ADVANCED MACHINING
TOWARDS IMPROVED MACHINABILITY OF DIFFICULT-TO-CUT MATERIALS

Edited by:
A.K.M. Nurul Amin (Chief Editor)
Dr. Erry Yulian Triblas Adesta
Dr. Mohammad Yeakub Ali

IIUM Press
SECTION A: HEAT ASSISTED MACHINING

1. CHAPTER 1: INFLUENCE OF WORKPIECE PREHEATING ON CHATTER AND MACHINABILITY OF TITANIUM LOY - Ti6Al4V
2. CHAPTER 2: MACHINABILITY IMPROVEMENT IN END OF MILLING TITANIUM ALLOY Ti-6Al-4V THROUGH PREHEATING
3. CHAPTER 3: SOME ASPECTS OF IMPROVED MACHINABILITY IN PREHEATED MACHINING OF TITANIUM ALLOY Ti-6Al-4V
4. CHAPTER 4: MACHINABILITY ASPECTS IN HEAT ASSISTED MACHINING OF HARDENED STEEL AISI H13 USING COATED CARBIDE TOOL
5. CHAPTER 5: TOOL WEAR AND SURFACE ROUGHNESS ASPECTS IN HEAT ASSISTED END MILLING OF AISI D2 HARDENED STEEL
6. CHAPTER 6: MODELING IN PREHEATED MACHINING OF AISI D2 HARDENED STEEL
7. CHAPTER 7: RELATIVE PERFORMANCES OF PREHEATING, CRYOGENIC COOLING AND HYBRID TURNING OF STAINLESS STEEL AISI 304

SECTION B: CHATTER AND SELECTED METHODS OF CHATTER SUPPRESSION

8. CHAPTER 8: ROLE OF THE FREQUENCY OF SECONDARY SERRATED TEETH IN CHATTER FORMATION DURING TURNING OF CARBON STEEL AISI 1040 AND STAINLESS STEEL
9. CHAPTER 9: INFLUENCE OF THE ELASTIC SYSTEM AND CUTTING PARAMETERS ON CHATTER DURING MACHINING OF MILD STEEL
10. CHAPTER 10: INFLUENCE OF CHATTER ON TOOL LIFE DURING END MILLING OF ALUMINIUM AND ALUMINIUM ALLOY ON VMC
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>CHAPTER 11: A NEW METHOD FOR CHATTER SUPPRESSION AND IMPROVEMENT OF SURFACE ROUGHNESS IN END MILLISELING OF MILD STEEL</td>
<td>83</td>
</tr>
<tr>
<td>12</td>
<td>CHAPTER 12: APPLICATION OF PERMANENT ELECTROMAGNET FOR CHATTER CONTROL IN END MILLING OF MEDIUM CARBON STEEL</td>
<td>91</td>
</tr>
<tr>
<td>13</td>
<td>CHAPTER 13: APPLICATION OF PERMANENT ELECTROMAGNET FOR CHATTER CONTROL IN END MILLING OF TITANIUM ALLOY - Ti6Al4V</td>
<td>99</td>
</tr>
<tr>
<td>14</td>
<td>CHAPTER 14: CHATTER SUPPRESSION IN END MILLING OF TITANIUM ALLOY Ti6Al4V APPLYING PERMANENT MAGNET CLAMPED ADJACENT TO THE WORKPIECE</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>SECTION C: MODELLING AND OPTIMIZATION IN MACHINING</td>
<td>117</td>
</tr>
<tr>
<td>15</td>
<td>CHAPTER 15: A COUPLED ARTIFICIAL NEURAL NETWORK AND RSM MODEL FOR THE PREDICTION OF CHIP SERRATION FREQUENCY IN END MILLING OF INCONEL 718</td>
<td>117</td>
</tr>
<tr>
<td>16</td>
<td>CHAPTER 16: APPLICATION OF RESPONSE SURFACE METHODOLOGY COUPLED WITH GENETIC ALGORITHM FOR SURFACE ROUGHNESS OF INCONEL 718</td>
<td>123</td>
</tr>
<tr>
<td>17</td>
<td>CHAPTER 17: DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE PREDICTION OF SURFACE ROUGHNESS IN END MILLING OF STAINLESS STEEL SS 304</td>
<td>133</td>
</tr>
<tr>
<td>18</td>
<td>CHAPTER 18: DEVELOPMENT OF AN ARTIFICIAL NEURAL NETWORK ALGORITHM FOR PREDICTING THE CUTTING FORCE IN END MILLING OF INCONEL 718 ALLOY</td>
<td>143</td>
</tr>
<tr>
<td>19</td>
<td>CHAPTER 19: DEVELOPMENT OF AN ARTIFICIAL NEURAL NETWORK ALGORITHM FOR PREDICTING THE SURFACE</td>
<td>149</td>
</tr>
<tr>
<td>20</td>
<td>CHAPTER 20: DEVELOPMENT OF TOOL LIFE PREDICTION MODEL OF TIAIN COATED TOOLS DURING PART C: HIGH SPEED HARD MILLING OF AISI H13 STEEL</td>
<td>155</td>
</tr>
<tr>
<td>21</td>
<td>CHAPTER 21: MODELING FOR SURFACE ROUGHNESS IN END-MILLING OF TITANIUM ALLOY Ti-6Al-4V USING UNCOATED WC INSERTS</td>
<td>161</td>
</tr>
</tbody>
</table>
Advanced Machining

List of Contents

22 CHAPTER 22: MODELING OF SURFACE ROUGHNESS DURING END MILLING OF AISI H13 HARDENED TOOL STEEL 167

23 CHAPTER 23: MODELING OF TOOL LIFE USING RESPONSE SURFACE METHODOLOGY IN HARD MILLING OF AISI D2 TOOL STEEL 175

24 CHAPTER 24: OPTIMIZATION OF SURFACE ROUGHNESS IN HIGH SPEED END MILLING OF TITANIUM ALLOY Ti-6Al-4V UNDER DRY CONDITION 181

25 CHAPTER 25: COMPARISON OF SURFACE ROUGHNESS IN END-MILLING OF TITANIUM ALLOY Ti-6Al-4V USING UNCOATED WC-CO AND PCD INSERTS THROUGH GENERATION OF MODELS 189

26 CHAPTER 26: ASSESSMENT OF PERFORMANCE OF UNCOATED AND COATED CARBIDE INSERTS IN END MILLING OF TI-6AL-4V THROUGH MODELLING 195

SECTION D: CRYOGENIC AND HIGH SPEED MACHINING OF METALS AND NON METALS 203

27 CHAPTER 27: THE EFFECT OF CRYOGENIC COOLING ON MACHINABILITY OF STAINLESS STEEL DURING TURNING 203

28 CHAPTER 28: COMPARISON OF MACHINABILITY OF CERAMIC INSERT IN ROOM TEMPERATURE AND CRYOGENIC COOLING CONDITIONS DURING END MILLING INCONEL 718 209

29 CHAPTER 29: HIGH SPEED END MILLING OF SINGLE CRYSTAL SILICON SING DIAMOND COATED TOOL 217

30 CHAPTER 30: IMPLEMENTATION OF HIGH SPEED OF SILICON USING DIAMOND COATED TOOLS WITH AIR BLOWING 225

31 CHAPTER 31: ELIMINATION OF BURR FORMATION DURING END MILLING OF POLYMETHYL METHACRYLATE (PMMA) THROUGH HIGH SPEED MACHINING 233

32 CHAPTER 32: WEAR MECHANISMS IN END MILLING OF INCONEL 718 239
CHAPTER 33: PERFORMANCE OF UNCOATED WC-CO INSERTS IN END MILLING OF ALUMINUM SILICON CARBIDE (ALSiC) 247

CHAPTER 34: APPLICATION OF PCD INSERTS IN END MILLING OF ALUMINUM SILICON CARBIDE (ALSiC) 253

CHAPTER 35: EFFECTS OF Scribing WHEEL DIMENSIONS ON LCD GLASS CUTTING 259
Chapter 25

Comparison of Surface Roughness in End-Milling of Titanium Alloy Ti-6Al-4V Using Uncoated WC-Co and PCD Inserts through Generation of models

Tunad L. GINTA\(^1\), A.K.M. Nurul Amin\(^2\), M. H. ISHTIYAQ\(^4\)

\(^1\),\(^2\),\(^3\),\(^4\) Faculty of Manufacturing and Material Engineering, IIUM Malaysia
Corresponding Author: akamin@iiu.edu.my

1.0 INTRODUCTION

Titanium alloys are widely known as difficult to cut materials, especially at higher cutting speeds, due to their several inherent properties. Siekmann \([1]\) suggested that machining of titanium and its alloys would always be a problem, no matter what techniques are employed to transform this metal into chips. When machining Ti-6Al-4V, conventional tools wear rapidly because the poor thermal conductivity of titanium alloys resulting in higher cutting temperature closer to the cutting edge. There also exists strong adhesion between the tool and workpiece material \([2]\). Since the performance of conventional tools is poor in machining Ti-6Al-4V, a number of newly evolved tool materials, such as cubic boron nitride (CBN) and polycrystalline diamond (PCD), are being considered to achieve high-speed milling \([3]\). A machinability model may be defined as a functional relationship between the input of independent cutting variables (speed, feed, depth of cut) and the output known as responses (tool life, surface roughness, cutting force, etc) of a machining process \([4]\). Response surface methodology (RSM) is a combination of experimental and regression analysis and statistical inference. RSM is a dynamic and foremost important tool of design of experiment (DOE), wherein the relationship between response(s) of a process with its input decision variables is mapped to achieve the objective of maximization or minimization of the response properties \([5\text{-}6]\). Many machining researchers have used response surface methodology to design their experiments and assess results. Kaye et al \([7]\) used response surface methodology in predicting tool flank wear using spindle speed change. A unique model has been developed which predicts tool flank wear, based on the spindle speed change, provided the initial flank wear at the beginning of the normal cutting stage is known. An empirical equation has also been derived for calculating the initial flank wear, given the speed, feed rate, depth of cut and workpiece hardness. Alaaddin et al \([8]\) applied response surface methodology to optimize the surface finish in end milling of Inconel 718 under dry condition. They developed contours to select a combination of cutting speed, and feed without increasing the surface roughness.

Fuh and Wang \([9]\) developed a model for predicting milling force model in end milling operation. They found that the proposed model is suitable for practical engineering application, since the milling force analyzed in the model has already encompassed the structural characteristics of the milling machine and the real conditions of the tool and workpiece. They also suggested that the proposed force model had a good correlation with experimental values. Choudhury and el-Baradie \([10]\) found that response surface