# Contents

About the Author Preface		ii xi
1	.1 Working and Auxiliary Motions in Machine Tools 1	
1	.2 Parameters Defining Working Motions of a Machine Tool 3	
1	.3 Machine Tool Drives 19	
1	.4 Hydraulic Transmission and Its Elements 23	
1	.5 Mechanical Transmission and Its Elements 34	
1	.6 Technico-economical Prerequisites for Undertaking the Design of a New Machine Tool	52
1	.7 General Requirements of Machine Tool Design 54	
1	.8 Engineering Design Process Applied to Machine Tools 57	
1	.9 Layout of Machine Tool 60	
	Review Questions 65	
	References 67	
2.	REGULATION OF SPEED AND FEED RATES	68
2	2.1 Aim of Speed and Feed Rate Regulation 68	
2	2.2 Stepped Regulation of Speed: Design of Speed Box 69	
2	2.3 Design of Feed Box 90	
2	2.4 Machine Tool Drives Using Multiple-speed Motors 95	
2	2.5 Special Cases of Gear Box Design 98	
2	2.6 General Recommendations for Developing the Gearing Diagram 105	
2	2.7 Determining the Number of Teeth of Gears 108	
2	2.8 Classification of Speed and Feed Boxes 118	
2	2.9 Stepless Regulation of Speed and Feed Rates 124	
2.	10 Kinematics of Machine Tools 140	
	Review Questions 163	
	References 166	
3.	DESIGN OF MACHINE TOOL STRUCTURES	167
3	6.1 Functions of Machine Tool Structures and their Requirements 167	

3.2 Design Criteria for Machine Tool Structures 167

- 3.3 Materials of Machine Tool Structures 170
- 3.4 Static and Dynamic Stiffness 175
- 3.5 Profiles of Machine Tool Structures 182
- 3.6 Basic Design Procedure of Machine Tool Structures 188
- 3.7 Design of Beds 197
- 3.8 Design of Columns 213
- 3.9 Design of Housings 216
- 3.10 Design of Bases and Tables 219
- 3.11 Design of Cross Rails, Arms, Saddles and Carriages 221
- 3.12 Design of Rams 222
- 3.13 Model Technique in Design of Machine Tool Structures 224 Review Questions 228 References 231

### 4. DESIGN OF GUIDEWAYS AND POWER SCREWS

- 4.1 Functions and Types of Guideways 233
- 4.2 Design of Slideways 234
- 4.3 Design Criteria and Calculations for Slideways 243
- 4.4 Guideways Operating under Liquid Friction Conditions 251
- 4.5 Design of Aerostatic Slideways 265
- 4.6 Design of Anti-friction Guideways 267
- 4.7 Combination Guideways 273
- 4.8 Protecting Devices for Slideways 274
- 4.9 Design of Power Screws 276 Review Questions 285 References 287

#### 5. DESIGN OF SPINDLES AND SPINDLE SUPPORTS

- 5.1 Functions of Spindle Unit and Requirements 288
- 5.2 Materials of Spindles 289
- 5.3 Effect of Machine Tool Compliance on Machining Accuracy 290
- 5.4 Design Calculations of Spindles 294
- 5.5 Anti-friction Bearings 303
- 5.6 Sliding Bearings 310

Review Questions 332 References 333 233

288

Contents ix

335

386

419

494

# 6. DYNAMICS OF MACHINE TOOLS 6.1 Machine Tool Elastic System-cutting Process Closed-loop System 335 6.2 General Procedure for Assessing Dynamic Stability of Ees—Cutting Process Closed-Loop System 336 6.3 Dynamic Characteristics of Elements and Systems 339 6.4 Dynamic Characteristic of the Equivalent Elastic System 340 6.5 Dynamic Characteristic of the Cutting Process 352 6.6 Stability Analysis 366 6.7 Forced Vibrations of Machine Tools 378 Review Questions 383 References 385 7. CONTROL SYSTEMS IN MACHINE TOOLS 7.1 Functions, Requirements and Classification 386

- 7.2 Control Systems for Changing Speeds and Feeds 386
- 7.3 Control Systems for Executing Forming and Auxiliary Motions 396
- 7.4 Manual Control Systems 397
- 7.5 Automatic Control Systems 410
- 7.6 Adaptive Control Systems 415 References 418

### 8. NUMERICAL CONTROL OF MACHINE TOOLS

- 8.1 Fundamental Concepts, Classification and Structure of Numerical Control Systems 419
- 8.2 Manual Part Programming 440
- 8.3 Computer Aided Part Programming 465 Review Questions 486 References 493

## 9. EXTENSIONS OF NUMERICAL CONTROL— CNC, DNC, MACHINING CENTRES

- 9.1 Distributive Numerical Control (DNC-1) 495
- 9.2 Computer Numerical Control (CNC) 495
- 9.3 Machining Centres 498
- 9.4 Direct Numerical Control (DNC-2) 501
- 9.5 CNC Programming 504 Review Questions 538

### Index