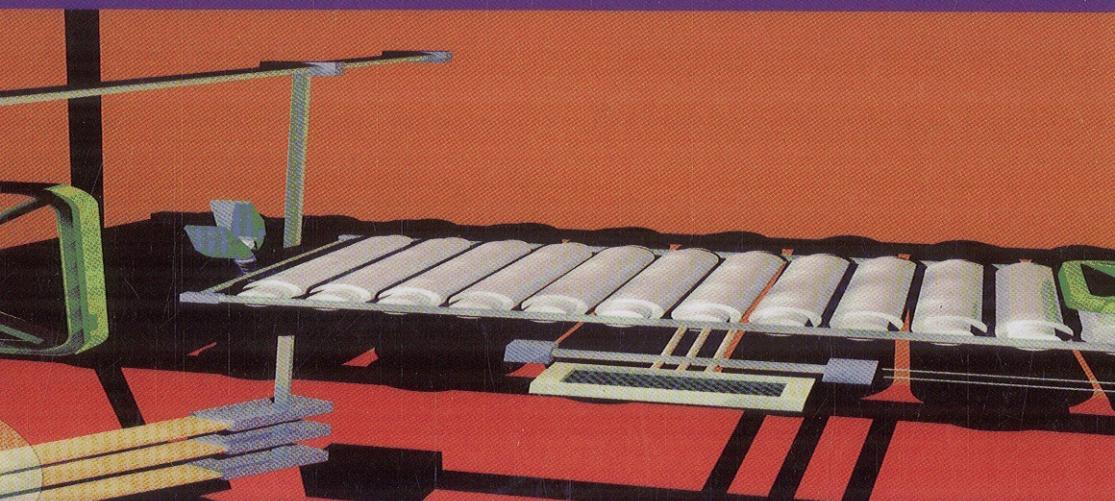


CAM

Control Systems, Robotics and Manufacturing Series



Intelligent Machining

Edited by
Tugrul Özel and J. Paulo Davim

iSTE

WILEY

Table of Contents

Preface	xi
Chapter 1. Modern Machining Process	1
Luis Norberto LOPEZ DE LACALLE, Joaquim DE CIURANA and Tugrul ÖZEL	
1.1. Introduction	1
1.2. High speed cutting	2
1.3. Hard turning	3
1.3.1. Tool micro-geometry	8
1.3.2. Surface quality and integrity	11
1.3.3. Tool wear and failure	11
1.4. High-speed milling	15
1.4.1. Historical remarks	15
1.4.2. Current meaning of HSM	18
1.4.3. High-speed milling of aluminum alloys	21
1.4.4. High-speed milling of titanium alloys	30
1.4.5. High-speed milling of die/mould steels	31
1.4.6. High-speed milling of superalloys	36
1.4.7. Machine tool technology	37
1.4.8. Cutting tool technology	42
1.5. High-throughput drilling	43
1.5.1. Throughput drilling process parameters	45
1.5.2. Models for cutting forces in throughput drilling	49
1.5.3. Optimal conditions in throughput drilling	55
1.6. Environmentally benign manufacturing	58
1.6.1. Dry and near-to-dry machining	59

1.6.2. Reduction of machine power consumption	60
1.7. References	61
Chapter 2. Analytical and Mechanistic Modeling of Machining Processes	71
Wit GRZESIK	
2.1. The essential features of metal cutting processes	71
2.1.1. Orthogonal (two-dimensional) machining	71
2.1.2. Oblique (3D) machining	72
2.2. Plastic deformation and fracture	74
2.2.1. Mechanisms of plastic deformation	74
2.2.2. Measures of plastic deformation	74
2.2.3. Material constitutive models	75
2.2.4. Mechanism of fracture in metal cutting	76
2.3. Chip formation in metal cutting operations	78
2.3.1. Models for primary deformation zone	78
2.3.2. Chip formation mechanisms	80
2.3.3. Chip formation models	82
2.3.4. Relationships for shear angle	88
2.3.5. Chip flow rules	93
2.3.6. Fracture in chip breaking	96
2.4. Cutting forces and stresses	97
2.4.1. Force distribution in the cutting zone	97
2.4.2. Models for cutting forces	99
2.4.3. Ploughing force and minimum UCT	100
2.4.4. Stresses on the shear plane	102
2.5. Cutting energy and power	103
2.5.1. Components of cutting energy	103
2.5.2. Specific cutting energy/power	104
2.6. Friction in metal cutting	106
2.6.1. Models for tool/chip interface	106
2.6.2. Tool/chip contact length	108
2.6.3. Determination of friction coefficient	109
2.6.4. Relationships between friction and plastic deformation	111
2.7. Thermal modeling	111
2.7.1. Heat partitioning	111
2.7.2. General analytical model for cutting temperature	113
2.7.3. Temperature in the primary and secondary deformation zone	114

2.8. Mechanistic and predictive models for orthogonal and oblique cutting	115
2.8.1. Mechanistic models	115
2.8.2. Strain rate analysis	117
2.8.3. Similarity method	119
2.9. References	121
Chapter 3. Finite Element Modeling of Machining Processes	125
Pedro J. ARRAZOLA and Tugrul ÖZEL	
3.1. Introduction	125
3.2. Finite element modeling at the meso scale (cutting edge)	127
3.2.1. Finite element models: formulations	130
3.2.2. Commercial software	135
3.3. Sensitivity study to define input parameters	137
3.4. Finite element model definition	137
3.5. Sensitivity analysis of input parameters	139
3.5.1. Test plans	139
3.5.2. Analysis of the results	141
3.5.3. Process and numerical parameter influence	143
3.5.4. Identification tolerance	143
3.5.5. Inverse identification of input parameters	144
3.6. Identification of input parameters	148
3.6.1. Material behavior law	148
3.6.2. Friction coefficient	153
3.6.3. Identification of the other parameters	157
3.7. Finite element model validation	157
3.7.1. In-process techniques	157
3.7.2. Before and post-process techniques	159
3.7.3. Validation of FEM results	159
3.7.4. Summary	161
3.8. Conclusions	162
3.9. Acknowledgments	163
3.10. References	163
Chapter 4. Computational Modeling of Machining Systems	173
Ramón QUIZA and J. Paulo DAVIM	
4.1. Introduction	173
4.1.1. Relevance of the modeling of machining systems	173
4.1.2. Brief historical note	174
4.1.3. Off-line versus on-line modeling	177

4.2. Computational tools for modeling of machining systems	178
4.2.1. Preliminary considerations	178
4.2.2. Artificial neural networks.	178
4.2.3. Fuzzy logic.	182
4.2.4. Neuro-fuzzy systems.	184
4.2.5. Other non-conventional techniques	185
4.3. Modeling for monitoring and control.	187
4.3.1. Tool wear monitoring	187
4.3.2. Tool breakage and fault detection	194
4.3.3. Monitoring of other parameters	195
4.3.4. Intelligent control.	196
4.4. Modeling for process planning and optimization	197
4.4.1. Modeling of tool wear and tool life	197
4.4.2. Modeling of surface roughness	198
4.4.3. Modeling of cutting forces	198
4.4.4. Modeling of other parameters	199
4.5. A case study	199
4.5.1. Experimental set-up	200
4.5.2. Neural network-based modeling	202
4.5.3. Comparison between statistical and neural network models	206
4.6. Concluding remarks.	208
4.7. Acknowledgment	209
4.8. References.	209
Chapter 5. Design of Experiments	215
Vinayak N. GAITONDE, Ramesh S. KARNIK and J. Paulo DAVIM	
5.1. Introduction.	215
5.1.1. Conventional approach	216
5.1.2. Need for mathematical modeling	216
5.2. Design of experiments	217
5.2.1. Classification of DOE	218
5.3. Modeling using response surface methodology	223
5.3.1. Steps for the development of an RSM-based model	223
5.3.2. Response surface modeling – a case study using FFD.	226
5.3.3. Response surface modeling – a case study using CCD	227
5.3.4. Response surface modeling – a case study using BBD	229
5.4. Taguchi-based designs	231
5.4.1. Experimental plans and orthogonal arrays	231

5.4.2. Signal-to-noise ratio	233
5.4.3. Taguchi optimization procedure	234
5.4.4. Taguchi multi-objective optimization	235
5.5. Summary	241
5.6. Acknowledgement	242
5.7. References.	242
Chapter 6. Single and Multi-objective Optimization Methods. . .	245
Tugrul ÖZEL	
6.1. Machining optimization	245
6.2. Intelligent optimization techniques	248
6.3. Case studies in machining optimization	253
6.3.1. Case study 1: minimizing surface roughness and minimizing machining time	253
6.3.2. Case study 2: maximizing tool life and maximizing material removal rate	258
6.3.3. Case study 3: minimizing machining induced stress and minimizing surface roughness	259
6.4. References.	267
List of Authors	271
Index	273