Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-244

Volume 3, Issue 7, July-2016

Optimization of machining parameters on AZ91 magnesium alloy

Karanpreet Singh[1], Dr. N.M. Suri[2], *Sandeep Kumar*[3]

Karanpreet Singh[1], ME Scholar[1], Prod. & Ind. Engineering Department, PEC University of Technology, Chandigarh, India
Dr. N.M. Suri[2], Associate Professor[2,] Prod. & Ind. Engineering Department, PEC University of Technology, Chandigarh, India
Sandeep Kumar, Phd. Scholar, Prod. & Ind. Eng. Department PEC University of Technology, Chandigarh, India

ABSTRACT - From past many years lightweight materials like magnesium are enhancing their usage in many applications and industries. This rising need of magnesium inspires many researchers to learn its usage in diverse practices. The present paper investigates the turning of one of the magnesium alloy named AZ91 with SiC at 0%, 1%, and 3%; analyzing different parameters of machining: feed rate, speed of cut. The whole investigation is done with dry machining conditions. For evaluation of turning process three cylindrical bars with three slots were used. The evaluation of process is done by taking surface roughness as the response variable. In this study Taguchi's L9 orthogonal array with different combinations are used and S/N plots are made and outcomes are analyzed with the help of Analysis of Variance (ANOVA). In results it is analyzed that the important parameter in all tests is feed rate. In addition to this cutting speed were not found to be significant source of variation. Additionally machining at lower feed rates dispersion of surface roughness values in terms of Ra was identified more.

KEYWORD – Magnesium Alloy, Taguchi, Optimization, Machining process, surface roughness

I. INTRODUCTION

In recent years magnesium has attracted a lot of attention because of its light weight. As the density of magnesium is very low it is used in automobile industries as the improvement in fuel economy is major challenge for the automobile makers. The density of magnesium is 1740 kg/m^3 which are lower than all other metals and little more compared to plastics. In addition to low density magnesium also has very impressive properties like high strength to noise ratio. Additionally, magnesium also has very good machining properties. So, magnesium has very vast applications like automobile industries, electronic devices, aerospace industries, medical etc. However, it also has some disadvantages like corrosion, risk of ignition, reactivity with water. So dry machining is preferable in case of machining of magnesium. The increasing demand of magnesium in different industries makes important to see its usage in various machining processes. The quality of surface is an important parameter in the mechanical parts and also cost of production. The goal of manufacturing industrial is to manufacture product having good class and high finish of surface. Technique of Taguchi is an influential and humble tool for designing of good quality structures.

II. LITERATURE REVIEW

Pavl et al.[1] studies the turning of two work pieces made up of steel one is continuous and other interrupted i.e. shaft with 10 splines. The parameters taken were feed rate **-** 0.102 and 0.15 mm/rev, cutting speed – 120 and 175 m/minute and depth of cut **-** 0.178mm. Behavior of uninterrupted and irregular turning was investigated. In the first case i.e. of continuous cutting as the tool wear increases the parameter surface roughness also increases. However in case of discontinuous cutting surface roughness increases very slightly in beginning of cut then starts decreasing.

Kathirvel et.al [2] (2009, 2011) investigates the parameter that affects roughness of surface in HMM composites established by Analysis of variance. The main factors that effects surface roughness are SiC, depth of cut, feed and cutting speed.

Liang et al. [3] investigates the process of turning in A390 aluminum alloy. There are two work pieces one is continuous and other is discontinuous cylindrical bars with four 9.5 mm slots. The factors taken were: speed of cut (from 650 to 1400 m/min), cutting depth (0.635 mm) and feed (0.125 mm/rev). The finish of surface found in discontinuous cutting was 20% improved than in unbroken cutting.

Though there are very less studies regarding machining of the magnesium in the literature some of the major investigations are highlighted in this section.

Pu et al [4]: investigates the process of turning of AZ31 B Mg alloy, showing effect of atmosphere mainly and cryogenic refrigeration as well as dry machining. Feed rate and speed of cut were fixed at 0.1 mm/rev and 100 m/min. The values of surface finish in terms of Ra i.e. arithmetic average roughness were below 0.2um.

Tonshoff and winkeler [5] : investigates the effect of coatings of tool in machining of AZ91 Mg alloy. The values obtained are calculated using Rz value. The values obtained were below 30um with cutting speed between 300 and 2400 m/min, feed rate 0.4 mm/rev and depth of cut 1.5 mm.

Wojtowicz et al [6]: investigates the process of turning in Electron 21 alloy by using Taguchi's design. In the research cutting depth, speed, feed and radius of tool nose were evaluated on surface finish. In the results it is observed that interaction between tool nose radius and feed rate is the significant factor.

Rubio et al [7] studies the dry facing of UNSM 11917 magnesium alloys. The factor studied were spindle speed at 280, 500 and 800 rpm, depth of cut was .25mm and feed rate at .04, .08 and .12 m/mm. The surface roughness thus obtained was in the range of .19 - .82 um.

The present study works on the turning process of AZ91 magnesium alloy by taking SiC, spindle speed and feed rate as the factors at three levels and surface roughness as the response variable to optimize.

III. EXPERIMENTAL PROCEDURE

3.1 MATERIALS AND EQUIPMENT

A HMT NH26 lathe with a maximum speed of spindle 2300 rpm was used for experiments. The turning process is done in dry machining condition without any cutting fluid. **Figure 1** shows an image of the lathe machine used in the process.
Tools used in the research were HS steel.

Fig. 1 Lathe machine used in the process

Fig. 2 Machining of work piece

Work pieces are of AZ91 magnesium alloy with SiC of 0%, 1% and 3% added in it. Silicon carbide (SiC) with size of 40µm is used as additional element. It has many applications which include brakes of automobiles, clutches of cars etc. Three rods were casted in stir casting machine. The main chemical composition of AZ91 alloy is aluminum 9 %, zinc .7%, manganese .03% and balance is magnesium. The XRF spectrometer analysis is done on one of the work piece with SiC added. Magnesium alloy bars had an actual dia of 20 mm and a length of 125 mm (75 mm being useful). Work pieces were fixed from one end to spindle using the three-jaw chuck. The machining of work piece is shown in **Figure 2**.

The rods with 0%, 1% and 3% SiC are further divided into three slots on which turning process is done. The three rods are shown in **Figure 3**.

Fig. 3 Three rods prepared for experiment

Fig. 4 Surface Roughness Tester

All experiments are performed without using any lubricant. Surface finish (Ra) was measured using an instrument with stylus as shown in the **Figure 4.**

IV. METHODOLOGY

Main motive of the experimentation is to analyze the effect of different parameters of machining on surface roughness in the process of turning of magnesium, in dry machining condition. Thus, surface roughness is selected as response variable for this experiment. Surface roughness is evaluated in terms of Ra. i.e. arithmetic average roughness. The factors that selected are founded on earlier results, but are not reviewing the tool material effect. Feed (f) is a factor that is known to be a significant parameter for the surface roughness of the work pieces, especially, in turning process of magnesium. The predictable effect of cutting speed (v) is poorer to that of the feed rate, but many literature shows that it may give an important outcome on surface roughness.

The parameters selected for machining were: SiC 0%, 1% and 3%, cutting speed 250, 325 and 420 rpm and feed rate 0.1, 0.2, 0.4 mm.

V. EXPERIMENTATION

Taguchi anticipated the plan of experiment in relations with orthogonal array. The present study consists of three controllable variables, i.e. SiC, feed rate and speed of spindle. The response variable taken is surface roughness. Three levels for each factor are shown in the **Table 1**. In present study L9 orthogonal array was chosen, which consists of 9 rows as shown in the **Table 2**. The outcomes of experiment were shown in **Table 3**. The main objective of the experiment is to have the significant parameters affecting the process of machining to have low surface finish.

Table1 Three factors with three levels

LEVELS	SiC	Speed of Cut	Feed
1	0%	250	0.1
2	1%	325	0.2
3	3%	420	0.4

Table 2 General table for L9

No of Experiment	A1	A2	A3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 3 Outcomes of experiment

Number of Experiment	SiC	Cutting Speed	Feed rate	Ra
1	0	250	0.1	1.07
2	0	325	0.2	2.27
3	0	420	0.4	10.30
4	1	250	0.2	2.20
5	1	325	0.4	13.05
6	1	420	0.1	1.46
7	3	250	0.4	7.96
8	3	325	0.1	1.50
9	3	420	0.2	1.89

VI. RESULTS AND DISCUSSION

The data of experiment are analyzed by usage of Signal to Noise (S/N) ratio. According to the outcomes optimum factors for minimum surface finish were found and then confirmed. In Taguchi, Signal to noise ratio is amount of quality representative and abnormality from the anticipated result. The word signal signifies wanted result and noise signifies unwanted result for the output parameter. S/N ratio is figured by equation as follows:

$\eta = -10\log(M.S.D)$

M.S.D refers to mean square deviation.

Smaller is better kind of S/N ratio is taken for improved exactness.

S/N ratio for $R_a = -10\log_{10} 1/n\sum(y^2)$

where n= no. of observations, y= observed data (R_a)

The study of above experimental data was conceded by software named MINI-TAB 17. **Table 4** shows the response data for S/N ratio. **Table 5** shows the response data for mean Ra, giving the similar outcomes as signal to noise ratio. **Figure 3 and 4** shows the main effects plots for means and S-N.

Table 4 Response Table for Signal to Noise Ratio

Level	A	B	C
1	-11.517	-11.072	-10.357
2	-14.617	-9.836	-16.727
3	-5.496	-10.723	-4.547
Delta	9.121	1.236	12.179
Rank	2	3	1

Table 5 Response Table for Means

Level	A	B	C
1	4.978	5.620	4.062
2	7.473	4.603	8.595
3	1.918	4.147	1.713
Delta	5.555	1.473	6.882
Rank	2	3	1

Table 6 shows the results of S-N and means Ra and are confirmed by analysis of variance (ANOVA). It was seen that feed rate has 92.04%, SiC has 2.91% and speed of spindle has 3.16%. The error percentage was detected to be 1.88%, which is insignificant. Therefore it is measured that the design, analysis and are in the correct way. Henceforth, the optimum factors for turning of AZ91 magnesium alloy are:

SiC % = 3%
Spindle speed (N) = 250rpm
Feed (f) =0.10mm/rev

The link between the parameters and outcome was established by multiple regressions. The regression equation which gives the projected outcome of surface finish for any factor level is shown as:

Regression Equation

$Ra1=4.633- 0.087\ A_1+ 0.937\ A_2- 0.850\ A_3-0.890\ B_1+ 0.973\ B_2- 0.083\ B_3- 3.290\ C_1- 2.513\ C_2 + 5.803\ C_3$

Table 6 Results of Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution
A	2	4.822	2.411	1.55	0.392	2.91%
B	2	5.239	2.620	1.68	0.373	3.16%
C	2	152.459	76.229	48.94	0.020	92.04%
Error	2	3.115	1.558			1.88%
Total	8	165.636				100%

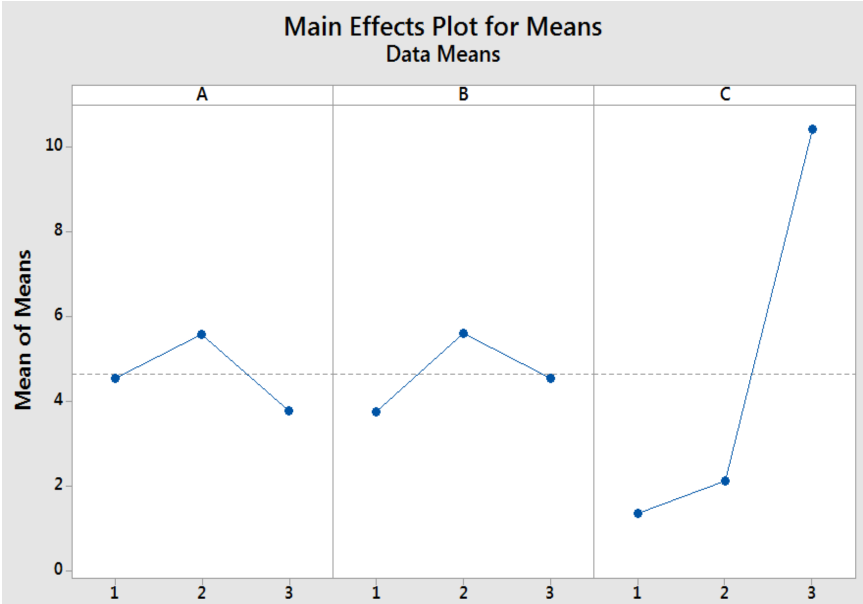

Fig. 5 Main effect plots for Means

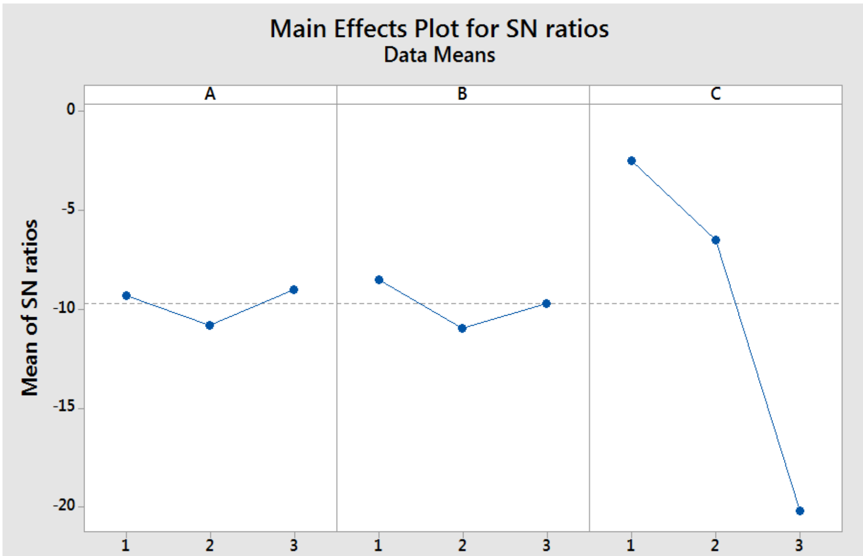

Figure 6 Main effect plots for S/N ratio

VII. CONCUSIONS

According to the outcomes of experiments the inferences are as follows:

With the help of technique of Taguchi the outcome of parameters of machining on the surface roughness (Ra) has been estimated. Optimum factors for minimum surface roughness for AZ91 magnesium alloy are Feed rate (f) = 0.1mm/rev, Spindle speed (N) =250rpm and SiC (%) = 3%. The response table and graphs for S-N ratio and means are also symbolized. According to ANOVA, it is discovered that feed rate has a main influence on the surface roughness (92.04%) followed by cutting speed (3.16%) and the SiC % (2.91%).

VIII. REFRENCES

[1] Pavel, Radu, et al. "Effect of tool wear on surface finish for a case of continuous and interrupted hard turning." *Journal of Materials Processing Technology* 170.1 (2005): 341-349.

[2] Kathirvel, M., Palani Kumar, K., Muthraman,S., 2009. Implementation of echo state neural network for single point tool wear estimation using hybrid aluminium silicon carbide metal matrix. ARPN journal of engineering and applied science. 4(10), 93-99

[3] Liang, Qi, Yogesh K. Vohra, and Raymond Thompson. "High speed continuous and interrupted dry turning of A390 aluminum/silicon alloy using nanostructured diamond coated WC–6 wt.% cobalt tool inserts by MPCVD."*Diamond and Related Materials* 17.12 (2008): 2041-2047.

[4] Pu, Z., et al. "Enhanced surface integrity of AZ31B Mg alloy by cryogenic machining towards improved functional performance of machined components." *International journal of machine tools and manufacture* 56 (2012): 17-27.

[5] Tönshoff, H. K., and J. Winkler. "The influence of tool coatings in machining of magnesium." *Surface and Coatings Technology* 94 (1997): 610-616.

[6] Wojtowicz, N., et al. "The influence of cutting conditions on surface integrity of a wrought magnesium alloy." *Procedia Engineering* 63 (2013): 20-28.

[7] Rubio, Eva Maria, et al. "Experimental study of the dry facing of magnesium pieces based on the surface roughness." *International Journal of Precision Engineering and Manufacturing* 14.6 (2013): 995-1001.