The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Surface Mining of coal

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Today I would like to describe the events that take place when a company chooses to surface mine coal from under the earth. Of all aspects of mining this is, perhaps, the most controversial, in part because of the large surface disruption that often occurs during the time that it is happening. This post will try, however, to just describe the process, without using any of the emotive words that usually surround this topic.

For those wondering what this is, on many weekends I post a small technical talk, which tries in a relatively simple way to explain some aspect of fossil energy extraction. I will direct you to earlier talks at the bottom end of this one. For those that are more knowledgeable I recognize that I am often simplifying considerably, however, by knowing some of the basics it may be possible to achieve a better understanding.

This becomes particularly true when one talks about coal mining, since there is often discussion on these pages about the relative investments in energy in a process, relative to the amount of energy recovered. Part of that evaluation involves the nature and structure of coal as it is mined and treated, and I will go into more depth on that subject next time.

It is relevant here, since it is one of the bases of judgment as to how a seam of coal is mined. If you remember, I had suggested that you might think that coal is found as being similar to a layer of cream in a cake. Separated by the layer of rock above, and more rock below, the coal itself is a relatively even thickness of material that can stretch for miles. However you should note the word "relatively" in that description, and look at the rock layers in a road cut the next time that you drive through one. You will see variations in the layer at the top and bottom all along the length. Also the layers do not have to be flat, geological movements may have tilted the seams until they are at angles all the way up to vertical. (The coal is the Urals is often highly angled, as are some of the seams in Washington State).

Coal bed thicknesses can vary from the thick seams found in Wyoming, for example, which can be more than 200 ft thick, to thin stringers of coal that are only a fraction of an inch high. When the coal lies near the surface, it is this relative thickness of the coal, to the thickness of the rock above it to the surface, that decides whether it is going to be economic to mine at all, and if it is economic whether to remove the rock from over the coal to get it out (hence the strip of strip mining) or whether the coal is better mined from underground. (The name also comes because you work on one strip of land at a time, as you remove the coal sequentially across the property).

This relative ratio, the stripping ratio, varies with the quality of the coal, and other operational costs. For example a coal seam that was 100 ft underground, and some 6 ft thick, would have a stripping ratio of around 16.7, and there was a time that that would have been about the economic limit. But as the price of coal increases, and earth-moving equipment gets more efficient, that

ratio may increase.

So what is involved in strip mining (apart from all the permits, surveys etc that make the whole process of installing a mine take a number of years)? The first step is to remove the top soil, and that which lies under it, as either one or two separate lifts. Generally these are scrapped from the surface using specially designed equipment. Depending on the final size of the mine, the soils are then stored until needed, or carried to the part of the mine that has already been worked and, as a final step in restoring the land contour, the soil will be replaced and the appropriate ground cover planted.

Once the top cover has been removed, the layers under it are usually rock, and this must be broken first, before it can be moved. The fracturing is usually done by drilling large (say 8-inch) diameter holes down through the rock, and then filling them about two-thirds full of an explosive. As a general rule you don't want to fill them all the way, since if you did, then when the explosive went off it would just shoot back out of the hole. The large columns of black smoke you see shooting from such blasts in movies are for effect. A skilled blaster will fire the entire round, and if you were to watch a slow-motion movie, the ground level would rise in a pattern, as the individual rows of charges went off, but there would be almost no gas vented from the holes. To confine the charge, the top part of each hole is filled with what is known as stemming, usually some of the rock particles that were removed from the hole during the drilling operation.

I said that the explosive is fired in rows, and this is to make the explosive work more efficiently. When you "fire" an explosive you are causing the chemicals in the charge to very rapidly turn to gas. At the same time the blast wave from the start of the reaction will have cracked the rock immediately around the drilled hole. Thus as the explosive turns to gas, that gas can penetrate into the cracks around the hole, causing them to grow out into the solid. The gas follows the cracks, and helps them to grow, while, at the same time "lifting" the rock away from the solid as the gas penetrates. At the same time, firing the explosive in a sequence lowers the overall vibration directed into the ground.

If the mine so chooses it may angle the holes that were drilled so that as this gas penetrates under pressure, it will also throw the rock some distance towards the area of the mine that has previously been worked. This is known as blast-casting and is not always needed. However by firing the rows of charges in sequence (using small delays set into the detonators that are connected together to set-off the individual charges) the rock nearest the edge of the last layer of rock removed is broken first. This removes some of the confinement of the next layer in (working the other way around to the increased strength from confinement that I mentioned in the Longwall section). In this fashion and with only millisecond level delays in each row, the entire rock in a strip overlying the coal can be fragmented. (Note that in the video I referenced, the dust is from the rock impact, not the blast).

Once the rock is broken, then it is moved away from over the coal. There are two different machines that can be used for this, either a drag-line excavator, or a shovel. However the size of these machines may be somewhat larger than most folks imagine. Because of the large quantities of rock that have to be removed, there are usually economies of scale that mean that the larger the machine, the faster and more economic the removal is.

With a drag-line, the machine usually sits on top of the rock, and will lower a bucket that is dragged up the free surface of the blasted rock, until it is full. The dragline then swings its boom, until it is over the strip of land where the last pass of the process had removed the coal, and dumps the rock into that space. By steadily working across the face and back down the area that was blasted, all the coal seam is exposed, and is ready for removal. At the same time, the previous

strip of ground is filled back up to about the starting level of the ground.

If the coal is relatively shallow, or the rock is being removed in several lifts, then a different machine can be used. This is called a shovel, though again, its bucket can often hold a large family size car. As with the excavator, the shovel scoops up the broken rock, swings around and dumps it in the cut behind the machine. Note that it is more economic for the rock to be moved only once, and so the width of the strip will be governed by the size of the machine that is used. And a shovel will often only remove rock layers of around 15 - 45 ft high, depending on machine size.

After the coal has been exposed, then, depending on the strength and thickness, it can either be removed without any further process, or it may require some additional explosive fracturing to make it easier to pick up. It depends on the coal. In either case, when it is loose enough, the coal can be picked up by a smaller shovel, and this will usually load the coal into trucks, that will carry it away to the plant where it will be cleaned.

At which point you may say, wait a minute, you have just dug a hole 100 ft deep, and have trucks being loaded with coal, but how do they get out? Good point! Generally during the creation of the spoil banks behind the working area, bulldozers will create a ramp that slopes down, from the surface, to the coal level, and this will be kept moving forward as the strip of ground that is being mined moves across the property.

Once the coal has been taken out, then the space is available for the excavators and shovels to place the rock there, as the next strip of ground is worked. The initial appearance of the spoil banks is usually a series of large hummocks, prescribed by the movement of the earth-movers, but once the pass placing that rock is over, then the ground is restored to contour, generally using some form of bulldozer, though larger than those normally seen in public.

After the ground contour has been restored, then the top soil is replaced, and the ground seeded, and brought back into production. Where, because of the shape of the original surface, that is not possible, then, before mining took place, an approved location for the excess rock will have been established and approved. That area will also, post-mining, be treated and brought up to a specified condition. Where the original shape of the land does not allow full restoration of contour, then, as in mountaintop mining. Note that there are a number of sites that have pictures that show that land has been returned to productive farm use after mining. In the spirit of the times, I thought I would show a different end use.

This is a part of a series of talks that has, most recently, dealt with coal mining. Earlier talks in that series dealt with two forms of underground mining;

Longwall Mining

Room and Pillar Mining

Last year the subjects covered related to oilwell drilling, and, for convenience, I will post a collective list for this in a separate pose, hopefully also this weekend.

As usual any concerns, corrections, or questions, should be addressed in comments.