

Jos van Schijndel

Integrated Modeling using MatLab, Simulink and COMSOL

with heat, air and moisture applications for building physics and systems



CONTENTS

SUMMARY		Vii		
NOM	IOMENCLATURE			
Chap	oter 1 – General Introduction	1		
1.1	IMPORTANCY	2		
1.2	STATUS OF RESEARCH	3		
	1.2.1 HAM simulation tools	3		
	1.2.2 Integration efforts	4		
	1.2.3 Simulation environment requirements	4		
	1.2.4 The Matlab environment	5		
	1.2.5 Other simulation environments	7		
1.3	PROBLEM STATEMENT	8		
1.4	OBJECTIVES AND METHODOLOGY	8		
	1.4.1 Research	9		
	1.4.2 Design	10		
1.5	OUTLINE OF THE THESIS	12		
REFE	ERÉNCES	13		
PAR	RT I. RESEARCH. THE SIMULATION E AS A SUBJECT OF AND TOOL FOR E			
Prefa	ce	17		
Chap	oter 2 -Advanced Simulation of building systems ar	nd control		
	with SimuLink	19		
2.1 IN	NTRODUCTION	20		
2.2 T	THE BUILDING MODEL HAMBASE	21		
2.3 T	HE HAMBASE MODEL IN SIMULINK	25		
2.4 T	2.4 THE HEATING SYSTEM IN SIMULINK			

Contents

2.5 ANALYSIS		29
2.6 CONCLUSIO	ONS	33
REFERENCES &	k APPENDIX	33
Chapter 3 Mode	eling and solving building physics problems with Comsol	37
3.1 INTRODUCT	ΓΙΟΝ	39
3.2 HOW COMS	OL WORKS	39
3.3 TEST CASES	S FOR RELIABILITY	45
3.3.1 10	Moisture transport in a porous material	45
3.3.2 2D	Airflow in a room	47
3.3.3 Di	scussion on reliability	50
3.4 3D COMBIN	IED HEAT AND MOISTURE TRANSPORT	50
3.5 CONCLUSIO	ONS	54
REFERENCES		54
Chapter 4 -Integ	grated building physics simulation	
with	n Comsol/SimuLink/Matlab	55
4.1 INTRODUC	TION	57
4.2 A COMPLET	TE EXAMPLE	58
4.3 AIRFLOW A	AND CONTROLLER	59
4.4 OTHER DEV	VELOPMENTS	63
4.4.1 2D	O Convective airflow around a convector	63
4.4.2 A	Comsol model connected to a model in SimuLink	66
4.5 CONCLUSIO	ONS	69
REFERENCES		70
PART II.	DESIGN. THE SIMULATION ENVIRONMENT AS A TOOL FOR DESIGN	
Preface		71

Chapter 5 -Indoor climate design for a monumental building with			
periodic high indoor moisture loads	73		
5.1 INTRODUCTION	75		
5.2 BACKGROUND	75		
5.3 SIMULATION RESULTS	77		
5.4 DISCUSSION OF THE RESULTS	88		
5.4.1 Evaluation of the scenarios	88		
5.4.2 Evaluation of the moisture buffering effect on the HVAC			
performance	89		
5.5 CONCLUSIONS	90		
REFERENCE	91		
Chapter 6 -Application of an integrated indoor climate & HVAC			
model for the indoor climate performance of a museum	93		
6.1 INTRODUCTION	95		
6.2 THE CURRENT INDOOR CLIMATE PERFORMANCE	96		
6.2.1 Review on climate recommendations	96		
6.2.2 Measurements	96		
6.3 HAM MODELING AND VALIDATION			
6.3.1 A short review on HAM modeling	99		
6.3.2 The indoor climate and HVAC modeling	99		
6.3.3 The showcase modeling	100		
6.4 SIMULATION RESULTS OF NEW DESIGNS	102		
6.4.1 A new HVAC controller strategy without showcase	102		
6.4.2 The current HVAC system with a showcase	104		
6.4.3 A new HVAC controller with a showcase	105		
6.5 CONCLUSIONS			
REFERENCES			

Chapter 7 - Optimal set point operation of the climate control	
of a monumental church	107
7.1 INTRODUCTION	109
7.2 MODELING	
7.2.1 The church indoor climate model using HAMBase SimuLink	110
7.2.2 The moisture transport model using Comsol	111
7.2.3 The controller (Proportional) using SimuLink	112
7.2.4 The complete model in SimuLink	113
7.3 RESULTS	114
7.3.1 Validation of the HAMBASE model	114
7.3.2 Validation of the Comsol model	115
7.3.3 Drying rates	115
7.4 SET POINT OPERATION STUDY	118
7.4.1 Limitation of the air temperature changing rate	118
7.4.2 Limitation of the relative humidity changing rate	120
7.5 DISCUSSION	123
7.5.1 Comparing the control strategies	123
7.5.2 Optimal set point operation	125
7.6 CONCLUSIONS	120
REFERENCES	126
Chapter 8 - Optimal operation of a hospital power plant	129
8.1 INTRODUCTION	130
8.2 THE APPLICATION	133
8.3 MODELING AND OPTIMIZATION	134
8.3.1 Design a model	134
8.3.2 Define non-controllable and controllable inputs and output	13:
8.3.3 Define constraints	13:
8.3.4 Define optimization criteria	13
8.3.5 Build a numerical model	13
8.3.6 Select an appropriate time scale	14

Conter	115

8.3.7 Build a numerical optimization routine and calculate the optima	142
8.4 RESULTS	
8.4.1 The non-controllable input signals of the model i(t)	144
8.4.2 The optimization results	145
8.4.3 Comparing the different strategies	146
8.4.4 The total efficiency of the power plant	148
8.5 CONCLUSIONS	149
REFERENCES	150
Chapter 9 – General discussion and conclusions	151
9.1 RESEARCH ORIENTED (PART I)	151
9.1.1 Evaluation	151
9.1.2 Ongoing research driven projects	153
9.2 DESIGN ORIENTED (Part II)	
9.2.1 Evaluation	154
9.2.2 Ongoing design driven projects	155
9.3 RECOMMENDATIONS	156
Literature	157
Index of models	167
Appendix A IEA Annex 41 preliminary results	169
Appendix B Ongoing research projects	179
Appendix C Preliminary Guideline	185
Appendix D Ongoing design projects	187
Appendix E Additional example of the HAMBase room model	193
Biography	197