coal (30%) in a standard Indian coal-fired power plant
  - Carbon Dioxide – 1.045 kilograms carbon dioxide per kilo watt hour commercial power
- Other Co-benefits: Reduction in auxiliary power consumption, reduction in fly-ash management costs at power plants, lowered ESP loading, reduced emissions
Some good opportunities for GHG reduction in India are found in:

- Electric power generation, transmission & distribution
- Industrial energy utilization
- Transportation

![Annual GHG Mitigation Potential in India](chart)
Technical and Economic Limitations of Coal Preparation

- Technical
  - ROM coal characteristics
  - Available technology

- Economic
  - Capital costs
  - Operating costs
  - Yield/energy recovery
Levels of Coal Cleaning

- Level 1
  - Rough Scalping and Crushing
- Level 2
  - Coarse Coal (+1/2 inch) Cleaning only
- Level 3
  - Coarse and Fine Coal Cleaning
- Level 4
  - Coarse, Fine, and Ultra Fine Coal Cleaning
- Level 5
  - Level 4 Cleaning plus middlings crushing and rewash
Equipment-Cleaning

• Conventional
  – Heavy media separators (vessels and cyclones)
  – Pulse water separators (jigs)
  – Constant velocity separators (water only cyclones)
  – Froth Flotation (Aeration) Cells
MOST COMMON COAL CLEANING EQUIPMENT
WITH THEIR COMMON APPLICATION
RANGES AND APPROXIMATE Ep VALUES

<table>
<thead>
<tr>
<th>Particle Size</th>
<th>HMV</th>
<th>HMC</th>
<th>BMJ</th>
<th>BCJ</th>
<th>WOC</th>
<th>SPI</th>
<th>DT</th>
<th>Deister Table</th>
<th>FC</th>
<th>Rotary Breaker</th>
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<td>0.014 - 0.016</td>
<td>0.024 - 0.026</td>
<td>0.018 - 0.020</td>
<td>0.020 - 0.024</td>
<td>0.020 - 0.024</td>
<td>0.007 - 0.010</td>
<td>0.006 - 0.009</td>
<td>0.004 - 0.007</td>
<td>0.006 - 0.009</td>
<td>0.004 - 0.007</td>
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<tr>
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<td>0.002 - 0.004</td>
<td>0.004 - 0.006</td>
<td>0.004 - 0.006</td>
<td>0.001 - 0.003</td>
<td>0.001 - 0.002</td>
<td>0.001 - 0.002</td>
<td>0.001 - 0.002</td>
<td>0.001 - 0.002</td>
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<tr>
<td>0.002 - 0.004</td>
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<td>0.006 - 0.008</td>
<td>0.004 - 0.006</td>
<td>0.004 - 0.006</td>
<td>0.002 - 0.004</td>
<td>0.002 - 0.003</td>
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<td>0.002 - 0.003</td>
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<tr>
<td>0.0004 - 0.0006</td>
<td>0.004 - 0.006</td>
<td>0.002 - 0.004</td>
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<td>0.0004 - 0.0006</td>
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</tbody>
</table>

Separation Gravity
1.35 1.40 1.50 1.55 1.60 1.70 1.80 1.90 2.00
IMPORTANCE OF EFFICIENCY
DIFFERENCE BETWEEN THEORETICAL AND PRACTICAL YIELD AS A FUNCTION OF PERCENTAGE OF NEAR GAVITY MATERIAL (Ep = Probable Error)

% Near Gravity, (+/-0.1)

NEAR GRAVITY MATERIAL: AMOUNT OF MATERIAL WITHIN +/-0.1 SPECIFIC GRAVITY OF THE SEPARATING GRAVITY
# Ep Values Using Heavy Media Cyclone Separation for Dipka’s Coals

Guranteed Coefficient = 1.15

<table>
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<th>Size Fraction</th>
<th>Separation Sp.Gr.</th>
<th>Ep Predicted</th>
<th>Guranteed</th>
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<td></td>
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<td></td>
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<td>0.019</td>
<td>0.022</td>
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<td></td>
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<td>0.020</td>
<td>0.023</td>
</tr>
<tr>
<td>13mmx1mm</td>
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<td>0.032</td>
<td>0.037</td>
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<td></td>
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<td>0.033</td>
<td>0.038</td>
</tr>
<tr>
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<td>0.034</td>
<td>0.039</td>
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<tr>
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<td>0.035</td>
<td>0.040</td>
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<tr>
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<td>1.70</td>
<td>0.036</td>
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<td></td>
<td>1.75</td>
<td>0.037</td>
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<tr>
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<td>0.038</td>
<td>0.044</td>
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<td>1mmx0</td>
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<td>0.171</td>
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<tr>
<td></td>
<td>1.75</td>
<td>0.174</td>
<td>0.200</td>
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<tr>
<td></td>
<td>1.80</td>
<td>0.177</td>
<td>0.204</td>
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</tbody>
</table>
Heavy Media Vessel

Fig. 7-10. DSM vessel. Source: Roberts & Schaefer Co.
Heavy Media Cyclone

Fig. 7-51. Dense-medium cyclone.

Fig. 7-52. Idealized flow pattern in a dense-medium cyclone.
Jig
(picture courtesy McNally)
Equipment-Cleaning

• Advanced
  – Large Diameter cyclones (+1.0 meter)
  – CLIMAXX Magnetic Separator
  – Spiral separators
  – Column Flotation
  – Falcon Concentrator
  – Knelson Concentrator
  – Oil Agglomeration
Equipment-Dewatering

- Conventional
  - Screens
  - Centrifugal Dryers
  - Vacuum filters
- Advanced
  - Screen Bowl Centrifuge
  - Hyperbaric Filter
Centrifugal Dryer

Fig. 8-22. Vibrating-basket centrifuge (Courtesy: WEMCO).
Fig. 8-25. Screen-bowl centrifuge (Courtesy: Bird Machine Co.).
Conclusion

• Coal Preparation is a major contributor to the economic and environmental viability of coal as a source of fuel for thermal power generation,

• An unavoidable fact is that the second largest populated country in the world, India, is rich in coal resources and will further develop its utilization for the generation of electricity,
Conclusion (cont.)

• The technologies of coal preparation must be promoted as an integral part of the coal-to-power undertakings in the India.

• Coal cleaning can have the most significant impact on the reduction of “greenhouse gases” in these developing countries.
THANK YOU