Advanced Machining Process

Editors
Mohammad Yeakub Ali
AKM Nurul Amin
Erry Yulian Triblas Adesta

IIUM PRESS
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
Advanced Machining Process

Editors
Mohammad Yeakub Ali
AKM Nurul Amin
Erry Yulian Triblas Adesta

IIUM Press
Advanced Machining Process

Table of Contents

Preface ii
Acknowledgement iii
Copyright iv

PART 1: ELECTRO DISCHARGE MACHINING .........................1

Chapter 1 Tool Wear rate during Electrical Discharge Machining (EDM) with Eccentric Electrode
Ahsan Ali Khan, Affendi Bin Saad and Mohd Zulfadli Isma Bin Mohd Isa 2

Chapter 2 Wear Ratio and Work Surface Finish during Electrical Discharge Machining (EDM) with Eccentric Electrode
Ahsan Ali Khan, Affendi Bin Saad and Mohd Zulfadli Isma Bin Mohd Isa 7

Chapter 3 Role of Current, Voltage and Spark on-time on Electrode Material Migration during EDM
Ahsan Ali Khan, Nurul Shima Mohd Noh 12

Chapter 4 A Study on Material Removal Rate during EDM with Tantalum Carbide-Copper Compacted Electrode
Ahsan Ali Khan, Mohammad Azhadi Bin Mohammad Hambiyah and Mohd Faiz Bin Nazi Nadin 18

Chapter 5 Features of EDM of Mild Steel with Ta-Cu Powder Compacted Electrodes
Ahsan Ali Khan, Mohammad Azhadi Bin Mohammad Hambiyah and Mohd Faiz Bin Nazi Nadin 23

Chapter 6 Relationship between Machining Variables and Process Characteristics during Wire EDM
Ahsan Ali Khan, M. B. M. Ali and N. B. M. Shaffiar 28
Chapter 7
Influence of Machining Parameters on Surface Roughness during EDM of Mild Steel
Ahsan Ali Khan, Erry Y.T. Adesta and Mohammad Yeakub Ali

Chapter 8
Machining of Ceramic Materials: A Review
Abdus Sabur, Md. Abdul Maleque and Mohammad Yeakub Ali

Chapter 9
Formation of Micro-cracks and Recast Layer during EDM of Mild Steel using Copper Electrodes
Ahsan Ali Khan, Erry Y.T. Adesta and Mohammad Yeakub Ali

Chapter 10
Features of Electrode Wear during EDM of Mild Steel with TaC-Cu Powder Compacted Electrodes
Ahsan Ali Khan, Mohd Faiz Bin Nazi Nadin and Mohammad Azhadi Bin Mohammad Hambiyah

Chapter 11
Influence of Current, Spark On-time and Off-time on Electrode Wear during EDM of Mild Steel
Ahsan Ali Khan, Mohd Faiz Bin Nazi Nadin and Mohammad Azhadi Bin Mohammad Hambiyah

Chapter 12
A Comparative study on Work Surface Hardness EDMed by Ta-C Powder Compacted and Copper Electrodes
Ahsan Ali Khan, Mohd Faiz Bin Nazi Nadin and Mohammad Azhadi Bin Mohammad Hambiyah

Chapter 13
An Introduction to Electrical Discharge Machining
Ahsan Ali Khan and Mohammed Baba Ndaliman

Chapter 14
Developments in EDM Process Variables
Ahsan Ali Khan, Mohammed Baba Ndaliman and Mohammad Yeakub Ali
PART 2: MICROMACHINING ......................................................... 76

Chapter 15
Focused Ion Beam Micromachining: Technology and Application
Irshad Hakin Jaafar, Nur Atiqah, Asfana Banu, Mohammad Yeakub Ali

Chapter 16
Finish Cut of Titanium Alloy using Micro Electro Discharge Milling for Nano Surface Finish
Mohammad Yeakub Ali, Muhamad Faizal, Asfana Banu, and Nur Atikah

Chapter 17
Investigation of MRR for Finish Cut of Titanium Alloy using Micro Electro Discharge Milling
Mohammad Yeakub Ali, Mohd Saifuddin, Nur Atiqah, and Asfana Banu

Chapter 18
Investigation of TWR for Finish Cut of Titanium Alloy using Micro Electro Discharge Milling
Mohammad Yeakub Ali, Mohd Saifuddin, Nur Atiqah, and Asfana Banu

Chapter 19
Investigation of Chip Formation and Minimum Chip Thickness in Micro/Meso Milling: Methodology and Design of Experiment
Mohammad Yeakub Ali, Noor Adila Mansor and Siti Hamizah Mass Duki

Chapter 20
Micro/Meso Milling of Aluminium Alloy 1100: Analysis and Modelling of Minimum Chip Thickness
Mohammad Yeakub Ali, Noor Adila Mansor and Siti Hamizah Mass Duki

Chapter 21
Effect of Micro End Milling Tool Diameter on Minimum Chip Thickness
Mohammad Yeakub Ali, Noor Adila Mansor and Siti Hamizah Mass Duki

Chapter 22
Micro Wire Electrical Discharge Machining of Tungsten Carbide: Methodology and Procedure
Mohammad Yeakub Ali, Ahmad Chaaban Elahtahe and Musah Jamal Alrefaie

Chapter 23
Micro Wire Electrical Discharge Machining of Tungsten Carbide: Analysis of Surface Roughness
Mohammad Yeakub Ali, Ahmad Chaaban Elahtahe and Musah Jamal Alrefaie

Chapter 24
Micro Wire Electrical Discharge Machining of Tungsten Carbide: Analysis of Material Removal Rate
Mohammad Yeakub Ali, Musah Jamal Alrefaie and Ahmad Chaaban Elahtahe

Chapter 25
Micro Electro Discharge Machining of Micro Pillar Array: Process
Chapter 25
Micro Electro Discharge Machining of Micro Pillar Array: Process Development
Mohammad Yeakub Ali, Wan Emira Azaty and Nor Suriza

Chapter 26
Micro Electro Discharge Machining of Micro Pillar Array: Analysis of Surface Finish
Mohammad Yeakub Ali, Wan Emira Azaty and Nor Suriza

Chapter 27
Micro Electro Discharge Machining of Micropillar Array: Analysis of Material Removal Rate
Mohammad Yeakub Ali, Nor Suriza and Wan Emira Azaty

Chapter 28
Vibration Issue in Micro End Milling
Mohammad Yeakub Ali, Muhamad Lutfi and Mohamad Ismail Fahmi

Chapter 29
Fabrication of Micro Filter by Electro Discharge Machining
Abdus Sabur and Mohammad Yeakub Ali
PART 3: PRECISION MACHINING ........................................ 165

Chapter 30
High Speed Milling of Mould Steel using 1.5mm-diameter End-mills
Mohamed Konneh, Khairunnisa Ahmad and Rose Fazleen

Chapter 31
Precision Grinding of Silicon Carbide using 46 μm Grain Diamond Cup Wheel
Mohamed Konneh and Ahmad Fauzan

Chapter 32
Precision Grinding of Silicon Carbide using 76 μm Grain Diamond Cup Wheel
Mohamed Konneh and Mohd Shukur Zawawi

Chapter 33
Precision Grinding of Silicon Carbide using 107 μm Grain Diamond Cup Wheel
Mohamed Konneh and Mohd Fadzil

Chapter 34
Investigation of Surface Integrity during Precision Grinding of Silicon Carbide using Diamond Grinding Pins
Mohamed Konneh, Mohamad Lutfi and Mohamad Shahrilnizam

Chapter 35
A Comparative Study on Flank Wear and Work Surface Finish during High Speed Milling of Cast Iron with Different Carbide Tools
Ahsan Ali Khan, Zuraida Aman Nor Rusid and Izainsmawati Yusof

ix
Investigation of Chip Formation and Minimum Chip Thickness in Micro/Meso Milling: Methodology and Design of Experiment

Mohammad Yeakub Ali, Siti Hamizah Mass Duki and Noor Adila Mansor
Department of Manufacturing and Materials Engineering
Faculty of Engineering, International Islamic University Malaysia
P.O. Box 10, 50728 Kuala Lumpur, Malaysia
☎: mmyah@iiuvm.edu.my

*Keywords:* Micromilling, Chip formation, minimum chip thickness, Design of experiment

**Abstract.** This chapter discusses the methodology and design of experiment for the investigation of chip formation and minimum chip thickness in micro/meso milling for the development of relationship of feed rate, cutting speed and depth of cut with the minimum chip thickness. Literature related to micromilling chip formation and minimum chip thickness is briefly discussed. Experimental procedure is presented for experiment and data collection for modelling the relationship.

**Introduction**

In the recent years, the production of miniaturized components becomes very important due to increasing demand of microcomponents. Although the sizes are reducing, the performances of the components must be exactly the same or even better from its initial sizes. Micro/meso mechanical manufacturing (M4) can be defined as the production of three-dimensional products that scaled ranging from tens of micrometers to a few millimetres in various types of materials. The major role of M4 is to relate the conventional manufacturing which is macromanufacturing with nanomanufacturing. Nowadays, there are many products that apply M4 in their fabrication such as in automotive, aerospace, biomedical, telecommunications and military industry. Micromilling is one type of direct micromachining processes which means that the structure can be shaped directly and fabricated without molding process. It is also classified as a removing process where it is destroying cohesion among particles to produce desired shape [1]. In addition, micromilling has its own characteristics such as size effect, tool edge radius and minimum chip thickness. The minimum chip thickness has significant impact on the micromilling operation, especially when the uncut chip thickness is closed to micro tool edge radius. So the micromilling process can be divided into two situations which are chip forms and no chip form [2].

**Objectives**

The objectives of the chapter are as listed below:

1. To study the mechanism of chip formation in micromilling.
2. To study the parameters that affects the formation of minimum chip thickness in micromilling.