

Contents

Preface, v

Glossary of glass fibre terms, vii

Note on the units used, x

Chapter I. A brief history, 1

Chapter II. Glass and glass fibres, 4

References, 12

Chapter III. The products and the manufacturing processes, 13

III.1. The products, 13

III.1.1. Mats 13

III.1.2. Rovings, 14

III.1.3. Roving cloth or woven rovings, 17

III.1.4. Yarns, 18

III.1.5. Chopped strands, 19

III.1.6. Milled fibres, 21

III.2. An outline of the manufacturing processes, 22

Chapter IV. Glass manufacture, 27

IV.1. General, 27

IV.2. Glass compositions, 28

IV.3. Selection of raw materials for “E” glass manufacture, 31

IV.3.1. Raw materials for introducing alumina (Al_2O_3), 31

IV.3.2. Raw materials for introducing boric oxide (B_2O_3), 32

IV.3.3. Raw material for introducing fluoride (F_2), 33

IV.3.4. Raw materials for introducing magnesia (MgO), 34

IV.3.5. Raw material for introducing calcium oxide (CaO), 34

- IV.3.6. Raw material for introducing silica (SiO_2), 35
- IV.3.7. Use of sodium sulphate, 35
- IV.3.8. Iron oxide (Fe_2O_3), 36
- IV.3.9. Comment on particle size of raw materials for “E” glass manufacture, 36
- IV.4. Handling, weighing, and mixing of raw materials into batch, 36
- IV.5. Production of “E” glass in the traditional type of glass furnace, 38
 - IV.5.1. The characteristics of “E” glass from the point of view of glass melting, 39
 - IV.5.2. Production of “E” glass by unit melter, 40
 - IV.5.3. Design parameters of melter, 41
 - IV.5.4. Special features, 44
 - IV.5.5. Services and safety, 48
 - IV.5.6. Instrumentation, control and alarms, 53
- IV.6. The forehearth, 56
 - IV.6.1. Forehearth for marble manufacture, 56
 - IV.6.2. Forehearth for direct-melt operation, 60
 - IV.6.2.1. Some alternative configurations for forehearths, 60
 - IV.6.2.2. Some constructional details of forehearths, 63
 - IV.6.2.3. Choice of refractories, 67
 - IV.6.2.4. Firing system of the forehearth, 68
 - IV.6.2.5. Instrumentation, control, and alarms, 70
- IV.7. Technical control of glass manufacture, 70
 - IV.7.1. The commissioning of a marble furnace, 71
 - IV.7.2. Operating the furnace, 74
 - IV.7.2.1. Control of melter, 75
 - IV.7.2.2. Control of forehearth, 75
- IV.8. A new approach – the Pochet furnace, 79
- References, 85

Chapter V. The conversion of glass into glass fibre, 86

- V.1. Marbles. Quality control, sorting and feeding of marbles to bushings, 88
- V.2. The fibre-drawing furnace – the bushing, 89
 - V.2.1. The nozzles, 93
 - V.2.2. The construction of a bushing, its assembly and mounting in a frame, 97

- V.2.3. Nozzle shields, 106
- V.3. Bushings — heating and associated services, temperature control, and their start-up and operation, 110
 - V.3.1. Bushing electrics, 110
 - V.3.2. Temperature control and temperature ramps, 114
 - V.3.3. Power and control connections to the bushing, start-up and operation, 119
 - V.3.4. The behaviour of bushings as they age, 121
 - V.3.5. The replacement of bushings, 121
- V.4. Fibre size applicators, 122
 - V.4.1. Types of applicators, 123
- V.5. Gathering shoes or combs, water sprays, and pull-down rollers, 128
 - V.5.1. Water sprays, 128
 - V.5.2. Gathering shoes and combs, 129
 - V.5.3. Pull-down rollers, 130
- V.6. Winders — their principles of operation and construction, 132
 - V.6.1. The collet, 134
 - V.6.2. The traverse, 136
 - V.6.3. Changes occurring during the winding of a cake, 142
 - V.6.4. Automatic winders, 144
- V.7. Geometry of a single bushing position, 148
 - V.7.1. Principles of bushing position geometry, 149
 - V.7.2. Services required in a fibre-drawing department, 155
 - V.7.2.1. Soft or distilled water, 157
 - V.7.2.2. Public water supply, 158
 - V.7.2.3. Electricity, 160
 - V.7.2.4. Air conditioning and working conditions, 160
 - V.7.2.5. Fibre size supply and return (if any), 162
 - V.7.2.6. Compressed air, 165
 - V.7.2.7. Waste disposal, 165
 - V.7.2.8. The operators, 167
 - V.7.3. Layout of a fibre-drawing department, 168
- V.8. The handling of fibre cakes, 172
- V.9. The drying of glass fibre cakes, 176
 - V.9.1. Dielectric drying, 178
- V.10. Control of the fibre-drawing process, 179
 - V.10.1. Fibre size — correct type and quantity deposited, 180

- V.10.2. Water content, 180
- V.10.3. Splitting efficiency, 181
- V.10.4. Control of tex (or count), 182
- V.11. The commissioning of a direct-melt furnace and associated fibre-drawing department, 185
- References, 190

Chapter VI. Fibre sizes for continuous glass fibres, 191

- VI.1. Fibre sizes for yarns and glass fibre products derived from yarns, 191
- VI.2. Fibre sizes for reinforcing organic polymers, 197
 - VI.2.1. Properties imparted by the fibre size which form a necessary part of the manufacturing process and/or properties of the product, 198
 - VI.2.2. The nature of glass surfaces and the problem of linking glass fibres to polymers, 201
 - VI.2.3. Polymers for composites, 202
 - VI.2.4. Keying agents, 203
 - VI.2.5. The film-former and adhesive, 211
 - VI.2.6. Plasticisers, 214
 - VI.2.7. Lubricants or softeners, 214
 - VI.2.8. Antistatic agents, 216
 - VI.2.9. Miscellaneous other materials, 216
 - VI.2.10. Formulation of fibre sizes for the reinforcement of plastics, etc., 217
 - VI.2.11. Mixing equipment, 224
 - VI.2.12. Some examples of fibre size formulations for a variety of applications, 225
 - VI.2.13. Factors influencing adjustments to fibre size formulations, 232
- References, 233

Chapter VII. The conversion of glass fibre strand into saleable products, 234

- VII.1. The manufacture of chopped strand mat, 234
 - VII.1.1. The forming section, 236

- VII.1.2. The binder applicator section, 243
- VII.1.3. The oven, 245
- VII.1.4. Ancillary equipment, 247
- VII.1.5. Chopped strand mat — some general operational procedures, 248
- VII.2. The manufacture of continuous filament mat, 248
- VII.3. The manufacture of rovings, 251
 - VII.3.1. Rovings for chopping, 257
 - VII.3.2. Rovings for weaving, 259
 - VII.3.3. Rovings for winding and rodmaking, 261
 - VII.3.4. The directly-wound roving, 261
- VII.4. The manufacture of roving cloth, 263
- VII.5. The manufacture of chopped strands, 266
- VII.6. The manufacture of yarns, 266
- VII.7. The disposal of waste glass fibre strands and products, 272
- References, 272

Author Index, 273

Subject Index, 274