EFFECT OF CHIP MORPHOLOGY ON MACHINING TITANIUM (TI-6AL-4V) ALLOY WITH UNCOATED CARBIDE INSERTS USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT: *Machining of titanium (ti-4v-4v) alloy is always a difficult task to manufactures of titanium products in the automobile, aerospace and bio medical industries, due to its chemical and physical properties machining of titanium alloys with various machining techniques to achieve good surface finish and tool life, good chip formation are important, because based on type of chips we can describe surface finish and tool life. The impact of chip morphology is important to understand and to evaluate the tool life and surface roughness. In this examination different cutting parameters are utilized like speed ,feed , depth of cut , including flood cooling to evaluate the chip morphology while machining titanium (ti-6al-4v)alloy with uncoated carbide inserts. The results show that machining parameters effects the chip morphology, different machining parameters delivered different type of chips but based on past literature review continues chips are good for machining. It will improve surface finish and tool life . High speed ,low feed, low depth of cut provides continuous chips . In order to achieve good surface finishing high speed ,low feed, good tool life with high speed with low depth of cut is required .*

INTRODUCTION

Titanium alloys are utilized in different applications for making different components in automobile, medical equipment, turbine blades . There are three different titanium alloys α ,β,α+β alloys based on the applications Manufactures are selecting various titanium alloys, but titanium (ti-6al-4v) alloys is used in most of the applications because of its properties , when compared to steel it is 60% less dense ,high strength ,hardness 35-38HRC . It comes under α+β alloys and grade 5. Machining of titanium alloys is a tough task to manufactures because of high thermal resistance, low modulus of elasticity, it comes under difficult to cut materials category. To machine titanium alloys there are different machining process, lot of machining techniques with cooling conditions are available in the industries. But still production of titanium components not reaching required level in markets, so still there is a scope of introducing new methodology to improve machining of titanium alloys to get good surface finish and tool life, will leads to reduce the cost of production while machining titanium alloys.

Sl.no	Cutting parameters	Level 1	Level 2	Level 3
1	Cutting speed (m/min)	100	150	200
2	Feed (mm/rev)	0.1	0.15	0.2
3	Depth of cut (mm)	0.4	0.6	0.8

Table 1: process parameters

EXPERIMENTAL PLAN:

Std	run	Speed(m/min)	Feed(mm/rev)	Depth of cut(mm)	Surface roughness(μ)	Cutting force(N)
8	1	200	0.15	0.8	0.81	172
15	2	150	0.15	0.6	0.76	132
5	3	100	0.15	0.4	0.6	82
10	4	150	0.2	0.4	0.83	168
9	5	150	0.1	0.4	0.65	97
17	6	150	0.15	0.6	0.74	128
4	7	200	0.2	0.6	0.85	179
2	8	200	0.1	0.6	0.53	122
14	9	150	0.15	0.6	0.72	129
6	10	200	0.15	0.4	0.79	152
16	11	150	0.15	0.6	0.75	122
12	12	150	0.2	0.8	0.87	159
1	13	100	0.1	0.6	0.49	76
3	14	100	0.2	0.6	0.61	98
11	15	150	0.1	0.8	0.67	92
13	16	150	0.15	0.6	0.75	129
7	17	100	0.15	0.8	0.55	103

Table 2: design layout

ANOVA for surface roughness:

ANOVA for Response Surface Quadratic model						
Source	**Sum of Squares**	**df**	**Mean Square**	**F Value**	**p-value Prob > F**	
Model	0.078	9	8.634E-003	24.82	0.0002	significant
A-speed	*6.801E-003*	*1*	*6.801E-003*	*19.55*	*0.0031*	
B-feed	*5.706E-004*	*1*	*5.706E-004*	*1.64*	*0.2411*	
C-depth of cut	*2.542E-003*	*1*	*2.542E-003*	*7.31*	*0.0305*	
AB	*3.188E-003*	*1*	*3.188E-003*	*9.16*	*0.0192*	
AC	*4.875E-004*	*1*	*4.875E-004*	*1.40*	*0.2751*	
BC	*2.202E-005*	*1*	*2.202E-005*	*0.063*	*0.8086*	
A^2	*0.015*	*1*	*0.015*	*44.05*	*0.0003*	
B^2	*1.592E-003*	*1*	*1.592E-003*	*4.58*	*0.0697*	
C^2	*2.438E-003*	*1*	*2.438E-003*	*7.01*	*0.0331*	
Residual	2.435E-003	7	3.479E-004			
Lack of Fit	*2.124E-003*	*3*	*7.079E-004*	*9.10*	*0.0293*	*significant*
Pure Error	*3.113E-004*	*4*	*7.783E-005*			
Cor Total	0.080	16				

Table 3: ANNOVA for surface roughness

The Model F- value of 24.82 suggests the model is siginificant. There is only a 0.02% chance that an F-value this large could occur because of noise. Values of "Prob > F" under 0.0500 demonstrate model terms are significant. In this case A, C, AB, A^2, C^2 are significant model terms. Values more prominent than 0.1000 show the model terms are not significant. If there are many insignificant model terms (not including those required to help hierarchy), model reduction may improve your model. The "Lack of Fit F-value" of 9.10 infers the Lack of Fit is significant. There is just a 2.93% chance that an "Lack of Fit F-value" this large could happen because of noise.

Std. Dev.	0.019		R-Squared	0.9696
Mean	0.84		Adj R-Squared	0.9305
C.V. %	2.23		Pred R-Squared	0.5699
PRESS	0.034		Adeq Precision	16.688
-2 Log Likelihood	-102.22		BIC	-73.89
			AICc	-45.56

The "Pred R-Squared" of 0.5699 isn't as close to the "Adj R-Squared" of 0.9305 as one might normally expect; i.e. the difference is more than 0.2. This may demonstrate a large block effector a possible problem with your model and/or data. Things to consider are model reduction, response transformation, outliers, and so forth. All emperical models should be tested by doing confirmation runs. "Adeq Precision" measures the signal to noise proportion. A proportion more significant than 4 is desirable. Your ratio of 16.688 demonstrates an adequate signal.
Final equation in terms of actual factors:

$$\sqrt{Ra}=0.38030+0.005986speed+1.73406feed0.91508doc+0.011292speed*feed+0.001103speed*doc+0.23463feed*doc-0.000241speed^2-7.7781feed^2+0.60161doc^2$$

ANOVA for cutting force:

ANOVA for Response Surface Linear model						
Source	**Sum of Squares**	**df**	**Mean Square**	**F Value**	**p-value Prob > F**	
Model	29.97	3	9.99	44.87	< 0.0001	significant
A-speed	*18.14*	*1*	*18.14*	*81.48*	*< 0.0001*	
B-feed	*11.63*	*1*	*11.63*	*52.24*	*< 0.0001*	
C-depth of cut	*0.20*	*1*	*0.20*	*0.91*	*0.3585*	
Residual	2.89	13	0.22			
Lack of Fit	*2.79*	*9*	*0.31*	*11.62*	*0.0154*	*significant*
Pure Error	*0.11*	*4*	*0.027*			
Cor Total	32.87	16				

Table 4: ANNOVA for surface roughness

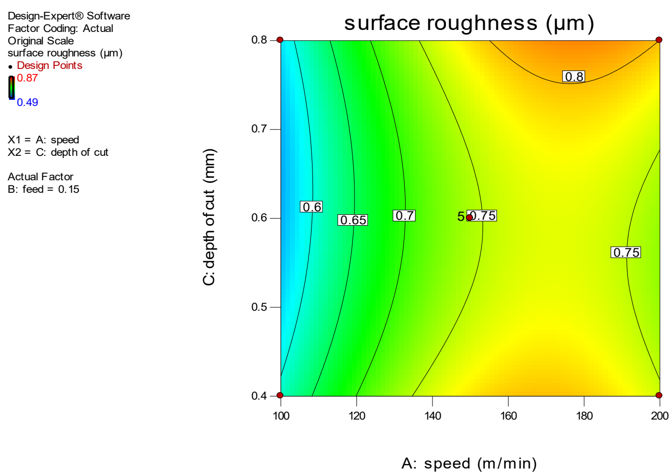
The Model F-value of 44.87 infers the model is significant. There is only a 0.01% possibility that a F-value this large could happen because of noise. Values of "Prob > F" under 0.0500 show model terms are significant. In this case A, B are significant model terms. Values more prominent than 0.1000 demonstrate the model terms are not significant. If there are many insignificant model terms (not including those required to help hierarchy), model reduction may improve your model. The "Lack of Fit F-value" of 11.62 infers the Lack of Fit is significant. There is just a 1.54% chance that an "Lack of Fit F-value" this large could happen because of noise.

Std. Dev.	0.47		R-Squared	0.9119
Mean	11.13		Adj R-Squared	0.8916
C.V. %	4.24		Pred R-Squared	0.8235
PRESS	5.80		Adeq Precision	23.694
-2 Log Likelihood	18.15		BIC	29.48
			AICc	29.48

The "Pred R-Squared" of 0.8235 is in reasonable agreement with the "Adj R-Squared" of 0.8916;i.e. the difference is under 0.2. "Adeq Precision" measures the signal to noise proportion. A proportion more prominent than 4 is desirable. Your ratio of 23.694 shows a adequate signal. This model can be utilized to navigate the design space.

Final equation in terms of actual factor:

$\sqrt{Fc}=2.522+0.030116speed+24.11476feed+0.79400doc$



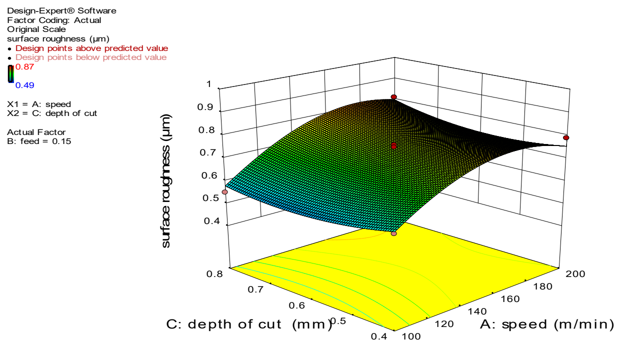
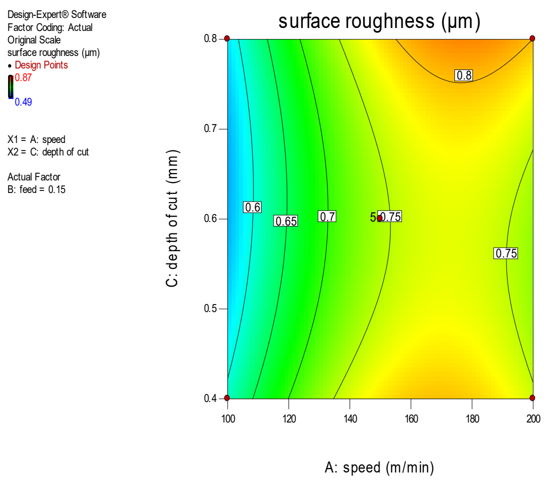


Fig 1:3 Dsurface graphs for Ra&Fc data



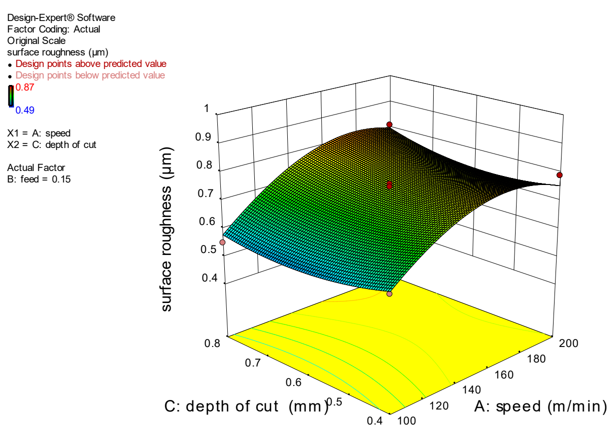
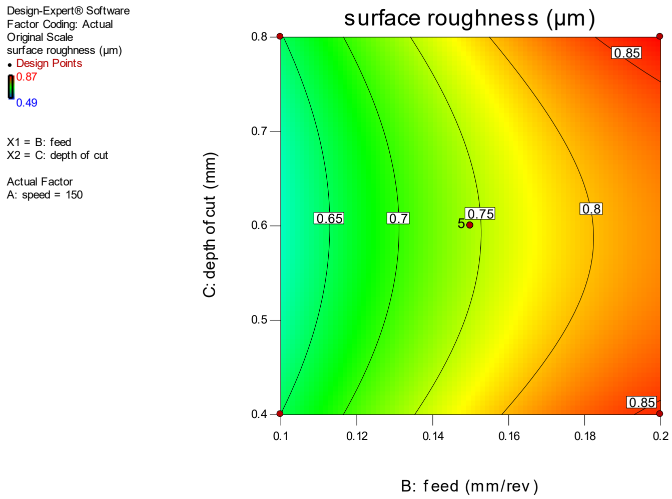


Fig2:3 Dsurface graphs for Ra&Fc data



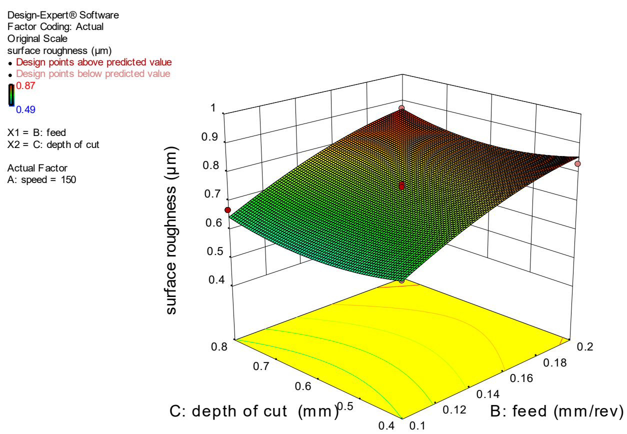
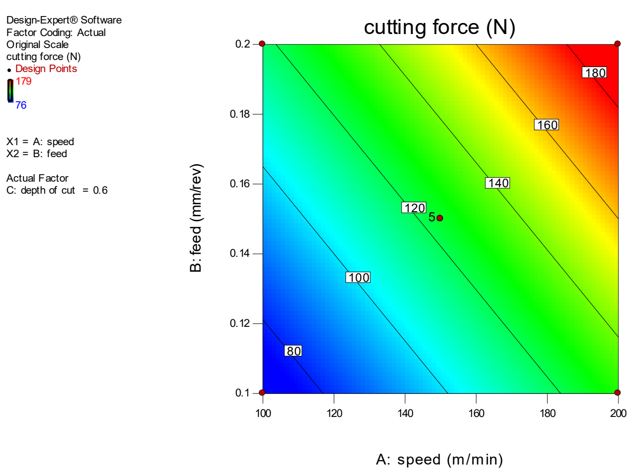


Fig 3:3 Dsurface graphs for Ra&Fc data



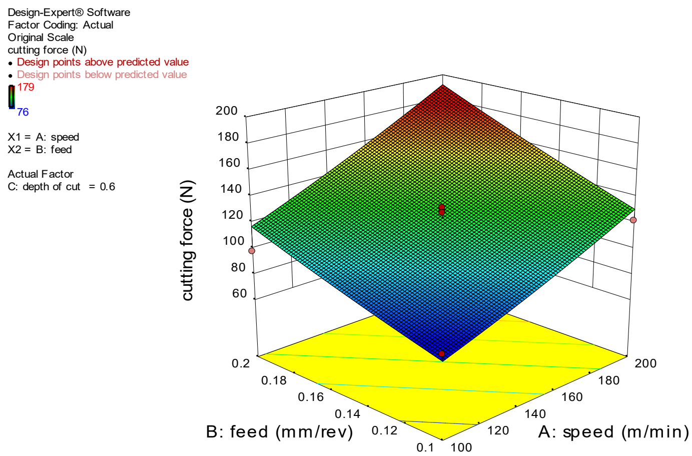
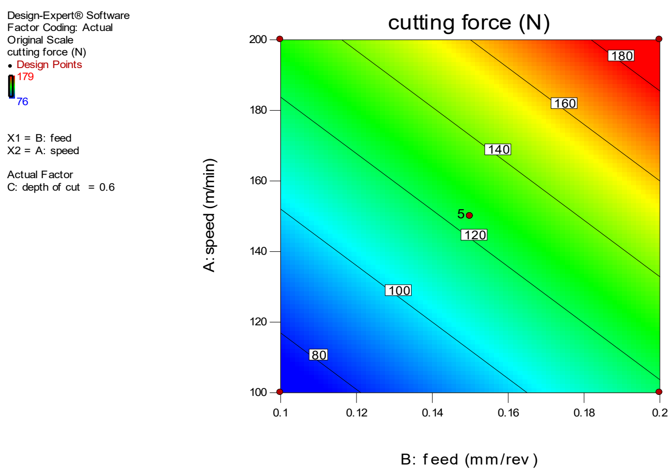


Fig 4:3 Dsurface graphs for Ra&Fc data



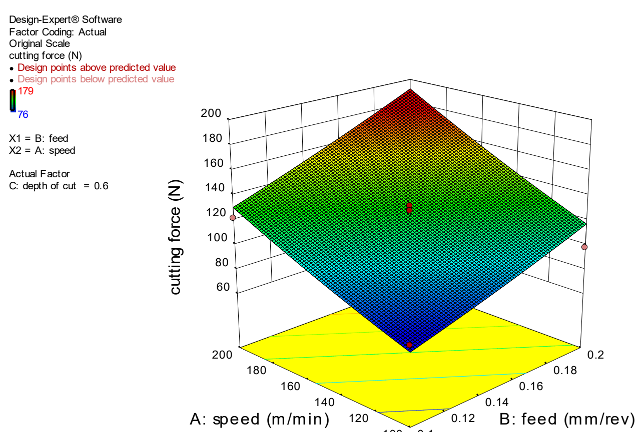


Fig 5:3 Dsurface graphs for Ra&Fc data

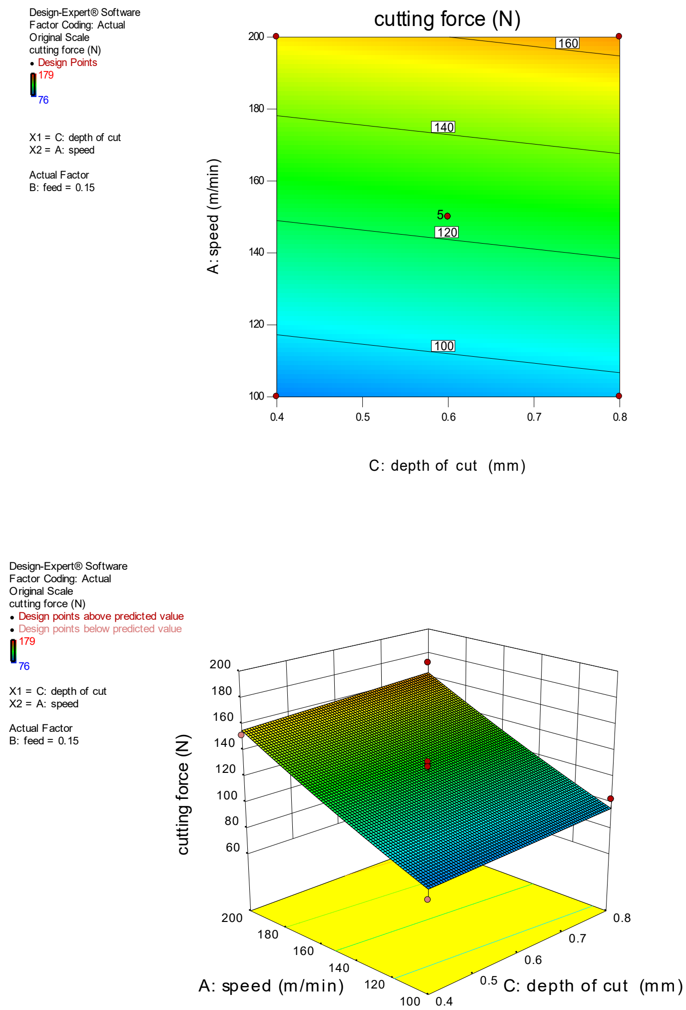


Fig 6:3 Dsurface graphs for Ra&Fc data

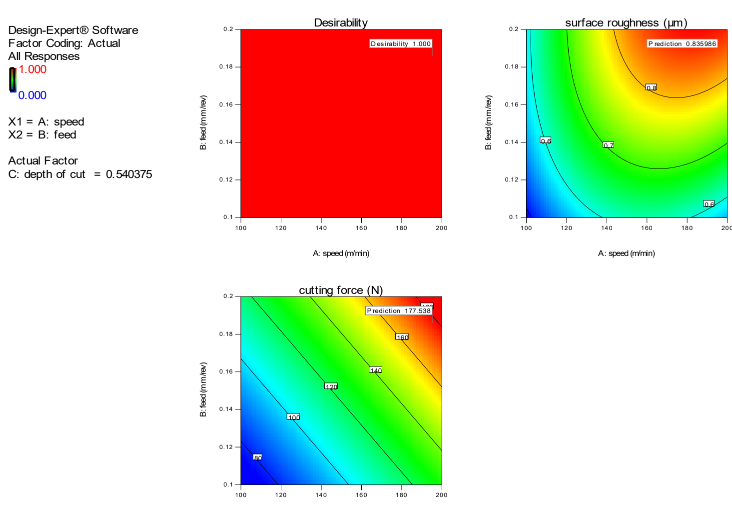


Fig 7:3 Dsurface graphs for Ra&Fc data

Fig 8: chips at speed 200m/min

Fig 9: chips at speed of 150 m/min

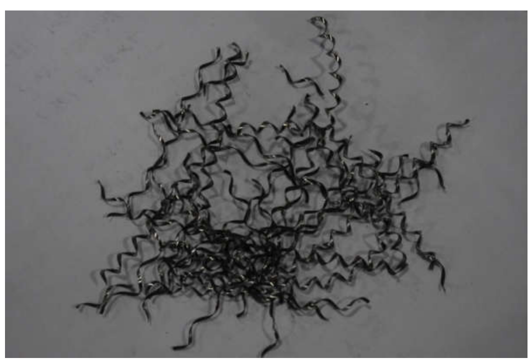


Fig 10: chips at speed of 100m/min

CONCLUSIONS

In this investigation tests are done on CNC lathe machine utilizing different cutting parameters and the results of the experiments are to anticipate surface roughness (Ra) and chip morphology. The following conclusions are extracted from this investigation:

The surface roughness (Ra) could be effectively predicted by utilizing depth of cut, cutting speed, and feed rate as the inputs variables. Increasing feed rate will cause increase in surface roughness for various cutting speeds and different depth of cuts. Increasing cutting speed will cause decreasing in surface roughness for various feed rates and different depth of cuts. Increasing depth of cut from for small and medium feed rate (0.2 and 0.4 mm/rev) will decrease surface roughness for various speeds. However, increasing depth of cut will cause increase in surface roughness. it is demonstrated that increasing depth of cut at high feed rate will not have remarkable effect on surface roughness and this may be on the grounds that that the feed rate turns into the dominant factor affecting the surface roughness.

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