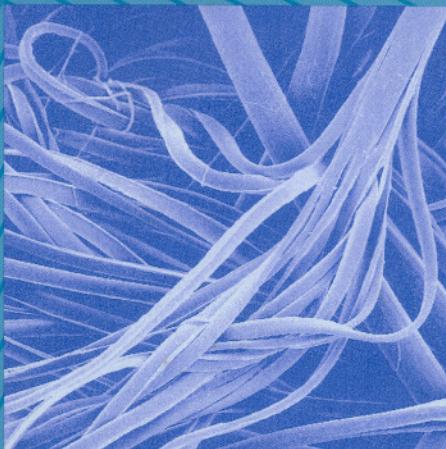


WOODHEAD PUBLISHING IN TEXTILES



Handbook of nonwovens

Edited by S. J. Russell



The Textile Institute

WP

Contents

109	Mechanical bonding	guturable in chapter 7.3	133
101	10.1 Assess the environmental sustainability of laid nonwovens	101	10.1
101	10.2 Develop a mechanical bonding strategy for different markets	101	10.2
101	10.3 Implementing bonding technology for bonding fabrics	101	10.3
101	10.4 Case study: the use of bonding in the carpet industry	101	10.4
101	10.5 Summary introduction – informed and held back	101	10.5
101	The future of the market for bonded nonwovens	101	10.6
101	The global market for bonded nonwovens	101	10.7
101	10.8 Summary	101	10.8
101	10.9 References	101	10.9
101	10.10 Summary	101	10.10
101	10.11 Summary	101	10.11
101	10.12 Summary	101	10.12
101	10.13 Summary	101	10.13
101	10.14 Summary	101	10.14
101	10.15 Summary	101	10.15
101	10.16 Summary	101	10.16
101	10.17 Summary	101	10.17
101	10.18 Summary	101	10.18
101	10.19 Summary	101	10.19
101	10.20 Summary	101	10.20
101	10.21 Summary	101	10.21
101	10.22 Summary	101	10.22
101	10.23 Summary	101	10.23
101	10.24 Summary	101	10.24
101	10.25 Summary	101	10.25
101	10.26 Summary	101	10.26
101	10.27 Summary	101	10.27
101	10.28 Summary	101	10.28
101	10.29 Summary	101	10.29
101	10.30 Summary	101	10.30
101	10.31 Summary	101	10.31
101	10.32 Summary	101	10.32
101	10.33 Summary	101	10.33
101	10.34 Summary	101	10.34
101	10.35 Summary	101	10.35
101	10.36 Summary	101	10.36
101	10.37 Summary	101	10.37
101	10.38 Summary	101	10.38
101	10.39 Summary	101	10.39
101	10.40 Summary	101	10.40
101	10.41 Summary	101	10.41
101	10.42 Summary	101	10.42
101	10.43 Summary	101	10.43
101	10.44 Summary	101	10.44
101	10.45 Summary	101	10.45
101	10.46 Summary	101	10.46
101	10.47 Summary	101	10.47
101	10.48 Summary	101	10.48
101	10.49 Summary	101	10.49
101	10.50 Summary	101	10.50
101	10.51 Summary	101	10.51
101	10.52 Summary	101	10.52
101	10.53 Summary	101	10.53
101	10.54 Summary	101	10.54
101	10.55 Summary	101	10.55
101	10.56 Summary	101	10.56
101	10.57 Summary	101	10.57
101	10.58 Summary	101	10.58
101	10.59 Summary	101	10.59
101	10.60 Summary	101	10.60
101	10.61 Summary	101	10.61
101	10.62 Summary	101	10.62
101	10.63 Summary	101	10.63
101	10.64 Summary	101	10.64
101	10.65 Summary	101	10.65
101	10.66 Summary	101	10.66
101	10.67 Summary	101	10.67
101	10.68 Summary	101	10.68
101	10.69 Summary	101	10.69
101	10.70 Summary	101	10.70
101	10.71 Summary	101	10.71
101	10.72 Summary	101	10.72
101	10.73 Summary	101	10.73
101	10.74 Summary	101	10.74
101	10.75 Summary	101	10.75
101	10.76 Summary	101	10.76
101	10.77 Summary	101	10.77
101	10.78 Summary	101	10.78
101	10.79 Summary	101	10.79
101	10.80 Summary	101	10.80
101	10.81 Summary	101	10.81
101	10.82 Summary	101	10.82
101	10.83 Summary	101	10.83
101	10.84 Summary	101	10.84
101	10.85 Summary	101	10.85
101	10.86 Summary	101	10.86
101	10.87 Summary	101	10.87
101	10.88 Summary	101	10.88
101	10.89 Summary	101	10.89
101	10.90 Summary	101	10.90
101	10.91 Summary	101	10.91
101	10.92 Summary	101	10.92
101	10.93 Summary	101	10.93
101	10.94 Summary	101	10.94
101	10.95 Summary	101	10.95
101	10.96 Summary	101	10.96
101	10.97 Summary	101	10.97
101	10.98 Summary	101	10.98
101	10.99 Summary	101	10.99
101	10.100 Summary	101	10.100
101	10.101 Summary	101	10.101
101	10.102 Summary	101	10.102
101	10.103 Summary	101	10.103
101	10.104 Summary	101	10.104
101	10.105 Summary	101	10.105
101	10.106 Summary	101	10.106
101	10.107 Summary	101	10.107
101	10.108 Summary	101	10.108
101	10.109 Summary	101	10.109
101	10.110 Summary	101	10.110
101	10.111 Summary	101	10.111
101	10.112 Summary	101	10.112
101	10.113 Summary	101	10.113
101	10.114 Summary	101	10.114
101	10.115 Summary	101	10.115
101	10.116 Summary	101	10.116
101	10.117 Summary	101	10.117
101	10.118 Summary	101	10.118
101	10.119 Summary	101	10.119
101	10.120 Summary	101	10.120
101	10.121 Summary	101	10.121
101	10.122 Summary	101	10.122
101	10.123 Summary	101	10.123
101	10.124 Summary	101	10.124
101	10.125 Summary	101	10.125
101	10.126 Summary	101	10.126
101	10.127 Summary	101	10.127
101	10.128 Summary	101	10.128
101	10.129 Summary	101	10.129
101	10.130 Summary	101	10.130
101	10.131 Summary	101	10.131
101	10.132 Summary	101	10.132
101	10.133 Summary	101	10.133
101	10.134 Summary	101	10.134
101	10.135 Summary	101	10.135
101	10.136 Summary	101	10.136
101	10.137 Summary	101	10.137
101	10.138 Summary	101	10.138
101	10.139 Summary	101	10.139
101	10.140 Summary	101	10.140
101	10.141 Summary	101	10.141
101	10.142 Summary	101	10.142
101	10.143 Summary	101	10.143
101	10.144 Summary	101	10.144
101	10.145 Summary	101	10.145
101	10.146 Summary	101	10.146
101	10.147 Summary	101	10.147
101	10.148 Summary	101	10.148
101	10.149 Summary	101	10.149
101	10.150 Summary	101	10.150
101	10.151 Summary	101	10.151
101	10.152 Summary	101	10.152
101	10.153 Summary	101	10.153
101	10.154 Summary	101	10.154
101	10.155 Summary	101	10.155
101	10.156 Summary	101	10.156
101	10.157 Summary	101	10.157
101	10.158 Summary	101	10.158
101	10.159 Summary	101	10.159
101	10.160 Summary	101	10.160
101	10.161 Summary	101	10.161
101	10.162 Summary	101	10.162
101	10.163 Summary	101	10.163
101	10.164 Summary	101	10.164
101	10.165 Summary	101	10.165
101	10.166 Summary	101	10.166
101	10.167 Summary	101	10.167
101	10.168 Summary	101	10.168
101	10.169 Summary	101	10.169
101	10.170 Summary	101	10.170
101	10.171 Summary	101	10.171
101	10.172 Summary	101	10.172
101	10.173 Summary	101	10.173
101	10.174 Summary	101	10.174
101	10.175 Summary	101	10.175
101	10.176 Summary	101	10.176
101	10.177 Summary	101	10.177
101	10.178 Summary	101	10.178
101	10.179 Summary	101	10.179
101	10.180 Summary	101	10.180
101	10.181 Summary	101	10.181
101	10.182 Summary	101	10.182
101	10.183 Summary	101	10.183
101	10.184 Summary	101	10.184
101	10.185 Summary	101	10.185
101	10.186 Summary	101	10.186
101	10.187 Summary	101	10.187
101	10.188 Summary	101	10.188
101	10.189 Summary	101	10.189
101	10.190 Summary	101	10.190
101	10.191 Summary	101	10.191
101	10.192 Summary	101	10.192
101	10.193 Summary	101	10.193
101	10.194 Summary	101	10.194
101	10.195 Summary	101	10.195
101	10.196 Summary	101	10.196
101	10.197 Summary	101	10.197
101	10.198 Summary	101	10.198
101	10.199 Summary	101	10.199
101	10.200 Summary	101	10.200
101	10.201 Summary	101	10.201
101	10.202 Summary	101	10.202
101	10.203 Summary	101	10.203
101	10.204 Summary	101	10.204
101	10.205 Summary	101	10.205
101	10.206 Summary	101	10.206
101	10.207 Summary	101	10.207
101	10.208 Summary	101	10.208
101	10.209 Summary	101	10.209
101	10.210 Summary	101	10.210
101	10.211 Summary	101	10.211
101	10.212 Summary	101	10.212
101	10.213 Summary	101	10.213
101	10.214 Summary	101	10.214
101	10.215 Summary	101	10.215
101	10.216 Summary	101	10.216
101	10.217 Summary	101	10.217
101	10.218 Summary	101	10.218
101	10.219 Summary	101	10.219
101	10.220 Summary	101	10.220
101	10.221 Summary	101	10.221
101	10.222 Summary	101	10.222
101	10.223 Summary	101	10.223
101	10.224 Summary	101	10.224
101	10.225 Summary	101	10.225
101	10.226 Summary	101	10.226
101	10.227 Summary	101	10.227
101	10.228 Summary	101	10.228
101	10.229 Summary	101	10.229
101	10.230 Summary	101	10.230
101	10.231 Summary	101	10.231
101	10.232 Summary	101	10.232
101	10.233 Summary	101	10.233
101	10.234 Summary	101	10.234
101	10.235 Summary	101	10.235
101	10.236 Summary	101	10.236
101	10.237 Summary	101	10.237
101	10.238 Summary	101	10.238
101	10.239 Summary	101	10.239
101	10.240 Summary	101	10.240
101	10.241 Summary	101	10.241
101	10.242 Summary	101	10.242
101	10.243 Summary	101	10.243
101	10.244 Summary	101	10.244
101	10.245 Summary	101	10.245
101	10.246 Summary	101	10.246
101	10.247 Summary	101	10.247
101	10.248 Summary	101	10.248
101	10.249 Summary	101	10.249
101	10.250 Summary	101	10.250
101	10.251 Summary	101	10.251
101	10.252 Summary	101	10.252
101	10.253 Summary	101	10.253
101	10.254 Summary	101	10.254
101	10.255 Summary	101	10.255
101	10.256 Summary	101	10.256
101	10.257 Summary	101	10.257
101	10.258 Summary	101	10.258
101	10.259 Summary	101	10.259
101	10.260 Summary	101	10.260
101	10.261 Summary	101	10.261
101	10.262 Summary	101	10.262
101	10.263 Summary	101	10.263
101	10.264 Summary	101	10.264
101	10.265 Summary	101	10.265
101	10.266 Summary	101	10.266
101	10.267 Summary	101	10.267
101	10.268 Summary	101	10.268
101	10.269 Summary	101	10.269
101	10.270 Summary	101	10.270
101	10.271 Summary	101	10.271
101	10.272 Summary	101	10.272
101	10.273 Summary	101	10.273
101	10.274 Summary	101	10.274
101	10.275 Summary	101	10.275
101	10.276 Summary	101	10.276
101	10.277 Summary	101	10.277
101	10.278 Summary	101	10.278
101	10.279 Summary	101	10.279
101	10.280 Summary	101	10.280
101	10.281 Summary	101	10.281
101	10.282 Summary	101	10

2.15	Developments in airlaying	98
2.16	Airflow and fibre dynamics in airlaying	101
2.17	Bonding and web consolidation	104
2.18	Physical properties and practical applications of airlaid fabrics	106
2.19	Direct feed batt formation	109
2.20	References	109
3	Wet-laid web formation	112
	C WHITE, <i>Consultant, France</i>	
3.1	Introduction	112
3.2	Background and historical developments	112
3.3	Theoretical basis of wet forming	114
3.4	Raw materials for wet-laid nonwovens	116
3.5	Cellulose fibre preparation	126
3.6	Man-made fibre preparation	126
3.7	Web-forming process technology	128
3.8	Bonding systems for wet-laid nonwovens	135
3.9	Finishing	138
3.10	Product applications	139
3.11	Sources of further information	141
3.12	References	141
4	Polymer-laid web formation	143
	G S BHAT, <i>University of Tennessee, USA</i> and S R MALKAN, <i>Synfil Technologies, USA</i>	
4.1	Introduction	143
4.2	Resins for spunbonding and meltblowing	143
4.3	Spunbond fabric production	149
4.4	Spunbond production systems	155
4.5	Bonding techniques	157
4.6	Operating variables in the spunbond process	160
4.7	Structure and properties of spunbond fabrics	168
4.8	Spunbond fabric applications	171
4.9	Meltblown fabric production	172
4.10	Meltblown characterization techniques	180
4.11	Characteristics and properties of meltblown fabrics	184
4.12	Meltblown fabric applications	185
4.13	Mechanics of the spunbond and meltblown processes	186
4.14	Composite fabrics and other extrusion processes	192
4.15	Future trends	195
4.16	References	195

5	Mechanical bonding	201
	S C ANAND, <i>The University of Bolton, UK</i> (Sections 5.1–5.8); D BRUNNSCHWEILER, <i>Consultant</i> , and G SWARBRICK, <i>Foster Needle Ltd, UK</i> (Sections 5.9–5.13); and S J RUSSELL, <i>University of Leeds, UK</i> (Sections 5.14–5.19)	
5.1	Stitch bonding: introduction	201
5.2	The Maliwatt and Malivlies stitch-bonding systems	202
5.3	The Malimo stitch-bonding system	206
5.4	Malipol	214
5.5	Voltex	215
5.6	Kunit	216
5.7	Multiknit stitch-bonding systems	217
5.8	Recent developments in stitch bonding	220
5.9	Needlepunching: introduction	223
5.10	Needle design and selection	226
5.11	Penetration depth and other factors affecting needle use	234
5.12	Needlepunching technology	240
5.13	Applications of needlepunched fabrics	251
5.14	Hydroentanglement: introduction	255
5.15	The principles of hydroentanglement	256
5.16	Fibre selection for hydroentanglement	264
5.17	Process layouts	269
5.18	Hydroentanglement process technology	275
5.19	Applications of hydroentangled fabrics	288
5.20	Acknowledgements	294
5.21	References	294
6	Thermal bonding	298
	A POURMOHAMMADI, <i>Consultant, Iran</i>	
6.1	Introduction	298
6.2	Principle of thermal bonding	299
6.3	Raw materials	300
6.4	Calender (contact) bonding	305
6.5	Through-air and impingement bonding	318
6.6	Thermal radiation/infra-red and ultrasonic bonding	322
6.7	Thermally bonded fabric structure	325
6.8	Applications of thermally bonded fabrics	327
6.9	References	328
7	Chemical bonding	330
	R A CHAPMAN, <i>Warwick Innovation Limited, UK</i>	
7.1	Introduction	330
7.2	Chemical binder polymers	331

7.3	Mechanism of chemical bonding	344
7.4	Methods of binder application	349
7.5	Drying	356
7.6	Applications of chemically bonded nonwovens	361
7.7	References	366
8	Nonwoven fabric finishing A I AHMED, <i>NIRI, UK</i>	368
8.1	Introduction	368
8.2	Wet finishing	369
8.3	Application of chemical finishes	376
8.4	Lamination	385
8.5	Mechanical finishing	389
8.6	Surface finishing	394
8.7	Developing technologies	398
8.8	Fabric inspection	399
8.9	Acknowledgements	400
9	Characterisation, testing and modelling of nonwoven fabrics N MAO and S J RUSSELL, <i>University of Leeds, UK</i> (Sections 9.1–9.21); B POURDEYHIMI, <i>Nonwovens Cooperative Research Centre, North Carolina State University, USA</i> (Section 9.22)	401
9.1	Introduction: characterisation of nonwoven fabrics	401
9.2	Characterisation of fabric bond structure	403
9.3	Fabric weight, thickness, density and other structural parameters	408
9.4	General standards for testing nonwovens	413
9.5	Measurement of basic parameters	426
9.6	Measuring fibre orientation distribution	430
9.7	Measuring porosity, pore size and pore size distribution	431
9.8	Measuring tensile properties	439
9.9	Measuring gas and liquid permeability	440
9.10	Measuring water vapour transmission	441
9.11	Measuring wetting and liquid absorption	442
9.12	Measuring thermal conductivity and insulation	448
9.13	Modelling pore size and pore size distribution	449
9.14	Modelling tensile strength	452
9.15	Modelling bending rigidity	455
9.16	Modelling specific permeability	457
9.17	Modelling absorbency and liquid retention	467
9.18	Modelling capillary wicking	468
9.19	Modelling thermal resistance and thermal conductivity	474

9.20	Modelling acoustic impedance	478
9.21	Modelling filtration properties	483
9.22	The influence of fibre orientation distribution on the properties of thermal bonded nonwoven fabrics	492
9.23	References	502
	<i>Index</i>	515

Chapter 1

- Introduction to nonwovens
Nonwoven fabric production
Nonwoven fabric design
Properties of nonwovens
Fabric 1.52 941

Chapter 2

- Nonwoven fibres
1.1 General 10
1.2 Special 10
1.3 100
1.4 Fibres 17.2 653

Chapter 3

- Nonwoven fabric production 654

Chapter 4

- Nonwoven fabric properties 434
Suspension 434
Connective materials 434
Thermal 434
Textile 434 434
178

Index

- Index 480

Chapter 1

- 1.1.1 Introduction to nonwovens 1
1.1.2 Nonwoven fabric production 1
1.1.3 Nonwoven fabric design 1
1.1.4 Properties of nonwovens 1
1.1.5 Fabric 1.52 941

Chapter 2

- 2.1.1 Nonwoven fibres 10
2.1.2 Connective materials 10
2.1.3 Textile 10
2.1.4 Fibres 17.2 653

Chapter 3

- 3.1.1 Nonwoven fabric production 654
3.1.2 Suspension 654
3.1.3 Connective materials 654
3.1.4 Thermal 654
3.1.5 Textile 654

Chapter 4

- 4.1.1 Nonwoven fabric properties 434