PREPARATION AND TRANSPORTATION OF COAL

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Summary

Coal preparation refers to the physical and mechanical processes applied to coal to make it suitable for particular use. Its unit operations can broadly be divided into coal cleaning and three associated processes: (a) the pretreatment of feed coal, (b) subsequent treatment of products; and (c) the storage and loading of products. Coal cleaning is the key process in coal preparation to reduce mineral matter content and

inorganic sulfur content. The introduction of mechanized, high-productivity extraction methods has resulted in run of mine coals that are finer, wetter, and dirtier than in the past, and has given rise to an increasing need to prepare or clean the material in some way before utilization. Several cleaning methods for the removal of ash-bearing minerals from coal have been commercialized during the past decades. All of these methods are based on the differences in physical characteristics between organic matter and mineral impurities, such as specific gravity, surface, and magnetic properties. After having been liberated by crushing, the undesirable components of coal are removed by washing—normally using jig and dense medium for coarse coal, and flotation for fine coal. Transport of coal from mines or preparation plants to consumers is also very important for the coal cost and environment. The main methods of inland transporting of coal are rail, road, barge or other water transport, slurry pipeline and conveyor. Ocean transportation is carried out by barges or ships of a wide range of sizes.

1. Introduction

The role of coal in energy has shifted from a fuel used in all sectors to one that is used primarily in electricity generation and in a few industrial sectors, such as steel, cement, and chemicals. Though coal has lost market share to petroleum, natural gas, and nuclear power, it continues to be a key source of primary energy. In 1995, coal accounted for 25 percent of the world's primary energy consumption and 36 percent of the energy consumed worldwide for electricity generation. Total recoverable reserves of coal are estimated enough for another 220 years at current production levels and coal's share in energy use is not projected to change substantially in the near future.

The quality of mined coal is highly variable because coal is a heterogeneous material and because of the unavoidable incorporation of non-coal bands and possibly a certain amount of out of coal seam rock material. Coal preparation refers to the physical and mechanical processes applied to coal to make it suitable for particular use. Unit operations of coal preparation can broadly be divided into coal cleaning and three associated processes: (a) the pretreatment of feed coal, (b) subsequent treatment of products; and (c) the storage and loading of products. Coal cleaning is the key process in coal preparation to reduce mineral matter content. The introduction of mechanized, high-productivity extraction methods has resulted in run of mine coals that are finer, wetter, and dirtier than in the past, and have given rise to an increasing need to prepare or clean the material in some way before utilization.

Originally, coal preparation was confined to the hand picking of coarse discard from belts or tables and the crushing and screening of coal to get the appropriate size ranges required by the market at that time. Mechanical cleaning of coal to remove much of the impurity began in the second quarter of the nineteenth century, but it took more than 100 years for the practice to become widespread and develop into the multiple-process preparation plants that are part of most current mining operations. Depending on the circumstances of production and consumption in each individual case, coal preparation may involve any combination of crushing, screening, and removal of a wide range of mineralogical contaminants from the various mined products.

The need for coal preparation is more related to consumer demands than to the requirements of the producer, but it is also due to the development of greater environmental constraints than in the past. Though conventional physical cleaning processes are not sufficient to clear the emissions standards of air pollution, they can considerably reduce the load placed upon producers by environmental control measures.

2. Coal Preparation

2.1 Outline of Coal Cleaning

Coal cleaning processes divides feed coal into products depending on the differences in characteristics between organic matter and mineral impurities. Minerals identified in coal, some of the properties of these constituents, and the names of the cleaning method are given in Tables 1, 2, and 3, respectively. The relative density of organic coal changes with its chemical composition and is lowest at just below 90% of carbon. The pyrites are a kind of mineral matter, but their physical properties are so different from the main other bulk of the mineral matter in coal, that it makes sense to treat them as a separate category.

MINERAL	OCCURRENCE	MINERAL	OCCURRENCE
Clay minerals		Sulfates	
Illite-Sericite	Dominant-abondant	Barite	Rare
Montmorilloniterare	Common		
Kaolinite	Common-very common	Silicates	
Halloysite	Rare	Zircon	Rare
		Biotite	Very rare
Iron disulfides		Staurolite	Very rare
Pyrite	Rare-common	Tourmaline	Very rare
Marcasite	Rare	Garnet	Very rare
Melnikovite	Rare	Epidote	Very rare
		Sanidine	Rare
Carbonates		Orthoclase	Very rare
Siderite	Common-very common	Augite	Very rare
Ankerite	Common-very common	Amphibole	Very rare
Calcite	Common-very common	Kyanite	Very rare
Dolomite	Rare-common	Chlorite	Rare
Oxides		Salts	
Hematite	rare	Gypsum	Rare
Quartz	Rare-common	Bischofite	Very rare-common
Magnetite	Rare	Sylvite	Very rare-common
Rutile	Rare	Halite	Very rare-common
		Kieserite	Very rare-rare
Hydroxides		Mirabilite	Very rare-rare
Limonite	Rare-common	Melanterite	Very rare
Goethite	Rare	Keramohalite	Very rare
Diaspore	Rare		
Sulfides		OCCURRENCE (% of mineral matter)	

Sphalerite	Rare	Dominant	: > 60%
Galena	Rare	Abundant	: 30 – 60%
Chalcopyrite	Very rare	Very common	: 10 – 30%
Pyrhotite	Very rare	Common	: 5 -10%
		Rare	: 1 – 5%
Phosphates		Very rare	: <1%
Apatite	Rare		
Phosphorite	Rare		

Table 1. Minerals identified in coal

"Coal Preparation 5th Edition" Society for Mining, Metallurgy, and Exploration, Inc. 1991

PROPERTY	unit	ORGANIC COAL	MINERAL (except PYRITE)	PYRITE
Color		Black	Dark gray	Golden
Cleaveability		Good	Good	Bad
Hardness	Moh	2.0 – 2.5	2.0 – 4.5	6.0 – 6.5
Density	t/m^3	1.15 – 1.5	2.4 – 3.9	4.8 – 5.0
Contact angle	Degrees	49 – 68	13	58 – 73
Resistivity	Ohm m	$10^6 – 10^{11}$	$10^2 – 10^6$	$1 - 10^2$
Dielectric constant		2.0 – 2.5	4.7 – 7.8	5.2 – 8.6
Volume susceptibility	10^6 cgs	-0.6	20 - 400	38 - 63

Table 2. Physical properties of the constituents of raw coal

("Physical coal beneficiation and electricity costs" IEA Coal Research, 1986)

PROPERTY	CLEANING METHOD
Appearance (color)	Hand picking
Friability	Selective crushing
Specific gravity	Gravity separation
	Washing
	Dense medium separation
	Pneumatic separation
Surface wettability	Flotation
	Selective flocculation / agglomeration
Electric conductivity	Electrostatic separation
Magnetic property	Magnetic separation

Table 3. Coal Cleaning methods and relevant property

Most of conventional cleaning processes depends on the difference in relative density (specific gravity) of organic coal material and mineral impurity. In any commercial coal preparation process, this separation is imperfect and some of the feed constituents are misplaced into other products. There are appropriate size ranges and separating density ranges for each density dependent cleaning device. Preferred size ranges of feeds to major coal cleaning devices are shown in Figure 1. Typical efficient separating gravity ranges are given in Figure 2. For below about 0.5 mm raw coal fines, the difference of surface property is utilized since conventional gravity dependent processes are inefficient for this size range. Coal preparation plants are designed to suit their particular feed coal and the specifications of their products. Various kinds of data are necessary to decide the most effective types of processing equipment, and to incorporate the appropriate capacity for each individual component. The most important properties to be assessed are the distribution of size and washability of each size fraction. The standard test methods of the above are defined as ISO 1953:1994, 7936:1992 and 8858-1, respectively.

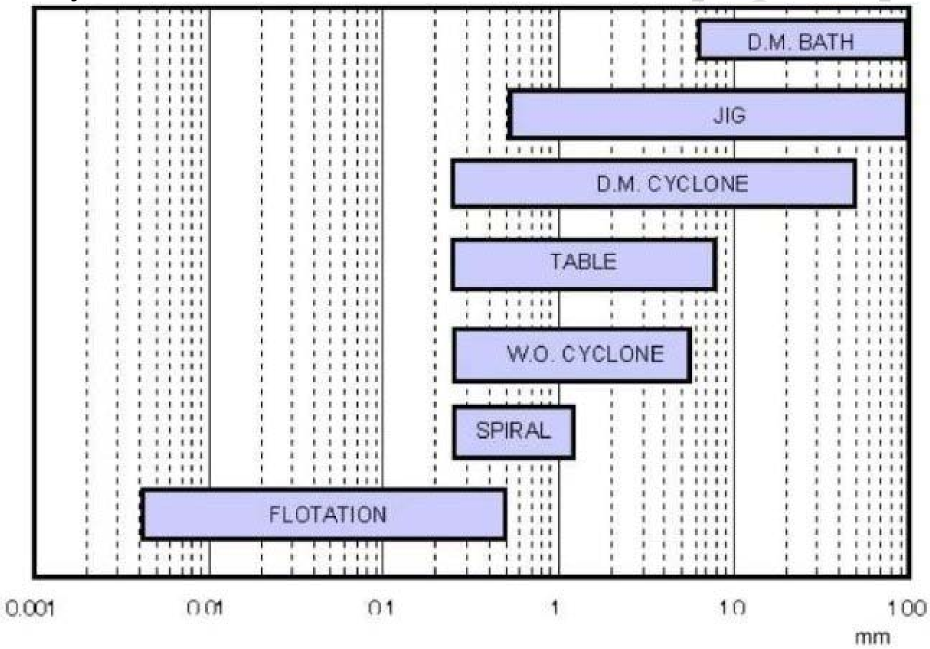

Figure 1. Preferred size ranges of feeds to major coal cleaning devices

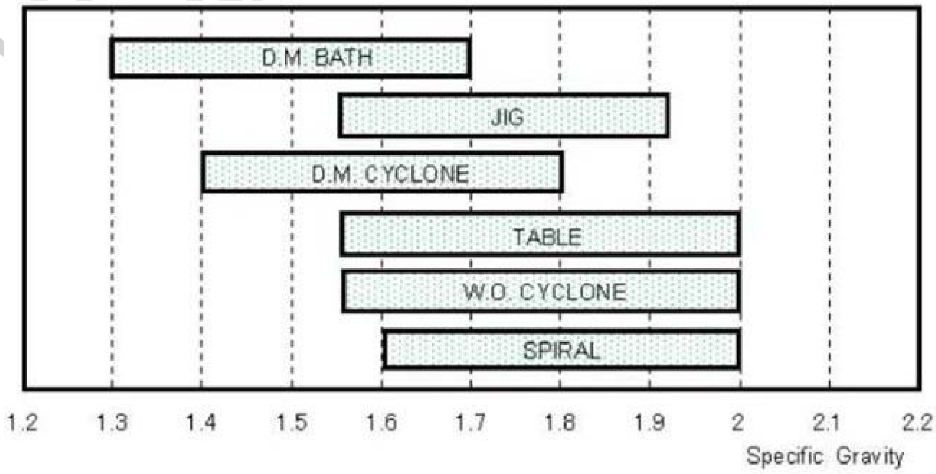

Figure 2 Typical efficient separating gravity ranges

Basically, the level of cleaning is based on the quality difference between the raw coal and clean coal. Various degrees of cleaning are shown in Figure 3. If the ash content of raw coal is already below the clean coal ash specification, no washing will be applied. But considering the fluctuation of mined coal quality, continuous monitoring of quality parameters and adequate sorting and blending are necessary for a no washing configuration to produce a consistent quality of coal. In case the difference is relatively small, partial washing seems to be most applicable method. Total washing circuits may be required when it is necessary to produce a low ash product, such as metallurgical coking coal. Retreatment of products is sometimes advantageous to minimize the loss of combustible material.

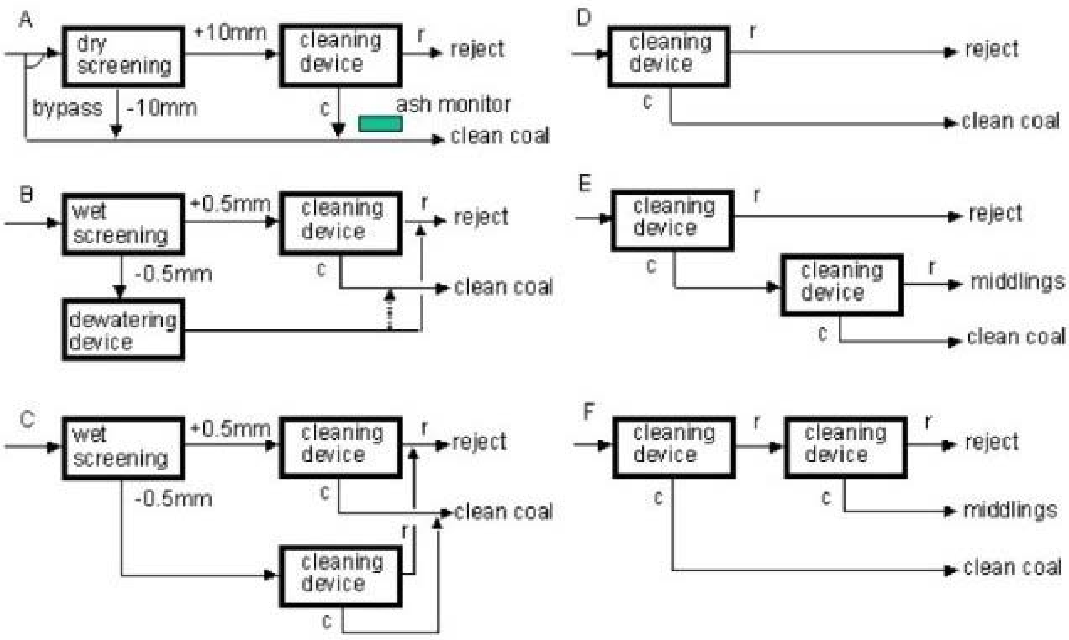

Figure 3 Various degrees of cleaning

2.2 Typical Cleaning Processes

2.2.1. Jig

The jig is one of the most common devices in conventional coal cleaning. Though cost effective jigs are widely used for thermal and coking coal treatment, the latter is still poorly understood and commonly treated as a black box.

In the jig, a bed of particles is retained on a screen and a water current periodically passes through the screen. Jigging is a process of particle stratification resulting from an alternate expansion and compaction of a bed by pulsating fluid flow. The repetition of the jig stroke permits vertical movement of different density particles by their initial settling velocities (which is more dependent on the particle's specific gravity than its size), rather than by the particle's terminal velocity (which is more dependent on the particle's relative mass). Although the elements of a jig stroke seem simple, success in achieving the bed conditions that permit the particles to stratify by density is highly dependent on coordinating the ascending and descending water movements with the condition of the bed during each phase of the jig cycle. The rearrangement results in layers of particles that are arranged by increasing density from top to bottom of the bed. There is also a small, steady flow of water through the screen on which the pulses are superimposed, which assists in the longitudinal transport of the bed to the discharge end where the stratified products are separately removed. A typical jig and the simplified components of a jig cycle are illustrated in Figure 4.

Within the solids discharge location at the end of compartment, the two layers (lighter and heavier) are split and a refuse ejector withdraws the bottom layer into the boot of an elevator which is built to be integral with the jig. The adjustment of the refuse gate height, the refuse withdrawal rate, and a float control determine the refuse separation. The rate of refuse withdrawal is usually controlled by a float located in the jig bed. The upper particle layers containing quality coal pass over a weir into a delivery sluice for dewatering.

The jig box may be divided vertically into compartments. As the compartments are separated by fixed weirs and have separate reject withdrawal systems, this multi-compartment jig is really a series of jigs designed to produce multiple products. According to the difficulty of separation, each compartment is divided into two, three, or four cells. Individual cells can be controlled separately by pulsation and water introduction. Water is introduced continuously into the chamber of each cell and its volume is an important control parameter. The support screen normally has about 20 mm apertures and may be may be horizontal or sloped towards the feed or discharge end of the jig, depending on the nature of the feed, processing objective, and manufacturer design.

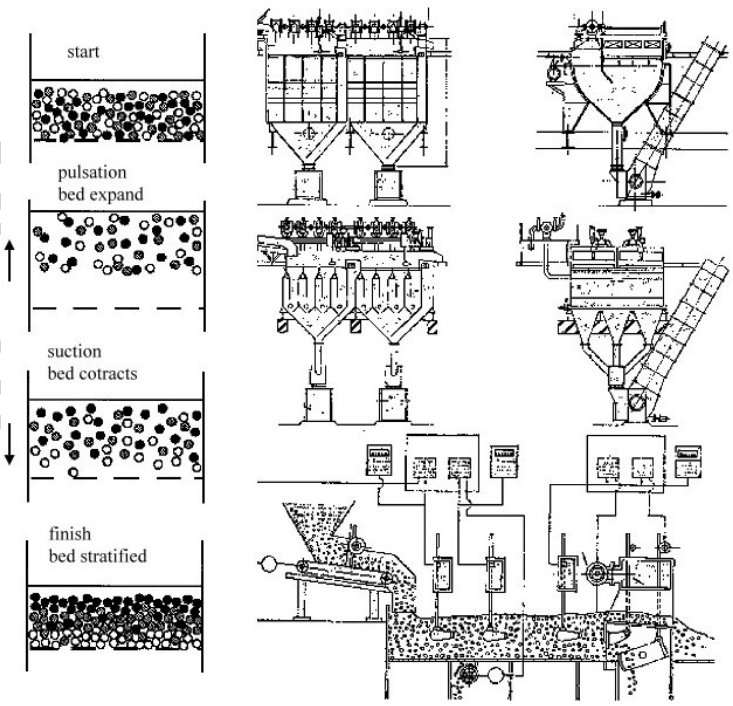

Figure 4. The typical simplified components of a jig cycle

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Biographical Sketches

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