

Machined Surface Topography Investigation in Turning of Titanium Alloy (Ti-6AL-4V) Using Steam as a Coolant

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ABSTRACT

In today's highly competitive world where most businesses focus on cost and quality, organizations with efficient and effective machining are able to stand out with inherent competitive advantages. The attainment of high quality, in terms of dimensional accuracy, surface finish, high production rate and cost saving, with a reduced environmental effect is mostly concentrated by modern machining industries. Such goals are strongly affected by numerous fundamentals among unique of them is the cooling lubricants. The machinability with coolant in turning operation with flood coolant, MQL and cryogenic cooling and it is perceived that surface finish, cutting forces, chip formation and tool wear are all affected with the type of coolant, cutting speed, depth of cut and feed rate have examined by plenty of authors. The steam as a coolant has been selected to discover the machinability of titanium alloy with the introduction of environmental friendly coolant because very little analysis in steam as coolant is present in the literature.

Key words: Flood coolant, Cryogenic cooling, Environmental friendly coolant and Topography.

INTRODUCTION

Surface topography is the representation of geometric as well as functional features of the surfaces produced. Due to machining or metal working process assessment of surface topography comprises measurement of surface roughness which gives idea about the smoothness of the surface and the examination of the surface alterations. Surface alterations are fundamentally damage or flaws which are produced when the machining conditions abusive, which grounds severe thermo-mechanical deformation of the layer underneath the mechanical surface. In this chapter, surface topography is assessed wherein surface roughness is statistically analyzed and surface damages are examined using scanning electron microscopy. The analysis of the experimental data to determine the result of

cutting velocity with feed rate on surface topography exists elucidated in this paper.

Analysis of surface roughness

On the basis of experiments the machined surface roughness is measured by the surface roughness tester for each sample at six positions on the circumference. The average of those six values was considered for the analysis. And statistical analysis of the surface roughness parameters with respect to cutting speed and feed rate remains discussed using main effect plots and analysis of variance. Table 1 shows the Ra values of the nine machined samples with the particular conditions.

It can be observed from the normal probability plot of residuals (Figure 1) that, the

Table 1: Surface roughness values at different machining conditions in machining of Ti-6Al-4V alloy

Expt. No.	Machining condition Cutting speed (m/min)	Feedrate (mm/rev)	Surface roughness Ra (μm)
1	60	0.08	0.267
2	60	0.16	0.990
3	60	0.32	2.430
4	120	0.08	0.470
5	120	0.16	0.090
6	120	0.32	2.448
7	180	0.08	0.428
8	180	0.16	1.135
9	180	0.32	1.998

residuals are normally distributed except first and last observations all other points are lying very close to the line.

Effect of Cutting Speed on Surface Roughness

The cutting speed effect on the surface roughness is examined statistically using main effect plots (see Figure 2). It is perceived from Figure 2 that surface roughness values at different cutting speeds is slightly changes. But there is a significant change in surface roughness at different feed rates. It is observed that the machined surface produced at 60 m/min cutting speed has higher values of surface roughness according to main effects plot. Though further escalation in the cutting speed to 120 m/min to 180 m/min causes little surface roughness decreases. This tendency leads to thermal softening and consequent reshuffle of the machined surface layer due to the increase in

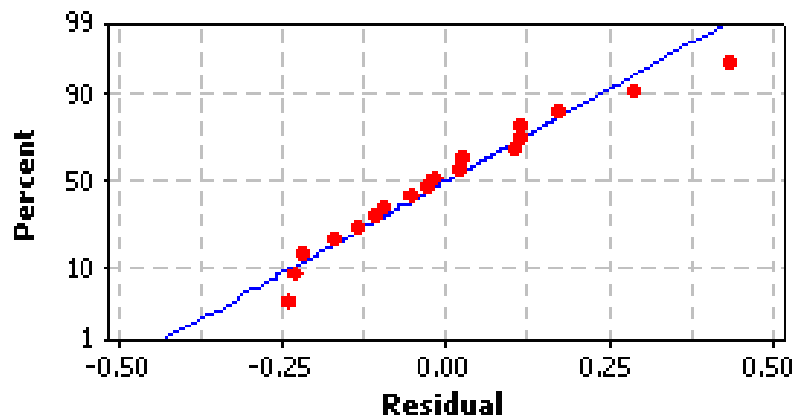


Fig. 1: Normal probability plot of residuals

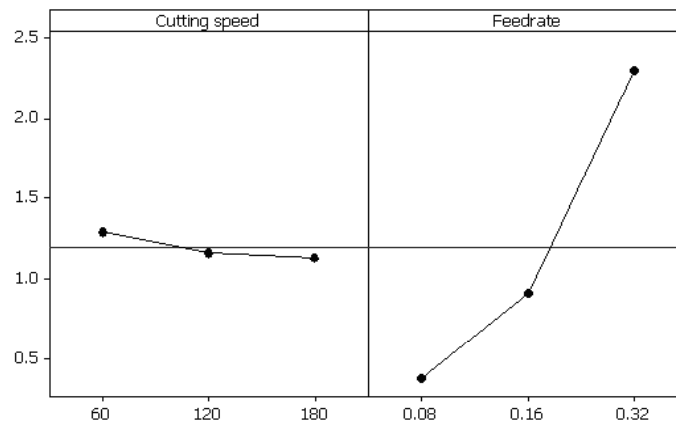


Fig. 2: Main effects subversions for surface roughness

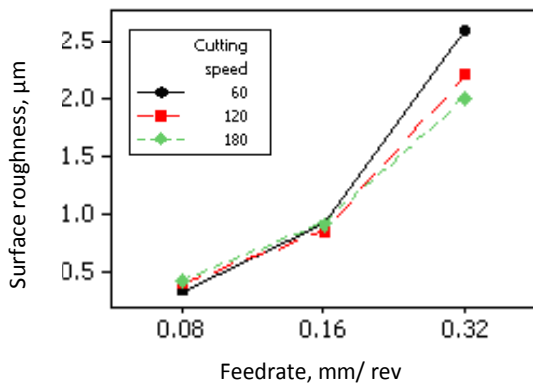


Fig. 3: Interaction plots for surface roughness

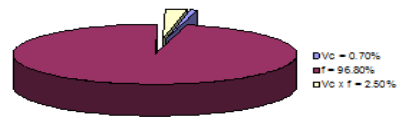
the machining temperature. Therefore the machined surface shows lower roughness causes due to less changes on the surface. At 0.08 mm/rev feed rate, surface roughness is very less and it rises with an increase in the feedrate. The surfaces show more alterations due to higher cross sectional area that involves in deformation and hence higher surface roughness is due to higher deformation of the machined surface layer.

Interaction between Feedrate and Cutting Speed

It has been seen from the interactions plot that by changing the cutting speeds at lower feed rate

Table 2: ANOVA for Surface roughness

Source	D.F.	S.O. S.	M.S	F-ratio	P-value	Percentage contribution of factors
V_c	2	0.0908	0.0453	1.48	0.278	
F	2	11.7659	5.8740	192.6	0.000	
$V_c \times f$	4	0.2984	0.0744	2.34	0.123	
Error	9	0.2734	0.0304			
Total	19	12.4571				
$R^2 = 97.78\%$						



of 0.08mm/rev, the change in surface roughness is almost negligible. But at higher feed rate 0.32mm/rev, there is a moderate change in the surface roughness when the cutting speed rises from 60 to 180 m/min. again similar decrease in the surface roughness is found.

Surface Roughness ANOVA (Analysis of Variance)

It is seen from the ANOVA in Table 2 that the feedrate has significance at 95% confidence level.

CONCLUSIONS

In this research work the major conclusions have been arrived based on the analysis of surface topography. Based on the measurement of the surface roughness and SEM examination the following conclusions are drawn.

1. It is perceived that the machined surface generated higher values of surface roughness at 60 m/min. Though auxiliary increase in

the cutting speed up to 120 m/min to again at 180 m/min causes slight decrease in the surface roughness. This tendency influence due to the rise in the machining temperature, which causes thermal softening and resulting reshuffle of the machined surface layer. Therefore the machined surface indorses lower roughness is due to less errors on the sample surface.

2. A variety of alterations/defects are formed in machining of Ti-6Al-4V. It is detected that the cutting speed and feedrate are the prominent limits, which influences the occurrence and magnitude of these defects on machined surfaces of Ti-6Al-4V.
3. The outcome of feedrate on surface roughness shows that surface roughness is very fewer and it increasing with an increase in the feedrate at 0.08 mm/rev. It is due to higher cross sectional area that involves in deformation and thus surfaces appearance having more variations.

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