

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	First Steps in Optimization	1
1.2	Terminology and Aim in Optimization	1
1.3	Different Facets in Optimization	6
1.3.1	Design of Experiments and Response Surface Modelling	6
1.3.2	Optimization Algorithms	7
1.3.3	Robust Design Analysis	8
1.4	Layout of the Book	10

## Part I Optimization Theory

<b>2</b>	<b>Design of Experiments</b>	<b>13</b>
2.1	Introduction to DOE	13
2.2	Terminology in DOE	14
2.3	DOE Techniques	15
2.3.1	Randomized Complete Block Design	15
2.3.2	Latin Square	15
2.3.3	Full Factorial	17
2.3.4	Fractional Factorial	21
2.3.5	Central Composite	24
2.3.6	Box-Behnken	25
2.3.7	Plackett-Burman	26
2.3.8	Taguchi	27
2.3.9	Random	30
2.3.10	Halton, Faure, and Sobol Sequences	32
2.3.11	Latin Hypercube	33
2.3.12	Optimal Design	36
2.4	Conclusions	41

<b>3</b>	<b>Response Surface Modelling</b>	43
3.1	Introduction to RSM	43
3.2	RSM Techniques	44
3.2.1	Least Squares Method	44
3.2.2	Optimal RSM	49
3.2.3	Shepard and K-Nearest	50
3.2.4	Kriging	50
3.2.5	Gaussian Processes	59
3.2.6	Radial Basis Functions	61
3.2.7	Neural Networks	65
3.3	Conclusions	70
<b>4</b>	<b>Deterministic Optimization</b>	77
4.1	Introduction to Deterministic Optimization	77
4.2	Introduction to Unconstrained Optimization	78
4.2.1	Terminology	78
4.2.2	Line-Search Approach	80
4.2.3	Trust Region Approach	81
4.3	Methods for Unconstrained Optimization	82
4.3.1	Simplex Method	82
4.3.2	Newton's Method	85
4.3.3	Quasi-Newton Methods	85
4.3.4	Conjugate Direction Methods	87
4.3.5	Levenberg–Marquardt Methods	89
4.4	Introduction to Constrained Optimization	90
4.4.1	Terminology	90
4.4.2	Minimality Conditions	92
4.5	Methods for Constrained Optimization	93
4.5.1	Elimination Methods	93
4.5.2	Lagrangian Methods	94
4.5.3	Active Set Methods	95
4.5.4	Penalty and Barrier Function Methods	96
4.5.5	Sequential Quadratic Programming	97
4.5.6	Mixed Integer Programming	97
4.5.7	NLPQLP	98
4.6	Conclusions	98
<b>5</b>	<b>Stochastic Optimization</b>	103
5.1	Introduction to Stochastic Optimization	103
5.1.1	Multi-Objective Optimization	105
5.2	Methods for Stochastic Optimization	107
5.2.1	Simulated Annealing	107
5.2.2	Particle Swarm Optimization	110
5.2.3	Game Theory Optimization	113

5.2.4	Evolutionary Algorithms . . . . .	116
5.2.5	Genetic Algorithms. . . . .	121
5.3	Conclusions . . . . .	128
<b>6</b>	<b>Robust Design Analysis. . . . .</b>	<b>131</b>
6.1	Introduction to RDA . . . . .	131
6.1.1	MORDO . . . . .	132
6.1.2	RA . . . . .	133
6.2	Methods for RA . . . . .	135
6.2.1	Monte Carlo Simulation . . . . .	135
6.2.2	First Order Reliability Method . . . . .	136
6.2.3	Second Order Reliability Method . . . . .	137
6.2.4	Importance Sampling . . . . .	137
6.2.5	Transformed Importance and Axis Orthogonal Sampling . . . . .	139
6.3	Conclusions . . . . .	141
 <b>Part II Applications</b>		
<b>7</b>	<b>General Guidelines: How to Proceed in an Optimization Exercise . . . . .</b>	<b>147</b>
7.1	Introduction . . . . .	147
7.2	Optimization Methods. . . . .	147
7.2.1	Design of Experiments . . . . .	149
7.2.2	Response Surface Modelling . . . . .	149
7.2.3	Stochastic Optimization. . . . .	150
7.2.4	Deterministic Optimization . . . . .	151
7.2.5	Robust Design Analysis . . . . .	152
<b>8</b>	<b>A Forced Convection Application: Surface Optimization for Enhanced Heat Transfer . . . . .</b>	<b>153</b>
8.1	Introduction . . . . .	153
8.2	The Case . . . . .	154
8.3	Methodological Aspects . . . . .	159
8.3.1	Experiments Versus Simulations. . . . .	160
8.3.2	Objectives of the Optimization. . . . .	160
8.3.3	Input Variables. . . . .	162
8.3.4	Constraints. . . . .	164
8.3.5	The Chosen Optimization Process . . . . .	165
8.4	Results . . . . .	166
8.5	Conclusions . . . . .	172

<b>9</b>	<b>A Natural Convection Application: Optimization of Rib Roughened Chimneys . . . . .</b>	<b>175</b>
9.1	Introduction . . . . .	175
9.2	The Case . . . . .	176
9.3	Methodological Aspects . . . . .	178
9.3.1	Experiments Versus Simulations. . . . .	179
9.3.2	Objectives of the Optimization. . . . .	179
9.3.3	Input Variables. . . . .	181
9.3.4	Constraints. . . . .	182
9.3.5	The Chosen Optimization Process . . . . .	183
9.4	Results . . . . .	185
9.5	Conclusions . . . . .	190
<b>10</b>	<b>An Analytical Application: Optimization of a Stirling Engine Based on the Schmidt Analysis and on the Adiabatic Analysis . . .</b>	<b>195</b>
10.1	Introduction . . . . .	195
10.1.1	The Stirling Thermodynamic Cycle . . . . .	196
10.1.2	The Schmidt Analysis. . . . .	197
10.1.3	The Adiabatic Analysis. . . . .	200
10.2	The Case . . . . .	204
10.3	Methodological Aspects . . . . .	206
10.3.1	Experiments Versus Simulations. . . . .	206
10.3.2	Objectives of the Optimization. . . . .	206
10.3.3	Input Variables. . . . .	208
10.3.4	Constraints. . . . .	209
10.3.5	The Chosen Optimization Process . . . . .	210
10.4	Results . . . . .	211
10.5	Conclusions . . . . .	223
<b>11</b>	<b>Conclusions . . . . .</b>	<b>225</b>
11.1	What Would be the Best Thing to do? . . . . .	225
11.2	Design of Experiments . . . . .	227
11.3	Response Surface Modelling . . . . .	228
11.4	Stochastic Optimization. . . . .	228
11.5	Deterministic Optimization . . . . .	229
11.6	Robust Design Analysis. . . . .	229
11.7	Final Considerations . . . . .	230
	<b>Appendix A: Scripts . . . . .</b>	<b>233</b>
	<b>References . . . . .</b>	<b>251</b>
	<b>Index . . . . .</b>	<b>257</b>

Optimization Methods

From Theory to Design Scientific and Technological  
Aspects in Mechanics

Cavazzuti, M.

2013, XVIII, 262 p., Hardcover

ISBN: 978-3-642-31186-4