

---

# Index

---

- Adaptive design 11
- Aesthetics 2, 351 et seq.
- Alloys, *see* Metals
- Approximate solutions for standard problems 375  
et seq.
- Atomic bonding 43, 46
- Attributes:
  - materials 66, 67
  - processes 261
  
- Bar codes 354
- Batch rate 276
  - size 275
- Beams 73, 75
  - static solutions 73, 75, 167 et seq., 380, 382
  - vibrating 398
- Bearings for ships rudders 157
- Bells 46
- Bending of beams 167 et seq., 380, 382
- Bicycle forks 198
- Buckling:
  - local 176
  - of columns 384
  - shape factor for 171
  
- Case studies, *see* particularly Chapters 6, 8, 10  
and 12
  - bar codes 354
  - bearings for ships rudders 157
  - bicycle forks 198
  - ceramic valves for taps 154, 290
  - connecting rods 228, 278
  - cork screws 14
  - data for a ceramic 340
  - data for a ferrous alloy 334
  - data for a glass-filled polymer 342
  - data for a metal-matrix composite 344
  - data for a natural material 347
  - data for a non-ferrous alloy 335
  - data for a polymer 338
  - data for a polymer-matrix composite 345
  - deflection-limited design with brittle polymers  
192
  - diaphragms for pressure actuators 122
  - disposable coffee cups 241
  - economical casting 292
  - elastic hinges 116
  - energy-efficient kilns 143
  - fabricating a pressure vessel 284
  - fans 105, 281
  - floor joists 200
  - flywheels 100, 388
  - forks 359
  - forming a fan 281
  - forming a silicon nitride micro-beam 289
  - forming ceramic tap valves 290
  - golf-ball print heads 108
  - hairdryers 357
  - heat-storing walls 147
  - knife-edges and pivots 125
  - magnet windings 232
  - man-powered planes 194
  - manifold jacket 293
  - micro-beams 289
  - oars 85
  - precision devices 151
  - pressure vessels 133, 284, 396
  - seals 119
  - shaker tables 137
  - short-term isothermal containers 140
  - spark plug insulator 298
  - springs 111, 206, 219, 334
  - stiffened steel sheet 204
  - structural materials for buildings 97, 200
  - table legs 93
  - taps 290
  - telephones 355
  - telescope reflectors 89, 344
  - vacuum cleaners 4
  - wing spars 194
- Catalogue of data sources 313 et seq.
- Centrifugal forces and stresses 100, 388
- Ceramic valves for taps 154, 290
- Ceramics, *see also* Charts, and Material properties  
20, 35, 88, 96, 104, 114, 125, 323
  - alumina 35, 127, 156, 160
  - brick 100, 149
  - cement 149, 324
  - common rocks 149, 325

Ceramics (*continued*)

- concrete 92, 100, 140, 149, 324
  - diamond 35, 127, 154
  - ice 53, 149
  - magnesia 160
  - mullite 156
  - porous ceramics 147
  - sapphire 127
  - selection of 32 et seq.
  - sialons 35, 156
  - silicon 127, 154
  - silicon carbide 35, 127, 154, 156
  - silicon nitride 35, 127, 156
  - stone 100, 325
  - tungsten carbide 127
  - zirconia 35, 142, 340 et seq.
- Charts, *see* Material Selection Charts and Process Selection Charts
- Classes:
- materials 20, 21, 35, 414
  - processes 246, 248, 416
- Cold working 250
- Columns 76, 384
- Complexity 266 et seq.
- Composites, *see also* Charts, and Material properties 21, 35, 324
- carbon fibre reinforced polymer, CFRP 88, 92, 96, 104, 108, 114, 135, 196, 199, 345
  - ceramic matrix 367
  - glass fibre reinforced polymer, GFRP 88, 92, 96, 104, 108, 114, 135, 140, 147
  - glass filled nylon 342
  - intermetallic matrix 367
  - Kevlar fibre reinforced polymer, KFRP 140
  - metal matrix composites, MMC 230, 236–7, 344, 367
- Compound objectives 211 et seq., 228 et seq.
- Conceptual stage of design 8, 9, 15
- Connecting rods 228, 278
- Constitutive equations 376
- Constraints 66, 69 et seq.
- multiple 210 et seq., 215, 228 et seq.
- Contact stresses 391
- Cork 36, 122, 147
- Cork screws 14
- Correlations between material properties *see also* Charts 310
- Corrosion 59, 60
- Co-selection of material and shape 186
- Cost 276 et seq.
- capital 277
  - case studies 278, 292
  - dependence on finish 271
  - estimation 276
  - modelling 276
  - of casting 278, 292
  - of labour 277

- of material 22, 56, 276–7
  - of process 274
  - of product 241–2
  - technical modelling of 278
- Coupling lines and equations 218
- Cracks 133 et seq., 394
- Creep solutions 398
- Damage-tolerant design 44, 133
- indices 411
- Damping, *see* Loss coefficient
- Data:
- catalog of sources 313 et seq.
  - checking methods 309
  - correlations 310
  - estimation 309, 313
  - examples 334 et seq.
  - for a ceramic 340
  - for a ferrous alloy 334
  - for a glass-filled polymer 342
  - for a metal-matrix composite 344
  - for a natural material 347
  - for a non-ferrous alloy 335
  - for a polymer 338
  - for a polymer-matrix composite 345
  - for further information 307
  - for material properties, *see* Material properties
  - for screening 305
  - handbooks 313 et seq., 334 et seq.
  - information services 330 et seq.
  - Internet access 308
  - levels, of breadth and precision 303
  - needs 303
  - sheets 334 et seq.
  - sources and their use 303 et seq., 334 et seq.
  - structure 305
  - types 305
  - world-side web sources 330 et seq.
- Data sources 334 et seq.
- for cement and concrete 324
  - for ceramic-matrix composites 324
  - for ceramics and glasses 323
  - for foams 324
  - for manufacturing processes 327
  - for metal-matrix composites 324
  - for metals 314 et seq.
  - for natural fibres 326
  - for polymer-matrix composites 324
  - for polymers and elastomers 322
  - for stone, rocks and minerals 325
  - for woods and wood-based composites 326
  - world-wide web sites 327 et seq.
- Decoration 353
- Density:
- charts 37, 39, 41
  - data 37

- definition 22
- origins 36
- Deflection-limited design 73, 167, 192, 380, 389
- Deflection-limited design with brittle polymers 192
- Design:
  - adaptive 11
  - conceptual 8
  - detailed 8
  - embodiment 8
  - flow chart 9
  - industrial 351 et seq.
  - mechanical 1
  - museums 353
  - original 10
  - process 8 et seq.
  - tools 11
  - types 10
  - variant 11
- Design-led selection 8, 17
- Detailed stage of design 8
- Diaphragms for pressure actuators 122
- Diffusion 404
- Disks:
  - elastic deflection 388
  - spinning 388
- Disposable coffee cups 241
  
- Economics of casting 292
- Economic criteria for selection 275
- Elastic bending 73, 167 et seq., 380
  - buckling 171, 176, 384
  - contacts 390
  - energy 111, 206, 219, 330
  - hinges 116
  - stress concentrations 392
  - twisting 386
- Elastomers, *see also* Charts, and Material properties
  - 21, 36, 114, 119, 125, 147
  - butyl rubber, BR 36, 143
  - chlorosulphinated polyethylene, CSM 143
  - natural rubber 36
  - polychloroprene, CR 143
  - polyurethanes 36
  - silicones 36
- Electro-mechanical design 232, 412
- Embodiment stage of design 8
- Energy content of materials 368 et seq.
- Energy-efficient kilns 143
- Energy storing devices:
  - flywheels 100 et seq., 388
  - pressure vessels 133 et seq., 284, 396
  - springs 111, 206, 219, 334
- Engineering alloys, *see* Metals
- Engineering ceramics, *see* Ceramics
- Engineering polymers, *see* Polymers
- Environmental attack 59, 60
- Environmental impact of materials 367, 373
  - indices 368
- Estimation methods for material data 309
- Evolution:
  - of engineering materials 3
  - of hairdryers 357
  - of telephones 355
  - of vacuum cleaners 4
- Exchange constants 218, 220
- Expert systems 308
  
- Fabricating a pressure vessel 284
- Failure diagrams 178
- Failure in bending 75, 170, 382
- Failure in torsion 170, 386
- Fans 105, 281
- Finite element analysis 8
- Floor joists 200
- Flywheels 100, 388
- Foams, *see also* Charts, and Material properties 36, 122, 143, 324
  - cork 36, 122, 147
  - phenolic foam 239, 241
  - polycarbonate foam 243
  - polyester foam 36
  - polyethersulphone foam 239
  - polyethylene foam 243, 245
  - polymethacrylimide foam 239
  - polypropylene foam 241, 245
  - polystyrene foam 36, 92, 239, 241, 243, 245
  - polyurethane foam 241
- Forces for change 363 et seq.
- Forks 359
- Forming a fan 281
- Forming a silicon nitride micro-beam 289
- Forming ceramic tap valves 290
- Forming, *see* Processes
- Fracture toughness:
  - case studies 133, 192
  - charts 43 et seq.
  - data 43 et seq.
  - definition 26
  - lower limiting value 45
  - origins 43 et seq.
- Function 8, 13, 69
- Function structure 8, 17
- Functional requirements 17
- Functionally graded materials 367
- Fuzzy logic 214
  
- Glasses, *see also* Charts, and Material properties
  - 20, 35, 92, 125
  - borosilicate glass 35
  - quartz 127

- Glasses (*continued*)  
 silica glass 35, 160  
 soda glass 35
- Glass temperature:  
 definition 28  
 influence on damping 46
- Golf-ball print heads 108
- Green engineering 367
- Guide lines for materials selection 80 et seq.
- Hairdryers 357
- Handbooks 313 et seq., 334 et seq.
- Heat capacity, *see* Specific heat
- Heat flow 402
- Heat-storing walls 147
- History of material usage 3
- Hot working 250
- Hysteresis, *see* Loss coefficient
- I-Beams 163 et seq., 172 et seq.
- Indices, *see* Material indices
- Industrial design 2, 334 et seq.
- Information content 266 et seq.
- Insulation:  
 for kiln walls 143  
 for thermal storage 147  
 latent heat 'sinks' 142  
 short term 140
- Intelligent materials 367
- Introduction 1
- Internet data sources 308
- J-integral 40
- Joists 200
- Kilns 143
- Knife-edges and pivots 125
- Lattice resistance 39
- Leak-before-break criterion 133
- Lightweight design 71 et seq., 408–9
- Local buckling 176
- Local issues in selection 68
- Log decrement, definition 27
- Loss coefficient:  
 chart 48  
 data 48  
 definition 27  
 origins 46
- Magnet windings 232
- Man-powered planes 194
- Manifold jacket 293
- Market need 8–9, 12
- Market pull 363
- Material classes 21, 35
- Material indices 69 et seq., 78, 408 et seq.  
 catalog 407 et seq.  
 damage-tolerant design 411  
 definition 70  
 derivation of 71, 78  
 efficient thermal design 411  
 elastic design 408  
 electro-mechanical design 232, 412  
 examples of derivations 71 et seq.,  
 minimum cost design 76  
 minimum energy-content design 368 et seq.,  
 408, 409  
 minimum weight design 71, 73, 75  
 stiffness-limited design 408  
 strength-limited design 409  
 tables of 78, 408 et seq.  
 thermo-mechanical design 411  
 vibration-limited design 410  
 with shape included 180 et seq.
- Material properties 20 et seq., 32 et seq.  
 coefficient of friction 59–60  
 corrosion 62  
 cost 22, 56, 58, 364  
 creep constants 28  
 definitions of 22  
 density 22, 37, 39, 41  
 eco-indicators 369  
 endurance limit 22  
 energy content 369  
 environmental 367  
 failure strain 40  
 fatigue ratio 27  
 fracture toughness 26, 41, 45, 47  
 glass temperature 28  
 hardness 25, 266  
 high temperature strength 55  
 J-integral, critical 40  
 log decrement 27  
 loss coefficient 26  
 maximum service temperature 28  
 melting point 28  
 moduli 22, 37, 42, 45, 48, 52, 57, 266, 309  
 modulus of rupture 24  
 parabolic rate constant 30  
 process zone size 46–7  
 Q-factor 27  
 relative cost 57–8  
 resilience 25  
 softening temperature 28  
 specific damping capacity 27  
 specific heat 28, 48  
 strength 23, 39, 42, 47, 58  
 surface energy 43  
 tensile strength 38  
 thermal conductivity 27, 31, 49

- thermal diffusivity 28, 49
- thermal expansion coefficient 28, 52, 312
- thermal shock resistance 28
- toughness 26, 45
- ultimate strength 25
- wave velocity 37–8
- wear constant 29, 60
- Material Selection Charts 32 et seq., 413 et seq.
  - modulus/density 37, 418
  - strength/density 39, 420
  - fracture toughness/density 41, 422
  - modulus/strength 42, 424
  - specific modulus/specific strength 44, 426
  - fracture toughness/modulus 45, 428
  - fracture toughness/strength 47, 430
  - loss coefficient/modulus 48, 432
  - thermal conductivity/thermal diffusivity 49, 434
  - thermal expansion/thermal conductivity 51, 436
  - thermal expansion/modulus 52, 438
  - strength/thermal expansion 54, 440
  - strength/temperature 56, 442
  - modulus/relative cost 57, 444
  - strength/relative cost 58, 446
  - coefficient of friction 59
  - wear rate/hardness 60, 448
  - resistance to environmental attack 62
  - modulus/energy content 370, 450
  - strength/energy content 371, 452
  - use of 77 et seq.
- Materials, *see* Metals, Ceramics, Polymers, Glasses, Elastomers, Composites, Wood, Foams, Porous ceramics or individual material names
- Materials in design 1
- Materials selection, 65 et seq.
  - case studies, *see* Case studies
  - software 375 et seq.
- Mechanical design 1
- Merit indices, *see* Material indices
- Metals, *see also* Charts, and Material properties
  - 20, 35, 314 et seq.
  - aluminium alloys 92, 104, 111, 135, 154, 196, 199, 230, 337
  - beryllium alloys 92, 104, 119, 213, 231
  - cast irons 100, 104, 108, 140, 230
  - copper alloys 135, 154, 236
  - gold 154
  - invar 43, 122, 154
  - lead alloys 104
  - magnesium alloys 92, 104, 111, 140, 199, 231
  - manganese–copper alloys 140
  - molybdenum alloys 154
  - nickel alloys 293
  - silver 154, 237
  - speculum metal 89, 92
  - steels, carbon 92, 100, 114, 119, 125, 127, 135, 196, 199, 201, 204, 230, 236
  - steels, stainless 334 et seq.
  - tin alloys 111, 135, 199
  - titanium alloys 104, 125, 213, 230
  - tungsten alloys 154
  - type metal 111
- Micro-beams 289
- Microscopic ('microstructural') shape factors 182
- Minimum cost design 76 et seq., 408–9
- Minimum energy-content design 368 et seq., 408–9
- Minimum weight design 71 et seq., 408–9
- Modelling: 69 et seq., 86 et seq.
  - aids 376 et seq.
  - examples 86 et seq.
- Moduli:
  - charts 37, 42, 44–5, 48, 52, 57, 370
  - data 37
  - definitions 23
  - origins 36
- Moments of sections 164, 378
- Multiple constraints 210 et seq., 228 et seq.
- Multiple design objectives 210 et seq., 228 et seq.
- Museums 253
  
- Normalized strength:
  - charts 44
  - data 44
  - definition 43
- Oars 85
- Objectives 66, 69, 218 et seq.
- Optimization 67 et seq.
- Optimum design 65 et seq.
- Original design 10
  
- Peierls stress, *see* Lattice resistance
- Performance 65 et seq., 79
- Performance-maximising criteria, *see* Material indices
- Pivots 125
- Poisson's ratio, *see* Moduli
- Polymer forming 180, 183
- Polymers, *see also* Charts, Foams and Material properties
  - 21, 35, 129, 143, 147, 332
  - epoxies, EP 111
  - nylons, glass-filled 342
  - nylons, PA 108, 111, 114, 119, 122, 125, 129
  - polycarbonates, PC 129
  - polyethylene, high density, HDPE 108, 119, 122, 143, 149, 160
  - polyethylene, low density, LDPE 119, 122, 338
  - polypropylene, PP 119, 122, 125, 143
  - polystyrene, PS 129
  - polytetrafluorethylene, PTFE 119, 122, 125, 160
  - polyurethanes, PU 122

- Polymers (*continued*)
  - polyvinylchloride, PVC 108
  - silicones 122
- Porous ceramics, *see also* Charts and Material
  - Properties 147
  - brick 100, 149
  - cement 149, 324
  - common rocks 149, 325
  - concrete 92, 100, 140, 149, 324
  - ice 53, 149
- Precision 270 et seq., 282, 286, 290–1, 295
- Precision devices 151
- Pressure vessels 133, 284, 396
- Primary forming methods 246
- Problems Appendix C
- Process:
  - attributes 261
  - catalog of methods 246
  - classes 246, 248
  - costs 274 et seq., 292
- Process selection 246 et seq., 281 et seq.
  - case studies 281 et seq.
  - ranking 274
  - screening 264
  - strategy 273
  - supporting information 279
- Process selection charts 264 et seq., 454 et seq.
  - complexity /size 270, 284, 464
  - hardness/melting temperature 266, 285, 456
  - material/process matrix 454
  - shape classification 268, 460
  - shape/process matrix 462
  - surface area/section/slenderness/volume 269, 283, 458
  - tolerance/surface roughness 265, 270, 286, 466
- Process zone:
  - chart 47
  - definition 46
- Processes 246 et seq., 327
  - adhesive bonding 256, 258
  - ballistic-particle manufacture 259
  - blow moulding 249, 251
  - casting 247–8, 288, 292
  - cold working 250
  - composite forming 254
  - CVD 248, 291
  - deformation 248, 250
  - die casting 282, 287, 292
  - die pressing 253
  - drawing 253
  - electroforming 287, 291, 297
  - electron-beam casting 291
  - extrusion 252
  - fabrication 256, 288
  - fastening 256–7
  - filament winding 254
  - finishing 248, 257
  - forging 252
  - friction welding 258
  - grinding 256
  - heat treatment 248, 256
  - HIPing 253
  - hot working 250, 288
  - injection moulding 250, 282
  - investment casting 247, 282, 297
  - joining 248, 256
  - laminated object manufacture 260
  - machining 48, 255, 288
  - micro-fabrication 289
  - moulding 249
  - polymer forming 248–9
  - powder methods 248, 252, 291
  - primary forming 246
  - rapid prototyping 258
  - resin-transfer moulding 250, 287
  - rolling 251
  - sand casting 247–8, 292
  - secondary forming 247
  - sheet forming 253
  - sintering 248, 252, 291, 299
  - solid-ground curing 259
  - special forming methods 248, 254
  - spray forming 255
  - squeeze casting 287
  - stereo-lithography 260
  - tertiary forming 247
  - transfer moulding 250
  - turning 255
  - warm working 250
  - welding 256–7
- Processing 246 et seq.
- Production rate 276
- Properties, *see* Material properties
- Property limits 68, 70
- Property profiles 20, 66
  
- Ranking of materials 65, 67
- Ranking of processes 274
- Recycling of materials 373
- Reuse of materials 373
- Roughness 265, 270–1
- Rubber, *see* Elastomers
  
- Science push 366
- Screening of materials 65, 67
- Screening of processes 264
- Seals 119
- Secondary forming processes 247
- Section shape, *see* Shape
- Shaker tables 137

- Shape, *see also* Shape factors 13, 162 et seq., 194 et seq.  
 case studies 194 et seq.  
 classification 268  
 efficiency of 172  
 macroscopic 162  
 microscopic 13, 182 et seq.  
 moments of area 164  
 selection of 186
- Shape factors 162 et seq., 190  
 co-selection with material 186  
 definition of 162  
 examples of use 186, 194 et seq.  
 for elastic bending 167, 180  
 for elastic buckling 171  
 for elastic twisting 170, 180  
 for failure in bending 170, 181  
 for failure in twisting 170, 182  
 geometric constrains for 190 et seq.  
 in material indices 180, 195  
 limits imposed by material 175 et seq.  
 microscopic or "microstructural" 182 et seq.  
 values for 165, 166
- Shear modulus, *see* Moduli
- Short-term isothermal containers 140
- Software for materials selection 375 et seq.
- Spark plug insulator 298
- Specific heat:  
 chart 49  
 data 49  
 definition 28  
 origins 49
- Specific stiffness:  
 chart 44  
 data 44  
 definition 43
- Specific strength:  
 chart 44  
 data 44  
 definition 43
- Springs 111, 206, 219, 334
- Standard solutions of mechanics and heat flow 375 et seq.
- Stiffened steel sheet 204
- Stiffness-limited design 408
- Strength-limited design 409
- Strength:  
 charts 39, 42, 44, 54  
 data 39  
 definition 23, 38  
 origins 38
- Strength at elevated temperature:  
 chart 56  
 data 56  
 definition 55
- Stress concentrations 392
- Stress intensity factors 394
- Structural index 71, 82 et seq.
- Structural load coefficient, *see* Structural index
- Structural materials for buildings 97, 200
- Structure-sensitive properties 34
- Supporting information for materials 67–8
- Supporting information for processes 279
- Surface finish 271
- Table legs 93
- Taps 290
- Technical systems 8–9
- Telephones 355
- Telescope reflectors 89, 344
- Tertiary forming processes 247
- Texture 253
- Thermal conductivity :  
 charts 33, 49, 51  
 data 49  
 definition 27  
 origins 47 et seq.
- Thermal diffusivity:  
 chart 33  
 data 49  
 definition 27  
 origins 47 et seq.
- Thermal distortion:  
 case study 151  
 chart 54  
 definition 28  
 origins 54
- Thermal expansion coefficient:  
 charts 51–2, 54  
 data 51  
 definition 28  
 origins 50
- Thermal shock resistance:  
 chart 52  
 data 52  
 definition 28  
 origins 53
- Thermal stress:  
 chart 52  
 data 52  
 definition 53  
 origins 53
- Tolerance 265, 270–1
- Torsion of shafts 386  
 shape-factors for 170–1
- Toughness:  
 chart 43  
 data 43  
 definition 26  
 origins 43

## 502 Index

- Tubes 175 et seq.
  - failure mechanisms 177
- Types of design 10
  
- Useful solutions to standard problems 375
  
- Vacuum cleaners 4
- Value functions 218, 220
- Van der Waals bonding 40
- Variant design 11
- Vibration 398
  - natural 151
  - damping of 137, 151
  - suppressing 151, 204
  
- Warm working 250
- Wave velocity:
  - chart 37
  - data 37
  - definition 38
  
- Wear constant:
  - chart 60
  - data 60
  - definition 61
- Weight factors 212
- Wing spars 194
- Woods, *see also* Charts, and Material properties
  - 84, 92, 96, 100, 115, 147, 182, 200, 326
  - ash 347
  - balsa 196, 347
  - bamboo 199–200
  - hickory 347
  - pine 201
  - spruce 196, 199, 347
  - wood products (ply, etc.)
  - yew 347
- World-wide web 308, 330 et seq., 340
  
- Yield-before-break criterion 250
- Youngs modulus, *see* Moduli