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

Edited by:
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IIUM PRESS

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

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Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Advanced Machining Towards Improved Machinability of Difficult-To-Cut Materials: A.K.M. Nurul Amin, Erry Yulian Triblas Adesta & Mohammad Yeakub Ali

ISBN: 978-967-418-175-8

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
IIUM PRINTING SDN.BHD.
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan
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List of Contents

Chapter 29

High Speed End Milling of Single Crystal Silicon using Diamond Coated Tool

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1.0 INTRODUCTION

Brittle materials are hard to machine while maintaining the surface roughness desired. A brittle material will have little tendency to deform before it fractures when it is subjected to stress. Brittle material is also consider as a material which fails in tension rather than shear and has little or no evidence of plastic deformation before it fails. Thimmaiah et al. [1] specified that brittle materials, silicon by their inherent properties, are difficult to machine while maintaining the desired surface roughness but J. Yan et al. [2] reviewed that silicon is a nominally brittle material that can be deformed plastically in machining, yielding ductile chips under the influence of high hydrostatic pressure. Mariayyah [3] , stated that under certain controlled conditions, it is possible to machine brittle materials in ductile regime so that material removal is by plastic deformation, leaving a damage free surface. Rusnaldy et al. [4] research on the cutting parameters effect. They study about the effect of the depth of cut, feed rate and spindle speed. Rusnaldy et al. [5] showed that the dominant ductile cutting mode was achieved for $Ft/Fc>1.0$, which indicates that the thrust force is dominant over the cutting force. Cutting to a very small uncut chip thickness can cause ploughing, resulting in a poor surface due to high friction. Siva [6] proposes a predictive model to determine the undeformed chip thickness in micro-machining of single crystal brittle materials, where the mode of chip formation transitions from the ductile to the brittle regime. The proposed model would support the determination of the cutting conditions for the micro-machining of a brittle material in ductile manner without resorting to trial and error. Furthermore, Sreejith [7] was able to obtain ductile mode of machining on silicon nitride by using Poly Crystalline Cubic Diamond (PCD) tools. His findings show that there is a maximum value of rake angle which will obtain ductile mode machining. Thimmaiah et al. [1] also did machining on silicon nitride but performed it using single point diamond turning. Their result indicates that small values of feed, small tooltip radius and at high speeds; conditions of pressure and temperature exist that facilitate ductile behaviour during machining. Negative rake angles are more likely to cause brittle to ductile transition when compared with the positive or zero degree rakes. These findings also correspond with Thimmaiah et al. [1] findings which also show that cutting force and thrust force increases as the rake angle becomes negative. The experimentation results differ with a crossover at between thrust force and cutting force at -45°. Furthermore, J. Yan et al (2000) stated that there is no inherent advantage in using rake angle more negative than -40°.