NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

Study the Wear on High Speed Steel (HSS) Cutting Tool by Variable Parameters in Turning Operation

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Engineering (Honours) Manufacturing (Process)

By

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STUDY THE WEAR ON HIGH SPEED STEEL (HSS) CUTTING TOOL BY VARIABLE PARAMETERS IN TURNING OPERATION

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DECLARATION

I hereby, declare this thesis entitled "Study the Wear on High Speed Steel (HSS) Cutting Tool by Variable Parameters in Turning Operation" is the results of my own research except as cited in the reference.

Signature	:	....
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Date	:	31 May 2006

ABSTRACT

The main goal of this project is to 'Study the Tool Wear on High Speed Steel (HSS) cutting tool in Turning Operation' and also the influence of cutting conditions such as cutting speed, feed rate, depth of cut and cutting time on tool life and surface finish of the workpiece in the turning operation. Aiming to achieve this goal, several turning experiments were carried out with different cutting speeds, cutting time and feed rate. In the first phase of the experiments, cutting time is varied in such a way that cutting speed and feed rate are kept constant. Tool flank wear and surface roughness of the workpiece are measured as cutting time elapsed by using Optical Microscope and Profilometer. Machining productivity and associated costs are directly related to process planning decisions that determine machining parameters and cutting tool management strategies. The present study tested the hypothesis that tool wear can be more comprehensively related to the surface roughness of a machined part than provided by the traditional measure of tool wear, namely flank wear land width. The proposed method uses an Optical Microscope and Profilometer to measure flank wear of High Speed Steel (HSS) cutting tool employed in a turning operation. The conclusions of this project are that cutting speed, feed rate and depth of cut has an influence on tool life, regardless of whether feed velocity and an increase in surface roughness of the workpiece is not closely related to increase in wear of the primary cutting edge.

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In the name of Allah, the Most Merciful and the Most Beneficent. It is with the deepest senses gratitude of the almighty that gives strength and ability to complete this project and technical report.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

N	-	Rotational speed of the workpiece,(RPM)
F	-	Feed, (mm/rev or in/mm)
v	-	Feed Rate or linear speed of the tool along workpiece length
V	-	Cutting speed of workpiece, (m/min or ft/min)
l	-	Length of cut, (mm or in)
D	-	Diameter, (mm)
D_0	-	Original diameter of workpiece, (mm or in)
Df	-	Final diameter of workpiece, (mm or in)
Davg	-	Average diameter of workpiece, (mm or in)
d	-	Depth of cut, (mm or in)
t	-	Time, (s or min)
MRR	-	Material Removal Rate (mm^3/min or in^3/min)
w	-	2 ΠN radians/min
P	-	Power
SEMs	-	Scanning Electron Microscopes
HSS	-	High Speed Steel
T	-	Tool life, (min)
C	-	Constant, y intercept cutting speed at tool life of 1 minute
n	-	The index for the particular combination of tool and workpiece material

APPROVAL

This thesis summitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to-metal contact between the chip and workpiece, under conditions of very high stress at high temperature. The situation is further aggravated (worsened) due to the existence of extreme stress and temperature gradients near the surface of the tool.

During machining, cutting tools remove material from the component to achieve the required shape, dimension and surface roughness (finish). However, wear occurs during the cutting action, and it will ultimately result in the failure of the cutting tool. When the tool wear reaches a certain extent, the tool or active edge has to be replaced to guarantee the desired cutting action.

As can be seen in the articles cited in this work, as well as in others, much has been done to achieve a better understanding of the phenomena that occur in this process caused by the interrupted cutting that each cutting edge performs. Besides, much effort has been done to establish the relationship between cutting speed and tool wear and tool life. When cutting speed varies, two different conditions can occur. If feed velocity varies proportionately, feed per tooth is kept constant. If feed velocity is not varied simultaneously, then feed per tooth decreases as cutting speed increases. Therefore, it is necessary to verify if the influence of cutting speed on tool wear and tool life is independent of feed velocity. Besides, it is also important to verify how all these parameters influence the surface roughness of the workpiece. The main goal of this project is to answer these questions. Several turning experiments were carried out under different cutting conditions. In the first part of the experiments, cutting speed was varied without varying feed velocity, which caused a variation in feed per tooth. In the second phase of the experiments, cutting speed and feed velocity were varied in such a way that feed per tooth was kept constant. Tool flank wear and surface roughness of the workpiece were measured as cutting time elapsed.

1.2 DESCRIPTION OF THE PROJECT

In the past, considerable research has been conducted to study tool wear during the turning process and its relationship to process outputs such as cutting forces, surface finish, part quality, and dynamic stability. Wear on the flank face (flank wear) of the tool is of specific interest because it has the effect of increasing the cutting forces and decreasing surface finish quality.

1.3 OBJECTIVES OF THE RESEARCH

i. To study the general characteristics of tool wear
ii. To measure and identify the effect of tool wear by using variable cutting parameter.
iii. To identify the proper machining parameter for Lathe Machine.
iv. To understand the causes of tool wear and their consequences
v. To identify the major causes of wear especially flank wear on the workpiece.
vi. To set up the tool failure criteria and understand the meaning of tool-life.
vii. To describe the relationships between cutting speed, feed rate and depth of cut.
viii. To solve for the correct speed value on the lathe using the appropriate formula.

CHAPTER 2

LITERATURE REVIEW

2. 1 THE CUTTING THEORY

2.1.1 OVERVIEW

Machining is the most important of the manufacturing processes. Machining can be defined as the process of removing material from a work piece in the form of chips. The term metal cutting is used when the material is metallic. Most machining has very low set-up cost compared to forming, molding, and casting processes. However, machining is much more expensive for high volumes. Machining is necessary where tight tolerances on dimensions and finishes are required. The Machining section is divided into the following categories such as drilling, turning, milling, and grinding operation.

1. TURNING:

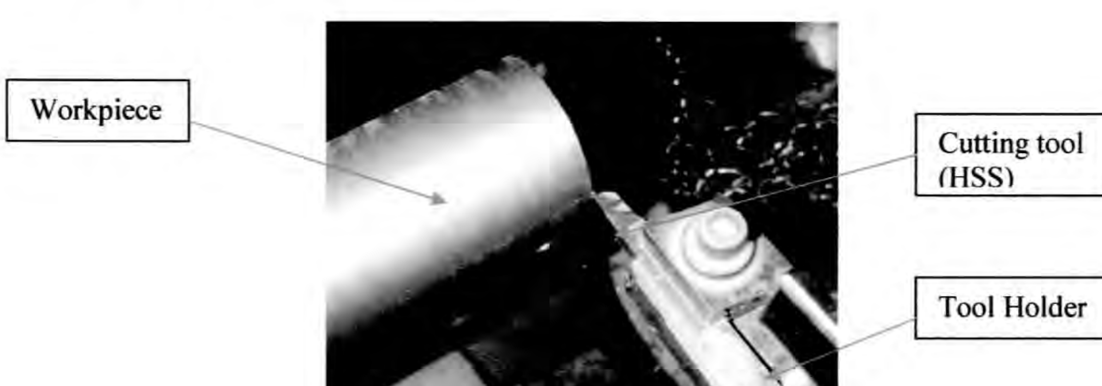

Figure 2.1: Illustrated of turning operation

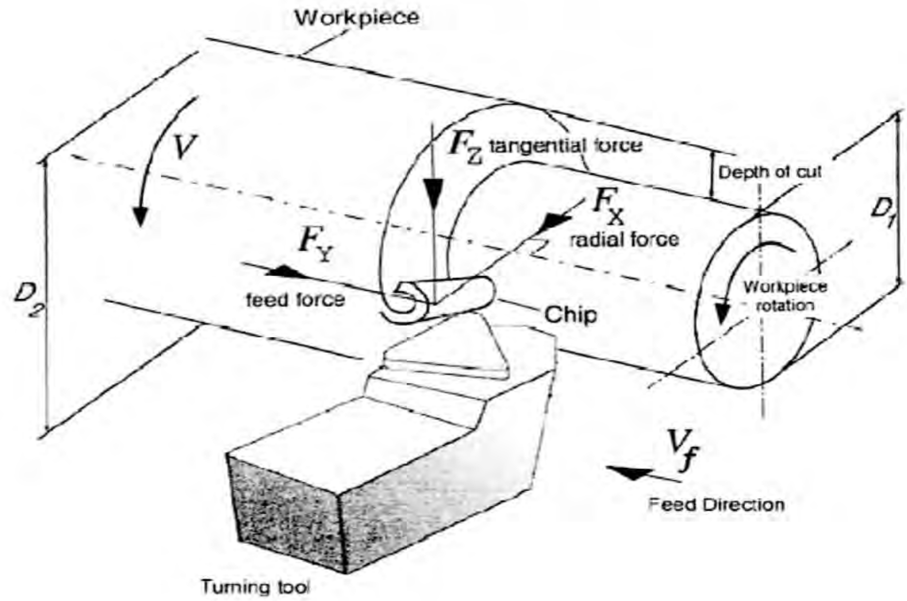

Figure 2.2: Machining parameter in turning operation

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

i. Longitudinal turning

ii. Face turning

iii. Copy turning

iv. Face turning

Figure 2.3: Turning operation

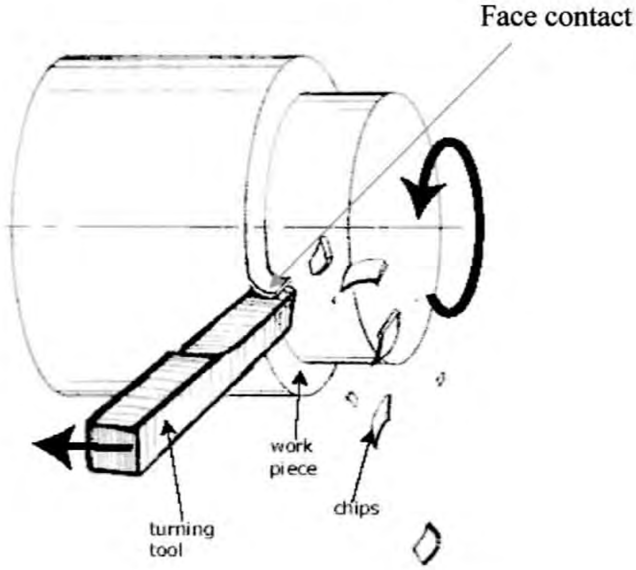

Figure 2.4: Roughing operation

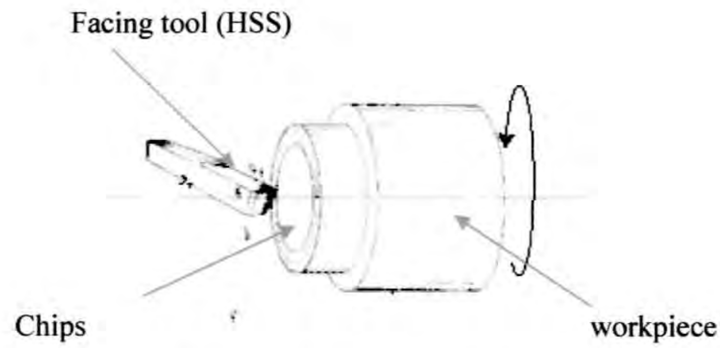

Figure 2.5: Facing operation

The term facing is used to describe the 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.

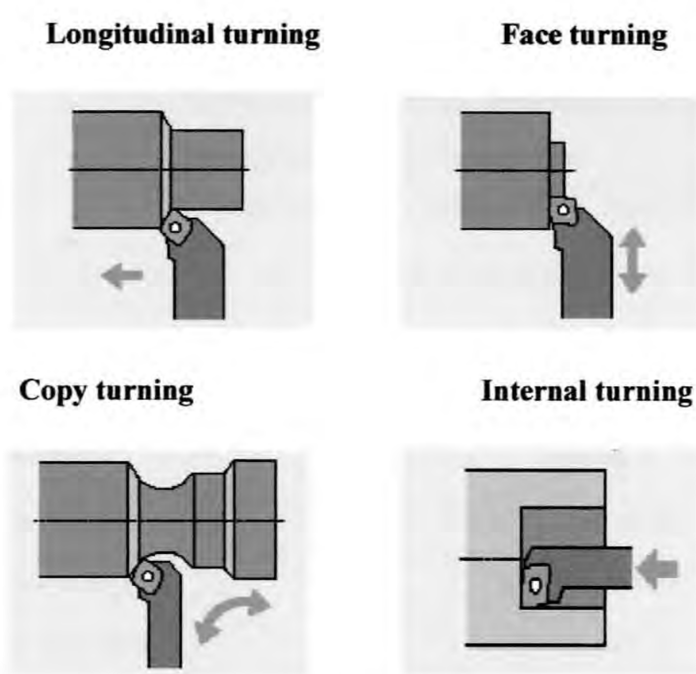

Figure 2.6: Common types of turning operation

Table 2.1: Factors Influencing Cutting Processes (Kalpakjian, Schmid, Manufacturing Engineering and Technology)

Parameter	**Influence and interrelationship**
Cutting speed, depth of cut, feed, and cutting fluids.	Forces, power, temperature rise, tool life, type of chip, surface finish.
tool angles	As above, influence on chip flow direction, resistance to tool chipping.
Continuous chip	Good surface finish, steady cutting force: undesirable in automated machinery.
Build-up edge chip	Poor surface finish, thin stable edge can protect tool surface.
Discontinuous chip	Desirable for ease of chip disposal; fluctuating cutting forces; effect on the surface finish and cause vibration and chatter.
Temperature rise	Influence tool life, particularly crater wear, and dimensional accuracy of workpiece surface.
Tool wear	Influence surface finish, dimensional accuracy, temperature rise, force and power.
Machinability	Related to tool life, surface finish, force and power.

Table 2.2: Machining Speed Recommendations

Material	**Speed**
Cast Iron	600-1200 m/min
Sintered Iron	100-175 m/min
Hard Cast Iron	60-175 m/min
Hardened Steel	100-200 m/min
Super alloys	200-300 m/min

2.1.2 MECHANICS OF CUTTING

In general, machining is 3D-process for providing an understanding of mechanics of machining, we simplify the process into a 2D-process called as Orthogonal Cutting as shown in figure 2.7. In orthogonal cutting, the workpiece is a flat plate and is machined using a wedge-shaped tool with a *rake angle* (α) and a *relief angle* (σ). The workpiece is moving at a cutting speed, (V) with a depth of cut, (d) to remove material. The width remains unaffected. Merchant has developed an analysis based on the classical thin zone mechanics for materials that yield continuous chip with planar shear process. The following assumptions were made:

i. The tool tip is sharp and no rubbing occurs between the tool and workpiece.

ii. Plain strain conditions, such as there is no side spread and therefore the deformation is two dimensional.

iii. The stresses on the shear plane are uniformly distributed.

The resultant force on the chip applied at the shear plane is equal, opposite and collinear to the force applied which is the force applied to the chip at the tool-chip interface.

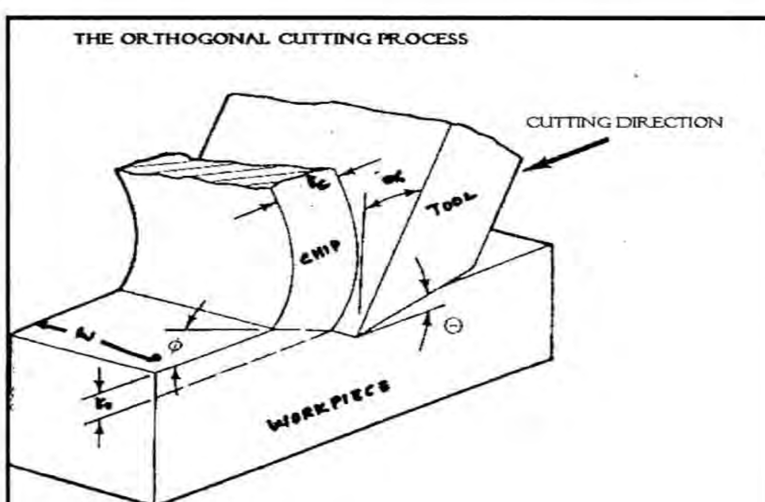

Figure 2.7: The orthogonal cutting process

2.2 TYPES OF CHIP

2.2.1 Chip Formation: Introduction

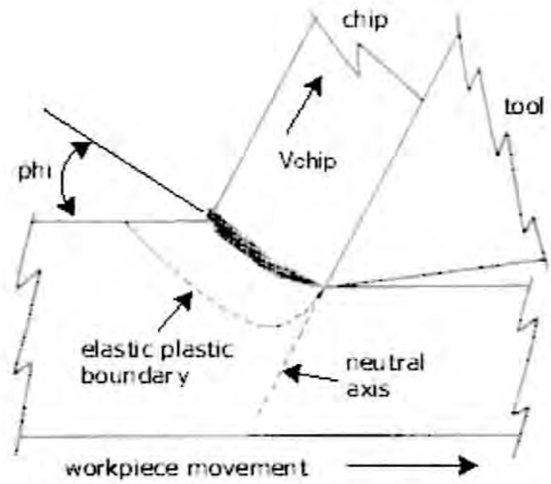

Figure 2.8: Illustrated of Chip Formation

The chip formation process is the same for most machining processes, and it has been researched in order to determine closed-form solutions for speeds, feed rate, and other parameters which have in the past been determined by the "feel" of the machinist.

With Computer Numerical Control (CNC) machine tools producing parts at ever-faster rates, it has become important to provide automatic algorithms for determining speeds and feeds. The information presented in this section is some of the more important aspects of chip formation. Reasons for machining being difficult to analyze and characterize can be summarized as follows:

- The strain rate is extremely high compared to that of other fabrication processes.
- The process varies considerably depending on the part material, temperature, cutting fluids, etc.
- The process varies considerably depending on the tool material, temperature, chatter and vibration.