FORRESTER'S FORMULA FOR THE DETERMINATION OF CALORIFIC VALUE OF INDIAN COALS

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RESULTS of proximate analysis like ultimate ones have been employed for calculating the calorific value of coals, and from time to time various formulæ have been proposed for the purpose. Forrester[1] proposed a formula specially for coals of Raniganj and Jharia fields as follows:—

$$C_g = 80 \cdot 8\ C + KV,$$

where C_g = calories per gram

C = fixed carbon per cent

V = volatile matter per cent

and K is a factor which varies from $86 \cdot 5$ to $103 \cdot 25$ for various seams.

compared with those calculated from Forrester's formula applying as far as possible correct 'K' values for respective seams proposed by Forrester as given below.

As shown in Table I, wide differences have been noticed between the two values for each sample. It is, however, interesting to note that, in general, with increasing ash content the difference between the observed and calculated values goes on increasing. Although there is fair justification in accepting the figure $80 \cdot 8$ as the calories contributed by each 1% of fixed carbon present in one gram of

Seams	..	5, 6, 7	10	11	12	13	14 & 14 A	15	16	17 & 18	Raniganj
K =	..	103·25	95·53	98·35	97·2	96	97·75	94·5	94	90·5	86·5

The calorific values of nine representative samples of Indian coals obtained from Bengal and Bihar fields through official sources were determined by Bomb method and the values

coal,[*] the reason for this wide difference may be attributed to the empirically derived values of 'K', and as such, they are to be accepted with reserve.

TABLE I

Sample No.	Source	Proximate Analysis (oven-dry coal)			Calorific value (oven-dry coal) calories per gram		Difference
		Volatile matter %	Fixed carbon %	Ash %	Experimental by Bomb method	Calculated by Forrester's Formula	
1	Raniganj Series, Dishergarh Seam, Saltore Colliery	38·16	47·95	13·89	7218	7175	43
2	Raniganj Series, Dishergarh Seam, Parbelia Colliery	36·93	48·89	14·18	6955	7145	−190
3	Jharia Field, New Jeenagora Colliery, Seam No. 6 in Geological order	22·70	56·92	20·38	6667	6943	−296
4	Jharia Field, New Jeenagora Colliery, Seam Nos. 5 and 6 in Geological order	21·75	52·87	25·38	6211	6518	−307
5	Jharia Field, Central Jeenagora Colliery, Seam Nos. 6 and 7 in Geological order	22·73	55·69	21·58	6542	6847	−305
6	Jharia Field, North Borari Colliery, Seam No. 10 (3rd section)	22·66	52·42	24·92	6185	6394	−109
7	Jharia Field, North Borari Colliery, Seam Nos. 5 & 6 in Geological order	17·15	43·43	39·42	4833	5280	−457
†8	Jharia Field, Khas Kusunda Colliery. No. 8 Seam, Bottom section	18·48	64·74	16·78	6998	7139	−141
†9	Jharia Field, Central Keshalpur Colliery, Nos. 8 and 9 Seams	17·51	61·40	21·09	6571	6769	−198

[*] Calorific value of carbon being taken as 8080 calorie per gram.

† 'K' values for seams 8 and 9 are not given by Forrester. We have taken average figure between those of 5, 6, 7 seams and 10 seam.

Obviously, the values of 'K' were derived by Forrester on the assumption that for a seam the volatile matter has the same composition everywhere and hence the same calorific value. This is not correct since the amounts of vitrain, durain and fusain materials vary from place to place in the same seam[2] and even at one spot when traversed from floor to roof.[3] Another important factor which has generally been overlooked is the error introduced by inert ingredients such as (a) occluded gases in coal, (b) moisture from mineral matters and (c) product of decomposition of pyrites, which escape during volatile matter determination. The errors of volatile matter naturally appear in the ash. In other words, the ash 'as found' gives a lower figure than the true mineral matter in the coal. The necessary correction according to Parr[4] will be

Mineral matter = Ash × 1·08 + ·55 sulphur or volatile matter 'as found' should be decreased by 8% of the 'as found ash' plus ·55 times total sulphur in coal.

Although Parr's correction is not mentioned with any special reference to Indian coals, Forrester's formula was applied after introducing Parr's correction to volatile matter. From Table II it is clear that even by making the aforesaid correction appreciable difference exists, though reduced in magnitude, between the calculated and determined values. In case of four samples, however, the values are in close agreement.

Hence it is suggested that a correction similar to that of Parr's on volatile matter must be applied before any calculation of calorific value is attempted by the use of any formula such as Forrester's. Parr's correction may not be applicable as such to Indian coals owing to the high percentage of ash they contain and the difference in the mineral matter composition from British and American coals. Reliable data on the nature of mineral matter and also the composition of volatile matter for various seams at different places must be available to make use of any empirical formula based on proximate analysis. Investigations in obtaining such useful data are in progress.

TABLE II

Sample No.	Oven dry coal		Correction to be applied to Vol. matter (according to Parr)	Corrected Vol. Matter %	Calorific value by Forrester's formula on Corrected Vol. Matter	Difference between Experimental and Calculated Figures
	Ash %	Total sulphur %				
1	13·89	0·33	−1·30	36·86	7063	155
2	14·18	0·29	−1·30	35·63	6952	3
3	20·38	0·46	−1·89	20·81	6748	− 81
4	25·38	0·41	−2·26	19·49	6234	− 73
5	21·58	0·31	−1·90	20·83	6650	− 108
6	24·92	0·46	−2·25	20·41	6185	nil
7	39·42	0·28	−3·31	13·85	4938	−105
8	16·78	0·34	−1·53	16·95	6981	17
9	21·09	0·36	−1·89	15·62	6574	− 3

1. Forrester, C., *Colliery Guardian*, 1932, **145**, 382-84.
2. —, *Trans. Min. Geol. Inst. India*, 1932, **26**, 277-301.
3. —, *J. Inst. Fuel*, 1935, **9**, 30-58. 4. Parr, S. W., *J. Ind. Eng. Chem.*, 1922, **14**, 919-22.

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