COAL EXTRACTION AND PROCESSING

The following section will discuss many important aspects of the coal extraction and processing process. The section will be comprised of two major parts, each with subsections. Part one (definitions and context) will discuss purpose, history, regulations, and tools and equipment, and is designed to give the reader a general understanding of the process. Part two (the major stages) discusses in great detail the stages that comprise coal extraction and processing.

PART I: DEFINITIONS AND CONTEXT

Introduction

Coal Extraction and Processing is a mineral removal and refinement process in which coal (black or brownish-black sedimentary rock composed mostly of carbon and hydrocarbons that contain energy that is released when burned) is removed from the Earth and treated for further use. There are two main methods used in coal extraction: surface mining (above the ground) and subsurface mining (below the ground). Location is the biggest factor in determining what method will be used. Normally surface mining occurs west of the Mississippi river and subsurface occurs to the east. Mount Storm Generating Station, which is in West Virginia, operates entirely on subsurface thermal coal (coal finely ground to generate steam), therefore this document will specifically describe the process of subsurface coal extraction and thermal coal processing.

Purpose

Coal is used for its potential heat energy when burned and since the 1880s has been widely used to generate electricity in power plants. To generate electricity coal is first burned inside a power plant and the heat generated by the coal is then used to heat water. After the water is heated it produces pressurized steam which is channeled through a turbine. As the steam is sent into the turbine it is forced to rotate and this rotation generates electricity.

Coal is also used in the creation of materials such as steel. Steel industries use a specific type of coal called coke. Coke is coal that has been placed in a coking oven to remove all parts of the coal that is not carbon. When coke burns it creates the high temperature and chemical reaction necessary to turn iron or into raw iron. Raw iron is the key raw material used in the steelmaking process and coal is necessary to create it. Along with steel, coal has used over the centuries for many different purposes.

History

Mining is an important part of history and records and findings indicate that it has been around since the at least the 2nd century AD. The Romans were mining major coalfields during this time, and used the coal for many different things. The Industrial Revolution, which began in Britain in the 18th century and later spread to Europe and North America, was heavily influenced by the availability of coal to power steam engines. International trade expanded rapidly when coal generated steam
engines were built for the railways and steamships. Until the late nineteenth century coal was mined underground using a pick and shovel, and children were generally employed underground in treacherous conditions. “Coal-cutting” machines were introduced in the 1880s. By 1912, surface mining was performed by using steam shovels designed for coal mining.

Safety
Mining underground certainly poses some major health risks to workers, but today's workers have highly advanced equipment that protects them in dangerous scenarios. Also, the technology used in the planning and development stage of mining allows engineers, scientists, and technicians, to be more accurate with their assessment of geography, therefore creating safer environments for the miners to work in. For example, in the 19th century, miners would construct support systems entirely out of wood and nails. This resulted in a larger number of cave-ins. Also, there was hardly any geographic technology, and most miners were digging blindly. Today, mines come with highly advanced support systems, and powerful tools that allow the miners to work in safer conditions.

Social Issues

America is once again attempting to revive the coal industry. Recents changes in political administration have ushered in an era of deregulation that is benefiting the coal industry in a major way. During the Obama administration (2008-2016), regulations were created to cut the amount of carbon emissions that stem from coal facilities and power plants, therefore reducing the amount of coal that could be produced and consumed. Less coal consumption lead to less coal production. Now, president Trump has begun to heavily change the way the Environmental Protection Agency (EPA) regulates carbon emissions, effectively increasing the amount of emissions that can be produced annually. This decision to deregulate carbon emissions has received much criticism from global warming and climate change advocates, who believe that an increase in carbon emissions directly correlates with global warming.

Working in coal mines prior to the second half of the 20th century was considerably more dangerous than working in coal mines today. Although considered to be one of the more dangerous trades in industry, coal mining has come a long way in terms of safety and risks. There are now major protections for coal workers in the United States, and organizations have been created to protect the rights of the coal miners.

Because of the social and environmental effects caused by subsurface coal mining, the U.S Department of Labor’s Mine Safety and Health Administration (MHSA) was created to reduce death, injury, and health issues caused by mining by enforcing strict regulations and safety measures such as wearing protective head gear. The United Mine Workers of America (UMWA) was also established in 1890 by coal miners and “represents workers in and around underground coal mines, surface mines, and preparation plants.” Presently, worksites represented by the UMWA are among the safest in the United States and Canada according to the UMWA.
There are many types of equipment used during the process of subsurface mining. There are three main needs for the equipment which include: extraction, support, and transportation.

Extraction is the process of taking out something by using effort or force. To extract coal there are five main pieces of machinery used which include: longwall shearer (electrically driven hydraulic cutting machine also referred to as a power loader, stage loader or shear loader used in the longwall mining of coal), continuous miner (a machine with a large rotating steel drum equipped with teeth that scrape coal from the seam), blasting (the process of splitting predetermined volume of material by using explosives), pneumatic drill (hand held drill run by compressed air used for drilling into rock), and hand pick (tool with a pointed head and chiseled edges that are used to break coal loose from vein).

Having support in the mine is an important factor for ensuring the mines structural integrity. There are a few tools that are used to support the mine. These tools include: hydraulic roof supports (a hydraulic powered support machine used in longwall mining that is placed along the edge of a wall which creates a roof like shape that supports the weight ceiling of the mine), steal beams (a long sturdy piece of steel shaped to conform to the walls of the mine in order to offer structural support), and bearing plates (a plate connected to a support device that is bolted to the roof of the mine that allows a more even distribution of pressure on the ceiling instead of a small centralized point).
Once the coal has been extracted from the mine there must be a way for it to be transported, this is where transportation equipment is necessary. Equipment used for transportation of coal includes shuttle carts/mine carts (a cart that moves along a railway in the mine that can carry coal or other materials that need to be transported), armoured face conveyor (a conveyor belt system with two long and large chains that have scraping devices connected to them that move coal that has fallen on its surface, often used in longwall mining), and a coal hoist (an elevator type machine used to lift coal from the bottom of a mine to the surface).

There are different types of coal that are used for generating power in power stations. Basically, coal is ranked by its degree of metamorphosis between two major states: lignite and anthracite. Lignite produces the least amount of power when combusted, and anthracite produces the most power when combusted. Combustible power is rated by the number of British Thermal Units (BTUs) generated when combusted. As shown in the figure above, the Northern Appalachian High Volatile “A” Bituminous produces the most BTUs and is, therefore, the highest ranked and most valuable.

There are three major stages in the process of coal extraction and processing: (1) exploration and development of geography and coal reserves, (2) mining the coal, and (3) refinery involving crushing, screening, and beneficiation (further processing to increase value).
PART II: THE MAJOR STAGES

As stated earlier, there are three major stages involved in the process of coal extraction and processing. Those stages are exploration and development, subsurface mining, and refinery. Within each major stage, there are minor stages that are equally important to the entirety of the process. These major and minor stages must occur in sequential order for the process to work. The major and minor stages are represented here:

STAGE I: Exploration and Development

1. Defining Coal Reserves
2. Planning, Research, and Design
3. Construction

STAGE II: Subsurface Mining (two methods: Room-and-Pillar mining and Longwall mining)

1. Drilling
2. Extraction of coal
3. Delivery to processing plant

STAGE III: Refinery (processing to meet the customer's requirements)

1. Crushing
2. Screening
3. Beneficiation
Exploration and Development

Exploration and development is the first major stage of coal extraction in which suitable coal is located and methodology for extraction is determined. Basically, coal exploration involves discovering new coal seams (coal deposits). In this stage, coal must be defined by its size, shape, and quality; and a detailed schedule and method for extraction and management must be planned. Additionally, the geographical site must be prepared in a manner that preserves the natural elements of the land, thus this stage is very sensitive. Exploration and development involves the expertise of engineers, technologists, surveyors, and geologists. There are many types of measuring and survey techniques and equipment used during this stage. Exploration and development must occur before mining can begin.

As mentioned earlier, the type of coal that is suitable for generating power in power plants is coal that produces a high BTU when combusted. Geographical surveyors search for high-ranking coal with high BTUs through exploration activities. Exploration activities include a wide array of geographical techniques including field mapping, the analysis and interpretation of satellite images and air photos, and ground geophysical surveys like gravity, seismic, and magnetic studies. These studies are used to define the coal reserves. The exploration stage certainly begins the coal mining process, but it also continues throughout the process in various forms.

Defining Coal Reserves. Defining coal reserves or seams is a minor stage within the exploration and development stage of coal extraction and processing wherein surveyors compile data to find suitable coal deposits for mining. The studies mentioned earlier give surveyors a wealth of geological information to sift through such as core logs (dirt samples taken from drilled holes), base maps (ground level maps showing types of soil), and seismic reflections (data about the geological structure of an area) that can be integrated using computer database and modeling systems. The result of the integrated systems is a three dimensional understanding (maps or images) of the coal deposit, which acts as a map for constructionists and engineers to begin the planning of extraction and management.
Research and Design. Research and design is a minor stage within the exploration and development stage of coal extraction and processing wherein constructionists and engineers design three things: the physical mine with regard to efficient mine operations and minimum safety hazards, the operations and systems by which the coal will be excavated, and prevention plans aimed at preserving the natural area from which the coal will be mined.

Designing the physical mine is unique for every different mining situation, and can vary in time depending on the obstacles that engineers have to overcome. Each geographical location where mining occurs is unique due to the natural randomness of geophysical patterns; this means that each new mine presents new drawing plans and troubleshooting. Engineers and technicians also want the mine to be highly efficient in its production, therefore scrutiny of technical specifications and a thorough analysis of the production plans are essential. Permits and approvals for the use of land must also be completed before moving forward.

Construction. Construction is the minor stage within exploration and development where the mine and mine facilities are built. After the research and design portion of this minor stage, and after permits and approvals have been completed, the physical construction of the mining facility begins. Mining facilities are very large operations, and even small mines can have over 500 employed workers at a given time. In the construction process, engineers build transportations roads and tracks, processing facilities, employee living arrangements, and environmental management systems.

Detailed maps and accurate geographical information from surveyors are crucial to the success of specialists who construct the extraction and management systems. If there are natural, unexpected circumstances that involve the coal and strata (layers of earth where mines are dug) such as sand channels, water sources, and unusually soft earth, safety hazards can potentially occur. Surveyors do their best to provide accurate information to the specialists who plan.

Usually, the time between exploration and full production mining can take anywhere from seven to fifteen years if the operation is a large one. Smaller operations can take anywhere from two to five years. If a mining operation is located in an area where mining regularly occurs, the process may be expedited due to the abundance of resources.
Subsurface Mining

Subsurface coal mining is the second major stage in the process of coal extraction and processing wherein coal is removed from underneath the surface of the earth. During the mining stage, workers use powerful machines to drill into the earth and extract raw coal which can be refined during the processing stage. The equipment used for underground mining includes drilling devices, transportation machines, and support devices that keep the roofs and walls from collapsing. This stage is considered by many to be highly technical and requires the coordination and collaboration of a large team that includes engineers, geographers, project managers, equipment mechanics, technicians and, of course, coal miners. The process begins with drilling, then extraction, and finally transportation.

There are two methods of underground coal mining: room-and-pillar mining, and longwall mining. Technical factors like the physical characteristics of the coal seam determine what method of underground mining will be used. Surveyors take into consideration the location, depth, length, thickness, and inclination of the seam before determining a method of mining. Longwall mining is primarily used for more moderate depths due to its weaker support system, whereas room-and-pillar mining is used for deeper seams.

Room-and-pillar mining is a form of mining in which miners create a grid-like system within a seam of coal. In this method, the grid-like system leaves pillars that support the roof of the mine. Room-and-pillar mining is considered to be a more advantageous method of mining because it offers excellent operational flexibility in creating sequences of seam extraction. It is also less damaging to geographical sites and requires less maintenance in terms of structural integrity and support. The downside to this method is the pillars that support the roof of the mine are made of coal for the most part. This means that less coal is able to be extracted from the deposit. In this method, approximately 40% of the coal in the seam may be extracted.

Longwall mining is a form of mining in which a linear length of a seam is extracted entirely by means of a hydraulic, self-advancing drilling machine called a longwall shearer. This method allows for extraction of up to 75% of the deposit in a seam, but is considered to be a greater risk. Mining in a manner that allows for more than 75% coal extraction creates more stress on the structure of the mine, therefore roof support design is critical for this method, and planning can take longer.
Subsurface Drilling. Subsurface drilling is the physical act of removing earth to reach a deeper destination. This stage is commonly referred to as production, as it involves the act of producing raw minerals for later processing. Drilling involves the use of many different types of tools and machinery, and is done heavily in part by coal miners who operate the machinery. Tools range from small, hand-held pneumatic power drills, to very large continuous drillers (huge automated drills that produce 20 to 30 foot work areas).

Drilling also involves the use of high-energy explosive material to remove or loosen rock. This method is called blasting. Commonly, pyro technicians (deals with explosives) will use remote controlled or wired explosives in the form of dynamite, ammonium nitrate fuel oil (ANFO), and emulsions for blasting. This process involves attaching the explosive to the obstacle that needs removal and detonating the explosive. The result is broken up or more manageable pieces. Blasting is considered dangerous because it causes vibrations that can potentially create instability in the structural components of the mine. It also poses a risk to the technician because of its force and volatile nature.

Simultaneously occurring during the drilling process is the removal of rock and debris that occurs as a result of the drilling. This debris is extracted to the surface by way of transport machines. Miners commonly use train powered shuttle carts (small carts on tracks moved by a train engine), or hand steered powered vehicles to remove the debris from the mine. Once debris is moved and the coal deposit is reached, miners begin the process of coal extraction.

Coal Extraction. Coal extraction is the minor stage within the stage of coal mining wherein coal is physically removed from the ground by means of force. Drilling machines that are both handheld and power operated are used for this stage. In many mines, a large machine weighing close to 100 tons called a shearer uses sharp drill bits to cut coal from rock and grind the coal into a transportable form. Basically, shearers break down the coal so that is may be transported. After the coal extraction stage comes the transportation stage.

Coal Transportation. Coal transportation is the minor stage within the coal mining stage in which extracted coal is moved by some method out of the subsurface mine to the processing center. The transportation stage is quite similar to the method of removing debris during the drilling stage; removed mineral is taken from one place to another. Depending on the size and location of the coal, different machines are used for transportation.
In very large mines with ceilings over 40 feet, **haul trucks** are used to carry large quantities of coal. Haul trucks may carry up to 300 tonnes of raw material. The second largest vehicle that may go into the coal mine is a **scooptram**. A scooptram is a moving vehicle with a front mounted loader that is used to move material. The scooptram may carry approximately 20 tonnes depending on the manufacturer. Equal in capacity to the scooptram but different in shape is the **shuttle hauler**. The shuttle hauler is a product transportation vehicle that is long, slender, and has a low clearance. The shuttle hauler is able to maneuver in smaller places inside mines. Shuttle haulers also carry about 20 metric tonnes.

Transportation vehicles like the ones shown above are driven either directly to the processing plant, or are driven to a **conveyor belt system** that is in close proximity to the mine. Conveyor belt systems are transportation devices that move material from one location to another on a continuously moving platform. Conveyor belt systems are more cost effective because they save gas required to operate the transportation vehicles. They also attach directly onto the assembly line at the processing facility where the raw coal is refined.

**Coal Refinery**

Coal refinery is the third and final major stage of the coal extraction and processing process in which coal is transformed from its raw form into a usable form by artificial methods. The purpose of processing and refining the coal is not only to create a usable product, but also to increase the value of the coal. As stated earlier, the more combustible the coal is, the higher the value of the coal. By refining the coal from its raw stage into a usable stage, its value is increased. Coal refinement occurs in a coal processing facility, and the three minor stages of coal refinery are **crushing**, **screening**, and **beneficiation**.
Crushing. Crushing is the process in which coal is reformed from a larger size to a smaller size for further refinement. When coal makes its way from the mining site to the processing facility, it is often in large chunks that may be up to a meter in size. To break the coal down into a more manageable size, it is crushed in a large crushing machine called a hammer mill. The hammer mill breaks the coal down into pieces that are usually no more than 75 millimeters in circumference. Once the coal has been crushed, it then goes through a process called screening.

Screening. Screening is the second minor stage in the major stage of coal refinery wherein industrial screening machines separate crushed coal into different sizes. Different customers require different sizes of coal for different purposes. Therefore, the screening process must occur before the coal can be beneficiated (cleaned).

Beneficiation. Beneficiation is the final minor stage in the coal refinery stage wherein the crushed and screened coal is cleaned and processed by machines that remove impurities to enhance the combustibility and value of the coal. In this stage, impurities like ash, sulfur, and moisture are removed, effectively giving the coal higher BTUs. Of the minor stages in the refinery process, beneficiation is the most technically complicated and takes the longest amount of time. This stage requires the use of many different kinds of machines with varying systems and functions. After this stage, the refined coal may be packaged and shipped to a buyer.
Overall, the coal extraction process is necessary to obtain coal for the power stations we use to generate electricity. Without this process these power stations would be completely useless. Coal’s exceptional ability to generate long lasting high heat makes it the perfect choice for power generation and there aren’t many other natural resources that can match its abundance and availability. Coal dates back thousands of years, and it is one of the oldest energy sources still used today. Though coal mining is still considered a rather dangerous job, rules and regulations have come quite a ways in ensuring safer working environments for coal miners.

The coal mining industry requires a very large list of equipment and materials. Modern day mining equipment is very expensive and sophisticated. The equipment used in today's mines such as the longwall shearer, continuous miner, hydraulic roof supports, conveyor systems, and shuttle vehicles have made the mining process much more efficient and effective. This has allowed for much larger amount of coal to be mined in a smaller amount of time. Equally important are the three main steps needed for coal extraction: exploration and development, subsurface mining, and refining. Each of these three steps are necessary to extract coal from a mine and refine it, making it ready for use in a power generation station.

Exploration and development is the first major stage in the coal extraction process and during this stage a location and method for extraction is chosen. When determining a location one of the most important factors in deciding is the amount of coal in the location and its quality. The location of the mine is usually determined during an exploration activity, which is the process of using many different tools such as geophysical surveys, satellite images, field maps, and seismic and magnitude studies to determine areas with large coal reserves. After the location is determined the mine must then be constructed and prepared for mining, the time from exploring, determining the location, and constructing the mine could be anywhere from two to five years.

Subsurface mining is the second major stage in the coal extraction process and during this stage the coal is removed from the mine. In this stage proper equipment, tools, and collaboration are essential for success and safety during this stage. This stage requires many different types of workers such as engineers, geographers, technicians, and coal miners to work together to ensure the completion of this stage.

Refinement is the third and last stage during the coal extraction process. In this last stage the coal that was extracted in the second stage is purged of impurities so that it is ready for use. Coal is refined in three main steps: crushing, screening, and beneficiation. After the coal is refined it is ready to be shipped and used. The coal extraction process is completed after these three major stages are complete.