"RELATIVE CALORIFIC VALUE OF SOME COALS ON KANSAS MARKETS."

BY

SCOTT S. FAY.

OUTLINE.

The fuel value of coals, while it is a subject that hitherto has attracted but little attention, is one that the engineers of today are begining to consider seriously; but it is not only these thoughtful engineers that are wide awake to the question, but practically all scientists as well, and even many coal dealers, and to a less extent the general public.

Ordinarily coal is priced not on its real or its practical value as a producer of heat, but on an entirely different basis, namely, the cost necessary to "lay it down" on the market. After calculating the expenditure of wealth in mining, transportation, storing and a reasonable profit for all concerned, and considering nothing more its market value is determined. Now this, while it must need be borne in mind, is not the principal item that should be used in ascertaining their commercial values. Since coal is used for the production of energy the all important question in rating the article should be how much energy will it produce compared with others? It is to be hoped that further investigation will revise this, and give us a more scientific price list. Certainly it would be a valuable piece of work that would assign each its proper place in the system.

It is the object of this experiment to arrive at some conclusions regarding the calorific value of a few coals on Kansas markets. Of the fourteen samples used thirteen were obtained from the dealers, while the other one the college coal coming from Lansing is not on the market at all.

Sampling was done in the manner about to be described: A sample filling an ordinary coal bucket was taken from various parts of the bin. This was broken into small pieces, not larger than walnuts, and then spread out upon the sampling table, letting each shovel-full fall upon the same spot giving each particle an equal opportunity to roll in the direction and to the distance it would. When all was thus spread out the pile was divided into halves and again these halves into quarters at right angles to the first division; all of the alternate fourths was then taken as the sample and the remainder thrown away. This was again pounded into much smaller pieces and in the same way sampled. This sample was pulverised into pieces the size of coarse sand and again sampled and sub-sampled until a sufficiently small amount for the work was obtained; the whole of which was powdered until it would pass through a .25 mm. mesh (100 to the inch) sieve. This powder was well mixed and tested as given below.

The instrument used was Parr's Calorimeter, and as there are many types of calorimeters the instrument itself may need a little description. The bomb consists of a cylinder with screw caps for either end and into which are led insulated by fiber, two good conductors. These may be connected from without with a storage batery and within with a wire of high resistance e. g. iron, so that when the current passes through enough heat will be generated to ignite the charge.

This bomb stands in a vessel of 2000 C. C. of water which is supported and surrounded by a double fiber vessel to prevent the absorption or the radiation of heat. By means of a motor it is made to rotate clockwise so the fans attached to it will produce a downward current in the water. Now the speed of this revolution must not be too great or the mechanical work will of itself raise the temperature. All is covered with a plate of fiber through which passes a delicate Fahrenheit thermometer graduated to read to hundredths of a degree.

Exactly 1/2 gram of the respective coals was thoroughly mixed with a measured amount of sodium peroxide, the bomb then tapped enough to jar down what adhered to the top of the cylinder. At this moment it was inserted into the water and after 3 minutes rotation, the temperature having become constant, the charge was fired by connecting the circuit.

The difference between the initial temperature and that when the mercury was the highest will give the rise of temperature due to the burning. Since the specific heat of the metal used was 134 and there being 2 liters of water it can be considered that 2134 C. C. of water was raised through the degrees indicated by the thermometer. In the reaction however, 73 per cent is due to the combination of carbon and hydrogen with oxygen and 27 per cent to the combination of the gas and water with the chemical. If now, in the reaction 1/2 gram of coal causes 2134 grams of water to rise through "t" degrees and only 73 per cent of the heat is due to such combustion, then 2134 x .73 x t x 2 = rise of temperature due to one gram of coal.

But by experiment it was found that the burning of the wire produced a rise of .02° F., so for this, there need be made a correction. Thus 2134 x .73 x 2 x(t - .02) = British Thermal Units. This unit (B. T. U.) is the amount of heat absorbed by a pound of water when its temperature is raised one degree F. and is .2578 + of the calorie.

For Anthracitic coals a special chemical is prepared which necessitates a correction of 1.° for every 1-1/2 grams which amount is used in a single charge. That is to say, 1-1/2 grams of it will raise the temperature 1.° F. With the two coals Pennsylvania

Anthracite and Arkansas Semi-Anthracite this was used.

The following are the results of such experiments on the fourteen coals arranged in order of their calorific value:

	Price per ton	Initial temp.	Final temp.	Dif. of temp.	B.T.U.	Average
Blacksmith	11.00	69.97	74.43	4.46	13,830	13,924
		65.11	69.63	4.52	14,019	
Rugby	7.00	67.45	71.80	4.35	13,487	13,518
		66.34	70.71	4.37	13,550	
Ark. Semi-Anth.	9.00	67.82	73.16	5.34	13,520	13,504
		65.42	70.75	5.33	13,488	
Wier City Lump	4.00	65.79	70.24	4.35	13,487	13,457
		67.92	72.25	4.33	13,428	
Penn. Anthracite	12.00	67.14	72.45	5.31	13,421	13,377
		66.69	71.97	5.28	13,334	
Wier City Nut	3.75	66.46	70.60	4.14	12,834	12,927
		66.52	70.72	4.20	13,020	
Farmer's Lump or Missouri	4.50	67.60	71.76	4.16	12,899	12,883
		66.78	70.93	4.15	12,868	
Lexington Deep Shaft	4.75	71.05	75.12	4.07	12,616	12,582
		66.74	70.79	4.05	12,549	
Burlingame or Osage	3.75	65.39	69.34	3.95	12,240	12,210
		65.11	69.04	3.93	12,180	
Lexington or Surface	4.25	67.40	71.28	3.88	12,024	11,967
		66.74	70.58	3.84	11,910	
Semi-Anthracite	9.00	65.01	68.84	3.83	11,868	11,868
		68.04	71.87	3.83	11,868	
Union Pacific R. R.	7.00	65.87	69.58	3.71	11,494	11,462
		66.12	69.81	3.69	11,431	
College		66.49	70.17	3.68	11,400	11,351
		68.05	71.69	3.64	11,302	
Denmark Lincoln Co.	2.00	65.81	68.98	3.17	9,812	9,718
		66.90	70.01	3.11	9,625	

Such then are the results of the coal combustion and of the water content upon the chemical. It is evident, therefore, that in getting the energy of the coal alone we must make a correction for the water therein. To do this I first of all determined the units yielded by the Farmer's Lump or Missouri Coal when dehydrated, and this is the data obtained:

Orig. temp.	Final temp.	Difference	B.T.U.	Average
69.21	73.45	4.24	13,147	
69.67	73.92	4.25	13,177	13,162

Now this coal originally contained 3.1 per cent water. But if one gram of the coal alone gave 13,162, .969 grams, which is the amount actually present in a gram of the substance, would give 13,162 x .969 or 12,754; but I actually obtained from the coal in its natural state 129 additional B. T. Us; and since this much heat was given by .031 grams of water, 4 of such units are produced by the action of every milligram of water on the peroxide. On this ratio amounts have been subtracted from the results given above and accordingly the revision is:

	Heat of water and coal	% of H_2O	Heat of coal alone.	Price
Blacksmith	13,924	.75	13,894	$11.
Ark. Semi-Anthra.	13,504	1.12	13,464	9.
Rugby	13,518	1.86	13,444	7.
Wier City Lump	13,457	1.96	13,379	4.
Penn. Anthracite	13,377	1.93	13,300	12.
Wier City Nut	12,927	1.36	12,873	3.75
Farmer's Lump or Mo.	12,883	3.1	12,759	4.50
Lexington Deep Shaft	12,582	2.	12,502	4.75
Burlingame or Osage	12,210	3.5	12,070	3.75

Lexington Surface	11,967	1.97	11,889	$4.25
Semi-Anthracite	11,868	.55	11,846	9.
College	11,351	.55	11,329	
U. P. R. R.	11,462	6.4	11,206	7.
Denmark Lincoln Co.	9,718	.6	9,694	2.

Glancing over these results a few not uninteresting things are noted. First of all that the highest priced coal, Pennsylvania Anthracite ($12) is fifth in the list. To this class of coals, generally speaking, belong such as are characterized by a large per cent of carbon and a small amount of volatile substances. Due to the fact that they give but little carbon in the smoke, they have been called smokeless coals; and while they are considered as having the highest calorific value, it is not altogether true. Some it is true are not excelled in this respect yet there are other anthracites from the same state as low as the harder coals of Kansas. In the volume "Calorific Power of Fuels", by Herman Poole, member of the Society of Chemical Industry, of the American Chemical Society, and of the American Society of Engineers, the following data and many other may be obtained:

Pennsylvania Anthracite

Name of Location	B. T. U.	Authority
Blackheath	15,619	Isherwood
Arondale	14,200	Carpenter
Cayuga	13,800	"
Honey Brook	13,332	Barrus
Cross Creek	12,872	"

Here we note the wide range in value of what is termed Pennsylvania Anthracite. Apparently much depends upon the place from which it comes.

Second, that the next in market value is first in the Calorific list. This, Blacksmith coal, is a deep black glossy, granular coal, so fine that its use as a fuel for many purposes is hampered, yet its heat from total combustible material is high. ,Its limited use doubtless makes its commercial value a trifle higher than it would be were it otherwise.

Third, that coals of the same price vary much in their Calorific value. For example, the two $9.00 varieties have a difference of 1,600 B. T. U., and of the two $7.00 varieties a difference of 2,238. Another interesting consideration is, how many units can be produced per dollar, and this works out as the table below shows. The most striking fact it reveals is, that compared with the table just given, the first is last and the last first; and since Pennsylvania Anthracite does stand so low, and its calorific value also low, it would not be stretching our imagination unduly to suspect that the eastern dealers send to the westerners for the price of the better quality, an inferior grade.

It seems also that in cases where two coals come from the same mine that they are well rated, at least compared with themselves.

	B. T. U. per dollar.
Denmark Lincoln Co.	4,897
Wier City Nut	3,432
Wier City Lump	3,344
Burlingame or Osage	3,192
Farmer's Lump or Mo. Coal	2,813
Lexington Surface	2,797
Lexington Deep Shaft	2,631
Rugby	1,920

U. P. R. R.	1,601
Ark. Semi-Anthracite	1,316
Blacksmith	1,263
Pennsylvania Anthracite	1,108

It must not be understood that it is the object here to get the actual amount of energy available, but rather that of the total combustible material they contain. The fact that one coal will give more heat in a calorimeter does not insure that it will do so in a stove or under a boiler. Even under the most careful firing the available energy is always less. The ash is always serving to enclose some of the combustible substance, and prevent contact with air, and if much ash be present much will be enclosed. Again, some of the coal is volatile, some of which passes off without burning. The design of the furnace may help to utilize this but always some is lost.

With these considerations in mind, it is evident that it is perfectly possible that the U. P. R. R. coal would rank much higher in the list if actual utility was the consideration or that Penn. Anthracite might lead the list. So it is that the task of giving the correct valuation of coals is by no means a small one, and at best can be done only approximately.