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TAGUCHI LOSS FUNCTION APPLY ON INFLUENCING OF DIFFERENT TOOLS IN MACHINING PROCESS PARAMETERS TO OPTIMIZE

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ABSTRACT

The optimization of conventional machine process parameters is absolute importance in order to improve the productivity and reduces the losses. The conventional machine process parameters were performed with the different cutting conditions and tool characteristics on the three kind of tool used. Inconel 825, a nickel based alloys, has found in many industries because of their unique combination of properties such as high strengths at elevated temperatures, resistance to chemical degradation, and have high wear resistance. Working time is fixed for each performance is 150 second, while other parameters have significant effect. Taguchi loss function technique has been implemented to convert multiple responses in machining parameters into a single one and optimize the above responses. The ANOVA approach found the significant parameters which affect the individual responses and combined responses.

KEYWORDS: Optimization; Surface Roughness; Taguchi Design.

1. INTRODUCTION

During machining nickel-based super alloys, the cutting tools are subjected to extreme level of mechanical and thermal stress leading to accelerated tool wear. HSS is inexpensive compared to other tool materials, but it has limitation of cutting parameters. HSS can work at low cutting speed range of 30-50 m/min owing to poor wear resistance along with low thermal and chemical stability. Therefore, selection of cutting tool is an important factor when machining nickel-based super alloys. Tool material should possess sufficient wear resistance, thermal stability, good combination of hardness and toughness, chemical stability and thermal shock resistance. Athawale & Chakraborty [2] highly competitive global market, the organizations are now forced to focus more on increasing productivity while decreasing cost by right selection of machine tools. Cemented carbide possesses high fatigue and transverse rupture strength, high compressive strength, high stiffness and hot hardness. It exhibits lower friction and is chemically stable. It has strong metallic characteristics with good electrical and thermal conductivities. It can operate at higher cutting speed than HSS, but are more brittle and expensive than HSS. Cemented carbide tools are classified into three grades; P, M and K according to ISO designation. The properties of both P and K grades are included in M grade. Each grade within a group is assigned a number to represent its position from maximum hardness to maximum toughness (higher the number, tougher the tool). Ceramics are non-metallic materials and can withstand extreme temperature during machining. The capability to retain the stiffness and hardness of the material at elevated temperature as high as 1000 °C is the major advantage of ceramic tools. Bushlya et al. [4] aimed at the identification and characterization of wear mechanisms of SiC whisker-reinforced alumina when turning aged Alloy 718 under different cutting conditions and when machining dry and with coolant. Machinability which roughly and qualitatively specifies the degree of ease by which a work material can be machined, was quantitatively defined in earlier times in terms of machinability index. However, this definition suffers from a great deal of limitations since, it considers only cutting speed and tool life. It has been observed that a particular work material under a constant cutting speed can result in different values of tool life which also depends on initial condition of the work piece material.

2. OBJECTIVE OF PRESENT WORK

Although considerable work on tool wear during machining of nickel-based super alloys with major focus different other grades is relatively incoloy. It is known that machining characteristics of a particular work piece material depend primarily on its composition properties. Although coated tools have been used in variation of at least three types included uncoated tool, detailed responses are observed. Effect of tool coating on cutting force surface roughness and tool wear are also not evident from the past research work. However, role of CVD and PVD coating techniques on responses optimization of machinability is still not clear. However, there was barely any effort to critically analyze the optimum responses of different coating layers deposited by CVD and PVD techniques with uncoated tools.

1. To investigate the effect of cutting speeds and comparatively evaluates the performance of uncoated and CVD coated cemented carbide tools on three important characteristics such as tool wear, chip characteristics and surface integrity.
2. To investigate the effect of environment (dry, conventional flood cooling and MQL) on various machining characteristics to determine if usage of cutting fluid can be completely eliminated with the help of best performing coated tool under different cutting condition (roughing and finishing).

3. METHODS AND MATERIALS

Incoloy 825 is highly resistant to corrosion. It has 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. Chromium gives resistance to oxidizing conditions, such as nitric acid solutions, nitrates and oxidizing salts. It is particularly useful in sulphuric & phosphoric acids, sulphur containing flue gases, sour gas and oil wells and sea water. The alloy is titanium stabilized to resist pitting and intergranular attack after fabrication, particularly welding, which includes heating in the critical sensitization temperature range (650°C – 760°C). Brittle phases may form in alloy 825 at temperatures above 540°C, so it is not normally used at these temperatures, where creep-rupture properties would be design factors. PVD (Physical Vapor Deposition) and CVD (Chemical Vapor Deposition) are two techniques that are used to create a very thin layer of material into a substrate; commonly referred to as thin films. They are used largely in the production of semiconductors where very thin layers of n-type and p-type materials create the necessary junctions. CVD and PVD 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 &PVD coating. Using full factorial the number of experimental configurations to be studied. Furthermore, the conclusions drawn from small scale experiments are valid over the entire experimental region spanned by the control factors and their settings. 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 and tools components experiments with combination of different cutting parameters were designed by MINITAB 14. The L27 full factorial design has been selected for DOE in MINITAB 14. The design are shown in table 1.

Table 1 Design of Experiment Run

S. No.	Cutting Speed Cs	Feed Fd	Tool T
1	60	0.08	Uncoated
2	60	0.12	CVD
3	60	0.2	PVD
4	80	0.08	Uncoated
5	80	0.12	CVD
6	80	0.2	PVD
7	120	0.08	Uncoated
8	120	0.12	CVD
9	120	0.2	PVD
10	60	0.08	CVD
11	60	0.12	PVD
12	60	0.2	Uncoated
13	80	0.08	CVD
14	80	0.12	PVD
15	80	0.2	Uncoated
16	120	0.08	CVD
17	120	0.12	PVD
18	120	0.2	Uncoated
19	60	0.08	PVD
20	60	0.12	Uncoated
21	60	0.2	CVD
22	80	0.08	PVD
23	80	0.12	Uncoated
24	80	0.2	CVD
25	120	0.08	PVD
26	120	0.12	Uncoated

27	120	0.2	CVD

Output Responses

The cutting or tangential force acts downward on the tool tip allowing deflection of the work piece upward. It supplies the energy required for the cutting operation. The specific cutting force required to cut the material is called specific cutting force. Surface roughness has been precisely measured with the help of a portable Mitutoyo Surfest SJ-410 device. A stereo zoom microscope was used to capture the image of the tools (both rake and flank surfaces) after each duration of machining shown in Fig. 1 The instrument uses two separate optical paths with two objectives and eyepieces to provide slightly different viewing angles to the left and right eyes.

Fig 1 Stereo zoom microscope for tool wear

4. TAGUCHI QUALITY LOSS FUNCTION

The Taguchi quality loss function is to calculate the deviance between the experimental value and desired value [3]. The calculation of Taguchi quality loss function is following steps,

1. All experimental value converted to loss function (Lij).
2. Normalized loss function (Nij).
3. Calculated the total loss function (TLij).
4. Finally calculated the Taguchi quality loss function (ηj).

5. RESULT ANALYSIS

Responses are obtained by performing the machining operation as per design of experiment is shown in table 5.1. As seen in the responses are obtain lower value is better for cutting Force its lower value is obtain on parameters is 120 cutting speed, 0.08 Feed and PVD coating tools. Minimum value for surface roughnesses obtain on parameters is 120 cutting speed, 0.08 Feed and PVD coating tools. Lower value for tool wear obtain on parameters is 60 cutting speed, 0.08 Feed and PVD coating tools. Cutting force and surface roughness are obtaining their best responses in same parameter whereas for tool wear are obtain its optimum value in different cutting speed only. So for the above case all factor are influencing the responses, and it can be optimize by loss function to known the optimum parameters for all responses.

ANOVA ANALYSIS OF RESPONSES

The analysis of variance (ANOVA) of all three responses that is cutting force, surface roughness and Tool Wear are shown in table 2 to table 4 respectively was used to study the significance and effect of the cutting parameters on the response variables i.e. cutting force, surface roughness and Tool Wear. ANOVA analysis significant factor are depend on P Value is less than 0.05.

Table 2 Analysis of Variance for Cutting force

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cs	2	188403	188403	94201.6	96.74	0.000
F	2	19541	19541	9770.3	10.03	0.001
T	2	109618	109618	54809.1	56.29	0.000
Residual Error	20	19475	19475	973.8		
Total	26	337037				

Table 3 Analysis of Variance for Surface Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cs	2	0.3281	0.3281	0.16403	5.62	0.012
F	2	1.7425	1.7425	0.87124	29.84	0.000
T	2	2.6006	2.6006	1.30030	44.54	0.000
Residual Error	20	0.5839	0.5839	0.02920		
Total	26	5.2551				

Table 4 Analysis of Variance for Tool Wear

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cs	2	0.000596	0.000596	0.000298	22.31	0.000
F	2	0.000109	0.000109	0.000055	4.09	0.032
T	2	0.001757	0.001757	0.000879	65.77	0.000
Residual Error	20	0.000267	0.000267	0.000013		
Total	26	0.002730				

6. OPTIMIZATION

Optimization for this multi- objective problem is done by Taguchi loss function, in this method is first responses are normalized for lower the better. After that the Taguchi loss function is obtained with is rank higher the value of loss function is the optimum solution for combined all responses are shown in fig 2. Main effect plots shows the optimum parameter for all responses in terms of higher the better, higher point for each factor shows the optimum for responses as shown in Fig 3.

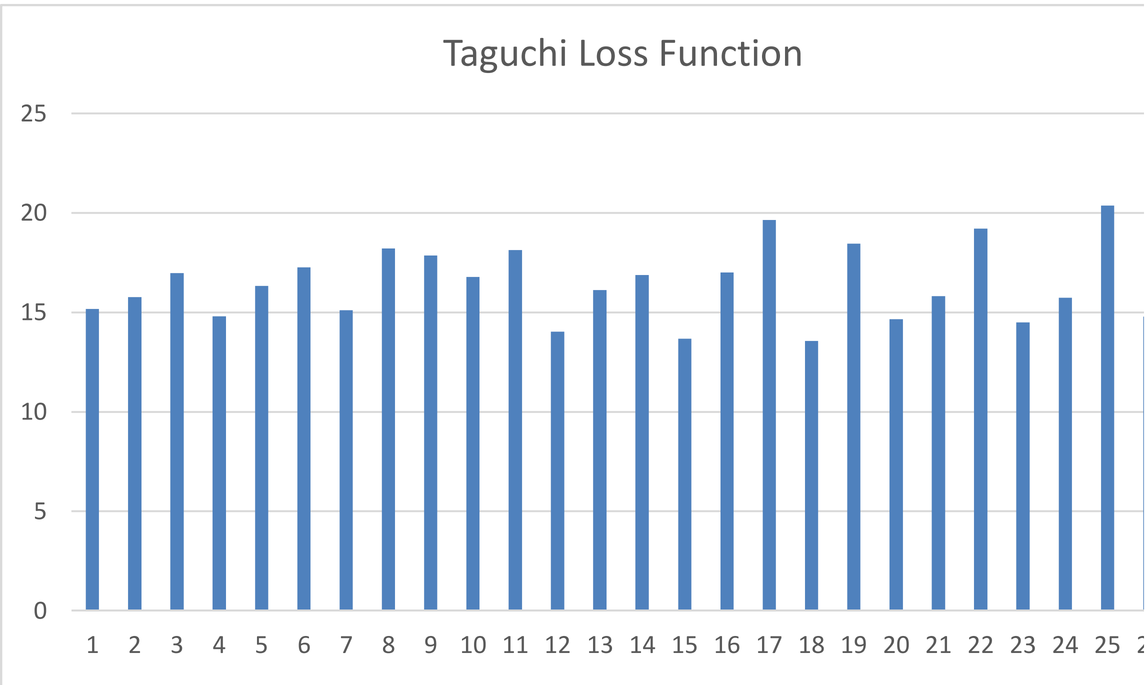

Fig 2 Taguchi Loss Function Optimize for 27 Run Experiment

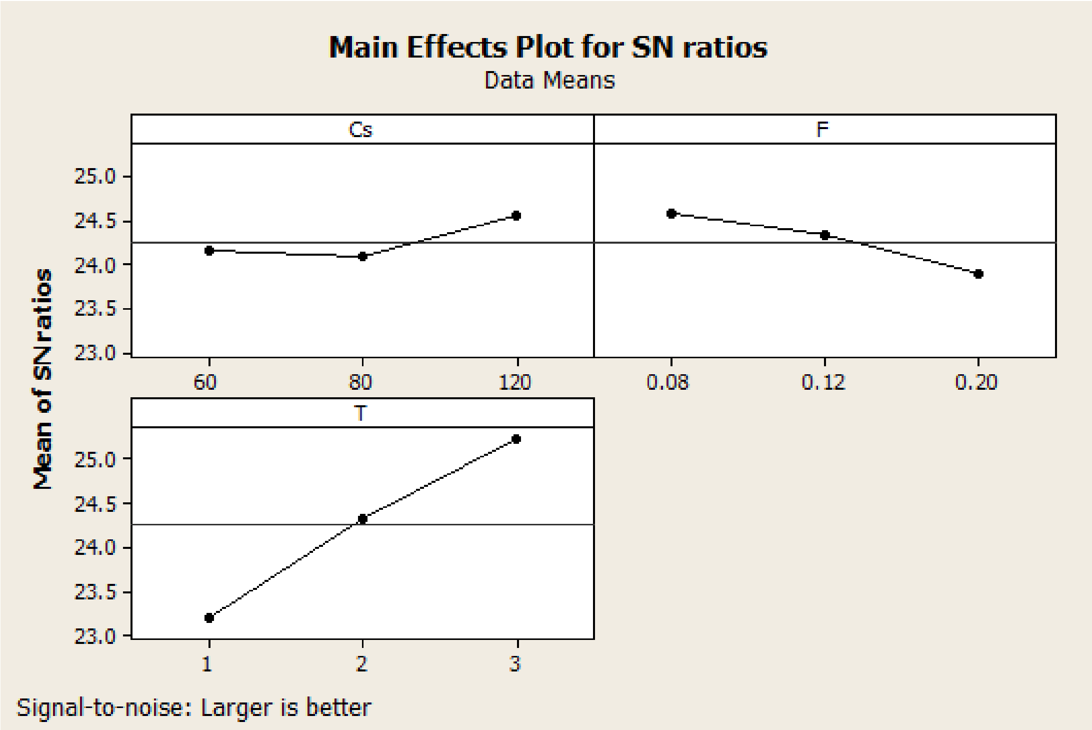

Fig 3 Main Effect plot for Loss Function

7. CONCLUSIONS

Based on the experimental results presented and discussed, the following conclusions can be drawn on the effect of cutting speed, feed and depth of cut on the performance of Tungsten carbide tipped tools when turning Inconel 825. Finally the optimization approach are used for all responses to obtain the best or optimum parameters are cutting speed =120 m/min, f=0.08 mm, tool used is PVD. But from main effect plots are suggest another best parameters for all responses is cutting speed =120 m/min, f=0.20 mm, tool used is PVD which is very close to the optimization parameters. Mist application of cutting fluid could be applied in the future to the same tool-work combination for the same domain of cutting parameters as chosen in the present study and its effects on the surface roughness and tool wear could be studied and analyzed.

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