CHARACTERISATION OF CHARS FROM THE COMBINED CYCLE GASIFICATION OF COAL

N. Neal, T.J. Mays, and B. McEnaney
Department of Materials Science and Engineering
University of Bath, Bath, BA2 7AY UK

Introduction

Coal is still a major fuel in the world, fulfilling over 20% of the worlds energy demand. However, coal fired power stations are also heavy polluters, show low conversion, have low thermal efficiency and can suffer due to variable coal quality. A number of methods used to combat these problems have been combined into the Air Blown Gasification Cycle (ABGC). A pilot plant of this process has been developed in the UK and is now licensed to Mitsui Babcock Energy Ltd. This abstract reports some initial surface structure data for ABGC coal chars that have been obtained using temperature-programmed desorption (TPD) and thermogravimetric analysis (TGA). These data are of use in predicting the performance of ABGC plant.

Experimental

A typical TPD temperature profile is shown in Figure 1. A coal char sample is first degassed at 900 °C under vacuum. The temperature is then lowered to 250 °C and 1 bar O_2 is passed over the sample for 4 hours. After chemisorption the sample is heated at 10 °C min^{-1} in vacuum. The CO and CO_2 evolved during this ramp are detected by a quadrupole mass spectrometer.

In order to evaluate the degree of chemisorption at different times and temperatures, and the possibility of gasification, samples were exposed to 1 bar O_2 in a Setaram TG-DTA92 thermogravimetric analyser.

Results and Discussion

Figure 2 shows plots of weight gain against time for Dawmill candle filter fines exposed to oxygen at three different chemisorption temperatures. Candle filter fines are fine char particles extracted from the gasifier flue gas prior to it being burnt in a gas turbine. At 200 °C the weight gain in the first hour of chemisorption is about 0.4% but an equilibrium is never reached and the sample is still gaining weight after 14 hours. At 250 °C the weight gain in the first hour is nearly double the weight gain at 200 °C and the sample goes on to reach equilibrium after about 7 hours, reaching 90% of this value after 4 hours. The sample chemisorbed at 300 °C has a 0.8% increase in weight in the first hour but then reaches a maximum after 2 hours and begins to loose weight. This is indicative of the onset of gasification of the sample.

Figure 3 shows a typical TPD curve for a Dawmill primary fines char. The curves are similar for all primary fines samples obtained from the pilot plant gasifier. The area under the TPD curves can be used to determine the active surface area (ASA) of each char [1]. The relationship between ASA for primary fines and the fixed carbon content of the parent coal is shown in Figure 4. This indicates that coals with lower fixed carbon contents have higher surface areas. Lower fixed carbon contents are indicative of either higher mineral contents or more volatiles in the parent coal. Figure 5 shows a correlation between the volatile matter of the coal and the primary fines. There is a positive correlation between the volatile content and the ASA though there is some scatter in the results. Figure 6 shows a correlation between ASA in the primary fines and Na content in the parent coal; again there is a positive correlation. Higher volatiles may open up the porosity of the chars exposing more ASA. And Na may result in more (catalytic) active sites.

Conclusions

Gasification has been demonstrated to occur above 300 °C for Dawmill candle filter fines char. There is evidence to suggest that volatile matter and the presence of Na in a coal can enhance the ASA of a char after the coal has passed through an ABGC gasifier.

References

1. Wang J, McEnaney B. Quantitative calibration of a TPD-S system for CO and CO_2 using calcium carbonate and calcium oxalate. Thermochimica Acta, 1991;190:143-153.

Acknowledgements

We thank the British Coal Utilisation Research Association and the European Coal and Steel Community for financial support.

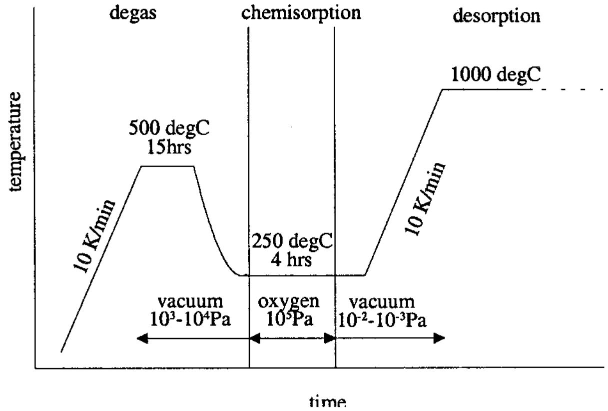

Figure 1. Typical temperature profile used during temperature-programmed desorption.

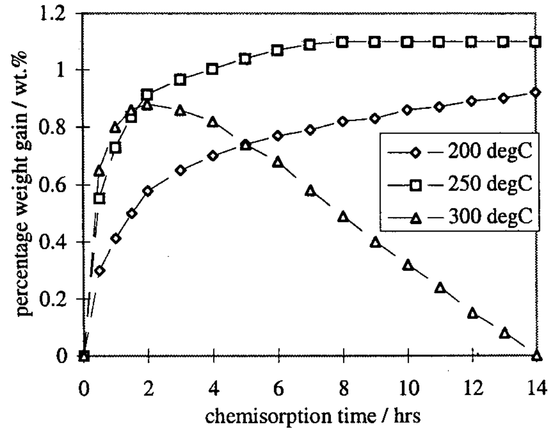

Figure 2. Chemisorption isotherms of Dawmill candle filter fines in an oxygen atmosphere produced by thermogravimetric analysis.

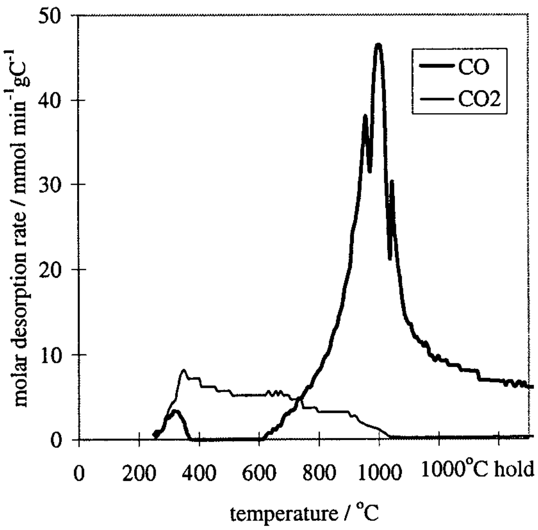

Figure 3. A typical TPD curve produced for primary fines from an ABGC plant.

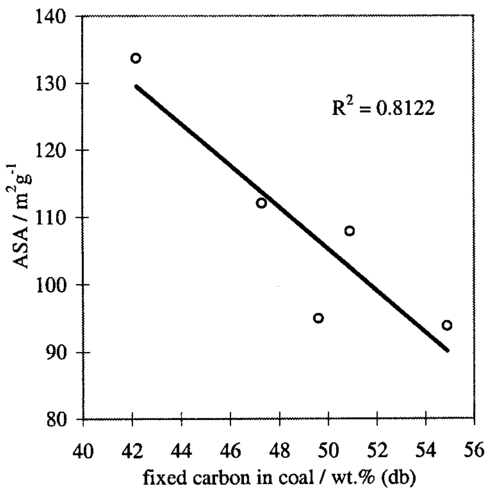

Figure 4. Correlation between fixed carbon in parent coal and ASA in primary fines for five bituminous coals.

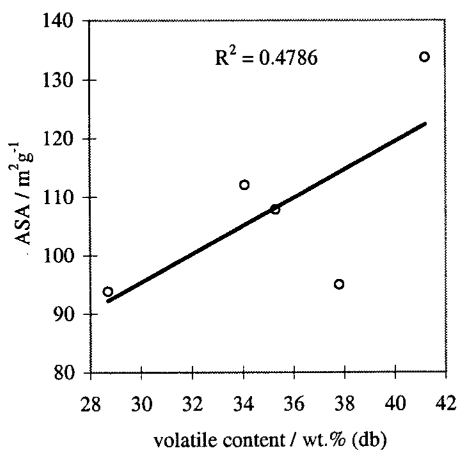

Figure 5. Correlation between the volatile content of the parent coal and the ASA of the primary fines for five bituminous coals.

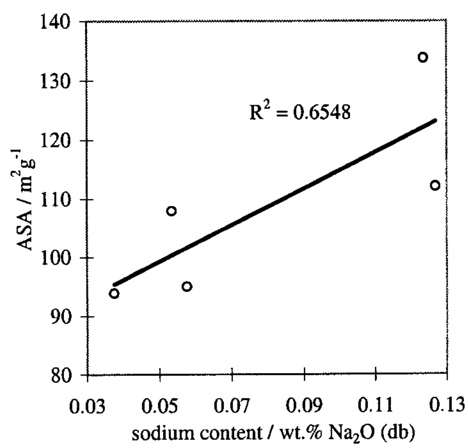

Figure 6. Correlation between the sodium content in the parent coal and the ASA in the primary fines for five bituminous coals.