ANALYZING THE EFFECT OF PARAMETER SETTING ON SURFACE ROUGHNESS OF TURNING PROCESS

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DECLARATION

I declare that this project entitled “ Analyzing The Effect Of Parameter Setting On Surface Roughness Of Turning Process Using Carbide Cutting Tool” is the result of my own research except as cited in the references. The project has not been accepted for any master and is not concurrently submitted in candidate of any other master.

Signature :

Name : Mohd Fairuz Bin Alias

Date : 15-July-2022

APPROVAL

I hereby declare that I have read this project report and in my opinion this project report is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Manufacturing System Engineering).

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATION

To my lovely wife Norsuria Binti Azis, my childrens, family and my employer Emerson Process Management (M) Sdn Bhd for the support and utmost dedication and understanding for completing my research.

ABSTRACT

Turning on a high carbon martensite-coated carbide insertion of 440C grade stainless steel was the subject of this experiment (UNS S44004). Following trials and investigations, the major goal was to verify that the Reaction Surface Methodology was used to assess the impacts of machining parameters, such as cutting speed, feed, and cutting depth, on machine material surface roughness. The goal is to discover the best machining parameters for the specified tools and workpieces in the chosen experimental area to reduce surface roughness. The tests were carried out using a Response Surface with Historical Data Design experimental matrix. The Surtronic S-100 from Taylor Hubson was used to evaluate surface roughness. The data to be obtained will be compiled and entered Design Expert 6 for analysis. The relationships between machining parameters and response variables (surface roughness) were modelled and analyzed using the Response Surface Methodology (RSM). Analysis of Variance (ANOVA) was used to investigate the importance of this parameter on the responding variable, and to determine the regression equation for the responding variable with the machining parameter as the independent variable, using the aid of a quadratic model. The main effects and interaction plots from the ANOVA were obtained and studied along with the contours and 3-D surface plots. The results would be expected to show that feed was the most significant factor influencing surface roughness, followed closely by cutting speed and cutting depth, while the only important factor influencing tool wear was found to be cutting depth. The information gathered will be collated and analyzed. The Response Surface Methodology was used to construct and analyses the interactions between machining parameters and response variables (surface roughness). With the help of a quadratic model, analysis of variance (ANOVA) was performed to determine the impact of this parameter on the responding variable, as well as the regression equation for the responding variable with the machining parameter as the independent variable. Along with the contours and 3-D surface plots, the main effects and interaction plots from the ANOVA were collected and evaluated. The findings should reveal that feed was the most important factor impacting surface roughness, followed by cutting speed and cutting depth.(Bertinetto et al., 2020)

ABSTRAK

Menghidupkan sisipan karbida bersalut martensit karbon tinggi daripada keluli tahan karat gred 440C adalah subjek eksperimen ini (UNS S44004). Berdasarkan daripada percubaan dan penyiasatan, matlamat utama adalah untuk mengesahkan bahawa Metodologi Permukaan Tindakbalas digunakan untuk menilai kesan parameter pemesinan, seperti kelajuan pemotongan, suapan dan kedalaman pemotongan, kepada kekasaran permukaan bahan mesin. Matlamatnya adalah untuk menemui parameter pemesinan terbaik untuk alat dan bahan kerja yang ditentukan di kawasan eksperimen yang dipilih untuk mengurangkan kekasaran permukaan. Ujian telah dijalankan menggunakan Tindakbalas Permukaan dengan matriks eksperimen Data Reka Bentuk. Surtronic S-100 dari Taylor Hubson digunakan untuk menilai kekasaran permukaan. Data yang akan diperolehi akan disusun dan dimasukkan ke “Design Expert 6” untuk dianalisis. Hubungan antara parameter pemesinan dan pembolehubah tindak balas (kekasaran permukaan) telah dimodelkan dan dianalisis menggunakan Kaedah Permukaan Respons (RSM). Analisis Varians (ANOVA) digunakan untuk mengenal pasti kepentingan parameter ini pada gerak balas pembolehubah, dan untuk menentukan persamaan bagi pembolehubah bergerak balas dengan parameter pemesinan sebagai pembolehubah bebas, dengan menggunakan bantuan model kuadratik. Kesan utama dan plot interaksi daripada ANOVA telah diperoleh dan dikaji bersama dengan kontur dan plot permukaan 3D. Keputusan dijangka menunjukkan bahawa suapan adalah faktor paling ketara yang mempengaruhi kekasaran permukaan, diikuti dengan kelajuan pemotongan dan kedalaman pemotongan, manakala satu-satunya faktor penting yang mempengaruhi kehausan mata alat ialah kedalaman pemotongan. Maklumat yang diperolehi akan dikumpul dan dianalisis. Metodologi Permukaan Tindak Balas digunakan untuk membina dan menganalisis interaksi antara parameter pemesinan dan pembolehubah tindak balas (kekasaran permukaan). Dengan bantuan model kuadratik, analisis varians (ANOVA) dilakukan untuk menentukan kesan parameter ini terhadap gerak balas pembolehubah, serta persamaan bagi gerak balas pembolehubah dengan parameter pemesinan sebagai pembolehubah bebas. Bersama-sama dengan kontur dan plot permukaan 3D, kesan utama dan plot interaksi daripada ANOVA telah dikumpulkan dan dinilai. Penemuan harus mendedahkan bahawa suapan adalah faktor terpenting yang mempengaruhi kekasaran permukaan, diikuti dengan kelajuan pemotongan dan kedalaman pemotongan.(Bertinetto et al., 2020)

ACKNOWLEGMENT

First and foremost, I would like to thank Allah, my lord for giving me the strength, patience and guidance to go through this Master Project II. I also wish to express my deepest gratitude to Emerson Process Manufacturing (M) Sdn Bhd and all the members, who have given me this opportunity in pursuing and completing this program.

I would like to take this opportunity to express my sincere acknowledgement to my supervisor Dr. Nadiah Binti Ahmad from the Faculty of Manufacturing Engineering Universiti Teknikal Malaysia Melaka (UTeM) for her essential supervision, support and encouragement towards the completion of this master project.

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Special thanks to my wife, all my peers and siblings for their moral support in completing this master degree. Lastly, thank you to everyone who had been to the crucial parts of realization of this project.

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CHAPTER 1

1. INTRODUCTION

1.1 Background

One of the most frequent processes for cutting, especially when finishing the product, is the turning process, which involves removing metal from the outside diameter of a rotating cylindrical workpiece. Cutting parameters such as feed rate, cutting speed, and depth of cut in a turning process must be carefully chosen to increase productivity and lower overall production costs for each component, hence increasing profit. A high level of cutting parameter causes a poor surface finish, lower productivity, and a shorter tool life. As a result, this parameter should be managed. In this experiment, the impacts of these cutting parameters on the turning process of a workpiece made of UNS S4404 stainless steel are investigated. The experiments were designed using statistical methods. To accomplish the condition of optimize cutting parameter, these parameters are tuned using analysis of variance, regression, and optimization approaches, resulting in improved surface roughness after the turning process.(Gugulothu et al., 2021)

1.2 Problem Statement

Based on challenge in my operation with low volume and high mix, we have many new part number activation every day. From this scenario we need to ensure our production will running with short lead time and no compromise with quality of the surface roughness.

1.3 Research Objective

To investigate the effect of machining parameter from cutting speed, feed rate and depth of cut to achieve surface roughness (Ra and Rz) with short lead time and propose optimum combinations parameter based on validation result between experimental and prediction by ANOVA.

1.4 Scope Research

The study was conducted to examine the machinability of workpiece surface roughness (Ra and Rz) and changes on the machining parameter in dry cutting condition. The surface roughness mechanism also studied to determine the parameter setting of cutting speed, feed rate and depth of cut. The experimental design (DOE) used in this study was the ANOVA method (Bertinetto et al., 2020). Based on the method, the optimal cutting parameters recommended for a cutting speed range between 120-235 m/min, feed rate 0.05- 0.15 mm/rev, cutting depth 0.3 - 0.9mm.

1.5 Contribution Of Research

Contribution of this research are made in the following related areas:

1.5.1 Workpiece quality is the top priority, high performance with providing high precision and efficiency machining in operation applied at appropriate cutting condition will be the correct approach.

1.5.2 Will use as reference for machinist to run production as per parameter setup to minimize the machining lead time, increase productivity and obtain better surface finish.

1.5.3 Run production with short Leadtime without neglect the quality of final product.

1.5.4 The parameters are revolutions per minute (either the workpiece or the cutting tool) and the corresponding feed of the cutting tool in mm per minute. Generally, only the three controllable parameters are listed as cutting or process parameters and they are (i) cutting speed, (ii) feed rate and (iii) depth of cut.(Sharan & Kumar Patel, 2019)

1.6 Thesis Outline

1.6.1 Chapter 1. Introduction. This chapter presents the background of the study, research problems, objectives, scopes, contributions, and significance of the research.

1.6.2 Chapter 2. Literature review. This chapter starts with brief overview of current machining process for turning machine operation and machine parameter and other factor will impact on final product quality. A summary of the turning process, followed by other factor involve in final product quality. This chapter presents various literatures on references on characterization of optimization of process parameters based on surface roughness.

1.6.3 Chapter 3. Methodology. In this chapter present the methodology that has been developed to estimate effect of parameter setting using Design Expert by ANOVA.

1.6.4 Chapter 4. Result and discussion. In this chapter, the effect of parameter on machining surface in lathe turning process have been tested and verified through experimental on the actual process and parameter.

1.6.5 Chapter 5. Conclusion and Recommendation. The chapter summarize the main conclusion as well as achievements of the experimental in this researched and suggests areas for future work.

CHAPTER 2

2. LITERATURE REVIEW

2.1 Introduction

The turning operation is a fundamental metal machining process that is widely employed in metal cutting industries. In a turning operation, a high-precision single point cutting tool is rigidly held in a tool post and fed at a constant rate past a rotating work piece in a direction parallel to the work piece's axis of rotation, removing unwanted material in the form of chips, resulting in a cylindrical or more complex profile (Katheria et al., n.d.). This procedure is performed in a Lathe Machine either manually under the direction of an operator or automatically by a computer programme. This procedure is performed in a Lathe Machine either by manually or automatically. In a turning operation, there are two types of motion. The cutting motion, which is the circular motion of the work, and the feed motion, which is the linear motion delivered to the tool, are two different things. The basic turning operation with the motions involved is shown in Figure 2.1 and 2.2

Figure 2.1 : Basic turning operation in Lathe

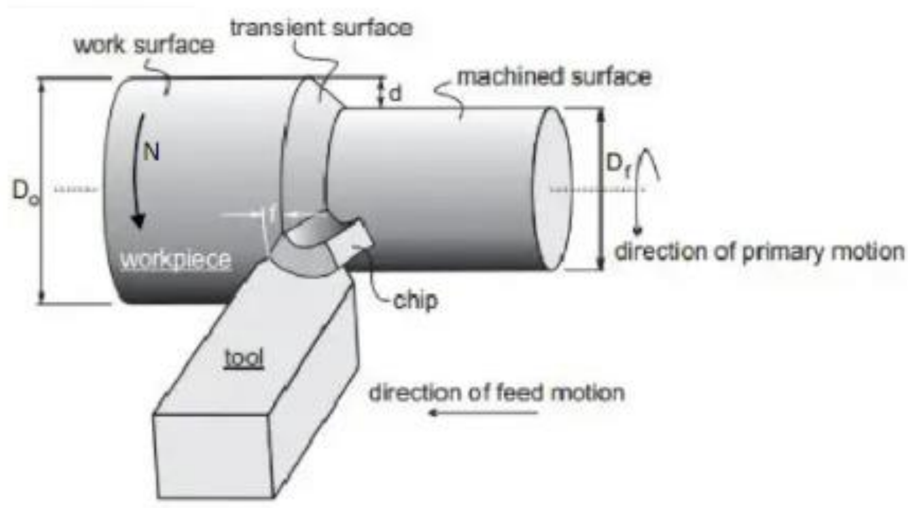


Figure 2.2 : Schematic illustration of the basic turning operation showing depth of cut (d), feed (f) and cutting rotation N in rev/min.

2.2 Machining Parameter

The three principal modifiable machining parameters in a basic turning process are the subject of this research. We may conclude that surface roughness increases with increasing depth of cut (d) and feed rate (f), but reduces with greater cutting speeds for the range studied (Vc). Cutting speed, feed rate, and depth of cut all contribute to surface roughness, with cutting speed accounting for 69.35 percent, feed rate for 30.13 percent, and depth of cut for 0.52 percent. Cut depth, feed rate, and speed are these three factors are depicted in Figure 2.3. The combination of these three parameters results in material removal. (Sharan & Kumar Patel, 2019)

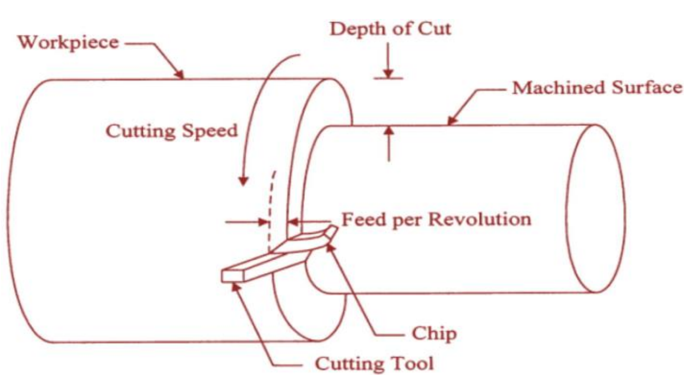


Figure 2.3 : Turning Process Parameter

2.2.1 Cutting Speed

Cutting speed is the rate at which the work piece's uncut surface goes through the cutting tool. It is commonly referred to as surface speed and is measured in metres per minute (m/min), however feet per minute (ft/min) is also acceptable. The cutting speed can be used to calculate cutting speed. The cutting speed is the rotational speed of the spindle, and thus the work piece. It is expressed in terms of the number of times the work item rotates every minute (rpm). The cutting speed is V' c (in m/min) if the spindle speed is N rpm. (Kanaujia et al., 2022)

2.2.2 Feed rate

For each revolution of the work piece, feed is the distance travelled by the tool tip along its direction of movement. It's written as f and measured in mm/rev. It is also sometimes expressed in terms of cutting speed in mm/min.

2.2.3 Dept of cut

The distance between the newly machined surface and the uncut surface is defined as the depth of cut (d). In other terms, it refers to the amount of material eliminated from the work piece. It can alternatively be described as the tool's depth of penetration into the work piece, as measured from the work piece surface prior to rotation. Due to the rotation of the work, the diameter after machining is reduced by twice the depth of cut, since this thickness is removed from both sides.

2.3 Cutting Tool

A cutting tool is a component of a machine tool that removes extra material from a work piece through direct mechanical abrasion and shear deformation. Cutting tools that are effective should have the following characteristics:

a) Hardness: The tool material should be harder than the work material.

b) Hot hardness: The tool must maintain its hardness at elevated temperatures encountered during the machining process.

c) Wear Resistance: The tool should have served to its acceptable level of life before it wears out and needs to be replaced.

d) Toughness: The material should be strong enough to withstand shocks and vibrations. During interrupted cutting, the tool should not chip or fracture. For the ensuing study, the cutting tool used will be a clamped insert-type tool (Abas et al., 2020).

2.3.1 Cutting tool insert

When a cutting tool is screwed or fastened to a holder, which is then secured to the tool position, then insert is used. Inserts are held in place by a variety of locking mechanisms. Inserts have the advantage of being able to be rotated to present a new cutting edge when one edge wears out. After all such edges have been used up, the insert can be removed, turned upside down, and clamped again in same situations, if the geometry allows, to reveal a new array of cutting edges. Inserts come in a varied range of shapes and sizes some of which are shown in Figure 2.4

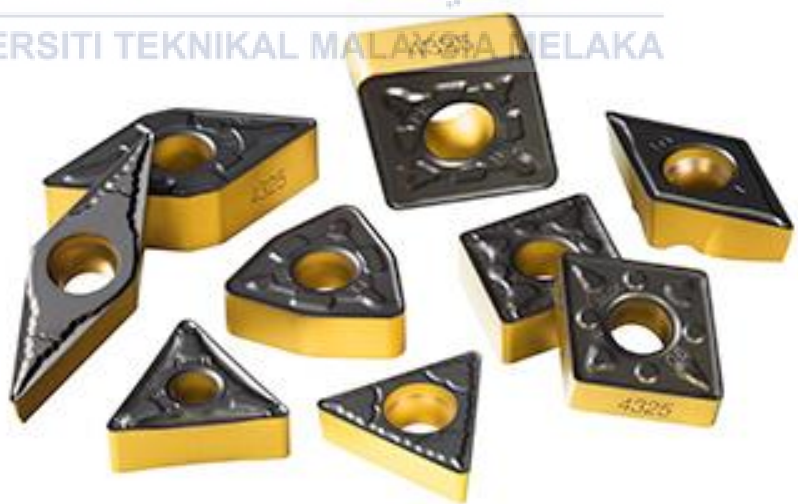


Figure 2. 4 : Various shapes of cutting tool inserts

2.3.1.1 Insert material

There is a large variety of cutting tool materials that are available, each having its own specific properties and performance abilities. Examples of insert materials are Carbides, HSS (High speed steel), CBN (Cubic boron nitride), Diamond, Carbon speed steels etc. Carbide tools find common use in the metal cutting industry due to their ability to machine at elevated temperatures and higher speeds.

2.3.1.2 Insert coating

There is a variety of coating materials each having their own specific applications and advantages. We want a cutting edge to be hard so it can cut faster and have a longer life (Vasilko et al., 2021). Unfortunately, the harder a cutting tool material is, the more brittle it is and the easier it breaks. We need two opposite qualities, toughness and hardness. We want the body of the insert to be tough, but the cutting-edge surface to be hard, with high wear resistance (Denkena et al., 2020). To improve the wear resistance and life of an insert, we just coat it with hard but brittle materials like Aluminium Oxide, Titanium Nitride, or Titanium Carbonitride. Physical vapour deposition (PVD) method is one of the widely used methods used to achieve the coating of a cutting tool. Another technique is Chemical vapour deposition (CVD). The CVD coating technique requires higher temperature which makes it unfeasible for coating tool steels (Kamble et al., 2022).

2.3.1.3 Insert specification

2.3.1.3.1 Insert numbering code, referring from Mitsubishi Material.

1	2	3	4	5	6	7	8	9	10
C	N	M	G	12	04	08	(E)	(N)-	MP

Insert Shape	Relief angle

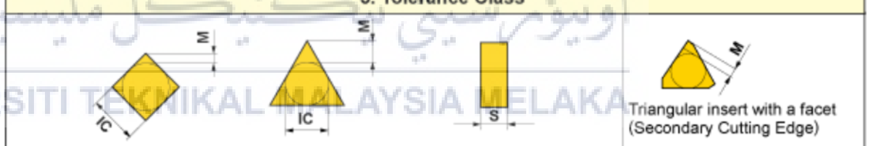
1. Insert Shape

Symbol	Insert Shape
H	Hexagonal
O	Octagonal
P	Pentagonal
S	Square
T	Triangular
C	Rhombic 80°
D	Rhombic 55°
E	Rhombic 75°
F	Rhombic 50°
M	Rhombic 86°
V	Rhombic 35°
W	Trigon
L	Rectangular
A	Parallelogram 85°
B	Parallelogram 82°
K	Parallelogram 55°
R	Round
X	Special Design

2. Relief Angle

Symbol	Normal Clearance
A	3°
B	5°
C	7°
D	15°
E	20°
F	25°
G	30°
N	0°
P	11°
O	Other Relief Angle
	Major Relief Angle

3. Tolerance Class



3. Tolerance Class

Symbol	Tolerance of Nose Height **M** (mm)	Tolerance of Inscribed Circle **IC** (mm)	Tolerance of Thickness **S** (mm)
A	±0.005	±0.025	±0.025
F	±0.005	±0.013	±0.025
C	±0.013	±0.025	±0.025
H	±0.013	±0.013	±0.025
E	±0.025	±0.025	±0.025
G	±0.025	±0.025	±0.13
J	±0.005	±0.05−±0.15	±0.025
K*	±0.013	±0.05−±0.15	±0.025
L*	±0.025	±0.05−±0.15	±0.025
M*	±0.08−±0.18	±0.05−±0.15	±0.13
N*	±0.08−±0.18	±0.05−±0.15	±0.025
U*	±0.13−±0.38	±0.08−±0.25	±0.13

The surface of insert with * mark is sintered.

Detail of M Class Insert Tolerance

● Tolerance of Nose Height **M** (mm)

D.I.C.	Triangular	Square	Rhombic 80°	Rhombic 55°	Rhombic 35°	Round
6.35	±0.08	±0.08	±0.08	±0.11	±0.16	–
9.525	±0.08	±0.08	±0.08	±0.11	±0.16	–
12.70	±0.13	±0.13	±0.13	±0.15	–	–
15.875	±0.15	±0.15	±0.15	±0.18	–	–
19.05	±0.15	±0.15	±0.15	±0.18	–	–
25.40	–	±0.18	–	–	–	–
31.75	–	±0.20	–	–	–	–

● Tolerance of Inscribed Circle **IC** (mm)

D.I.C.	Triangular	Square	Rhombic 80°	Rhombic 55°	Rhombic 35°	Round
6.35	±0.05	±0.05	±0.05	±0.05	±0.05	–
9.525	±0.05	±0.05	±0.05	±0.05	±0.05	±0.05
12.70	±0.08	±0.08	±0.08	±0.08	–	±0.08
15.875	±0.10	±0.10	±0.10	±0.10	–	±0.10
19.05	±0.10	±0.10	±0.10	±0.10	–	±0.10
25.40	–	±0.13	–	–	–	±0.13
31.75	–	±0.15	–	–	–	±0.15

4. Chipbreaker and Clamping System									
Metric									
Symbol	Hole	Hole Configuration	Chip Breaker	Figure	Symbol	Hole	Hole Configuration	Chip Breaker	Figure
W	With Hole	Cylindrical Hole +	No		A	With Hole	Cylindrical Hole	No	
T	With Hole	One Countersink (40–60°)	One Sided		M	With Hole	Cylindrical Hole	Single Sided	
Q	With Hole	Cylindrical Hole +	No		G	With Hole	Cylindrical Hole	Double Sided	
U	With Hole	Double Countersink (40–60°)	Double Sided		N	Without Hole	–	No	
B	With Hole	Cylindrical Hole +	No		R	Without Hole	–	Single Sided	
H	With Hole	One Countersink (70–90°)	One Sided		F	Without Hole	–	Double Sided	
C	With Hole	Cylindrical Hole +	No		X	–	–	–	Special Design
J	With Hole	Double Countersink (70–90°)	Double Sided						

5. Insert Size							
Symbol							Diameter of Inscribed Circle (mm)
R	W	V	D	C	S	T	
	02		04	03	03	06	3.97
	L3	08	05	04	04	08	4.76
	03	09	06	05	05	09	5.56
06							6.00
	04	11	07	06	06	11	6.35
	05	13	09	08	07	13	7.94
08							8.00
09	06	16	11	09	09	16	9.525
10							10.00
12							12.00
12	08	22	15	12	12	22	12.70
15	10		19	16	15	27	15.875
16							16.00
19	13		23	19	19	33	19.05
20							20.00
			27	22	22	38	22.225
25							25.00
25			31	25	25	44	25.40
31			38	32	31	54	31.75
32							32.00

6. Insert Thickness

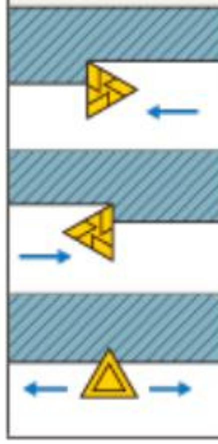
*Thickness is from the bottom of the insert to the top of the cutting edge.

Symbol	Thickness (mm)
S1	1.39
01	1.59
T0	1.79
02	2.38
T2	2.78
03	3.18
T3	3.97
04	4.76
06	6.35
07	7.94
09	9.52

7. Insert Corner Configuration	
Symbol	Corner Radius (mm)
00	Sharp Nose
V3	0.03
V5	0.05
01	0.1
02	0.2
04	0.4
08	0.8
12	1.2
16	1.6
20	2.0
24	2.4
28	2.8
32	3.2
00 : Inch M0 : Metric	Round Insert

8. Cutting Edge Condition		
Figure	Cutting Edge	Symbol
	Sharp Cutting Edges	F
	Round Cutting Edges	E
	Chamfered Cutting Edges	T
	Chamfered and Rounded Cutting Edges	S

Mitsubishi Materials omit the honing symbol.

9. Cutting Direction		
Figure	Hand	Symbol
	Right	R
	Left	L
	Neutral	N

10. Chip Breaker

LP	MP	RP
LM	MM	RM
LK	MK	RK
LS	MS	RS
FP	LP	MP
MA	SW	MW
HZ	HX	HV