UPGRADING SOUTH AUSTRALIAN
LIGNITES BY
HIGH-TEMPERATURE PRE-TREATMENT

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by
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SUMMARY

Low rank South Australian coals contain substantial amounts of moisture, sodium, chlorine and sulphur. High-temperature pre-treatment is a process which has the potential to reduce these impurities and enhance the value of these coals as sources of fuel. The process uses high temperature and pressure to modify the structure of the coal.

The primary aim of this project was to examine high-temperature, high-pressure pre-treatment of Bowmans coal under controlled conditions in microautoclaves in order to determine the extent of removal of unwanted constituents and to establish the kinetics of water removal and devolatilization. Investigations were also undertaken to shed light on the chemistry and mechanisms of the process.

The results of high temperature pre-treatment experiments on Bowmans coal using microautoclaves are presented. Temperatures of between 250°C and 350°C were studied for residence times up to 1 hour, and the extents of moisture and impurity removal for a coal to water ratio of 1:1 were determined. It was found that up to 80% moisture, 60% of both sodium and chlorine, 50% oxygen and 40% organic sulphur was removed from coal during processing. The reduction of m.a.f coal due to decarboxylation and pyrolysis reactions results in the loss of 33% of the volatile matter as a low calorific value gas, while there is 30% less ash from combustion of dewatered coal. The net energy loss from this process through devolatilization reactions is only about 3%, while there is an increase in energy available for combustion, caused by water removal, of about 8%. The energy required to heat the coal slurry to reaction temperature is about 5% of the energy in raw coal.
The leaching characteristics of coal were examined as an aid to determining mechanisms of mineral matter removal during dewatering. The extents of sodium and chlorine removal during hot water dewatering were comparable to that found during leaching experiments, while magnesium, calcium and sulphate ions appeared to be retained. While 40% of the organic sulphur was removed from the coal during dewatering, only 24% of total sulphur was removed and sulphate sulphur appeared to increase. This may be due to precipitation of magnesium/calcium sulphate during dewatering. The use of methanol as an additive in the slurry to enhance dewatering was not successful, although further work should be performed on fresh Bowmans coal to confirm this result.

In later tests there was a marked reduction in the efficiency of dewatering; this was attributed to oxidation of the coal surface over a long period. It was also found that slower heating to reaction temperature slightly improved dewatering.

The kinetics of devolatilization and water removal were studied using time-temperature equivalence and distributed-activation-energy models. Both models fitted experimental results adequately. The removal of various gaseous species from coal during dewatering was modelled using distributed activation energy kinetics.

Investigations of FT-IR and NMR spectroscopic methods of analysis have been carried out on raw and dewatered coal samples. NMR spectra of Bowmans coal show an unusually low carbon aromaticity which increases following dewatering. A general decrease in carboxyl functional groups as a result of dewatering was observed using both of these methods. Na NMR indicated that there is much less sodium present as sodium chloride in dried coal than expected from extraction analysis and also indicated the presence of an unidentified sodium compound.
The filtration characteristics of dewatered coal slurries showed a marked improvement over untreated coal-water slurries; cloth binding would no longer be a problem.

Analysis of the aqueous effluent from high-temperature dewatering showed that it is a strong organic wastewater, with high dissolved solids content and high sulphide content.
TABLE OF CONTENTS

DECLARATION
ACKNOWLEDGEMENTS
SUMMARY
TABLE OF CONTENTS

| 1. INTRODUCTION                                                                 | 1 |
| 2. REVIEW OF THERMAL DEWATERING TECHNOLOGY                                      |   |
| 2.1 Fleissner Steam Thermal Dewatering                                            | 4 |
| 2.2 Evans-Slonc Thermal Dewatering                                               | 7 |
| 2.3 Koppelman Steam Thermal Dewatering                                            | 8 |
| 2.4 Kamyk Hot Water Dewatering                                                   | 9 |
| 2.5 Hot Water Dewatering (UNDERC)                                                | 10|
| 3. EXPERIMENTAL SYSTEM                                                           | 14|
| 4. EXPERIMENTAL PROCEDURE                                                        | 20|
| 4.1 Use of the Tube Bomb Reactor                                                 | 20|
| 4.2 Proximate Analysis                                                           | 22|
| 4.3 Equilibrium Moisture                                                         | 23|
| 4.4 Liquor Analysis                                                              | 23|
| 4.5 Gas Analysis                                                                | 24|
| 5. RESULTS AND DISCUSSION                                                        | 25|
| 5.1 Introduction                                                                 | 25|
| 5.2 Effect of Temperature                                                        | 26|
| 5.3 Altering the Experimental Conditions                                         | 44|
| 5.3.1 Varying Tube Bomb Loading                                                  | 41|
| 5.3.2 Rate of Heating                                                            | 43|
| 5.3.3 Particle Size                                                              | 44|
| 5.3.4 Adding Methanol                                                            | 45|
| 5.4 Decomposition of Carboxyl Groups                                              | 47|
5.4.1 Introduction  42
5.4.2 Experimental Technique  47
5.4.3 Results  48
5.5 Kinetic Experiments  52
   5.2.1 Proximate Analysis  52
   5.2.2 Ion Removal  58
   5.2.3 Gas Removal  64
5.6 Thermal Efficiency  69
5.7 Long Term Moisture Reabsorption  75
5.8 Discussion on the Effect of Coal Age  78

6. KINETICS OF DEWATERING  81
   6.1 Introduction  81
   6.2 Modelling Heating Rates for Tube Bombs  85
   6.3 Results and Discussion  86
   6.4 Parametric Study of the Distributed Activation Energy Model  89
   6.5 Kinetics of Gas Removal  90
   6.6 Conclusions  92

7. MECHANISMS AND STRUCTURAL CHANGES  106
   7.1 Introduction  106
   7.2 Fourier Transform Infra-red Spectroscopy  109
      7.2.1 Introduction  109
      7.2.2 Experimental  110
      7.2.3 Results and Discussion  111
      7.2.4 Conclusions  114
   7.3 Carbon Nuclear Magnetic Spectroscopy  125
      7.3.1 Introduction  125
      7.3.2 Experimental  126
      7.3.3 Results and Discussion  127
      7.3.4 Conclusions  131
   7.4 Sodium Nuclear Magnetic Spectroscopy  141
      7.4.1 Introduction  141
      7.4.2 Experimental  143
      7.4.3 Results and Discussion  145