COAL IN RELATION TO METALLURGICAL OPERATIONS.

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Although the total world output of coal averages one thousand million tons annually, only one-fifth of it is used as a raw material (15 per cent in the preparation of coke and 5 per cent in gas works) and the remainder is all used as fuel and most of this coal is burned for steam raising. In India, where the coal production during 1938 was over 28 million tons, barely 2·5 million tons or about 9 per cent was used as raw material, most of it for coke making, for the smelting of iron ore and the preparation of steel.

Thus by far the greater part of the coal raised in India is burned raw as a fuel. In this connection I would like to say that the calorific value of Indian coals from the Damodar Valley fields averages from 13,500 B.T.U's. per pound in the best qualities to somewhat more than 11,000 B.T.U's. in the inferior grades, but 13,000 B.T.U's. may be taken as a mean of the coals now being exploited. In the case of the high moisture coals of the Central Provinces the average calorific value may be taken as 11,000 B.T.U's. per pound.

Physical chemists in India have complained that there is a tendency towards misunderstanding in the use of the terms B.T.U's. per pound and calories if the latter term is not made quite clear, *i.e.* whether we mean kilogram-calories or calories per pound. Since one kilogram equals 2·204 pounds and one degree centigrade represents 1·8 degrees fahrenheit, it is clear that one kilogram-calorie must equal 3·968 B.T.U's. If therefore we adopt the term calorie for kilogram-calories we cannot apply it to any other measure.

Now returning once more to the subject of fuel for metallurgical processes it is of interest to consider the coke in a blast furnace. It is estimated that about 1·8 tons of iron ore with 1·1 tons of coke will normally yield one ton of pig iron. In the process of smelting about one-third of the coke, say 7 cwts. in this case, is actually involved in the reactions which result in the reduction of the highly heated iron ore to produce the iron. Here again, then, the major part of the coke, two-thirds, is consumed in heating and melting the charge in the furnace.

If we examine the metallurgical processes involved in dealing with copper, lead, zinc or other ores we find very little insistence on the nature of the fuel and in fact there is a tendency in almost all these cases to adopt electrical energy for heating. In the case of aluminium there can of course be no other as the process at present employed is both electro-thermic as well as electrolytic. The great difficulties in zinc extraction, due to the necessity of using a distillation process, are being partly met by electric methods of heating. One may go on repeating various cases.

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It is when we come to questions of making ferro-alloys and special steels that the question of their preparation in this country becomes direct. India and Burma have become noted for the chromite, manganese and tungsten (wolfram) ores which are almost entirely exported. It is thus a question whether these important substances cannot be used for the preparation of ferro-alloys in this country, and this again brings in its train the problem of coal as a direct fuel vs. electricity obtained from coal or from water-power. Except in special instances, as in the case of the Mettur project, where the electric energy is a by-product water-power cannot be as attractive as coal in a coalfield's power station for the generation of electric energy.

The main problem is that of cost. Can we generate electric energy from coal at so low a price as to carry on the manufacture of say ferro-manganese in the Central Provinces where rich manganese ore is available but the coal is of a relatively low calorific value? If electric energy can be generated cheaply enough for the electro-metallurgy of ferro-alloys in India, can it not be used also for the electric smelting of iron ore in a modified blast furnace on the Trölhatten (Swedish) pattern? Again I must say that it is a question of cost.

Theoretical calculations show that raw coal used direct will be the cheapest fuel unless the cost of the equivalent amount of coke is as cheap, and, again, whether the electric energy can be generated at a cost where the electrical power is equal to 0·66, *i.e.* two-thirds, of the cost of the coke. These are questions of importance and of a fundamental character. They are simple and involve principles we have to consider when examining how the conditions may be satisfied.

Appendix I.

Electrical power and energy.

1.	One Kilogram Calorie or *Cal.*	= 2·2 *Calbs.*
		= 3·88 B.T.U's.
		= 1,000 gram calories or *Cals.*
	One Pound Calorie or *Calb.*	= 453·6 ,, ,,
	One B.T.U. = $\frac{5}{9}$ *Calbs.*	= 252 ,, ,,
	One Evaporative Unit	= 976 B.T.U's.

2. One amp. through one ohm produces 0·238882 cals. per sec., *i.e.* one watt = 0·238882 cals. per sec. = 0·0568776 B.T.U's. per min. and one kilowatt or Kw. = 14·3329 cals. per min. One kilowatt hour = 859·974 cals. = 3412·66 B.T.U's.*

3. As the year contains 8,766 hours one kilowatt continuously produced for a year yields 29,895,902 or say 30 million B.T.U's. which is somewhat less than that yielded by one ton of good coal averaging 14,000 B.T.U's. per lb. which equals 31 million B.T.U's. and since one E.H.P. year is 22,320,000 B.T.U's. the heat value of coal is 1¼ E.H.P. year also one lb. of coal produces as much heat as 4 Kw. hours. (See above *.)

4. Thus when a consumer pays 2 annas per unit for electric energy (light) where coal costs Rs.8 per ton, the ratio of the electrical heat Rs.0-2-0 × 8766 × 1½ = *Rs.1,461* to Rs.8 the coal heat is as 180 to 1. And in a generating station where the unit is one pice and coal is Rs.2-8-0 the ratio will be over 200 to 1 and cheaper units should be possible.

5. Efficiencies of furnaces for melting metals :—

Coke-fired crucible steel furnace ..	2 to 3 per cent.
Reverberatory furnaces	10 to 15 ,,
Regenerative open hearth (steel) ..	20 to 30 ,,
Shaft furnaces (cupolas, etc.) ..	30 to 50 ,,
Large electrical furnaces	60 to 85 ,,

It is thought that similar efficiencies would be obtained for the same furnaces if employed for smelting ores.

(' The Electric Furnace ' (1914) by Alfred Stansfield, 2nd Edn., p. 40.)

APPENDIX II.

Melting temperatures of metals and heat required.

Metal.	C°	F°	*Calb.*	B.T.U.	Watt hours.
Tin ..	232	450	28	51	15
Lead ..	327	620	16	28	8
Zinc ..	419	786	68	122	36
Aluminium ..	657	1214	256	465	136
Brass (65 Cu) ..	920	1688	130	234	60
Copper ..	1083	1983	162	292	85
Cast Iron ..	1200	2192	245	441	129
Tool Steel ..	1425	2600	300	540	158
Wrought Iron ..	1500	2737	343	617	181