Analysis for Reduction of Tool Wear Rate of CNC Turning for B_4C Tool

Animesh Sarkar[1], Anil Kumar Panja[2],Apurba Biswas[1], Nayan Saha[1],Shishir Kumar Biswas[3], Ramprosad Dey[1], SK.Hikmat[1], Bidyut Karmakar[1], Rakesh Biswas[1], Papai Bairagya[1] ,B.Mallick[1*]

[1]ME DEPARTMENT, GLOBAL INSTITUTE OF MANAGEMENT & TECHNOLOGY, KRISHNANAGAR,W.B. INDIA

[2]ME DEPARTMENT, BRAINWARE UNIVERESITY, BARASAT, W.B. INDIA

[3]ME DEPARTMENT, JIS COLLEGE OF ENGINEERING, KALYANI, W.B. INDIA

***corresponding author**

Abstract-

CNC is now a day's plays a vital role in industry. This papers deals with the parametric effects such as spindle speed (1500-2100 rpm) (N) (X1), depth of cut (DOC) (.15-.55 mm) (X2) and feed rate (f) (30-50 mm/min) (X3) on machining characteristics of tool wear rate (TWR) during fabrication of IS-617 Aluminum miniature component by advanced CNC lathe using Boron-carbide tool. The article analyzes the second-order mathematical model development with co-relation of co-efficient of regression and analysis of variances (ANOVA) using desirability function analysis (RSM) during the production of the miniature segment. The article also consists of single objective optimization for achieving the optimal parametric combination for minimum tool wear rate for this manufacturing operation. The project also shows the fabricated micro-product of Aluminum at the optimal parametric conditions using CNC programming.

Keywords- CNC, Boron-carbide, Turning, TWR, Optimization,

1. Introduction

CNC Lathe is a highly advanced machine-tool which is involved now a day for production and fabrication of precise job with higher accuracy. Some of the researchers used various optimization processes and algorithms during straight turning by CNC Lathe. Optimization of process parameters helped for findings acceptable results during machining operations [1-2]. The surface roughness of job specimens was the key factor to maintain the product quality as well as manufacturing cost [3]. The formation of irregularity on the job depended on process parameters [4-5-6]. Upadhyay et al. [7] were used acceleration amplitude of vibration in axial, radial and tangential direction for reducing the surface irregularities. Moriwaki [8] applied the pattern recognition process to identify the states of cutting during CNC turning. Dhabale et al. [9] developed mathematical models for the rate of material removal and surface roughness. K.palani kumar et. al.[10]reported thatfeedrateistheparameterwhichhasgreatereffectonsurfaceroughness, followed by cutting speed and % volume fraction of SiC in machining of Al/SiC particulate composites using response surface methodology. Sahin and Motorcu [11] mathematical model was developed of surface roughness factor for turning of mild steel using coated carbide tools and RSM was applied .They reported that feed rate was main effecting parameter on the surface roughness. They found that with increasing feed rate surface roughness increased where it decreased with increasing depth of cut and speed.From all parameters depth of cut was significant compared with cutting speed. By Noordin et al. [12] the coated carbide tools performance has been described by response surface methodology though the turning of AISI1040 mild steel. They reported that feed rate is the most important parameter effecting the surface roughness and tangential force. By Sing and Kumar [13]the optimization of feed force has been studied though selection of process parameters that is to say feed, speed, and depth of cut in turning of EN24 steel using TiC coated tungsten carbide as a tool materials. Taguchi method was used by researcher and reported that the feed force were affected by variation of depth of cut and feed as compare to speed. The TLBO algorithm was used for CNC turning for optimization of the process parameters [14]. But most of the researchers used boron carbide tools or stainless steel tools and not applied their findings in production or fabrication of miniature components as well as in the manufacturing of products.

To date more research gap is found about CNC lathe operations, the objective of the present research has been drawn out to reach the objective of the research. Desirability function analysis has been performed to satisfied the second-order mathematical models, correlating with ANOVA test and multi-response optimization during fabrication of miniature products with high precession and less tool wear rate the findings have been applied to produce a tiny product that can enthusiasts the researcher and scientist to reach the goal.

2. Materials and Experimental set up

It is hard to select a particular job specimen and corresponding cutting tool material from a huge range of standard materials. IS-6063 aluminum was chosen as a job specimen and it is ductile and can be easily machined by CNC lathe at high spindle speed. Fig. 1, and 2 shows the CNCmachine, CNC machining set up. Surface roughness is measured by Tally-surf and tool wear rate by weighing machine of least count 10^{-3}. The Boron-carbide tool has been used as a tool for the operation.

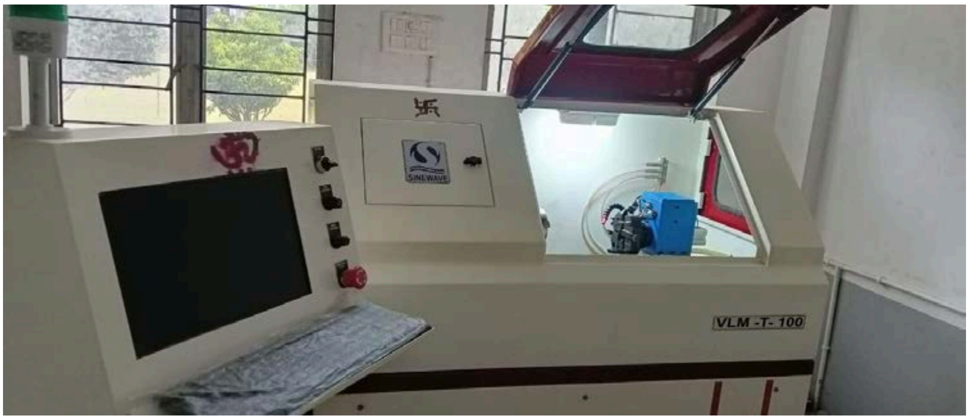

Fig.1 CNC Machine

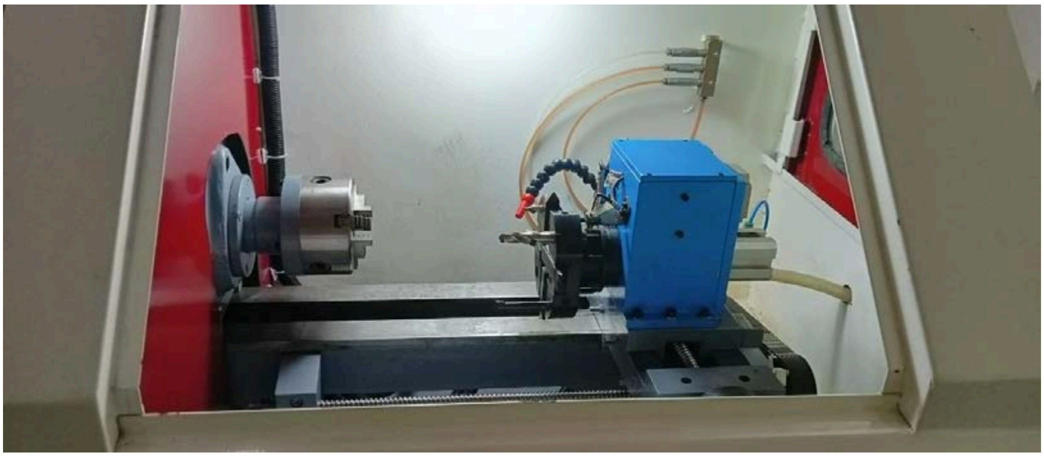

Fig.2 Experimental set up of CNC Machine

2.1 PROPERTIES OF ALUMINIUM 6063 ALLOY

The material selected for this operation is Aluminium 6063 plate which is commonly used alloy for several household appliances and industrial uses. It is the soft material and its surface roughness is comparatively higher. It is mainly used for moulding complex shapes. Some of the main applications of aluminium 6063 are roof tops, window frames etc... Comparatively Al6061 and Al6082 have higher strength than Al6063.The thermal properties of Al6063 are shown in Table 1. Its Chemical compositions are shown in Table 2.

Table-1 the thermal properties of Al6063

Thermal properties	**Composition**
Melting onset (Solidus)	620 °C (1150 °F)
Specific heat capacity	900 J/kg-k
Thermal conductivity	200w/m-k
Thermal diffusivity	82m^2/s

Table 2 Chemical compositions of Al 6063

Material properties	**Composition**
Base metal price	16% rel
Density	2.7 g/cm^3 (170lb/ft^3)
Strength to weight ratio	93kN-m/kg
Physical properties	**Composition**
Electrical conductivity	53% IACS
Calomel potential	740 mV
Electrical resistivity order of magnitude	$7\ 10^{x}$ Ω-m

3. Experimental results analysis based on RSM

Table 3 represents the process parameters and their levels as per the central composite design of experiments (DOE).

Table3-the process parameters and their levels

Variable	levels		
Spindle speed	**1500**	**1750**	**2100**
Depth of cut	**0.15**	**0.35**	**0.55**
Feed rate	**30**	**40**	**50**

3.1 Development of mathematical models and ANOVA Test

Mathematical models have been established as non-linear complex models by co-relating the machining responses with the regression coefficient and analysis of variances has been performed for verified the fitness of models as well as fitness and validation of test results. Equation 1 show the developed models for tool wear rate respectively. Table 4 represent their ANOVA table.

Table 4 Analysis of variances (ANOVA) Test for TWR

SOURCE.	DOF	SS	MS	F	P
Regression	9	0.007780	0.000864	13.87	0.000
Linear	3	0.007419	0.002473	39.67	0.000
Square	3	0.000021	0.000007	0.11	0.951
Interaction	3	0.000340	0.000113	1.82	0.207
Residual Error	10	0.000623	0.000062		
Lack – of - Fit	5	0.000181	0.000036	0.41	0.825
Pure Error	5	0.000442	0.000088		
TOTAL	19				

R^2 = 95.16%,adj R^2 = 92.58%

From the above table 4 it is clear that the R^2, as well as adjusted R^2 value for both cases, are near about 95% confidence level which validated the test results and developed non-linear models and the F, ratio test value is less than 4.06 for 5 degrees of freedom (DOF) for the lack of fit and also the P, value is also very less, so the tested results meets the models.

3.2 Parametric influences on machining characteristics

Parametric analysis for tool wear rate has been analyzed to reduce tool wear rate by response surface methodology.

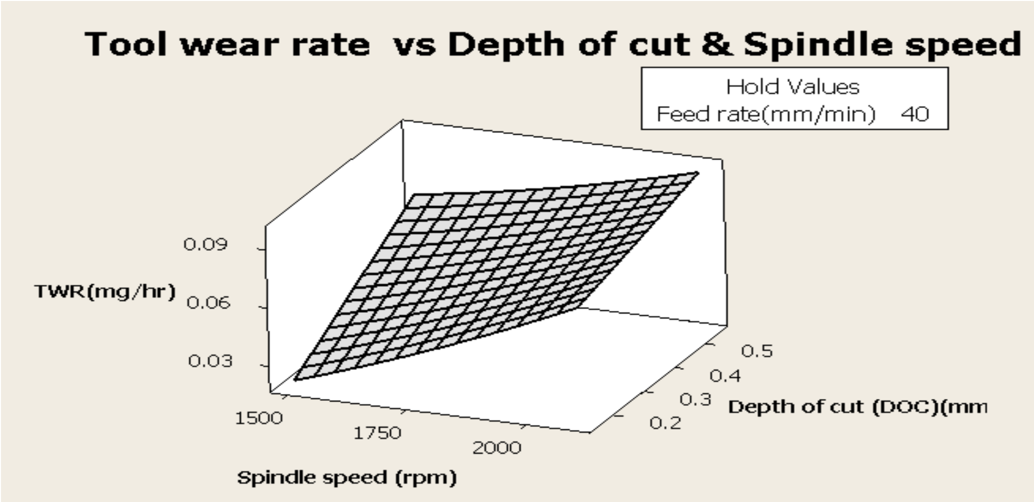

Fig.3 Effects of cutting speed and depth of cut on tool wear rate

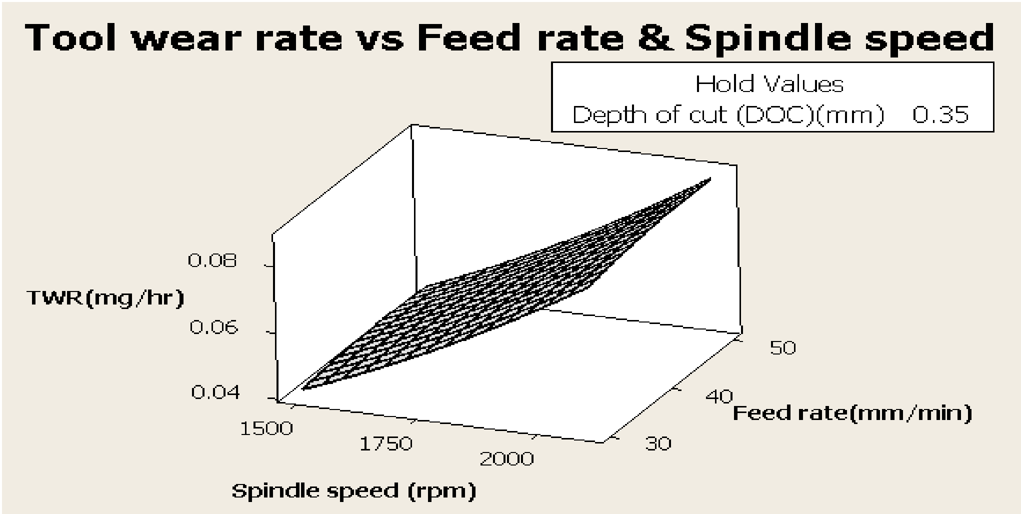

Fig.4 Effects of cutting speed and feed rate on tool wear rate

From the figure 3 and 4 it can propounded that TWR is increased if spindle speed, depth of cut as well as feed rate are increased. When spindle speed and depth of cut is increased, feed rate is kept hold at 40mm/min as per fig.3 and from fig.4 it is obviously found that if spindle speed and feed rate is increased then depth of cut is kept constant at 0.35mm, for both cases TWR is occurred due to direct contraction of tool as well as to increase the temperature at the machining zone, though cutting fluid is used. It is found that tool wear rate is very less for boron-C tool.

3.3 Optimization for minimum tool wear rate (TWR)

For finding the parametric combination for the minimum TWR, is shown in figure 5 and minimum TWR is achieved 0.0192mg/hr. at the parametric combination of 1500 rpm/0.15mm/30mmmin-1 by single objective optimization using desirability function analysis of Response Surface Methodology (RSM).But for considering both surface roughness as well as TWR, multi-responses optimization has been performed and shown in figure 6, surface roughness is achieved 1.0472 µm and TWR is found 0.0210mg/hr.At the parametric combination of 1525rpm/0.015mm/30mm min-1 and figure 7 represents the stepped turning as well as fabrication of the miniature component. Figure 7 shows the product which has been produced by CNC machine and the dimensions of that product.

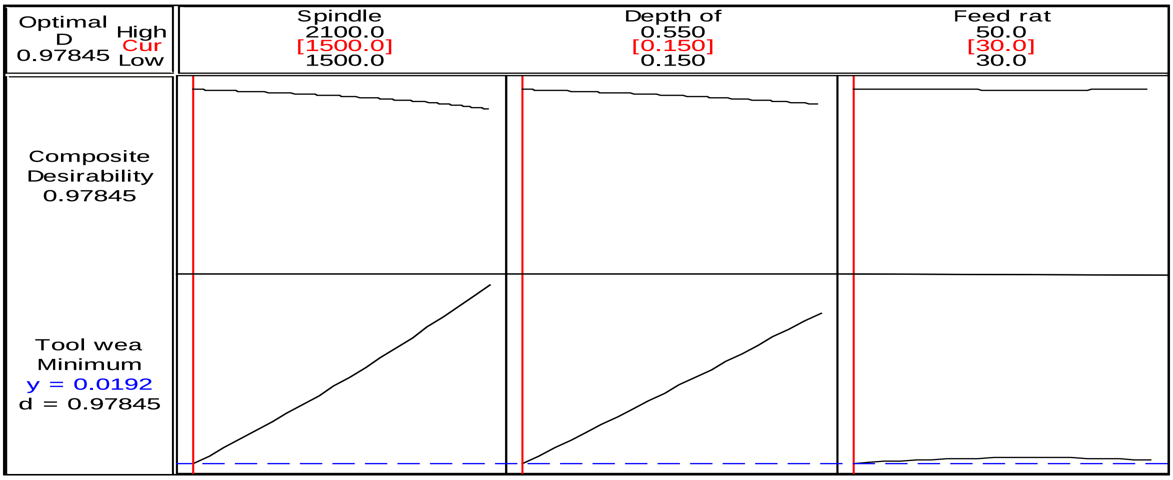

Fig.5 Single objective optimization for minimum TWR during fabrication of miniature product

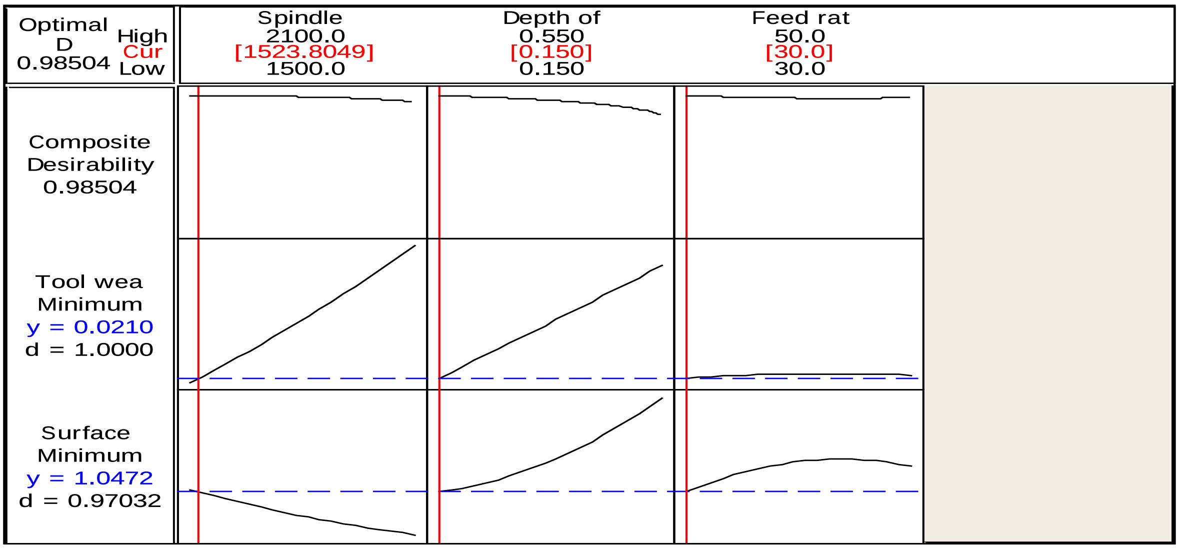

Fig.6 Multi-objective optimization for minimum surface roughness and tool wear rate during fabrication of miniature product

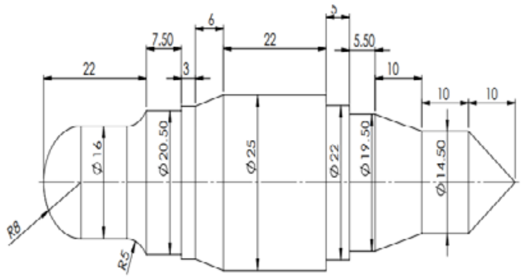

Fig.7 Fabrication of miniature product of IS-6063 Aluminum using CNC programming at optimal conditions

4. Conclusions

To reach the goal and to fulfill the objective of the present research the following conclusions can be drawn-

- TWR is increased if spindle speed, depth of cut as well as feed rate are increased.
- Developed mathematical models have been validated by the adequacy test (ANOVA).
- Minimum TWR of the Boron-Carbide tool is achieved by 0.0192mg/hr at the parametric combination of 1500 rpm/0.15mm/30mmmin^{-1} by single objective optimization using desirability function analysis.
- Multi responses optimized for surface roughness = 1.0472 µm and TWR = 0.0210mg/hr at the parametric combination of 1525rpm/0.015mm/30mm min-1.

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