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Optimization of CNC Turning Process Parameters on INCONEL 718 Using Taguchi technique

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Abstract— In this study, an attempt has been conducted to investigate the effects of cutting parameters on MRR and surface roughness during hard turning of Inconel 718 material By taking into account the taguchi method .The experimental results have revealed that the depth of cut has most significant effect on MRR. Where as the surface roughness is strongly influenced by the feed rate and speed. The present approach and results will be helpful for understanding the machinability and surface characteristics of Inconel 718 during high speed turning for the manufacturing engineers Analysis of variance is used to study the effect of process parameters and established correlation among the cutting speed ,feed and depth of cut with respect to Ra and tool MRR .The result are further confirmed by experiments. Finally output parameters like surface finish and metal removal rate can also be optimized for economical production

Keywords — MRR, surface roughness, ,Inconel 718.

1 Introduction

Superalloy, Inconel 718 is one of the important alloys among all the Nickel and Nickel based alloy. Inconel 718 has found in many industries, owing to its unique properties. Inconel 718 material is widely used in as aircraft engine parts, steam turbine power plants, space vehicles, medical applications, marine applications, pollution control equipment, automotive sector etc. Since machining is basically a finishing process with specified dimensions, tolerances and surface finish, the type of surface that a machining operation generates and its characteristics are of great importance in manufacturing. Carbide cutting tools are the oldest amongst the hard cutting tool materials. Tungsten carbides are mainly used for continuous cutting operations Carbide tools are used to machine nickel-base superalloys in the speed range of 30-80 Several research efforts have been conducted in order to improve the machined surface accuracy, reduce the tool wear and subsequently extend the tool life; which directly affects to the cost of machining and productivity.

2 Literature Review

Nickel based super alloy are widely employed in aerospace industry .In particular for the hot sections of gas turbine engines due to their high temp strength and high corrosion resistance there ability to maintain there mechanical properties at high temperature severely hinders the machinability of these alloys . they are generally referenced as difficult to cut materials .we focus our study on the inconel 718 alloys.

Liao and Shiue (1996) The wear surfaces of cutting tool are investigated in detail using micro analysis and more evidences are given and a new carbide tool wear mechanism in cutting of inconel 718 is proposed .The tool material are K20 and P20 carbides respectively with the cutting geometry of The feed rate and the depth of cut were 0.10 mm/rev and 1.5 mm, respectively. The cutting speed was either 35 or 15 m/min. On the wear surface of the K20 carbide, they observed a sticking layer very close to the cutting edge. Built-up edge (BUE) was formed at a cutting speed of 35 m/min with chipping of the cutting edge. When P20 carbide was used, the sticking layer also could be found, but comparatively, the wear was more irregular, the flank wear length was larger and the groove was deep

M .Rahman (1997) In their study there were a total four input parameters namely SCWA, cutting speed, feed rate and depth of cut .It was been absorbed that tool life is significantly increase in the side. Tool life is significantly increased with an increase in the SCEAs from -5^0 to 15^0 then to 45^0 . for speed of 30m/min and a feed rate of 0.2mm/rev, the tool life of the EH20Z-UP insert decreased by 64.3% when the SCEA was changed from 45^0 to 5^0 . on the whole the inserts performed best at a SCEA of 45^0.

***I** A Choudhury (1998)* in this paper a general review of their material characteristic and properties together with their machinability assessment when using different cutting tools . The advantages and dis advantages of different tool materials with regard to the machining inconel are highlighted. Uncoated carbide tool are better than coated tool for machining inconel 718 . apparently the coating does not improve the performance of coated tool.

D Dudzinski (2004) focused mainly on the developments towards dry and high speed machining of inconel 718. He has used different types of cutting tools and has concluded that cemented carbide tool are largely used for machining nickel based alloys at very low cutting speed at 20 -30 m/min the K20 grade appears to be the best for cutting inconel 718 higher cutting speed certainly upto 100 m/min under dry condition may be achived wuth coated carbide tools. The use of coolent is undesirable for environment hence new concept has been introduced to minmised coolent lubrication the objective of this paper is to find the suitable tool an appropriate coating to define the better geometrical tool configuration.

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Abdullah Altin (2007) has study the effect of cutting speed and cutting tool geometry on cutting force metal removing process is carried out for four different cutting speed while constant fed and depth of cot .as a result of experiments the lowest mean cutting force which depends on tool geometry is obtain as 672N with KYON2100SNGN120 712 ceramic tool maximum cutting force is determained as 1346 N with the cersmic cutting tool having KYON4300 RNGN120 700 geometry

D Dudzinski (2007) results of orthonal cutting test are first presented in terms of cutting force and gear patterns for each test the feed translation was two mm for specimen dia. Of about 260 mm , then only the first stage of toole wear was invested flanks wear crater wear and notch wear were observed with the help of SEM.

R S Pawade (2008) in this paper an experimental insvestigation to access the effect of machining process and cutting edge geometry related parameter on surface integrity in high speed inconel 718.the following conclusion has been drawn from the inestigation that the machining condition of speed 475 m.min and lowest feed rate 0.05mmrev and low to moderate depth of cut 0.5/ 0.75 mm.

D Thakur (2008) the experiment result show that the taguchi parameter desing is an effective way of determine of optimal cutting parameter for the cutting force and feed force evolution the anoma analysis shows that the cutting parameter is more significant from the mean effective it has been found that feed and depth of cut are less significant as the slope is small.

Thakur et al. (2009) did experiments on machining of Inconel 718 on latationship he and proposed investigations of high speed turning on Inconel 718 using Taguchi optimization technique for cutting force, cutting temperature, and tool life in high speed turning of Inconel 718 using cemented tungsten carbide (K20) cutting tool. A correlation between cutting speed, feed, and depth of cut with respect to cutting force, cutting temperature also demonstrated in order to identify the optimum combination of cutting parameters.

V Dhana lakshmi (2010) she mainly studies on wear analysis if ceramic cutting tool the experiment result indicate that the cutting speed is the moist signifficient factor to overall performance the co realation with cutting speed and feed with tool wear and surface are obtained by variable linear regration it has been found that the less tool wear and good surface finish are obtained using ceramic tool when finished turning inconel at low speed the optimum cutting condition for good surface finish is 100 mm/min. and 0.1 mm/rev the tool failure are obtained when cutting speed of 200m/mim and feed rate of 0.15mm/rev and has concluded that performance is better at low cutting speed.

Ahmad Yasir Moh (2011) has focus on the tool performance when finish turning Inconel 718 using single layer PVD coated TiAIN carbide insert at high cutting speed at various cutting speeds, depth of cut and feed rate under dry cutting condition . He concluded that the most significant factor that influences the flank wear or tool life at high cutting speed and dry machining is depth of cut followed by feed rate and cutting speed, respectively. Tool life is significantly influenced by temperature generated at the cutting zone when machining Inconel 718 under dry cutting condition. Increaseing the cutting speed and depth of cut affected the tool life and promoted wear progression.

.*Colak (2012)* deals with experimental investigation on machinability of Inconel 718 in conventional and alternative high pressure cooling conditions The experiment results have proven that the tool flank wear and cutting forces considerably decrease with the delivery of high pressure coolant to the cutting zone. Moreover, ANOVA results also indicate that high pressure cooling has a significant beneficial effect on cutting tool life

Chinmaya and Manas (2014) proposes and experimental investigation and optimization of the various machining parameters for electrical discharge machine process on inconel 718 using multobjective particle.They propsed a model shows that the interactive and complex effects of various important process variable.The propsed model can be used for selecting ideal process states for achieving improved machinging condition for Inconel 718

3. EXPERIMENTAL PROCEDURE

The workpiece material used in the machining test was Inconel 718.Its chemical composition confirms to the following specification in table 1

Table 1 chemical composition

Elements	Percentage (%)
Ni (+Co)	50 – 55
Fe	Bal
Mo	2.3 – 3.3
Ti	0.65 – 1.15
C	0.08
Si	0.35
Cu	0.3
Cr	17 – 21
Co	1
Nb (+Ta)	4.75 – 5.5
Al	0.2 – 0.8
Mn	0.35
B	0.006

4 Design of Experiments

4.1 Taguchi Method

Taguchi methods are the most recent additions to the toolkit of design, process and manufacturing engineers, and

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quality assurance experts. In contrast to statistical process control, which attempts to control the factors that adversely affect the quality of production, Taguchi methods focus on design – the development of superior performance designs (of products and manufacturing processes) to deliver quality

Taguchi's orthogonal arrays, in general, are available in various sizes like L4, L8, L9, L12, L16, L18, L27, L32. But when several factors need to be considered all at the same time, then the situation makes separation of any of the main factors, especially any interaction effects. Some factors may make a positive contribution while the others make a negative combination without any hint of doing so. Even though one might argue that the use of a full factorial experiment is the only reliable option, the use of strategic orthogonal arrays might prove to be just as powerful.

1 Smaller the better characteristics;

S/ N = $-10\log\frac{1}{n}\left(\sum y^2\right)$

2 larger the better characteristics;

S/N = $-10\log\frac{1}{n}\left(\sum\frac{1}{y^2}\right)$

3 Nominal the best characteristics;

S/N = $10\log\frac{\bar{y}}{sy^2}$

4.2 Taguchi L27 Orthogonal Array

The orthogonal array for two factors at three levels was used for the elaboration of the plan of experiments the array L_{27} was selected, which has 29 rows corresponding to the number of tests (26 degrees of freedom) with 13 columns at three levels. The factors and the interactions are assigned to the columns. The first column was assigned to the Cutting speed m/min (A), the second column to Feed mm/rev (B),. The output to be studied was the surface roughness, further an analysis of variance (ANOVA) was carried out for surface roughness

Table 2 Cutting parameters

Parameters	Levels		
	1	2	3
Cutting sped , Vc (m/min)	55	65	75
Feed, f (mm/rev)	0.5	1	1.5
Depth of cut, d (mm)	0.2	0.4	0.8

Table 3 Orthogonal array and experimental result

Expt No	Speed (m/min)	Feed (mm/Rev)	DoC (mm)	Ra (μm)	MRR (Cm3/min)
1	65	0.5	0.4	0.12	1279
2	65	1.5	0.4	0.94	3838
3	65	0.5	0.2	0.14	645
4	75	1.5	0.4	0.96	4428
5	55	1.5	0.8	0.94	6389
6	75	1	0.4	0.42	2952
7	75	0.5	0.4	0.14	1476
8	75	0.5	0.8	0.12	2904
9	75	1.5	0.2	0.92	2232
10	75	1	0.2	0.44	1488
11	55	1.5	0.2	0.96	1637
12	65	0.5	0.8	0.14	2517
13	55	1	0.8	0.42	4259
14	55	0.5	0.4	0.12	1082
15	65	1	0.8	0.42	5034
16	65	1.5	0.2	0.94	1934
17	55	1	0.4	0.46	2165
18	75	0.5	0.2	0.12	744
19	55	1	0.2	0.44	1091
20	55	1.5	0.4	0.96	3247
21	55	0.5	0.8	0.14	2130
22	75	1.5	0.8	0.94	8712
23	65	1	0.4	0.42	2558
24	55	0.5	0.2	0.14	546
25	75	1	0.8	0.44	5808
26	65	1	0.2	0.42	1290
27	65	1.5	0.8	0.86	7550

5. Result and Discussions

The purpose of the statiscical analysis of variance is to investage which design parameter significantly effects the surface roughness and MRR. Based on the ANOVA the relative importance of machnnig parameter wirh respect to surface roughness and MRR was investigated to determine to obtaion combination of machining parameter table 5 show the result of the ANIOVA analysis of surface roughness similarly table

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six show the result of analysis of MRR the analysis was carried out significant level of α=0.05 for confidential level.

Table 4 shows the ANOVA for surface roughness. The purpose of the ANOVO is to determine the process parameters which significantly affect the performance characteristic .It has absorbed that the depth of cut has insignificant effect on surface roughness It has found that cutting speed and feed has significant effect on Ra.Based on ANOVA analysis ,the optimum cutting parameters for surface roughness are the cutting speed at level ,feed rate at level and depth of cut at level

Table 4 ANOVA table for surface roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Speed	2	0.806	0.806	0.403	3.75	0.210
Feed	2	467.74	467.7	233.87	217	0.00
Doc	2	0.509	0.509	0.254	2.3	0.297
Residual error	2	0.215	0.215	0.107		
Total	8	469.27				

Table 5 ANOVA table for MRR

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Speed	2	6.098	6.098	3.049	0.30	0.768
Feed	2	76.834	76.834	38.427	3.80	0.208
Doc	2	229.648	229.648	114.824	11.35	0.081
Residual error	2	20.235	20.235	10.118		
Total	8	332.815				

5.1 Regration analysis

A various regression analysis was performed to know the effectiveness an application of the experimental result . to arry out the regration analysis MINITAB stastical software is used an imperical equation is derived between the roughness and cutting parameter . is given in equation 1 and the regreation analysis between MRR and cutting parameter in equation 2

The obtain equation is as follows

Ra (actual) = -0.267 – 0.00044 speed (m/min) + 0.804 feed (mm/rev) – 0.0206 DoC (mm)…….1

MRR(Cm3/min) = - 47.1 + 0.762 Speed(m/min) + 49.5 Feed (mm/Rev) - 5.3 DoC (mm)

+ 96.0 Sfd…..2

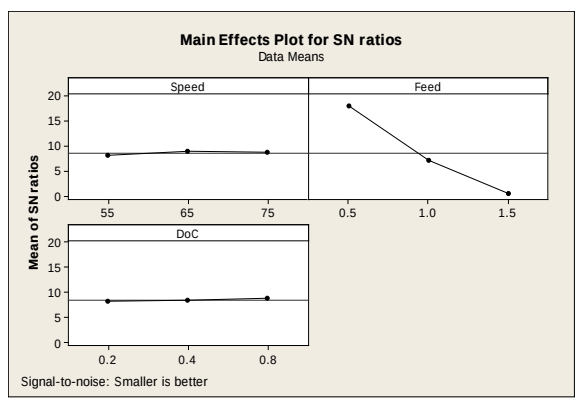
5.2 Taguchi optimization analysis of surface roughness

Taguchi recomendates analyzing means of S/N ratio using conceptual approach that involves graphical method for study the effect the surface roughness are analysed usin statistical software the mean S/N ratio for each level of the machining parameter were calculated based upon the data present in table the optimal performance for the surface roughness of turning process was obtain at a cutting speed (65 m/ min) feed (0.5mm/rev) DoC (0.8 mm) ranking of machining parameter are also calcuted based of difference in S/N ratio. The rank indicate the dominet the machining parameter that effects surface roughness figure show that the plot for surface roughness which indicate that the surface roughness decreases with increases of cutting speed. and very low influence on the depth of cut since delta value is very low

Table 6 Response Table for Signal to Noise Ratios Smaller is better

Detail	Machining parameter Mean S/N ratio		
	Cutting speed	Feed	Depth of cut
Level 1	8.119	17.97	8.2486
Level 2	8.8296	7.1369	8.5053
Level 3	8.6340	0.4765	8.8296
Delta	0.7097	17.49	0.5810
Rank	2	1	3

Fig 1 Mean effect plot for SN ratio



5.3 Taguchi optimasation analysis of MRR Is one of the most critical factor to decide the cost effectiveness The analysis of the experimental observations highlights that MRR in CNC turning process is greatly influenced by depth of cut. Based on analusis using table for optimum for MRR was obtain

Table 7 Response Table for Signal to Noise Ratios larger is better

Detail	Machining parameter Mean S/N ratio		
	Cutting	Feed	Depth of cut

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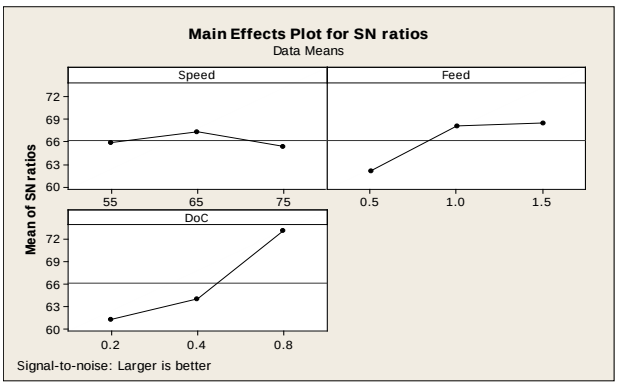
	speed		
Level 1	65.85	62.05	61.31
Level 2	67.30	68.07	64.08
Level 3	65.36	68.41	73.14
Delta	1.94	6.36	11.83
Rank	2	1	3

Fig 2 Mean effect plot for SN ratio



6 Conclusion

In these work full factorial design of experiment was conducted and taguchi optimization analysis were carried out for selecting the optimium machining parameter

1 Based on the taguchi design of experiments an analysis the feed and cutting speed is the main factor that has highest influence on surface roughness

2Optimum machining parameter for minimum surface roughness was determined.

3 The analysis of the experimental observations highlights that MRR in CNC turning process is greatly influenced by DOC

References

1. Journal of Materials Processing Technology 205, (2008), pp. 439–450.
2. Dudzinski A., Devillez A., Moufki A, Larrouque`re D, Zerrouki V., Vigneau J., "A review of developments towards dry and high speed machining ofInconel 718 alloy", International Journal of Machine Tools & Manufacture, pp. 439–456.
3. Ezugwu E. O., "Improvements in the machining of aero-engine alloys using self-propelled rotary tooling technique", Journal of Materials Processing Technology 185, (2007), pp. 60–71.
4. Hong J. K, Park J. H., Parka N. K., "Microstructures and mechanical properties of Inconel 718 welds by CO2 laser welding".
5. Krain, H. R, Sharman A. R, Ridgway K., "Optimisation of tool life and productivity when End milling Inconel 71", Journal of Materials Processing Technology 189, (2007), pp.153–161.
6. Krzysztof Jemielniak, "Finish turning of Inconel 718".
7. Li H. Z., Zeng H. and Chen X. Q., "An Experimental study of tool wear and cutting force fariation in the end milling of Inconel 718 with coated carbide inserts".
8. Liao Y. S., Shiu R. H., "Carbide tool wear mechanism in turning of Inconel 718 superalloy", Wear, 193, (1996), pp. 16–24.
9. Mathew A., Kuttolamadom, Sina Hamzehlouia, "Effect of machining feed on surface roughness in cutting 6061 Aluminum" SAE International, 2010-01-0218.
10. Rahman M., Seah W., Teo T., " The machinability of Inconel 718", Journal of Materials Processing Technology 63, (1997), pp. 199–204.