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PERFORMANCE MODELING OF DIAMOND TOOL DURING TURNING OF A356/SiC/10P METAL MATRIX COMPOSITE

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ABSTRACT

This paper presents a new approach of optimizing the machining parameters during machining of particulate aluminium metal matrix composite (PAMMC). In this work, based on face centered central composite design (CCD) involving 31 runs, machining experiments were conducted for 10%AlSiCp composites using PCD tipped turning tool. The machining parameters such as cutting speed (*V*), feed rate (*f*), depth of cut (*d*) and machining time (*t*) are optimized by multi-responses of flank wear (VB_{max}) and surface roughness (Ra). The contour plots were generated to study the effect of process parameters as well as their interactions. Based on composite desirability value, the optimum levels of parameters have been identified. Thus, the application of desirability function analysis proves to be an effective tool for optimizing the machining parameters during machining of 10%AlSiCp MMC.

Key words: *Metal Matrix Composites (MMC), Response Surface Methodology (RSM), Central Composite Design (CCD), Tool Wear (VB_{max}) and Surface Roughness (Ra).*

1. Introduction

Currently research in the material science has been directed towards development of new materials possessing high temperature and wear resistance yet with light weight in order to enhance the performance in the aerospace and automotive applications. Of the developments, metal matrix composites (MMCs) are receiving considerable attention. Among the MMCs Particulate Metal-Matrix Composites (PMMCs) are of particular interest, since they exhibit higher ductility and lower anisotropy than fiber reinforced MMCs [1, 2]. While many engineering components made from PMMCs, are produced by the near net shape forming and casting processes, they frequently require machining to achieve the desired dimensions and surface finish. The machining of PMMCs presents a significant challenge, since a number of reinforcement materials are significantly harder than the commonly used high-speed steel (HSS) and carbide tools [3, 4]. Although the hard reinforcement phase provides the preferred high wear resistance, they are detrimental to cutting tools and causes rapid tool wear and therefore the widespread usage of PMMCs is significantly impeded by their poor machinability and high machining costs.

Several researchers have indicated that PCD tools are the only tool material that is capable of providing a useful tool life during the machining of SiC/Al PMMCs. PCD is harder than Al_2O_3 and SiC, and does not have a chemical tendency to react with the work piece material. Therefore in this study tipped PCD tool is used for conducting experiments. Hung et al [5] found that polycrystalline cubic boron nitride (PCBN) and polycrystalline diamond (PCD) tool are one and two orders of magnitude better than tungsten carbide tools in terms of wear resistance in machining MMC reinforced with Al_2O_3 or SiC respectively. Lin et al. [6] observed the flank wear as the primary mode of tool failure in machining Al-SiC MMC using PCD tool. El-Gallab and Sklab [7, 8] studied the dry high-speed cutting at different cutting parameters. The results indicated that PCD tools provide satisfactory tool life compared to Al_2O_3 and coated-cemented carbide. Surface roughness measurements showed that the surface roughness improves with an increase in the feed rate and cutting speed, but slightly deteriorates with an increase in the depth of cut. Andrewes et al. [9] investigated the tool wear in machining Al/SiC composites using diamond tools and found that tool wear involves two stages, one

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being initial flank wear caused by abrasion of hard particles, and the other combined adhesion-abrasion when the work materials start accumulatively adhering to the tool wear-land. Paulo Davim et al**.** [10, 11] reported that cutting velocity has the most influence on tool wear followed by cutting time and feed rate; with respect to surface finish feed rate observed to have greater influence.

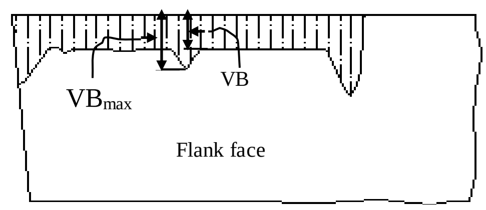
Ding et al**.** [12] investigated the machinability characteristics with PCBN and PCD tools. The PCD tools were found to have superior performance in terms of tool life. The PCBN tools exhibited stronger tendency to form built-up edge (BUE) and also significant amount groove wear than PCD tools. Use of coolant was observed to enhance the tool life and retard BUE formation. In the work done by Yuan et al. [13] it was found that the depth of cut has no significant effect on the surface roughness. However, it was reported by Lane [14] that the tool life of the PCD cutting tool was found to be inversely proportional to the depth of cut. Muthukrishnan et al**.** [15, 16] studied the influence of various grades of PCD inserts. Results indicated formation of BUE at low cutting speeds and good surface finish at high cutting speed. Seeman et al. [17] investigated the effect cutting parameters on tool wear and surface roughness during machining of 20% SiC_p LM25 Al MMC using RSM based desirability function analysis. The results showed that formation of BUE significantly affects the tool wear at low speeds whereas thermal influence plays important role at higher speeds and feed rates. Naveen Sait et al. [18] studied optimization of machining parameters using RSM based desirability function analysis during machining of glass-fibre-reinforced plastic (GFRP) pipes. The study clearly identified the improvement achieved through desirability function analysis multi-responses. Kadirgama *et al.* [19] used response surface method and radial basis function network to optimize surface roughness when milling mould aluminium alloys with carbide coated inserts.

From the literature it was found that several uncovered potential remains especially in the case of tool wear and surface finish while machining PAMMC. Therefore the study of this paper mainly aimed at developing suitable modeling technique to control process parameters and optimize the important functional parameters viz. surface finish and tool wear.

2. Experimental Work

Turning experiments were performed on a PSG 141 centre lathe which is having a spindle speed range of 30-1600 rpm with feed range 0.05-3.5 mm/rev with adequate spindle power. A356 (LM-25) aluminium alloy (7 Si, 0.33 Mg, 0.3 Mn, 0.5 Fe, 0.1 Cu, 0.1 Ni, 0.2 Ti) reinforced with green bonded silicon carbide average grain size 25 µm with a volume fraction of 0.10, which was manufactured through stir casting route was used as work material for carrying experimentation. The size of the work piece was 90 mm diameter and 250 mm length. Considering the abrasive nature of work material tipped polycrystalline diamond (PCD) was used for turning. The turning experiments were carried out as per the conditions given by the design matrix at random to avoid systematic errors.

The tool wear was measured using CLEMAX optical microscope with following specification: working distance 1 to 5 mm, magnification 50 to 1000 X, illumination 12V, 100W. To quantify the tool wear the maximum width of flank wear land was considered which is illustrated in Fig. 1. The average surface roughness (Ra), which is mostly practiced in industries, was taken in this study. The surface roughness was measured by using Mitutoyo Surf III surface tester. The specifications of the tester is as follows: speed of traverse 2-5 mm/s, range of traverse 2.5 mm, driving power 2VA, measuring range 0.3-100 µm.



VB_{max} – Maximum flank wear
VB – Flank wear

Fig. 1 Measurement of Flank Wear

3. Design of Experiments Based on Response Surface Methodology

In this study, four principal machining parameters viz. cutting speed (*V*), feed rate (*f*), depth of cut (*d*) and machining time (*t*) were taken as important design factors in the turning process. To study the performance of the PCD tool flank wear (VB_{max}) and surface roughness (Ra) were considered as response variables.

The experiments were designed using face centered the Central composite design (CCD). The factorial portion of CCD is a full factorial design with all combinations of the factors at two levels (high, +1 and low, −1) and composed of the eight star points and seven central points (coded level 0) which is the midpoint between the high and low levels. The star points are at the face of the cubic portion on the design which corresponds to a α value of 1 and this type of design is commonly called the face centered CCD. Table 1 shows the levels of four machining parameters and their ranges. The experimental plans were carried out using the stipulated conditions based on the face centered CCD involving 31 runs in the decoded form as shown in Table 2. The design was generated and analyzed using MINITAB statistical package.

Table 1: Cutting Parameter and their Levels

Control parameter	unit	symbol	Levels		
			-1	0	+1
Cutting speed	V	m/min	50	100	150
Feed rate	f	mm/rev	0.05	0.15	0.25
Depth of cut	d	mm	0.5	1.0	1.5
Machining time	t	min	2	4	6

Response surface method (RSM) was adopted to model the process parameters with the response variables. RSM is the procedure for determining the various performance criteria and exploring the effect of these process parameters on the desired responses. Based on RSM the quantitative form of relationship between the desired responses and independent input variables can be represented as

$$Y = F(V, f, d, t) \quad (1)$$

Where Y is the desired response and F is the response function (or response surface). In the procedure of analysis, the approximation of Y was proposed using the fitted second-order polynomial regression model, which is called the quadratic model. The quadratic model of Y can be written as follows:

$$Y = a_O + \sum_{i=1}^{4} a_i X_i + \sum_{i=1}^{4} a_{ii} X_i^2 + \sum_{i \prec j}^{4} a_{ij} X_i X_j \quad (2)$$

Where a_O is constant, a_i, a_{ii} and a_{ij} represent the coefficients of linear, quadratic and cross coded variables that correspond to the studied machining parameters. The coded variables X_i, i = 1, 2, 3, 4 are obtained from the following transformation equations:

$$X_1 = \frac{v - v_0}{\Delta v} \quad (3) \qquad X_2 = \frac{f - f_0}{\Delta f} \quad (4)$$

$$X_3 = \frac{d - d_0}{\Delta d} \quad (5) \qquad X_4 = \frac{t - t_0}{\Delta t} \quad (6)$$

Where X_1, X_2, X_3 and X_4 are the coded values of parameters V, f, d and t respectively and V_0, f_0, d_0 and t_0 are the values of V, f, d and t respectively at zero level. ΔV, Δf, Δd and Δt are the intervals of variation in V, f, d and t respectively. The flank wear (VB_{max}) and surface roughness (Ra) indicated as Y_{VBmax} and Y_{Ra} respectively were analyzed as responses. The purpose of using this quadratic model in this study was not only to investigate over the entire factor space, but also to locate the region where the response approaches its optimum or near optimal value for the desired target.

Table 2: Design Matrix with Responses

Run	Actual factors				Response variable	
	V	f	d	t	VB_{max} in mm	Ra in µm
1	50	0.15	1.0	4	0.053	1.74
2	150	0.15	1.0	4	0.106	1.36
3	100	0.05	1.0	4	0.093	1.21
4	100	0.25	1.0	4	0.097	1.98
5	100	0.15	0.5	4	0.089	1.55
6	100	0.15	1.5	4	0.092	1.60
7	100	0.15	1.0	2	0.087	1.43
8	100	0.15	1.0	6	0.100	1.62
9	50	0.25	1.5	6	0.081	2.14
10	150	0.05	0.5	2	0.106	0.92
11	50	0.05	1.5	6	0.071	1.40
12	150	0.25	0.5	2	0.112	1.73
13	50	0.05	0.5	6	0.068	1.42
14	150	0.25	1.5	2	0.115	1.78
15	50	0.05	0.5	2	0.055	1.30
16	150	0.25	1.5	6	0.125	1.93
17	50	0.25	0.5	6	0.078	2.12
18	150	0.05	1.5	2	0.109	0.95
19	50	0.25	0.5	2	0.064	1.98
20	150	0.05	1.5	6	0.120	1.12
21	50	0.25	1.5	2	0.066	2.09
22	150	0.05	0.5	6	0.117	1.10
23	50	0.05	1.5	2	0.057	1.35
24	150	0.25	0.5	6	0.123	1.91
25	100	0.15	1.0	4	0.090	1.55
26	100	0.15	1.0	4	0.089	1.56
27	100	0.15	1.0	4	0.091	1.55
28	100	0.15	1.0	4	0.090	1.58
29	100	0.15	1.0	4	0.089	1.55
30	100	0.15	1.0	4	0.090	1.56
31	100	0.15	1.0	4	0.091	1.54

4. Development of Mathematical Model

The mathematical relationship between responses (i.e. VB_{max}, Ra) and machining parameters was established using the experimental test results shown in Table 2 that was obtained from planned set of experiments based on CCD. The coefficients of regression analysis for flank wear (VB_{max}) and surface roughness (Ra) are shown in Table 3 along with their P-value. From the P-values of regression analysis of flank wear (VB_{max}), it can distinctly seen that linear and square effect of cutting speed, feed rate and machining time, cutting speed interaction with feed rate and machining time are most significant, the other effects are not so significant. Similarly, from the P-values of regression analysis of surface finish (Ra), it can be seen that linear, square effect of feed rate and machining time, linear and interaction of cutting speed with feed rate and machining time, depth of cut interaction with machining time are most significant. The other effects are not so significant since the P-values are more than 0.05.

Table 3: Regression Analyses of Flank Wear and Surface Roughness

Symbol	Flank wear		Surface roughness	
	Coefficient	P-value	Coefficient	P-value
Constant	-0.038760	0.003	1.19250	0.000
V	0.002716	0.000	-0.00399	0.003
f	-0.171921	0.000	3.41469	0.000
d	-0.010582	0.192	-0.07694	0.491
t	-0.006087	0.007	0.08875	0.006
V^2	-0.000012	0.000	-0.00000	0.669
f^2	0.467496	0.000	-2.49126	0.010
d^2	0.006539	0.087	0.07675	0.170
t^2	0.001409	0.000	-0.00770	0.035
Vf	0.000016	0.007	0.00413	0.000
Vd	-0.000010	0.841	-0.00010	0.648
Vt	0.000005	0.017	0.00020	0.002
fd	-0.000619	0.841	0.11681	0.182
ft	0.008053	0.841	-0.00265	1.000
dt	-0.000125	0.841	-0.01250	0.033

The Equations 7 and 8 represent the regression model for flank wear (VB_{max}) and surface roughness (Ra).

$$Y_{VBmax} = -0.038760 + (0.002716\,V) - (0.171921\,f) - (0.010582\,d) - (0.006087\,t) - (0.000012\,V^2) + (0.467496\,f^2) + (0.006539\,d^2) + (0.001409\,t^2) + (0.000016\,Vf) - (0.000010\,Vd) + (0.000005\,Vt) - (0.000619\,fd) + (0.008053\,ft) - (0.000125\,dt) \quad (7)$$

$$Y_{Ra} = 1.19250 - (0.00399\,V) + (3.41469\,f) + (0.07694\,d) + (0.08875\,t) - (2.49126f^2) + (0.07675d^2) - (0.00770t^2) + (0.00413Vf) - (0.00010\,Vd) + (0.00020\,Vt) + (0.11681\,fd) - (0.00265\,ft) - (0.01250\,dt) \quad (8)$$

Table 4 gives the values of estimated standard deviation (S) about the regression line, R^2 statistic and adjusted R^2 statistic. Since the S-value being measurement of error, smaller the value, better the model. Thus the mathematical model for VB_{max} is less deviated from the regression line than that of Ra (Table 5). The higher value of R^2 is better to determine the coefficients of regression equation. So the coefficient in the regression equation for Ra has been determined more effectively than that of VB_{max}.

Table 4: Summary of Regression Analysis

Responses	S-value	R^2	Adjusted R^2
VB_{max}	0.00122297	99.80%	99.63%
Ra	0.0214966	99.77%	99.56%

The closeness of the adjusted R^2 with R^2 determines the fitness of model. In both the causes the adjusted R^2 value is closer to the R^2 value. From the Tables 3 and 4 it can be concluded the developed mathematical model clearly model the relationships between the process parameters and response variables VB_{max} and Ra in turning of particulate metal matrix composite.

5. Results and Discussion

5.1. Effect of machining parameters on flank wear (VB_{max})

Tool wear is one of the important performance indicators of any cutting tool. In the machining of MMCs reinforced with abrasive particles such as SiC, abrasion is the major mechanism causing tool wear. Fig. 3 illustrates the predicted value of flank wear (VB_{max}) in terms of cutting speed and feed rate. The unstable built up edge is formed at lower cutting speed when machining ductile nature of the aluminum matrix it's protect cutting wedge from wearing of the tool [15]. The formation of built-up edge at low cutting speed is shown in Fig. 4(a**)**. But with increase in cutting speed an increase in tool wear is observed which could be due to generation of higher temperature at higher cutting speed and associated thermal softening and deterioration of form stability of the cutting wedge [21]. At a cutting speed of 150m/min, a reduction in the size and stable BUE is observed seen from Fig. 4(b), which could be due to generation of higher temperature at high cutting speed.

From the Fig. 3 with increase in feed rate, a decrease in flank wear (VB_{max}) is seen up to around 0.12 mm/rev of feed rate. At low feed rate, there is increase in contact time, which in turn leads to increase in contact temperature and consequent higher flank wear (VB_{max}). However with increase in feed rate beyond 0.12 mm/rev increase in flank wear (VB_{max}) is seen. With higher the feed rate, consequent larger cross-sectional area of the un-deformed chip and resistance to chip deformation, lead to higher change in the geometry of tool wedge. The changes in the geometry further lead to thermal induced tool wear thus resulting into higher flank wear [10].

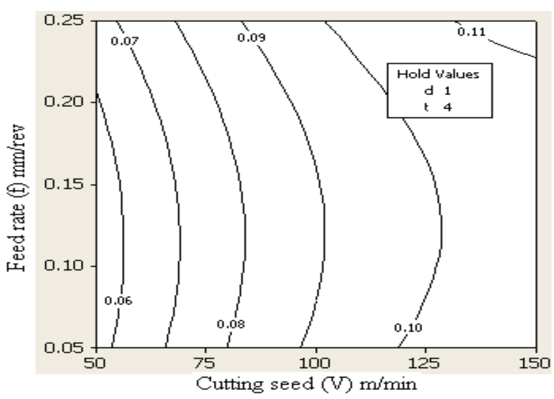
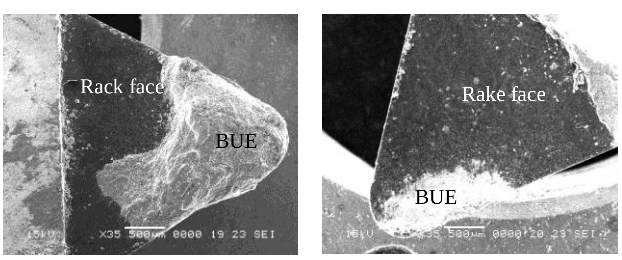


Fig.3 Effect of Cutting Speed and Feed Rate on Flank Wear

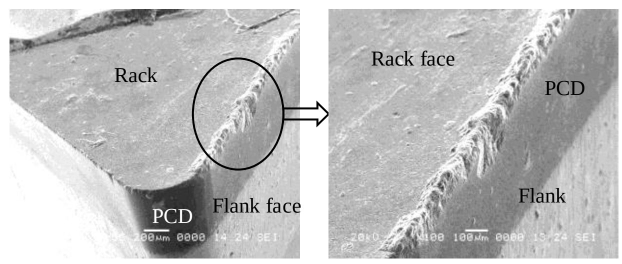


(a) V- 50 m/min, f- 0.15 mm/rev, d- 1.0 mm, t- 4 min

(b) V-150 m/min, f- 0.15 mm/rev, d- 1.0 mm, t- 4 min

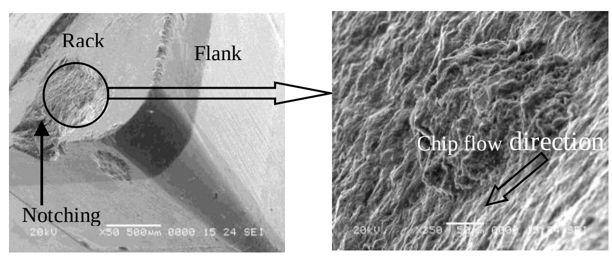
Fig. 4 BUE Formation at *V*- 50 m/min, *f*- 0.15 mm/rev, *d*- 1.0 mm and *t*- 4 min

The wear pattern of PCD tool observed under scanning electron microscope (SEM) while turning at low cutting speed is shown in Fig. 5. From the Fig. 5 (a) and (b) distinct chipping at the main cutting edge could be seen while turning Al/SiC_p metal matrix composite material at low cutting speed 50 m/min. Cutting tools usually experience maximum temperature at cutting nose, secondary cutting edge and primary cutting edge. The high temperatures and stresses cause the tool material to undergo thermal softening and subsequent deformation [6].



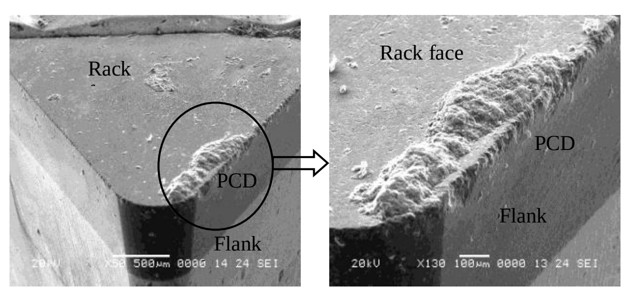
(a) Flank wear (b) Higher magnification of circle area

Fig. 5 SEM of PCD Tool at *V*- 50 m/min, *f* - 0.25 mm/rev, *d*- 1.5 mm and *t*- 6 min



(a) Notching in secondary edge (b) Higher magnification of Circle area

Fig. 6 SEM of PCD Tool at *V*- 150 m/ min, *f* - 0.25 mm/ rev, *d* - 1.0 mm and *t*- 6 min



(a) Flank wear (b) Higher magnification of Circle area

Fig. 7 SEM of PCD tool at *V*- 150 m/ min, *f* - 0.05 mm/ rev, *d* - 0.5 mm and *t*- 2 min

From the SEM micrograph shown in Fig. 6 notching over secondary edge can be noticed. Notching is mainly due to oxidation wear. Hence the notching may be due to oxidation wear associated with high temperature at this region. The edge chipping that formed on the tool face was filled with work piece material. The adhering layer somewhat protected the tools flank face against further chipping. When the cutting speed increased to 150 m/min, visible changes in the chipping at the flank face and work material adhesion along tool wedge seen from Fig. 7.

However, wear on the rake face can be seen from Fig. 6, which could be due to higher sliding of flow of chips with hard particles at higher cutting speed. This sliding of chips combined adhesion–abrasion of work material on the rake face away from the cutting edge could have resulted in to degradation of tool over the flank portion [9].

Fig. 8 illustrates the influence of machining time (t) and depth of cut (d) on flank wear (VB_{max}). The flank wear generally increases with increase machining time, due to degradation of cutting tool and alteration in the form of tool wedge [7]. The influence of depth of cut (d) on flank wear (VB_{max}) is not seen from the illustration. This results correlates results of P value given in Table 3 wherein the depth of cut was observed as the least influence factor compare to cutting speed, feed rate and machining time on flank wear (VB_{max}) in machining of MMC [13]. If the depth of cut is beyond 1mm, the flank wear (VB_{max}) increases due to increase in area of contact, normal load and friction. This in turn increases temperature, which will cause work softening and thus results in increased flank wear (VB_{max}).

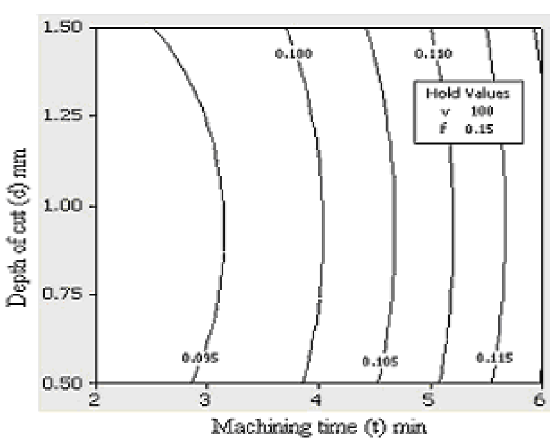


Fig.8 Effect of Machining Time and Depth of Cut on Flank Wear

5.2. Effect of machining parameters on surface roughness (Ra)

The influence of cutting speed and feed rate on surface roughness is illustrated in Fig. 9. From the illustration increase in the value surface roughness (Ra) can be seen with increase in feed rate (*f*). With lower feed rates, the BUE forms readily and is accompanied by feed marks resulting in increased roughness. With further increase in feed rate increases the surface roughness. Higher feed rates increases the temperature in cutting zone causing decrease in bonding effect between SiCp and Al matrix, thus leading to pull out of SiC particles from the softened aluminum matrix resulting in poor surface finish [8]. Also at higher feed rate the cusp height is more which also lead to higher values of surface roughness. From Fig. 9 at low cutting speed (*V*), there is a formation of larger unstable larger BUE and the chips fracture readily thus producing the poor surface finish. As the cutting speed (*V*) is increased, the BUE vanishes, chip fracture decreases, and hence the roughness decreases [16]. The best surface finish was achieved at the lowest feed rate and highest cutting speed combination.

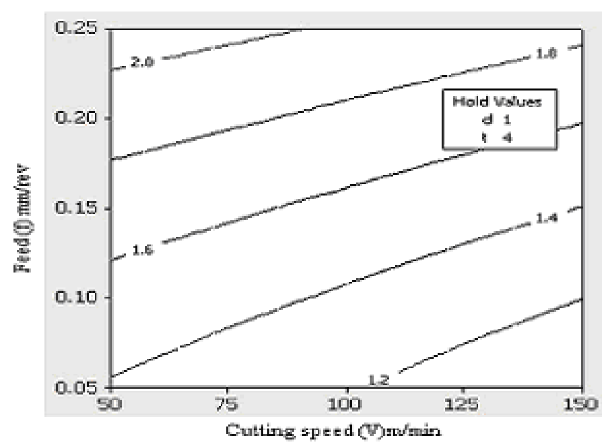


Fig.9 Effect of Cutting Speed and Feed Rate on Surface Roughness

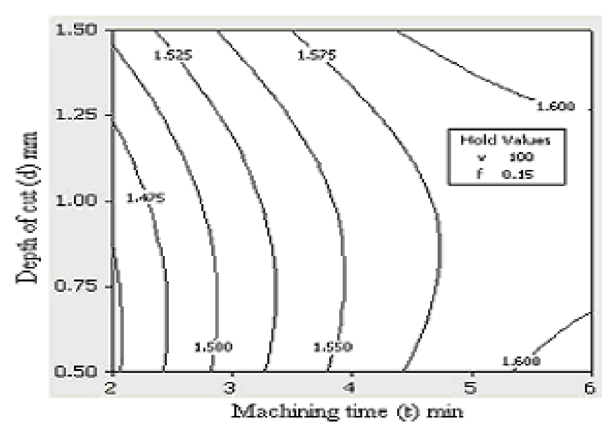


Fig.10 Effect of Machining Time and Depth of Cut on Surface Roughness

The effect of depth of cut (*d*) and machining time (*t*) on the surface roughness (*R*a) is shown in Fig. 10. The depth of cut is lower influencing machining parameter on surface roughness compared to cutting speed, feed rate and machining time [13], which was seen from the observed 'P' values given in Table 3. The machining time is one of the important parameters on surface roughness since, with machining time tool geometry gets altered. Surface finish is the direct replication of tool geometry. From the illustration it is seen that the surface roughness increases with the increase in the machining time up to around 4.5 min and beyond which no significant variation noticed. Actually machining time is the ratio between the length of cut and the product of spindle speed and feed rate. That is, machining time includes both cutting speed and feed rate and thus the influence of machining time much reflected by the significant contribution of cutting speed and feed rate.

6. Analysis for Optimization of the Responses

Apart from the study of interaction between process parameters and their effect on desired response variables, it is necessary to optimize the process parameters for the multiple responses of tool wear and surface roughness. One useful approach to optimize the multiple responses is to use the simultaneous optimization technique popularized by Derringer and Suich [20]. Their procedure introduces the concept of desirability functions. The general approach is to first convert each response Y into an individual desirability function d_i that varies over the range.

$$0 \le d_i \le 1 \tag{9}$$

When the response Y is at its goal or target then d_i = 1 and if the response is outside an acceptable region then d_i = 0. The weight of the desirability function for each response defines its shape. For each response, one can select a weight (r_i) to emphasize or de-emphasize the target. Finally the individual desirability functions are combined to provide a measure of the composite or overall desirability of the multi-response system [17]. This measure of composite desirability is the weighted geometric mean of the individual desirability of the responses. The optimal operating conditions can be determined by maximizing the composite desirability [18]. In the present investigation, the response parameters are chosen to maximize the overall desirability as follows:

$$D = (d_1^{i1}\, d_2^{i2})^{1/(i1+i2)} \tag{10}$$

Where d_1 and d_2 are the desirability functions for flank wear (VB_{max}) and surface roughness (*R*a), respectively and i_1 and i_2 are the importance of transformed response parameters of d_1 and d_2. Usually a reduced gradient algorithm with multiple starting points is employed for maximize/minimize the composite desirability to determine the optimal input parameter settings. Most of the standard statistical software packages (Minitab, Design expert, etc.) employ this popular technique for response optimization. In this study Minitab is used to optimize the response parameters.

The optimization plot for flank wear is illustrated in Fig. 11. The goal was to minimize the flank wear. The upper value and target has been fixed at 0.125 mm and 0.054 mm respectively. The parameter settings for achieving a flank wear as low as of 0.054 mm has been predicted as cutting speed (*V*) - 50 m/min, feed rate (*f*) - 0.1672 mm/rev, depth of cut (*d*) - 0.5 mm and machining time (*t*) – 2.8 min. The desirability of optimization has been calculated as 1 i.e. all parameters are within their working range.

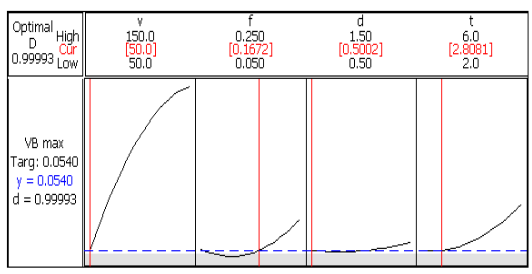


Fig. 11 Optimum Results for Minimum VB_{max}

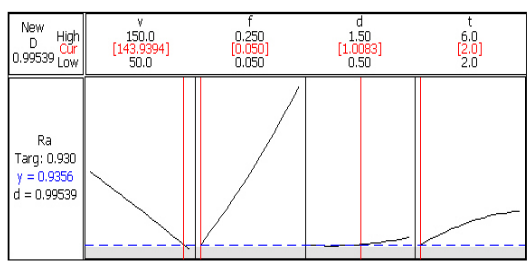


Fig. 12 Optimum Results for Minimum Ra

The optimization plot for surface roughness is shown in Fig. 12. The goal was to minimize the surface roughness. The upper value and target has been fixed at 2.15 µm and 0.93 µm respectively. The parameter setting for achieving a surface roughness as low as of 0.9356 µm has been predicted as cutting speed (*V*) - 143.94 m/min, feed rate (*f*) - 0.05 mm/rev, depth of cut (*d*) – 1.0 mm and machining time (*t*) - 2 min. The desirability of optimization has been calculated as 0.99539 i.e. all the parameters are within their working range.

Optimization plot for both the responses is shown Figure 13. The objective is to minimize both responses considered at a time. As the composite desirability is 0.46626, it can be concluded that the parameters are within their working range. The optimized values of cutting parameters are cutting speed (*V*) - 100 m/min, feed rate (*f*) - 0.05 mm/rev, depth of cut (*d*) – 0.86 mm and machining time (*t*) – 3.78 min.

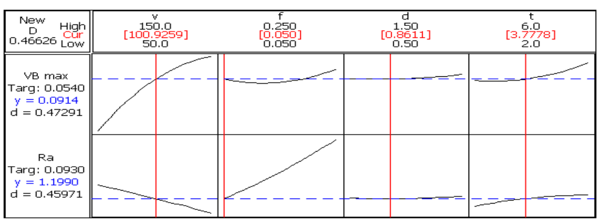


Fig.13 Optimum Results for Minimum VB_{max} and Ra

7. Conclusions

From the modeling and optimization of process parameters with responses of tool wear and surface roughness the following conclusions can be drawn.

i. Cutting speed, feed rate and machining time of the regression models are found to be more significant when compared to depth of cut. The proposed models for flank wear and surface roughness are found to be adequate and can be used to predict the characteristics with in the experimental range.

ii. Formation of BUE significantly affects the tool wear at low speeds whereas thermal softening plays important role at higher speeds and feed rates. Surface topographies of the tool indicate that the main wear mechanism of PCD tool is abrasive, adhesive wear and edge chipping.

iii. The surface roughness is significantly affected by BUE formation at low speeds. Higher feed rates increase the temperature in cutting zone and cause to decrease bonding effect between SiCp and Al matrix. Pull out of SiC particles from the softened aluminum matrix resulting in poor surface finish.

iv. Based on the desirability function approach, at the cutting speed of 100 m/min, feed rate of 0.05 mm/rev, depth of cut of 0.86 mm and machining time of 3.78 min for minimum flank wear of 0.0914 mm and minimum surface roughness of 1.1990 µm results indicating optimal conditions in the turning of Al/SiCp MMC.

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