
Contents

· Preface	xiii
Preface to the First Edition	xv

Chapter 1. Quality Concepts	1
1.1 What Is Quality?	1
1.2 Quality Assurance and Product/Service Life Cycle	3
1.3 Development of Quality Methods	8
1.4 Business Excellence, Whole Quality, and Other Metrics in Business Operations	17
1.5 Summary	20
Chapter 2. Six Sigma and Lean Fundamentals	21
2.1 What Is Six Sigma?	21
2.2 Process: The Basic Unit for the Six Sigma Improvement Project	22
2.3 Process Capability and Six Sigma	28
2.4 Overview of Six Sigma Process Improvement	34
2.5 Lean Operation Principles	39
2.6 Process Mapping, Value Stream Mapping, and Process Management	45
2.7 Six Sigma Goes Upstream: Design for Six Sigma (DFSS)	54
2.8 Summary	55
Chapter 3. Product Development Process and Design for Six Sigma	57
3.1 Introduction	57
3.2 More on the Product Development Process	59
3.3 Lean Principles in Product Development	71
3.4 Lean Product Development Approaches	74
3.5 What Is Design for Six Sigma?	86
3.6 Why “Design for Six Sigma”?	89
3.7 Design for Six Sigma (DFSS) Phases	91
3.8 More on Design Process and Design Vulnerabilities	95
3.9 Differences between Six Sigma and DFSS	97
3.10 What Kinds of Problems Can Be Solved by DFSS?	99
3.11 Design for a Six Sigma (DFSS) Company	101

3.12 Features of a Sound DFSS Strategy	101
Appendix: Historical Development in Design	103
Chapter 4. Design for Six Sigma Deployment	107
4.1 Introduction	107
4.2 Black Belt–DFSS Team: Cultural Change	107
4.3 DFSS Deployment Prerequisites	110
4.4 DFSS Deployment Strategy	112
4.5 DFSS Deployment Strategy Goals	115
4.6 Six Sigma Project Financial Management	122
4.7 DFSS Training	123
4.8 Elements Critical to Sustain DFSS Deployment	123
4.9 DFSS Sustainability Factors	124
Chapter 5. Design for Six Sigma Project Algorithm	129
5.1 Introduction	129
5.2 Form a Synergistic Design Team (DFSS Algorithm Step 1)	132
5.3 Determine Customer Expectations (DFSS Algorithm Step 2)	133
5.4 Understand Functional Requirements Evolution (DFSS Algorithm Step 3)	147
5.5 Generate Concepts (DFSS Algorithm Step 4)	148
5.6 Select the Best Concept (DFSS Algorithm Step 5)	152
5.7 Finalize the Physical Structure of the Selected Concept (DFSS Algorithm Step 6)	153
5.8 Initiate Design Scorecards and Transfer Function Development (DFSS Algorithm Step 7)	157
5.9 Assess Risk Using DFMEA/PFMEA (DFSS Algorithm Step 8)	159
5.10 Transfer Function Optimization (DFSS Algorithm Step 9)	167
5.11 Design for X (DFSS Algorithm Step 10)	175
5.12 Tolerance Design and Tolerancing (DFSS Algorithm Step 11)	176
5.13 Pilot and Prototyping Design (DFSS Algorithm Step 12)	178
5.14 Validate Design (DFSS Algorithm Step 13)	179
5.15 Launch Mass Production (DFSS Algorithm Step 14)	180
5.16 Project Risk Management	181
5.17 Other DFSS Roadmaps	183
Chapter 6. DFSS Transfer Function and Scorecards	185
6.1 Introduction	185
6.2 Design Analysis	186
6.3 DFSS Design Synthesis	186
6.4 Design Scorecards and Transfer Function Development	195
Chapter 7. Quality Function Deployment (QFD)	213
7.1 Introduction	213
7.2 History of QFD	215
7.3 QFD Benefits, Assumptions, and Realities	215
7.4 QFD Methodology Overview	216
7.5 Kano Model of Quality	224

7.6 The Four Phases of QFD	225
7.7 QFD Analysis	226
7.8 QFD Example	226
7.9 Summary	236
Chapter 8. Axiomatic Design	237
8.1 Introduction	237
8.2 Why Axiomatic Design Is Needed	238
8.3 Design Axioms	239
8.4 The Independence Axiom (Axiom 1)	240
8.5 Coupling Measures	252
8.6 The Implications of Axiom 2	262
8.7 Case Study: Axiomatic Design of the Water Faucet	269
8.8 Summary	272
Appendix 8A: Axiomatic Design Theorems and Corollaries	273
Appendix 8B: Historical Development of Axiomatic Design	278
Chapter 9. Theory of Inventive Problem Solving (TRIZ)	281
9.1 Introduction	281
9.2 TRIZ Foundations	285
9.3 TRIZ Problem-Solving Process	295
9.4 Physical Contradiction Resolution/Separation Principles	298
9.5 Technical Contradiction Elimination—Inventive Principles	307
9.6 Functional Improvement Methods/TRIZ Standard Solutions	314
9.7 Complexity Reduction/Trimming	330
9.8 S-Curve Analysis of Technical Systems	331
9.9 Evolution of Technological Systems	333
9.10 Physical, Chemical, and Geometric Effects Database	339
9.11 Comparison of Axiomatic Design and TRIZ	339
Appendix: Contradiction Table of Inventive Principles	347
Chapter 10. Design for X	353
10.1 Introduction	353
10.2 Design for Manufacture and Assembly (DFMA)	356
10.3 Design for Reliability (DFR)	365
10.4 Design for Maintainability	367
10.5 Design for Serviceability	368
10.6 Design for Environmentality	378
10.7 Design for Life-Cycle Cost (LCC): Activity-Based Costing with Uncertainty	380
10.8 Summary	385
Chapter 11. Failure Mode—Effect Analysis	387
11.1 Introduction	387
11.2 FMEA Fundamentals	390
11.3 Design FMEA (DFMEA)	396
11.4 Process FMEA (PFMEA)	406
11.5 Quality Systems and Control Plans	410

Chapter 12. Fundamentals of Experimental Design	413
12.1 Introduction to Design of Experiments (DOE)	413
12.2 Factorial Experiment	418
12.3 Two-Level Full Factorial Designs	426
12.4 Fractional Two-Level Factorial Design	437
12.5 Three-Level Full Factorial Design	446
12.6 Incomplete Factorial Experiments	450
12.7 Summary	468
Chapter 13. Taguchi's Orthogonal Array Experiment	469
13.1 Taguchi's Orthogonal Arrays	469
13.2 Taguchi Experimental Design	472
13.3 Special Techniques	476
13.4 Taguchi Experiment Data Analysis	483
13.5 Summary	491
Appendix: Selected Orthogonal Arrays	491
Chapter 14. Design Optimization: Taguchi's Robust Parameter Design	499
14.1 Introduction	499
14.2 Loss Function and Parameter Design	500
14.3 Loss Function and Signal-to-Noise Ratio	508
14.4 Noise Factors and Inner-Outer Arrays	516
14.5 Parameter Design for Smaller-the-Better Characteristics	521
14.6 Parameter Design for Nominal-the-Best Characteristics	525
14.7 Parameter Design for Larger-the-Better Characteristics	528
Chapter 15. Design Optimization: Advanced Taguchi Robust Parameter Design	533
15.1 Introduction	533
15.2 Design Synthesis and Technical Systems	535
15.3 Parameter Design for Dynamic Characteristics	546
15.4 Functional Quality and Dynamic S/N Ratio	565
15.5 Robust Technology Development	568
Chapter 16. Tolerance Design	571
16.1 Introduction	571
16.2 Worst-Case Tolerance	576
16.3 Statistical Tolerance	580
16.4 Cost-Based Optimal Tolerance	587
16.5 Taguchi's Loss Function and Safety Tolerance Design	592
16.6 Taguchi's Tolerance Design Experiment	599
16.7 Computer-Aided Robust Parameter and Tolerance Design	602
Chapter 17. Response Surface Methodology	611
17.1 Introduction	611
17.2 Search and Identify the Region That Contains the Optimal Solution	615
17.3 Response Surface Experimental Designs	622
17.4 Response Surface Experimental Data Analysis for Single Response	628

17.5 Response Surface Experimental Data Analysis for Multiple Responses	632
17.6 Mixture Experiments	642
Chapter 18. Design Validation	665
18.1 Introduction	665
18.2 Design Analysis and Testing	670
18.3 Prototypes	682
18.4 Process and Production Validation	689
18.5 DFSS Validation and Measurement	697
Appendix: Glossary of Terms	702
Acronyms	705
References	709
Index	717