Coal proximate analyses correlations with airborne respirable dust and spontaneous combustion temperature

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Dear Sir

The US Bureau of Mines has previously[1] shown that the concentration of airborne respirable dust generated from a coal sample is strongly correlated with what can be called the moist fuel ratio of that sample. The moist fuel ratio can be expressed as the quantity:

$$\text{Moist fuel ratio} = \frac{\text{fixed carbon (\%)/volatile matter (\%)}}{\text{moisture (\%)}}$$

Over a broad range of moist fuel ratios, the airborne respirable dust concentration showed a thirty-fold change in values. It is the intent of this letter to show that the moist fuel ratio is also highly correlated with the spontaneous combustion temperatures of a wide variety of

In a study of spontaneous combustion in coal, Smith and Lazzara[2] measured the self-heating temperatures of 23 US coals ranging from lignite to low volatile bituminous in rank. *Table 1* shows the measured self-heating temperatures and reported proximate analyses of these coals.

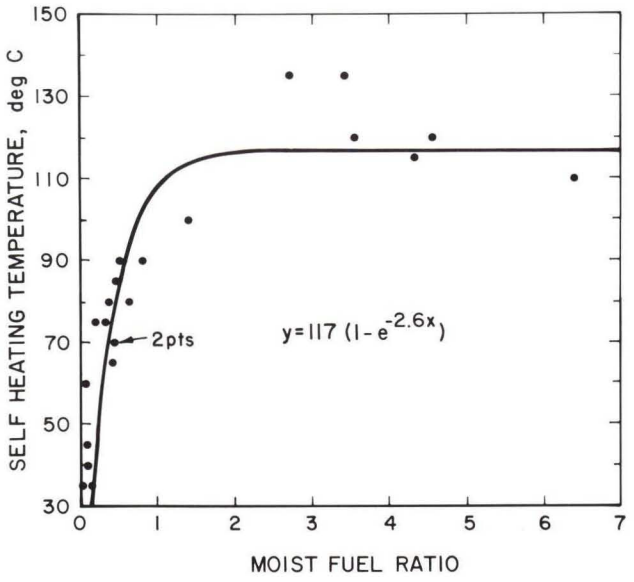

Figure 1 Minimum self-heating characteristics of US coals

Using the data of Smith and Lazzara, the moist fuel ratio values corresponding to the proximate analyses for each coal were calculated. *Figure 1* plots the self-heating temperature and an exponential function fitted to the data versus the moist fuel ratio with a multiple *R*-squared value of 0.96, which is a strong correlation. The relationship is in full agreement with what is currently known about spontaneous combustion of coal, that:

1. High fixed carbon (high rank) coals have a higher self-heating temperature than low rank coals and are less susceptible to spontaneous combustion.
2. High volatile and high moisture (low rank) coals have lower self-heating temperatures and are more susceptible to spontaneous combustion.

In another spontaneous combustion study, Unal *et al.*[3] describes the 'auto-ignition' tendencies of Turkish lignites and Australian bituminous coals. These data were also analysed in terms of the moist fuel ratio. *Figure 2* shows a plot of the crossing point temperature (similar to the self-heating temperature) as described by Unal *et al.* and an exponential function fit of the same form as used in *Figure 1* versus the moist fuel ratio. The multiple *R*-squared value for this fit is 0.94. Except for a constant asymptotic difference, the two exponential curves of *Figures 1* and *2* are identical. The differing asymptotic values are probably due to the different measures of spontaneous combustion temperatures.

Table 1 Self-heating temperatures (SHT) and proximate analyses of coals

Seam	SHT (°C)	As-received (wt%) Moisture	Volatile matter	Fixed carbon
Beulah Zap	60	27.3	29.9	31.8
Lehigh	35	42.6	32.8	19.5
F	45	11.4	40.9	45.3
No. 6	70	2.2	41.8	42.7
No. 80-1	35	7.6	38.3	44.1
No. 80-2	40	11.0	39.5	43.9
B-1	70	2.8	38.3	49.6
B-2	75	3.9	40.1	53.8
Clarion	75	4.8	43.0	44.4
D-1	90	2.1	43.9	47.8
D-2	80	2.7	44.2	47.3
E-1	65	3.9	39.7	54.6
E-2	65	3.2	40.5	54.4
L. Kittaning	100	1.0	31.7	44.9
L. Sunnyside-1	85	3.2	36.2	54.2
L. Sunnyside-2	80	2.3	38.6	56.2
Pittsburgh	90	1.7	38.8	53.9
Coal Basin-1	120	0.7	22.0	70.4
Coal Basin-2	120	0.9	21.6	69.5
Bluecreek	135	1.1	19.2	72.7
Mary Lee	135	1.3	20.2	71.3
Pocohontas 3-1	115	0.9	18.7	73.2
Pocohontas 3-2	110	0.6	17.6	67.5

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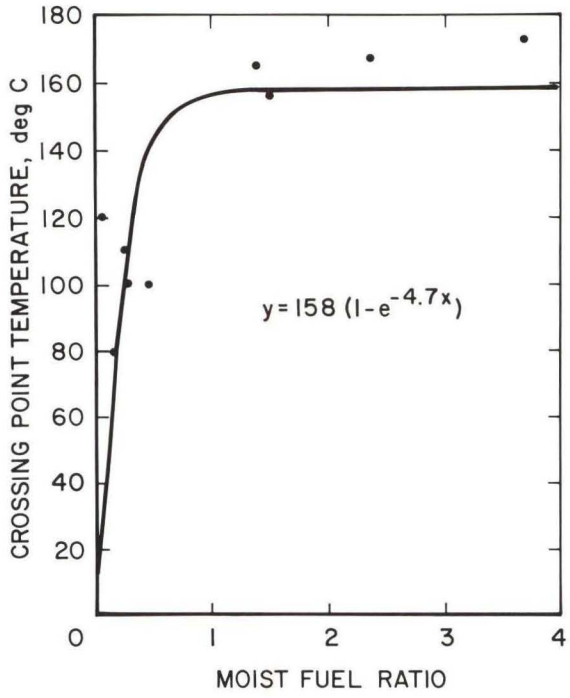

Figure 2 Auto-ignition characteristics of Turkish and Australian coals

The US Bureau of Mines has found a combined parameter, called the moist fuel ratio, based on the proximate analyses of coals which appears to be highly correlated with both the spontaneous combustion and dust-producing characteristics of coals. It appears quite remarkable that the moist fuel ratio is successful in modelling both physical breakage mechanisms and chemical behaviours of coals which range from lignite to low volatile bituminous coals from the United States, Turkey and Australia, as well as three totally independent sets of data. Although it is generally known that self-heating and spontaneous combustion of coal is a function of coal rank along with other factors such as oxygen concentration, temperature, moisture and ventilation, an explanation for moist fuel ratio significance is not known. These correlations suggest that a fundamental relationship may exist between the physical and chemical characteristics of coals and that some fundamental importance may be associated with the moist fuel ratio.

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3 Unal, S., Piskin, S. and Dincer, S. *Fuel* 1993, **72**, 1357