International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

OPTIMIZATION OF TOOL GOEMETRY WEAR IN HIGH STRENGTH CARBIDE CHAMFERING TOOLS

V S Ramprasad Nalamati [1], Dr.S. Chakradhar Goud[2]

1. Research Scholar, Shri JJT University, Junjhunu, Rajasthan, nvsrprasad@yahoo.com
2. Professor, Department of Mechanical Engineering, Shri JJT University, Junjhunu, Rajasthan, anveshanacgoud@gmail.com

Abstract: Optimum Tool Geometry for Minimization of Cutting Force for milling of Hardened Steel. Tool Geometry is important mechanical component in removing metal during machining operations. The effect of cutting tool geometry has long been an issue in understanding mechanics of milling operations. Tool geometry has significant influence on chip formation, heat generation, tool wear, surface finish and surface integrity during turning. This article presents a survey on variation in tool geometry and different Taguchi Methods applied on the high strength carbide chamfering tools to find out the surface roughness and Noise ratios of the machined surface. The cutting tool is an important basic tool required in the machining process of a part in production. It not only performs the cutting action but helps in getting required surface finish and accuracy of the part. In order to perform these tasks, the tool has to be strong enough to withstand wear resistance and serve for long period of time to produce a greater number of components with the same accuracy. Machining is important in metal manufacturing process to achieve near-net shape good dimensional accuracy and for aesthetic requirements.

Keywords: High strength carbide chamfering tools, Taguchi Methods

1.0 INTRODUCTION

Recent development of science and technology has placed considerable demands on the manufacturing sector. In the manufacturing industry, cutting costs are reduced, machine quality is improved, and more rigid materials are fabricated. High-speed machining improves machining efficiency by cutting down on machining time [1]. High carbon content makes machining steels, cast irons, and super alloys harder. Limiting factors for cutting speed include temperature softening and the chemical stability of the tool material itself. As manufacturing processes become more productive, the development and evolution of improved cutting tools are enhanced to obtain better tribological performance and wear resistance [2]. Because of the cutting's severe nonlinearity and the nuanced interactions between deformation and temperature fields, there is a significant knowledge gap in metal cutting mechanics today. Mechanical engineers' primary focus has long been on high-speed manufacturing. As production increases, so do the number of cutting tools available, both in terms of materials and designs. Instead of increasing productivity and improving surface smoothness, high-speed machining causes significant amounts of heat to be generated during the cutting process.

Significance of metal cutting:

Using metal cutting, metal chips are removed from a work piece to create a completed product of the required size, shape, and finish. Thousands of machining instruments can be found in nearly every manufacturing industry, including vehicles, railroads, ships, aircraft manufacture, household appliances, consumer electronics, and construction. Machining contributes to more than a quarter of the total value of goods produced in industrial countries. Metal cutting allows for better customization of the operating conditions than any other way of shaping metals, resulting in higher outcomes and better production rates at a lower cost.

Theory of metal cutting:

Every modern consumer product uses some form of metal cutting as it's the backbone of engineering and manufacturing. An effective metal-cutting operation depends heavily on the cutting tool. As economic competition has increased, so has research into metal cutting tool materials, resulting in the development of novel materials with exceptional performance and future scope for productivity growth that is simply incredible [3]. Using cutting tools designed to process new materials at maximum efficiency, manufacturers are always on the lookout for new materials and applying them to advanced composite solutions. The following are the primary features that each cutting material must have in order to fulfil its necessary functions:

- To overcome wearing action, it is necessary
- The ability to withstand high temperatures
- A high level of resistance to vibration

As hardness increases, so do the tensile properties of many materials. When heavy cuts are made on work pieces with holes or pockets, materials in the list's more incredible hardness section will shatter. To make a good tool, and the material must have the following features:

Tool wear: When cutting tools wear out over time through regular use, it's called "tool wear." Machine tools' tipped tools, tool bits, and drill bits are all affected. Cutting tools that break down unexpectedly reduce production, cause components to be rejected, and result in financial losses. Roughness is reduced from tool's relief face by rubbing on machined surface. Abrasion from the crater causes the chip and rake face to become extremely rubbed together, leaving a scar that runs parallel to the primary cutting edge as the chip flows away.

Optimisation of machining parameters

Determining the appropriate cutting settings for all of the different cutting tools being utilised is crucial in metal component process planning. Increasing productivity and competitiveness boost machining processes' profitability. This research aims to find the best milling cutting parameters that reduce machining time while also improving surface smoothness. Time and surface finish are affected by a variety of machining parameters, such as cutting speed, feed rate per tooth, and axial depth. Machine tool eight users can save time and effort by adjusting cutting parameters. This also improves the smoothness of the finished surface. The technical guide specifies feed rate, cutting speed, cut depth, and axial immersion for many applications. It's important to remember that the tool and spindle dynamics strongly influence these characteristics. To get the optimal cutting parameters, you must reduce machining time while still utilising the entire set of cutting parameters available. If you want a better surface roughness, you must accurately set the cutting parameters before starting the process

Objectives:

- To study Improved materials and manufacturing methods for tool life.
- To design Tool and method advances for efficient manufacturing
- To learn about Single Point Cutting Tools and Basic Definitions and Geometry of Cutting Tools

Scope of the work:

Machining of lightweight components represents nowadays one of the technology challenges. Low static and dynamic stiffness of thin wall work pieces lead to significant problems during the milling process with respect to static deflections and vibration of both the work piece and tool induced by exciting the tool and work piece system by process forces. The objectives have to cover tool path planning module, tool path simulation with consequent material removal calculation, calculation of the work piece dynamics and process simulation with the prediction of process forces.

2.0 Literature review

The primary problem that metal-cutting companies face is the requirement to improve manufacturing quality while also lowering production costs. Other factors like as lubricants and coatings affect both the quality and the price of the finished product depending on how the cutting parameters are set up as well as the wear and tear on the tooling [4]. Thus, businesses are compelled to use the approach of trial and error. The problem can be solved significantly by optimising the controllable variables. developed a turning process surface roughness prediction knowledge-based system [5]. This project necessitated the usage of fuzzy set theory and neural networks. Set theory that is a bit fuzzy Surface roughness can be predicted using process variables. the authors constructed a rule that also predicts process variables for known surface roughness. in their research, they focus on micromachining, namely metals micro-milling and the study of micro-cutting in this context [6]. Tools having a diameter of less than 1 mm and a resolution of 0.05 mm are used in micro-milling. Due to manufacturing issues, these tools do not have the same complicated and sharp geometries as traditional tools. examined the field's prior research. It's vital to do research on how orthogonal machining affects heat generation and dissipation. Detection methods for metal-slicing temperature were also investigated [7]. This research looked at the outcomes of high-speed cutting tests on high-strength alloys using a thermal imaging camera. At long last, the most recent findings in this field of metal machining were also investigated. In the end, they discovered that the pattern of heat dispersion varies based on the tool-work material's size and thermal conductivity as well as the cutting conditions [8]. The results were specific to mild steel work when a carbide insert cutting tool was used in a dry turning process. Feed rate, cutting force, and cut depth are all important factors in determining the temperature of the shear zone, although chip thickness and friction force have far less of an impact.

3.0 Research Methodology

This chapter deals with the significance of machining process, cutting tools and different methods employed for coating on cutting tools. The need for mach inability studies, related tool wear, surface integrities and mechanism of chip formations are discussed. Cemented carbide cutting tool inserts (WC/Co) are commonly used in the machining of hard materials such as metals and alloys. However, machining can be problematic for particular materials due to high tool wear and a lack of understanding of the underlying mechanics. Machining processes use metals like titanium. The outstanding mechanical properties and corrosion resistance of titanium alloys make them popular in the aerospace, energy, and chemical industries [9]. However, titanium alloys' low heat conductivity and high chemical reactivity make it difficult to process titanium parts and products, making the switch to a different material unprofitable. At the tool-chip interface, temperatures as high as 1100°C can be experienced when milling titanium. Due of titanium machining quick and severe tool wear;

it is a difficult and expensive material to machine. It is commonplace to employ cutting tools made of uncoated cemented carbide (WC/Co). Due to the difficulty in detecting temperatures near the cutting edge, they are generally simulated instead of being used. Most people are aware that hotter cutting surfaces result in quicker reactions as well as potentially faster tool wear.

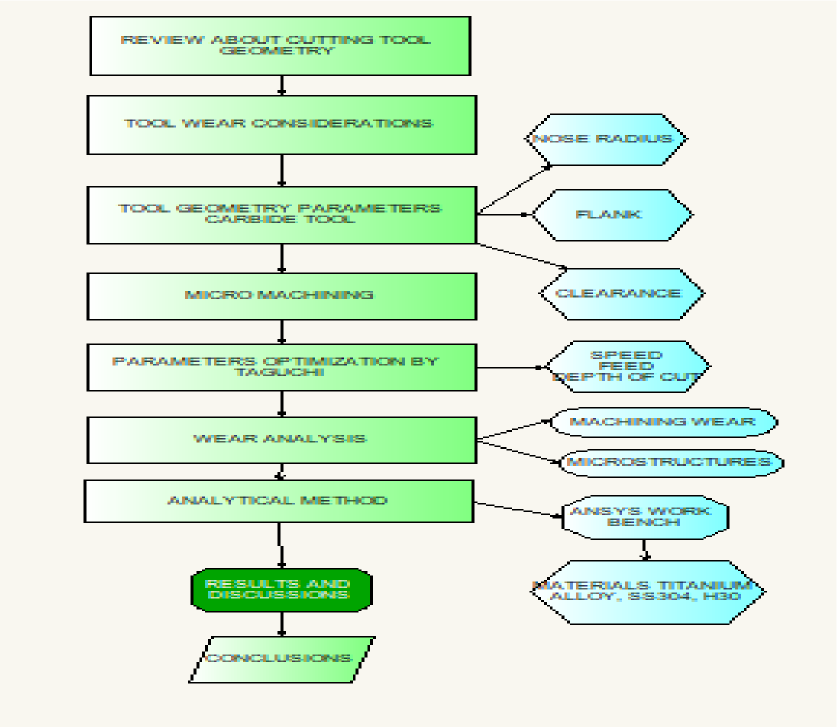


Figure 3.1: Flow chart

Cutting tool forces and machined surface temperatures decreased as cutting speed rose, according to this study (VC). Increasing tool wear, combined with an increase in chip temperature, led to higher cutting tool forces and surface temperatures [10]. It was discovered throughout the experimentation phase that cutting rates more than 40 m/s resulted in temperatures stabilising and approaching a saturated value in the chip, with an un-deformed chip thickness greater than 0.25mm. We can see from the data above that the material's outer surface will experience increased heat removal and a rapid temperature reduction.

Analysis of S/N Ratio:

In design of experiments, signal expresses the appropriate measure whereas noise describes unsuitable measure. For optimizing the quality features of any machining experiment, larger level factors are perpetually considered by experimentalist for evaluating signal to noise ratio. This means that the way of evaluating signal to noise ratio depends on the quality features picked and the mathematical formulation can be made by picking either a smaller or a larger or nominally better model. The test trials' output characteristics include tool flank wear and surface roughness, and a high signal to noise ratio is always preferred. Using the data, the optimal machining parameters may be pinpointed with pinpoint accuracy.

Table 3.1: Main machining parameters of the experiment

Parameters	Value
Feed (mm/rev)	800,1000,1100,1200

Speed (rpm)	1500,2000,2500,3000
Depth of cut (mm)	0.1,0.2,0.3,0.4,

Measurement of Tool Wear

Each run used a different cutting edge. They made use of a fresh cutting edge. Using a Toolmaker's Microscope and a digital readout device, the tool wear was calculated See Fig. 2 for an eye-level view of the tool insert.

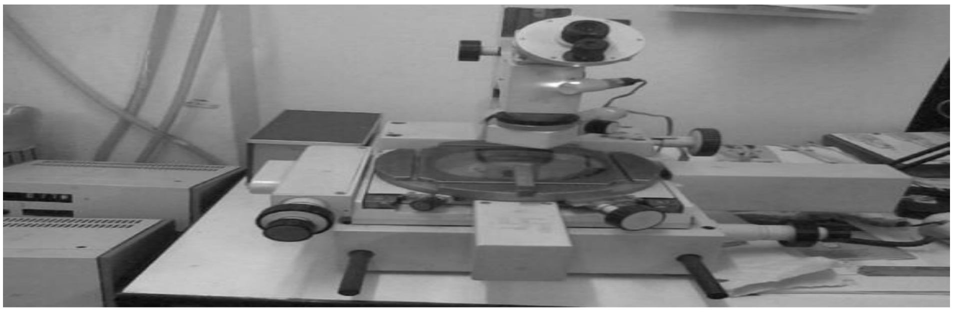


Figure 3.2: Tool makers' Microscope

Optimization Techniques in Metal cutting

Researchers have devised a slew of optimization approaches to figure out the ideal conditions for removing metal during milling operations. Approaches fall into two categories: standard and non-traditional optimization techniques. Various mathematical models have found the ideal cutting conditions, which are cost-effective yet sophisticated in nature, and these approaches are expanding and increasing.

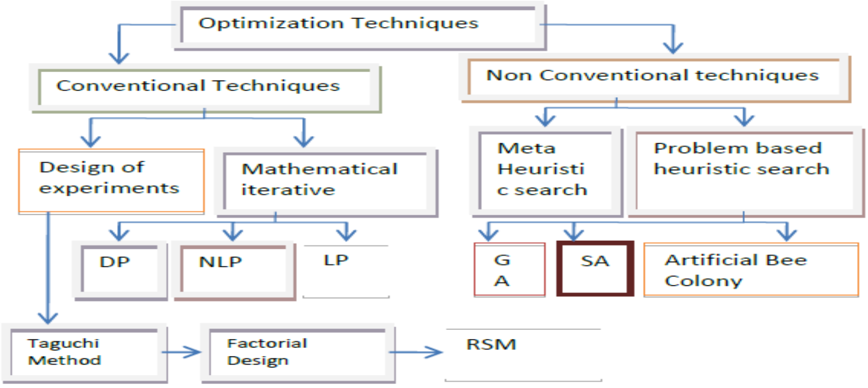


Figure 3.3: Optimization techniques (adapted from Mukherjee and Ray, 2006)

Design of Experiments (DOE) and mathematical iterative search are the two most used traditional methodologies. Tokuo Taguchi is responsible for the creation of the DOE A factorial design based on Taguchi and RSM has been used to tackle manufacturing-related challenges. The mathematical search is divided into Dynamic Programming (DP), Non-Linear Programming (NLP), and Linear Programming (LP). The standard techniques are sluggish and gradient-based, and thus have a hard time cutting complicated models.

4.0 Taguchi's Design of Experiments

Exploratory research can be used to evaluate and improve process parameters. The most influenced process parameters on output responses are listed at different columns in an intended orthogonal array. Machine parameters such as machining speed, feed rate, and depth of cut all influence tool wear and surface roughness. It is better to use lower values when dealing with wear on the flanks or surface roughness Because of this, the preferred machining output responses are low surface roughness and cutting tool flank wear. As a result, the lower the S/N ratio, the better the results were thought to be. S/N ratio for the nominal output response can be calculated from the following characteristics.

Smaller the better $$\frac{S}{N} = -10 \log\left(\frac{1}{n}\sum_{i=1}^{n} Y_i^2\right)$$ ………………… (1)

From S/N ratio, the actual influencing parameters and the best optimal range of selected parameters can be characterized.

Selection of Machining Parameters for Set 1 the set of cutting parameters were chosen according to the preliminary studies and the same is listed in Table The tool nose radius of 0.8 mm was considered for the first set of study. The duration of each level is allowed to run for 10 minutes. For each cutting fresh tip of cutting tool was used.

Figure 4.1: Micro machining of Inconel and steel

Tool flank wear and nominal surface roughness are desirable reactions in turning operations. As a result, it was decided that the smaller the output responses, the better the S/N ratio, the better. Using ANOVA, the impact of each cutting parameter on output responses was determined. A series of confirmation tests compared the optimised results to an empirically predicted value.

Table 4.2: Taguchi parameters

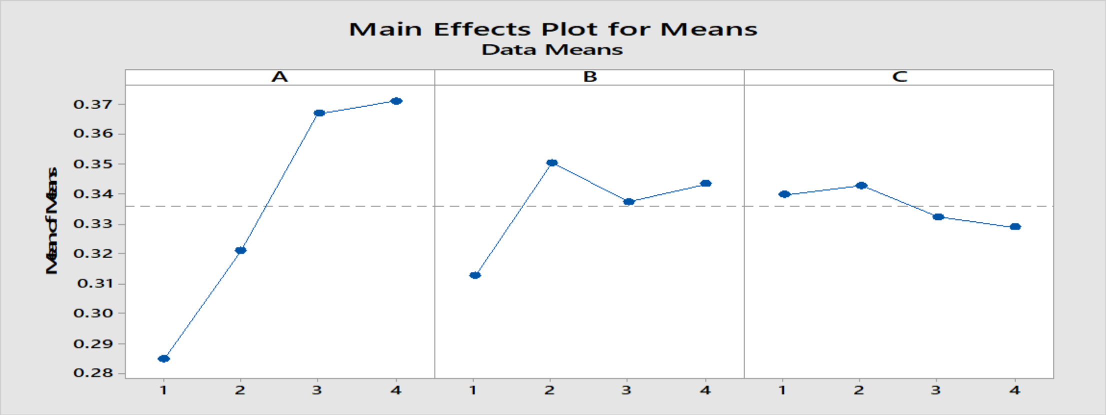
Parameters	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Spindle Speed	600	800	1000	1200
Feed	1500	2000	2500	3000
Depth of cut	0.1	0.2	0.3	0.4

ANOVA results coated carbide tool

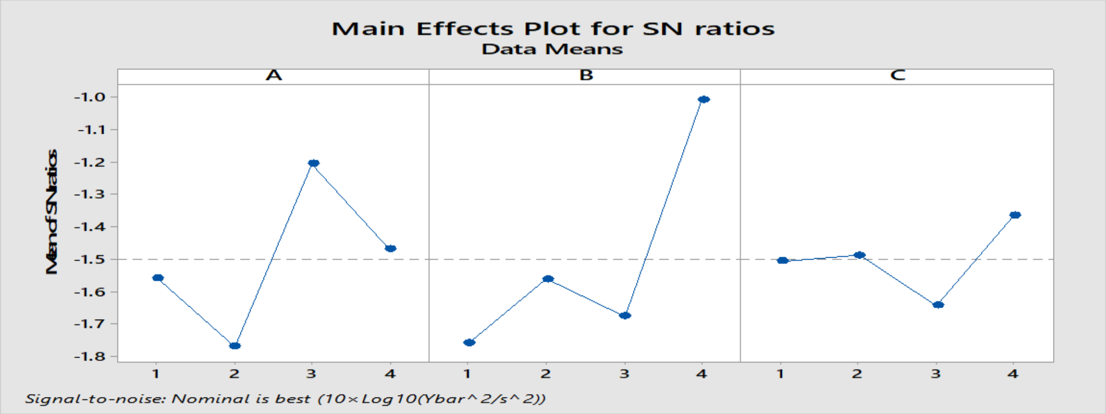
Table 4.3: L16 experimental results with uncoated carbide tool Inconel625

S no	Depth o cut	Feed rate	Spindle speed	Tool flank wear(mm)	Surface finish (µm)
1	0.1	600	1500	0.030	0.510
2	0.1	800	2000	0.044	0.525
3	0.1	1000	2500	0.028	0.528
4	0.1	1200	3000	0.074	0.539
5	0.2	600	2000	0.039	0.585
6	0.2	800	2500	0.042	0.655

7	0.2	1000	3000	0.034	0.585
8	0.2	1200	1500	0.055	0.573
9	0.3	600	2500	0.048	0.638
10	0.3	800	3000	0.065	0.684
11	0.3	1000	1500	0.079	0.659
12	0.3	1200	2000	0.084	0.679
13	0.4	600	3000	0.052	0.599
14	0.4	800	1500	0.065	0.724
15	0.4	1000	2000	0.055	0.732
16	0.4	1200	2500	0.069	0.674



Graph:4.1 Main effects plot for Means

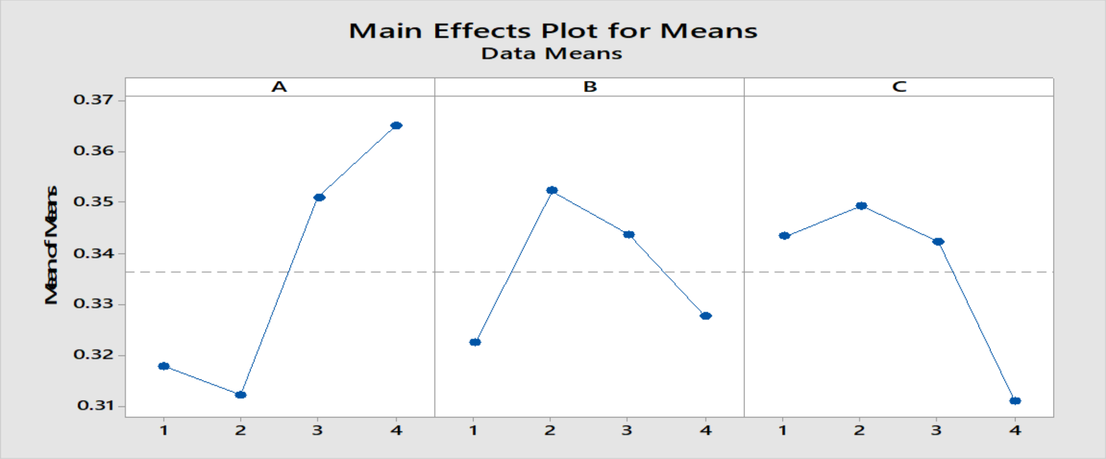


Graph: 4.2 Main effects plot for SN ratios

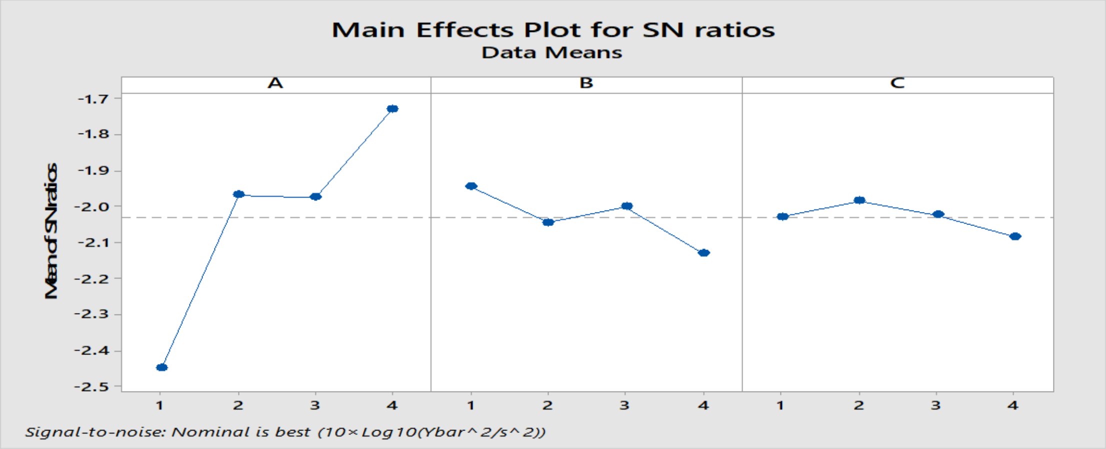
Table 4.4: L16 experimental results with uncoated carbide tool Titanium alloy

S.no	Depth o cut	Feed rate	Spindle speed	Tool flank wear(mm)	Surface finish (µm)
1	0.1	600	1500	0.024	0.628
2	0.1	800	2000	0.023	0.642
3	0.1	1000	2500	0.018	0.655
4	0.1	1200	3000	0.015	0.538
5	0.2	600	2000	0.036	0.589
6	0.2	800	2500	0.039	0.625
7	0.2	1000	3000	0.034	0.555

8	0.2	1200	1500	0.032	0.588
9	0.3	600	2500	0.043	0.631
10	0.3	800	3000	0.032	0.685
11	0.3	1000	1500	0.042	0.658
12	0.3	1200	2000	0.040	0.677
13	0.4	600	3000	0.045	0.584
14	0.4	800	1500	0.055	0.717
15	0.4	1000	2000	0.058	0.730
16	0.4	1200	2500	0.042	0.689



Graph: 4.3 Main effects plot for Means

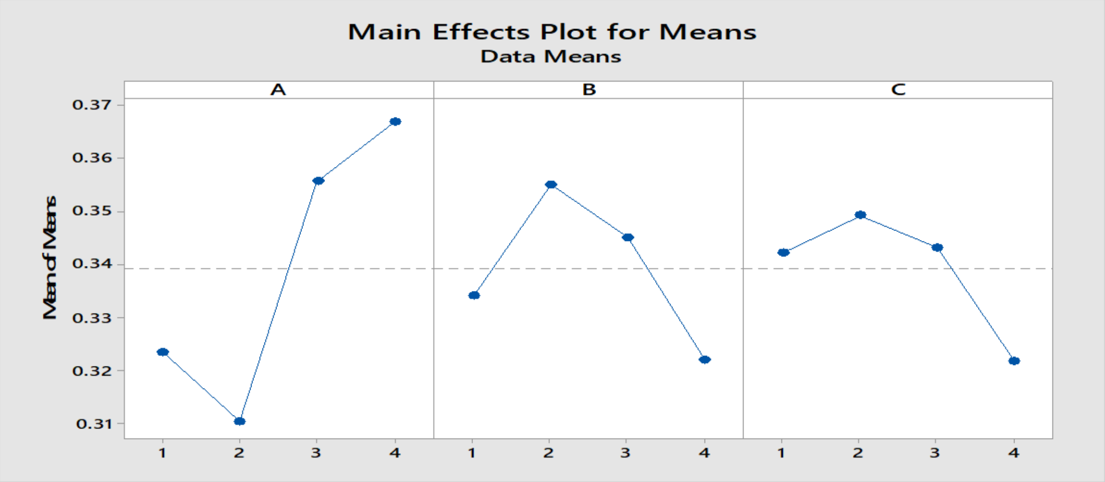


Graph: 4.4 Main effects plot for SN ratios

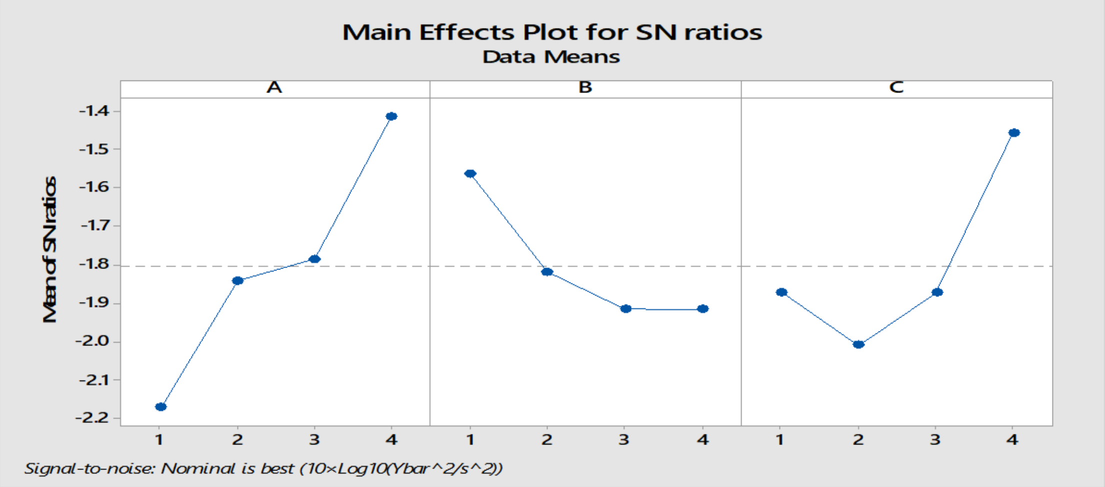
Table 4.5: L16 experimental results with uncoated carbide tool H30

S .no	Depth cut	Feed rate	Spindle speed	Tool flank wear(mm)	Surface finish (µm)	Accuracy
1	0.1	600	1500	0.032	0.651	
2	0.1	800	2000	0.025	0.638	
3	0.1	1000	2500	0.025	0.649	
4	0.1	1200	3000	0.035	0.533	
5	0.2	600	2000	0.042	0.588	
6	0.2	800	2500	0.040	0.617	

7	0.2	1000	3000	0.040	0.549	
8	0.2	1200	1500	0.034	0.574	
9	0.3	600	2500	0.049	0.639	
10	0.3	800	3000	0.057	0.688	
11	0.3	1000	1500	0.047	0.658	
12	0.3	1200	2000	0.034	0.674	
13	0.4	600	3000	0.080	0.593	
14	0.4	800	1500	0.062	0.714	
15	0.4	1000	2000	0.051	0.742	
16	0.4	1200	2500	0.049	0.644	



Graph: 4.5 Main effects plot for Means

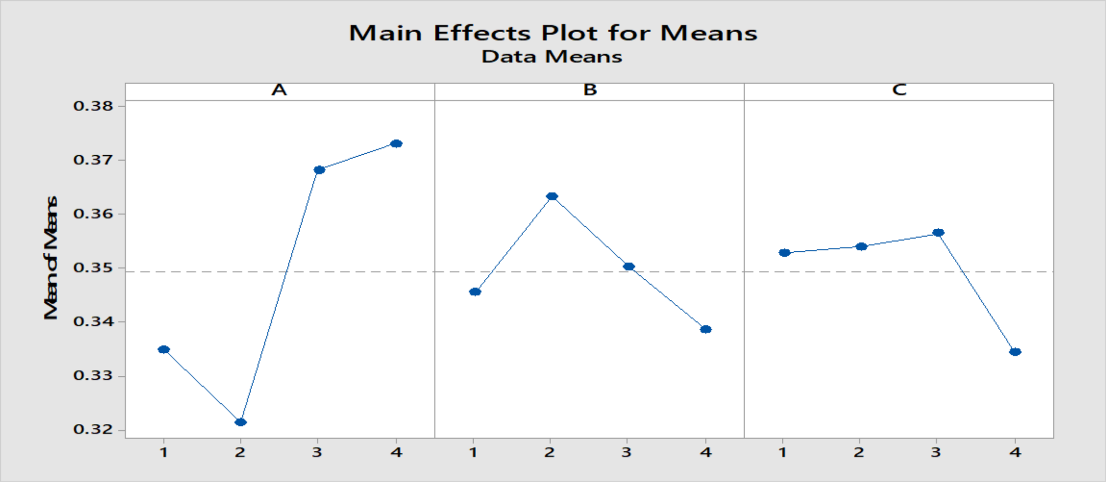


Graph: 4.6 Main effects plot for SN ratios

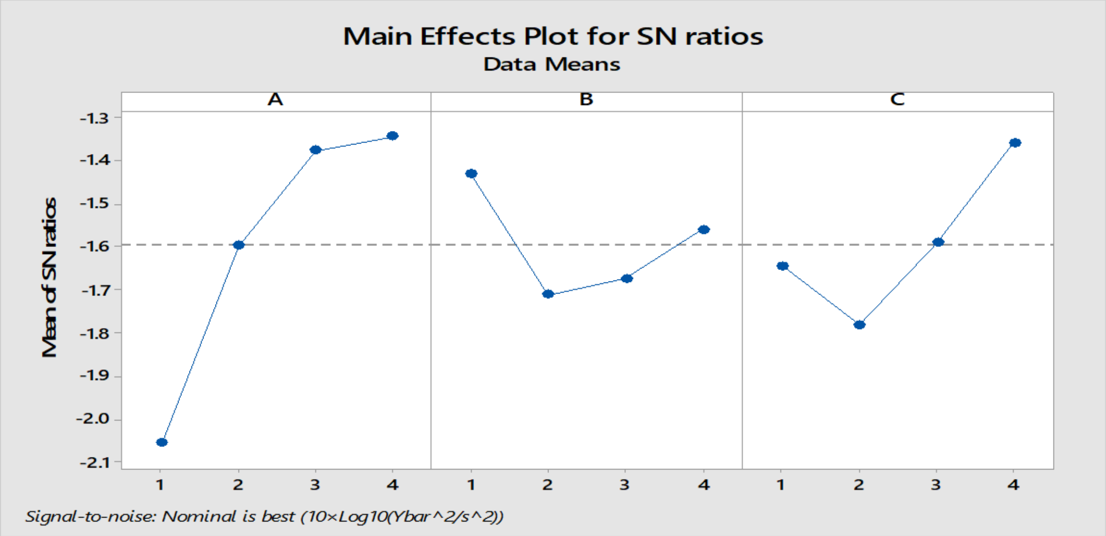
Table 4.6: L16 experimental results with uncoated carbide tool SS316

S no	Depth cut	Feed rate	Spindle speed	Tool flank wear(mm)	Surface finish (µm)	Accuracy
1	0.1	600	1500	0.041	0.664	
2	0.1	800	2000	0.028	0.636	
3	0.1	1000	2500	0.033	0.652	
4	0.1	1200	3000	0.037	0.589	
5	0.2	600	2000	0.044	0.588	

6	0.2	800	2500	0.045	0.652	
7	0.2	1000	3000	0.048	0.555	
8	0.2	1200	1500	0.055	0.585	
9	0.3	600	2500	0.058	0.674	
10	0.3	800	3000	0.062	0.689	
11	0.3	1000	1500	0.067	0.653	
12	0.3	1200	2000	0.065	0.677	
13	0.4	600	3000	0.085	0.610	
14	0.4	800	1500	0.069	0.725	
15	0.4	1000	2000	0.050	0.744	
16	0.4	1200	2500	0.052	0.649	



Graph: 6.34 Main effects plot for Means



Graph: 4.7 Main effects plot for SN ratios

An SEM was used to inspect the micro tool and determine how much the flanks had worn down. Images of tool wear development on the flank face near the cutting edge of coated and uncoated tools were compared and measured. For bottom cross-sectional views, example micrographs of tool wear on the flank are presented. Machining is the term used to describe this process. With machining, a wide range of characteristics can be created, such as openings slots pockets and flat surfaces. Apart from that, while metals like steel and aluminium are the most commonly machined materials, almost any material can be machined as well. Some of the most common methods of removing material involve mechanically cutting away small shards of material using a sharp tool, known as conventional or traditional machining Abrasive machining and multi-point cutting are two of the most common conventional machining methods. Chemical, mechanical, electrical, or thermal techniques of removing material can be used in non-conventional machining procedures. Developing new machining processes for hard, high-strength, temperature-resistant alloys was motivated by the search for better ways to produce complex forms SS304 and heat resisting steels etc.). Rapid advancement in the aerospace, automobile, nuclear engineering and medical fields has been made possible by using these difficult-to-machine materials.

Conclusions and future commendations

Cemented Carbide tool-chip contact temperature A low-medium-and high-speed machining technique determines the Single Point Cutting Tool. Fluke's IR Thermal Imaging system is used to measure the temperature of the tool or chip being tested at the connection point. According to the ANOVA table, speed and depth of cut are the most critical machining variables for rising the temperature.

When a material is plastically deformed, only a small part of the total deformation is due to elastic deformation. So, when the cut depth grows, the tool-to-work piece interface compresses more, increasing the energy transferred to the system throughout the material cutting process.

- Carbide tools generate higher temperatures during machining than Cemented Carbide tools, as demonstrated by experiment and finite element analysis.

Future Scope:

It uses the Taguchi approach to optimise the micromachining process parameters such as cut depth, feed rate, speed, nose radius, tool material and type, and even workpiece material, etc., to increase tool life and reduce surface roughness in an experimental setting. It will be possible to complete the number of levels using orthogonal arrays using the Taguchi technique, which will lead to a conclusion of experiments. It is also possible to observe the behaviour of workpiece quality parameters using the signal to noise ratio.

Recommendations

- Present work is the motivation of components machining of high strength materials with economic cost which is very useful for accuracy of minimum tolerance machining.
- Micro-level machining is needed to serve industries how the parameters effect the tool life as well as machining materials finishing.
- An extension to the present work with angle tool s with ball-nose should be observed as extensive research**.**

REFERENCES:

1. Abdullah, K.; Ulvi, S. (2005): The effect of chamfer angle of polycrystalline cubic boron nitride cutting tool on the cutting forces and the tool stresses in finishing hard turning of AISI 52100 steel. Mater. Des. 26 ISSN: 7236-1203, vol.8, no. 1, pp. 979-984.
2. Abukhshim N.A., Mativenga P.T., Sheikh M.A., “Heat generation and temperature prediction in metal cutting: A review and implications for high-speed machining”, International Journal of Machine Tools & Manufacture xx (2005) 1–19.
3. Abukhshim N.A., Mativenga P.T., Sheikh M.A., “Heat generation and temperature prediction in metal cutting: A review and implications for high-speed machining”, International Journal of Machine Tools & Manufacture xx (2005) 1–19.
4. Amini, S.; Fatemi, M.H. (2014); Ateli, R.: High-speed turning of Inconel 718 using ceramic and carbide cutting tools. Arab. J. Sci.Eng. 39, ISSN: 2320-2084, vol. 15, no, 6, pp. 13069-13096.

5. Arivazhagan S., Shebiah R. N., Divya K., Subadevi M. P. Skin disease classification by extracting independent components. Journal of Emerging Trends in Computing and Information Sciences. 2012;3(10):1379–1382.
6. Byrne G., Thermoelectric signal characteristics and average interfacial temperature in the machining of metals under geometrically defined conditions, Int. J. Mach. Tools Manuf. 27 (2) (1987) 215-224.
7. Chou, Y.K.; Evans, C .J. (1997): Tool wear mechanism in continuous cut-ting of hardened tool steels. Wear 212, ISSN: 1207-8532, no. 9, pp. 29-39.
8. Chou, Y.K.; Evans, C.J.; Barash, M.M. (2009): Experimental investigation on CBN turning of AISI 51200 steel. J. Mater. Process. Tech-nol. ISSN: 1245-7530, vol. 2403, pp. 221-242.
9. Chung D. H., Sapiro G. Segmenting skin lesions with partial differential-equations-based image processing algorithms. IEEE Transactions on Medicine Image. 2000; 19(7):763–767. doi: 10.1109/42.875204.