

Contents

Chapter 1	Units, Mathematics, and Formulae	1
	<i>E. H. Werninck</i>	
1.1	Systems of Units	1
1.2	Metric Multiples and Submultiples	3
1.3	Units of Length	4
1.4	Units of Area	4
1.5	Units of Volume	4
1.6	Units of Mass, Weight, and Force	5
1.7	Units of Torque	6
1.8	Units of Power, Work, and Energy	6
1.9	Units of Temperature	6
1.10	Units of Pressure	7
1.11	Units of Viscosity	7
1.12	Trigonometric Functions and Equations	8
1.13	Vectors and Phasors	12
1.14	Fourier Analysis	13
1.15	Circuit and Network Calculations	14
1.16	Kirchhoff's Rules	16
Chapter 2	Application Considerations	19
	<i>D. D. Stephen and E. H. Werninck</i>	
2.1	Introduction	19
2.2	Problem Statements	20
2.3	Small Power Motors	21
2.4	Medium and Large Power Motors	22
2.5	Inertia	22
2.6	Starting Torque	23
2.7	Pull-out Torque	24
2.8	Transient Response	24
2.9	Inherent Motor Characteristics	25
2.10	Summary Table of Major Differences in Motor Characteristics	26
2.11	Rated Output	27
2.12	Criteria for Selecting Motors	28
2.13	Calculation of Load Power Requirements	29

Chapter 3	Direct Current Motors	48
	<i>D. Legg</i>	
	3.1 Motor Equations	48
	3.2 Circuits and Characteristics	60
	3.3 Constructional Features	70
	3.4 Commutation	85
	3.5 Specification and Performance	92
	References	104
Chapter 4	Alternating Current Motors	106
	<i>D. D. Stephen, E. H. Werninck and G. H. Rawcliffe</i>	
	4.1 Types of a.c. Motors	106
	4.2 Rotating Fields	106
	4.3 Speeds of a.c. Motors	111
	4.4 Rotors, Rotor Currents, Torque, and Slip	112
	4.5 The Equivalent Circuit of the Induction Motor	
	4.6 Synchronous Watts and Torque	117
	4.7 The Circle Diagram	120
	4.8 The effect of Voltage and Frequency on the Characteristics of the Induction Motor	126
	4.9 Multi-speed Induction Motors	128
	4.10 PAM Winding Induction Motor	130
	4.11 Synchronous Motors	135
	4.12 Three-phase a.c. Commutator Motors	142
	References	149
Chapter 5	Dimensions and Performance Standards	150
	<i>M. Bradford</i>	
	5.1 Introduction	150
	5.2 General Requirements of Electric Motors	151
	5.3 Motors for Particular Applications	171
	5.4 Application Requirements	179
	5.5 Other related standards and Codes of Practice	
	5.6 Definitions	181
	5.7 Summary of Probable Future Changes in Motor Standards	182
	5.8 List of British Standards	182
	5.9 List of International Standards	184
	References	185
Chapter 6	Linear Motors	186
	<i>E. R. Laithwaite</i>	
	6.1 Essential Differences Between Linear and Rotary Machines	186
	6.2 Forms of Construction	201
	6.3 Application Considerations	213
	6.4 Typical Applications	217
	6.5 Commercially Available Types	222
	References	223

Chapter 7	Small Power (Fractional Horsepower) Motors	224
	<i>G. I. Biscoe</i>	
	7.1 Introduction	224
	7.2 Induction Motors	225
	7.3 Polyphase Induction Motors	226
	7.4 Single-phase Induction Motors	226
	7.5 Split-phase Induction Motors	228
	7.6 Repulsion Start Induction Motors	230
	7.7 Repulsion Induction Motors	231
	7.8 Capacitor-Start Induction Motors	232
	7.9 Capacitor Start and Run Induction Motors	233
	7.10 Two-value Capacitor Motor	235
	7.11 Shaded-pole Induction Motor	235
	7.12 Synchronous Motors	238
	7.13 Reluctance Motors	239
	7.14 Single-phase Reluctance Motors	241
	7.15 Single-phase Capacitor Reluctance Motors	241
	7.16 Hysteresis Motors	242
	7.17 Polarized Synchronous Motors	246
	7.18 A.C. Commutator (Universal) Motors	247
	7.19 Repulsion Motors	250
	7.20 The Deri Motor	252
	7.21 Motor Selection Factors	252
	References	256
Chapter 8	Definite-purpose Motors	257
	<i>D. Knights</i>	
	8.1 Introduction	257
	8.2 Low-voltage Motors for Battery-powered Vehicles	257
	8.3 Crane, Hoist, Lift, and Conveyor Motors	271
	8.4 Motors for Fans, Blowers, and Pumps	273
	8.5 Submersible Motors	276
	8.6 Marine Motors	279
	8.7 Power-station Auxiliaries	281
	8.8 Motors for Vibratory Applications	283
	8.9 Textile Motors	285
	8.10 Motors for the Chemical Industry	289
	8.11 Motors for the Steel Industry	291
	8.12 Motors for Agricultural Machinery	292
	8.13 Motors for Woodworking Machinery	292
	8.14 Rotor-stator Units	293
	References	293
Chapter 9	Electric Motors for Flammable Atmospheres	295
	<i>P. B. Greenwood</i>	
	9.1 Introduction	295
	9.2 Classification of Hazardous Areas	295
	9.3 Grouping of Gases	296
	9.4 Types of Motor Available	297

9.5	Certification	298
9.6	Flameproof Motors	298
9.7	Motors for Use in Mines	304
9.8	Pressurized Motors	304
9.9	Type 'e' Motors	309
9.10	Type 'N' Motors	316
9.11	Combinations of Different Types of Protection	316
9.12	Choice of Motors	317
	References	317
Chapter 10	Small Special-purpose Motors	318
	<i>D. Knights</i>	
10.1	Introduction	318
10.2	Brushless d.c. Motors	318
10.3	The External Rotor Motor	325
10.4	Clock and Timer Motors	327
10.5	Electromagnetic Vibrating Motors	330
10.6	Direct-current Axial Air-gap Motors	333
10.7	High-frequency Motors	334
10.8	The Steromotor	335
	References	338
Chapter 11	Large a.c. Motors	339
	<i>J. C. H. Bone</i>	
11.1	Introduction	339
11.2	General Considerations	340
11.3	High-voltage Stator Windings	347
11.4	Squirrel-cage Induction Motors	352
11.5	Slipring Motors	356
11.6	Synchronous Motors	359
11.7	A.C. Commutator Motors	363
11.8	Enclosures	365
11.9	Standardization and Optimization	372
11.10	Motors and Systems	377
11.11	Conclusions	381
11.12	References	381
Chapter 12	Electronic Controls for Electric Motors	385
	<i>K. H. Williamson</i>	
12.1	Introduction	385
12.2	Power Control Devices	386
12.3	Variable Voltage Using Thyristors, Triacs, and Transistors	395
12.4	Variable Frequency from an a.c. Supply	399
12.5	Examples of Systems Using Electronic Control	403
12.6	Practical Problems	413
12.7	Mains Disturbance and Distortion	416
12.8	Maintenance	417
12.9	Specification Considerations	418
12.10	Static Contactors	420

Chapter 13 Materials and Components 421

E. H. Werninck

- 13.1 Bearings and Lubrication 421
- 13.2 Commutators, Brush-holders, and Brushes 426
- 13.3 Insulating Materials 429
- 13.4 Lubricants 432
- 13.5 Copper 433
- 13.6 Aluminium 435

Chapter 14 Motor Control Gear 436

R. F. Mathieson

- 14.1 Introduction 436
- 14.2 Starters for d.c. Motors 437
- 14.3 Speed Control of d.c. Motors 442
- 14.4 Speed Control of d.c. Motors under Overhauling Conditions 447
- 14.5 Emergency Stopping of d.c. Motors 449
- 14.6 Starters for a.c. Motors 450
- 14.7 Primary Resistance or Reactance Starters for Induction Motors 451
- 14.8 Star-Delta Starting of Cage Induction Motors 453
- 14.9 Auto-transformer Starting of Induction Motors 455
- 14.10 Part Winding Starters 456
- 14.11 Transient Peaks 457
- 14.12 Continuous Torque Closed Transition or Wauschope Star-Delta Starters 458
- 14.13 Auto-transformer Korndorfer Starter 458
- 14.14 Polyphase Wound Rotor Motor Starters 460
- 14.15 Starting of Single Phase Motors/Ferraris-Arno 461
- 14.16 Speed Control—a.c. Induction Motors 465
- 14.17 Speed Control of Wound-rotor Induction Motors 466
- 14.18 Speed Control of Single-phase Motors 467
- 14.19 Speed Control of a.c. Motors under Overhauling Conditions 467
- 14.20 Emergency Stopping of a.c. Motors 469
- 14.21 Protective Devices 470
- References 475

Chapter 15 Installation and Mounting 476

D. D. Stephen

- 15.1 Preliminaries 476
- 15.2 Forces in Electrically Driven Shaft Systems 476
- 15.3 Foundations 483
- 15.4 Machine Erection 484
- 15.5 Auxiliaries and Interfaces 485
- 15.6 Testing 486

Chapter 16 Geared Motors 488

H. Greiner (translated E. H. Werninck)

- 16.1 Low-speed Drives 488
- 16.2 Limitations of Speeds obtainable from Three-phase Motors 488
- 16.3 Economic Limits to Speed of Three-phase Induction Motors 488
- 16.4 Constructional Features 490
- 16.5 Sizes of Geared Motors 492
- 16.6 Construction and Space Requirements 492
- 16.7 The Drum Motor 494
- 16.8 Nominal Torque 497
- 16.9 Loading of Output Shaft Bearings 498
- 16.10 Selecting Transmission Elements for Reversing Drives 498
- 16.11 Electrical Protection of the Motor 502
- 16.12 Mechanical Protection 504
- 16.13 Special Geared Units 504

Chapter 17 Clutches and Brakes 508

R. G. Oakes

- 17.1 Introduction 508
- 17.2 Definition of Terms 508
- 17.3 Types of Clutches and Brakes 509
- 17.4 Friction Materials 522
- 17.5 Brake Motors 523
- 17.6 Life and Reliability 524
- 17.7 Disengaged Friction and Drag 524
- 17.8 Excitation and Switching 525
- 17.9 Response Time 526
- 17.10 Clutch Applications 526
- 17.11 Clutch/Brake Selection 527

Chapter 18 Control Motors 529

G. I. Biscoe

- 18.1 General Introduction 529
- 18.2 Alternating-current Servo-motors 531
- 18.3 Direct-current Servo-motors 537
- 18.4 Moving Coil Motors 541
- 18.5 Printed Circuit Motors 546
- 18.6 Stepping Motors 553
- 18.7 Direct-current Torque Motors 582
- 18.8 Selsyns 585
- References 591

Chapter 19 Maintenance 593

Part 1. Economics and planning 593

F. E. Butcher

- 19.1 Introduction 593
- 19.2 Clarification and Ratification of Policy

19.3	Planning	594
19.4	Standardized Maintenance Management	596
19.5	Plant Utilization	597
19.6	Planning Recurrent Activities	598
19.7	Aggregated Total Cost	598
19.8	Standard Motors	602
19.9	Over Capacity	602
Part 2. Procedures		603
<i>E. C. Haverley</i>		
19.10	Introduction	603
19.11	Cleaning	604
19.12	Overhaul	605
19.13	Breakdowns	611
Chapter 20	Measurement and Rating of Machine Noise	615
<i>E. H. Werninck and N. Binks</i>		
20.1	Introduction	615
20.2	Fundamental Aspects of Noise	615
20.3	Loudness	617
20.4	Noise Power Levels	619
20.5	Methods of Measurement and Interpretation of Results	620
20.6	Induction Motor Noise	620
Index		625