Minimum Chip Thickness in Machining MEMS Structure Using Tool Based Micromilling

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ABSTRACT

Tool based micromilling is a promising micromanufacturing technology to produce miniaturized features of about 25 µm in size for MEMS and Bio-MEMS applications. It is the most flexible and the fastest way to produce complex three dimensional micro components including sharp edges with surface finish at a reasonable cost. Moreover, it is capable of machining a broader range of materials such as engineering plastics, aluminium, titanium, etc. However, the issue in tool based micromilling is the minimum chip thickness which is often between 5-30% of the tool edge radius. No chip will form if the depth of cut cannot achieve the minimum chip thickness value. The lack of control on minimum chip thickness often leads to the coarse machined surface, poor machining accuracy and difficult in chip removal from the machining zone which leads to burr formation. Hence, the chip formation mechanism should be studied deeply to avoid these problems. In this research WC was selected for tool material and Aluminium Alloy 1100 for work material for the investigation of minimum chip thickness. The experiment is being conducted on a miniature machine known as Microtools Integrated Multi-purpose machine modelled DT-110. The value of chip thickness produced by tool 4.8 µm with 3 mm/min feed rate, 3000 rpm cutting speed and 5 µm depth of cut. The minimum chip thickness is useful for machining Microelectromechanical System (MEMS) and Bio-MEMS structures.

PROBLEM STATEMENT

If the ratio of tool edge radius and depth of cut is not well established, it will lead to a rising of slipping forces and ploughing of the machined surface and causes the increasing of cutting forces, burr formation and surface roughness.

OBJECTIVES

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.
3. To study the various ratios between tool edge radius and depth of cut that affects minimum chip thickness.
4. To analyze the relationship among tool diameter, feed rate, cutting speed and depth of cut for minimum chip thickness.

CONCLUSIONS

- ❑ Minimum chip thickness in tool base micromilling is found to be 4.8µm. This minimum chip thickness was obtained for low feed rate, high cutting speed and low depth of cut.
- ❑ Applying the minimum chip thickness parameters MEMS structures can be produced with higher accuracy
- ❑ The main challenges in this project are to monitor the formation of chip and measurement of chip thickness by using the SEM.

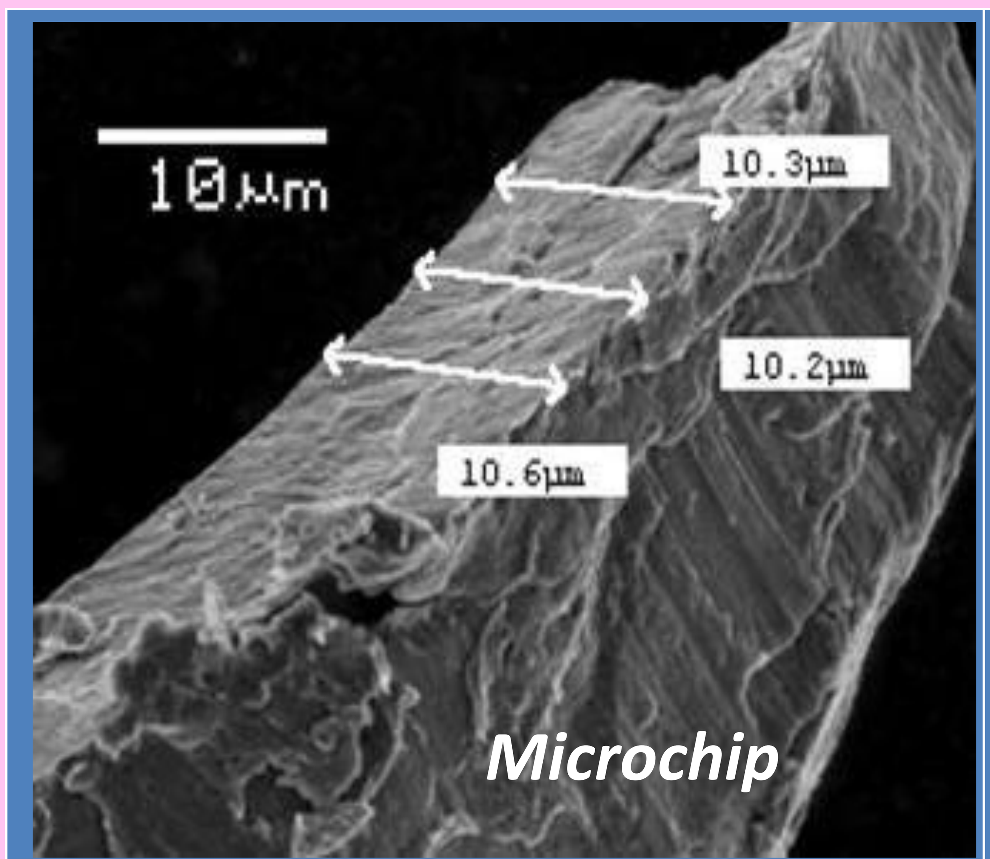
EXPERIMENTAL SETUP

WC microtool

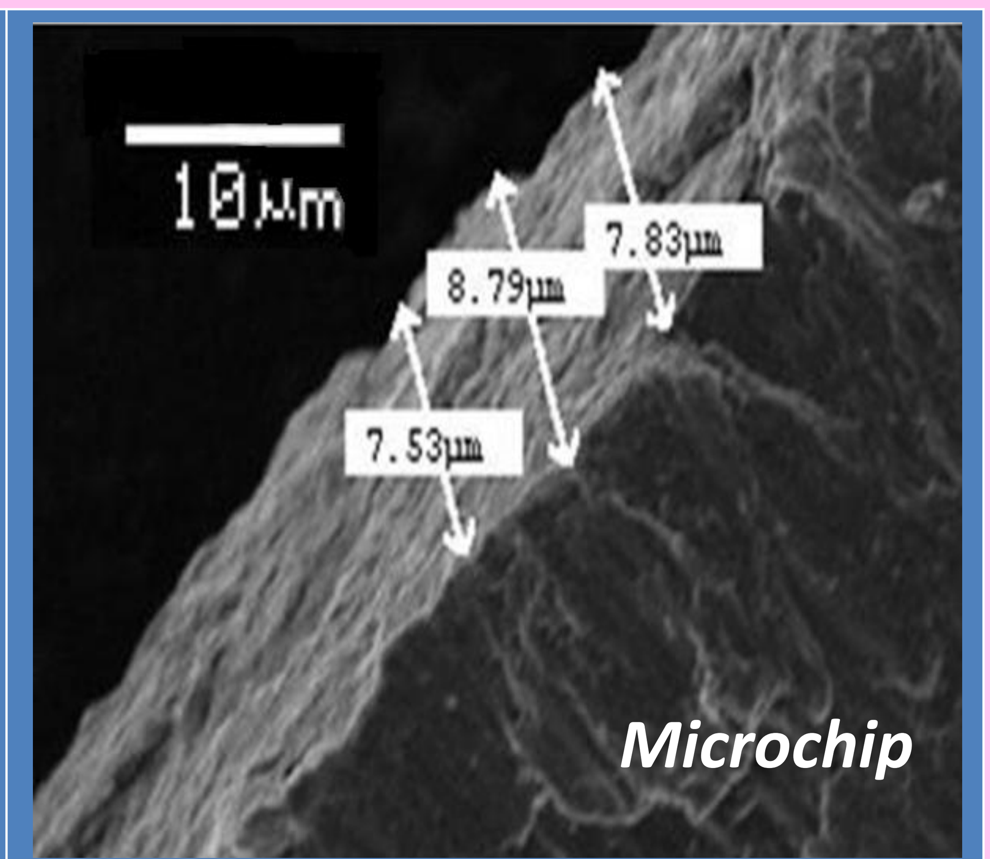
Mcromilling microchannel on Al alloy 1100 using DT 110 (Mikrotools, S'pore)

SEM JSM 5600 (JEOL, Japan)

RSEULTS AND MODELS

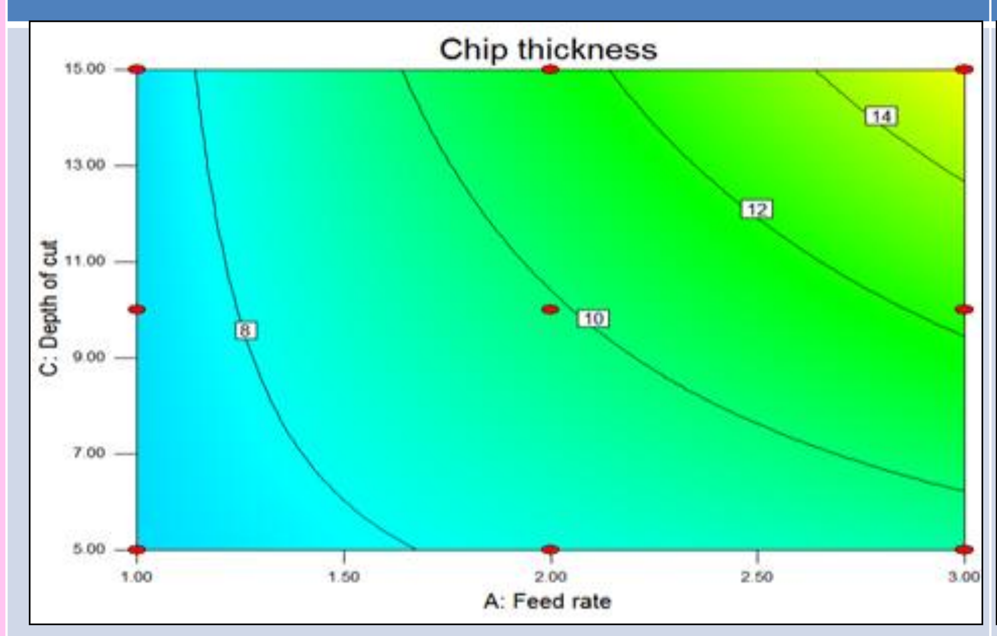


Ø 0.8 mm
f: 3 mm/min, n: 3000 rpm, d: 5 µm



Ø 1.0 mm
f: 1 mm/min, n: 1000 rpm, d: 10 µm

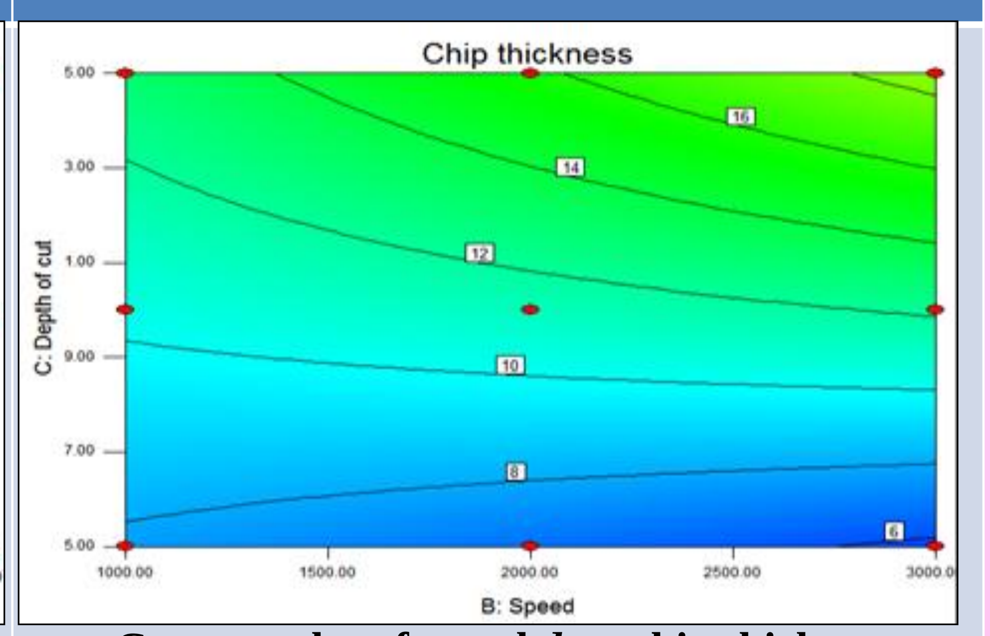
Ø 0.8 mm



Contour plot of *f* and *d* on chip thickness

$t = 9.9+2.5f-1.4n+1.6d+1.2fn+1.5fd - 0.7nd$

Ø 1.0 mm

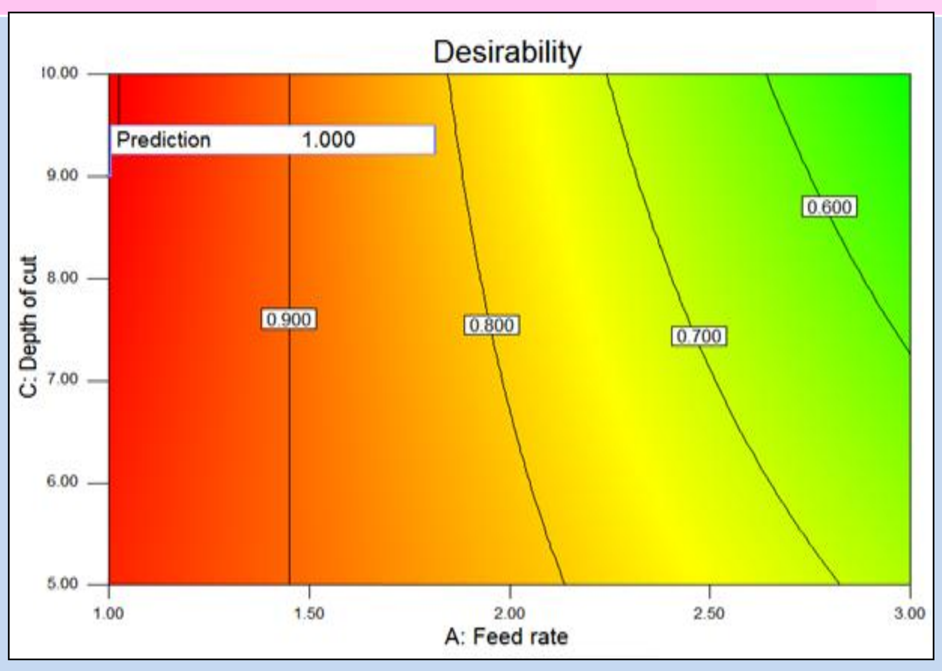


Contour plot of *n* and *d* on chip thickness

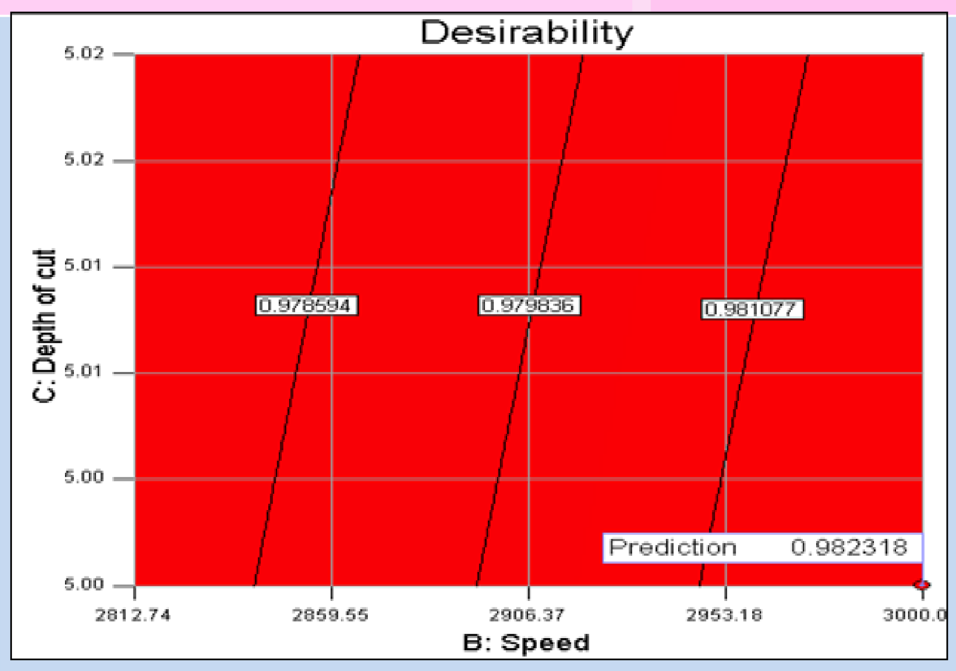
$t = 11.5-0.2f+3.1n+3.5d-2.2fn+1.0fd+1.9nd$

t: Chip thickness (µm) f: Feed rate (mm/min) n: Spindle speed (rpm) d: Depth of cut (µm)

OPTIMIZATION



Ø 0.8 mm, t: 4.8µm
f: 1mm/min, n: 3000 rpm, d: 10µm



Ø 1.0 mm, t: 5.75µm
f: 3mm/min, n: 3000 rpm, d: 5µm