

Contents

1. Surface texture: two-dimensional	1
1.1 Introduction	3
1.2 Establishing the <i>Ra</i> numerical value of surface texture from the production process	8
1.3 Surface texture roughness comparison blocks and precision reference specimens	8
1.4 The basic operating principle of the pick-up, its stylus and skid	9
1.5 Filters and cut-off	13
1.6 Measuring lengths	15
1.7 Filtering effects (λ_s , λ_c and λ_f)	19
1.8 Geometrical parameters	21
1.9 Surface profile parameters	22
1.9.1 Amplitude parameters (peak-to-valley)	23
1.9.2 Amplitude parameters (average of ordinates)	24
1.9.3 Spacing parameters	29
1.9.4 Hybrid parameters	29
1.9.5 Curves and related parameters	29
1.9.6 Overview of parameters	32
1.10 Auto-correlation function	32
1.11 Appearance of peaks and valleys	34
1.12 Stylus-based and non-contact systems	37
1.12.1 Pick-up	40
1.12.2 Skid or pick-up operation	43
1.12.3 Portable surface texture instruments	45
1.12.4 Surface form measurement	46
1.12.5 Non-contact systems	50
1.13 Nanotopographic instruments	63
2. Surface texture: three-dimensional	69
2.1 Introduction	71
2.1.1 Stylus speed and dynamics	72
2.1.2 Envelope and mean systems	74
2.1.3 Three-dimensional characterisation	74
2.2 Three-dimensional analysis software	79
2.2.1 Functional 3-D performance	85
2.3 Portable three-dimensional measuring instruments	89
2.4 Fractal techniques	90

2.4.1	Topological characterisation	90
2.5	Textured metal sheets	93
2.6	Surface topography characterisation by neural networks	94
2.7	Non-contact measurement	96
3.	Surface microscopy	101
3.1	Introduction	103
3.2	Scanning electron microscope	105
3.2.1	Energy-dispersive X-ray spectrometer	112
3.2.2	Transmitted electron image	114
3.3	Transmission electron microscope	114
3.3.1	Transmission electron microscopy: general application	119
3.4	Atomic force microscope	119
3.4.1	Criteria for using scanning probe microscopes	121
3.4.2	Atomic force microscope: operating principle	123
3.4.3	Atomic force/scanning probe microscope: applications	125
3.4.4	Ultrasonic force microscope: developments	128
3.5	X-ray photoelectron spectroscopy	130
4.	Roundness and cylindricity	135
4.1	Introduction	137
4.1.1	Roundness measurement: basic approach	143
4.2	Roundness: measuring instruments	144
4.2.1	Types of instrument	145
4.2.2	Spindle and bearings	146
4.3	Methods of measurement	150
4.3.1	Assessment of part geometry	152
4.4	Display and interpretation	156
4.5	Roundness measurement from the display	157
4.5.1	Roundness reference circles	159
4.5.2	Numerical value of roundness	160
4.5.3	Filtering and harmonics	162
4.6	Geometric roundness parameters	171
4.6.1	Cylindricity	173
4.6.2	Cylindricity measurement techniques	176
4.6.3	Cylindrical measurement problems	177
4.7	Non-contact spherical and roundness assessment	178
4.7.1	Sphericity interferometer	178
4.7.2	Spherical and roundness assessment by error separation	180
5.	Machined surface integrity	185
5.1	Introduction	187
5.2	The machined surface	189
5.2.1	Residual stresses in machined surfaces	192
5.2.2	Tribological cutting effect on surface	196

5.2.3	Micro-hardness testing	198
5.2.4	Surface cracks and “white layers”	203
5.2.5	Machined surface topography	211
5.2.6	Machined roundness	220
5.2.7	Power spectrum analysis of machined surfaces	234
5.2.8	Manufacturing process envelopes	236
5.3	Surface engineering	243
6.	Quality and calibration techniques	249
6.1	Size and scale	252
6.2	Predictable accuracy: its evolution	253
6.3	Traceability of measurement	255
6.4	Measurement uncertainty	262
6.5	Calibration: surface texture	274
6.5.1	Surface texture artefacts	274
6.5.2	Stylus damage	281
6.6	Calibration: roundness	282
6.7	Probing uncertainty: roundness and form	288
6.8	Nanotechnology instrumentation: now and in the future	289
	Appendices	297
	Appendix A – Previous and some current surface texture parameters	299
	Appendix B – Amplitude–wavelength analysis: “Stedman diagrams”	317
	Appendix C – Surface texture and roundness: calibration diagrams and photographs	320
	Appendix D – Hardness conversion chart	325
	Index	327