# RELATIVE FUEL VALUE OF SOME COALS ON THE KANSAS MARKETS.

by

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## AIM AND OBJECT.

The importance of coal as fuel in the factory, railroad, and home, warrants the expending of time and effort in securing information that will give it a more intelligent use, and its consumer a more scientific basis for choosing his variety of coal.

As yet coal is practically without a rival. The more important question then is: How does one variety of coal compare with another? and not: How does coal in general compare with other fuels?

The prices of coals are based on the cost of mining and transportation, and sometimes on the caprices of the dealer. In the fixing of such prices little or no attention is paid to the worth of the coal as a fuel, and if the prcies and values of coals are concordant it is wholly coincidental.

The error of such a method in fixing the price-list is wholly obvious, and has led many to undertake to give to the consumer information that should enable him to secure the greatest value for his money when purchasing coal. The writer limits his observations to the more common coals handled by Kansas dealers. Most of these are mined in or near our own state, and only meet with successful competition by coals handicapped by the increased expense of a long shipment, in such services as for which the native coals are poorly adapted.

## GENERAL DESCRIPTION OF COAL.

The samples of most of the coals tested were secured from the bins of the Higginbotham Fuel Co., of Manhattan, Kansas, and the writer is indebted to them for many of the facts and figures herein contained.

Without attempting to be scientifically correct it may be said that there are about nine kinds of mineral fuel extracted from the earth. Peat being the first crude form, and remaining eight different varieties of coal. Bituminous coal is the common soft coal. It contains a larger proportion of tarry material than any other variety. When on destructive distillation it yields a moderate amount of gas, it is "dry" coal, when there is more pitchy substance in it, it is termed "fat" coal, and it becomes "caking" coal when in burning it softens like paste.

Anthracite is sometimes called "glance" or "stone" coal. It is a very hard, compact, lustrous mineral. It burns slowly with little or no flame, but producing a very high degree of heat. When less hard, and containing more pitch, it is termed semi-anthracite. Cannel is a variety of bituminous coal. In texture it is homogeneous and very compact, not in layers like soft coal, but resembling a black paste hardened into stone. It contains more mineral oil than any other coal. It is so highly bituminous that in some cases it is dangerous to use it on steamships, or in grates, so freely does the oil run when the coal is ignited.

It is a curious fact that different as these coals are in character they are often found in the same locality and in the same vein. In a booklet, descriptive of coals, published by John Wiley and Sons, the statements are made that there are beds in Pennsylvania that produce both anthracite and semi-anthracite coals. At one place on the Louisa river the miners work bituminous coal at one end of the gangway and cannel coal at the other, and this the whole thickness of the vein. Anthracite merges into semi-anthracite and thence to bituminous easily.

## DESCRIPTION OF COALS TESTED.

Pennsylvania anthracite has the characteristics of all anthracites, which vary but little. It is hard, black, and lustrous. It is mined comparatively dry and there is but little shrinkage from loss of water or from dirt. It is taken from mines varying in depth from 800 to 1200 feet.

Arkansas semi-anthracite approaches a cannel coal. It is grayish black and of high lustre. There are no layers visible. It breaks with difficulty and into lumps of irregular form. It suffers a total shrinkage of about six percent. after coming from the mines, and being stored indefinitely.

The other semi-anthracite tested is mined is eastern Missouri. It suffers about the same shrinkage, is less lustrous and exhibits fewer of the peculiarities of cannel coal. It is used chiefly for hot air furnaces.

Pennsylvania Blacksmith coal is fine, almost granular, and contains but little foreign material. It is very black and lustrous, and suffers but little shrinkage. Its use for general purposes is h ampered by its fineness. It is usually found between two layers of anthracite coal.

Rugby coal is taken from shafts in the mountains near Rugby, Colorado. It is hard, black, and lustrous. It very often comes in peculiar, round, knotty lumps. It is clean, dry, and burns very completely in ordinary stoves and furnaces. It leaves a very small percentage of ash.

The Lexington coals come from mines at Lexington, Missouri. They are wet when taken from the mines, and suffer great reduction in weight from evaporation and slack. This is more especially true of the surface coal.

Weir City Nut is the product of Missouri mines of approximately 100 feet depth. It contains some dirt and slate. It suffers considerable shrinkage but not nearly as much as the Weir City Lump, which comes from the same locality, but from shallower mines. In the latter the layers of coal are interspersed with layers of dirt. There are numerous vertical schists of other minerals marking the lines of cleavage.

Farmers Lump is a Missouri coal. It is of a poor grade contain- much lime and sulphur. It suffers a great loss from slack and evaporation.

Hanna Egg Coal is mined in Wyoming. It suffers but little shrinkage and burns quite completely.

Burlingame coal is mined at Burlingame, Kansas. It is of a very dull color, and is taken from relatively deep shafts. It suffers a very large shrinkage. The layers of non-fuel between the layers of coal are thin but numerous.

The Lincoln County coal is nearly representative of the coals of the central part of Kansas. It is dull in color, contains much dirt, and when mined is almost saturated with water. It burns incompletely and leaves a large percentage of ash.

The coal designated as College coal is that taken from the mines operated by prison labor at Lansing, Kansas. It is not on the market. It is a poor grade of coal, containing much dirt and moisture. It crumbles rapidly to dust, and can only be burned with any degree of completeness in furnaces where a high degree of heat is generated.

## METHOD OF SAMPLING.

In sampling the aim was to secure as nearly as possible a representative specimen. Pieces of coal were gathered from different parts of the bin. These were crushed until the largest particles were about the size of a plum. The size of the sample was reduced by the ordinary method of quartering and sub-quartering, until the specimen was of the desired size. This was pulverized until it passed through a 25 mm sieve (1/100 of an inch mesh). The sample was thoroughly mixed, and its water content and calorific value determined.

## DESCRIPTION OF CALORIMETER.

The calorimeter used in the well known Parr instrument. It is made up of a double jacket of fiber inside of which stands a vessel with silvered exterior. The vessel rests on points of cork, and is separated from the inner jacket by an air space. In the vessel is the bomb, a heavy metal cylinder, closed at each end by a cap, held by a burr. The cartridge has a shaft, which perforates the fiber lid of the calorimeter and is crowned by a pulley. This is connected by a belt to a motor, the bomb revolving on a pivot. The temperature of the water is equalized by being stirred by a set of vanes attached to the bomb. The temperature of the water is measured by a thermometer graduated to twentieths of a degree, the bulb of which hangs opposite the middle of the bomb.

## METHOD OF PROCEDURE.

A charge of exactly ½ grain of coal is weighed out dried and put into the bomb. It is mixed with sodium peroxide (Anthracite coals have also 1.5 grain of persulphate mixture added).

The whole is thoroughly mixed, and the bomb tapped sharply to jar the mixture to the bottom of the bomb. The charge is ignited by passing an electric current through an iron wire, dipping into the mixture until the wire becomes hot enough to incinerate the charge. Into the vessel is measured exactly two liters of water, approximately two degrees below room temperature. The loaded cartridge is put into place and the lid put on. The connections are completed and the bomb revolved at a rate of about 100 revolutions to the minute. When the temperature of the water becomes uniform the temperature is noted. The charge is then ignited and the machine allowed to run until the maximum temperature is reached. The difference between initial and final temperatures is noted.

## METHOD OF CALCULATION.

It had been determined previously that the water equivalent of the calorimeter is 215 cc. The water equivalent of calorimeter when filled with water then equals 2215 cc. (A different bomb with a water equivalent of 2220 was used for three samples). It was also determined (by the company putting out the calorimeter) that inthe burning of the charge 27% of the heat generated is due to chemical combination of the peroxide and the products of combustion. In the case of the anthracite coals a further deduction of ~~203°~~ 1.03° is necessary on account of the added heat due to the persulphate mixture. The burning of the iron wire causes a temperature rise of 022°.

If now .5 grams of coal raises the temperature of the equivalent of 2215 grams of water through "t" degrees, then 1 grain of substance will raise it through 2 "t" degrees. But only 73% of such rise is due to the combustion of the coal. Then

2215 X .73 X 2 "t" = units of heat produced by one gram of the substance.

If now a gram of coal raises the temperature of the equivalent of 2215 grams of coal through 2 "t" degrees Fahr., a pound of the same coal will raise the temperature of the equivalent of 2215 pounds of water through 2 "t" degrees Fahr. Hence the result may be read in British Thermal units.

The loss from radiation was so slight that it seemed impracticable to take it into account.

## MOISTURE DETERMINATION.

The samples of coal were gathered in the spring after having laid in the bins untouched for some time. Hence the percentage of moisture found is much less than that of green coal. In the determination of the moisture content the .5 gram of coal was weighed out in a watch glass and covered by a second watch glass, dried in the water oven for two hours, cooled in the dessicator, and weighed again, the difference in weight being the amount of water lost. The results obtained are given in a succeeding table.

Generally speaking it was found that the brighter the lustre of the coal, the less its moisture content. The deep shafted coals contain a smaller percent. of moisture. It is noticeable that in the duplicate samples carried through, that while they were weighed out of the same sample, and given precisely the same treatment, the percent. of moisture found varied greatly. In the case of Farmers Lump coal, a second set of duplicates were tested in an effort to secure results agreeing more closely than the first set. A glance at the tables show a variation of .2%, 1202

or, the moisture content of one is only 93.5% of the other.

Herman Poole, in his "Calorific Value of Fuels", directs that duplicate samples for the determination of moisture should agree with .3 or .4 of one percent. And that results agreeing thus closely can be obtained with reasonable care. In this case every precaution possible was taken in hopes of getting identical results. The failure to do so has already been pointed out.

## MOISTURE DETERMINATIONS.

| Name | Weight in grams Before drying | After drying | Lost | Moisture content in percent. of samples | Average |
|---|---|---|---|---|---|
| Lincoln | .5 | .4725 | .0275 | 5.50 | 5.58 |
| Co. coal | .5 | .4717 | .0283 | 5.66 | |
| Hanna or | .5 | .4727 | .0273 | 5.75 | |
| U.P.R.R.Coal | .5 | .4774 | .0286 | 5.71 | 5.58 |
| College coal | .5 | .4734 | .0266 | 5.2 | 5.18 |
| | .5 | .4742 | .0258 | 5.16 | |
| Burlingame | .5 | .4807 | .0193 | 3.86 | 3.83 |
| coal | .5 | .4810 | .019 | 3.80 | |
| Lexington | .5 | .4827 | .0173 | 3.45 | 3.525 |
| Surface coal | .5 | .4820 | .018 | 3.60 | |
| Farmers Lump | .5 | .4844 | .0156 | 3.12 | |
| | .5 | .4840 | .0160 | 3.20 | |
| | .5 | .4850 | .015 | 3.00 | 3.135 |
| | .5 | .4839 | .0161 | 3.22 | |
| Pennsylvania | .5 | .4877 | .0123 | 2.25 | 2.21 |
| Anthracite | .5 | .4891 | .0109 | 2.17 | |
| Semi-Anthra- | .5 | .4890 | .0110 | 2.20 | 2.185 |
| cite | .5 | .4891 | .0109 | 2.17 | |
| Lexington | .5 | .4890 | .0110 | 2.20 | 2.13 |
| Deep Shaft | .5 | .4897 | .0103 | 2.06 | |
| Weir City | .5 | .4914 | .0096 | 1.92 | 1.945 |
| Nut | .5 | .4901 | .0099 | 1.97 | |
| Arkansas | .5 | .4901 | .0099 | 1.98 | 1.93 |
| Semi-Anthra. | .5 | .4976 | .0094 | 1.88 | |
| Blacksmith | .5 | .4915 | .0085 | 1.70 | 1.66 |
| Coal | .5 | .4919 | .0081 | 1.62 | |
| Rugby Coal | .5 | .4920 | .0080 | 1.60 | 1.57 |
| | .5 | .4923 | .0077 | 1.54 | |
| Weir City | .5 | .4927 | .0073 | 1.45 | 1.445 |
| Lump coal | .5 | .4922 | .0078 | 1.44 | |

## CALORIFIC DETERMINATIONS.

The samples burned in the calorimeter were the same as those tested for moisture. The coal burned was then not .5 grain but that weight minus the weight lost in drying. The results obtained are found in tabulated form on a succeeding page.

It is a remarkable fact that two coals like the semi-anthracites tested, while agreeing in price and somewhat similar in appearance, should vary so widely in calorific value. Of course as developed by H. Brunte in an article in the Journal of the Society of Chemical Industry, it is impossible to secure better than approximately the value of fuels by calorimeter or analysis. Yet these results are at such wide variation that there is no chance for the difference to be more than slightly due to experimental error.

In considering the Lincoln County coal, it should be remembered that $2 per ton is the price of the green coal at the mine, and its popularity is not great enough to permit shipping.

## CALORIFIC DETERMINATIONS.

| Name | Price per ton | Temperature Fahr. Initial | Final | Change | Heat Produced in B.T.U. Of Samples | Average |
|---|---|---|---|---|---|---|
| Arkansas Semi-Anthra. | $9.00 | 77 | 83.27 | 6.27 | 16874 | |
| | | 77.05 | 83.31 | 6.26 | 16842 | 16858 |
| Pennsylvania Anthracite | 12.00 | 77.13 | 83.37 | 6.24 | 16810 | |
| | | 77.21 | 83.48 | 6.27 | 16874 | 16842 |
| Blacksmith Coal | 11.00 | 77.10 | 81.77 | 4.67 | 15031 | |
| | | 76.82 | 81.53 | 4.71 | 15178 | 15104.5 |
| Rugby | 7.00 | 77.50 | 81.85 | 4.35 | 13487 | |
| | | 78.20 | 82.57 | 4.37 | 13550 | 13518.5 |
| Lexington Deep Shaft | 4.75 | 76.95 | 81.13 | 4.18 | 13444 | |
| | | 77.25 | 81.38 | 4.13 | 13285 | 13364.5 |
| Weir City Nut | 3.25 | 78.20 | 82.27 | 4.07 | 13091 | |
| | | 77.84 | 81.90 | 4.06 | 13059 | 13075 |
| Farmer's Lump | 4.50 | 77.55 | 81.60 | 4.05 | 13025 | |
| | | 78.00 | 82.07 | 4.07 | 13091 | 13058 |
| Weir City Lump | 4.00 | 77.20 | 81.25 | 4.05 | 13025 | |
| | | 76.93 | 80.95 | 4.02 | 12961 | 13059 |
| Lexington Surface | 4.25 | 79.00 | 82.80 | 3.80 | 12217 | |
| | | 77.42 | 81.19 | 3.77 | 12121 | 12169 |
| Semi-Anthra. | 9.00 | 76.91 | 81.71 | 4.80 | 12132 | |
| | | 77.24 | 82.03 | 4.79 | 12084 | 12110.5 |
| Burlingame | 3.75 | 78.20 | 81.90 | 3.70 | 11896 | |
| | | 78.23 | 81.93 | 3.70 | 11896 | 11896 |
| College Coal | | 77.05 | 80.67 | 3.62 | 11636 | |
| | | 77.53 | 81.74 | 3.61 | 11603 | 11619.5 |
| Hanna | 7.00 | 78.20 | 81.80 | 3.60 | 11571 | |
| | | 78.35 | 81.92 | 3.57 | 11474 | 11522.5 |
| Lincoln Co. Coal | 2.00 at mine | 77.91 | 80.85 | 2.94 | 9437 | |
| | | 78.25 | 81.21 | 2.96 | 9501 | 9469 |

The prices attached to the respective coals were furnished us by the Higginbotham Fuel Company (except for the Lincoln County coal). Comparing prices with calorific values obtained, we find that per dollar the respective coals yield the following number of British Thermal Units:

| Name | B. T. U. per ton of coal as sampled |
|---|---|
| Lincoln County coal | 9469000 |
| Weir City Nut | 8046154 |
| Weir City Lump | 6469750 |
| Burlingame | 6344533 |
| Farmers Lump | 5803550 |
| Lexington Surface | 5726600 |
| Lexington Depp Shaft | 5627158 |
| Arkansas Semi-Anthracite | 3935111 |
| Rugby | 3876916 |
| Hanna | 3292143 |
| Pennsylvania Anthracite | 2807000 |
| Blacksmith coal | 2746273 |
| Semi-Anthracite | 2691222 |

It seems little less than remarkable that per dollar one coal should yield nearly three times as much heat as another (Lincoln County coal not taken into account.) Of course this might not be the case in combustion under ordinary circumstances. INcomplete combustion of one coal might make the difference decidedly less. Herman Fay and F. W. Snow, in an article in the Journal of the American Chemical Society for May, 1905, describe their efforts to determine the amount of unburned coal in the ashes from factories

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and railroads. They found that the fuel value of the ashes varied from 2.5% to 78.6% of the coal used. Then again there may be other reasons for using the more expensive coals. Though perhaps they yield less heat for the same money. For instance the Blacksmith coal cannot be replaced by the lignite-like coal from Central Kansas, nor can the latter be burned in same varieties of grates and furnaces.

Other items against the cheaper coals are the filth and the amount of ashes they leave, and as already pointed out, these coals when burned under a boiler might take different relative positions.

Be that as it may it cannot but seem reasonable that a knowledge of facts similar to these would aid at least the man who uses coal for only stoves and furnaces in making the proper selection of the coal he should use.