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EFFECT OF COOLING LUBRICANT ON MACHINING PROCESS PARAMETERS

Avinash Bhardwaj, Devendra Kashyap, Sagar Gupta, Chitrakant Tiger

Mechanical engineering Department
Chouksey Engineering College, Bilaspur

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Email: info@jusres.com

ABSTRACT

The usage of cutting fluids for manufacturing industries has also reduces manufacturing cost and also eliminates environmental hazards associated with cutting fluids. In order to have rudimentary knowledge on optimum machinability parameters of Incoloy 825 which was so far unknown in the initial stage of responses tool wear and surface roughness. Chemical vapour deposition (CVD) multilayer TiN/TiCN/Al2O3/ZrCN coated tool has growing range of applications, which gives good condition in conventional machining. The four factors are taken as input parameter with their three level and are designed by Taguchi design of experiment method to run the experiment. Factors of machining parameters are Cutting Speed, Feed, Depth of Cut and type of cooling during process of machining. CVD coated carbide tools and work piece material run experiment are evaluated in terms of tool wear and surface roughness. Two responses are optimize by multi objective technique (TOPSIS method) and their parameters are predicted by ANOVA method.

KEYWORD: Surface Roughness; Tool wear; TOPSIS; ANOVA.

1. INTRODUCTION

Cutting fluids are difficult and expensive to recycle, can cause skin and lung diseases to the machine operator and pollutes the air. Because of these negative aspects of chlorine based cutting fluid, alternative method for cooling the work-tool interface is a big field of interest for the researchers. Many advanced cooling techniques like, Cryogenic Cooling, Minimum Quantity

Lubrication (MQL), High Pressure Cooling (HPC) have been developed and applied. INCOLOY-825 nickel based super alloy was introduced to the market for many purpose to fill the need for a heat- and corrosion-resistant alloy with relatively low nickel content since nickel was, at the time, designated a "strategic" metal [1]. Applications include furnace components and equipment, petrochemical furnace cracker tubes, pigtails and headers, and sheathing for electrical heating. Metal cutting or simply machining, is one of the oldest processes for shaping components in the manufacturing industry. It is estimated that 15% of the value of all the mechanical components manufactured worldwide is derived from machining operations. Dimensional accuracy, tool wear and quality of surface finish are three factors that manufacturers must be able to control at the machining operations to ensure better performance and service life of engineering component [2]. In the leading edge of manufacturing, manufacturers are facing the challenges of higher productivity, quality and overall economy in the field of manufacturing by machining. The conventional types and methods of application of cutting fluid have been found to become less effective with the increase in cutting velocity and feed when the cutting fluid cannot properly enter into the chip-tool interface to cool and lubricate the interface due to bulk plastic contact of the chip with the tool rake surface. Ali et. al. [3] present paper on Minimum quantity lubrication (MQL) refers to the use of cutting fluids of only a minute amount typically of a flow rate of 50 to 500 ml/hour which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition.

Tool wear initially starts with a relatively faster rate due to what is called break-in wear caused by attrition and micro-chipping at the sharp cutting edges. With the progress of machining the tools attain crater wear at the rake surface and flank wear at the clearance surfaces due to continuous interaction and rubbing with the chips and the work surfaces respectively. Surface roughness has been measured at two stages; one, after a few seconds of machining with the sharp tool while recording the cutting temperature and forces and second, with the progress of machining while monitoring growth of tool wear with machining time. Surface roughness is a widely used index of product quality and in most cases a technical requirement for mechanical products [4]. The performance and surface life of any machined component is influenced by surface integrity of that component. Surface roughness has been measured at two stages; one, after a few seconds of machining with the sharp tool while recording the cutting temperature and forces and second, with the progress of machining while monitoring growth of tool wear with machining time.

2. OBJECTIVE OF PRESENT WORK

Optimization of machining cooling process on tool wear characteristics and surface integrity is also not evident from the past research work. Moreover, previous studies could not establish potential of coated tool with wet machining optimization of machining parameters. Therefore, a different grade of nickel-based super alloys may be chosen for which complete machinability characteristics can be evaluated addressing all such issues. Moreover, clear optimization on the suitability of CVD coating during machining of nickel-based super alloy is still lacking.

1. Design the experiment for machining with given factors by MINITAB 14.
2. Perform the Experiment As per the Order of DOE and evaluate Tool wear and surface Roughness of each run.
3. To investigate the effect of cutting speed and comparatively evaluate the performance of CVD coated cemented carbide tools on two important responses such as tool wear and surface integrity.
4. To evaluate the variation of tool wear and surface roughness with progression of machining by ANOVA Analysis.

3. EXPERIMENTAL METHODOLOGY

Incoloy 825 is highly resistant to corrosion. It has a high nickel content, sufficient to resist chloride ion stress corrosion cracking, and a very stable austenite structure. The levels of molybdenum and copper enable the alloy to resist reducing agents and acids. CVD coatings are used in many manufacturing applications as a wear-resistant coating: carbide milling and turning inserts, wear components, some plastic processing tools, etc. In high stress metal-forming applications, where the tool's tolerances and substrate permit, high temperature CVD coating. During the current research work, the influence of various parameters on di□erent performance measure in lathe machine were studied. The machining parameters which were investigated include Cutting Speed, Feed, Depth of cut and Machining Condition. With this parameter each of their three level are taken for experiment as shown in table 1.

Table 1 Parameters and level

Level	Cutting Speed Cs	Feed Fd	Depth of Cut Dc	Machining Condition M
1	54	0.08	.1	Dry
2	84	0.12	.2	MQL
3	124	0.16	.3	Flood

Mathematical models were deduced by software design Expert in order to express the influence degree of the main cutting variables such as cutting speed, feed rate, depth of cut and machining condition components experiments with combination of different cutting parameters were designed by MINITAB 14. The L27 OA has been selected for DOE in MINITAB 14. The design are shown in table 2.

Table 2 Design of Experiment Run

S. No.	Cutting Speed Cs	Feed Fd	Depth of Cut Dc	Machining Condition M
1	54	0.08	0.1	Dry
2	54	0.08	0.1	MQL
3	54	0.08	0.1	Flood
4	54	0.12	0.2	Dry
5	54	0.12	0.2	MQL
6	54	0.12	0.2	Flood
7	54	0.16	0.3	Dry
8	54	0.16	0.3	MQL
9	54	0.16	0.3	Flood
10	84	0.12	0.3	Dry
11	84	0.12	0.3	MQL
12	84	0.12	0.3	Flood
13	84	0.16	0.1	Dry
14	84	0.16	0.1	MQL
15	84	0.16	0.1	Flood
16	84	0.08	0.2	Dry
17	84	0.08	0.2	MQL

18	84	0.08	0.2	Flood
19	124	0.16	0.2	Dry
20	124	0.16	0.2	MQL
21	124	0.16	0.2	Flood
22	124	0.08	0.3	Dry
23	124	0.08	0.3	MQL
24	124	0.08	0.3	Flood
25	124	0.12	0.1	Dry
26	124	0.12	0.1	MQL
27	124	0.12	0.1	Flood

4. RESULT ANALYSIS

Work piece used is of INCOLOY 825 of 25mm dia and length 120 mm. Experimentation is carried in a fixed time 150 second machining for each run of experiment design. ANOVA is performed for regression analysis and is presented in table 3. The p-value in table indicates that the estimated model by regression analysis is significant at the α-level of 0.05. This implies that at least one coefficient is different from zero. According to ANOVA analysis of tool wear the p value is less than 0.05 for Machining condition, so for tool wear the significant factor is machining condition or use of lubricant during machining. ANOVA is performed for regression analysis and is presented in table 4. The p-value in table indicates that the estimated model by regression analysis is significant at the α-level of 0.05.

Table 3 ANOVA analysis for Tool Wear

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cs	2	0.000014	0.000014	0.000007	0.10	0.910
Fd	2	0.000100	0.000100	0.000050	0.70	0.531
Dc	2	0.000173	0.000173	0.000086	1.22	0.359
M	2	0.001155	0.001155	0.000577	8.16	0.019
Cs*M	4	0.000157	0.000157	0.000039	0.55	0.704
Fd*M	4	0.000244	0.000244	0.000061	0.86	0.537
Dc*M	4	0.000130	0.000130	0.000033	0.46	0.763
Residual Error	6	0.000424	0.000424	0.000071		
Total	26	0.002396				

Table 4 ANOVA Analysis for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cs	2	1.5073	1.5073	0.75363	11.04	0.010
Fd	2	0.3771	0.3771	0.18856	2.76	0.141
Dc	2	0.6053	0.6053	0.30264	4.43	0.066
M	2	0.4208	0.4208	0.21040	3.08	0.120
Cs*M	4	0.2378	0.2378	0.05944	0.87	0.533
Fd*M	4	0.1148	0.1148	0.02869	0.42	0.790
Dc*M	4	0.1151	0.1151	0.02879	0.42	0.789
Residual Error	6	0.4098	0.4098	0.06829		
Total	26	3.7879				

Finally the close coefficient in has been calculated, greater the CCI is the optimum for input parameter. In this case greater the CCI value is 0.9823 having its parameters are cutting speed 54, feed 0.16, DOC 0.3 and machining condition is MQL as shown in Fig 1. The ANOVA table experimental Variance is shown in table 5, it is also shown that the cutting speed is significant in combine responses according to CCI value. According to ANOVA analysis of optimize technique the p value is less than 0.05 for cutting speed, so for CCI significant factor is cutting speed during machining.

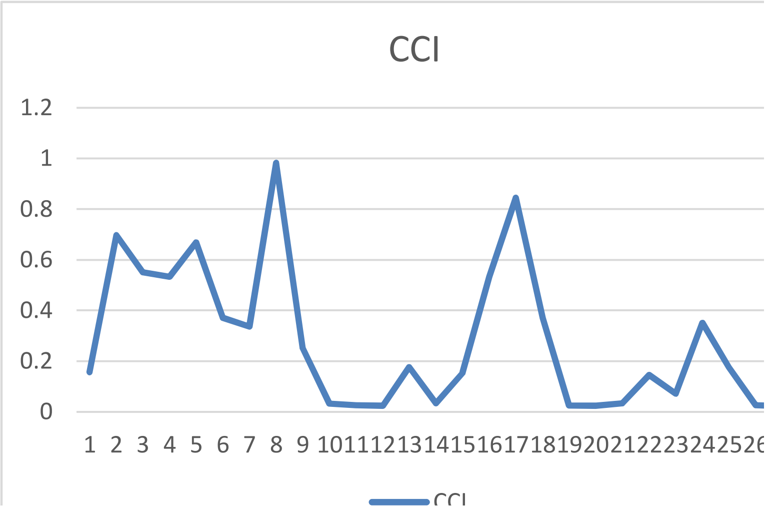

Figure 3 Close Coefficient index by Optimization

Table 5 Analysis of Variance for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cs	2	0.76875	0.76875	0.38437	5.68	0.041
Fd	2	0.23381	0.23381	0.11691	1.73	0.256
Dc	2	0.12698	0.12698	0.06349	0.94	0.442
M	2	0.11587	0.11587	0.05794	0.86	0.471
Cs*M	4	0.27025	0.27025	0.06756	1.00	0.476
Fd*M	4	0.07642	0.07642	0.01911	0.28	0.879
Dc*M	4	0.05337	0.05337	0.01334	0.20	0.931
Residual Error	6	0.40609	0.40609	0.06768		
Total	26	2.05154				

Main effects plot for SN ratios is used to determine whether pattern is statistically significant or not. In the plots, the X-axis indicates the value of cutting parameters and Y-axis indicates CCI in terms of SN ratio. Main effect plots determine the optimal design conditions. Figure 4 show the main effects plot for tool wear on workpiece Incoloy 825 and CVD carbide coated tool. Higher the point in each factor is the optimum value. This figure shows the optimum parameters for higher the optimum setting is cutting speed is 54, feed 0.08, DOC is 0.2 and Machining condition is dry machining.

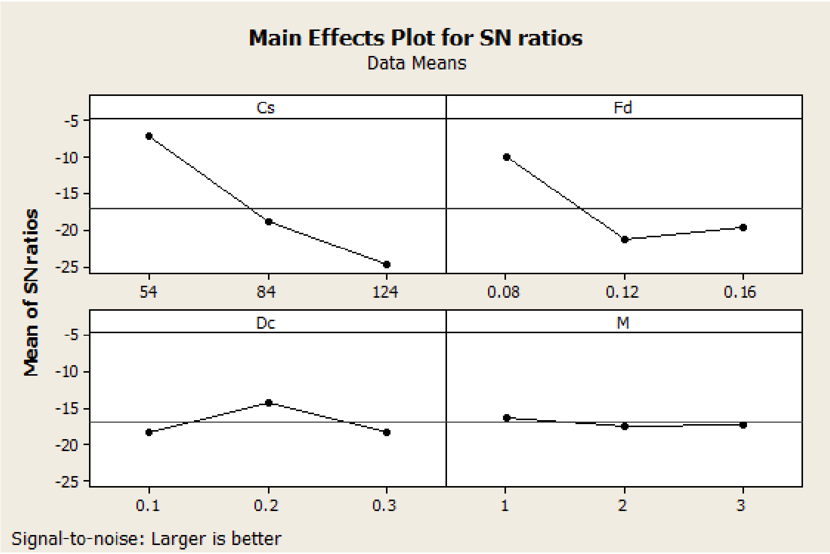

Fig 4 Main effect Plot for CCI

5. CONCLUSIONS

ANOVA analysis gives the significant factor for tool wear is machining condition, for surface roughness is cutting speed and for combining the tool wear and surface roughness the significant parameters are predicted is cutting speed. Mean effect graph analysis is shown the optimum parameters for their respective responses. Tool wear during machining condition of Incoloy 825 was characterized by adhesion, plastic deformation, diffusion and catastrophic failure. The average flank wear increased with both cutting speed due to rise in both plastic deformation and temperature. Optimization for both responses multi-objective technique are used to find the input parameter for optimum responses. TOPSIS method can easily convert the multi objective problem into single objective and can give the optimum parameters for both responses simultaneously.

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