UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Analysis of Maximum Temperature and Heat Generation of Cutting Tools during Machining

Thesis submitted in accordance with the requirements of the Universiti Teknikal Malaysia Melaka (UTeM) for the Degree of Bachelor of Engineering (Honours) Manufacturing (Design)

By

Norwadiah binti Mohd Andai

Faculty of Manufacturing Engineering

May 2007

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: **ANALYSIS OF MAXIMUM TEMPERATURE AND HEAT GENERATION OF CUTTING TOOLS DURING MACHINING**

SESI PENGAJIAN: 2/2006-2007

Saya **NORWADIAH BINTI MOHD ANDAI**

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
√	TIDAK TERHAD	

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PENYELIA)

Alamat Tetap:
1226, Lorong 12,
Kampung Besut, 24000 Chukai,
Kemaman, Terengganu.

Cop Rasmi:
RUZY HARYATI BINTI HAMBALI
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

Tarikh: 14th April 2007

Tarikh: 14 MEI 2007 .

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declare this thesis entitled "Analysis Temperature and Heat Generation of Cutting Tool during Machining" is the result of my own research except as cited in the reference.

Signature : ....

Author Name : NORWADIAH BINTI MOHD ANDAI

Date : 14TH MAY 2007

APPROVAL

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Design). The members of the supervisory committee are as follow:

Signature : ....

Supervisor: : PUAN RUZY HARYATI BINTI HAMBALI

Date : 14^{TH} MAY 2007

RUZY HARYATI BINTI HAMBALI
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

ABSTRACT

Penentuan suhu maksima dan kajian tentang penyebaran suhu sepanjang permukaan pada perkakas pemotong adalah sangat penting disebabkan untuk mengawal pengaruh terhadap jangka hayat perkakas pemotong dan juga kualiti bahan kerja tersebut. Pelbagai usaha digunakan untuk masalah tersebut iaitu secara membuat ujikaji, analisis dan juga secara menggunakan pengiraan.

Maka, kajian difokuskan kepada menentukan penyebaran suhu pada sepanjang permukaan bagi perkakas pemotong dan daripada data, analisis untuk menentukan suhu maksima telah dilakukan menggunakan graf yang telah diplot. Penggunaan mesin larik telah digunakan untuk menyiapkan kajian dan menggunakan perkakas pemotong yang telah disalut dengan Titanium Nitrite (TiN) dan kod nombor ialah WNMG080408E. Bahan kerja yang digunakan ialah besi lembut-AISI 1045. Kelajuan bagi proses pemesinan bagi ujikaji tersebut ialah a) kelajuan rendah iaitu 185m/min, b) kelajuan sederhana iaitu 425m/min dan c) kelajuan tinggi iaitu 1150m/min. Kadar suapan yang ditetapkan dalam proses pemotongan adalah malar manakala kedalaman pemotongan adalah 0.5mm dan 1.0mm. Nilai suhu diambil mengikut masa pemotongan dari 30, 60, 90, 120, 150, 180, 210, 240, 270 dan 300 saat. Alatan yang digunakan dalam penentuan suhu tersebut ialah dengan menggunakan "non-contact infrared thermometer."

Keputusannya, titik yang berada pada kedudukan paling dekat dengan fenomena sentuhan antara perkakas pemotong, pembentukan serpihan dan juga bahan kerja memberi nilai suhu yang lebih tinggi berbanding dengan titik lain pada permukaan perkakas pemotong. Nilai paling tinggi dengan nilai kadar suapan 0.5mm ialah 40.25 °C (kelajuan rendah 185 m/min), untuk kelajuan sederhana 425m/min ialah 51.25 °C dan nilai suhu bagi kelajuan tinggi ialah 87.25 °C. Bagi kadar suapan dengan nilai 1.0mm pula ialah 44.5 °C (kelajuan rendah 185 m/min), untuk kelajuan sederhana 425m/min ialah 57.25 °C dan nilai suhu bagi kelajuan tinggi ialah 107.25 °C.

ABSTRACT

Determination of maximum temperature and research of the heat generation along the rake face of cutting tool is particular importance due to its controlling influence on tool life and also the quality of the machining parts. Numerous attempts have been made to approach the problem with different methods including experimental, analytical and also numerical analysis.

Thus, the study is focussed to determine the temperature distribution along the rake face of the insert cutting tool and from the data, the analyze of the maximum temperature has been done by using the plotted graph. The application of lathe machine has been used to fulfill the project and the experiment concentrated in the insert carbide cutting tool which coated by Titanium Nitrite and the code number is WNMG080408E. The machining workpiece which has been used is mild steel-AISI 1045. The speed machining of the experiment are; a) low speed machining is 185m/min, b) medium speed machining is 425 m/min and c) high speed machining is 1150 m/min. The feed of rate for the machining experiment has been set to be constant at 0.5mm while for depth of cut variable; it has been set to 0.5mm and 1.0mm. The temperature value of the tool inserts were monitored at 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 seconds cutting times. The temperature measurement of the flank tip of insert cutting tool has been used radiation technique and the tool is the non-contact infrared thermometer.

As the result, the point which is located nearest to the contact phenomena between the tool, the chip and the workpiece give higher temperature value rather than the other point at the rake face of insert cutting tool. The highest value for depth of cut is 0.5 mm is 40.25 °C (low speed machining 185 m/min), for the medium speed machining 425 m/min is 51.25 °C and the value temperature in high speed machining 1150m/min is 87.25 °C. The highest value for depth of cut is 1.0 mm is 44.5 °C (low speed machining 185 m/min), for the medium speed machining 425 m/min is 57.25 °C and the value temperature in high speed machining 1150m/min is 107.25 °C.

DEDICATION

For my supervisor, lecturers, family and friends

ACKNOWLEDGEMENTS

The author would like to thank the following people for their contribution to this project:

Mrs. Ruzy Haryati binti Hambali, project supervisor, really thankful for her invaluable advice, guidance, helps, support and everything. God bless you;

Mr. Ismail bin Abu Shah, second supervisor who give the guidance and appropriate suggestion with the thesis work.

Mr Jaafar, the technician leader, for his eager assistance and for providing equipment that was required.

Mr Mohd Hisyam, the technician at Machine Shop Laboratory who helps me in run the experiment to fulfill the objective of the thesis.

Last but not least, my understanding family and friends that gave full love and support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

TiN- Titanium Nitrat

WC- Tungsten carbide

μm- Mikronmeter

emf- electromotive force

IHCM-Inverse Heat Conduction Method

HSM- High Speed Machining

BUE - built-up edge

FEA- Finite Element Analysis

FEM- Finite Element Method

CHAPTER ONE

INTRODUCTION

1.1 Background Introduction

In this study, it is clearly shown that the conditions of machining process are the important term in manufacturing industry. The important parameters which need to be controlled are the temperature and the heat generation of cutting tools during machining process. High cutting temperature of the cutting tool zone strongly influence tool wear, tool life, surface finish and integrity of the machined parts, the mechanism of chip formation and also contribute to the thermal deformation of the cutting tool which is considered as the largest source of error in the machining process.(Y. Takeuchi et al. , 1982)

The research of this study involved the fundamentals of cutting tool and also the connection with the temperature and also the heat generation of cutting tools during machining. The main focus of this study is to determine the temperature distribution along the rake face of the insert cutting tool. The purpose of this research also to analyze the maximum temperature and the effects to the insert cutting tools also depend on the parameters which involved in the experiment.

Measuring temperature and the prediction of heat generation in metal cutting is extremely difficult due to a narrow shear band, chip obstacles and the nature of the contact phenomenon where two bodies, tool and chip are in continuous contact and moving with respect to each other. Hence, the measuring of heat distribution along the tool rake face can be done by using the infrared digital thermometer. There is some equipment which more advanced but the research is in the academic area and the expenditure for the project is limited. The variables which have been determined in the experiment are the different value of the machining speed and also the depth of cut value.

The development of determination the maximum temperature has been done by using appropriate graphs which has been plotted in see the difference between the variable parameters which involved in the experiment. By the plotting graph, the analyzing and the conclusion can be obtained for this research.

1.2 Problem Statements

High cutting temperatures strongly influenced tool wear, workpiece surface integrity, chip formation mechanism and contribute to the thermal deformation of the cutting tool, which is considered as the largest source of error in the machining process.

Determination of the maximum temperature and temperature distribution along the rake face of the cutting tool is a particular importance because it's controlling influence on tool life as well as the quality of the machined parts.

1.3 Objectives of the Research

The objectives of the research such as

1. To determine the temperature distribution along the rake face of the insert cutting tool
2. To analyze the maximum temperature and the effects to the insert cutting tools

1.4 Scopes of the Research

1. This study will be involved the literature review of cutting tool and tool life concept.
2. Using Turning process of steel AISI material will be used, then determination the temperature distribution along the cutting tool will be measured experimentally by using Infrared Digital Thermometer.
3. Analysis will be made to get the maximum temperature and to locate the most affected area in the cutting tool

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This literature review will discuss thoroughly on the issue that is related with the heat generation of cutting tool in manufacturing industry. The legal requirement regarding heat distribution of cutting tool is stated in this part and explains further on how important the factor to be controlled in machining process operation. The other related topic is about the tool life concept which also has been affected by the heat generation of cutting tool. Here in this literature review also review the advanced techniques which used to measure the temperature of cutting tool while machining process and also the development of the computer simulation for prediction of the tool life.

2.2 Machining Processes

Machining is a general term describing a group of processes that consists of the removal of material and modification of the surfaces of a workpiece after it has been produced by various methods. Thus, machining involves secondary and finishing operations.

The machining consists of several major types of material removal processes

1) Cutting typically involving single-point or multipoint cutting tools, each with a clearly defined shape
2) Abrasive processes such as grinding and related processes
3) Advanced machining processes utilizing electrical, chemical, laser, thermal and hydrodynamic methods

As in other manufacturing operations, it is important to view machining operations as a system, consisting of the

1) Workpiece
2) Cutting tool
3) Machine tool
4) Production personnel

Machining cannot be carried out efficiently or economically and also meet stringent part specifications without a thorough knowledge of the interactions among these four elements.

2.3 Fundamentals of cutting operation

The cutting processes remove material from the surface of a workpiece by producing chips. Some of the more common cutting processes are illustrated in Figure 2.1.

1) Turning in which the workpiece is rotated and a cutting tool removes a layer of material as it moves to the left
2) Cutting-off operation in which the cutting tool moves radially inward and separates the right piece from the bulk of the blank
3) Slab-milling operation is a rotating cutting tool removes a layer of material from the surface of the workpiece
4) End-milling operation in which a rotating cutter travels along a certain depth in the workpiece and produces cavity

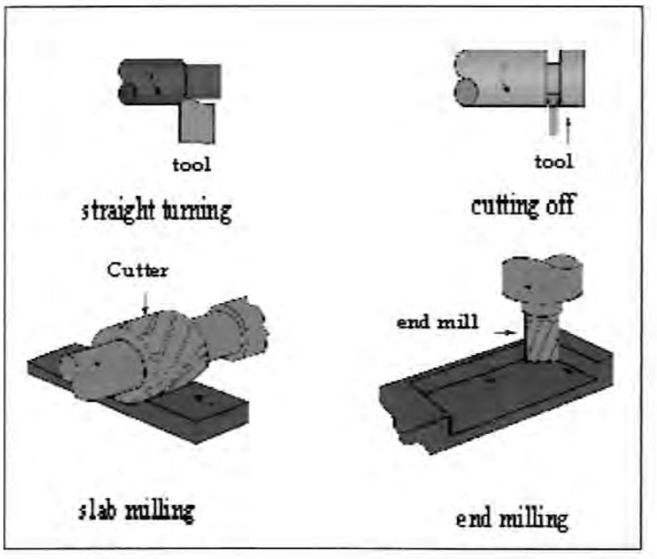

Figure 2.1: Some examples of common machining operations (Source: Kalpakjian, Schmid, 2006)

2.3.1 Description of turning operation

As Figure 2.2, the turning process can be shown by using lathe machine, and as illustrated in greater detail in Figure 2.3, the cutting tool is set at a certain depth of cut (mm or in) and travels to the left with a certain velocity as the workpiece rotates. The feed or feed rate is the distance the tool travels horizontally per unit revolution of the workpiece (mm/rev). This movement of the tool produces a chip, which moves up the face of the tool.

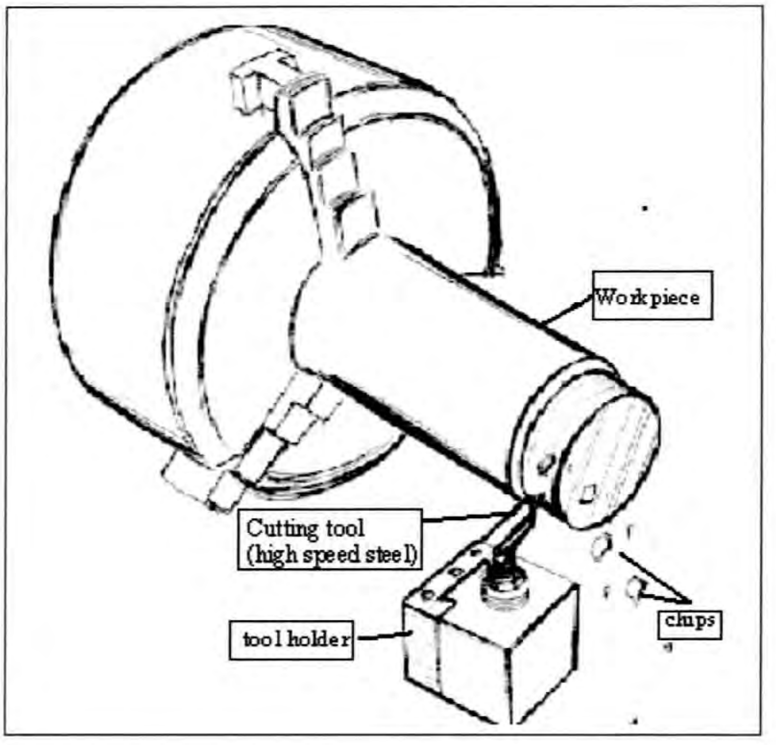

Figure 2.2: The turning operation (Source: Kalpakjian, Schmid, 2006)

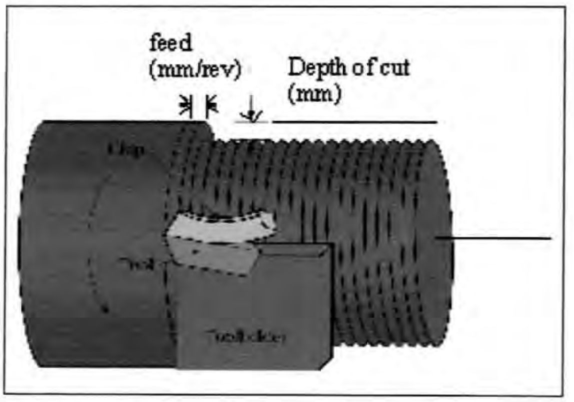

Figure 2.3: Schematic illustration of the turning operation showing various features (Source: Kalpakjian, Schmid, 2006)

Turning is the most common machining operation. There are number of common types of turning operation including:

1) Longitudinal turning
2) Face turning
3) Copy turning
4) Internal turning

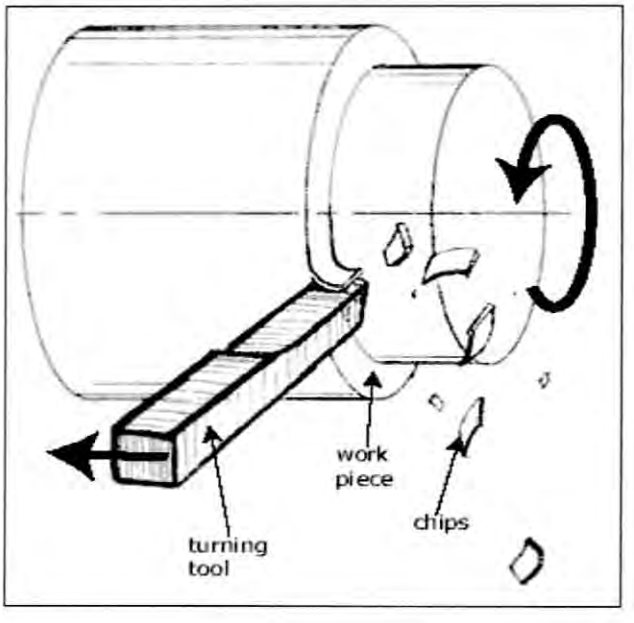

Figure 2.4: The roughing turning (Source: Kalpakjian, Schmid, 2006)

In Figure 2.4, the roughing process of turning operation can be illustrated which can be described that removal process material by followed as the parameters: depth of cut.

As Figure 2.5, the term "facing" is used to describe removal of material from the flat end of a cylindrical part, as shown below. Facing is often used to improve the finish of surfaces that have been parted.

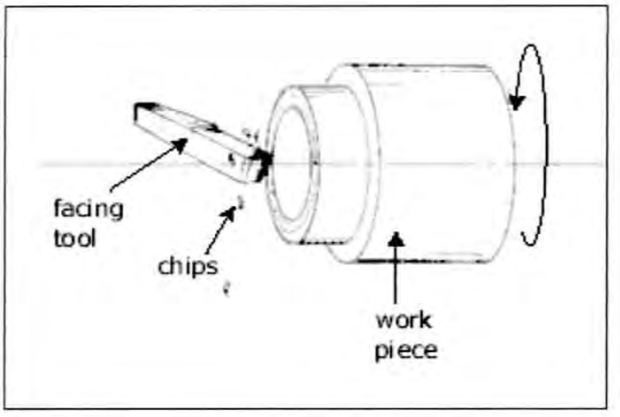

Figure 2.5: The facing turning (Source: Kalpakjian, Schmid, 2006)