The Cannel Coal Industry of Kentucky: A Brief History of Resource Development and Depletion

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INTRODUCTION

The mining of cannel coal was a small, but prestigious, component of coal production of Kentucky in the 1800’s and early 1900’s. Cannel coal sold for about $2.50/ton (at the mine) at a time when bituminous coal sold for less than $1.00/ton. Kentucky cannel coals were marketed throughout the United States and Canada, as well as to Europe and South America. Perhaps the most unusual marketing of Kentucky cannel occurred at the 1893 Columbian Exposition at the Chicago World’s Fair where a 23 foot by 27 foot cannel arch was constructed, modeled after the Arc de Triomphe. Cannel coal was retorted into liquid fuel, gasified as an enricher of municipal gas supplies, and distilled as a feedstock for the production of chemicals. Each peak in usage was subsequently tempered by a discovery of cheaper sources of liquid hydrocarbons.

The production of cannel, as with any mineral commodity, was at the mercy of market demands and available transportation. Cannel coal, more than banded bituminous coal, occurs in relatively limited areas, leading to the rapid exhaustion of commercial deposits as well as the failed attempts of investors to develop deposits that did not attain commercial size. This history of the Kentucky cannel industry provides a view of a limited resource, in many cases, mined to exhaustion, with a rather specialized market. In some respects, the history of the boom and bust years of the cannel industry is similar to the development of the coal industry on the whole. The latter’s resources are not as limited but they are, nevertheless, exhaustible. Furthermore, without a market and available transportation to get the coal from the mine to market, the resource will remain unmined.

Brief histories of two of the more important deposits serve to illustrate the history of the repeated rise and fall of the cannel coal industry. The Breckenridge deposit in Hancock County, Western Kentucky, and the Morgan County deposits, Eastern Kentucky, will serve as mirrors on an industry that was important in its own right but, overall, was obscured by the larger bituminous mining industry.

CASE HISTORIES

Breckenridge

The Breckenridge cannel coal, from southern Hancock County in Western Kentucky, ranks as Kentucky’s most famous cannel. Owing to its outstanding quality, which surpassed that of the Scottish Torbanehill cannel, it is still among the best known cannels in the

Evolution of PYROGRAF III™: Process Produces Vapor-Grown Carbon Fibers Using Coal

Bob Alig
Applied Sciences, Inc.

Hydrogen sulfide has made it possible to produce vapor grown carbon fiber in practical quantities. Coal could eliminate the need for handling toxic Hydrogen sulfide at an acceptable price. Furthermore, this could potentially resolve emission problems and transform high-sulfur coal into a very desirable commodity.

Introduction

The basic process for producing vapor grown carbon fibers was developed by Dr. Gary Tibbetts at the General Motors NAO Research Labs and described in ENERGELIA, Vol. 1, No. 4, 1990. In this process, an organometallic compound containing iron is injected into a hydrocarbon vapor at temperatures above 1000 °C. The fibers lengthen and thicken as they move through the reactor with the gas stream and col-
Cannel Coal, (continued)

world. Local legend traces the discovery of the deposit to two hunters who found the cannel at the outcrop and proceeded to build a cabin and fireplace with the coal. The first local use of cannel as a building stone failed.

The development of the Breckenridge deposit dates to at least 1837 when it was sold for the use of Ohio River steamers at a price equivalent to $2.50/ton. In the 1850’s, the Breckenridge deposit was developed first as an exportable commodity and, later, as a source of liquid fuel. In the early 1850’s, the cannel was sold for up to $15/ton in New York and London for use as a gas enricher. Up to 10,000 tons/month were shipped to England, doubling as ballast for the ships. The export market ended in about 1856 with the construction of 30 retorts for coal oil refining. The Breckenridge Coal & Oil Company operation was one of 55 coal-oil companies operating in the United States in 1860. The discovery of petroleum in Western Pennsylvania the previous year and the subsequent decline in oil prices to $0.52/barrel in 1861 killed the coal-oil industry. Most of the retorts in the US, many of which had been based on Breckenridge cannel, were converted to crude-oil refining.

Mining resumed in the 1880’s and markets were found throughout the United States and as far away as Nova Scotia and Chile. The revival did not last as the reserves were depleted to the point where the mining production fell to 300-400 tons/month in 1896, the equivalent of one day’s production in 1887. Underground mining ended in November 1898, a victim of the market disruptions caused by the Spanish-American War, armed conflict with a major customer never being good for business. John Taulbee from Morgan County owned the deposit from about 1904 to his death in the early 1970’s. He attempted to mine the deposit but was unsuccessful. The next owner, John Corder, did surface mine the remains of the underground works in 1977, with his Warm Glow Coal Co. marketing the cannel as a fireplace coal. The mine site is now a private hunting club.

Morgan County

In the second decade of the 20th century, Kentucky was considered to be the premier cannel-producing state. Morgan County led Kentucky with production surpassing the total of any other state, probably surpassing the production from the Breckenridge mines (which, pre-dating Kentucky Department of Mines and Minerals records, is inaccurately known). In 1892, however, Morgan County was remote and the cannel resources were totally undeveloped. Lacking, also, was transportation. Morgan County is on the Licking River, and did not have the railroad access of the Big Sandy, completion of the link was delayed by the 1899 Kentucky River floods that washed away the rail bridge. A rail link to Morehead eventually served operations on the north side of the county.

The Kentucky Block Cannel Coal Co. was the largest producer, generally producing 5-10 times the cannel as its nearest competitor. The company also developed oil and gas wells on its Cannel City property in southern Morgan County.

The principal cannel coal mined, marketed as the Pluto cannel, and a thinner cannel were marketed as domestic fuel, gas enrichers, and for the production of cannel-oil by-products. During the World War I era, the chemical industry, which had become increasingly dependent upon a crude-oil feedstock, faced wartime shortages. Cannel oil and coal tars from coking were two of the alternative feedstocks used. Postwar industrial growth maintained the demand for cannel, leading to then-record production in Morgan County in 1920. The cannel boom collapsed in 1921, production decreasing by an order of magnitude, as the early development of the Persian Gulf oil fields and the domestic oil transportation networks reduced the desirability of using a solid fuel to produce a liquid product.

A second boom in production followed World War II. In the face of a rapid rise in oil prices fueled by the increased transportation and industrial demands, the US government funded shale- and coal-conversion projects in the late 1940’s. Again, the development of Persian Gulf oil fields, offshore petroleum resources in the Gulf of Mexico, and improved oil transportation networks effectively killed any hope of developing a synthetic-fuel industry. The most recent cannel mining in Morgan County, with the intended market being home heating in Ireland, was abandoned after mining a few hundred tons. For the first time since the beginning of cannel mining, Morgan County produced no coal, cannel or bituminous, in 1994.

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SUMMARY

The cannel industry in Kentucky garnered prestige far beyond its contribution to the total coal production of the Commonwealth. Cannel production compared with bituminous production peaked at 2.2% in 1895. By the time Morgan County came into full production in 1902, cannel production was only 1% of bituminous production.

Cannel filled a niche market as a specialty fuel. When those markets were serviced by cheaper, more convenient fuels, the market for cannel diminished. The coming of pulverized-fuel combustion, as opposed to stoker-fired combustion that could handle larger particle sizes, placed greater value on the easier-pulverized bituminous coals, further displacing the extraordinarily hard, although higher heating value, cannel coals.

Despite the dreams of investors, who still, at times when synthetic fuels may be approaching economic viability, hope to exploit cannels for their inherent high retortable oil content, cannel can now be best described as a novelty fuel. Considering the limited extent of cannel deposits and the near-exhaustion of the best deposits, the absence of a market for cannel in the utility sector, and the persistent future development of synthetic fuels (in which cannel, for the first reason cited, would not play a significant role), cannel use is not likely to expand beyond its current domestic markets.

Although there was only a limited production of cannel, lessons from its history can be applied to the coal industry as a whole. Cannel was a desired commodity, leading companies to develop resources which, owing to the limited nature of the deposits, were not able to support the market demand for the product. Prior to that point, the cannel could not be developed before rail transportation from the mine to the market was in place. Ultimately, cannel was displaced by cheaper, more easily transported fuels, losing the extensive market it had gathered through the late 1800’s and early 1900’s.

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PYROGRAF III™, (continued)

Hydrogen sulfide
Most of the PYROGRAF III™ made to date has used laboratory grade methane as a hydrocarbon source to assure reproducible results. Since one reactor can now produce almost a pound per hour, natural gas is frequently used and the hydrocarbon variations do not affect the output. A pound of fiber made with laboratory grade methane adds $70 to the cost as compared to $0.44 for natural gas. Although the addition of H\textsubscript{2}S was instrumental in achieving this improvement, it was used with great reluctance. Hydrogen sulfide is expensive, highly corrosive, flammable, and its toxicity is commensurate with hydrogen cyanide. Suppliers are hesitant to ship the material and prefer to ship H\textsubscript{2}S that has been diluted in CH\textsubscript{4} to the 1 to 3% level at an astronomical cost.

Coal
This suggests that a fossil fuel such as high sulfur coal may be especially appropriate for consideration since millions of tons of high sulfur coal are no longer being mined due to the 1990 Clean Air Act Amendment. As an example, Ohio coal production has fallen from 55 million tons in 1970 to 33 million tons in 1990 and projected to drop to 17 millions tons. Furthermore, coal would have a tremendous effect on the eventual price of the fiber. The hydrocarbon is the most expensive cost item, followed by the electric oven energy and the catalyst. Although the energy consumption and output capabilities are not yet optimized for a total cost picture, the formulations indicate that the hydrocarbon in coal could potentially cost ten times less than natural gas and totally eliminate the price and hazards of H\textsubscript{2}S.

Coal trials
A reactor that normally uses a feedstock of 99.9% pure methane was converted to accommodate the use of coal. For catalyst, helium was bubbled through liquid iron pentacarbonyl to provide Fe particles for the 1100° C reactor. A screw type apparatus was assembled to feed the coal into the injection stream and a carrier gas transported the coal and catalyst into the reactor.

Two types of coal trials were made. The first was to test the hypothesis that sulfur-bearing coal can replace H\textsubscript{2}S as the source of sulfur in the reaction. In this case, coal and methane were used as the hydrocarbon feedstock. Methane was the carrier gas and calculated to maintain a 1.6 molar sulfur/iron ratio.

Since coal contains many compounds of sulfur and all may not participate in the reaction, a 1.6 ratio was chosen that was higher than the usual “control” formulations with a 1.0 H\textsubscript{2}S/Fe(CO)\textsubscript{5} molar ratio. Ohio #8 Coal from CONSOL Inc., at 4.71% total sulfur and 46.6% total carbon, was pulverized to less than 63µ.

Trial 2 was to test the hypothesis that coal could be the only supply of the hydrocarbon and sulfur, and produce vapor grown carbon fiber. The pulverized coal was carried into the reactor with a non-hydrocarbon carrier, hydrogen. Upper Freeport Seam coal was obtained from Kaiser Engrs. with 2.5% total sulfur and an estimated 65% carbon content. In this trial designed to run without methane dilution, the molar sulfur/catalyst ratio was 4.5. The formulations are as follows in Table 2.

<table>
<thead>
<tr>
<th>Control Formulations*</th>
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<tbody>
<tr>
<td>Methane: 96.90</td>
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<tr>
<td>Coal: None</td>
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<tr>
<td>Sulfur: 0.47</td>
</tr>
<tr>
<td>Hydrogen: None</td>
</tr>
<tr>
<td>Helium: 0.96</td>
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<tr>
<td>Fe(CO)\textsubscript{5}: 1.68</td>
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</tbody>
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* Formulations are in percent by weight.

Results
In Trial 1, with coal, methane, and no H\textsubscript{2}S, the photomicrograph in Figure 3 shows very good growth and confirms that the sulfur contained in the coal plays an active role in the catalytic process, and can potentially replace the need for using H\textsubscript{2}S in the reaction. The sulfur content in coal is well beyond the optimum amount for the formation of carbon fibers. Nevertheless, this wide range of sulfur acceptability leads to the consideration of high sulfur coal. In spite of its problems for other uses, it may be a unique essential asset for the production of vapor grown carbon fiber.

In Trial 2, coal is the only source of both hydrocarbon and sulfur and an SEM photomicrograph is shown in Figure 4. There is good, but shorter fiber formation with a fair amount of soot and/or ash. Nevertheless, these results support the conclusion that the inherent carbon in coal is actively pyrolyzed to products which participate in the catalytic fiber nucleation and growth process.

Exhaust Emissions
Photomicrographs are the initial estimate of fiber formation. However, X-ray diffraction estimates the graphitic ordering for assuring the quality of the fiber’s strength and conductivity. Table 1 shows that the fiber samples from coal Trials 1 and 2 have a graphitization index that is typical for low modulus commercial fiber.

In earlier trials that rely on introducing H\textsubscript{2}S into a pure methane feedstock at equivalent ratios with the catalyst, periodic analyses were made of the exhaust. To date, sulfur has not been detected in the exhaust. This could be explained by the idea that the sulfur dissolves in such large amounts that it melts the iron catalyst and thus stays with the catalyst at the base of the fiber. How much sulfur can be dissolved as the sulfur increases is unknown. A packed column gas chromatograph (GC) with thermal conductivity detector was used to estimate the composition of the exhaust gases of a series of coal trials when the sulfur was running at 4.5 times the usual amount (Trial 2) and the presence of sulfur was not detected. This instrument does not have the sensitivity to measure nitrogen or sulfur compounds below about 0.1-1%. Future work is needed with a capillary column GC with dedicated nitrogen and sulfur detectors.

Residual Ash
There is a wide variation in the organic and ash content in coal. Trials to date indicate that their presence does not inhibit the growth of a carbon fiber. Furthermore, there is no indication that...
The Difference Between Informing and Educating

Richard Lawson
President National Mining Association

There is no other nation that surpasses the U.S. in terms of care for the environment, and we can support this by showing nearly $1.3 trillion in expenditures for environmental protection activity since 1980.

“Tell the miners from me that I shall promote their interests to the utmost of my ability; because their prosperity is the prosperity of the nation, and we shall prove in a very few short years that we are indeed the treasury of the world.” These words of Abraham Lincoln’s were transmitted to a westward-bound Cabinet secretary on the afternoon of April 14, 1865, one of the last official statements made by the president before he left for Ford’s Theatre. They illustrate the great perspectice insight and depth of understanding that Lincoln brought to so many issues of his time.

Undoubtedly, were Lincoln to be magically transported to the modern era, he would not be surprised by the critical position the products of mining have come to occupy in our society. There is no question that mining is inexorably linked, not only in broad terms to our nation’s prosperity, but specifically to our daily lives as citizens of the United States and the world.

This is a great and immeasurable responsibility which every component of our industry - from miner to corporate CEO - takes seriously. At the same time, mining companies also have long recognized another important aspect of their public obligation: that with the right of mineral and coal extraction comes the duty of restoring the land and operating in an environmentally responsible manner.

Our most extreme critics would have you believe otherwise. They are quick to demand that the mining industry feel ashamed of its environmental track record. The most severe of these individuals and groups would be satisfied with nothing less than a cessation of mining activity as we know it. Some others, while willing to begrudgingly tolerate limited mining, seek regulations and restrictions so harsh that they border more on the punitive than the practical. Our opponents have attempted to turn these viewpoints into public opinion and, ultimately, public policy. In some instances, as we know all too well, they have succeeded, much to the detriment of our industry and the nation.

Yet, we also know from opinion polls that in spite of this, the general public overall does not have a negative view of the mining industry and its environmental performance. In fact, most people do not have an opinion at all, either favorable or unfavorable. What this says, in part, is that we have been doing our job so quietly and efficiently that the average person simply doesn’t think about us. But there is also no doubt that we in mining have not done an adequate job of educating - not simply informing - but educating the public-at-large about our unmatched productivity, our environmental performance and mining’s importance to everyday life, and to the nation’s security.

Providing information and informing people is an action that, in essence, is rather benign. It infers that you are making data available; if your target audience wants to assimilate it, fine. If it doesn’t, then it really doesn’t matter how good your numbers and arguments are.

But education is another process entirely. As the ancient Chinese proverb says, “Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime.” Fundamentally, educating means providing the tools for an individual to make intelligent choices.

For these and other reasons, effectively educating constituent audiences about mining will be a key activity of the National Mining Association for the foreseeable future.

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able future. And teaching the truth about our industry’s environmental performance will be a key part of the message.

What the public will hear is this - without question, a fundamental reason the U.S. economy is so competitive is that our mining industry produces products so efficiently, productively, safely and inexpensively. There is no other nation that surpasses the U.S. in terms of care for the environment. And the U.S. mining industry is at the forefront of that great national environmental crusade.

This message will be carried in a variety of forums: the Internet, where NMA has its own home page; managing existing educational resources and creating new ones; and taking advantage of traditional media, publication, advertising and communications outlets. Over the long term, our successful use of these avenues to educate will result in a sustainable future, not only for our industry, but also for America and the world.