On the Relative Ignition Temperatures of Solid Fuels

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By

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ABSTRACT.

Twenty-two kinds of solid fuels, including lignites, bituminous as well as anthracitic coals of oriental origin, semi-coke, metallurgical coke and wood-charcoal were tested for their relative ignition temperatures in the sense of Wheeler's definition.

A special form of heating tube with a paraffin-bath fused in was used, and was found to give more uniform heating than the ordinary tube such as Wheeler used.

Wheeler's general conclusion that the higher the oxygen content of the coal, the lower the relative ignition temperature has been confirmed with most of the coals we examined. We found, moreover, that the volatile matter and ash-contents of the fuel have a decided influence on their relative ignition temperatures, that is, generally a high volatile or a low ash-content gives a low ignition temperature, provided the other conditions remain equal.

In connection with the spontaneous combustion of coal and its combustibility, the ignition temperature of coal has been studied by many investigators under various conditions, among whom Wheeler[1], Arms[2], Sinnatt, Moore and Slater[3] have recently published interesting results relating thereto. None of the methods proposed, however, is entirely satisfactory for the determination of the *ignition temperature* of the solid fuel, the definition of which itself is by no means absolute at the present. In the circumstances, we experimented in the light of Wheeler's method (*l. c.*) which we thought very practical and easy to copy. He declares that

1 J. Chem. Soc., **113**, 945 (1918); Fuel, **3**, 366 (1924).
2 Bull. 128, Univ. Illinois (1922).
3 J. Soc. Chem. Indust. **39**, 72T (1920); Fuel, **2**, 211 (1923); **4**, 194 (1925).

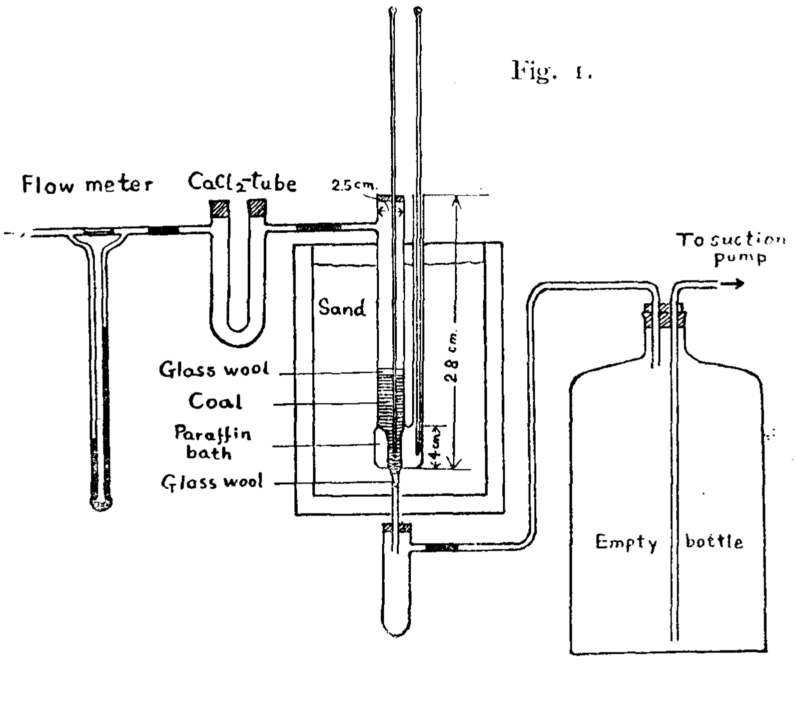
"from a practical as well as from a theoretical point of view, it is sufficient to know at what temperatures, under standard conditions, different coals begin to react with oxygen so rapidly that the ultimate appearance of flame is assured," and proposes a method to heat the coal powder by means of a sand-bath under specified conditions, and note the rise of temperatures of both the coal and the bath, the latter always higher than the former at the beginning of the experiment The temperature of the coal rising more rapidly than that of the bath, reaches the same temperature as the latter in due course, and finally exceeds it. The point at which both the coal and the sand-bath assume the same temperature is taken to be the ignition temperature of the coal relative to other coals tested in the same way.

Description of the Apparatus and the Method of Operation :—

Taking into consideration all the governing experimental factors, such as degree of fineness of the coal powder, the rate of the air current, the height of the coal column, the diameter of the heating tube, the position of the thermometer bulbs and the influence of the heating medium, we resorted to the following method.

Twenty grams of powdered coal (50—80 mesh) were put into a

Fig. 1.



glass tube as shown in Fig. 1, which is a mobified form of Wheeler's original tube. It was found to offer the advantage of more uniform heating owing to the presence of a paraffin-bath secondarily heated by the electrically heated sand-bath.

While a current of dry air was passed at a constant rate of 1100 c. c per minute, the temperature of the sand-bath was slowly raised as uniformly as possible in each experiment, and simultaneous readings of two thermometers, one in the coal column, and the other in the paraffin-bath, were taken at frequent intervals.

In this manner two time-temperature curves are obtained, one showing the rate of rise of temperature of the paraffin-bath, and the other that of the fuel. These two curves usually cross at a definite point, or the relative ignition temperature, characteristic of the fuel.

Fig. 2.

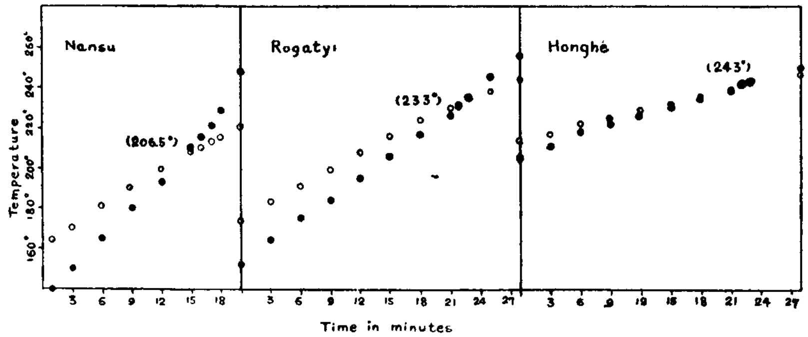


Fig. 2 shows the general form of the curves with three typical coals, Nansu (bituminous, vol. matter 30.84%) Rogatyi (semi-anthracitic, vol. matter 19.17%) and Honghé (anthracitic, vol. matter 10.00%). Generally bituminous coal, when it reaches its ignition temperature, shows so sudden a rise of temperature that often the hard glass tube may be fused in a few minutes, — in other words, the crossing of the two curves is very sharp. As for the anthracitic coal, not only is the relative ignition temperature very high, but the rate of self-heating of the coal is very much slower in comparison to other types of coal,— or the two curves do not cut each other as sharply as in the case of bituminous coals. There are, of course, intermediate forms between them.

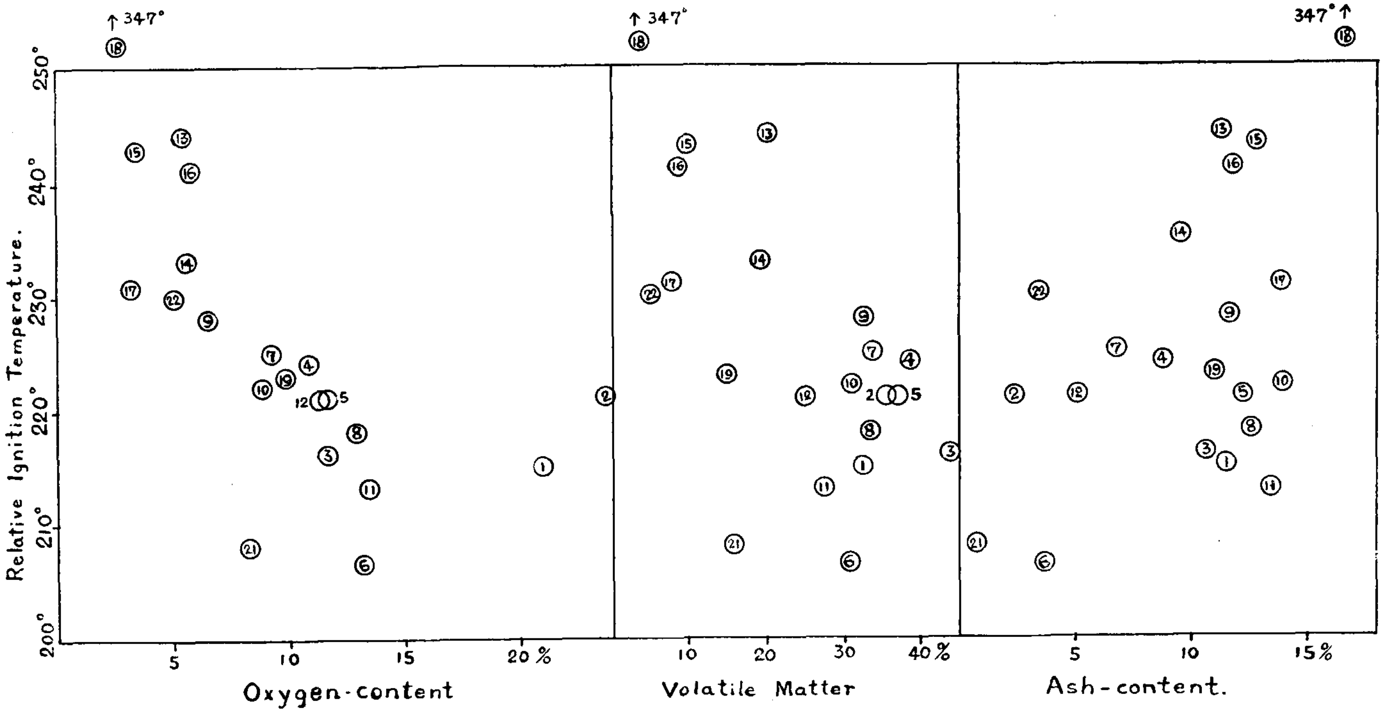
Twenty-two kinds of solid fuels, including various types of coal, semi-coke, metallurgical coke and wood-charcoal were tested for their relative ignition temperatures and the results are summarised in the following table, together with the analyses of the fuels showing their percentage of volatile matter, ash and oxygen contents.

	No.	Solid fuel	Analyses			Relative ignition temp. °C
			Volatile-matter (dry basis) %	Ash (dry basis) %	Oxygen (dry, ashless basis) 100−(C+H+N)%	
Lignites	1	Ten-tan	32·73	11·53	21·03	215
	2	Mgach 3ft	35·70	2·34	23·77	221
Bituminous Coals	3	Yubari No. 1 pit	43·39	10·69	11·74	216
	4	Koyaki	38·88	8·78	10·85	224
	5	Sakito	37·23	12·14	11·63	221
	6	Nansu	30·84	3·73	13·16	206·5
	7	Hashima	33·74	6·75	9·27	225
	8	Matsushima	33·57	12·63	12·93	218
	9	Besshu	32·81	11·70	6·56	228
	10	Sasa	30·80	13·99	8·92	222
Semi-anthracitic Coals	11	Kaiping	27·47	13·43	13·22	213
	12	Dui	24·69	5·03	11·46	221
	13	Poshan	20·02	11·27	5·40	244
	14	Rogatyi	19·17	9·56	5·64	233
Anthracites	15	Honghé	10·00	12·83	3·42	243
	16	Tsun-chin	8·75	11·85	5·83	241
	17	Kin tshou	7·68	13·95	3·21	231
	18	Mallien	3·52	16·61	2·74	347
Semi-Coke & coke	19	Semi-coke (Yubari No. 1 pit)	14·87	11·04	9·94	223
	20	Coke (Yubari No. 1 pit)	1·70	15·29	0·27	too high to measure
Wood charcoal	21	Charcoal (soft)	16·46	0·85	8·34	208
	22	Charcoal (hard)	5·10	3·41	5·01	230

It is known that coals that most readily self-heat are those containing the highest proportion of oxygen. As shown in Fig. 3a, this was found true with most of the fuels we examined, with occasional exceptions. So far as we have examined, this rule does not seem to hold with lignites, the oxygen content of which exceeds 20%.

Although not so distinct as the oxygen content, the volatile matter

Fig. 3a. Fig. 3b. Fig 3c.



and ash contents of the fuel were found also to exert a decided influence on its relative ignition temperature as shown diagrammatically in Figs 3b and 3c, contrary to Wheeler's conclusion that "no relationship exists between the ignition temperature now recorded and other (than oxygen content) analytical data."[1]

Hence, in general, the greater the oxygen content or volatile matter, or the less ash content tends to lower the relative ignition temperature of the solid fuel if other factors remain constant. On closer examination, it will be found that those the ignition temperatures of which deviate from the general trend have always a more prominent effect of other factors than the one in question.

Prof. J. Yonezawa of the Osaka Higher Technical School examined the relationship between the relative ignition temperatures and the amount of pyridine extract with several Hokkaido coals and Hokoku coals (unpublished), and came to the conclusion that the coals that yield less extract generally show lower ignition temperatures. We wish to take this opportunity to thank Prof. Yonezawa for kindly giving us his data on this subject.

In conclusion we offer our cordial thanks to Prof. M. Chikashige for his interest in this work.

1 J. Chem. Soc., **113**, 953 (1918).