



Stationary and Transient Behaviour of Polymer Electrolyte Fuel Cells

Yan Shi

Energie & Umwelt / Energy & Environment

Band / Volume 567

ISBN 978-3-95806-611-3

Forschungszentrum Jülich GmbH
Institut für Energie- und Klimaforschung
Elektrochemische Verfahrenstechnik (IEK-14)

Stationary and Transient Behaviour of Polymer Electrolyte Fuel Cells

Yan Shi

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 567

ISSN 1866-1793

ISBN 978-3-95806-611-3

Contents

1	Introduction	1
1.1	Background	1
1.1.1	Fuel cell technology	2
1.1.2	Fuel cell applications	2
1.1.3	Fuel cell types	3
1.2	PEM fuel cell	5
1.2.1	Fundamentals	5
1.2.2	Critical technical barriers for fuel cell commercialization	9
1.3	Water management of PEFCs	9
1.3.1	Water transport mechanism	10
1.3.2	Water fault issues in PEFCs	12
1.3.3	Experimental diagnostic methods for the water faults	14
1.4	The studies on water management	15
1.4.1	During-design water management strategies	16
1.4.2	Post-design water management strategies	17
1.5	Transient behavior study of PEFCs	20
1.6	Motivation and Thesis Layout	22
1.6.1	Motivation	22
1.6.2	Thesis Layout	22
2	Experimental Methods	23
2.1	Introduction	23
2.2	The general procedures for conducting a DoE approach	24
2.3	Factorial design	26
2.3.1	Full factorial design	26
2.3.2	Fractional factorial design	28
2.4	Split-plot design	30
2.5	Response surface methodology	31

Contents

2.6	Summary.....	33
3	Experimental setup and procedures	35
3.1	Test cell.....	35
3.1.1	Test cell components.....	35
3.1.2	Test cell assembly and leak testing.....	37
3.1.3	Test cell break-in and reconditioning procedure.....	39
3.1.4	Test cell modification	41
3.2	Test station.....	42
3.3	Ohmic resistance measurement	45
3.4	Summary.....	47
4	Accuracy study of the test cell performance	49
4.1	Definitions	49
4.2	Experimental	52
4.2.1	Operating conditions.....	52
4.2.2	Operating procedures.....	52
4.3	The statistical analysis procedures	53
4.3.1	The basic statistical model	53
4.3.2	The consistency statistics.....	55
4.4	Results and analysis	56
4.4.1	Assessment of Mandel's k statistics	57
4.4.2	Assessment of Mandel's h statistics.....	59
4.4.3	Assessment of the repeatability and reproducibility	61
4.5	Summary.....	62
5	Static behavior study of in-house assembled LT-PEFC	65
5.1	Experimental design method.....	65
5.1.1	The factor selection	65
5.1.2	The response selection	66
5.2	Experimental setup	68
5.2.1	Experimental apparatus.....	68

5.3	DoE study results and discussion	71
5.3.1	Results of linear regression models	71
5.3.2	Curvature examination	84
5.4	RSM study results and discussion	87
5.4.1	Results of quadratic regression model	87
5.4.2	Performance analysis	90
5.4.3	Optimization of selected parameters	96
5.5	Summary	99
6	Transient behavior study of in-house assembled LT-PEFC	101
6.1	DoE study of the operating parameters on cell transient behavior	101
6.1.1	The factor selection	101
6.1.2	The response selection	102
6.1.3	Experimental setup	103
6.1.4	DoE study results and discussions	104
6.2	Study of the load change ramps on cell dynamic behavior	115
6.2.1	Test conditions	115
6.2.2	Results and Discussion	117
6.3	Summary	120
7	Discussion	121
8	Conclusions	129
	Appendix	131
A.1	The basic statistics calculations in chapter 4	131
A.2	The intermediate statistics calculations in chapter 4	131
A.3	The critical k-value and critical h-value in chapter 4	133
A.4	The results of accuracy statistics in chapter 4	134
A.5	The raw data of test cell 3 in chapter 4	135
A.6	Derivation for Equation 5.1 in chapter 5	135
A.7	The validation of the pressure drop regression model in chapter 5	137
A.8	The validation of the voltage oscillation regression model in chapter 5	139

Contents

A.9 Design matrix of RSM study in chapter 5.....	140
A.10 The validation of the quadratic regression models in chapter 5.....	142
A.11 The validation of the dynamic regression models in chapter 6.....	146
A.12 The experimental results of test No.1 to test No.2 in chapter 6.....	147
A.13 The factors that are not selected in Pareto Chart in chapter 5.....	148
Reference.....	149
List of Figures.....	161
List of Tables.....	165
Nomenclature.....	167
Abbreviations.....	167
Latin symbols.....	168
Greek symbols.....	170
Acknowledgments.....	171

Energie & Umwelt / Energy & Environment
Band / Volume 567
ISBN 978-3-95806-611-3