## CONTENTS

Preface to the American Edition	xi
Acknowledgements	xv
INTRODUCTION	xvii
List of Symbols	xix
PART I: BASIC RESEARCH	
CHAPTER 1. MECHANICS OF METAL CUTTING	
(a) Historical development	3
(b) Shear angle and compression factor	
(c) The metal cutting velocities	
(d) Measuring the chip compression	15
(e) Friction and the apparent coefficient of friction	
(f) Theories of friction	22
(g) The basic equation in the theory of machinability	25
(h) A new approach to the basic equation	31
(i) Testing the new formulas	
CHAPTER 2. EFFECT OF MACHINING OPERATIONS ON THE PHYSICAL PROPERTIES OF WORK-MATERIALS	46
CHAPTER 3. DIMENSIONAL ANALYSIS OF METAL CUTTING RELATIONS	48
(a) The nature of dimensional analysis	48
(b) Dimensional analysis of tool temperatures	50
(c) Dimensional analysis of the tool life-cutting speed relationship	56
(d) Generalization of the Taylor equation	58
(e) Analysis of the Taylor constant $C_r$	61
(f) Analysis of the tool life-temperature relationship	61
(g) Dimensional analysis of the temperature-time relationship	62
Chapter 4. Thermal Research in Metal Cutting	65
(a) Temperature and heat in chip and tool	65
(b) Cooling and lubrication	71
Chapter 5. Tool Geometry	78
(a) The four principal angles between tool face and reference plane	78
(b) Definitions of the principal tool angles	81
(1) Irue rake (ii) Oblique rake	81 81
(iii) Angle of inclination of the cutting edge	82
(c) Reasons for definitions	82

1.40	
CONTENŤ	C
CONTENT	3

(d) Equations for tool geometry	83
(1) Equation for the true rake angle ( $\alpha$ ) (ii) Equation for the angle of indication (1)	84
(ii) Equation for the oblique rake $(\sigma)$	83. 88
(e) Positive and negative maxima for the true rake	88
(f) Alignment chart for true rake and inclination angle	89
(g) Practical conclusions	91
(i) The true rake	91
(ii) The angle of inclination (iii) Perinheral milling	91
(in) rempireral mining	92
PART II: EMPIRICAL RESEARCH AND PRACTICAL APPLICATION	
Survey of the metal cutting problems	95
SECTION 1: CUTTING SPEED	
CHAPTER 6. PREREQUISITES FOR EMPIRICAL LAWS	99
(a) General	99
(b) Tool life and wear criterion	99
Chapter 7. Tool Life and Cutting Speed ( $T_L$ - $v$ relationship)	104
(a) The Taylor equation	104
(b) Computation of the tool life exponent	108
(c) Recent tests on the $T_L - v$ relationship	110
(d) Comparison of tool life exponents	138
(e) The tool life exponent and the practical selection of tool materials	140
(f) The tool life exponent and the cost of machining	142
(g) Irregular $T_L - v$ relation for light cuts	143
CHAPTER 8. THE ELEMENTARY CUTTING SPEED LAW	147
(a) Chip cross-section-cutting speed relation $(A-v relation)$	147
(b) Derivation of the elementary cutting speed law $(A-v relation)$	152
(c) Metric-English conversion of the elementary cutting speed law	154
(d) Numerical data for the elementary cutting speed law	156
CHAPTER 9. THE EXTENDED CUTTING SPEED LAW	170
(a) The slenderness ratio of the chip cross-sectional area	170
(b) Derivation of the extended cutting speed law	171
<ul> <li>(i) Feed and depth of cut as separate quantities</li> <li>(ii) Feed and depth of cut united into chip cross-sectional area and slender-</li> </ul>	171
(a) Summery of outting speed acceptions on the second seco	173
(c) Summary of cutting speed equations and conversion factors (d) Slondorness ratio and side sutting stars and	175
(a) Numerical data for the autor data sufficiency 11	175
(c) runnerical data for the extended cutting speed law	177
$(f) \cup_{p}$ -constant and Brinell Hardness $(g)$ Examples for computation of sufficiency $f_{p}$	200
(g) Examples for computation of cutting speeds	204

viii

## CONTENTS

SECTION 2: CUTTING FORCE

BASIC CONSIDERATIONS Introduction Relation of cutting force and cutting speed Prerequisites for cutting force laws	209 209 213 214
<ul> <li>CHAPTER 10. THE ELEMENTARY CUTTING FORCE LAW</li> <li>(a) Derivation</li> <li>(b) Metric-English conversion of the elementary cutting force law</li> <li>(c) Numerical data for the elementary cutting force law</li> </ul>	224 224 224 225
<ul> <li>CHAPTER 11. THE EXTENDED CUTTING FORCE LAW</li> <li>1. The basic relationship <ul> <li>(a) Derivation of the extended cutting force law</li> <li>(b) Metric-English conversion of the Constants</li> <li>(c) Numerical data for the extended cutting force law</li> <li>(d) The minor cutting force components</li> </ul> </li> <li>2. Incorporation of tensile strength (or Brinell Hardness) into the cutting force laws <ul> <li>(a) Correlation of theoretical and empirical cutting force equations</li> <li>(b) Metric-English conversion</li> </ul> </li> <li>3. Incorporation of the true rake angle into the cutting force laws <ul> <li>(a) Commercial data for the true rake angle relation</li> </ul> </li> <li>4. Cutting force as a combined function of chip cross-section, tensile strength and tool geometry</li> </ul>	235 235 236 238 257 261 261 268 268 268 268 268 276 288
5. Integration of formulas and practical cutting force computations from "Best-Value Tables"	290
6. Direction of the resultant cutting force	294
7. The negative true rake and the stresses in the tool face	300
8. Vibration, chip formation and cutting force	306
9. Workpiece and cutting force	314
SECTION 3: APPLICATION TO MACHINE TOOLS	
CHAPTER 12. BASIC RELATIONSHIPS	319
(a) Cutting power and metal removal rate	319
(b) Numerical data	321
(c) Machine law and Tool law (the dual $A-v$ relation)	323
CHAPTER 13. PRODUCTIVITY (Relations of power, removal rates, forces, speeds, chip cross-sections, slenderness ratios, feeds, depths of cut for various work- and tool-materials)	325
(a) Introduction by examples	325
Example 1 ( $T_L$ -h.p. inter-section)	325
Example 2 (variation of $T_L$ )	326
Example 3 (variation of h.p.) Example 4 (variation of $v$ )	329 331

ix

CONTENTS

(b) Productivity charts	332
(1) Elementary productivity chart (ii) Extended productivity chart	332
(c) Derivation of generalized formulas	2/1
(d) Productivity conclusions and recommendations	241
B Geometrically dissimilar chin cross-sections	244
(a) The "coupled" cutting speed	345
(a) The coupled cutting speed (b) Productivity conclusions for geometrically dissimilar ship gross sections in	343
(b) Froductivity conclusions for geometrically dissimilar chip cross-sections in comparison with geometrically similar chip cross-sections	351
Outlook	352
Chapter 14. Case Histories	354
(a) Time-study for the machining of brass on automatic screw machines	354
(b) Metal cutting time-study for mass production	357
(c) Investigation of a new machining process	360
(d) Testing of a vertical boring mill	367
(e) Hot machining tests	370
(f) The logarithmic progression of spindle speeds	372
(g) Metal cutting tests with strain gauges	378
Appendix	
Recommended Best Values for cutting speed calculations	383
Recommended Best Values for metal cutting constants and exponents (non- ferrous metals)	385
Numerical data for exponents (recommended Best Values)	386
Recommended Best Values for cutting force computations (steel)	387
Recommended Best Values for cutting force computations (seei)	380
Summary of important metal cutting laws for the machining of steel and cast iron	309
with recommended Best Values for constants and composite exponents	390
Comparison of DIN and SAE steels	391
German carbide tools	393
Physical quantities of ceramic and carbide tools	393
Exponents and slope angles of straight logarithmic lines	394
Ten-thousandths of an inch converted into millimeters	395
Temperature conversion diagrams	397
Conversion diagrams:	
inch-millimeter	397
square inch-square millimeter	398
nsi-ka/mm <sup>2</sup>	398
in <sup>3</sup> /min/h.pkp/mm <sup>2</sup>	399
inch pounds-meter kiloponds	400
Heat conductivity of metals	400

401

405

SUBJECT INDEX

х