Krzysztof Czolczynski

Rotordynamics of Gas-Lubricated Journal Bearing Systems

With 90 Illustrations
Contents

Series Preface ........................................ v
Preface ................................................ vii
Introduction ......................................... 1

Part I Theory

1. Mathematical Model of a Gas Journal Bearing ............... 11
   1.1. Reynolds Equation .................................. 14
   1.2. Numerical Solution of the Reynolds Equation .......... 15
   1.3. Equations of Mass Flow through Feeding System ....... 18
   1.4. "Orbit" Model of Gas Bearing ...................... 22

2. Identification of Stiffness and Damping Coefficients ....... 25
   2.1. Free Vibrations .................................. 26
   2.2. Step-Jump ....................................... 27
   2.3. Harmonic Forcing ................................ 27
   2.4. Harmonic Motion of the Shaft ....................... 31
       2.4.1. Accuracy of the Method ....................... 37
       2.4.2. Estimation of the Coefficients for any $\Lambda$ and $v$ – Interpolation 41

   3.1. Equations of Motion – Symmetrical System ............. 49
   3.2. Reduced System .................................. 54
   3.3. Method of Calculation of Eigenvalues .................. 57
   3.4. Equations of Motion – Unsymmetrical System .......... 58
Part II Applications

4. Gas Bearings ............................................................. 63
   4.1. Static Characteristics of Gas Bearings ....................... 64
   4.2. Stiffness and Damping Coefficients of Gas Bearings ...... 66
       4.2.1. Self-Acting Bearings .................................... 66
       4.2.2. Bearings with the Direct Feeding System .......... 66
       4.2.3. Bearings with the Chamber Feeding System ....... 79
       4.2.4. Conclusions ............................................. 79

5. Stability of Rotor - Gas Bearing System .......................... 83
   5.1. Stability of Rotor with Unmovable Bushes ................. 83
   5.2. Stability of Rotor with Elastically Mounted Bushes - Symmetrical (Reduced) System .................. 85
       5.2.1. How to Design the Rotor Support .................... 93
   5.3. Stability of Unsymmetrical Rotor with Elastically Mounted Bushes 96
       5.3.1. Stability of the Homogeneous Shaft Supported in Two Bearings .................................. 96
       5.3.2. Stability of the Rotor with Concentrated Mass of the Shaft .................................... 98
       5.3.3. Stability of the Unsymmetrical Rotor with the Unsymmetrical Support of the Bushes .... 101
       5.3.4. An Influence of the Mass of the Bushes on the Size of Always-Stable Loops .......... 104

6. Air Rings .................................................................. 105
   6.1. Air Rings with the Direct Feeding System ................. 105
   6.2. Air Rings with the Chamber Feeding System .............. 112
       6.2.1. Air Hammer ................................................. 113
       6.2.2. Stiffness and Damping Coefficients of Air Rings ... 116

7. Stability of the Rotor - Bearing - Air Rings System (Applications) .... 125
   7.1. Application 1 ...................................................... 126
   7.2. Application 2 ...................................................... 129
   7.3. Application 3 ...................................................... 132
   7.4. Application 4 ...................................................... 135

References ................................................................. 141

Notation .......................................................................... 147

Index ............................................................................. 151