UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS PERFORMANCE OF TiC-CARBIDE CUTTING TOOLS WHEN TURNING WITH AISI 1045 STEEL

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

By

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Jun 2006

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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JUDUL: **Analysis performance of TiC-carbide cutting tools when turning with AISI 1045 steel**

SESI PENGAJIAN: 2/2006-2007

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"Analysis performance of TiC-carbide cutting tools when turning with AISI 1045 steel" is the results of my own research except as cited in the reference.

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ABSTRACT

This thesis contain the report of machining performance of tool coating when apply in machining process. The aim of this paperwork is to present flank wear characteristics of titanium carbide (TiC) as coated material on cemented carbide tool during machining a medium carbon steel (AISI 1045) material in dry turning. Machining performance is determined according to tool wear, tool life and surface finish that obtained. The nominal (starting) workpiece diameter is 50mm and the cutting speeds used are constant at 700 m/min with feed rate and depth of cut is 0.2mm/rev and 0.5mm, respectively. The cutting time is considered in this machining test to identify the tool life. Single interval of cutting time has been setup at constant cutting speeds which is 0.5 min each. From that, the appropriate cutting parameters for each cutting tool will be identify depending on tool wear and tool life. Tool wear that appeared is analyzed by flank wear as recommended in ISO 3685 (1993): Tool life testing with single point turning tools. From study, the rate of wear growth and wear mechanism at the end of tool life was investigated in detail using image analyzer. From the photographs of progressive wear, it has been observed that the time taken for the cutting edge of TiC coated carbide tools to initiate cracking and fracturing is longer when cutting at low speed than at high speed such as 700 m/min. The critical cutting speed influence the surface finish of work material. Tool variables, work material variables and setup variables are factor that affect surface roughness in rough turning.

ACKNOWLEDGEMENTS

Personally, I would like to thank Universiti Teknikal Malaysia Melaka for the opportunity given to me completing "Projek Sarjana Muda 1 and 2" at the year 4 semester 1 and 2.

My hearties appreciation especially to:

- Professor Dr. Mohd. Razali b. Muhamad, Dean of Faculty of Manufacturing Engineering, Universiti Teknikal Kebangsaan Malaysia.
- En. Mohd. Hadzley, Lecturer of Faculty Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, as my supervisor that always guides, support and gives important information until I completely finished my project.
- En. Sivarao, Lecturer of Faculty Manufacturing Engineering, Kolej Universiti Teknikal Kebangsaan Malaysia, as a head of project presentation panel that lead and guide me in this final year project.
- Pn. Zurina Bt Shamsudin, Lecturer of Faculty Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, as my second examiner that giving me ideas to analyzed and develop the findings of these project.

It was their kind efforts that given me opportunity and guidance to successfully undergo my "Projek Sarjana Muda 1 and 2" in accordance with the requirements of the Universiti Teknikal Malaysia Melaka of Bachelor of Engineering (Honours) Manufacturing (Process).

Last but not least, I would like to thanks all my friends that give full support and also my family for their support and encouragement in completed my final year project.

Your help and support will always be cherished.

Thank You.

Yours sincerely,

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

AISI	-	American National Standard Institute
Al_2O_3	-	Aluminum Oxide
CBN	-	Cubic Boron Nitride
CrC	-	Cromium Nitride
CNC	-	Computer Numerical Control
CVD	-	Chemical Vapor Deposition
d.o.c	-	Depth of cut
Da	-	Initial diameter
Db	-	Final diameter
H.S.S	-	High Speed Steel
ISO	-	International organization of Standardization
MRR	-	Metal Removal Rate
MTCVD	-	Medium Temperature Chemical Vapor Deposition
M-series	-	Molybdenum series
PVD	-	Physical Vapor Deposition
Ra	-	Arithmetic average
Rq	-	Root mean square value
Rpm	-	revolution per minute
Sfpm	-	Surface feet per minute
TiAlN	-	Titanium Aluminum Nitride
TiCN	-	Titanium Carbonitride
TiN	-	Titanium Nitride
TiC	-	Titanium Carbide
T-series	-	Tungsten series
WC	-	Tungsten Carbide

CHAPTER 1

INTRODUCTION

1.1 Background of project

Tool wear has been one of the most studied subjects in metal cutting, since wear minimization has been pursued by different means, beginning with tool steels and heat treatments, going later to new tool materials and, more recently, to coatings . The first great improvement happened with HSS, but its use in metal cutting has been strongly reduced, given place to sintered carbides, since the middle of the last century. An ideal cutting material has to combine high hardness and wear resistance with good toughness and chemical stability, but no material has ever shown all these properties together at their best combination. As an alternative, tools can be coated with materials more suitable to withstand cutting conditions at the interface tool–chip. Accordingly, better properties are added on the surface, combined with an adequate substrate. Coating materials usually offer higher hardness at high temperature, good chemical stability, lubricant properties, good thermal properties, etc. TiC have shown great advantages over other coatings since Aluminum can react with oxygen forming Al_2O_3, whose ceramic properties are much more adequate for interaction with hot and abrasive chips. The use of coated cutting tools to machine various materials represent state-of-the art machining technology, and today's machining process are becoming increasingly demanding on cutting materials. (DeGarmo, 1998)

The keyword for manufacturers of cutting tools and coatings for cutting tools is productivity: a 30% reduction of tool costs, or a 50% increase in tool lifetime results only in a 1% reduction of manufacturing costs (J modern coating). Advances in manufacturing technologies (increased cutting speeds, dry machining, etc.) triggered the fast commercial growth of PVD coatings for cutting tools. On the other hand, technological improvements in coating technologies (TiC, TiAlN, AlTiN, AlCrN and nanocomposite coatings) enabled these advances in manufacturing technologies. (Poulachon et. al, 2003)

It is a common belief that coatings deposited on different substrates improve the wear resistance of the tool and modify the contact conditions between the chip and the tool faces. Smith et al. showed that the performance of coating can be significantly affected by hard thin film of TiC. However, in general modifying the properties of tool inserts by applying hard or combined hard and soft protective coatings can substantially slow down some wear processes, reduce friction and prolong the tool life. In most cases coating layers can improve tool life due to a thermal barrier between the heats generated at the interface tool-chip. (Oberg et. al, 2004)

Although coating layers are not capable of blocking heat, if they have the appropriate thermal properties, a "thermal resistance" can be put between chip and substrate. Therefore, a lower temperature will result on the substrate and more heat will reside in the chip. That action can reduce workpiece material hardness and also delay temperature rise on the substrate, extending tool life. Moreover, theoretical and experimental work has demonstrated that heat flux is lower when using coating layers and the value is strongly influenced by their properties. (Abouelatta et. al, 2001)

This project investigates the wear and tool life of coated carbide with TiC (Titanium Caibide) during dry turning with medium carbon AISI 1045 under a specified machining conditions. Experimental procedures is used as a methodology in this project, by referred to experiment that will be done, the tools must undergo a machining test at various cutting condition before analysis is done to the tool. The evaluation of machining performance of the cutting tools mentioned above is depends on the tool wear and tool life and being examine using scanning electron microscopy and Portable Surface Roughness Tester. The important process variables in this project are tool's shape and material, cutting conditions such as speed, feed and depth of cut, the material characteristics of the workpiece and the machine tool are considered in analyzing the performance of a machine. (Edward, 1993)

1.2 OBJECTIVE OF PROJECT

The specific objective for Analysis performance of TiC-Carbide cutting tools in turning with AISI 1045 steel in this project are:

i.) To investigate the capabilities and limitations of commercial coating (TiC) when applied to carbide cutting tools.

ii.) To study about the tool life progression on the cutting tools used.

iii.) To study the effect of increasing cutting time at a constant cutting speed on the tool life and tool wear of the coated cutting tools.

iv.) To access and analyze the results obtained for tool and evaluated their performance based on the effects of the coating material used.

1.3 SCOPE OF PROJECT

Machining by using coated tools material is wide practiced in today's metal cutting industry, bringing about significant improvements in tool performance and cutting economy through lower tool wear, reduced cutting forces, and better surface finish of the workpiece. According to the high demanding of the usage of this type of material, our local manufacturer should study further for the development and capable performance of the tools to be upgraded, since there are still poor efforts to increase various high performance tools locally. This problem required a thorough knowledge of the cutting process so that requirements of the tools are correctly identified.

This project is concerned with the performance of caibide tools with coated by TiC when continuous turning AISI 1045 where varying parameter is the cutting speed and related with the constant parameter, the feed rate and the depth of cut. For this purpose a topographic analysis was employed to assess the tool wear volume evolution and the methodology is considered a more realistic alternative to study tool wear when compared to the bi-dimensional parameters established by ISO 3685/93. The turning test was conducted with variable high cutting speeds at 700 m/min with intervals for every 0.5 min continuously.

1.4 PROBLEM STATEMENT

The coating of alumina cutting tools with thin surfaces layers of materials such as titanium carbide (TiC) has now been carried out for many years in order to improve their machining performance. The use of coating materials to enhance the performance of cutting tool is not a new concept. These first generation TiC coated carbide tools were initially used in interrupted cutting applications such as the material removal of steels. However, over the last few years there has been a considerable amount of interest in a new generation of coatings with significantly improved performance compared to conventional coatings. Today, the usage of alumina cutting tools used in the industry is coated. There are now efforts to produce the cutting tool locally thorough knowledge of the cutting process so that requirements of the tools are correctly identified.

CHAPTER 2

LITERATURE REVIEW

2.1 SUBSTRATE MATERIAL - CARBIDE

2.1.1 Definition

Coated carbide is one of the most versatile of refractory ceramic oxides and finds use in a wide range of applications. It is found in nature as corundum in emery, topaz, amethyst, and emerald and as the precious gemstones ruby and sapphire, but it is from the more abundant ores such as bauxite, cryolite and clays that the material is commercially extracted and purified. Corundum exists as rhombohedral crystals with hexagonal structure. The unit cell is an acute rhombohedron of side length 5.2Å and plane angle ~55°. It is the close packing of the carbide and oxygen atoms within this structure that leads to its good mechanical and thermal properties. (Komvopoulos, 1997).

2.1.2 Process

The most common process for the extraction and purification of carbide is the 'Bayer' process. The first step in the process is the mixing of ground bauxite into a solution of sodium hydroxide. By applying steam and pressure in tanks containing the mixture, the bauxite slowly dissolves. The carbide released reacts with the sodium hydroxide to form sodium carbonate. After the contents of the tank have passed through other vessels where the pressure and temperature are reduced and impurities are removed, the solution of sodium carbonate is placed in a special tank where the alumina is precipitated out. The precipitate is removed from the tank, washed, and heated in a kiln to drive off any water present. The residue is a commercially pure alumina. Other extraction processes are used including pyrogenic treatment of bauxite with soda, and the extraction of aluminium hydroxide from meta kaolin via either the chloride or sulphate. The yield of alumina from these processes can approach 90% (Vernon et. al, 2003).

2.2 COATING

Thin-film coatings play a prominent role on the manufacture of many electric devices. They are used to apply dopants and sealants to chips and other microelectronic parts. Physical Vapor Deposition (PVD) and Chemical Vapor Deposition (CVD) are two most common types of thin-film coating methods. They are briefly discussed in this section. (Hultman, et. al 2001)

Table 2.2: Hardness value and color for various materials.

Materials	**Hardness** (HV)	**Color**
Titanium carbonitride	4000	silver
Titanium aluminum nitride	2600	brown
Titanium nitride	2900	gold
Chromium nitride	2500	silver
Zirconium nitride	2800	gold
Amorphous DLC	1000 - 5000	black