

Научная библиотека
БНТУ



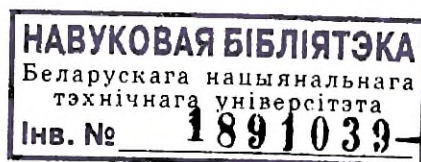
* 8 0 1 2 7 8 1 9 1 *

MATERIALS SCIENCE

МАТЕРИАЛОВЕДЕНИЕ

*Утверждено Министерством образования
Республики Беларусь в качестве учебника
для студентов учреждений высшего образования
по профилю образования «Техника и технологии»*

Под редакцией Н. К. Мышкина, В. А. Гольдаде



068 (30913)



Минск
«ИВЦ Минфина»
2023

Contents

Preface	3
SECTION I. FUNDAMENTALS OF MATERIALS SCIENCE	5
Chapter 1. Introduction	6
1.1. The subject of materials science.....	6
1.2. Overview of history of materials science.....	7
1.3. Problems and achievements of materials science.....	11
Chapter 2. Structure of materials	13
2.1. Atom	14
2.2. Chemical bond	15
2.3. Molecule	17
2.4. Phase state of substance	19
2.5. Gas and liquid.....	20
2.6. Solid body.....	21
2.7. Defects in crystals	24
2.8. Modelling of material structure	26
Chapter 3. Basic properties of materials	31
3.1. Mechanical properties.....	31
3.2. Corrosion resistance of material	38
3.3. Temperature characteristics.....	40
3.4. Electric and magnetic properties	43
3.5. Processing properties	47
3.6. Non-destructive test methods.....	48
Chapter 4. Engineering materials	59
4.1. Classification	59
4.2. Basics of materials standardisation	63
4.3. Materials databases	64
4.4. Materials science of the XXI century – nanomaterials and nanotechnologies.....	69
SECTION II. BASICS OF METAL SCIENCE	75
Chapter 5. General data on metals	76
5.1. Properties and classification	76
5.2. Atomic crystalline structure	77

5.3. Melt crystallization	78
5.4. Polymorphic transformations	82
5.5. Metal corrosion	84
Chapter 6. The theory of alloys	89
6.1. Phases of metal alloys.....	89
6.2. Alloys with complete miscibility of components.....	92
6.3. Alloys with partial miscibility of components.....	93
6.4. Alloys forming chemical compounds.....	95
6.5. Interrelation between structure and properties of alloys.....	98
6.6. Three-component alloys	99
Chapter 7. Strength of metals and alloys.....	101
7.1. Stress and strain	101
7.2. Strain hardening and fracture	103
7.3. Mechanical testing	105
7.4. Structural strength	107
7.5. Means of structural strength enhancement	108
Chapter 8. Recrystallization in metals and alloys.....	112
8.1. Recovery and recrystallization	112
8.2. Recrystallized metal structure.....	113
8.3. Cold and hot deformation	115
Chapter 9. Iron and its alloys	117
9.1. Iron-carbon alloys.....	118
9.2. State diagram of iron-carbon system.....	120
9.3. Effect of carbon and impurities on the properties of steel	125
9.4. Steel alloying	127
Chapter 10. Heat treatment of steel	131
10.1. Types of heat treatment	131
10.2. Transformation of pearlite into austenite.....	134
10.3. Transformations of supercooled austenite	136
10.4. Pearlitic transformation.....	137
10.5. Martensitic transformation.....	139
10.6. Bainitic transformation	140
10.7. Tempering and aging of steel.....	141
10.8. Effect of heat treatment on mechanical characteristics of steel	143

Chapter 11. Technology of heat treatment of steel	145
11.1. Annealing and normalizing.....	146
11.2. Hardening.....	148
11.3. Surface hardening	153
11.4. Tempering and artificial aging.....	155
11.5. Thermomechanical and mechanochemical treatment	155
Chapter 12. Thermochemical treatment of steel	157
12.1. Mechanism of surface layers modification.....	158
12.2. Carburizing.....	159
12.3. Nitridation, nitrocarburizing and cyanide carburizing	161
12.4. Boronizing, siliconizing and diffusion metallization.....	164
12.5. High-energy methods of chemical modification.....	166
SECTION III. METALLS AND ALLOYS	169
Chapter 13. Structural steels and alloys	170
13.1. Classification	170
13.2. Carbon structural steel	174
13.3. Building low-alloy steels.....	175
13.4. Carburizing alloy steels.....	176
13.5. Heat-hardenable alloy steels.....	176
13.6. High-strength steel.....	178
13.7. Spring steels.....	180
13.8. Wear-resistant structural steels	180
13.9. Corrosion-resistant steels and alloys	181
13.10. Heat resistant steel and high temperature steels and alloys.....	182
13.11. Cast steels	188
Chapter 14. Cast irons	190
14.1. Structure of cast iron	190
14.2. Grey and white cast iron.....	192
14.3. High strength cast iron	193
14.4. Wrought iron.....	194
14.5. Alloyed cast iron	195
Chapter 15. Tool steels	197
15.1. Steels for cutting tools	197
15.2. Steels for measuring tools	199
15.3. Steels for cold deformation tools.....	199
15.4. Steels for stamps of hot deformation	200

Chapter 16. Powder metallurgy	201
16.1. Metal powders production.....	202
16.2. Powder forming.....	211
16.3. Sintering	217
16.4. Antifriction materials	222
16.5. Frictional materials	224
16.6. Porous powder materials.....	227
16.7. Electrotechnical materials	229
16.8. Structural material	232
16.9. Refractory metals and alloys.....	237
16.10. Hard alloys.....	241
Chapter 17. Aluminum and aluminum-based alloys	242
17.1. Properties of aluminum and classification of its alloys.....	243
17.2. Deformable alloys	246
17.3. Casting alloys.....	248
17.4. Bearing alloys.....	249
Chapter 18. Copper and copper-based alloys	252
18.1. Properties of copper and classification of copper-bases alloys.....	252
18.2. Brasses.....	254
18.3. Bronzes.....	257
Chapter 19. Special-property alloys based on nonferrous metals	261
19.1. Titanium and titanium-based alloys	261
19.2. Magnesium and magnesium-based alloys	266
19.3. Tin-, lead- and zinc-based antifriction alloys	270
19.4. Beryllium and beryllium-based alloys	270
Chapter 20. Alloys with special physical properties	274
20.1. Conducting materials	274
20.2. Superconductors	275
20.3. Semiconductors	278
20.4. Magnet materials	279
20.5. Shape memory alloys	282
20.6. High-resistance alloys	284
20.7. Alloys with specified linear expansion coefficient.....	285
20.8. Steels and alloys with special elastic properties.....	287
20.9. Alloys for cryogenic technology	287

SECTION IV. NONMETALLIC MATERIALS.....	291
Chapter 21. Plastics	292
21.1. Classification of polymers.....	292
21.2. Main properties of polymers.....	298
21.3. Nomenclature of construction plastics.....	304
21.4. Technology of plastic processing.....	311
21.5. Polymer films.....	314
Chapter 22. Raw rubbers and rubbers.....	317
22.1. Natural and synthetic raw rubbers.....	318
22.2. Vulcanization of raw rubbers	318
22.3. Rubbers classification.....	321
22.4. Properties of rubbers	322
Chapter 23. Materials based on wood.....	325
23.1. Structure and properties of wood	326
23.2. Modification of whole timber	328
23.2. Classification of wood-based materials	330
23.4. Paper and cardboard	332
Chapter 24. Minerals and mineral-based materials	335
24.1. Hard and superhard materials.....	336
24.2. Mineral silicate-based materials	338
24.3. Glass and glassceramics.....	339
24.4. Technical ceramics.....	343
24.5. Graphite and graphite-based materials	345
Chapter 25. Technical fluids and gases.....	348
25.1. Classification of technical fluids	348
25.2. General characteristic of lubricants	348
25.3. Lubricating oils	350
25.4. Grease lubricants	352
25.5. Actuating and process media	353
25.6. Special technical fluids and gases.....	356
SECTION V. COMPOSITE MATERIALS.....	359
Chapter 26. Structure of composites	360
26.1. Basic terms and classification	360
26.2. Criteria for component combination	366
26.3. Structure formation.....	372

26.4. Perspectives on the use of composites	377
Chapter 27. Composite plastics	379
27.1. Components interaction.....	379
27.2. Filled plastics.....	381
27.3. Laminated and reinforced plastics	387
27.4. Polymer mixtures.....	394
Chapter 28. Metal matrix composites	398
28.1. Disperse reinforced materials	398
28.2. Eutectic composites	401
28.3. Fibrous materials	404
Chapter 29. Ceramic matrix composites	409
29.1. Classification	409
29.2. The choice of components	410
29.3. Technology	411
29.4. Properties and application.....	412
Chapter 30. Materials for coatings	415
30.1. Types of coatings and methods of their application.....	416
30.2. Paint and lacquer materials.....	419
30.3. Powder polymer coatings	422
30.4. Coatings of metals and alloys.....	428
30.5. Inorganic non-metal coatings.....	430
SECTION VI. THE BASIS OF MATERIALS SELECTION	433
Chapter 31. Materials selection during preproduction	434
31.1. Product development	434
31.2. Technological preproduction.....	436
31.3. Article cost and operating properties.....	438
Chapter 32. Economic effectiveness of materials	440
32.1. Prices for materials.....	440
32.2. Economic criteria for materials comparison.....	441
32.3. Materials effectiveness determination methodology	443
Conclusion	446
List of symbols and abbreviations	449
Recommended literature	450