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Optimizing and Analysing the Flank Wear for turning an Aluminum alloy using Taguchi Optimization Technique

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ABSTRACT: *Aluminum is light in weight and strong which makes it a good use material in manufacturing. It is used commonly in the manufacturing of spacecraft, airplanes, ships, and car components. Aluminum machining plays a key role in the manufacturing industry for the production of components. In this paper flank wear of tool, bits is analyzed and calculated. The tool bits were used for the machining of aluminum al 7075. The experiments were done on a CNC turning center. Taguchi analysis is further used to analyze different machining parameters like feed, speed, and Depth of cut. It is found that feed plays an important role in decreasing the flank wear during CNC machining.*

Keywords: *CNC, Turning, Flank Wear, Taguchi.*

I. INTRODUCTION

CNC machining is the most important form of manufacturing method present in the industry. The method provides precision, efficiency, productivity, and safety for manufacturing [1]. The method is widely used for the manufacturing of products in various industries which include aerospace, automotive, military, defense, construction etc. The components manufactured from CNC if fails can put the lives of people to death [2]. Hence, the precision of components should be analyzed and studied by researchers. The optimization of input parameters of CNC machining for better surface finish, surface roughness and tolerance will provide precision to components [3]. Mayur Verma et .al wants to decrease the time required for choosing the correct tool and machining parameters. since machining some alloys are difficult. The optimization of tool geometry, machining parameters were done followed by experimental validation. experiments were done on Aluminum with different tool inserts. The l9 Taguchi orthogonal array method was used for optimization [4]. Oluseyi O. Ajayi et. Al had studied the deformation behavior of metal cutting. The temperature, stress, the strain was also studied at the cutting zone. The finite element model was built to predict the best cutting parameters and tool geometry. effects of friction and speed of cutting were extensively studied and effects were noted. results conveyed the effects of an increase in friction on machining [5]. V.Vijayaraghavan et. Al experienced the poor performance of machining of Inconel 718 using turning process. the author used a mixed approach based on finite element analysis and a mathematical data model to optimize the parameters for machining. The parameters found using the study can help in saving time, cost and energy for machining of hard materials like Inconel 718 [6]. The most important parameters found using the study were the dept of cut and tool angle [7]. Hemant Jain et. Al in this study has used the Taguchi method for optimization of the CNC turning process. He used the method to analyze the machining parameters for CNC turning. the author extensively studies the machining parameters to achieve the maximum removal rate. The optimized parameters using the Taguchi method show significant improvement in the machining process [8-10].

The friction coefficient was studied deeply in this study to understand the influence of friction on the machining process. A model is developed to find the effect of friction on matching parameters. the results of modeling optimized the machining process of AISI 316 steel [11-13]. The study examined the effects of CNC parameters on surface roughness. The Taguchi method was used for the optimization of parameters. The workpiece used was AISI 304 stainless steel. The tool used in the experiment was coated carbide tool under dry conditions. a model was built for surface optimization using response surface methodology (RSM). the results found that feed rate and depth of cut have the highest effect on surface roughness [14-17].

Rajesh Nayak et . al have studied the chip mechanism process using the finite element method. The analysis of chip formation was done using software and followed by experimental validation [18-21]. a classification of chips was done using the study. The relation between rake angle and chip formation was found using experiments. the investigation of chip formation mechanism was don't on elastomers. the effect of machining parameters was analysed on chip formation during machining of elastomers [22-24].

Kyung SamPark et. Al has reviewed the various methods of optimizing CNC parameters the use of artificial intelligence is highlighted [25, 26]. The author talks about three methods that can be used in optimization parameters under ai. the research mainly uses real-time expert based ai systems for the calculation of CNC machining parameters. the need for the use of ai is highlighted in this research by the author. The deformation behavior by JC constitutive equation was used for analysis. the base material used was Al 2024-t351.experiments were conducted on different varying speeds and feed [27-30].

FEA model was used for the analysis of stress and strain data. The data was generated using JC model parameters. experiments results were compared with model results. the most appropriate stress, strain data was found out [31, 32].

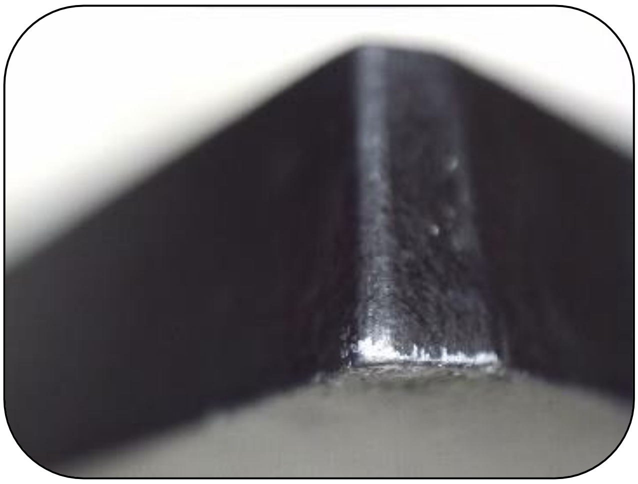

Figure 1: Image of Flank Wear

Flank wear is the wear that occurs on the flank side of the tool bit. it is a kind of wear that happens due of heat that is generated when machining is done.it occurs in three different stages.

1. Primary wear region
2. Secondary wear region
3. Tertiary wear region

In the present study, the tool wear is calculated using tool bits on CNC machining. The governing parameters were analyzed and optimized in the study. The base material used for the study was aluminum al 7075. The parameters optimized include speed, feed, dept of cut Results were obtained for different speeds, feed rate and depth of cut. The numerical study was followed by experimental validation on the LMW LL20TL3 CNC TURNING CENTER machine. The experimental data was then used to optimize the parameters of CNC machining [33, 34].

II. EXPERIMENTAL SETUP

The experimental setup includes LMW LL20TL3 CNC TURNING centre machine for machining of aluminium. The machine is capable of machining any material with different tool inserts. For taking the images of flank wear of tool a high precision coordinate measuring machine is used. Different tool bits are used for different experiments [35-36].

Flank wear images was then analysed using image j software. Image j is a software used for analysing and editing images. The software is capable of measuring distances and areas in the images. The software is used extensively in research areas. The image j edited images were used for flank wear calculations [37-38].

Figure 2: CNC Horizontal Turning Center

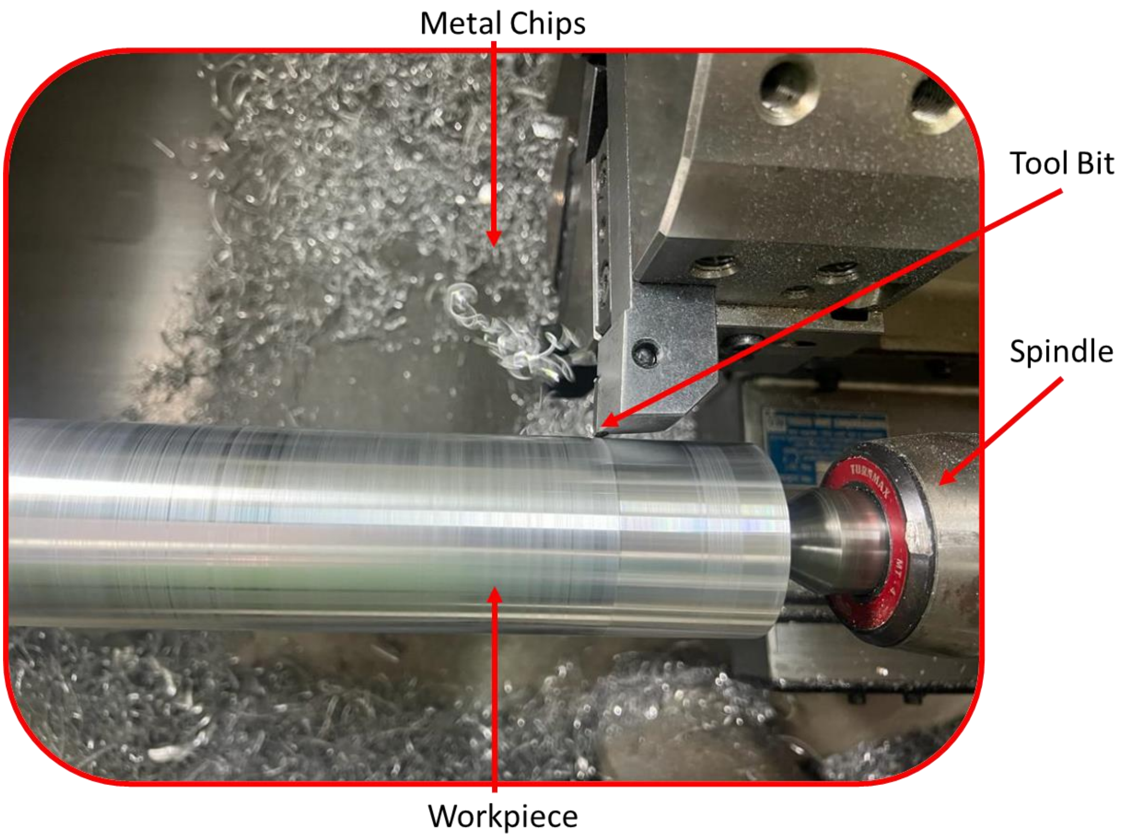

Figure 3: Machining process on the CNC Horizontal Turning Center

Figure 4: Coordinate Measuring Machine used to measure the Flank Wear on the Tool.

III. MACHINING PARAMETERS OPTIMIZATION

The design of experiments was constructed using Taguchi L12 orthogonal array method. Taguchi method is a tool used in research to investigate about the effects of parameters in a set of data. It is used extensively due to its various levels at which it can be used. In this paper L12 orthogonal array with (L 2*3) levels were used with 2 readings for every parameter. The parameters used were feed, speed and depth of cut. Taguchi L12 table was created for three parameters. Tool wear was minimized using Taguchi analysis based on these three parameters.

Table 1 Taguchi L_{12} Design of Experiment Matrix

Design of Experiments		
Speed	feed	DOC
1000	0.1	0.1
1000	0.1	0.1
1000	0.1	0.2
1000	0.2	0.1
1000	0.2	0.2
1000	0.2	0.2
1500	0.1	0.2
1500	0.1	0.2
1500	0.1	0.1
1500	0.2	0.2
1500	0.2	0.1
1500	0.2	0.1

Table 2 Taguchi L_{12} Experimental Results and Response Variable

Design of Experiments			Response Variable
Speed	feed	DOC	Flank Wear
1000	0.1	0.1	2.622
1000	0.1	0.1	2.449
1000	0.1	0.2	2.543
1000	0.2	0.1	2.56886
1000	0.2	0.2	2.818
1000	0.2	0.2	3.041
1500	0.1	0.2	2.108
1500	0.1	0.2	2.97
1500	0.1	0.1	0.71
1500	0.2	0.2	3.559
1500	0.2	0.1	3.625
1500	0.2	0.1	3.743

The workpiece was fixed firmly on the chuck. Chances of whirling of shaft was eliminated by proper shaft positioning on chuck and spindle. A rough cut is first done on the material to remove any foreign material and clean it.

The material was fixed in chuck. Experiments were conducted using different speeds and dept of cut to analyse the governing parameters in flank wear. The images were clicked at the end of every experiment to calculate flank wear.

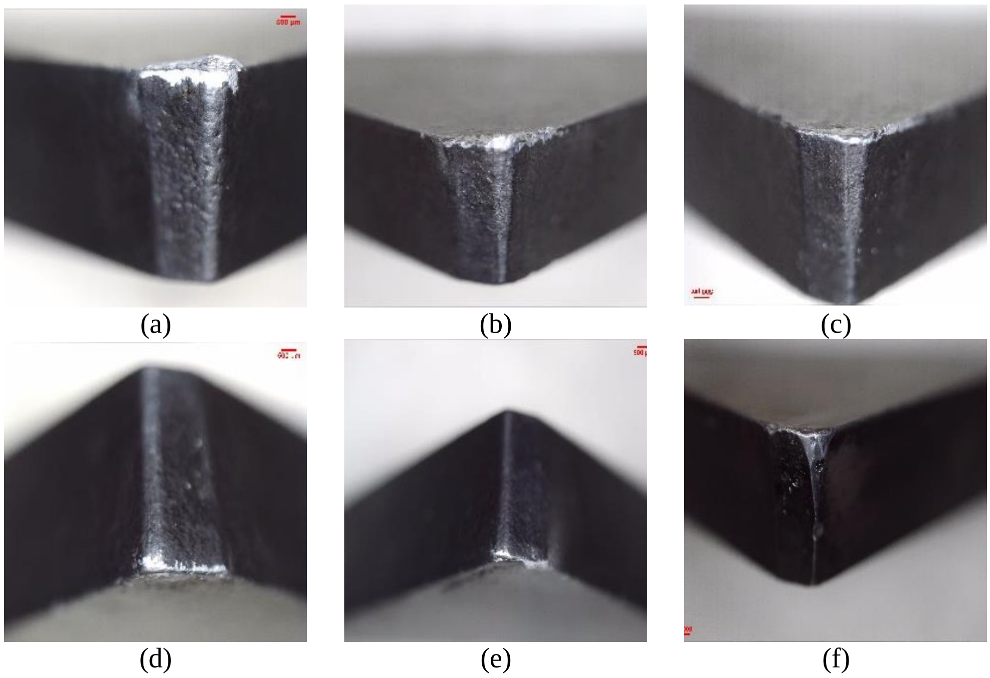

Figure 5: Images of Flank Wear of Tool Bits using Coordinate Measuring Machine.

IV. RESULTS AND DISCUSSION

Figure 5 shows that feed has most prominent effect on tool wear followed by depth of cut. Speed of the cnc machine has the least effect on tool wear. With increase in feed and depth of cut tool wear increases significantly.

Table 3 means response table for Speed, Feed and Depth of cut

Level	Speed	feed	DOC
1	2.644	2.082	2.375
2	2.623	3.185	2.893
Delta	0.021	1.103	0.518
Rank	3	1	2

Table 3 is the response table of Taguchi analysis. It tells us about the main parameter for tool wear rate. The input variable used for the response table was table 2.

Figure 4 incudes photos of flank wear of tool bits taken from coordinate measuring machine microscope. Figure 7 is a probability distribution plot for flank wear. It tells us about the error in the data which should be less than 5 percent. The data is correct with only 1 data point on the line.

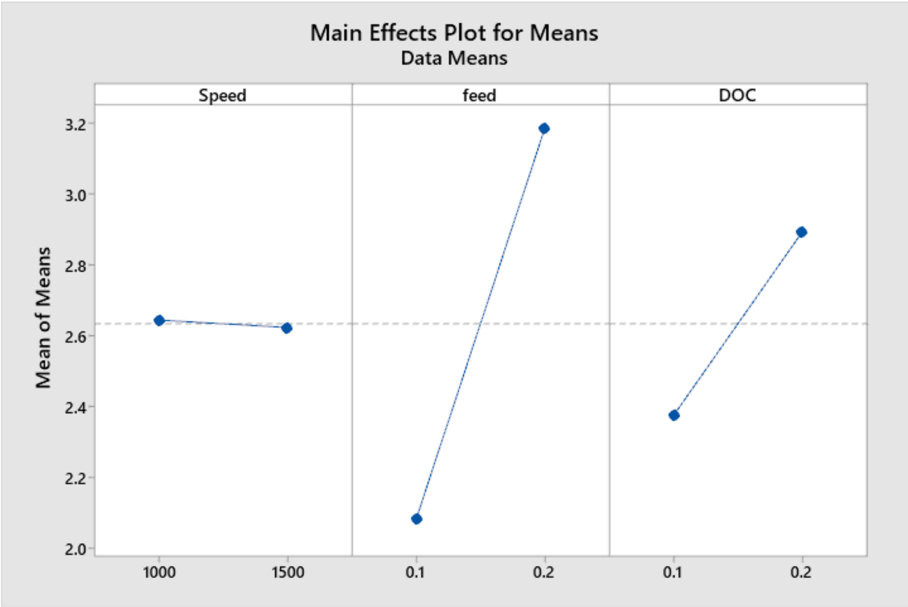

Figure 6 Means Response Graph for Speed, Feed and Depth of Cut

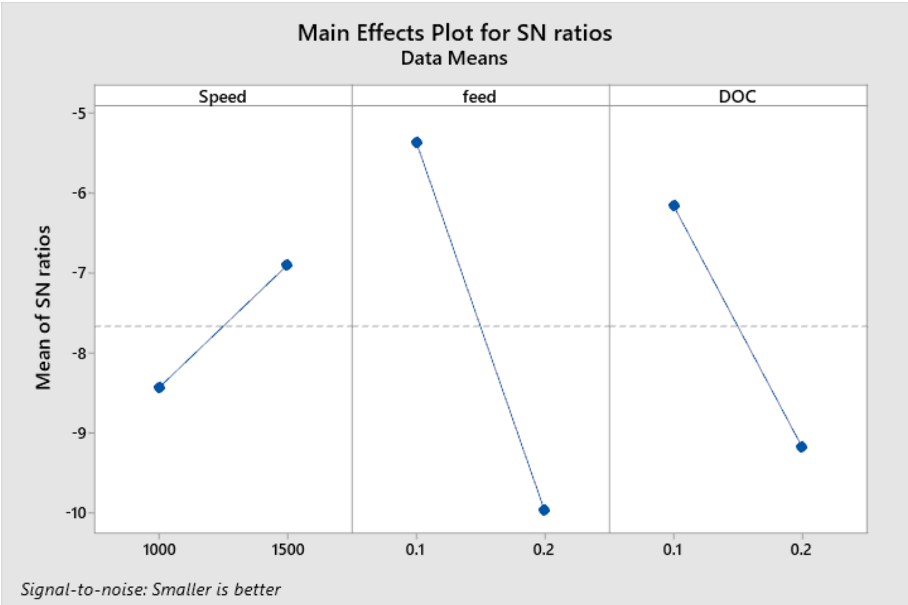

Figure 7 SN Response Graph for Speed, Feed and Depth of Cut

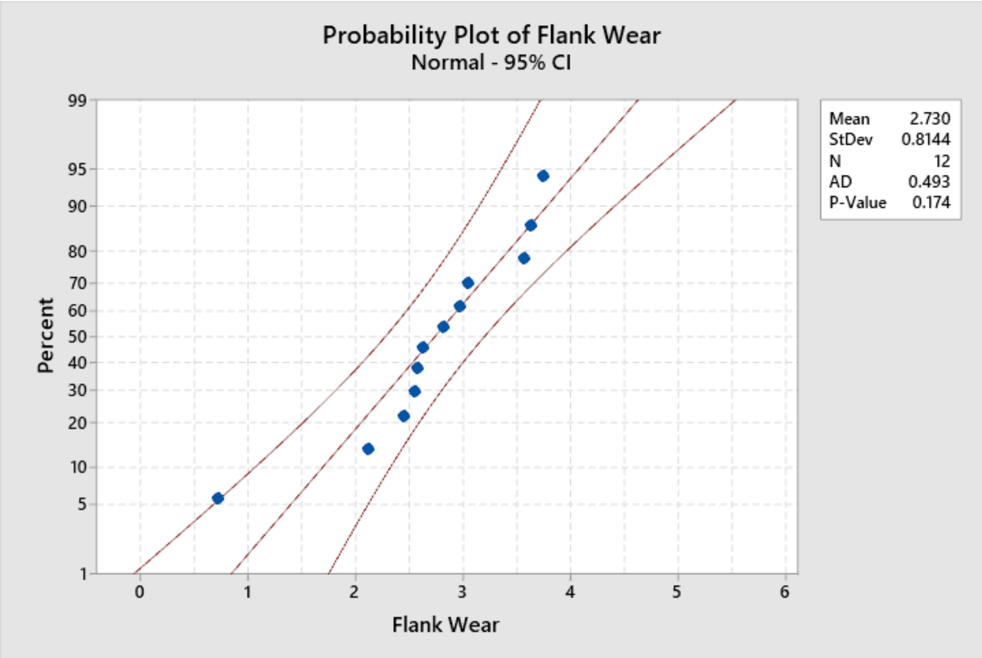

Figure 8 Probability Plot Graph for Flank Wear with Error Under 5%

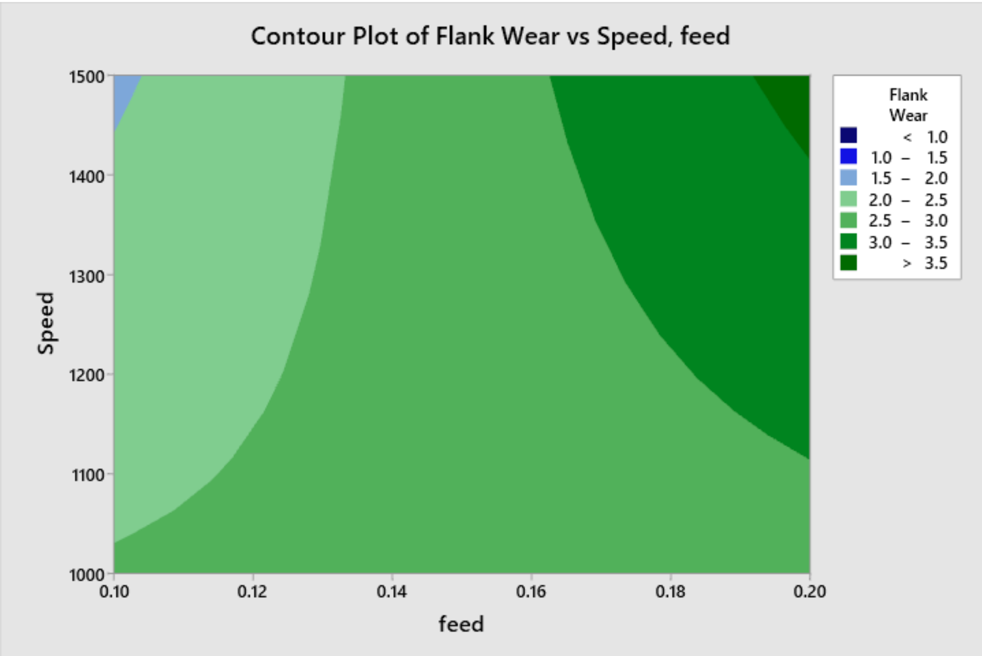

Figure 9 Contour Plot of Flank Wear vs Speed vs Feed

Figure 8 shows the variation of speed and feed with flank wear rate, figure 9 shows the variation of feed and depth of cut with flank wear rate. The contour plots tell us about the effects of parameters individually on flank wear rate.

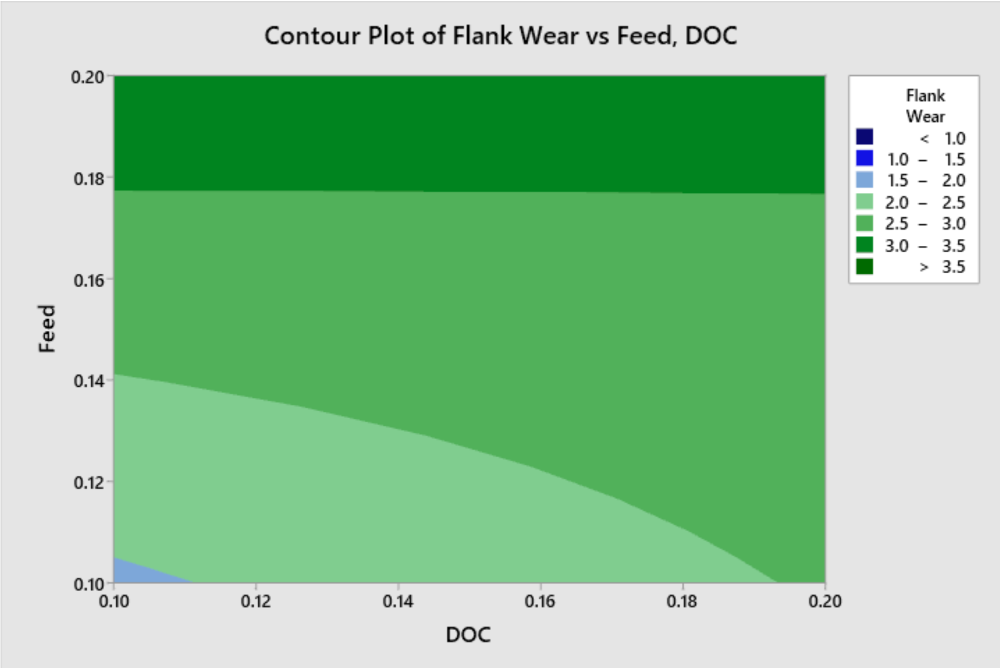

Figure 10 Contour Plot of Flank Wear vs Feed vs DOC

V. CONCLUSIONS

The results of the study include the effects of different machining parameters on flank wear of tool bits. Its was found that flank wear was maximum with high feed and depth of cut. Flank wear can be minimized by decreasing the speed and feed on CNC machining.

The study was concluded by the use of Taguchi analysis on data of tool wear rate. Data was collected by experimenting with different machining parameters. The results were calculated using coordinate measuring machine and imaging software's like image j. The results found using the study is concluded below

1. Flank wear is the most affected by feed and depth of cut, followed by speed. Increasing or decreasing feed and speed of CNC machining flank wear can be reduced.
2. Results were verified using different experiments on CNC machining with aluminium. Data was analysed using Taguchi analysis.
3. the results of Taguchi analysis were further plotted in different contour and line graphs for finding the effects of individual parameters. Probability plot further concluded the correctness of the data. Error in the data was found to be less than 5%.

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