

---

# Contents

<b>List of Figures</b> .....	X
<b>List of Tables</b> .....	XV
<b>1 Introduction</b> .....	1
1.1 Motivation and Structure of the Book .....	1
1.2 CAD/CAM Formats .....	3
1.3 Short Literature Survey .....	4
References .....	16
<b>2 Introduction to Five-Axis NC Machining</b> .....	25
2.1 Five-Axis NC Machining Concepts .....	25
2.2 NC Part Programming .....	28
2.3 Classification of Five-Axis Machines .....	34
2.4 Five-Axis Machine Kinematics .....	37
2.5 Five-Axis Machining Example .....	43
References .....	48
<b>3 Fundamental Issues in Tool Path Planning</b> .....	51
3.1 Surface Representation .....	51
3.2 Machining Strip Width Estimation .....	53
3.3 Optimal Tool Orientation and Gouging Avoidance .....	60
3.4 Kinematics Error .....	63
3.5 Tool Path Generation .....	66
References .....	68
<b>4 Space-Filling Curve Tool Paths</b> .....	73
4.1 History of Space-Filling Curves and Their Applications .....	73
4.2 Tool Path Optimization .....	75
4.3 Tool Path Generation using Adaptive Space-filling Curves ..	77
4.3.1 Grid Construction .....	77

4.3.2	Space-Filling Curve Generation .....	78
4.3.3	Tool Path Correction .....	80
4.4	Examples and Discussion .....	83
	References .....	94
<b>5</b>	<b>Tool Paths in Adaptive Curvilinear Coordinates .....</b>	<b>97</b>
5.1	Introduction .....	97
5.2	A Historical Note on Grid Generation .....	98
5.3	Variational Grid Generation for Tool Path Optimization....	101
5.3.1	Preliminary Examples .....	101
5.3.2	Variational Method and Functionals .....	102
5.3.3	The Harmonic Functional .....	109
5.3.4	Examples of the Tool Path Optimization .....	110
5.4	Application of Harmonic Functional to Tool Path Generation	116
5.5	Space-Filling Curve Generation on Block Structured Grid ..	124
5.6	Examples and Discussion .....	125
	Appendix: Derivation of Computational Formulas for Adaptive-Harmonic Grid Generation .....	133
	References .....	144
<b>6</b>	<b>Optimization of Rotations .....</b>	<b>151</b>
6.1	Introduction .....	151
6.2	Kinematics Error and Angle Variation .....	155
6.3	Optimization Problem .....	160
6.4	Optimization Problems: Examples and Practical Machining .	162
6.5	Uniform Angular Grids.....	168
6.6	Uniform Angular Grids: Numerical and Machining Experiments .....	176
	Appendix: The APT cutter .....	182
	References .....	183
<b>7</b>	<b>Theory of Optimal Setup for Five-Axis NC Machining ...</b>	<b>185</b>
7.1	Introduction .....	185
7.2	Tool Trajectory Analysis .....	189
7.2.1	Invariant Parameters .....	189
7.2.2	Workpiece Setup and the Tool Trajectory .....	190
7.3	Least-Squares Optimization and Dependent Variables .....	192
7.3.1	Least-Squares Optimization.....	192
7.3.2	Dependent Variables.....	193
7.4	Examples and Discussion .....	194
7.4.1	Numerical Method.....	194
7.4.2	Examples .....	195
	References .....	202
	<b>Index .....</b>	<b>205</b>

Advanced Numerical Methods to Optimize Cutting  
Operations of Five Axis Milling Machines

Makhanov, S.S.; Anotaipaboon, W.

2007, XVII, 206 p., Hardcover

ISBN: 978-3-540-71120-9