

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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Table of content

Certificate of Authorship/Originality	ii
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ABSTRACT	iii
-----------------	------------

ACKNOWLEDGEMENTS	v
-------------------------	----------

Table of content	vi
-------------------------	-----------

Table of Figures	xiii
-------------------------	-------------

CHAPTER 1	1
------------------	----------

Introduction.	1
1.1 APPLICATIONS AND DESCRIPTIONS OF ROTARY KILNS	1
1.2 “OIL FROM OIL SHALE” PROCESS	2
1.2.1 Oil shale in Australia	2
1.2.2 The Stuart project	3
1.2.3 The AOSTRA-Taciuk Processor	4
1.3 RESEARCH OBJECTIVES	6
1.4 THESIS STRUCTURE	7
1.5 CHAPTER SUMMARY	7

CHAPTER 2 **8**

Mixing, segregation and heat transfer mechanisms of granular materials.	8
2.1 MIXING OF GRANULAR MATERIALS	8
2.1.1 Shear mixing of granular materials	10
2.1.2 Convective mixing of granular materials	10
2.1.3 Diffusive mixing of granular materials	11
2.2 SEGREGATION OF GRANULAR MATERIALS	12
2.2.1 Percolation segregation mechanism of granular materials	13
2.2.2 Flow or trajectory segregation mechanism of a granular material	14
2.2.3 Vibration segregation mechanism of a granular material	15
2.3 HEAT TRANSFER IN GRANULAR MATERIALS	15
2.3.1 Heat transfer paths between particles	15
2.3.2 Heat transfer in a granular medium	17
2.4 CHAPTER SUMMARY	18

CHAPTER 3 **20**

Rotating drums and kilns – literature review.	20
3.1 TRANSVERSE MOTION IN A ROTATING DRUM	21
3.1.1 Transverse bed regimes	21
3.1.2 The transverse rolling regime in a rotating drum	23
3.1.2.1 Description of the active layer in the rolling regime	23
3.1.2.2 Description of the stagnant layer in the rolling regime	26
3.1.2.3 Description of the mixing and segregation in the rolling regime	27
3.2 AXIAL MOTION IN A ROTATING DRUM	33
3.2.1 Motion in the axial section of a rotating drum	33
3.2.2 Residence times in rotating kilns	34
3.2.3 Mixing and segregation in the axial direction	36
3.3 HEAT TRANSFER IN ROTARY KILNS	37

3.3.1 Heat transfer paths in the transverse direction of a rotary kiln	38
3.3.2 Review of rotary kiln heat transfer modelling	39
3.4 SCALE UP THEORY.	40
3.5 CHAPTER SUMMARY	41

CHAPTER 4 **43**

Experimental design.	43
4.1 PARTICLE AND GRANULAR MEDIUM CHARACTERISATION	43
4.1.1 Physical properties of Stuart oil shale	44
4.1.1.1 Particle sizes	44
4.1.1.2 Static angle of repose	44
4.1.1.3 Bulk density	45
4.1.2 Chemical properties of Stuart oil shale	47
4.1.3 Preparation of the raw materials	48
4.2 ROTATING DRUM DESIGN	49
4.3 IMAGE CAPTURE AND ANALYSIS	50
4.4 PROPOSED EXPERIMENTS	51
4.5 EXPERIMENTAL PROCEDURE	52
4.6 CHAPTER SUMMARY	53

CHAPTER 5 **54**

Active layer characterisation.	54
5.1 IMPORTANT ACTIVE LAYER PARAMETERS	54
5.2 EXPERIMENTAL PROCEDURE	56
5.3 ACTIVE LAYER RESULTS FOR THE EXPERIMENTS IN THE 570 MM DIAMETER DRUM	57
5.3.1 Active layer proportion	57
5.3.2 Mean velocity and flux of the stagnant layer	59
5.3.3 Mean velocity and flux of the active layer	60
5.3.4 Radius A, Radius B and Angle A	61
5.4 SCALABILITY OF ACTIVE LAYER RESULTS	62

5.5 CHAPTER SUMMARY	63
---------------------	----

CHAPTER 6	64
------------------	-----------

Mixing in the transverse direction of a rotary drum.	64
6.1 TRANSVERSE MIXING EXPERIMENTS	64
6.2 EXPERIMENTAL ANALYSIS METHODOLOGY	66
6.3 EXPERIMENTAL MIXING RESULTS	69
6.4 ANALYSIS OF THE EXPERIMENTAL MIXING RESULTS	74
6.4.1 Stepwise mixing behaviour	74
6.4.2 Mixing rates and final contact distances	75
6.4.2.1 Rotational velocity effects	75
6.4.2.2 Drum loading effects	76
6.4.2.3 Particle size effects	77
6.4.2.4 Material ratio effects	78
6.4.3 Analysis of the experimental errors	79
6.5 MODELLING OF THE MIXING IN THE TRANSVERSE DIRECTION OF A ROLLING DRUM	80
6.5.1 Mixing rate modelling	80
6.5.2 Final mixing contact distance modelling	83
6.6 APPLICATION AND VERIFICATION OF THE MIXING MODEL	85
6.6 TRANSVERSE MIXING SUMMARY	86

CHAPTER 7	88
------------------	-----------

Segregation in the transverse direction of a rotating drum.	88
7.1 TRANSVERSE SEGREGATION EXPERIMENTS	89
7.2 EXPERIMENTAL ANALYSIS METHODOLOGY	91
7.3 EXPERIMENTAL SEGREGATION RESULTS	93
7.4 ANALYSIS OF THE SEGREGATION RESULTS	95
7.4.1 Segregation dynamics	96
7.4.2 The final segregated bed	98

7.5 MODELLING OF THE SEGREGATION IN THE TRANSVERSE DIRECTION OF A ROLLING DRUM	99
7.6 APPLICATION AND VERIFICATION OF THE SEGREGATION MODEL	101
7.7 CHAPTER SUMMARY	103

CHAPTER 8 **104**

Simulation of the mixing and segregation of solids in the transverse section of a rotating drum. **104**

8.1 “STREAM” DEFINITION	104
8.2 ‘STAGNANT LAYER’ CONTROL VOLUMES	105
8.3 ‘ACTIVE LAYER’ CONTROL VOLUMES	106
8.3.1 Streams of the ‘active layer’ control volume	107
8.3.2 Mixing in the ‘active layer’ control volume	107
8.3.3 Segregation in the ‘active layer’ control volume	108
8.4 SELECTION OF A GRID SYSTEM TO REPRESENT A ROLLING BED	110
8.5 SPECIFICATION OF THE SIMULATION	112
8.5.1 ‘Stagnant layer’ control volume characterisation	112
8.5.2 ‘Active layer’ control volume characterisation	113
8.5.3 Simulation sampling time	114
8.5.4 Material balance	114
8.6 MIXING AND SEGREGATION PERFORMANCE OF THE SIMULATION	115
8.6.1 Mixing	115
8.6.2 Segregation	119
8.7 CHAPTER SUMMARY	120

CHAPTER 9 **121**

Simulation of the retort zone of the AOSTRA-Taciuk Processor. **121**

9.1 DERIVATION OF THE GRANULAR HEAT TRANSFER MODEL	121
9.1.1 Granular heat transfer model assumptions	121
9.1.2 Natural convection heat transfer	123
9.1.3 Radiation heat transfer	124

9.1.4 Total heat transfer between the granular materials	125
9.1.5 Calculation of the new material temperatures and the amount of volatile evolution	125
9.2 SIMULATION OF THE RETORT ZONE OF THE AOSTRA-TACIUK PROCESSOR	129
9.2.1 Material properties	129
9.2.2 Case studies of the AOSTRA-Taciuk Processor operation	129
9.2.3 Results from Case 2	130
9.2.3.1 Mixing and segregation of Case 2	131
9.2.3.2 Heat transfer, mean shale temperature and volatile evolution of Case 2	132
9.2.4 Results from the case studies	134
9.2.4.1 Mean particle size effects	134
9.2.4.2 Initial temperature of the materials effects	135
9.2.4.3 Ratio of the materials effects	136
9.2.4.4 Rotational velocity effects	137
9.3 LIMITATIONS OF THE SIMULATION	138
9.4 CHAPTER SUMMARY	139
<u>CHAPTER 10</u>	<u>140</u>
Conclusions	140
<u>Nomenclature</u>	<u>143</u>
<u>References</u>	<u>148</u>
<u>APPENDICES</u>	<u>154</u>
Appendix 1: The bitmap file format.	154

A1.1 STRUCTURE OF THE BITMAP FILE	154
A1.1.1 File Header	155
A1.1.2 Bitmap Header	156
A1.1.3 Colour Palette	156
A1.1.4 Bitmap	157
A1.2 READING THE BITMAP FILE	158
Appendix 2: Psuedo codes for the software written as part of the thesis.	159
A2.1 CONVERTING THE BITMAP IMAGES TO AN ARRAY	159
A2.2 PSUEDO CODE FOR THE MIXING ANALYSIS	160
A2.3 PSUEDO CODE FOR THE SEGREGATION ANALYSIS	160
Appendix 3: Industrial rotating kiln simulation program.	162
A3.1 SIMULATION STRUCTURE	162
A3.2 START FORM	163
A3.3 DATA SPECIFICATION FORM	163
A3.3.1 Specify Feed Form	164
A3.4 RESULTS FORM	165
A3.4.1 Segregation	166
A3.4.2 Mixing	168
Appendix 4: Papers submitted or published.	170
A4.1 UNREFEREED CONFERENCE PUBLICATIONS	170
A4.2 REFEREED CONFERENCE PUBLICATIONS	170
A4.3 INTERNATIONAL REFEREED JOURNAL PUBLICATIONS	170

Table of Figures

<i>Figure 1.1: Map of Australia showing the location of Gladstone.</i>	4
<i>Figure 1.2: Schematic of the AOSTRA-Taciuk Processor (Southern Pacific Petroleum, 1991).</i>	5
<i>Figure 2.1: Shear mixing of a granular material.</i>	10
<i>Figure 2.2: Convective mixing of a granular material.</i>	11
<i>Figure 2.3: Diffusive mixing of a granular material subject of an oscillating horizontal velocity.</i>	12
<i>Figure 2.4: Different packing arrangements showing the difference in particle size to gap size: a) diameter ratio = 6.3, b) diameter ratio = 2.4 (Williams & Khan, 1973).</i>	13
<i>Figure 2.5: Percolation segregation of a granular material.</i>	14
<i>Figure 2.6: Flow segregation of a granular material.</i>	14
<i>Figure 2.7: Vibration segregation of a granular material.</i>	15
<i>Figure 2.8; Heat transfer paths between particles (Yagi & Kunii, 1957).</i>	16
<i>Figure 3.1 Different motion regimes in a rolling drum (Henein et al, 1983a, b).</i>	21
<i>Figure 3.2: Active layer configurations; A) Lehmberg et al (1977), B) Mu & Perlmutter (1980), Woodle & Munro (1993), C) Ferron & Singh (1991).</i>	24
<i>Figure 3.3: Rolling bed velocity profile (Nakagawa et al, 1992; Boateng, 1993).</i>	25
<i>Figure 3.4: Convective mixing in a rotary kiln (Hogg & Fuerstenau, 1972).</i>	28
<i>Figure 3.5: Schematic of the segregated core.</i>	30
<i>Figure 3.6: Schematic illustrating the pseudo-helical trajectory of particles through a rotary kiln.</i>	34
<i>Figure 3.7: Schematic showing axial segregation patterns (Henein et al, 1985).</i>	37
<i>Figure 3.8: Heat transfer paths in the transverse direction of a rotary kiln (Barr et al, 1989a, b).</i>	38
<i>Table 4.1: Particle size distribution of Stuart oil shale and combusted spent shale.</i>	43
<i>Table 4.2: Static angle of repose of raw and coloured shale.</i>	45
<i>Table 4.3: “Loose” and “tapped” bulk densities of raw and coloured shale.</i>	46
<i>Figure 4.1: Mass loss and heat flow of Stuart oil shale.</i>	47
<i>Figure 4.2: Schematic of the rotating drum section - a) front, b) rear.</i>	49
<i>Figure 4.3: Speed calibration curves for the rotating drum.</i>	50
<i>Figure 4.4: Initial bed configurations – a) smile, b) layer.</i>	52
<i>Figure 5.1: Schematic of an ideal rolling bed.</i>	54

<i>Figure 5.2: Schematic of a real rolling bed illustrating the wave like upper surface shape.</i>	55
<i>Figure 5.3: Example of contour lines in the rolling bed.</i>	57
<i>Figure 5.4: Active layer proportion as a function of rotational velocity and drum loading.</i>	58
<i>Figure 5.5: Illustration of the transverse section velocity profile as measured by Nakagawa et al (1992) & Boateng (1993).</i>	60
<i>Table 5.1: Deviation, as a percentage, between the experimental results and the predicted results using Equation 5.2 for the active layer proportion in the 200 and 400 mm diameter drums.</i>	62
<i>Table 6.1: Experimental conditions for the mixing experiments.</i>	65
<i>Figure 6.2: Sample photos from a typical mixing experiment.</i>	70
<i>Figure 6.3: Typical results for a mixing experiment, this graph shows the results for experiment 3.</i>	71
<i>Table 6.2: Experimental mixing rates and calculated data for the modelling of the mixing rates.</i>	72
<i>Table 6.3: Experimental final contact distances and calculated data for the modelling of the final contact distances.</i>	73
<i>Figure 6.4: Enlarged view of the initial part of Figure 6.3 illustrating the step nature of mixing of experiment 3.</i>	75
<i>Figure 6.5: Measured mixing rates (Γ) and final contact distances (l_f) with respect to the rotational velocity (N) of the drum.</i>	76
<i>Figure 6.6: Measured mixing rates (Γ) and final contact distances (l_f) with respect to drum loading (L) by percentage volume.</i>	77
<i>Figure 6.7: Measured mixing rates (Γ) and final contact distances (l_f) as a function of particle size (d_p).</i>	78
<i>Figure 6.8: Measured mixing rates (Γ) and final contact distances (l_f) with respect to calculated material ratios (κ).</i>	79
<i>Figure 6.9: Modelling of the mixing rate (Γ) as a function of the active layer parameter (ϕ).</i>	83
<i>Figure 6.10: Modelling of the final mixing contact distance (l_f) as a function of the final contact distance parameter (λ).</i>	84
<i>Figure 7.1: Rolling bed showing segregated core and the centre of rotation.</i>	88
<i>Table 7.1: Segregation experiments and results.</i>	90
<i>Figure 7.2 – Bed outline used in the segregation analysis.</i>	92
<i>Figure 7.3: Results from a typical segregation experiment.</i>	94

<i>Fig 7.4: Sample final segregation beds for experiment 32.</i>	95
<i>Table 7.2: Calculated segregation parameters used in the segregation modelling.</i>	97
<i>Figure 7.5: Concentration proportion for the inner and outer layer for experiments 30a to 30f.</i>	98
<i>Figure 7.6: Modelling of $m(\text{PSR})$ and $i(\text{PSR})$ for the inner layer.</i>	100
<i>Table 7.3: Parameters used in the segregation model.</i>	101
<i>Table 7.4: Summary of the deviations for Experiments 35, 36a and 36b.</i>	102
<i>Figure 8.1: C++ computer code for the definition of the “stream” structure.</i>	105
<i>Figure 8.2: Schematic of a ‘stagnant layer’ control volume.</i>	106
<i>Figure 8.3: Schematic of an ‘active layer’ control volume.</i>	107
<i>Figure 8.4: Schematic of the control volume grid used in the simulation.</i>	111
<i>Table 8.1: Experimental and simulation mixing results.</i>	115
<i>Figure 8.5: Experimental and simulation results for Experiment 3.</i>	116
<i>Table 8.2: Comparison of the speed mixing experiments to the predicted simulation results.</i>	117
<i>Figure 8.6: ‘Active layer’ schematic illustrating the different velocity regions.</i>	118
<i>Figure 8.7: Deviation between the predicted and experimental mixing times as a function of the mean ‘active layer’ velocity.</i>	118
<i>Table 8.3: Comparison of the mean particle size in the inner and outer layer for the experimental and simulation segregation results.</i>	119
<i>Table 9.1: Shale sample used in the simulation.</i>	126
<i>Figure 9.1: Enthalpy content of the shale and ash sample described in Table 9.1 (Berkovich, 1999).</i>	127
<i>Figure 9.2: Mass loss of the shale sample described in Table 9.1.</i>	128
<i>Table 9.2: Details of the case studies.</i>	130
<i>Figure 9.3: Mixing dynamics of Case 2.</i>	131
<i>Figure 9.4: Final segregated configuration of Case 2.</i>	132
<i>Figure 9.5: Mean shale temperature and mixing extent for Case 2.</i>	133
<i>Figure 9.6: Simulation results for testing different mean particle sizes.</i>	134
<i>Figure 9.7: Simulation results for testing different initial material temperatures.</i>	136
<i>Figure 9.8: Simulation results for changes in the material ratio.</i>	137
<i>Figure 9.9: Simulation results for different rotational velocities.</i>	138
<i>Figure A1.1: Text display of a 256 colour bitmap file.</i>	155
<i>Figure A1.2: Image represented by data of Figure A1.1.</i>	157
<i>Figure A3.1: Start Form of the simulation.</i>	162

<i>Figure A3.2: Data Specification Form.</i>	163
<i>Figure A3.3: Specify Feed Form.</i>	164
<i>Figure A3.4: Results Form.</i>	165
<i>Figure A3.5: Initial segregation results form (Case 2)</i>	167
<i>Figure A3.6: Segregated results form after 60 seconds (Case 2)</i>	168
<i>Figure A3.7: Mixing results.</i>	169