Industrial Rotating Kiln Simulation

This thesis is presented for the degree of Doctor of Philosophy

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Certificate of Authorship/Originality

I certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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ABSTRACT

A new industrial process is being developed to allow the commercial recovery of oil from oil shales. As part of this process, a rotating kiln is used to pyrolyse the organic component of the oil shales. The configuration and application of this rotating kiln is unique and hence previous rotating kiln models cannot be used to predict the solid behaviour in the current processor. It is the aim of this work to develop mathematical models which allow the prediction of mixing, segregation and heat transfer in industrial rotating kilns, especially with respect to the new rotating kiln technology trialed in the oil shale industry.

Experiments were developed to observe and measure the mixing and segregation behaviour of solids in rotating drums. These experiments used image analysis and provided quantitative results. Further experiments were carried out to allow suitable scaling parameters to be developed.

All the mixing experiments followed a constant mixing rate until the bed became fully mixed. The mixing rate and the final amount of mixing depended on the rotational velocity, the drum loading, the particle size and the material ratio. The segregation dynamics occurred too fast to be measured. However the final segregated state was measured and depended on the rotational velocity and the differences in particle sizes. Scaling parameters were developed that related the mixing and segregation results to the operational variables of the rotating kiln.

Mathematical models were derived for the mixing and segregation of solids in a rotating kiln and these models included the developed scaling parameters so that these models would be useful for the prediction of the solid behaviour in industrial rotating kilns. The mathematical models were applied to independent experiments and it was found that they predicted the mixing and segregation to within the

experimental error, even for different sized drums indicating that the developed scaling parameters were suitable.

A computational simulation of the industrial rotating kiln processor was developed by combining the mathematical models of the mixing and segregation with heat transfer modelling applicable to this industrial rotating kiln. A case study was completed to study the behaviour of the industrial rotating kiln by changing operational variables, such as the rotational speed and the particle size.

The developed simulation can be used to predict the dynamic behaviour of the rotating kiln used in the emerging oil from oil shale industry. This simulation can assist in further commercialisation of this new industrial process.

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