IJRAME

ISSN (ONLINE): 2321-3051

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

EFFECT OF MACHINING PARAMETERS ON TITANIUM ALLOY WET AND DRY MACHIN ING

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ABSTRACT

This paper deals with the optimization of machining parameters in turning of Titanium alloy grade 2 using Ti-Al-N (PVD) coated on cemented carbide tools. During the experiment, process parameters such as speed, feed, depth of cut and nose radius are used to explore their effect on the surface roughness (R_a) of the work piece. The experiments have been conducted using full factorial design in the Design of Experiments (DOE) on CNC machine. Further, the analysis of variance (ANOVA) was used to analysis the influence of process parameters and their interaction during machining. From the analysis, it is observed that the feed is the most significant factor that influences the surface roughness followed by nose radius. An attempt has been made to generate to prediction models for surface roughness. The predicted values are confirmed by using validation experiments.

Keywords: Optimization; Titanium alloy grade 2; Machining; Turning; Surface Roughness; Ti-Al-N (PVD) coating.

1. INTRODUCTION

Surface roughness has become the most significant technical requirement and it is an index of product quality (1). In order to improve the tribological properties, fatigue strength, corrosion resistance and aesthetic appeal of the product, a reasonably good surface finish is desired. Now a days, manufacturing industries specially concerned to dimensional accuracy and surface finish. In order to obtain optimal cutting parameters(2), manufacturing to obtain optimal cutting parameters, manufacturing industries have depended on the use of handbook based information which leads to decrease in productivity due to sub-optimal use of machining capability this causes high manufacturing cost and low product quality(3).

Hence, there is need for a systematic methodological approach by using experimental methods and statistical/mathematical models. The design of experiments (DOE) is an efficient procedure for the purpose of planning experiments. Further the data can be analyzed to obtain valid and objective conclusions.

Several experimental investigations have been carried out over the years in order to study the effect of cutting parameters, tool geometries on the work pieces surface integrity using several work pieces. Tool

Vol.2 Issue.3, March 2014. Pgs: 217-223

geometry plays an important role in machining. It is mentioned that the nose radius will affect the performance of the machining process. Nose radius is a major factor that affects the surface finish of work piece. It is proved that high values of nose radius causes rough surface with high value of run out(6). But very few researchers have studied the interaction effect of nose radius.

A high work hardening rate, low thermal conductivity and resistance to corrosion. It was reported that austenitic Titanium alloys come under the category of difficult to machine materials. Little work has been reported on the determination of optimum machining parameters when machining Titanium alloys. investigated surface roughness variations of different grades of Titanium alloy under different cutting conditions in high speed fine turning. developed a mathematical model for process parameters on hard turning of Titanium alloy grade 2. Surface roughness and tool wear was predicted by Regression analysis and ANOVA theory.

Optimize surface roughness using Taguchi Dynamic Experiments concept (5)., conducted experiments to evaluate the performance of Titanium alloy machining by using Taguchi method. Results revealed that tools shape and feed are significant factors. Empirical models for tool life, surface roughness and cutting force are developed for turning. Multiple regression analysis techniques, Response surface methodology and computational neural networks were used to predict models of process functions.

Titanium alloy grade 2 finds it application in general industrial and process-industry machinery and equipment, electrical machinery/equipment, automotive industry, Structural, bus body etc., But, it is found that no work has been reported in the literature on optimization of process parameters in turning Titanium alloy grade 2. In the present investigation, full factorial experiment has been employed to determine the best combination of the machining parameters such as cutting speed, feed, depth of cut and nose radius to attain the minimum surface roughness and the predictive models obtained for surface roughness. The predicted and measured values are fairly close to each other.

2. TURNING PROCESS PARAMETERS

- Cutting environment (wet/dry)(A)
- Cutting speed(B)
- Feed(C)
- Depth of cut(D)
- Nose radius(E)

3. MATERIALS AND METHODS

3.1 Work piece material

The work piece material selected for the study was Titanium alloy grade 2. It has high strength, high quality surface finish, advanced corrosion resistances and excellent biocompatibility. The size of the work piece was 25mm diameter and 70 mm length. 1 mm thickness of work piece material at the top surface of work piece was removed in order to eliminate any surface defects and residuals stress that can adversely affect the machining result (8). The chemical compositions and mechanical properties of work piece materials are given in Table-1.

Table-1: Chemical composition (wt %) of Titanium alloy grade 2

N	**C**	**H**	**Fe**	**O**	**Ti**
0.03	0.08	0.015	0.3	0.25	Balance

Table-2: Mechanical properties of Titanium alloy grade 2

Tensile(MPa)	Yield(MPa)	4D% Elong ED	RA %
345	275	20	30

3.2 Cutting inserts and cutting conditions

Coated carbide tools have shown better performance when compared to the uncoated carbide tools. For this reason, commonly available Physical Vapour Deposition (PVD) Ti-Al-N coated cemented carbide inserts of 1.2, 0.8 and 0.4mm as nose radius are used in the present experimental investigation. The Process parameters and levels used in the experiment Tables-3.

Table-3: Process parameters and their levels

Factors	Parameters	Units	Level 1	Level 2	Level 3
A	Cutting Environment		Wet	Dry	-
B	Cutting speed	m/min	55	75	95
C	Cutting feed	mm/rev	0.15	0.25	0.35
D	Depth of cut	Mm	0.10	0.15	0.20
E	Nose radius	Mm	0.4	0.8	1.2

3.3 Experimental design

In the present work, using DOE technique.The experiments are designed as shown in Table-4.

Table-4: L18 orthogonal array for present work

Trial no.	A (CE)	B (V)	C (F)	D (DOC)	E (NR)
1	Wet	55	0.15	0.20	1.2
2	Wet	55	0.25	0.10	0.4
3	Wet	55	0.35	0.15	0.8
4	Wet	75	0.15	0.15	1.2
5	Wet	75	0.25	0.20	0.4
6	Wet	75	0.35	0.10	0.8

7	Wet	95	0.15	0.20	0.8
8	Wet	95	0.25	0.10	1.2
9	Wet	95	0.35	0.15	0.4
10	Dry	55	0.15	0.20	1.2
11	Dry	55	0.25	0.15	0.4
12	Dry	55	0.35	0.10	0.8
13	Dry	75	0.15	0.15	1.2
14	Dry	75	0.25	0.20	0.4
15	Dry	75	0.35	0.10	0.8
16	Dry	95	0.15	0.20	0.8
17	Dry	95	0.25	0.10	1.2
18	Dry	95	0.35	0.15	0.4

3.4 Experimental results

Machining was carried out on CNC machine under wet and dry conditions .The machining process on CNC is programmed by speed, feed and depth of cut. Surface roughness measurement is carried out by using a Surf coder SE1700. Fig.2 Shows the surface roughness characteristics of the machining

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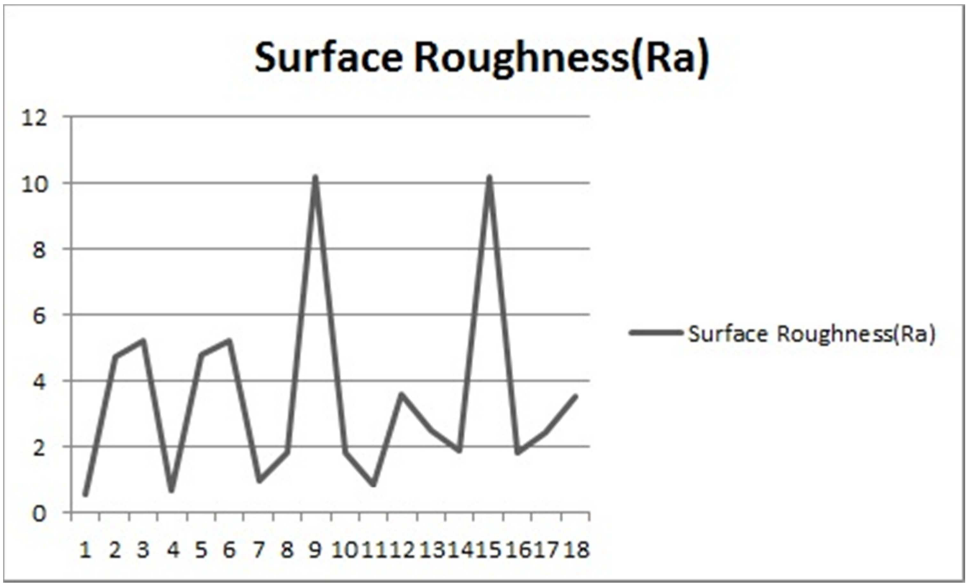

Fig.1 Surface Roughness(µm)

Vol.2 Issue.3, March 2014. Pgs: 217-223

4. Result analysis.

Using the minitab software the experiment results are analysed to find the effect of machining parameters. The details of analysis are given in the table.6

Table-5: ANOVA for Surface Roughness

Source	DF	SS	MS	F	P	% contribution
CE	1	1.71	1.71	0.20	0.663	1.213
V	2	5.98	2.99	0.33	0.723	4.241
F	2	77.21	38.60	9.08	0.003	54.754
DOC	2	4.35	2.17	0.24	0.791	3.085
NR	2	17.33	8.67	1.05	0.374	12.289
Error	8	34.49	4.3113			24.459
Total	17	141.01				

Table -6: Response table for surface roughness

LEVEL	CE	V	F	DOC	NR
1	3.78667	2.78000	1.39167	4.13667	2.14833
2	3.17000	4.19167	2.74167	3.34167	3.80000
3		3.46333	6.30167	2.95667	4.48667
Delta	0.61667	1.41167	4.91000	1.18000	2.33833
Rank	5	3	1	4	2

The ranks indicate the relative importance of each factor to the response. The ranks and the delta values for the various parameters show that nose radius has the greatest effect on surface roughness and is followed by feed, cutting speed, depth of cut and coolant condition in that order. As surface roughness is the lower the better type quality characteristic, from table 4.5, it can be seen that the first level of coolant condition (A1), third level of cutting speed (B3), first level of feed (C1), second level of depth of cut(D2) and third level of nose radius (E3) result in minimum value of surface roughness.

Minitab Results in Graphs

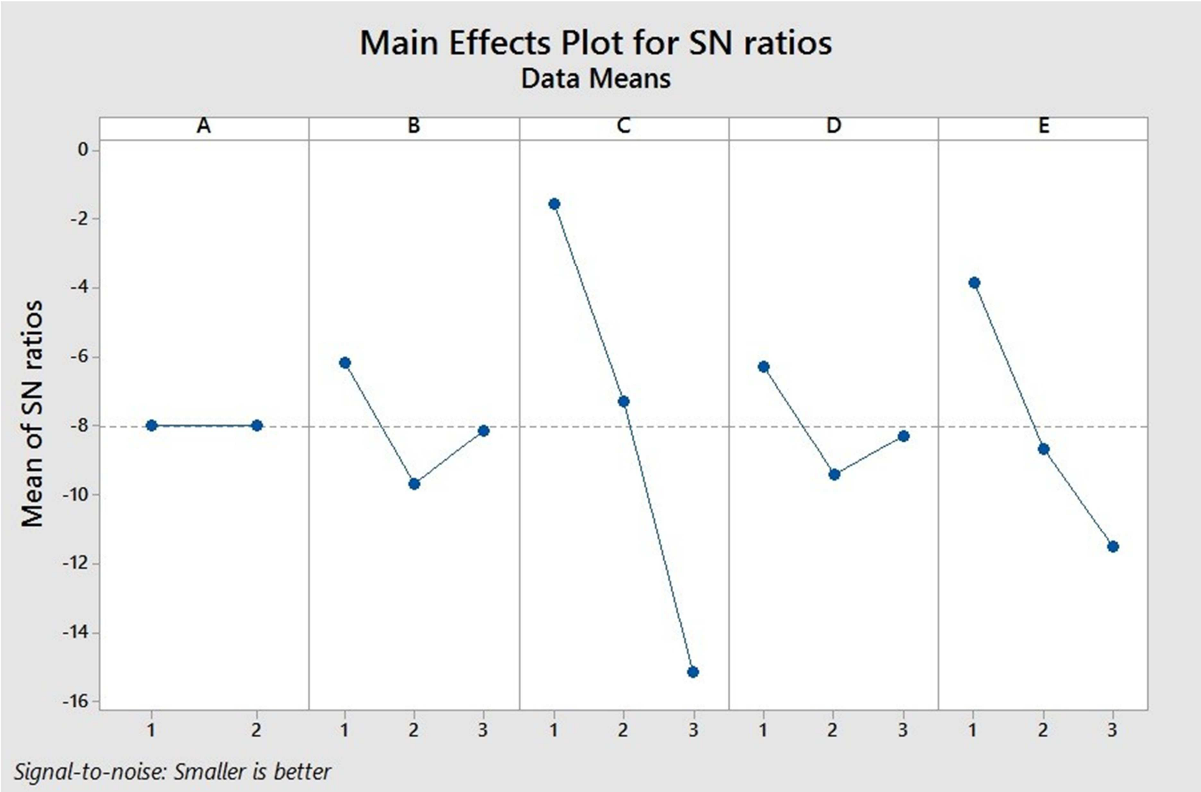

Fig.2 S/N ratio

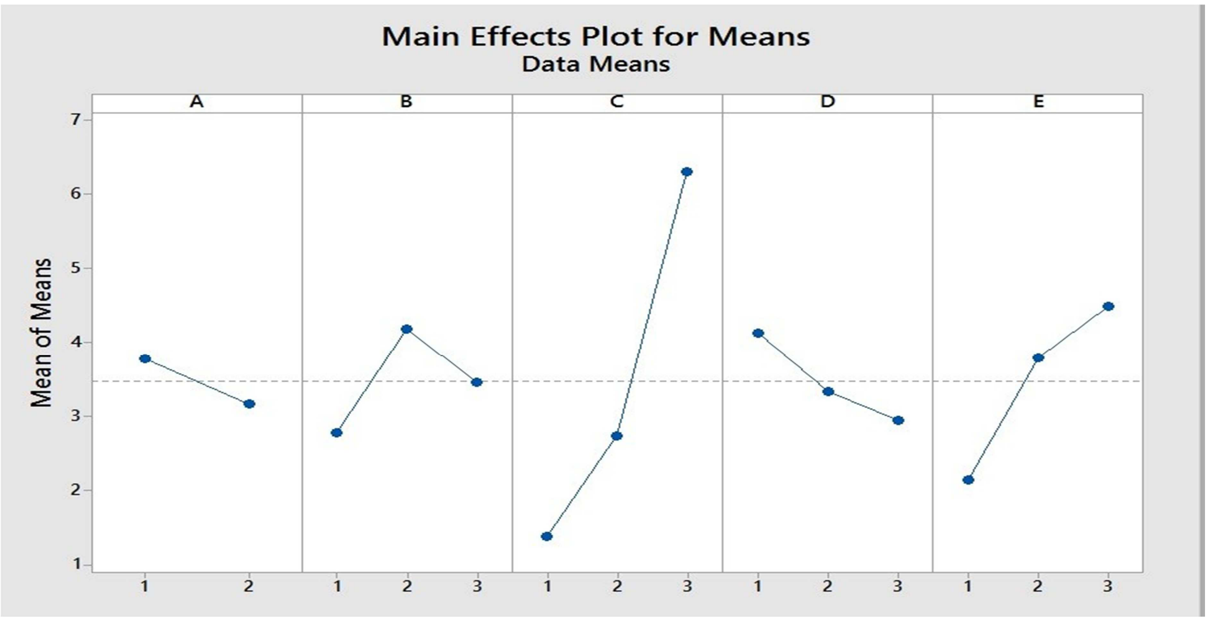

Fig.3

5. CONCLUSION

Vol.2 Issue.3, March 2014. Pgs: 217-223

Based on the results obtained, the following conclusions can be drawn

1.Analysis of variance suggest the feed rate is most significant factor for surface roughness

2. ANOVA (S/N data) results shows that Feed rate, Nose radius, Cutting speed, Depth of cut and Cutting environment affects the surface roughness by54.754%,12.289%, 4.241%, 3.085%,1.213% respectively.

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