

## Table of contents provided by Syndetics

- **Preface** (p. vii)
- **Chapter 1 Introduction to DeGarmo's Materials and Processes in Manufacturing** (p. 1)
  - **1.1 Materials, Manufacturing, and the Standard of Living** (p. 1)
  - **1.2 Manufacturing and Production Systems** (p. 3)
  - **Case Study: Famous Manufacturing Engineers** (p. 27)
- **Chapter 2 Properties of Materials** (p. 28)
  - **2.1 Introduction** (p. 28)
  - **2.2 Static Properties** (p. 30)
  - **2.3 Dynamic Properties** (p. 42)
  - **2.4 Temperature Effects (Both High and Low)** (p. 47)
  - **2.5 Machinability, Formability, and Weldability** (p. 50)
  - **2.6 Fracture Toughness and the Fracture Mechanics Approach** (p. 50)
  - **2.7 Physical Properties** (p. 52)
  - **2.8 Testing Standards and Concerns** (p. 53)
  - **Case Study: Separation of Mixed Materials** (p. 55)
- **Chapter 3 Nature of Metals and Alloys** (p. 56)
  - **3.1 Structure-Property-Processing-Performance Relationships** (p. 56)
  - **3.2 The Structure of Atoms** (p. 57)
  - **3.3 Atomic Bonding** (p. 57)
  - **3.4 Secondary Bonds** (p. 59)
  - **3.5 Atom Arrangements in Materials** (p. 59)
  - **3.6 Crystal Structures of Metals** (p. 59)
  - **3.7 Development of a Grain Structure** (p. 61)
  - **3.8 Elastic Deformation** (p. 62)
  - **3.9 Plastic Deformation** (p. 63)
  - **3.10 Dislocation Theory of Slippage** (p. 64)
  - **3.11 Strain Hardening or Work Hardening** (p. 64)
  - **3.12 Plastic Deformation in Polycrystalline Metals** (p. 65)
  - **3.13 Grain Shape and Anisotropic Properties** (p. 66)
  - **3.14 Fracture of Metals** (p. 66)
  - **3.15 Cold Working, Recrystallization, and Hot Working** (p. 66)
  - **3.16 Grain Growth** (p. 68)
  - **3.17 Alloys and Alloy Types** (p. 68)
  - **3.18 Atomic Structure and Electrical Properties** (p. 68)
- **Chapter 4 Equilibrium Phase Diagrams and the Iron-Carbon System** (p. 71)
  - **4.1 Introduction** (p. 71)
  - **4.2 Phases** (p. 71)
  - **4.3 Equilibrium Phase Diagrams** (p. 71)
  - **4.4 Iron-Carbon Equilibrium Diagram** (p. 79)
  - **4.5 Steels and the Simplified Iron-Carbon Diagram** (p. 80)
  - **4.6 Cast Irons** (p. 82)
  - **Case Study: The Blacksmith Anvils** (p. 88)
- **Chapter 5 Heat Treatment** (p. 89)

- **5.1 Introduction** (p. 89)
- **5.2 Processing Heat Treatments** (p. 89)
- **5.3 Heat Treatments Used to Increase Strength** (p. 92)
- **5.4 Strengthening Heat Treatments for Nonferrous Metals** (p. 93)
- **5.5 Strengthening Heat Treatments for Steel** (p. 96)
- **5.6 Surface Hardening of Steel** (p. 109)
- **5.7 Furnaces** (p. 112)
- **5.8 Heat Treatment and Energy** (p. 114)
- **Case Study: A Carpenter's Claw Hammer** (p. 116)
- **Chapter 6 Ferrous Metals and Alloys** (p. 118)
- **6.1 Introduction to History-Dependent Materials** (p. 118)
- **6.2 Ferrous Metals** (p. 118)
- **6.3 Iron** (p. 119)
- **6.4 Steel** (p. 120)
- **6.5 Stainless Steels** (p. 132)
- **6.6 Tool Steels** (p. 134)
- **6.7 Alloy Cast Steels and Irons** (p. 136)
- **Case Study: Interior Tub of a Top-Loading Washing Machine** (p. 138)
- **Chapter 7 Nonferrous Metals and Alloys** (p. 139)
- **7.1 Introduction** (p. 139)
- **7.2 Copper and Copper Alloys** (p. 140)
- **7.3 Aluminum and Aluminum Alloys** (p. 144)
- **7.4 Magnesium and Magnesium Alloys** (p. 152)
- **7.5 Zinc-Based Alloys** (p. 154)
- **7.6 Titanium and Titanium Alloys** (p. 155)
- **7.7 Nickel-Based Alloys** (p. 157)
- **7.8 Superalloys and Other Metals Designed for High-Temperature Service** (p. 157)
- **7.9 Lead and Tin, and Their Alloys** (p. 158)
- **7.10 Some Lesser Known Metals and Alloys** (p. 159)
- **7.11 Metallic Glasses** (p. 159)
- **7.12 Graphite** (p. 160)
- **Case Study: Nonsparking Wrench** (p. 161)
- **Chapter 8 Nonmetallic Materials: Plastics, Elastomers, Ceramics, and Composites** (p. 162)
- **8.1 Introduction** (p. 162)
- **8.2 Plastics** (p. 163)
- **8.3 Elastomers** (p. 173)
- **8.4 Ceramics** (p. 175)
- **8.5 Composite Materials** (p. 182)
- **Case Study: Two-Wheel Dolly Handles** (p. 194)
- **Chapter 9 Material Selection** (p. 195)
- **9.1 Introduction** (p. 195)
- **9.2 Material Selection and Manufacturing Processes** (p. 197)
- **9.3 The Design Process** (p. 199)
- **9.4 Procedures for Material Selection** (p. 200)
- **9.5 Additional Factors to Consider** (p. 203)

- **9.6 Consideration of the Manufacturing Process** (p. 204)
- **9.7 Ultimate Objective** (p. 205)
- **9.8 Materials Substitution** (p. 207)
- **9.9 Effect of Product Liability on Materials Selection** (p. 207)
- **9.10 Aids to Material Selection** (p. 208)
- **Case Study: Material Selection** (p. 212)
- **Chapter 10 Measurement and Inspection and Testing** (p. 213)
- **10.1 Introduction** (p. 213)
- **10.2 Standards of Measurement** (p. 214)
- **10.3 Allowance and Tolerance** (p. 220)
- **10.4 Inspection Methods for Measurement** (p. 227)
- **10.5 Measuring Instruments** (p. 229)
- **10.6 Vision Systems for Measurement** (p. 238)
- **10.7 Coordinate Measuring Machines** (p. 240)
- **10.8 Angle-Measuring Instruments** (p. 240)
- **10.9 Gages for Attributes Measuring** (p. 242)
- **10.10 Testing** (p. 245)
- **10.11 Visual Inspection** (p. 247)
- **10.12 Liquid Penetrant Inspection** (p. 247)
- **10.13 Magnetic Particle Inspection** (p. 248)
- **10.14 Ultrasonic Inspection** (p. 250)
- **10.15 Radiography** (p. 252)
- **10.16 Eddy-Current Testing** (p. 253)
- **10.17 Acoustic Emission Monitoring** (p. 255)
- **10.18 Other Methods of Nondestructive Testing and Inspection** (p. 256)
- **10.19 Dormant versus Critical Flaws** (p. 257)
- **Case Study: Measuring An Angle** (p. 261)
- **Chapter 11 Fundamentals of Casting** (p. 262)
- **11.1 Introduction to Materials Processing** (p. 262)
- **11.2 Introduction to Casting** (p. 263)
- **11.3 Casting Terminology** (p. 265)
- **11.4 The Solidification Process** (p. 266)
- **11.5 Patterns** (p. 276)
- **11.6 Design Considerations in Castings** (p. 278)
- **11.7 The Casting Industry** (p. 280)
- **Case Study: The Cast Oil-Field Fitting** (p. 282)
- **Chapter 12 Expendable-Mold Casting Processes** (p. 283)
- **12.1 Introduction** (p. 283)
- **12.2 Sand Casting** (p. 283)
- **12.3 Cores and Core Making** (p. 298)
- **12.4 Other Expendable-Mold Processes with Multiple-Use Patterns** (p. 302)
- **12.5 Expendable-Mold Processes Using Single-Use Patterns** (p. 304)
- **12.6 Shakeout, Cleaning, and Finishing** (p. 310)
- **12.7 Summary** (p. 310)
- **Case Study: Movable and Fixed Jaw Pieces for a Heavy-Duty Bench Vise** (p. 312)
- **Chapter 13 Multiple-Use-Mold Casting Processes** (p. 313)

- **13.1 Introduction** (p. 313)
- **13.2 Permanent-Mold Casting** (p. 313)
- **13.3 Die Casting** (p. 316)
- **13.4 Squeeze Casting and Semisolid Casting** (p. 320)
- **13.5 Centrifugal Casting** (p. 322)
- **13.6 Continuous Casting** (p. 324)
- **13.7 Melting** (p. 325)
- **13.8 Pouring Practice** (p. 328)
- **13.9 Cleaning, Finishing, and Heat Treating of Castings** (p. 329)
- **13.10 Automation in Foundry Operations** (p. 330)
- **13.11 Process Selection** (p. 330)
- **Case Study: Baseplate for a Household Steam Iron** (p. 333)
- **Chapter 14 Fabrication of Plastics, Ceramics, and Composites** (p. 334)
- **14.1 Introduction** (p. 334)
- **14.2 Fabrication of Plastics** (p. 334)
- **14.3 Processing of Rubber and Elastomers** (p. 346)
- **14.4 Processing of Ceramics** (p. 347)
- **14.5 Fabrication of Composite Materials** (p. 351)
- **Case Study: Fabrication of Lavatory Wash Basins** (p. 362)
- **Chapter 15 Fundamentals of Metal Forming** (p. 363)
- **15.1 Introduction** (p. 363)
- **15.2 Forming Processes: Independent Variables** (p. 364)
- **15.3 Dependent Variables** (p. 366)
- **15.4 Independent-Dependent Relationships** (p. 366)
- **15.5 Process Modeling** (p. 367)
- **15.6 General Parameters** (p. 368)
- **15.7 Friction and Lubrication under Metalworking Conditions** (p. 369)
- **15.8 Temperature Concerns** (p. 371)
- **Case Study: Repairs to a Damaged Propeller** (p. 380)
- **Chapter 16 Bulk Forming Processes** (p. 381)
- **16.1 Introduction** (p. 381)
- **16.2 Classification of Deformation Processes** (p. 381)
- **16.3 Bulk Deformation Processes** (p. 382)
- **16.4 Rolling** (p. 382)
- **16.5 Forging** (p. 389)
- **16.6 Extrusion** (p. 401)
- **16.7 Wire, Rod, and Tube Drawing** (p. 406)
- **16.8 Cold Forming, Cold Forging, and Impact Extrusion** (p. 409)
- **16.9 Piercing** (p. 413)
- **16.10 Other Squeezing Processes** (p. 414)
- **16.11 Surface Improvement by Deformation Processing** (p. 416)
- **Case Study: Handle and Body of a Large Ratchet Wrench** (p. 420)
- **Chapter 17 Sheet-Forming Processes** (p. 421)
- **17.1 Introduction** (p. 421)
- **17.2 Shearing Operations** (p. 421)
- **17.3 Bending** (p. 430)

- **17.4 Drawing and Stretching Processes** (p. 437)
- **17.5 Alternative Methods of Producing Sheet-Type Products** (p. 451)
- **17.6 Pipe Welding** (p. 451)
- **17.7 Presses** (p. 452)
- **Case Study: Fabrication of a One-Piece Brass Flashlight Case** (p. 459)
- **Chapter 18 Powder Metallurgy** (p. 460)
- **18.1 Introduction** (p. 460)
- **18.2 The Basic Process** (p. 461)
- **18.3 Powder Manufacture** (p. 461)
- **18.4 Rapidly Solidified Powder (Microcrystalline and Amorphous)** (p. 463)
- **18.5 Powder Testing and Evaluation** (p. 463)
- **18.6 Powder Mixing and Blending** (p. 463)
- **18.7 Compacting** (p. 464)
- **18.8 Sintering** (p. 468)
- **18.9 Hot-Isostatic Pressing** (p. 469)
- **18.10 Other Techniques to Produce High-Density P/M Products** (p. 470)
- **18.11 Metal Injection Molding (MIM) or Powder Injection Molding (PIM)** (p. 471)
- **18.12 Secondary Operations** (p. 473)
- **18.13 Properties of P/M Products** (p. 475)
- **18.14 Design of Powder Metallurgy Parts** (p. 476)
- **18.15 Powder Metallurgy Products** (p. 478)
- **18.16 Advantages and Disadvantages of Powder Metallurgy** (p. 478)
- **18.17 Process Summary** (p. 480)
- **Case Study: Impeller for an Automobile Water Pump** (p. 483)
- **Chapter 19 Electronic Electrochemical Chemical and Thermal Machining Processes** (p. 484)
- **19.1 Introduction** (p. 484)
- **19.2 Chemical Machining Processes** (p. 485)
- **19.3 Electrochemical Machining Processes** (p. 504)
- **19.4 Electrical Discharge Machining** (p. 510)
- **Case Study: Fire Extinguisher Pressure Gage** (p. 522)
- **Chapter 20 Fundamentals of Machining/Orthogonal Machining** (p. 523)
- **20.1 Introduction** (p. 523)
- **20.2 Fundamentals** (p. 524)
- **20.3 Energy and Power in Machining** (p. 533)
- **20.4 Orthogonal Machining (Two Forces)** (p. 538)
- **20.5 Merchant's Model** (p. 542)
- **20.6 Mechanics of Machining (Statics)** (p. 543)
- **20.7 Shear Strain [ $\gamma$ ] and Shear Front Angle [ $\phi$ ]** (p. 545)
- **20.8 Mechanics of Machining (Dynamics)** (p. 547)
- **20.9 Summary** (p. 556)
- **Case Study: Orthogonal Plate Machining Experiment at Auburn University** (p. 559)
- **Chapter 21 Cutting Tools for Machining** (p. 560)
- **21.1 Introduction** (p. 560)
- **21.2 Cutting-Tool Materials** (p. 565)
- **21.3 Tool Geometry** (p. 577)

- **21.4 Tool Coating Processes** (p. 578)
- **21.5 Tool Failure and Tool Life** (p. 582)
- **21.6 Flank Wear** (p. 583)
- **21.7 Economics of Machining** (p. 588)
- **21.8 Cutting Fluids** (p. 591)
- **Case Study: Comparing Tool Materials Based on Tool Life** (p. 597)
- **Chapter 22 Turning and Boring Processes** (p. 598)
- **22.1 Introduction** (p. 598)
- **22.2 Fundamentals of Turning, Boring, and Facing Turning** (p. 600)
- **22.3 Lathe Design and Terminology** (p. 607)
- **22.4 Cutting Tools for Lathes** (p. 614)
- **22.5 Workholding in Lathes** (p. 619)
- **Case Study: Estimating the Machining Time for Turning** (p. 627)
- **Chapter 23 Drilling and Related Hole-Making Processes** (p. 628)
- **23.1 Introduction** (p. 628)
- **23.2 Fundamentals of the Drilling Process** (p. 629)
- **23.3 Types of Drills** (p. 631)
- **23.4 Tool Holders for Drills** (p. 643)
- **23.5 Workholding for Drilling** (p. 645)
- **23.6 Machine Tools for Drilling** (p. 645)
- **23.7 Cutting Fluids for Drilling** (p. 649)
- **23.8 Counterboring, Countersinking, and Spot Facing** (p. 650)
- **23.9 Reaming** (p. 651)
- **Case Study: Bolt-down Leg on a Casting** (p. 655)
- **Chapter 24 Milling** (p. 656)
- **24.1 Introduction** (p. 656)
- **24.2 Fundamentals of Milling Processes** (p. 656)
- **24.3 Milling Tools and Cutters** (p. 663)
- **24.4 Machines for Milling** (p. 669)
- **Case Study: HSS versus Tungsten Carbide Milling** (p. 676)
- **Chapter 25 Workholding Devices for Machine Tools** (p. 677)
- **25.1 Introduction** (p. 677)
- **25.2 Conventional Fixture Design** (p. 677)
- **25.3 Design Steps** (p. 680)
- **25.4 Clamping Considerations** (p. 682)
- **25.5 Chip Disposal** (p. 683)
- **25.6 Unloading and Loading Time** (p. 684)
- **25.7 Example of Jig Design** (p. 684)
- **25.8 Types of Jigs** (p. 686)
- **25.9 Conventional Fixtures** (p. 688)
- **25.10 Modular Fixturing** (p. 690)
- **25.11 Setup and Changeover** (p. 691)
- **25.12 Clamps** (p. 694)
- **25.13 Other Workholding Devices** (p. 694)
- **25.14 Economic Justification of Jigs and Fixtures** (p. 698)
- **Case Study: Fixture versus No Fixture in Milling** (p. 701)

- **Chapter 26 Numerical Control (NC) and the A(4) Level of Automation** (p. 702)
- **26.1 Introduction** (p. 702)
- **26.2 Basic Principles of Numerical Control** (p. 710)
- **26.3 Machining Center Features and Trends** (p. 721)
- **26.4 Ultra-High-Speed Machining Centers (UHSMCs)** (p. 725)
- **26.5 Summary** (p. 726)
- **Case Study: Process Planning for the MfE** (p. 730)
- **Chapter 27 Other Machining Processes** (p. 731)
- **27.1 Introduction** (p. 731)
- **27.2 Introduction to Shaping and Planing** (p. 731)
- **27.3 Introduction to Broaching** (p. 736)
- **27.4 Fundamentals of Broaching** (p. 737)
- **27.5 Broaching Machines** (p. 742)
- **27.6 Introduction to Sawing** (p. 743)
- **27.7 Introduction to Filing** (p. 751)
- **Case Study: Cost Estimating-Planing vs. Milling** (p. 755)
- **Chapter 28 Abrasive Machining Processes** (p. 756)
- **28.1 Introduction** (p. 756)
- **28.2 Abrasives** (p. 757)
- **28.3 Grinding Wheel Structure and Grade** (p. 763)
- **28.4 Grinding Wheel Identification** (p. 767)
- **28.5 Grinding Machines** (p. 771)
- **28.6 Honing** (p. 780)
- **28.7 Superfinishing** (p. 781)
- **28.8 Free Abrasives** (p. 783)
- **Case Study: Overhead Crane Installation** (p. 789)
- **Chapter 29 Thread and Gear Manufacturing** (p. 790)
- **29.1 Introduction** (p. 790)
- **29.2 Thread Making** (p. 795)
- **29.3 Internal Thread Cutting-Tapping** (p. 798)
- **29.4 Thread Milling** (p. 803)
- **29.5 Thread Grinding** (p. 805)
- **29.6 Thread Rolling** (p. 805)
- **29.7 Gear Making** (p. 808)
- **29.8 Gear Types** (p. 811)
- **29.9 Gear Manufacturing** (p. 812)
- **29.10 Machining of Gears** (p. 813)
- **29.11 Gear Finishing** (p. 821)
- **29.12 Gear Inspection** (p. 823)
- **Case Study: Bevel Gear for a Riding Lawn Mower** (p. 826)
- **Chapter 30 Fundamentals of Joining** (p. 827)
- **30.1 Introduction to Consolidation Processes** (p. 827)
- **30.2 Classification of Welding and Thermal Cutting Processes** (p. 828)
- **30.3 Some Common Concerns** (p. 828)
- **30.4 Types of Fusion Welds and Types of Joints** (p. 829)
- **30.5 Design Considerations** (p. 832)

- **30.6 Heat Effects** (p. 832)
- **30.7 Weldability or Joinability** (p. 839)
- **30.8 Summary** (p. 840)
- **Chapter 31 Gas Flame and Arc Processes** (p. 842)
- **31.1 Oxyfuel-Gas Welding** (p. 842)
- **31.2 Oxygen Torch Cutting** (p. 846)
- **31.3 Flame Straightening** (p. 848)
- **31.4 Arc Welding** (p. 849)
- **31.5 Consumable-Electrode Arc Welding** (p. 851)
- **31.6 Nonconsumable-Electrode Arc Welding** (p. 859)
- **31.7 Welding Equipment** (p. 864)
- **31.8 Arc Cutting** (p. 865)
- **31.9 Metallurgical and Heat Effects in Thermal Cutting** (p. 867)
- **Case Study: Bicycle Frame Construction and Repair** (p. 870)
- **Chapter 32 Resistance and Solid-State Welding Processes** (p. 871)
- **32.1 Introduction** (p. 871)
- **32.2 Theory of Resistance Welding** (p. 871)
- **32.3 Resistance Welding Processes** (p. 874)
- **32.4 Advantages and Limitations of Resistance Welding** (p. 879)
- **32.5 Solid-State Welding Processes** (p. 879)
- **Case Study: Field Repair to a Power Transformer** (p. 888)
- **Chapter 33 Other Welding Processes, Brazing and Soldering** (p. 889)
- **33.1 Introduction** (p. 889)
- **33.2 Other Welding and Cutting Processes** (p. 889)
- **33.3 Surface Modification by Welding-Related Processes** (p. 898)
- **33.4 Brazing** (p. 901)
- **33.5 Soldering** (p. 909)
- **Chapter 34 Adhesive Bonding, Mechanical Fastening, and Joining of Nonmetals** (p. 915)
- **34.1 Adhesive Bonding** (p. 915)
- **34.2 Mechanical Fastening** (p. 924)
- **34.3 Joining of Plastics** (p. 927)
- **34.4 Joining of Ceramics and Glass** (p. 929)
- **34.5 Joining of Composites** (p. 929)
- **Case Study: Golf Club Heads with Insert** (p. 932)
- **Chapter 35 Surface Engineering** (p. 933)
- **35.1 Introduction** (p. 933)
- **35.2 Mechanical Cleaning and Finishing Blast Cleaning** (p. 940)
- **35.3 Chemical Cleaning** (p. 946)
- **35.4 Coatings** (p. 948)
- **35.5 Vaporized Metal Coatings** (p. 958)
- **35.6 Clad Materials** (p. 958)
- **35.7 Textured Surfaces** (p. 959)
- **35.8 Coil-Coated Sheets** (p. 959)
- **35.9 Edge Finishing and Burrs** (p. 959)
- **35.10 Surface Integrity** (p. 961)



- **Case Study: Dana Lynn's Fatigue Lesson** (p. 968)
- **Chapter 36 Quality Engineering** (p. 969)
- **36.1 Introduction** (p. 969)
- **36.2 Determining Process Capability** (p. 970)
- **36.3 Inspection to Control Quality** (p. 981)
- **36.4 Process Capability Determination from Control Chart Data** (p. 985)
- **36.5 Determining Causes for Problems in Quality** (p. 986)
- **36.6 Summary** (p. 996)
- **Case Study: Boring QC Chart Blunders** (p. 1000)
- **Chapter 37 Manufacturing Automation** (web-based chapter) ([www.wiley.com/college/DeGarmo](http://www.wiley.com/college/DeGarmo))
- **Chapter 38 The Enterprise** (web-based chapter) ([www.wiley.com/college/DeGarmo](http://www.wiley.com/college/DeGarmo))
- **Chapter 39 Rapid Prototyping, Tooling And Fabrication** (web-based chapter) ([www.wiley.com/college/DeGarmo](http://www.wiley.com/college/DeGarmo))
- **Selected References for Additional Study** (web-based)
- **Index** (p. 1001)