Low Temperature Oxidation of Coal

by

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The Academic Senate on 19 July 2002 resolved that the candidate had satisfied requirements for admission to the degree of MSc.
This thesis represents a major part of the prescribed program of study.

CORRECTIONS AND CLARIFICATIONS

Throughout this thesis, the rate of oxygen consumption or moisture uptake by the coal has been expressed in units of g O_2/g/s or g H_2O/g/s, respectively. These units are intended to mean grams of O_2 (or H_2O) per gram of coal per second, i.e. g O_2 g^{-1} coal s^{-1}.

Chapter 2 p. 36 The thermocouple used in the reactor to measure the sample temperature was a T type (copper-constantan).

p. 36 The MTI gas chromatograph was fitted with a thermal conductivity detector.

Chapter 3 p. 50 Line 9: "various partial pressures of CO_2 so than an isotherm" should read "various partial pressures of CO_2 so that an isotherm"

p. 56 Figure 3.10 shows the dependence of apparent activation energy on mean particle diameter. The data from which this plot was made are listed below:

Mean Particle Diameter (mm)	Apparent Activation Energy (kJ mol^{-1})
0.13	53.1 ± 2.4
0.30	44.2 ± 6.8
0.47	48.1 ± 5.3
0.68	54.4 ± 6.4
1.01	36.0 ± 1.4
2.25	46.9 ± 0.8
5.73	46.1 ± 0.5
9.00	36.3 ± 3.5
24.0	43.5 ± 0.4

Stuart Day

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Abstract

The kinetics of oxidation of a high volatile bituminous coal have been studied at temperatures between 75 and 120 °C and particle sizes between 0.125 and 24 mm. The rate of oxidation was found to increase with increasing temperature yielding an activation energy of about 45 kJ/mol. At temperatures below about 75 °C the oxidation rate was essentially independent of the particle size but at higher temperatures, the rate tended to decrease with increasing particle size. For all of the temperatures examined, however, the rate remained independent of particle size if the particles were less than about 1 mm in diameter. This suggests that in those regimes where there is no particle size dependence, the overall rate of oxidation is under chemical control whereas in regions where the rate reduces with increasing particle diameter, diffusion becomes the rate limiting mechanism.

Several oxidation rate models were tested against the experimental results. Of these, a modification of the shrinking core model in which each particle was assumed to be made up of many individual shrinking cores provided the best fit yielding excellent agreement with the measured rates.

Moisture adsorption isotherms and the rate of moisture uptake by the coal were studied at temperatures between 10 and 60 °C and relative humidities ranging from about 10 to 100 percent. At all temperatures, moisture adsorption followed the Langmuir isotherm up to about 80 percent relative humidity but above this level the moisture content of the coal was substantially underestimated by the Langmuir model. An empirical model originally proposed by Henderson was found to provide a better fit over the full relative humidity range. The rate of moisture uptake increased with increasing relative humidity and temperature but decreased with increasing particle size. A rate model, similar in form to the shrinking core model, provided a very good fit to the experimental data and successfully predicted the effects of temperature, relative humidity and particle size on the rate of adsorption.

Declaration

I hereby declare that this thesis is my own work and that none of the material contained within it has been submitted, in part or in full, for a higher degree to any other university or institution.

Stuart John Day

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