

Contents

Preface	ix
About the Authors	xi
1 Using Precise Mechanisms in Modern Vacuum Technological Equipment	1
References	18
2 Typical Vacuum Mechanisms	21
2.1 Functions of Vacuum Mechanisms	21
2.2 Rotary-Motion Feedthroughs	21
2.3 Linear-Motion Feedthrough	25
2.4 Manipulators	27
2.5 Micro Mechanisms	29
References	32
3 Friction in Vacuum	33
3.1 Friction Coefficients of Different Materials in Atmosphere and in Vacuum	33
3.2 Dry Friction Laws in Atmosphere and in Vacuum	33
3.3 The Main Factors, which Determine the Surface Coverage at “Dry” Friction	35
3.3.1 Influence of the Residual Pressure and Temperature	36
3.3.2 Influence of the Sliding Velocity and Roughness Geometry ..	37
3.4 The Theoretical Analysis of Friction in the Different Ranges of Coverage	39
3.4.1 Viscous Component of a Friction Force	40
3.4.2 Capillary Component of a Friction Force	41
3.4.3 Adhesive-Viscous Friction	43
3.4.4 Adhesive Friction	47
3.4.5 Cohesion Friction	48

- 3.5 The Possibility to Use the Described Method for the Calculation of the Friction Coefficient of Real Surfaces 51
- 3.6 Exchange of Gases at Friction in Vacuum 55
- References 65
- 4 Matrix Method of the Design of New Mechanisms Structure 69**
 - 4.1 The Stages of the Matrix Method of the Mechanisms Generation . . . 70
 - 4.2 The List of the Parameters of Vacuum Mechanisms Which Are Used in Matrix Analysis 77
 - 4.2.1 The First (Highest) Level Parameters 77
 - 4.2.2 The Second Level Parameters 79
 - 4.2.3 The Third Level Parameters 80
 - 4.2.4 The Fourth Level Parameters 81
 - 4.3 Algorithm of the Matrix Method of the Generation of New Mechanisms 83
 - References 86
- 5 Precision of Vacuum Mechanisms 87**
 - 5.1 The Constituents of Errors of Vacuum Mechanisms 87
 - 5.2 The Basic Positions of the Precision Theory of Vacuum Mechanisms 93
 - 5.2.1 Open-Loop-Controlled Drive 93
 - 5.2.2 Completely Loop-Controlled Drive 96
 - 5.3 Determination of the Error Components of Different Origins 98
 - 5.3.1 Calculation of the Kinematic Component of the Error 98
 - 5.3.2 Calculation of the Error from Elastic Deformations 113
 - 5.3.3 Calculation of the Error Caused by the Deformation of the Thin-Wall Sealing Elements 114
 - 5.3.4 Calculation of the Positioning Error Caused by the Resistance Forces at Movement 120
 - 5.4 Summarizing the Components of different Types and Forms 129
 - 5.5 Correlation of Total Error of the Mechanisms with Economic Parameters 133
 - References 134
- 6 Vacuum Mechanisms of Nanoscale Precision 137**
 - 6.1 The Principles of Nanometer Precision of Vacuum Mechanisms . . . 138
 - 6.2 Physical Effects Which Are Used for Vacuum Mechanisms of Nanometer Precision Creation 146
 - 6.2.1 Piezo Effect 146
 - 6.2.2 Magnetic and Electric Rheology Effects 148
 - 6.3 Vacuum Drives and Manipulators of Nanoscale Precision 152
 - 6.3.1 Vacuum Piezo Drives 153
 - 6.3.2 Multi-Coordinate Magnetic and Rheology Drives and Manipulators 157
 - References 166

7	Ultrahigh Vacuum Rotary-Motion Feedthroughs	167
7.1	Analysis of Design Variants of Thin-Wall Sealing Elements on Parameter “Manufacturability”	167
7.2	Precision of Harmonic Gear Rotary Feedthroughs	171
7.3	Longevity of Harmonic Gear Rotary Feedthrough	172
7.4	Outgassing Flow of Harmonic Rotary-Motion Feedthrough	173
7.5	Calculation of Hermetic Harmonic Gear Feedthrough	177
7.5.1	Determination of the Number of Teeth	177
7.5.2	Calculation of Main Sizes of Flexible Gears	178
7.5.3	Calculation of Control Rollers Size of Rigid Gear	179
7.5.4	Calculation of Flexible Gear Geometry, Calculation of Geometry Sizes which Ensure Hermetic Properties of Flexible Gear	180
7.5.5	Calculation of Assurance Factor of Flexible Gear Teeth	183
7.5.6	Calculation of Flexible Gear Wave Generator	183
	References	184
8	Ultrahigh Vacuum Non-Coaxial Linear-Motion Feedthroughs	185
8.1	The Hermetic Drive Designs Principles Based on Non-Coaxial Nut-Screw Couples	187
8.2	Geometry of Nut-Screw Coupling of Linear-Motion Hermetic Feedthrough	191
8.3	Kinematic Calculation	195
8.4	Force Calculation of Hermetic Feedthroughs Based on Non-Coaxial Nut-Screw Mechanisms	198
8.5	System Losses and Efficiency Factor of Hermetic Feedthroughs Based on Non-Coaxial Nut-Screw Mechanisms	200
8.6	Analysis of Loading Ability of Planetary Nut-Screw Feedthroughs	203
	References	206
9	Vacuum Frictionless Mechanisms	209
10	Flow of Microparticles Originating from Mechanisms in Vacuum	225
10.1	Theory of a Flow of Microparticles Originating from Mechanisms in Vacuum	225
10.2	The Design of the Equipment Which Generates a Minimal Number of Microparticles by the Mechanisms in Vacuum	230
	References	234