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FUTURE USE OF RAW COAL

By

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A very significant movement of modern industrial life is the study now being made of the use of coal. The high volatile coals of Pennsylvania could be made to yield from four to six times the quantity of oil now being gotten in the State from oil wells. Knowing this, are we justified in continuing to burn raw bituminous coal for raising steam, when such method does not utilize the possible by-products? At least one author has gone so far as to say: "Within a few years it will be against the law to burn bituminous coal directly; it will have to be utilized for its valuable by-products, worth many times what the coal is worth in its raw state; and the thing to be burned will be the coke or residue which is left behind, which after all, is greatly superior and more economical than the raw coal for domestic and power purposes."

Present use wasteful. It has long been recognized that our present methods of burning raw coal are most wasteful. For over [illegible] years we made coke in beehive ovens. Then came the by-product oven which makes from 7 to 25 per cent more coke from the same quantity of coal, and in addition yields from 7 to 15 gallons of tar and oil, 16 to 30 pounds of sulphate of ammonia, and 6,000 to 7,000 feet of gas per ton of coal treated. We have long known that when used for power production in the ordinary steam plant driving a poorly insulated engine with a low piston speed and a slide valve, there is delivered only about 4 per cent of the energy in the coal. Multiple expansion engines invented many years ago develop about 15 per cent of the energy. Then came the turbine engine, which obtains nearly 20 per cent. Most of this loss is not in burning the coal but in the engine. As a matter of fact, boiler practice obtains 60 to 75 per cent or more of the heating value of the coal; the final result however is in strong contrast with the use of liquid fuels in internal-combustion engines, which reach a relatively high efficiency.

Sources of oil. But there is another reason for studying the better use of coal. Because of the increasing use of gasoline and the rapid depletion of the oil reserves of both the United States and Mexico, it will soon become necessary to find additional sources of petroleum. Besides the oil obtained from the ground by the drill there are two other sources - oil shales and coal. Extensive studies are being made of the oil shale deposits of the country and commercial experiments are in progress looking to their utilization. As yet these experimental plants have not reached commercial production so that their product can compete with petroleum in the general market. In the meantime more and more attention is being given to what can be accomplished with coal.

Distillation of coal. The use of coal in making illuminating gas is a well-known process, and the burning of coal in beehive ovens to make coke has long been practiced. The introduction of by-product coke ovens has been in progress for some years, a progress greatly hastened by the war. In all these processes the coal is heated to a relatively high temperature, about 1800° F. As a result of this heating, gas, tar and ammonia are driven off from the coal, and coke is left. In the beehive oven the gas, tar and ammonia are lost. In the by-product oven they are saved except for so much of the gas as is used in the process of coking.

It has long been known that if coal be heated to a moderately high temperature, say 1200° F, the quantity of gas driven off is less than at a higher temperature and in place of the usual type of tar may be obtained a small amount of light oil and usually a much larger amount of heavy oil. The residue is heavier and denser than coke, and contains more volatile matter.

Today experiments on "low temperature distillation of coal" are reaching the stage of commercial production in England, Germany, and the United States.

Experiments in the United States. In the United States some progress has been made. One company experimented for several years on by-products from low temperature distillation in a plant at Irvington, New Jersey, where over 100 American coals were tested. Subsequently this company built a plant at South Clinchfield, Virginia, having a daily capacity of 500 tons of a new fuel called carbocoal.

In the carbocoal process raw coal is crushed and fed continuously by paddles into low temperature retorts. The volatile products driven off are treated much as in by-product coke oven practice. The horizontal retorts continuously discharge a semi-coke product that is softer than ordinary coke, contains 8 to 10 per cent volatile matter, burns readily and could be used as it is, but it is not suited to the general market. The second part of the process involves grinding of this semi-coke, after which it is mixed with pitch, fluxed and briquetted, then carried to inclined retorts and distilled for six hours at a temperature of 1800° F. The retorts are about 18 feet long and constructed of carborundum blocks. The ends of cast iron are lined with fire brick. Each retort is operated about one-third full and has a capacity of about one ton an hour. The material is advanced by paddles mounted on two parallel 12 inch paddle shafts which revolve at 1.8 revolutions per minute. The briquettes are dumped and quenched. The by-products from this high temperature distillation are treated with the similar products from the low temperature distillation.

One ton of Kentucky coal containing 3 per cent of moisture, 35 per cent volatile matter, 55 per cent fixed carbon, and 7 per cent ash, is said to yield 1400 pounds of carbocoal, 30 gallons of tar, 9,000 cubic feet of gas, 20 pounds of ammonium sulphate, and 2 gallons of light oil thrown down from the gas. In general, the quantity of carbocoal is between 65 and 72 per cent of the weight of coal used. The yield of tar, which is a block oil of petroleum-like fluidity, is 29 to 42 gallons; and of ammonium sulphate from 20 to 24 pounds per ton of coal. The yield of carbocoal is a little higher than the yield of coke from the same coal. About four times as much tar is produced. The tar is more valuable as it contains no napthalene, is higher in tar acids and cresols than gas tar or coke tar, and contains more phenol. After the removal of the phenol this distillate resembles crude petroleum in properties and uses. The amount of ammonium sulphate yielded is about the same as in making coke. A little less gas is produced, but more than enough for the needs of the process. The distillation of tar yields 20 gallons of salable oils of high market value; 40 per cent of the tar is tar acid. The pitch left over is used for briquetting the semi-coke in the last part of the process. This is an amorphous, black residue, less brittle and lustrous than high temperature pitches.

The briquettes are hard, nearly as dense as coal, and those derived from coal with 7 per cent ash have a heat value of 13,000 B.t.u. The briquettes have little tendency to clinker, are practically smokeless, and make a fire that is easily controlled. Tests show these briquettes nearly equal Pocahontas coal in efficiency and far excell that coal in "smokeless" character.

In studying American coals it should be remembered that very different results are obtained from the low temperature distillation of high volatile coals and low volatile coals. For example, a ton of Pittsburgh coal may yield 28 per cent of tar, while a low volatile Somerset County coal may yield only 7 per cent of tar. The quantity of gas yielded does not differ greatly, though the gas from the low volatile coals is much higher in hydrogen and lower in the hydrocarbon gases. Thus, gas derived from the Pittsburgh coal may show 44 per cent hydrogen, and gas from Somerset County coals may show over 60 per cent hydrogen. Again, there is a marked difference in the distillation products of the tar from these several coals. Thus Pittsburgh coal may yield 2 per cent of oil when distilled under 190 °C., 38 per cent between 190 and 300°C., 31 per cent between 300° and 360°C., leaving 28 per cent of pitch; while Somerset County coal yields no oil below 190°C., 27 per cent between 190° and 300°C., 32 per cent between 300° and 360°C., leaving 40 per cent of tar. The tar acids from Pittsburgh coal may be double those derived from Somerset County coals. The percentage of paraffine from the Somerset County coal is slightly less than from Pittsburgh coal. The percentage of ammonium derivatives in Somerset County coal is nearly double that from Pittsburgh coal.

Experiments in England. In England the best utilization of raw coal has been studied by several companies. Of these the Coalite Company formed in 1906 probably is best known. Over 200,000 tons of coal from all over the world have been treated in England in low temperature distillation tests. These and other experiments have shown that, from a commercial standpoint, the principal difficulties are the heating of the coal in a very thin layer and the removal of the swollen product from the retort. The principal requirement is that the coal be heated in a layer not more than three inches thick. Coal swells on heating and for this reason its removal from a simple retort is difficult. It may be of interest to note the method devised to meet these difficulties in the production of "coalite." In practice "coalite" is made by feeding a measured quantity of coal from a hopper above into a thin vertical retort of fire brick. The retorts are 9 feet high, 6 feet 6 inches long, and only 11 inches wide inside. But as this width is much too great, it is reduced by hanging inside the retort two movable plates. The coal is fed into the space between the chamber walls and the plates, a space only 3 inches wide, leaving the space between the plates empty. After the heating of the coal the plates are dropped together in the center of the retort, loosening the swollen "coalite" so that it can drop into a cooling chamber below. If a greater thickness of coal is used the inside is not heated high enough for the process, or the outside is heated too high.

The product of this process is a crisp, homogeneous mass, smokeless, clean, free from sulphur, having twice the bulk and, when burned, radiating nearly double the heat of an equal weight of coal. It pulverizes easily, is superior to powdered coal, and it has been suggested may replace oil as fuel on steamships.

Products possible from Pennsylvania coal. Of even greater interest to the people of Pennsylvania are the by-products of the process. It has been estimated from the results obtained in England that by carbonizing 140,000,000 tons of bituminous coal now mined in Pennsylvania more than 400,000,000 gallons of motor fuel, and 1,260,000,000 gallons of Diesel and lubricating oil could be produced. That would be about five times the quantity of oil now being produced in Pennsylvania. In addition there would be recovered about 1,050,000 tons of sulphate of ammonia, a fertilizer material. The residual material, amounting to about 105,000,000 tons, would be a smokeless fuel that should bring a higher price on the market than the present high volatile coals of the State.

It may be of interest to translate these figures of production into dollars and cents. At 20 cents a gallon, 400,000,000 gallons of motor oil would yield $80,000,000; at 5 cents a gallon, 1,250,000,000 gallons of fuel oil and lubricating oil would yield $62,500,000; at 1 cent a pound, 2,100,000,000 pounds of ammonium sulphate would yield $21,000,000, or a total for the three of $163,500,000. This might be increased by some slight advance in the price of the residual product because of its cleanliness and smokeless qualities. A difference of 50 cents a ton would mean an increased return of over $50,000,000. In brief, at present prices, (May 1922) the by-products of this process, as they have been described, should yield between $150,000,000 and $200,000,000 to meet the cost of manufacturing and of the 35,000,000 tons of coal used up in the process. At present prices for coal and gasoline this might not prove an attractive return. If the price of coal goes down, and the price of gasoline goes up, a time will certainly come when the value of the by-products will far exceed the cost of their production and the market value of the coal used. When that times comes raw, high volatile coal will no longer be burned in beehive ovens or under boilers, but will be used only in such plants as recover the valuable constituents.

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