

Contents

Introduction	1
Chapter 1 General Information About Composite Materials	12
1.1 Composite material, what is this?	12
1.2 Composite material classification	14
1.2.1 Composite material classification by components geometry	15
1.2.2 Composite material classification by components space arrangement	16
1.2.3 Composite material classification by nature of components	18
1.2.4 Composite material classification by matrix material	19
1.2.5 Composite material classification by reinforcing components geometry	19
1.2.6 Composite material classification by components structure and arrangement	20
1.2.7 Composite material classification by reinforcing scheme	20
1.2.8 Composite material classification by production technology	21
1.2.9 Composite material classification by application	21
1.3 Composite materials in the aircraft industry	22
1.4 Composite materials application trends	26
Questions	26
Chapter 2 Composite Materials' Components	28
2.1 Matrix materials	28
2.1.1 Metal matrix	28
2.1.2 Polymer matrices	30
2.1.3 Ceramic matrices	35
2.2 Reinforcing elements	39
2.2.1 Metallic fibers	40
2.2.2 Glass and silica fibers	43
2.2.3 Carbon fibers	49
2.2.4 Boron fibers	54
2.2.5 Organic fibers	56
2.2.6 Ceramic fibers	58

2.2.7 Crystal whiskers 59

2.3 Reinforcing elements formation 62

Questions 66

Chapter 3 Production of Polymeric Composite Materials and Products

from Them 67

3.1 Impression molding 68

 3.1.1 Hand lay-up 69

 3.1.2 Automated placement 70

 3.1.3 Schoop 71

3.2 Polymer composite material structure production on a base of an elastic diaphragm 74

 3.2.1 Vacuum forming 74

 3.2.2 Vacuum-autoclave forming 75

 3.2.3 Press-chamber molding 76

3.3 Polymer composite material structure production on a base of a pressure-forming technology 77

 3.3.1 Plenum-chamber process 77

 3.3.2 Impregnation in vacuum process 78

3.4 Polymer composite material production on a base of compression molding 79

 3.4.1 Direct compression molding 79

 3.4.2 Injection compression molding 81

 3.4.3 Thermocompression molding 82

3.5 Polymer composite material parts production on a base of a winding process 83

 3.5.1 Winding process types 83

 3.5.2 Contact pressure for winding process 85

 3.5.3 Composite material curing process 88

 3.5.4 Winding pattern types 89

3.6 Polymer composite material structure production on a base of the pultrusion 90

3.7 Preform substance processing for polymer composite materials parts production 92

Questions 94

Chapter 4 Mechanical Behavior of Polymer Composite Materials

4.1 Composite materials modulus of elasticity 95

4.1.1	Normal elastic modulus of one-directional composite material in the direction of the reinforcement axis	97
4.1.2	Normal elastic modulus of one-directional composite material in the transverse direction of the reinforcement axis	98
4.2	Composite materials tensile strength	100
4.2.1	Breaking strength of an unidirectionally reinforced composite material	100
4.2.2	Fiber orientation influence on composite material strength properties	101
4.2.3	Composite material strength properties reinforced with discrete fibers	103
4.2.4	Fiber volume fraction influence on composite material strength	104
4.3	Composite materials compression strength	107
4.4	Composite materials destruction features	108
	Questions	114
Chapter 5	Composite Materials Joints	116
5.1	Composite materials joints classification	116
5.2	Bonded joints	118
5.3	Molding joints	119
5.4	Welded joints	119
5.5	Threaded joints	120
5.6	Riveted joints	122
5.7	Self-locking joints	123
5.8	Stitching and needle joints	124
5.9	Combined joints	124
	Questions	125
Chapter 6	Polymeric Composite Materials Repair	126
6.1	Structural repair requirements	126
6.2	Requirements for repaired structures	130
6.3	Defects types	131
6.4	Repairing processes	134
6.4.1	Scratches repair	134
6.4.2	Delamination repair	135
6.4.3	Layer separation repair	135
6.4.4	Cracks repair	139

6. 4. 5	Dents, break-through and one-side holes smaller than 40 mm repair	142
6. 4. 6	Dents and one-side holes more than 40 mm repair	142
6. 4. 7	Thru hole repair	143
6. 4. 8	Units tips repair	144
6. 4. 9	Sound-absorbing structures delamination in the air-intake ducts repair	146
6. 4. 10	Manufactural solutions for the repair quality increasing	146
	Questions	151
Chapter 7 Composite Materials Structures Safety		152
7. 1	General safety issues for composite materials structures	152
7. 1. 1	Polymer composite material structure creation on the "Building Block" base	153
7. 1. 2	Polymer composite material selection criteria	154
7. 1. 3	Criteria for selecting the manufactural process	155
7. 1. 4	Criteria for selecting the design solutions	157
7. 1. 5	Polymer composite material aircraft with a safety high level and weight efficiency creation approach	158
7. 2	Testing and certification of the polymer composite material	162
7. 2. 1	Composite material behavior	163
7. 2. 2	Composite material test methods	176
7. 2. 3	Composite material environmental certification	201
7. 3	Certification approach for an aircraft with composite material units	201
7. 3. 1	Airframe structures certification	201
7. 3. 2	The design allowance development	201
7. 3. 3	Static strength demonstration	201
7. 3. 4	Fatigue strength demonstration	211
7. 3. 5	Damage tolerance demonstration	211
7. 3. 6	The impact damage threat assessment	211
	Questions	211
REFERENCES		211