Now available from the Abrasive Engineering Society $69.95 plus shipping.
To order see our online form or contact us at aes@abrasiveengineering.com

FOLLOWING ARE PAGES FROM THE BOOK SHOWING ITS CONTENT
Preface

The first edition of this book was intended to provide an integrated scientific foundation for understanding of the grinding process, which can be practically utilized for enhancing and optimizing grinding operations. After 18 years in print, the first edition is still selling and is widely referenced, but many of the newer developments in grinding led us to think that the time had come for a new edition. This second edition builds upon the first edition with greatly expanded coverage of the thermal aspects of grinding, creep-feed grinding, grinding with superabrasives, fluid flow, process simulation, optimization, and intelligent control of grinding machines.

This book is written both for the researcher and the practicing engineer. As with the first edition, it is expected that the second edition will be used as a textbook or supplement for advanced courses on machining and grinding, for industrial short courses, and as a source of fundamental and practical information about the grinding process and its utilization.

Preparation of the second edition of this book was undertaken by the authors as part of their collaborative relationship which began at the University of Massachusetts in 1989. During this time, we have had the good fortune to work with many outstanding graduate students and to benefit from interactions with and support from many colleagues and friends in academia and industry who are too numerous to mention individually.

...
Biographical Sketches for Authors

STEPHEN MALKIN

Stephen Malkin is Distinguished Professor and former head of the Department of Mechanical & Industrial Engineering at the University of Massachusetts. He graduated from MIT with BS (1963), MS (1965), and ScD (1968) degrees in mechanical engineering. Prior to joining the University of Massachusetts in 1986, he held faculty positions at the University of Texas, State University of New York, and Technion-Israel Institute of Technology. An author of more than 200 papers, he is internationally recognized for research on grinding and abrasive processes. As an industrial consultant and lecturer, he has been a leader in the practical utilization of grinding technology for enhancing productivity and quality. Dr. Malkin is a member of the National Academy of Engineering (NAE), and a fellow of the International Institution for Production Engineering Research (CIRP), the American Society of Mechanical Engineers (ASME), and Society of Manufacturing Engineers (SME). He received the ASME Blackall Award of 1993 for best papers related to machine tools, the SME Gold Medal of 1996 for his outstanding research accomplishments and contributions to the manufacturing profession, the University of Massachusetts Outstanding Engineering Faculty Award of 1997, and the ASME William T. Ennor Manufacturing Technology Award of 2004 in recognition of his leading role in the transformation of grinding and abrasive machining from an empirical craft to an applied science.

CHANGSHENG GUO

Changsheng Guo is Principal Scientist and Project Leader at the United Technologies Research Center (UTRC) where he leads projects in modeling, simulation, and optimization of manufacturing processes. He received his Ph.D. in mechanical engineering from University of Massachusetts, a Master’s degree in management from Rensselaer Polytechnic Institute, and a Master’s degree in manufacturing engineering and a bachelor’s degree in mechanical engineering from Northeastern University in China. Before joining UTRC, Dr. Guo was Co-Director of the grinding research program at the University of Massachusetts and Technical Director of Chand Kare Technical Ceramics. From 1985 to 1987, he was an assistant professor at Northeastern University in China. Dr. Guo’s research focus has been on the fundamentals and applications of machining processes including grinding, milling, superabrasive machining, and ceramic machining. With more than 80 published papers, Dr. Guo is an associate editor for Machining Science and Technology and an associate member of the International Academy for Production Engineering (CIRP). He has been the recipient of numerous awards including UTRC’s Outstanding Achievement Award, the Pratt & Whitney leadership award, the F. W. Taylor Medal of CIRP in 1996, the US DOE energy pioneer award in 1995, and the ASME Blackall Award in 1993.
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>vii</td>
</tr>
<tr>
<td>Preface to the First Edition</td>
<td>ix</td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>1.1 The Grinding Process</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Historical Development of the Grinding Process</td>
<td>3</td>
</tr>
<tr>
<td>1.3 Contents of this Book</td>
<td>7</td>
</tr>
<tr>
<td>2. Grinding Wheels: Composition and Properties</td>
<td>11</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>11</td>
</tr>
<tr>
<td>2.2 Grinding Wheel Specification: Conventional Abrasives</td>
<td>12</td>
</tr>
<tr>
<td>2.3 Grinding Wheel Specification: Superabrasives</td>
<td>17</td>
</tr>
<tr>
<td>2.4 Conventional Abrasive Materials</td>
<td>19</td>
</tr>
<tr>
<td>2.5 Superabrasive Materials</td>
<td>25</td>
</tr>
<tr>
<td>2.6 Bond Materials</td>
<td>26</td>
</tr>
<tr>
<td>2.7 Vitrified Wheel Composition and Phase Diagrams</td>
<td>31</td>
</tr>
<tr>
<td>2.8 Grinding Wheel Testing</td>
<td>34</td>
</tr>
<tr>
<td>3. Grinding Geometry and Kinematics</td>
<td>43</td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>43</td>
</tr>
<tr>
<td>3.2 Geometrical Wheel-Workpiece Contact Length</td>
<td>44</td>
</tr>
<tr>
<td>3.3 Cutting Path</td>
<td>47</td>
</tr>
<tr>
<td>3.4 Maximum Cutting Depth (Undeformed Chip Thickness)</td>
<td>54</td>
</tr>
<tr>
<td>3.5 Undeformed Chip Thickness-Continuity Analysis</td>
<td>59</td>
</tr>
<tr>
<td>3.6 Non-Uniform Wheel Topography</td>
<td>60</td>
</tr>
<tr>
<td>3.7 Traverse Grinding</td>
<td>65</td>
</tr>
<tr>
<td>3.8 Profile (Form), Angle, and Helical-Groove Grinding</td>
<td>67</td>
</tr>
<tr>
<td>3.9 Grinding Operations with Total Conformity</td>
<td>74</td>
</tr>
<tr>
<td>4. Wheel Truing, Dressing, and Topography</td>
<td>81</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>81</td>
</tr>
<tr>
<td>4.2 Dressing of Conventional Wheels</td>
<td>82</td>
</tr>
<tr>
<td>4.3 Truing and Dressing of Superabrasive Wheels</td>
<td>84</td>
</tr>
<tr>
<td>4.4 Generation of Wheel Topography—Conventional Wheels</td>
<td>88</td>
</tr>
<tr>
<td>4.5 Generation of Wheel Topography—Superabrasives</td>
<td>95</td>
</tr>
<tr>
<td>4.6 Measurement of Wheel Topography</td>
<td>98</td>
</tr>
<tr>
<td>4.6.1 Profilometry methods</td>
<td>98</td>
</tr>
<tr>
<td>4.6.2 Imprint methods</td>
<td>100</td>
</tr>
<tr>
<td>4.6.3 Scratch methods</td>
<td>102</td>
</tr>
<tr>
<td>4.6.4 Dynamometer and thermocouple methods</td>
<td>104</td>
</tr>
<tr>
<td>4.6.5 Microscopic methods</td>
<td>105</td>
</tr>
<tr>
<td>5. Grinding Mechanisms</td>
<td>115</td>
</tr>
<tr>
<td>5.1 Introduction</td>
<td>115</td>
</tr>
<tr>
<td>5.2 Grinding Debris (Swarj)</td>
<td>116</td>
</tr>
<tr>
<td>5.3 Grinding Forces, Power, and Specific Energy</td>
<td>118</td>
</tr>
<tr>
<td>5.4 Grinding Mechanisms: Conventional Abrasive</td>
<td>120</td>
</tr>
<tr>
<td>5.4.1 Size effect and energy considerations</td>
<td>120</td>
</tr>
<tr>
<td>5.4.2 Sliding forces and energy</td>
<td>121</td>
</tr>
<tr>
<td>5.4.3 Plowing and chip-formation energies</td>
<td>127</td>
</tr>
<tr>
<td>5.5 Grinding Mechanisms: CBN Wheels</td>
<td>134</td>
</tr>
<tr>
<td>5.6 Creep-Feed Grinding</td>
<td>141</td>
</tr>
</tbody>
</table>
energy partition 194-203, 216, 220-221, 224
external cylindrical grinding 44-47, 48, 49, 55, 66, 72, 160
face grinding 74-75, 179-180
fine dressing 94
flood application 232-236
flow rate 233, 237, 238-242
fluid flow 231-255
force components 135, 138, 223
form grinding 67-74
fraction bond fracture 93
fracture 90
fractile 21-22
garnet 20
gemotrical wheel 44-47
geometry 43-79
grade 34-35
grain dimensions 14-15, 108
grain fracture 90, 289
grain size 12
grains 1
grains 19-20
G-ratio 287, 298
grinding cycle 319-321
grinding debris 115-117
grinding deflections 315-338
grinding fluids 304-308
grinding forces 118-120
grinding mechanisms 115-156
grinding operations 2
grinding powers 211-212
grinding process 1-3
grinding ratio 287
grinding vibrations 331-335
grinding wheels 1, 11-42
geometry 43-79
phase diagrams 31-34
testing 34-40
grinding zone 232-242
GrindSim(D 345
grit number 12-14, 17
grit size 19, 278
grits 1
grome-scratching hardness 36
ground surface morphology 258-260
hardness 15-17, 21-22, 28, 34-36
heat transfer 159-169
heavy-duty grinding 147-152
HEDG 224-229
helical-groove grinding 67-74, 340
high efficiency deep grinding see HEDG
historical development 3-7
hydrodynamic forces 242-254
hydrosol 24
imprint methods 100-101
inclined heat source 190
inclined surface 68
infeed analysis 315-319, 321-325
infeed angle 52-53
internal cylindrical grinding 44-47, 50, 55
inverse heat transfer 162-164
iso-grade lines 33
iso-grain lines 32
iso-porosity lines 33
kinematics 43-79
Knoop test 21
lower packing density see LPD line LPD line 32-33
lubrication 285-314
machine tool control 361-366
machining processes 7
marking system 13, 18, 27
material removal 43, 115
materials 19-25
maximum bond equivalent see MBE line
maximum cutting depth 54-59
maximum packing density see MPD line MBE line 32-33
measurement wheel topography 98-110
mechanisms grinding 115-156
metal bonds 29-30
microscopic methods 105-110
morphology 258-260
MPD line 32-33
natural abrasives 19-20
non-uniform wheel topography 60-65
normal force 143
nozzle position 234-236, 238
oils 304 operating speed 37-38
optical microscope 105
optimization 345-353, 359-361
oxides 22-23
oxychloride 27, 29
penetration depths 35, 44
peripheral bursting speeds 38-39
peripheral superabrasive wheels 85
phase diagrams 31-34
plowing 127-133
plunge grinding 45, 65, 67, 126, 128, 159-169, 272, 273, 316-317
porosity 16, 17, 31, 195, 233-235, 237, 241
power 118-120
profile grinding 67-74
profilometry methods 98-100
radial distribution 62, 108
references 7
rehardening 173-175
residual stresses 176-178
resin-bonded CBN wheels 86-87, 136
resinoid wheels 27-30, 38
rotary dimaond dressing 83
rotational stress 38
roughness 257-283
rubber-bonded wheels 27, 29
safety 38
scanning electron microscope 105, 115
scratch methods 102-104 s
creening 12 shellac 27, 29
shoulder grinding 72
sieve wire spacing 15
sieving 12, 17
silicate-bonded wheels 27, 29
silicon Carbide 12, 20-22, 24-25
simulation software 339-366
single grain model 201-203, 221
single point diamond 88-89
size effect 120-121
sliding forces 121-127
snagging 147
sol-gel abrasives 24
soluble oils 304
spacing 57, 60
spark-in and spark-out 327-331
specific grinding energy 115, 118-120,135,222
specifications 12-19
speed 37-38
spheres 116 s
standard marking system 13
static indentation hardness 21
steady-state force components 13
straight oils 304
straight surface grinding 44-46, 48,68
strength 37
stress 38-39
stress-strain behavior 132-133
structure number 16
superabrasive wheels 11, 84-88, 95-98
superabrasives 17-19, 25-26
surface 91
surface roughness 135, 257-283
surface texture 260-265
surface topography 264
swarf 115-117
synthetic abrasives 20

temperature 157-158, 167-168, 192-194,203-208,217
temperature distribution 196-200, 205-206
temperature matching 162-164
tempering 173-175
testing 34-40
texture 260-265
thickness 63
thermal aspects, CBN abrasives 215-230
conventional grinding 157-188
creep-feed grinding 189-214
thermal comparison 209-213
thermal damage 166,169-178
thermal stability 26
thermocouple method 104-105
thickness 54-59
tolerance 260-265
topography 60-65, 81-114, 264
total conformity 74-77
transient CBN grinding 137
transient temperature 203-208
transverse roughness 268-270
traverse grinding 65-67
trochoidal cutting path 47-49
truing 81-114
undeformed chip geometry 48
undeformed. chip thickness 54-60
velocity 44
vertical-spindle grinding 74-76
vibrations 331-336
Vickers test 21
vitreous bonds 27
vitrified CBN wheels 86-87, 136, 216-219
vitrified wheel 27-29, 31-34
volumetric removal 135
volumetric wheel wear 286
waviness 263
wear flats 121-125, 223
wheel grade 15-16
wheel specifications 12-19
wheel topography 60-65
wheel truing 81-114
wheel wear 285-314
wheels 11-42
workpiece 44-47
workpiece bum 170-173
workpiece temperature 192-194
zirconia 23