

HANSER

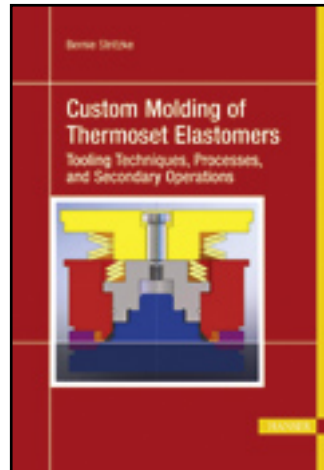


Table of Contents

Bernie Stritzke

Custom Molding of Thermoset Elastomers

A Comprehensive Approach to Materials, Mold Design, and Processing

ISBN: 978-3-446-41964-3

For further information and order see

<http://www.hanser.de/978-3-446-41964-3>
or contact your bookseller.

Contents

Acknowledgment	V
Preface	VII
Contents	IX
1 Introduction to Thermoset Elastomer Chemistry	1
1.1 Chemistry Overview	1
1.2 Polymerization	3
1.3 Thermoplastic Polymers	4
1.4 Thermoset Polymers	5
1.5 Organic and Silicone Elastomers	5
1.6 Cure Rates	7
1.7 Conclusion	7
2 Compounding, Mixing and Equipment	9
2.1 Introduction	9
2.2 Compounding	9
2.3 Mixing	10
2.3.1 TSE Compound Batch Release Tests	14
2.4 Silicone	14
2.5 Conclusion	15
3 Materials	17
3.1 Natural Rubber (NR)	17
3.2 Synthetic Polyisoprene (IR)	18
3.3 Styrene-Butadiene (SBR)	18
3.4 Polybutadiene (BR)	19
3.5 Butyl (IIR)	19
3.6 Ethylene-Propylene-Diene (EPDM)	20
3.7 Nitrile (NBR)	20
3.8 Polyacrylic (ACM)	21
3.9 Ethylene Acrylic (AEM)	21
3.10 Silicone (MQ, VMQ, and PMQ)	21

3.11	Fluoroelastomer (FKM)	22
3.12	Polyurethane (AU and EU)	23
3.13	Epichlorohydrin (CO and ECO)	23
3.14	Conclusion	23
4	Product Design	25
4.1	Introduction	25
4.2	Material	25
4.2.1	ASTM Classification System for Elastomeric Materials	27
4.3	Design	28
4.3.1	Tolerances	30
4.3.2	Material Shrinkage	32
4.4	Conclusion	33
5	Material Testing for TSE	35
5.1	Introduction	35
5.2	Physical and Chemical Properties Tests	35
5.2.1	Tensile Testing	36
5.2.2	Compression Set	37
5.2.3	Durometer	37
5.3	Heat Aging	38
5.3.1	Accelerated Aging	38
5.4	Rubber Property – Vulcanization Using Oscillating Disk Cure	38
5.5	Fluid Resistance	39
5.6	State-of-Cure	40
5.7	Conclusion	41
6	Polymer Flow	43
6.1	Viscosity	43
6.2	Elasticity	44
6.3	Plasticity	45
6.4	Rheology	45
6.4.1	Thermoplastic Fluid Properties	46
6.4.2	TSE Fluid Properties	48
6.5	Shear Thinning	49
6.6	Rotational Viscometers	50
6.7	Oscillating Rheometers	52
6.8	Conclusion	53

7	Molding Methods and Related Topics	55
7.1	Introduction	55
7.2	Choosing a Process	55
7.3	Book Mold	58
7.4	Bolt-In	59
7.5	Shuttling	59
7.5.1	Double Shuttle	59
7.5.2	Single Plate Shuttle	61
7.6	Rotary Molding	62
7.7	Core Bar	65
7.8	Mold Construction	66
7.8.1	Cavitation	67
7.9	Article Removal/Ejection	68
7.10	Mold Cavity Finish	68
7.11	Heaters	69
7.11.1	Heater Calculation	70
7.11.2	Running	72
7.11.3	Conclusion	72
7.12	Heat Transfer	72
7.13	Insulation	74
7.14	Vacuum	74
7.15	Release Aids	78
7.15.1	Mold Lubes	78
7.15.2	Mold Plating	78
7.16	Mold Cleaning	80
7.16.1	Plastic Media Blast	80
7.16.2	Ultrasonic Cleaners	81
7.16.3	Ice Blast	81
7.17	Conclusion	81
8	Compression Molding	83
8.1	Compression Presses	83
8.2	Preps	84
8.3	Operator Influence and Automation	85
8.4	Material Flow	86
8.4.1	Trapped Air	87
8.4.2	Molecular Orientation	87
8.5	Mold Construction	87

8.5.1	Disk Springs	88
8.5.2	Relative Cost	89
8.6	Pressure	89
8.7	Backrind	90
8.8	Mold Cleaning	90
8.9	Article Removal/Ejection	90
8.10	Compression Mold and Die-Cut	91
8.11	Dual Acting Spring Mechanism Compression Molding	92
8.11.1	Prep Compensating Mechanism	95
8.11.2	Secondary Trim	96
8.12	Conclusion	97
9	Transfer Molding	99
9.1	Self-Contained Pot	99
9.2	Bottomless Pot Transfer	100
9.3	Transfer Press	102
9.4	Flashless Transfer Molding	103
9.4.1	Split-Top Inserts	105
9.4.2	Vents	106
9.4.3	Trapped Air	107
9.4.4	Sprues/Gates	107
9.4.5	Knit Lines	108
9.4.6	Ring Gates	109
9.4.7	Mold Construction	109
9.4.8	Transfer Pressure	109
9.5	Mold Cleaning	110
9.6	Wasteless Transfer	111
9.6.1	Equalizing Platen	113
9.7	Conclusion	113
10	Injection Molding	115
10.1	Injection Unit	116
10.1.1	First In – First Out (FIFO)	118
10.1.2	Plunger Unit	119
10.1.3	Injection Controls	119
10.1.4	Injection Location	120
10.1.5	Material Feed – Stripped	121
10.1.6	Material Feed – Stuffer	121

10.2	Materials	121
10.3	Automation	121
10.4	Mold Construction	124
10.5	Molding Defects	124
10.5.1	Scorch	124
10.5.2	Cured Stock	125
10.5.3	Adhesive Wash	125
10.6	Injection Transfer	125
10.7	Injection Compression	125
10.8	Cold Runner Injection	126
10.9	Valve-Gated Cold Runner	127
10.10	Injection Pressure Considerations	128
10.10.1	Pressure Compensator	129
10.11	Conclusion	130
11	Liquid Silicone Rubber	131
11.1	The System	132
11.2	The Static Mixer	132
11.3	Injection Unit	133
11.4	Molds	135
11.5	Materials	136
11.6	Special Applications	137
11.6.1	Medical	137
11.6.2	Food Contact	137
11.7	Color Or Other Additives	137
11.8	Material Change	137
11.9	Similarity to Plastic Injection Molding	138
11.10	Two-Shot Molding	138
11.11	Conclusion	141
12	Secondary Operations and Additional Methods	143
12.1	Post Curing	143
12.2	Material Filtering	143
12.3	Flash	144
12.3.1	Cryogenic Deflash	145
12.4	Coatings	146
12.4.1	Parylene Coating	146
12.4.2	Plasma Treatment	147

12.4.3	Chlorination	150
12.4.4	Oils	150
12.5	Adhesion	151
12.5.1	Dipping	151
12.5.2	Tumble Baskets	152
12.5.3	Chain-On-Edge	154
12.5.4	Rotary Table	155
12.5.5	Other Application Methods	156
12.5.6	Self-Bonding Methods	156
12.5.7	Substrate Preparation	157
12.6	Conclusion	158
13	TSE Molding Processing	161
13.1	Prototype	161
13.1.1	Prototype Plan	163
13.2	Production	163
13.2.1	Cure Time/Temperature	163
13.2.2	Sampling Phase	165
13.2.3	Qualification Phase	165
13.2.4	Measurement Qualification	166
13.2.5	Continuous Improvement Phase	168
13.3	Troubleshooting	169
13.4	Conclusion	173
14	Manufacturing Process Planning.....	175
Appendix 1	TSE Common Terms and Definitions	179
Subject Index	183