

Contents

- 1 Snap-Fits and the Attachment Level™ Construct 1**
 - 1.1 Introduction 1
 - 1.2 Reader Expectations 2
 - 1.3 Snap-Fit Technology 4
 - 1.4 Feature Level and Attachment Level 6
 - 1.5 Using this Book 8
 - 1.5.1 The Importance of Sample Parts 8
 - 1.5.2 Snap-Fit Novices 8
 - 1.5.3 Experienced Designers 10
 - 1.5.4 Design for Assembly Practitioners 10
 - 1.6 Chapter Synopses 10
 - 1.7 Extending the ALC to Other Attachments 11
 - 1.8 Summary 11
 - 1.8.1 Important Points in Chapter 1 12
- 2 Overview of the Attachment Level™ Construct 14**
 - 2.1 Introduction 14
 - 2.2 The Key Requirements. 14
 - 2.2.1 Strength 16
 - 2.2.2 Constraint 17
 - 2.2.2.1 Improper Constraint. 19
 - 2.2.3 Compatibility 20
 - 2.2.4 Robustness 21
 - 2.3 Elements of a Snap-Fit. 25
 - 2.3.1 Function 27
 - 2.3.1.1 Action 27
 - 2.3.1.2 Attachment Type 27
 - 2.3.1.3 Retention 28
 - 2.3.1.4 Lock Type 29
 - 2.3.1.5 Function Summary 29
 - 2.3.2 Basic Shapes 29
 - 2.3.2.1 Mating Part and Base Part 31
 - 2.3.2.2 Basic Shape Descriptions 31
 - 2.3.2.3 Basic Shape Summary 33
 - 2.3.3 Engage Direction 35

5 Other Snap-Fit Concepts	135
5.1 The Importance of Constraint	135
5.1.1 Constraint Review	136
5.1.2 Constraint Principles	136
5.1.2.1 Perfect Constraint	136
5.1.2.2 Proper Constraint	139
5.1.2.3 Proper Constraint in Less than 12 DOM	139
5.1.2.4 Under-Constraint	139
5.1.2.5 Over-Constraint	140
5.1.2.6 General Constraint Rules	141
5.1.3 The Constraint Worksheet	143
5.1.4 Additional Comments on Constraint	151
5.2 Lock Decoupling	151
5.2.1 The Lock Feature Paradox	151
5.2.2 Decoupling Examples	151
5.2.3 Levels of Decoupling	153
5.2.3.1 No Decoupling (Level 0)	153
5.2.3.2 Level 1 Decoupling	154
5.2.3.3 Level 2 Decoupling	155
5.2.3.4 Level 3 Decoupling	156
5.2.3.5 Level 4 Decoupling	156
5.2.4 Decoupling Summary	159
5.3 Summary	160
5.3.1 Important Points in Chapter 5	160
5.3.2 Design Rules Introduced in Chapter 5	160
6 Feature Design and Analysis	162
6.1 Pre-Conditions for Feature Analysis	163
6.2 Material Property Data Needed for Analysis	163
6.2.1 Sources of Materials Data	163
6.2.2 Assumptions for Analysis	164
6.2.3 The Stress-Strain Curve	165
6.2.4 Establishing a Design Point	168
6.2.5 Coefficient of Friction (μ)	172
6.2.6 Other Effects	175
6.3 Cantilever Hook Design Rules of Thumb	178
6.3.1 Beam Thickness at the Base	178
6.3.2 Beam Length	178
6.3.3 Insertion Face Angle	181
6.3.4 Retention Face Depth	181
6.3.5 Retention Face Angle	182
6.3.6 The Threshold Angle	183
6.3.7 Beam Thickness at the Retention Feature	183

6.3.8 Beam Width	184
6.3.9 Other Features	185
6.4 Initial Strain Evaluation	185
6.5 Adjustments to Calculations	187
6.5.1 Adjustment for Stress Concentration	188
6.5.2 Adjustment for Wall Deflection	189
6.5.3 Adjustment for Mating Feature Deflection	191
6.5.4 Adjustment for Effective Angle	194
6.5.4.1 Effective Angle for the Insertion Face	195
6.5.4.2 Effective Angle for the Retention Face	196
6.5.5 Adjustments Summary	197
6.6 Assumptions for Analysis	198
6.7 Using Finite Element Analysis	198
6.8 Determine the Conditions for Analysis	199
6.9 Cantilever Hook Analysis for a Constant Rectangular Section Beam	199
6.9.1 Section Properties and the Relation between Stress and Strain	199
6.9.2 Evaluating Maximum Strain	201
6.9.2.1 Adjusting Maximum Allowable Strain for Stress Concentrations	202
6.9.2.2 Calculating the Maximum Applied Strain in a Constant Section Beam	203
6.9.2.3 Adjusting the Calculated Strain for Deflection Magnification	203
6.9.3 Calculating Deflection Force	204
6.9.4 Adjusting for Mating Part/Feature Deflection	205
6.9.6 Determine Maximum Assembly Force	206
6.9.6.1 Determine the Effective Insertion Face Angle	206
6.9.7 Determine Release Behavior	207
6.9.7.1 Additional Retention Considerations	208
6.10 Cantilever Hook Tapered in Thickness	209
6.11 Cantilever Hook Tapered in Width	211
6.12 Cantilever Hook Tapered in Thickness and Width	212
6.13 Modifications to the Insertion Face Profile	212
6.14 Modifications to the Retention Face Profile	215
6.15 Other Feature Calculations	215
6.16 Summary	215
6.16.1 Important Points in Chapter 6	216

7 The Snap-Fit Development Process	218
7.1 Introduction	218
7.1.1 Concept Development vs. Detailed Design	219
7.1.2 A General Development Process	219
7.2 The Snap-Fit Development Process	224
7.2.1 Is the Application Appropriate for a Snap-Fit? (Step 0).	224

7.2.2	Define the Application (Step 1)	228
7.2.3	Benchmark (Step 2)	230
7.2.3.1	Rules for Benchmarking	231
7.2.4	Generate Multiple Attachment Concepts (Step 3)	232
7.2.4.1	Select Allowable Engage Directions (Step 3.1)	233
7.2.4.2	Identify All Possible Assembly Motions (Step 3.2).	234
7.2.4.3	Engage Directions, Assembly Motions and Worker Ergonomics	236
7.2.4.4	Select and Arrange Constraint Pairs (Step 3.3).	237
7.2.4.5	Add Some Enhancement Features (Step 3.4)	242
7.2.4.6	Select the Best Concept for Feature Analysis and Detailed Design (Step 3.5)	242
7.2.5	Feature Analysis and Design (Step 4)	243
7.2.5.1	Lock Alternatives	245
7.2.6	Confirm the Design with Parts (Step 5)	249
7.2.7	Fine-Tune the Design (Step 6)	250
7.2.8	Snap-Fit Application Completed (Step 7).	250
7.3	Summary	250
7.3.1	Important Points in Chapter 7	250
8	Diagnosing Snap-Fit Problems	254
8.1	Introduction.	254
8.1.1	Rules for Diagnosing Snap-Fit Problems	255
8.1.2	Mistakes in the Development Process	255
8.2	Attachment Level Diagnosis.	256
8.2.1	Most Likely Causes of Difficult Assembly	257
8.2.2	Most Likely Causes of Distorted Parts.	257
8.2.3	Most Likely Causes of Feature Damage.	257
8.2.4	Most Likely Causes of Loose Parts.	258
8.3	Feature Level Diagnosis.	258
8.4	Summary	263
8.4.1	Important Points in Chapter 8	263
Index		265