Tech Talk: Breaking Rock in a Surface Coal Mine

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There is a growing concern, as fossil fuels are recovered from the ground, that the cost of the energy required to extract and process them is rising, and that a point may be reached where it is no longer energy-cost effective to continue with production. In this post, I would like to talk to you about the use of explosives, one of the ways that helps keeps the energy cost of surface mining down.

There is a growing concern, as fossil fuels are recovered from the ground, that the cost of the energy required to extract and process them is rising, and that a point may be reached where it is no longer energy-cost effective to continue with production. In this post, I'm going to discuss the use of explosives, one of the ways that helps keeps the energy cost of surface mining down but by showing two different ways in which they are applied, try to illustrate the difficulty in coming up with an energy cost.

Mining tends to use significantly more explosive than other industries (and that includes the military). I was reminded of this when, in the course of demilitarizing unused ammunition, we looked for civilian uses for the explosive that we had removed. To begin with, the explosives tend to be of different types, so the best of one is not necessarily that much use in the other, but more to the point the quantities that would be generated were trivial, relative to those of industrial need.

Why do we use the explosive in the first place? Well coal seams are generally found under a certain amount of rock and soil, the overburden, and while the soil can be relatively easily removed by scrapers, and similar equipment, the rock must be broken into easily handleable pieces before it can be moved. The soil is removed and stored, so that, after the coal is gone, the land can be restored – there are, in most countries now, strong regulations regarding reclamation, and a significant effort is made to achieve land recovery after mining.

Acorn Bank open cast site, just after reclamation.

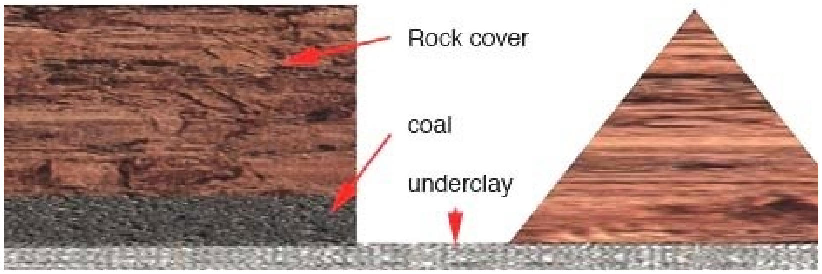
I have put this picture up in part, because it is rare for those who debate the issues of mining to show what the mine looks like after reclamation. To achieve this level of restoration, however, the site must be catalogued before mining, and the soil and overburden segregated so that it can be restored, and the conditions re-established, after the mine has passed.

Scraper that could be used to remove and replace soil (Source [Caterpillar]).

After the soil has been removed, then there are usually several tens of feet of rock that will lie over the coal. Before the coal can be mined this rock 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. Generally this fills the top third of the hole, after the explosive has been placed in the hole.

The explosive that is used is no longer gunpowder – though to get back to the EROI question that I started the post with – how do you count the amount of energy used by the explosive? Is it that required to make the powder – gathering the ingredients for gunpowder (as a number of novels will be glad to inform you) is not that energy intensive, and while milling the particles to achieve a better burn requires some effort, it is nowhere near the amount of energy released when the gunpowder is set off.

Modern blasting typically uses a mixture of ammonium nitrate and fuel oil, known as ANFO. (There are a number of videos on Youtube showing ANFO charges going off, you might start here). A single blasting operation might use between 2 million and 5 million lbs of explosive, in conventional blasting the rock over the coal. (One of the largest disasters in Texas occurred when a ship loaded with ammonium nitrate blew up in 1947). In the simplified sketch below, the rock over the coal is first drilled and broken using the explosive charges, and then it is moved from over the coal to the spoil bank on the other side of the active mining section, so that the underlying coal can be taken out and away.



The typical picture of large, uncontrolled blasts that make the popular press are actually quite far from the truth as to what usually happens in this stage. And the fireball from firing a shot in coal is very unusual. (It could come from igniting any gas in the coal, or from burning some of the very fine coal particles that are formed in firing the shot). Where the ground just heaves a little and then settles back is the sign of a good shot, since all the energy has gone into breaking the rock, so that it is then easier to move.

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.

However there is a fair amount of wasted energy in just lifting the rock with the explosive gases, and then allowing it to fall back into place. Thus there is a growing practice to use that energy more effectively by having it not only break the rock, but also to “cast” it into the open space beside it, where it would otherwise be loaded by machine.

To cast the coal the blast holes are angled so that as this gas penetrates under pressure, (video) 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 this fashion and with only millisecond level delays in each row, the entire rock in a strip overlying the coal can be fragmented and a significant portion of it moved into the open space beside the coal seam, where the last strip of coal had been removed. (Note that in the videos I referenced, the dust is usually from the rock impact, not the blast.)

The need is, therefore to use the explosive energy more efficiently, and I rather suspect that since, until recently this hasn't been much of a concern, there is still considerable progress to be made in improving the efficiency of the process. For example, by switching to an emulsion explosive the hole is filled more completely than with the granules of ANFO.

But once the rock is broken and displaced it is still very simple to use shovels (albeit the rock is often moved with a dragline, and the coal then removed with the more precise control of an electric shovel).