THE DEVELOPMENT OF SMOKELESS FUEL FROM ILLINOIS COAL

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Experiments directed toward the modification of the character of Illinois coals were begun in 1902, coincident with the strike of the miners in the anthracite field of Pennsylvania. While the lack of anthracite coal in the Illinois markets had none of the distressing features resulting from the hard coal famine of New England, still, the inconvenience was marked and the question very naturally arose as to whether we might not provide our own fuel of a smokeless type by devising some process of treatment applicable to Illinois coals which would bring them within the range of substitutes for anthracite.

The first published results of these experiments were given in the Year Book for 1906, issued as Bulletin No. 4 of the Illinois State Geological Survey, under the title "The Anthracizing of Bituminous Coal". This rather ambitious program and announcement seems, as we look back upon it, to be appropriately characterized as the exuberant expression of anticipatory zeal. At least, after the passing of ten or twelve years filled rather strenuously with investigational activities along this line, there is evidence of a greater mildness of announcement, if not born of wisdom then perhaps of experience and the very positive discovery of how much we do *not* know about coal.

However, a stage has been reached in recent months where we can properly consider that one chapter has been completed and another begun. The line of demarkation between chapters is not very distinct and the division relates more to the fact that a degree of progress has been attained where industrial scale operations are warranted and indeed essential before any final conclusions can be drawn as to the practicability of utilizing the results of purely scientific or laboratory investigations.

Of course, it will not be possible in eight or ten minutes to give any detail of the points covered by eighteen years of work. Besides, a few accessory facts must be given, since these are essential to a fair appreciation of the relation such an investigation may bear to present-day tendencies in the industries.

Let us assume then, and we are ready to affirm from the purely scientific standpoint be it understood, that we can produce from Illinois coal a new type of fuel having the following characteristics:—It is of uniform texture; of good density and of ample strength to withstand handling and shipping, even, as we believe, of sufficient strength to sustain the burden and meet the requirements of blast furnace practice, though our original purpose and effort had in mind primarily the development of a domestic fuel. It has in its composition a definite amount of combustible matter which at red heat will assume the volatile form, hence, in combustion it burns with a flame though the flame is entitrely without smoke. The volatile matter thus referred to and amounting to from 8 to 12 per cent is a feature of very great importance, since because of it the necessity of special draft regulation is obviated. That is to say, the material will burn under the same draft conditions as are required for coal. If the draft is closed, the fire is still kept alive by reason of the availability of the volatile matter. This same condition exists in the case of the anthracite coal, though to a less degree, since the average anthracite has only about four per cent or one-half as great an amount of volatile matter.

In the making of it, there is produced per ton from the average Illinois coal approximately 20 gallons of oil, 6,000 cu. ft. of very high grade gas with an average heat value of about 700 units per cubic foot and 25 to 30 pounds of ammonium sulphate.

The statement of the problem is as simple as it is difficult of accomplishment: The decomposition of coal which begins at about 250° C delivers between that point and approximately 750° C all of those heavy volatile constituents which are condensible into tars and oils and which are difficultly combustible under the ordinary conditions of draft and temperature, hence wholly responsible for the smoke, soot and grime which attend the combustion of bituminous coal in the raw state.

You will at once say therefore that it is a simple proposition of conducting a fractional distillation wherein the process is not allowed to exceed a temperature of 750° C. But there the difficulty is at once apparent of heating up a mass of non-conducting material through a range of 700° by means of the application of external heat which at once proceeds to build up against its own progress an impenetrable wall of greater non-conductivity between the source of heat and the mass to be heated. That, in concise form, is the statement of the problem. A detailed description of its solution as already noted would far exceed the time limit set for this paper. Certain accessory facts, however, are of interest and should be given in this connection:

The unmined coal reserves within the boundaries of the State of Illinois exceed the estimated tonnage of any other state in the Union, Pennsylvania and West Virginia *not* excepted. The average annual output of coal from this state is in round numbers from 90,000,000 to 100,000,000 tons. This yearly output is exceeded by Pennsylvania and in some years by West Virginia. It has a potential value annually as a source of oil on the basis of the investigations we are discussing to the extent of 2½ billion gallons, or approximately 1/5 of the entire annual petroleum output of the country. It has also a potential yield of 600 billion cubic feet of gas, an amount equal to the entire output of natural gas in the United States for the year 1915, and with an estimated value at that time of $100,000,000.

The above references to gas and oil may seem to be irrelevant but let us consider a few items in that connection. The modern industrial demand is increasingly urgent for fuels of the liquid and gaseous type. The generation of power by oil-burning, including gasoline-burning engines, in this country already equals if it does not exceed the power generated by solid fuel, or steam engines, and the end is by no means in sight. Motor trucks and farm tractors, delivery vehicles and pleasure cars are on the increase to such an extent that in the year past the consumption of gasoline exceeded the yield. The problem of keeping the supply ahead of the demand is already shaping itself as a definite question which must be answered in the near future.

Take another illustration: W. R. Ormandy, writing in the London Gas World for August, 1914, states "The advantages of oil over coal as a source of power for many purposes, but particularly for naval purposes have lately been so vigorously canvassed and so exhaustively discussed by engineering experts, that there is now no purpose in dilating upon them * * * it becomes much more pertinent at the moment to consider what resources we have for securing our supplies at home * * *. Public attention has been directed to the possibility of producing oils for the Navy from bituminous coal, shale, peat, or even sewage matter".

Our own Secretary of the Navy in a recent article in one of our super-popular prints has stated that the stoker force required to shovel coal on one of the great ocean liners is 275 men, and where oil is substituted the crew for the corresponding work drops to 17 or practically 6 per cent; that the steaming range with a given fuel capacity is practically doubled and the time between ports reduced by 25 per cent.

These are only a few instances which might be multiplied indefinitely. The fact is that oil as a fuel for power purposes, whether we like it or not, is here to stay and we are fast approachng the necessity of finding augmented supplies.

As for the use of gas as a fuel, we are destined to see even more revolutionary changes. Coal burned under a steam generator may deliver say 12 per cent of its power in the form of effective work. A gas engine may deliver 30 per cent of its heat in the form of work, a margin much more than enough to pay the toll of converting the solid fuel into the gas form, leaving a generous surplus of efficiency for the gas produced from a given unit of solid fuel.

René Masse, a French fuel authority, writing in Chemie and Industrie for 1918 (page 665) proposes a plan for conserving the coal resources of France by gasifying the entire production, recovering the by-products and utilizing the gas and tar oils in engines for the production of electric power, placing all the plants under centralized control at stations located at the mines. Note that this is a conservation measure and is not prompted primarily as might be supposed from an artistic or sanitary motive.

Here is another reference of the same import. Samuel Wellington, writing in the London Gas World for 1919 (page 405) says "From the analysis of thermal efficiencies given there is every attraction for the consideration of the claims of gas as a profitable process in the conservation of coal for whatever purpose it is required." Indeed, we are even now coming around to the point where it is in place to brush off the dust of time and burnish up the statement of Sir William Siemens, made in a lecture delivered in 1881, which reads as follows: "I am bold enough to go so far as to say that raw coal should not be used as a fuel for any purpose whatever, and that the first step toward the judicious and economic production of heat is the gas retort or gas producer, in which coal is converted either entirely into gas or into gas and coke".

Have you ever stopped to figure some of our extravagances along these lines? The annual output of pig iron in the United States for 1916-1917 was approximately 40,000,000 tons. This called for 40,000,000 tons of coke, 50 per cent of which was made in ovens of the beehive type which either burn the volatile gases or send them off as waste into the air. The sum of this waste per annum amounts to approximately 300 billion cubic feet, equivalent to ½ of the total natural gas output of the entire country.

But, we need not go so far from home for a horrible example. Of the coal mined annually in Illinois, approximately 25,000,000 tons are burned in domestic appliances, and something less than that amount in factories and industrial establishments, not including the railroads. Now, if the inventors of domestic heating appliances had set out to assemble an inefficient lot of devices, they could hardly have surpassed their present accomplishment. They are especially effective in distilling off the volatile constituents of the fuel in the most suitable form. I use the word advisedly and with a deformed spelling. I mean to say, therefore, they are the most suitable forms for smudging up the flues and passageways of the stove or heater and all creation outside when the products of combustion and *non*-combustion leave the chimney. The factories may make a good deal of smoke, the evidence of it is pronounced, but in the aggregate the domestic chimneys are the worst offenders. They work over-time, even 24 hours in the day. If they ever slumber or sleep that is the very stage of their highest effectiveness in the matter of smoke and soot production.

Now, as a matter of fact, the kitchen stove or the basement furnace is doing as well as can be expected. It has not the white hot fire or the mechanical stoker or the extended combustion chamber of the factory furnace, and indeed never can approach those conditions which in the well-appointed manufacturing establishment burns its coal with the minimum amount of smoke, and so we come back to our starting point, namely, the purpose which seems the logical course, to provide from Ilinois coals a fuel which has had the smoke producing constituents removed. Constituents which may be worth only 5 cents as fuel, but probably worth 5 dollars in some other form. If this result can be made to work out in a practical way, as well as the laboratory accomplishments would seem to indicate, the work will have been well worth the doing.