

# Contents

Preface — V

About the Editor — VII

List of contributing authors — XIII

Viktor P. Astakhov and Swapnil Patel

<b>1</b>	<b>Efficient drilling of high-silicon aluminum alloys — 1</b>
1.1	Introduction — 1
1.2	Short analysis of the known studies — 2
1.3	Urgent need for high-efficiency drilling and constraints — 3
1.3.1	The rising need for innovation — 3
1.3.2	Major constraints on high-penetration rate — 4
1.4	First level of the constraints analysis — 5
1.5	Second level of the analysis of constraints: work-material specific level — 9
1.5.1	General information about HSAA — 9
1.5.2	Analysis of the chemical composition — 10
1.5.3	Analysis of the mechanical and physical properties — 19
1.6	Casting defects affecting drilling — 22
1.6.1	Porosity — 22
1.6.2	Sludge — 24
1.6.3	Other casting defects — 26
1.7	Advanced design of PCD drills for HPR drilling of HSAA — 28
1.7.1	Problems with the existing designs — 28
1.7.2	Cross-PCD drill design and implementation practice — 30
	References — 35

Keng Soon Woon, Guan Leong Tnay and Swee Hock Yeo

<b>2</b>	<b>Deep hole gun drilling of nickel-based superalloys — 37</b>
2.1	Introduction: background and definition — 37
2.2	Gun drill design — 39
2.2.1	Nose grind contour — 40
2.2.2	Coolant hole — 41
2.2.3	Bearing pads — 42
2.3	Process mechanics — 43
2.3.1	Cutting force — 44
2.3.2	Drill deflection — 46
2.3.3	Wall deformation — 47
2.3.4	Process kinematics — 48

2.3.5	A case study —	49
2.4	Tool degradation —	51
2.4.1	General wear —	52
2.4.2	Thermal-mechanical damage —	53
2.4.3	Notching —	53
2.4.4	Edge flaking —	56
2.5	Coolant application —	59
2.5.1	Coolant transport passage —	59
2.5.2	Nose grind contour effects —	61
2.5.3	Coolant hole configuration effects —	61
2.5.4	Shoulder deb-off angle effects —	62
2.5.5	Optimized design —	63
2.6	Pilot hole drilling —	65
2.6.1	Engagement performance —	65
2.6.2	Engagement time —	66
2.6.3	A case study —	66
2.7	Gun drill re-sharpening —	71
2.7.1	Manual grinding —	72
2.7.2	Re-sharpening accuracy —	72
2.7.3	Tool failure —	73
2.7.4	Clearance regeneration —	74
2.8	Cutting edge preparation —	77
2.8.1	Problems with mechanical-based processes —	78
2.8.2	Common abrasive tools —	79
2.8.3	Soft grinding wheel —	81
2.8.4	Results and improvement —	83
2.8.5	Case study —	84
2.9	Summary and outlook —	85
	References —	85

Krishnaraj Vijayan, Simin Nasser, Vitale Kyle Castellano, Herve Sobtaguim,  
Joshua Hilderbrand and Hari Chealvan

**3 A new model pertaining to highspeed drilling of titanium alloy  
(Ti-6Al-4V) — 89**

3.1	Introduction —	89
3.2	Experimental conditions —	91
3.3	Governing equations —	93
3.4	Experimental results and modeling —	94
3.4.1	Uncut chip thickness analysis —	94
3.4.2	Torque analysis —	96
3.4.3	Thrust force analysis —	100

- 3.4.4 Specific cutting energy analysis — 102
- 3.5 Conclusions and discussions — 104
- References — 107

J. Babu, Lijo Paul and J. Paulo Davim

#### **4 Drilling of composite materials: methods and tools — 109**

- 4.1 Introduction — 110
- 4.2 Drilling processes — 111
  - 4.2.1 Conventional drilling — 111
  - 4.2.2 Grinding drilling — 112
  - 4.2.3 High-speed drilling — 112
  - 4.2.4 Nonconventional drilling processes — 112
    - 4.2.4.1 Ultrasonic machining — 113
    - 4.2.4.2 Ultrasonic Vibration-assisted machining — 114
    - 4.2.4.3 Laser machining — 114
    - 4.2.4.4 Electric discharge machining — 115
    - 4.2.4.5 Electrochemical discharge machining — 115
    - 4.2.4.6 Water-jet machining — 116
- 4.3 Drill bit classification — 116
  - 4.3.1 Twist drill — 117
  - 4.3.2 Candlestick drill — 118
  - 4.3.3 Saw drill — 119
  - 4.3.4 Core- drill — 119
  - 4.3.5 Step drill — 119
  - 4.3.6 Core-centered drill — 119
  - 4.3.7 Core-candlestick drill — 119
  - 4.3.8 Core-saw drill — 120
  - 4.3.9 Brad drill — 120
  - 4.3.10 Reamer drill — 120
  - 4.3.11 Special step core drill — 120
- 4.4 Drill bit materials — 121
  - 4.4.1 Carbide tools — 121
  - 4.4.2 Diamond-coated drill — 121
  - 4.4.3 Polycrystalline diamond (PCD) — 122
- 4.5 Drilling defects — 122
  - 4.5.1 Delamination and its mechanisms — 122
    - 4.5.1.1 Measurement of delamination — 123
    - 4.5.1.2 Assessment of Delamination — 124
    - 4.5.1.3 Thrust force and its influence on delamination — 125
    - 4.5.1.4 Effect of cutting conditions on thrust force — 127
    - 4.5.1.5 Methods to suppress delamination — 131

- 4.5.2 Geometrical damages in drilling — 136
- 4.5.2.1 Surface finish — 136
- 4.5.2.2 Hole size error — 137
- 4.5.2.3 Cylindricity/circularity error — 138
- 4.5.3 Thermal damages in drilling — 138
- 4.6 Tool wear — 141
- 4.7 Conclusions — 143
- References — 144

Akshay Hejjaji, Redouane Zitoune, Ameer Mohamed Fayçal,  
Bougherara Habiba

**5 Challenges of machining natural fiber-reinforced composites:  
A review — 149**

- 5.1 Introduction — 149
- 5.2 Machining of natural fiber composites — 152
- 5.2.1 Drilling — 152
- 5.3 Remarks — 159
- References — 159

V. N. Gaitonde, Shashikant, Anand Lakkundi, S. R. Karnik,  
A. S. Deshpande, J. Paulo Davim

**6 Analysis and optimization of hole quality parameters in cenosphere-  
multiwall carbon nanotube hybrid composites drilling using artificial  
neural network and gravitational search technique — 161**

- 6.1 Introduction — 161
- 6.2 Artificial neural network modeling — 163
- 6.3 Gravitational search optimization — 164
- 6.4 Experimental details — 167
- 6.4.1 Preparation of cenosphere-MWCNT-epoxy specimens — 167
- 6.4.2 Drilling experimentation and hole quality measurement — 168
- 6.5 Results and discussion — 173
- 6.5.1 ANN models for hole quality parameters — 173
- 6.5.1.1 Circularity error analysis — 174
- 6.5.1.2 Surface roughness analysis — 178
- 6.5.1.3 Delamination analysis — 178
- 6.5.2 GS optimization for hole quality parameters — 179
- 6.6 Conclusions — 184
- References — 185

**Index — 189**