

Contents

1	Introduction — 1
1.1	Outline — 1
1.2	Influence Factors of Magnetic Flux Leakage Testing — 3
1.2.1	The Influence of Magnetizing — 3
1.2.2	The Influence of Testing — 9
1.3	Research Status of Defect Quantification Method of Magnetic Flux Leakage Testing — 11
1.3.1	MFL Detection Theory and Technology Development — 11
1.3.2	Research on Quantitative Inversion Technique of Defects — 14
1.3.3	The Problems of Defect Quantitative Inversion in MFL Testing — 18
2	Testing Signal Processing Method — 21
2.1	Data Acquisition and Storage — 21
2.1.1	Data Acquisition of Magnetic Flux Leakage Testing — 21
2.1.2	Organization and Storage of Data — 22
2.2	Data Compression and Noise Reduction Method — 24
2.2.1	Testing Data Compression — 24
2.2.2	Noise Reduction Method of the Testing Signal — 27
3	Quantitative Method of Magnetic Flux Leakage Testing — 34
3.1	Outline — 34
3.2	Defect Quantification Method based on Statistical Identification — 39
3.2.1	Pretreatment of Magnetic Flux Leakage Signal — 39
3.2.2	Definition and Extraction of the Waveform Features — 41
3.2.3	Statistical Identification of Defect Length — 43
3.2.4	Multivariate Statistical Analysis Method — 45
3.2.5	Statistical Identification of Defect Width — 49
3.2.6	Statistical Identification of Defect Depth — 51
3.3	Defect Quantification Method Based on Radial Basis Function Neural Network — 52
3.3.1	The Iterative Method Based on Neural Network — 52
3.4	Defect Quantification Method Based on 3D Finite Element Neural Network — 60
3.4.1	Discretization Principle of Finite Element Method — 60
3.4.2	Finite Element Neural Network — 62
3.4.3	From One Dimension to Three Dimensions — 67
3.4.4	Solving Positive and Inverse Problems Using FENN — 70
3.4.5	Analysis on the Advantages of the FENN — 72
3.4.6	The Optimization of FENN — 73

- 4 Defect Profile Inversion of Three-Dimensional MFL Detection — 76**
 - 4.1 The Characteristics of Three-Dimensional MFL Signal — 76**
 - 4.1.1 The Basic Characteristics of the Signal — 76**
 - 4.1.2 The Signal Changes with the Size of Defects — 80**
 - 4.2 Random Search Iterative Inversion Method of Defect 3D Contour — 82**
 - 4.2.1 The Region Segmentation and Recognition — 82**
 - 4.2.2 Defect Opening Contour Detection Method — 86**
 - 4.2.3 Defect 3D Profile Mesh Model — 90**
 - 4.2.4 Random Searching Iterative Inversion for the 3D Profile of Defects — 92**
 - 4.3 Iterative Inversion of Neural Networks for Defect 3D Profiles — 115**
 - 4.3.1 Main Feature Extraction of 3D MFL Detection Signal — 115**
 - 4.3.2 Defect 3D Profile Strip Model — 126**
 - 4.3.3 Forward Prediction of MFL Signal Based on RBF Neural Network — 128**
 - 4.3.4 Iterative Inversion of RBF Neural Network for 3D Profile of Defects — 138**
 - 4.4 Multistage Successive Approximation Inversion Method for Defect 3D Profile — 145**
 - 4.4.1 Multistage Inversion of Defect Profiles — 147**
 - 4.4.2 Progressive Refinement of the Defect Mesh Model — 151**
 - 4.4.3 Progressive Refinement of Division Size of Finite Element Model — 155**
 - 4.4.4 Three-Dimensional Profile Inversion Test of Actual Defect — 160**
 - 4.5 Influence and Correction of Sampling Precision on the 3D Profile Inversion of Defects — 166**
 - 4.5.1 The Influence of Sampling Precision — 166**
 - 4.5.2 Interpolation Correction Method for Three-Dimensional MFL Signal — 167**
 - 4.5.3 Test Verification — 171**
- 5 Three-Dimensional MFL Imaging Detection — 175**
 - 5.1 Characteristics of Three-Dimensional MFL Signal — 175**
 - 5.1.1 Parameter Definition of Pits — 175**
 - 5.1.2 Parameter Definition of Horizontal Grooves — 178**
 - 5.1.3 Parameter Definition of Tangential Grooves — 179**
 - 5.2 Defect Classification Quantitative Method under Complete MFL Signal — 182**
 - 5.2.1 Defect Classification Method Based on RBF Neural Network — 183**
 - 5.2.2 Defect Quantization Method Based on BP Neural Network — 188**

5.3	Quantization and Display Method of Defect Under Incomplete Signal —	203
5.3.1	Defect Edge Recognition —	203
5.3.2	Defect Depth Estimation —	212
5.3.3	Real-Time Display of Defect Under Incomplete Signal —	218
References —		225
Index —		231