Improving The Tool Life Parameters of A Ceramic Tip of A Milling Cutter Using HDS Material

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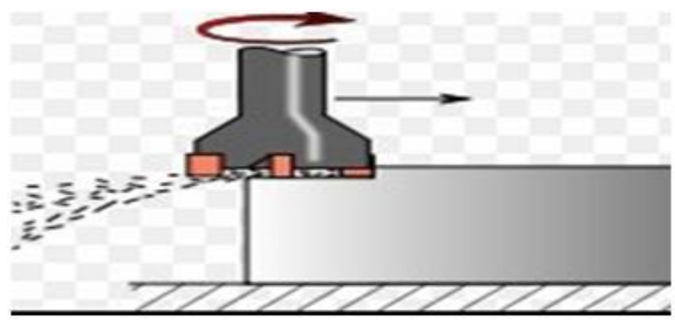
Abstract- *An ability to predict the tool life during machining is necessary for the design of cutting tools and the determination of cutting conditions and tool change strategies. The extensive research in this area during the past century or so has contributed greatly to our understanding of the problem. However, there is as yet no machining theory to provide adequate relationships between tool life and cutting conditions, tool geometrical parameters and, work and tool material properties. Some of the major difficulties are: (i) the complexity of the machining process which involves extreme conditions of very high strains, strain-rates and temperatures, and (ii) lack of suitable data. Moreover, tool life depends on a number of variables which include the machine tool, tool material and geometry, work material and cutting conditions.*
The experiment has been done with process parameters feed rate 1500mm/min, 2000mm/min, 3000 mm/min, spindle speeds are 1000rpm, 2000rpm, 2500rpm, and depth of cut 0.2mm, 0.4 and 0.6mm. The milling process is conducted on a CNC Vertical milling machine

I. INTRODUCTION

Metal cutting is one of the most important and widely used manufacturing processes in engineering industries and in today's manufacturing scenario, optimization of metal cutting process is essential for a manufacturing unit to respond effectively to severe competitiveness and increasing demand of quality which has to be achieved at minimal cost. As flexibility and adaptability needs increased in the manufacturing industries, computer numerical control systems was introduced in metal cutting processes that provided automation of processes with very high accuracies and repeatability. Because of high cost of numerically controlled machine tools compared to their conventional counterparts, there is an economic need to operate these machines as effectively as possible in order to obtain the required payback. Product quality, productivity and cost became important goals in manufacturing industries.

Many goals focused in a manufacturing industry, energy consumption plays a vital and dual role. One, it cuts down the cost per product and secondly the environmental impact by reducing the amount of carbon emissions that are created in using the electrical energy. Many have worked in optimizing the parameters of computer numerically controlled machine tools for minimum power requirement but in high tare machine tools, time dominates over power when optimizing for reduced energy.



Cutting Tool Translator and Rotational Motion Milling is a cutting process that uses a milling cutter to remove material from the surface of a work- piece. The milling cutter is a rotary-cutting tool, often with multiple cutting points. As opposed to drilling, where the tool is advanced along its rotation axis, the cutter in milling is usually moved perpendicular to its axis so that cutting occurs on the circumference of the cutter. As the milling cutter enters the work-piece, the cutting edges (flutes or teeth) of the tool repeatedly cut into and exit from the material, shaving off chips (swarf) from the work- piece with each pass. The cutting action is shear deformation; material is pushed off the work-piece in tiny clumps that hang together to a greater or lesser extent (depending on the material) to form chips. This makes metal cutting somewhat different (in its mechanics) from slicing softer materials with a blade.

GENERAL METHOD FOR CHOOSING SUITABLE PARAMETERS

The choice of cutting parameters is dependent on numerous

Productivity
Surface condition
Cost of the part
Machine characteristics
Part/machine/tool rigidity

The selection method takes these criteria into account, tog
adjustment of the following parameters:

Forces / power
Cutting speed
Feed
Engagements
Machining direction

CHOICE OF OPERATING CONDITIONS

The choice of cutting speed v_c allows the rotational speed N to be determined based on the following parameters:

1. type of alloy being machined type of milling cutter (geometry)
2. type of cooling (external, pressurised central)tool material (grade and coating)
3. Characteristics of the operation: rough, finish, part rigidity.

And **according to the following constraints and limitations**:characteristics of the machine: power, maximum rotational speed, rigidity Safety: Limitations of rotational speeds as a result of machine unbalance (balancing).techno-economic manufacturing criteria:

- Quality: shape, precision, surface condition.
- Part cost: a value that depends on the cost of the tool, the size of the production run and the tool life (resistance to wear) and therefore on the cutting parameters selected.
- When milling aluminium alloys, the cutting speeds used are high >>500 m min^{-1}. In general, for high-speed machining, machines are run at maximum rotational speed , except in the event of vibration problems, power limitations or spindle lifetime issues.

THERE ARE TWO MAJOR CLASSES OF MILLING PROCESS

- In face milling, the cutting action occurs primarily at the end corners of the milling cutter. Face milling is used to cut flat surfaces (faces) into the work- piece, or to cut flat-bottomed cavities.
- In peripheral milling, the cutting action occurs primarily along the circumference of the cutter, so that the cross section of the milled surface ends up receiving the shape of the cutter.

TYPES OF MILLING CUTTERS: **METRIC SLOT DRILLS**

Flute center cutting type: This cutter is used to drill blind and through holes. Its material is HSS.

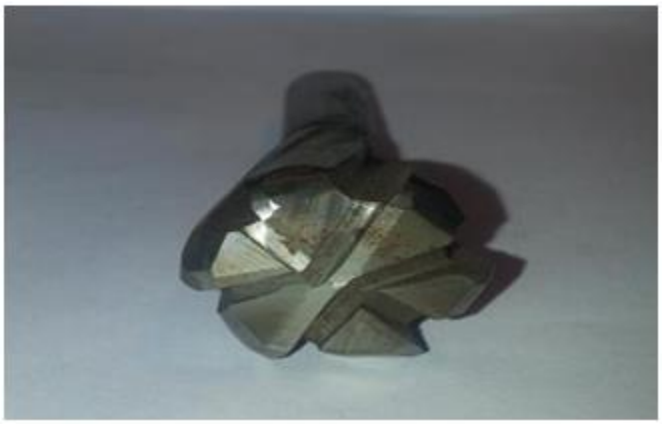
Flute center cutting type

SOLID CARBIDE BALL NOSE CUTTER: Short series

This ball nose cutter is used for finishing process. Cutter material is solid carbide.

ball nose cutter

Formed cutter: This type of cutter is called as formed cutters. These cutters are mainly used for special machining process. These cutters are made according to operation. Following cutter are used for making rough negative angles. Material is HSS.



formed cutter

Insert Cutter Holder: These types of cutters are used for roughing. For this cutter we can replace cutting inserts. These types of cutters are carbide tip cutters.

insert cutter holder

FACTORS AFFECTING TOOL LIFE IN MACHINING PROCESSES

Cutting tool life is important consideration in metal cutting processes. In machining operations, cutting conditions such as tool angles, cutting speeds and feed rates are usually selected to give an economical tool life. Conditions giving a short tool life are uneconomical because tool grinding and tool replacement costs are high. Factors affecting tool life should be carefully monitored to minimize their consequences

Tool damage can be classified into two groups, wear and fracture by means of its scale and how it progresses. Wear is loss of material on an asperity or micro-contact, or smaller scale, down to molecular or atomic removal mechanisms. It usually progresses continuously. There are two main types of tool wear Flank wear, Crater wear, Fracture, on the other hand, is damage at a larger scale than wear and it occurs suddenly.

Cutter is solid carbide ball nose cutters. They are failed due tothe applying more cutting depth.

Cutter is Bull nose tip cutter. It is failed due to by applying more cutting depth. More force is applied on damaged tip due to that tip is damaged.

An ability to predict the tool life during machining is necessary for the design of cutting tools and the determination of cutting conditions and tool change strategies. The extensive research in this area during the past century or so has contributed greatly to our understanding of the problem. However, there is as yet no machining theory to provide adequate relationships between tool life and cutting conditions, tool geometrical parameters and, work and tool material properties. Some of the major difficulties are:

(i) the complexity of the machining process which involves extreme conditions of very high strains, strain- rates and temperatures, and (ii) lack of suitable data.

OPTIMIZATION: Prediction of process parameters is one of the major areas of concern in machining. Machining Performance is evaluated mainly by measures such as cutting forces and by the quality level of surface finish, which directs this project to be done in this category. This project proposes the regression model using regression analysis and the development of neural network model for machining to predict specific power consumption, material removal rate and the surface roughness.

EXPERIMENTAL PROCEDURE: This experiment employed a CNC vertical milling machine. Ceramic cutting tool is used. The experiment has been done under conditions of feed rate 2000mm/min, 2500mm/min, 3000 mm/min, spindle speeds are 1000rpm, 1500rpm, 2000rpm, and depth of cut 0.3mm, 0.4 and 0.5mm.

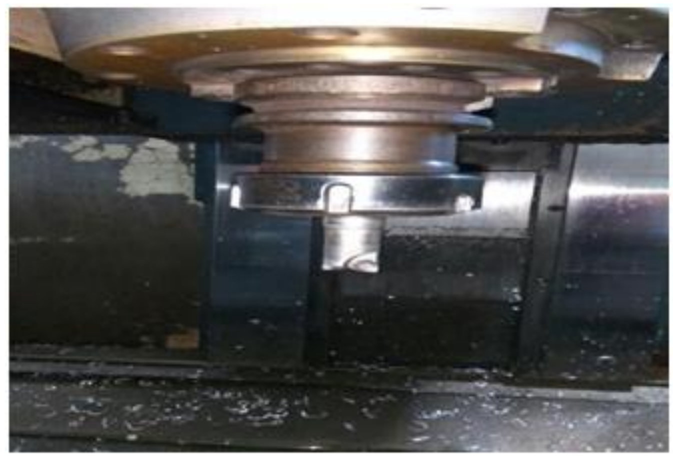
CNC Milling Machine

SELECTION OF PROCESS PARAMETERS AS TAGUCHI TECHNIQUE

PROCESS PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3
SPINDLE SPEED(rpm)	1000	2000	2500
FEED RATE (mm/min)	1500	2000	3000
DEPTH OF CUT(mm)	0.2	0.4	0.6

JOB NO.	SPINDLE SPEED (rpm)	FEEDRATE (mm/min)	DEPTH OFCUT (mm)
1	1000	1500	0.2
2	1000	2000	0.4
3	1000	3000	0.6
4	2000	1500	0.4
5	2000	2000	0.6
6	2000	3000	0.2
7	2500	1500	0.6
8	2500	2000	0.2
9	2500	3000	0.4

CUTTER USED: ROUGING:-50R6 BULL NOSE CUTTER



Cutting Tool with Ceramic Insert

While machining, tool wear is measured and tool life is measured for every experiment at given spindle speed, feed rate and depth of cut. Tool wear is measured for the removal of material from the edge of the tool. Tool Life is the time taken for the cutting tool to wear out in min’s.

The following are the observations measured by running the experiments.

JOB NO.	SPINDLE SPEED (rpm)	FEED RATE (mm/min)	DEPTH OFCUT (mm)	TOOL LIFE (min)	TOOL WEAR (mm)
1	1000	1500	0.2	28	0.15
2	1000	2000	0.4	24	0.18
3	1000	3000	0.6	21	0.24
4	2000	1500	0.4	18	0.17
5	2000	2000	0.6	15	0.20
6	2000	3000	0.2	14	0.28
7	2500	1500	0.6	12	0.19
8	2500	2000	0.2	10	0.25
9	2500	3000	0.4	8	0.37

THE ORETICAL TOOL LIFE CALCULATIONS

The Taylor tool life equation can be written as:
$vT^n = C$, where v is the cutting speed, m/min T is the tool life, in minutes
C is the cutting speed for a tool life of 1 minute
n is the Taylor exponent = 0.7 (Ceramic Tool)

Cutting Speed – 1000rpm = 314.1537m/min
$vT^n = C$
$314.1537\ T^{0.7} = 3000$
$T^{0.7} = 9.54$
$T = 24.228$min

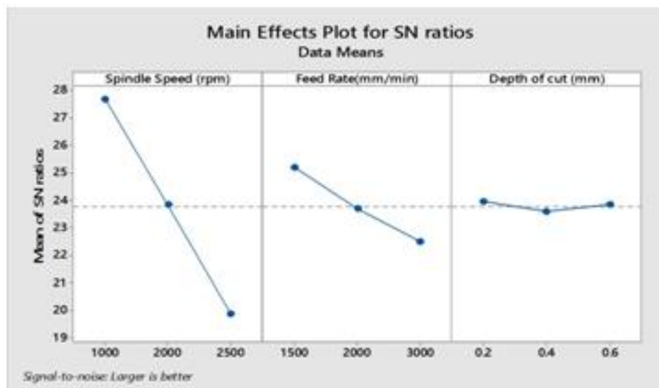
Cutting Speed – 2000rpm = 628.307m/min
$628.307\ T^{0.7} = 3000$
$T^{0.7} = 4.774$
$T = 9.322$min

Cutting Speed – 2500rpm = 785.38m/min
$785.38\ T^{0.7} = 3000$
$T^{0.7} = 3.819$
$T = 6.776$min

II. RESULTS

↓	C1	C2	C3	C4	C5
	Spindle Speed (rpm)	Feed Rate(mm/min)	Depth of cut (mm)	Tool Life (min)	SNRA1
1	1000	1500	0.2	28	28.9432
2	1000	2000	0.4	24	27.6042
3	1000	3000	0.6	21	26.4444
4	2000	1500	0.4	18	25.1055
5	2000	2000	0.6	15	23.5218
6	2000	3000	0.2	14	22.9226
7	2500	1500	0.6	12	21.5836
8	2500	2000	0.2	10	20.0000
9	2500	3000	0.4	8	18.0618

Results of S/N Ratio



Graph - Effect of milling on Tool Life for S/Nratio

Taguchi Analysis: Tool Life (min) versus Spindle Speed (r, FeedRate(mm/min, Depth of cut (mm)

Response Table for Signal to Noise Ratios Larger is better

Level	Spindle Speed (rpm)	Feed Rate (mm/min)	Depth of cut (mm)
1	27.66	25.21	23.96
2	23.85	23.71	23.59
3	19.88	22.48	23.85
Delta	7.78	2.73	0.36
Rank	1	2	3

Regardless of the performance characteristics, the a greater S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the greatest value.

Spindle Speed

The effect of parameters spindle speed on the Tool Life is shown above figure for S/N ratio. The optimum spindle speed is 1000 rpm.

Feed Rate

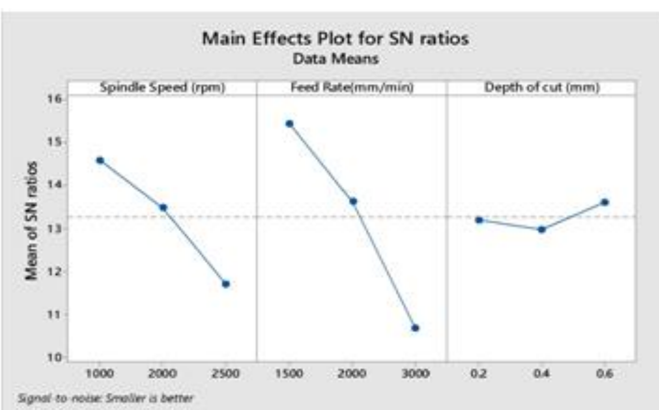
The effect of parameters Feed Rate on the Tool Life is shown above figure S/N ratio. The optimum Feed Rate is 1500 mm/min.

Depth of Cut

The effect of parameters Depth of Cut on the Tool Life is shown above figure S/N ratio. The optimum Depth of Cut is 0.4 mm.

C1	C2	C3	C4	C5
Spindle Speed (rpm)	Feed Rate(mm/min)	Depth of cut (mm)	Tool Wear	SNRA2
1000	1500	0.2	0.15	16.4782
1000	2000	0.4	0.18	14.8945
1000	3000	0.6	0.24	12.3958
2000	1500	0.4	0.17	15.3910
2000	2000	0.6	0.20	13.9794
2000	3000	0.2	0.28	11.0568
2500	1500	0.6	0.19	14.4249
2500	2000	0.2	0.25	12.0412
2500	3000	0.4	0.37	8.6360

Results of S/N Ratio



Graph - Effect of milling parameters on Tool Wear for S/N ratio

Taguchi Analysis: Tool Wear versus Spindle Speed (rpm), Feed Rate(mm/min), Depth of cut (mm)

Response Table for Signal to Noise Ratios
Smaller is better

Level	Spindle Speed (rpm)	Feed Rate(mm/min)	Depth of cut (mm)
1	14.59	15.43	13.19
2	13.48	13.64	12.97
3	11.70	10.70	13.60
Delta	2.89	4.74	0.63
Rank	2	1	3

III. CONCLUSION

Different parameters of tool feed rate, spindle speed and depth of cut are analyzed to optimize the parameters so that the tool wear is reduced and tool life is increased. Different experiments are conducted to optimize the process parameters in milling to achieve reduced tool wear and increased tool life using ceramic cutting tool while machining HDS material.

A series of experiments are done by varying the milling parameters spindle speed, feed rate and depth of cut considering L9 orthogonal array by Taguchi Method. The optimization is done using Taguchi method for less tool wear and more tool life in Minitab 17 software

The experiment has been done with process parameters feed rate 1500mm/min, 2000mm/min, 3000 mm/min, spindle speeds are1000rpm,2000rpm, 2500rpm, and depth of cut 0.2mm, 0.4 and 0.6mm. The milling process is conducted on a milling machine

By observing the experimental results and from Tahuchi Technique, the following conclusions can be made:

To achieve more tool life, the optimal parameters are spindle speed – 1000rpm, feed rate – 1500mm/min and depth of cut – 0.4mm. To reduced tool wear, the optimal parameters are spindle speed – 1000rpm, feed rate – 1500mm/min and depth of cut – 0.4mm.

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