How Can the Bituminous Slack of Our Coal Mines be Utilized?

BY EMERSON M'MILLIN.

Probably the first thought that would occur to one's mind on reading the title to this paper would be: "Is the slack worth anything? Has it an inherent value to be utilized?"

The total output of the coal mines of this State, as indicated by the Mine Inspector's report for the year ending December 31, 1886, equalled 7,099,024 tons lump, and 1,336,187 tons nut. The year 1887 will show a much larger production. In the production of these quantities, there was probably not less than 500,000 tons of slack, and probably 50,000 tons of unsold pea coal produced and carted off to various dumps, and its value—if it possessed any—forever lost.

It thus appears that in quantity there is sufficient slack to command attention, provided the quality is good enough.

I believe that we may safely assume that the following will fairly represent the average composition of the soft coal slack of this State, as it comes from the mines:

Moisture	9	per cent.
Volatile compound matter	32	"
Fixed Carbon	42	"
Ash	15	"
Sulphur	2	"
	100	"

While the composition above given shows the slack to have a value only twelve to fifteen per cent. less than that of lump coal, yet, owing to the fact of its powdered condition and the large percentage of extraneous matter intermixed, it is almost worthless for use in domestic stoves and grates, and not worth transportation for any considerable distance for use in ordinarily constructed furnaces in manufacturing establishments. But if used in apparatus constructed properly for its utilization, then its comparative value will not fall far short of that indicated by the approximate analysis above given.

I need not tell you that the proper way, and about the only way to successfully use it, is to first convert it into gas and then burn the gas for purposes of heating and, possibly, for illumination.

We have heard much of late years about the feasibility of constructing gas works at coal mines and piping the gas to markets in neighboring cities and towns, thereby saving the rail freight on the raw material.

Can this be done? If the gas can be piped 50 to 100 miles, can it be done at less expense than the coal can be transported by rail? The first question is occasionally asked, the second seldom or never, it seeming to have been taken for granted that the cost of conveying gas in large pipes could only be nominal—too insignificant when done on a large scale to be given much consideration. Let us investigate these questions.

The public probably assumes that because natural gas has been transported twenty-five, fifty, and even so far as eighty miles without serious difficulty, that the question of long distance transportation is thereby solved. They overlook the fact that the natural gas starts on its journey with an initial pressure ranging usually between 100 and 500 pounds per square inch, while manufactured gas is usually made and sent from the retorts or generators with no pressure at all, and never against a pressure above a half pound. Nevertheless, the first question may be answered in the affirmative. The gas can be conveyed an indefinite distance.

To answer the second question, many points must be considered. First — What will the rail freight cost per mile for this character of coal? It may be said that it will cost as much to haul a train of cars loaded with slack as to haul one loaded with lump coal. This is probably true. But it is almost a universal custom of railroads to base their freight rates largely upon the value of the product to be transported. Under this rule the slack would cost the user much less to move than would lump coal.

We cannot, in a paper of this character, undertake to figure out probable freight rates from all the mines of the State to all the markets of the State, and, therefore, must select for illustration of the subject some particular mining field and some particular market to be supplied.

We will consider the question, then, by attempting to show the relative cost of transporting slack by rail from the Hocking-Perry coal field, and of transporting the producer gas that could be made from the same quantity of slack, using the city of Columbus as the market for the product in each instance.

To make the piping of the gas commercially practicable, we must, of course, assume that it will be made in great quantity.

As a basis for figuring, we will assume that 2,000,000 feet per hour would be required during twelve hours of the twenty-four, and 1,000,000 feet per hour during the remaining twelve hours, or a total of 36,000,000 feet every day of twenty-four hours.

For several reasons it would probably be advantageous to duplicate the main pipe, the chief reasons being that should an accident occur to one main, the supply would not be entirely cut off, and again, the two lines could supply the demand during the day, and the pumping machinery of one of the mains could be closed down during the night—the twelve hours of light consumption.

On this basis, then, each main would needs have a capacity of 1,000,000 feet per hour.

Should these pipes be constructed of ⅛″ iron, weighing five pounds per square foot, the pipe (including laps and rivets) would weigh about seventy pounds per lineal foot, for each pipe 4′ in diameter. This equals about 190 tons per mile.

This pipe could probably be constructed in place and elevated 1′ above ground for $15,000 per mile, or $30,000 per mile for duplicate mains. It would probably require a line 75 miles long to reach the mines from this city, making a total cost for mains of $2,250,000.

To put through each of these mains 1,000,000 feet per hour will require a high initial pressure, or otherwise a light pressure at several points along the line. To avoid leakage, and to make possible the use of light iron for piping, the latter would doubtless be the better and cheaper mode of operating.

By the aid of eight pairs of blowers attached to each main, the first placed at the generating plant, and one at the end of each section of ten miles thereafter (the last one having to force the gas but five miles, but against an exit pressure made by gas holders, or with sufficient pressure above the atmosphere to effect perfect combustion in furnaces), 1,000,000 feet per hour may be sent through each of the two 48″ mains. Blowers of this capacity may be had for about $5,000 for each section of each main, or for a total cost of $80,000, including engines.

Suitable buildings, boilers and settings will add $20,000 more, making cost of pumping apparatus about $100,000.

This, then, gives us a total cost for transportation plant of $2,350,000, to which should be added for engineering services, valves, expansion joints, special connections and incidental contingencies, from 5 to 10 per cent., making in round numbers, say, $2,500,000.

To operate this plant, there will be required fuel for sixteen thirty-horse-power engines. Not less than thirty-five to forty employes will also be required, making a total cost of $125 to $150 per day, or, say, $45,000 to $50,000 per year. The depreciation to the line would not be great. To keep it in repair and properly painted, however, would cost several thousand dollars per annum. If the depreciation would be but two per cent., this sum alone equals $50,000 per annum.

The interest on an investment of $2,500,000 at six per cent. equals $150,000 Then, ignoring the repairs, painting and depreciation, and estimating only the interest on the investment and the expense of fuel and labor, the cost equals $200,000 per annum.

Now, what would the freight on nut coal sufficient in quantity to make 36,000,000 feet of gas per day amount to?

The present rate on lump and nut coal from the adjacent coal fields is seventy-five cents per ton. When we consider that the freighting of slack would be almost an entirely new business—an additional source of revenue, derived too, from what is now worse than waste material—we may reasonably conclude that the railroads would transport the slack in large quantities at fifty cents per ton of 2,000 pounds.

Because of the poor quality of the fuel, we will assume that one ton will make but 100,000 ft. of producer gas; at this rate, it would require 360 tons per day, and this, at fifty cents per ton for the freight, equals $180 per day, or say, $65,000 per year.

It thus appears that it will cost three times as much to pipe the gas as to pay freight on the coal. I think it safe to assume, then, that piping producer gas long distances in competition with railroad transportation of coal is impracticable.

While at first thought the above statement of the relative costs of transportation may seem surprising, yet, when we consider the question fully, the statement will be quite clear. In the first place, the lines of main cost about as much per mile as the railroad and equipment ought to cost. Second, the quantity estimated to be put through the pipe lines is equal to about three-fourths of their capacity, while the freighting of 360 tons of coal would not tax the road 2 per cent. of its capacity.

Again, while in these estimates the road has to carry but 360 tons of coal per day, the pipe lines have to transport about 1,200 tons of gas per day. Should this quantity of slack and pea coal be made into a mixture of coal gas, water gas and producer gas, the mixture being suitable for domestic use, but too costly for manufacturing or industrial purposes, then the gas would weigh about 400 tons, and in bulk would be but about 13,000,000 feet, instead of 36,000,000 feet.

This, of course, would require a very much less outlay for piping and machinery, but the interest on the investment and cost of operating would still equal a greater sum than would the freight on the coal.

While this is true where the distance is seventy-five miles, it would not be true if the distance was twenty-five miles.

Colonel Walter Crafts furnishes the writer with an estimate of the shipments from mines adjacent to this city for 1887.

The estimate is based on figures of actual tonnage for eleven months of the year, and estimated for December. These figures give an output of 3,323,000 tons from the Hocking and Perry county districts, and, in addition to this, the Brush Creek district, but recently opened up, probably ships 12,000 to 15,000 tons per month.

In these shipments there is some pea coal, in fact about all that was produced in mining. From the very valuable tables presented to this Institute by W. H. Jennings, C. E., at a former meeting, and from records furnished me by Colonel Crafts, it appears that pea and slack are produced in about equal proportions — say, in quantities each equal to about six per cent. of the total coal taken out of the mines. This would give in the Hocking-Perry district about 200,000 tons of each kind, and in the whole State about 500,000 tons of each kind.

It is questionable if the slack, after the pea coal has been taken from it, could be advantageously utilized; certainly the two could be more profitably worked together.

The relative value of the several grades of coal may probably be rated as follows, at the mines:

Lump coal	100
Nut coal	50
Pea coal	25
Slack	00

Should the last two grades be worked together in producer furnaces in the production of fuel gas, this would much more than double the value of the pea coal. In fact, a clear value of not less than $100,000 might be added each year to the productive values of the State, and this, too, in addition to the employment that it would be the means of giving to railroads and to labor, in transporting and manipulating the same.

Could manufacturers alone be induced to substitute gaseous fuel, the 1,000,000 tons of pea and slack coal could be made to do greater work than is now done with 1,500,000 tons of lump coal; could gaseous fuel be substituted for coal in domestic use, then the 1,000,000 tons of pea and slack converted into gas would do the work now done by 5,000,000 tons of lump coal.

In most branches of industry fuel is used with much greater economy than it is in domestic use; this is especially true with respect to steam generation. Less gain is effected here by converting the fuel to gas than would be the gain in almost any other operation in which fuel is used.

But even here the saving becomes one of magnitude when first cost of the coal used is considered — steam nut is much dearer than pea and slack coal. The saving, however, would be in inverse proportion to the distance the fuel would have to be freighted.

The slack coal may be converted into light indirectly by furnishing power to run the dynamo that produces electric light, and in doing this it hastens the day when the use of fuel gas will become general. It may be converted directly into light by the use of incandescent gas burners, a number of which are now before the lighting fraternity, and are being indorsed by some competent engineers.

Should any of these systems and inventions become so perfected as to meet the requirements of the public, then the day of fuel gas will have dawned upon us, and the question of "What shall be done with the slack coal of our bituminous mines?" will have been fully, and for the mine owners as well as the public, profitably answered.

DISCUSSION.

The President: That is a paper that ought to bring forth a good deal of discussion.

Mr. Jennings: I would like to ask what it would cost to produce that gas for heating purposes.

Mr. McMillen: Well, with the slack as cheap as I estimated there, probably it could be sold at 10 or 15 cents per thousand. About 25 to 30 cents is what I figure the gas when we have to pay $3 per ton for coal. I have a number of pamphlets in which these problems are worked out, and any of the gentlemen are welcome to copies if they desire them. Now, if the coal cost but $1 it would reduce it, I believe, 1 cent per thousand for every 50 cents saved on coal. That is about the real position. In making this gas, such as I speak of, for industrial purposes the cost would consist chiefly in the freight. There is very little labor. The estimate that I made in the calculations, which you will find in those other pamphlets, is based upon the best evidence I could gather from those who had made producer gas for many years, and shows labor and wear and tear to be only about 1¼ cents per thousand. The interest on the investment is really what adds to the cost. If you should pipe this town here for fuel gas, so as to supply one-half the public, probably you would have to invest two million dollars, and the interest on the investment would be by far the biggest item of expense to the consumer.

Prof. Lord: Do you refer to producer gas?

Mr. McMillin: The gas that I am advocating somewhat would be a mixture of water gas, producer gas and coal gas. The gas that I figured on transporting from the Hocking Valley here was simply producer gas alone.

Prof. Lord: How much nitrogen would there be in this gas?

Mr. McMillin: About 26 per cent.

Prof. Lord: Just about half producer gas?

Mr. McMillin: The mixture, I believe, has about 20 per cent. of coal gas, and 32 or 35 per cent. of water gas, and 47 per cent. of producer gas. That leaves you, after making that per cent. of coal gas, just enough to make the other portions of water gas and producer gas; so that it works up everything to the best advantage. In addition to that we assume there would be five times as much gas sold for heat as for illumination. The whole system is worked out with a view of utilizing plants already in existence.

Prof. Lord: Making an improved way of using coke?

Mr. McMillin: Yes, sir.

Mr. Haseltine: Mr. McMillin's paper is one that is very interesting to me in all its branches. I live in a neighborhood where the gas has been on my heels for several years. It has followed me out of the coal mines, and followed me now up to my coal yard. But what I was about to remark is this: Mr. McMillin's estimate of the cost of laying a main for seventy miles is, in my opinion, not more than thirty or forty per cent. of what it would actually cost, though he figures on a very light iron and a very large pipe. My experience has always been that an 8 or 10 main would weigh from thirty to forty pounds to the foot, and his system of calculation is made on the basis of making a complete pipe line. Now, I don't think that he, nor any other man, can figure out the quantity it would be necessary to produce at the mines in order to deliver the quantity that he estimates at Columbus. The leakage, in other words, in a gas main, is an unknown quantity. I will venture that in the four lines running from Pennsylvania to Youngstown, extending from thirty to forty miles, that there are not three tight joints to the mile, in any one of them. While they do not all leak very much, at certain temperatures they leak more or less. Some of them leak so that you can hear them in driving over that road. And if you take into consideration the loss by leakage, no mortal man can figure what that cost would be to be delivered in Columbus and manufactured at the mines. But, by his economical calculations, we are clearly shown that the railroad companies can transport the raw material for a great deal less money than it can be piped. It is demonstrated in practical experience that there is a limit to the practical piping of gas. There is a limit to the quantity of gas that will be delivered; so much so, that the gas companies of all Eastern Ohio and Western Pennsylvania have gone into a pool, as they say, to equalize the pressure,—as if they could control that.

Mr. McMillin: On the customer they mean.

Mr. Haseltine: The pressure is on the customer's pocketbook. When they first commenced piping they thought a one 10″ pipe line would be sufficient. They have discovered now that four lines will barely supply the domestic use, and with a very small and very uncertain amount for manufacturing purposes; and when a cold snap comes all the gas that can be passed through these lines is consumed. That is partially owing to the variation of the pressure, and largely to the amount of leakage; and it is owing to those two causes, more than to the amount consumed. I think the change in temperature and the leakage fixes the supply more than anything else, and this question of transportation of gas for long distances, in my opinion, will never prove a success.

Mr. McMillin: I presume that the President's remarks are all based upon his experience with natural gas. With reference first to his criticism of the estimate of the cost, I would say that he is probably figuring on rolled pipe, which is expensive, while I figured upon pipe made from sheet iron, which is, comparatively speaking, inexpensive The weight is probably 70 pounds per lineal foot, and any of you can figure out whether that would be more than $15,000 a mile. With regard to the leakage: While natural gas men do not know what their leakage is, and it is simply enormous, that is not so with manufactured gas. We have practically no pressure at all, and you have from one to five hundred pounds. Your gas would leak more than this because of the pressure. The quantity of leakage in manufactured gas has been reduced to a pretty fine system during the last fifty or seventy-five years. We would not have to guess on the leakage. That would be a matter of calculation. We run our exhauster, which at the end of each section takes the gas there at zero; on the exit of the exhauster it forces it against $1\frac{1}{2}$ pounds pressure. That will force through 1,100,000 feet of gas; that is, it will force 1,000,000 feet ten miles with no pressure at the exit end. Now, these exhausters are placed every ten miles, and while it is true that we can only give good guesses as to natural gas, that is not so when it comes to manufactured gas. I will try to put that in a form that will be easily understood by all.

FORMULA.

q = quantity per hour.
l = length of pipe in yards.
d = diameter of pipe in inches.
h = head, or pressure in inches of water.
s = specific gravity of gas.

Required to find the number of cubic feet of gas of specific gravity of .95 which will be discharged in one hour from a pipe 48 inches in diameter, and 17,600 yards (10 miles) long under a pressure of 42 inches.

Thus (h d) = 2016:

$$\left(\frac{h\,d}{s\,l} = \frac{2016}{.95 \times 17600} = .125;\ \text{square root} = .354.\right.$$

$$\left(1350\,d^2 \frac{h\,d}{s\,l} = 1350 \times 2304 \times .354 = 1{,}101{,}081 \text{ feet.}\right.$$

Or $\overset{h}{42} \times \overset{d}{48} = 2016 \div (\overset{s}{.95} \times \overset{l}{17600}) = .125.$

$\sqrt{.125} = .354 \times 1350 = 477.9 \times 2304 = 1{,}101{,}081$ feet discharge per hour.

This gives us an excess of about 10 per cent. to cover leakage and loss of capacity due to unavoidable curves in pipe lines.

Mr. ———: Your laying your pipe on top of the ground would expose it to the action of the atmosphere. It would be subject to greater expansion than it would be if it was buried deeper. That would increase your leakage.

Mr. McMillin: You can very easily work an expansion joint against a pressure not greater than $1\frac{1}{2}$ pounds. I place it above ground to cheapen it. If the iron was made heavy enough to last buried, the wealth of this city could hardly build a line. It would not last long enough buried. If it was placed above ground it would last indefinitely, for the inside would not corrode.

Edward Orton, Jr.: I have had some chance to observe the results of this producer gas, and I have always noticed that we have more trouble to prevent leakage into our pipes than to prevent leakage out of them. An influx of air is fatal to realizing any proper value from the gas at the time of combustion. It requires the use of a regenerative apparatus of some kind to get a sufficiently high temperature. The air which is used to burn with the gas must be heated well. When we come to heat the pure producer gas we have no trouble about keeping it from burning, but if our gas pipes have leaked in the slightest degree during this process of regeneration, why we get combustion before we want it, and only a small portion of hydrogen and hydrocarbon, and we miss our intensity of heat in the flame. Our pipes have been made of $\frac{3}{16}$ to $\frac{1}{4}$ iron, and in the period of nine months we have had numerous breakages, and subject to only the ordinary conditions; and such a pipe line would have had numerous breakages, and instead of leaks out, would have had leakages in. That is our trouble, and that is the cause of $\frac{9}{10}$ of the trouble in the work of producer gas. All this is applied to maintaining a high temperature. In using producer gas for domestic use, or for the generation of steam, the use of a regenerative apparatus to burn the coal gas makes it a very disagreeable fire to work with. In piping gas a long distance the parts that would tend to escape most of all would be the very cream of the gas, hydrogen and hydrocarbon.

Mr. McMillin: I am glad that these remarks are being made, as it affords an opportunity to possibly answer some of the objections that are raised. The difficulties that Mr. Orton has enumerated are quite common about manufacturing establishments, but it does not necessarily follow that they ought to be there. It is not necessary that you should have air in your gas. It would be very much easier to manufacture producer gas under the conditions named, and not get air in, than it is for us to manufacture coal gas. As to the breaking of the pipe, that of course is due to expansion and contraction about the works, and if you were making gas in the Hocking Valley you would probably have the same trouble that you have now. But it is quite easy to take the gas away from the retorts without pressure. The apparatus, of course, must be worked automatically. We don't have leakage around these retorts, and we don't get air, and there would be nothing in the way to break that pipe. I should not at all recommend producer gas pure and simple for domestic use, but the mixture of gas I speak of I not only know from observation and from calculations upon such basis, but from actual experiment, burns quite as readily, and even a little better than water gas alone.

Mr. Roy: If the discussion of this valuable paper is finished, I move a vote of thanks be tendered Mr. McMillin for his excellent paper.

Motion carried.