

Contents

- 1 Introduction 1**
 - 1.1 Historical Perspectives 2
 - 1.2 Rapid Prototyping – An Integral Part of Time Compression Engineering 6
 - 1.2.1 Geometrical Modelling Techniques 8
 - 1.2.1.1 Wireframe Modelling 9
 - 1.2.1.2 Surface Modelling 10
 - 1.2.1.3 Solid Modelling 10
 - 1.2.2 RP Data Formats 12
 - 1.3 RP Information Workflow 14
 - 1.4 Summary 16
 - References 17
- 2 Rapid Prototyping Processes 19**
 - 2.1 Classification of Rapid Prototyping Processes 19
 - 2.2 Processes Involving a Liquid 21
 - 2.2.1 Solidification of a Liquid Polymer 21
 - 2.2.1.1 Stereolithography (SL) 21
 - 2.2.1.2 Liquid Thermal Polymerization (LTP) 23
 - 2.2.1.3 Beam Interference Solidification (BIS) 24
 - 2.2.1.4 Objet Quadra Process (Objet) 25
 - 2.2.1.5 Solid Ground Curing (SGC) 25
 - 2.2.1.6 Holographic Interference Solidification (HIS) 27
 - 2.2.2 Solidification of an Electroset Fluid: Electrosetting (ES) 27
 - 2.2.3 Solidification of Molten Material 27
 - 2.2.3.1 Ballistic Particle Manufacture (BPM) 27
 - 2.2.3.2 Multi Jet Modelling (MJM) 29
 - 2.2.3.3 Fused Deposition Modelling (FDM) 30
 - 2.2.3.4 Three Dimensional Welding (3DW) 31
 - 2.2.3.5 Shape Deposition Manufacturing (SDM) 31

2.3 Processes Involving Discrete Particles.....	33
2.3.1 Fusing of Particles by Laser.....	33
2.3.1.1 Selective Laser Sintering (SLS).....	33
2.3.1.2 Laser Engineering Net Shaping (LENS™).....	34
2.3.1.3 Gas Phase Deposition (GPD).....	35
2.3.2 Joining of Particles with a Binder.....	36
2.3.2.1 Three-Dimensional Printing (3DP).....	36
2.3.2.2 Spatial Forming (SF).....	37
2.4 Processes Involving Solid Sheets.....	37
2.4.1 Laminated Object Manufacture (LOM).....	38
2.4.2 Paper Lamination Technology (PLT).....	39
2.4.3 Solid Foil Polymerisation (SFP).....	40
2.5 Summary.....	40
References.....	40

3 Technical Characteristics and Technological Capabilities of Rapid Prototyping Systems.....43

3.1 Stereolithography Apparatus (3D Systems).....	43
3.2 Solid Ground Curing Systems (Cubital Ltd).....	50
3.3 Fused Deposition Modelling Systems (Stratasys, Inc.).....	52
3.4 Selective Laser Sintering Systems (DTM Corp. and EOS GmbH).....	55
3.5 Laminated Object Manufacturing Systems (Helisys, Inc.).....	61
3.6 Paper Lamination Technology (Kira Corp).....	64
3.7 Laser Engineering Net Shaping (LENS™) Systems (Optomec Design Co.).....	65
3.8 Summary.....	67
References.....	68

4 Technical Characteristics and Technological Capabilities of Concept Modellers.....71

4.1 3D Systems ThermoJet™ Printer.....	72
4.2 Sanders ModelMaker II (Inkjet Modelling Technology).....	74
4.3 Z-Corporation Z402 3D Printer (Three Dimensional Printing).....	76
4.4 Stratasys Genisys Xs 3D Printer.....	78
4.5 JP System 5.....	80
4.6 Objet Quadra System.....	82
4.7 Summary.....	85
References.....	85

5 Applications of Rapid Prototyping Technology.....	87
5.1 Functional Models.....	87
5.2 Pattern for Investment and Vacuum Casting.....	92
5.3 Medical Models	97
5.4 Art Models	103
5.5 Engineering Analysis Models.....	106
5.6 Summary	109
References.....	109
 6 Indirect Methods for Rapid Tool Production.....	 111
6.1 Role of Indirect Methods in Tool Production	111
6.2 Metal Deposition Tools.....	112
6.3 RTV Tools	115
6.4 Epoxy Tools.....	118
6.5 Ceramic Tools.....	121
6.6 Cast Metal Tools.....	122
6.7 Investment Casting.....	125
6.8 Fusible Metallic Core.....	128
6.9 Sand Casting	131
6.10 Keltool™ Process	131
6.11 Summary	133
References.....	133
 7 Direct Methods for Rapid Tool Production	 135
7.1 Classification of Direct Rapid Tool Methods.....	135
7.2 Direct ACES™ Injection Moulds (AIM™)	137
7.3 Laminated Object Manufactured (LOM) Tools	139
7.4 DTM RapidTool™ Process	139
7.4.1 RapidSteel 1.0.....	140
7.4.2 RapidSteel 2.0.....	144
7.4.3 Copper Polyamide (PA).....	148
7.5 SandForm™	150
7.6 EOS DirectTool™ Process	150
7.7 Direct Metal Tooling using 3DP™	154
7.8 Topographic Shape Formation (TSF)	158
7.9 Summary	159
References.....	159

8 Applications of Rapid Tooling Technology	161
8.1 Insert Design	161
8.2 Insert Finishing.....	163
8.3 Rapid Tooling Inserts Wear Resistance	164
8.3.1 Wear Test Results	167
8.3.1.1 Non-coated RapidSteel 2.0 Insert	167
8.3.1.2 Non-coated EOSINT M Insert.....	169
8.3.1.3 Spray-coated Inserts.....	172
8.3.2 Discussion of the Wear Test Results.....	174
8.4 Case Studies	174
8.4.1 ABS Portable Electronic Tour Guide.....	174
8.4.2 Aluminium Windscreen Wiper Arm	180
8.5 Summary	182
References.....	182
9 Rapid Prototyping Process Optimisation	185
9.1 Factors Influencing Accuracy.....	185
9.1.1 Data Preparation	186
9.1.1.1 Errors due to Tessellation	186
9.1.1.2 Errors due to Slicing	187
9.1.2 Part Building.....	191
9.1.2.1 Part Building Errors in the SL Process	191
9.1.2.2 Part Building Errors in the SLS Process	194
9.1.3 Part Finishing.....	197
9.2 Selection of Part Build Orientation	198
9.2.1 Orientation Constraints of the SL Process	199
9.2.2 Orientation Constraints of the SLS Process	202
9.3 Summary	204
References.....	205
Author Index	207
Subject Index	211