EXPERIMENTAL INVESTIGATION ON DRILLING OF MAGNESIUM ALLOY AZ31B

R.M.Chellakarthikeyan[1], B.Chandrasekar[2], S.Sathiyanarayanan[3], A.Arumuga Dass[4], N.Ganesh[5]

[1,2,3,4] *UG Students, Department of Mechanical Engineering, K.Ramakrishnan College of Engineering, Tiruchirappalli, Tamilnadu, India-621112.*

[5] *Asst Prof, Department of Mechanical Engineering, K.Ramakrishnan College of Engineering, Tiruchirappalli, Tamilnadu, India-621112.*

Contact details: rm.chellakarthikeyan@gmail.com,shayamsekar@gmail.com

ABSTRACT

Drilling is a critical process in the machining industry to obtain good surface integrity. This investigation is forwarded with obtaining better optimal cutting conditions for drilling of Magnesium alloy AZ31B to minimize the Machining time. It is planned to carry out the experiments using Central Composite Design with, TiN coated HSS drill bits of 6 mm size. The test of hypothesis is to be applied to study its influences of drilling process on responses considered. Optimal values of drilling process can be obtained with applying techniques such as GA algorithms.

KEYWORDS: *Drilling Process, Central Composite Design, Magnesium alloy AZ31B, TiN coated HSS, Genetic Algorithm(GA) etc.,*

INTRODUCTION

In general drilling is the most important factor in manufacturing, because without drilling process any job or work cannot be carried. For example, to clamp any two objects with bolt and nut in first, the hole must be available in object to clamp or joined by bolt and nut. Drilling is a critical process in the machining industry to obtain good surface integrity. Drilling is the metal cutting process carried out by a rotating cutting tool to make circular holes in solid materials. Tool which makes hole is called as drill bit or twist drill. The Magnesium Alloy AZ31B is selected as the material. It is the mixture of aluminium, zinc, manganese, silicon, copper, rare earths and zirconium. It is the lightest structural metal. Cast magnesium alloys are used for many components of modern automobiles have been used in some high-performance vehicles and die-cast magnesium is also used for camera bodies and components in lenses. Magnesium alloys names are given by two letters following by two numbers. Letters can be named in main alloying elements (A = aluminium, Z = zinc, M = manganese, S = silicon). Numbers indicate respective nominal compositions of main alloying elements. Marking AZ31 for example covey's magnesium alloy with roughly 3 weight percent aluminium and 1 weight percent zinc. The AZ31 is the Magnesium wrought alloy. Its proof stress is 160-240 MPa, tensile strength is 180-440 MPa and elongation is 7-40%. Mechanical processing of magnesium alloys provides an alternative approach to controlling the biodegradation rate through the modification of the surface integrity, including grain size, residual stresses, and crystallographic orientations. It is planned to carry out the experiments using Central Composite Design. A Central composite design is an experimental design, useful in response surface methodology, for building a second order (quadratic) model for the response variable without needing to use a complete three-level factorial experiment. After the designed experiment is performed, linear regression is used, sometimes iteratively, to obtain results. Coded variables are often used when constructing this design. Magnesium Alloy AZ31B Plate has been drilled with TiN coated HSS drill bits of 6mm. High-speed steel (HSS) is a subset of tool steels, it is used as cutting tool material. HSS bits are hard and much more resistant to heat than high-carbon steel. This can be used to drill metal, hardwood, and most other materials at greater cutting speeds than carbon-steel bits and have largely replaced carbon steels. In this experiment to obtain better optimal cutting conditions for drilling of Magnesium alloy AZ31B to minimize the Machining time.

MATERIALS AND METHODS

This analysis deals with the finding the optimal cutting conditions in drilling of Magnesium Alloy AZ31B (work piece Length:100 mm and Breadth:40 mm) using High Speed Steel cutting tool in CNC drilling centre (AMS 6000 rpm) for two different values of Cutting speed, feed rate. The details of Levels and Factors are shown in Table 1.

Table 1: Levels and Factors

Levels/Factors	**Level 1**	**Level 2**
Cutting Speed(m/min)	40	60
Feed Rate(mm/rev)	0.05	0.2

EXPERIMENTAL DESIGN

Selection of experimental design is a decision-making process which decides the degree of validity of the desired model in finding optimal cutting parameters. This work is carried out using Response surface methodology. Methods such as Box Benhenken design and Central Composite Design (CCD) comes under Response surface methodology.

RESPONSE SURFACE METHODOLOGY

Response surface methodology is a collection of mathematical and statistical techniques that are useful for modelling and analysis of problems in which a response of interest is influenced by several variables and the objective is to find optimized values of cutting parameters for minimization or maximization of response. The response surface design is a better design, as it generates a second order linear model of regression, which is better predictive model than a first order linear model.

In this work, Central Composite Design (CCD) has been applied for the experimental investigation. The values of cutting parameters for CCD are shown in Table 2.

Table 2: Response Surface Design (CCD)

Std	**Run**	**Block**	**Cutting Speed(m/min)**	**Feed Rate(mm/rev)**
5	1	Block 1	40.00	0.13
1	2	Block 1	42.93	0.07
3	3	Block 1	42.93	0.18
6	4	Block 1	60.00	0.13
12	5	Block 1	50.00	0.13
13	6	Block 1	50.00	0.13
10	7	Block 1	50.00	0.13
9	8	Block 1	50.00	0.13
2	9	Block 1	57.07	0.07
11	10	Block 1	50.00	0.13
7	11	Block 1	50.00	0.05
4	12	Block 1	57.07	0.18
8	13	Block 1	50.00	0.20

DATA COLLECTION

Data collection plays a significant role in statistical analysis of any field, as it decides the progression of the analysis to the best or worst. A proper and suitable data collection leads to better results from analysis. In such focus it is very much essential to choose a well suitable data collection technique for the analysis. In this work, Data collection for the drilling process is selected for proceeding with Response surface methodology design, i.e., a second order linear model. The values predicted using the model in drilling of Magnesium Alloy AZ31B using HSS cutting tool has been shown in Table 3.

Table 3: Data Collection Using RSM

Run	Cutting Speed(m/min)	Feed Rate(mm/rev)	Machining Time(Sec)
1	40.00	0.13	5
2	42.93	0.07	6
3	42.93	0.18	3
4	60.00	0.13	3
5	50.00	0.13	4
6	50.00	0.13	4
7	50.00	0.13	4
8	50.00	0.13	4
9	57.07	0.07	5
10	50.00	0.13	4
11	50.00	0.05	8
12	57.07	0.18	3
13	50.00	0.20	3

EFFECTS OF CUTTING PARAMETERS

Analysis of Variance

Any Data collected for responses against set of chosen parameters must be validated for the significant influence of parameters. In this manner the data collected (responses) Machining time, Burr dimension and Circularity error are validated for the significant effects of drilling parameters cutting speed, feed rate. This is done by test of hypothesis at 94% significance level using F-test. The results of the test of hypothesis for Machining time are shown in Table 4. From Table 4 determines that all the factors Cutting speed and Feed Rate are having significant influence on Machining time. As the R2 values of Machining time respectively 0.9413. The model is suitable to navigate the design space.

Table 4: ANOVA for Machining Time

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob> F	Significant/Not significant
Model	23.32	5	4.66	22.45	0.0004	Significant
A-Cutting speed	1.83	1	1.83	8.82	0.0208	
B-Feed Rate	18.21	1	18.21	87.68	<0.0001	
AB	0.25	1	0.25	1.20	0.3089	
A^2	0.11	1	0.11	0.52	0.4929	
B^2	2.72	1	2.72	13.08	0.0085	
Residual	1.45	7	0.21			
Lack of Fit	1.45	3	0.48			
Pure Error	0.000	4	0.000			
Cor Total	24.77	12				
R^2 = 0.9413						

Surface Plot and Inference for Machining Time

Figure 1 determines

- When cutting speed increases considerably decrease in machining time.
- When feed rate increases considerably decrease in machining time.
- Minimum machining time can be obtained with maximum cutting speed and maximum feed rate.

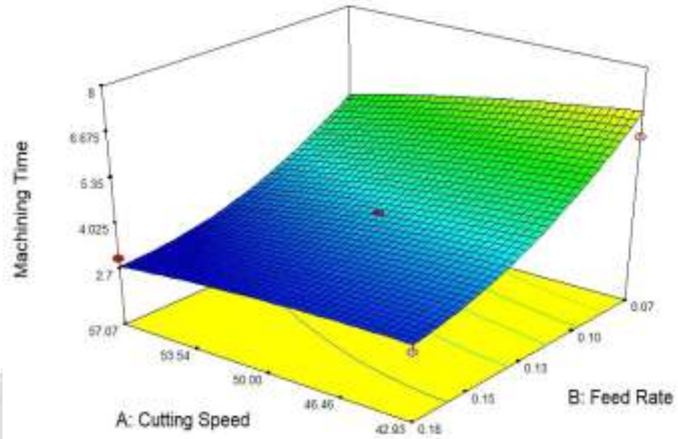

Figure 1: Graph for Machining Time

MATHEMATICAL EXPRESSION

The mathematical modelling is a better statistical tool used to evaluate the values of response outcomes for various combinations of input parameters. This method of data evaluation helps in theoretical decision making for finding optimal cutting conditions. Mathematical model can be derived by using Regression Analysis. In this work, a second order linear model has been deduced for the readings obtained from Response Surface method (Central composite design). The Central composite design enables the model to generate a second order correlation between the cutting parameters and the responses. A typical model of second order mathematical model has shown in equation 1.

$$y= nb_0+b_1x_1+b_2x_2+b3x_1^2+b4x_2^2+b5x_1x_2+\ldots+b_{nxn} \quad \ldots..(1)$$

where,
y – Response
n – Regression constant
b – Correlation coefficient
$x_1, x_2, \ldots, x_n$ – are cutting parameters.

The mathematical models of Machining time, Burr dimension and Circularity Error deduced for this work are shown in Equations (2).

$$\text{Machining Time} = +\ 12.32924 + 0.098989*C_S - 117.34067*f + 0.66667*C_S*f - 2.50000\text{X}10^{-3}*C_S^2 + 222.22222*f^2 \quad \ldots..(2)$$

where,
C_S– Cutting Speed
f - Feed rate.

OPTIMIZATION

Optimization is the approach of obtaining feasible outcome effectively from available key resources in a process. In such a way in this work in order obtain feasible values of Machining time from significant drilling parameters Cutting Speed and Feed rate an approach of optimization Genetic Algorithm is applied.

Genetic Algorithm

Optimization is the technique most needed in the current scenario of competitive growth in productivity, quality and cost of a product in order to obtain a best fit combination of values of cutting parameter that to lead effective improvement in responses.

A genetic algorithm (or short GA) is a search technique used in computing to find true or approximate solutions to optimization and search problems. Genetic algorithms are categorized as global search heuristics.

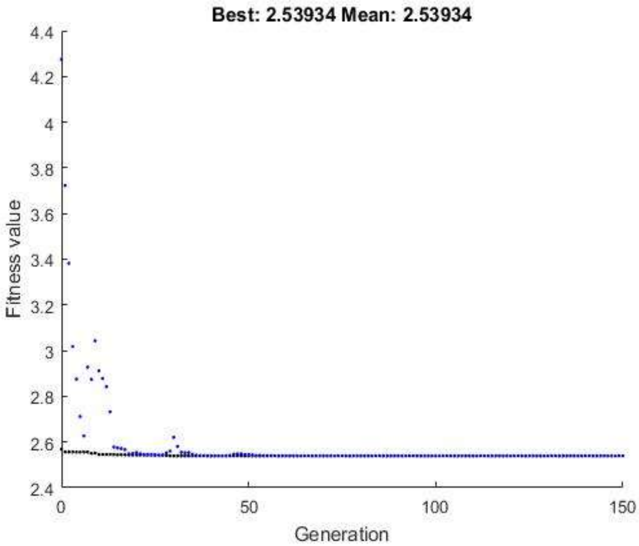

Figure 2: Graphical Simulation of Genetic Algorithm for Machining Time Using MATLAB

The genetic algorithm uses three main types of rules at each step to create the next generation from the current population:
Selection: Select the individuals, called parents, that contribute to the population at the next generation.
Crossover: Combine two parents to form children for the next generation.
Mutation: Apply random changes to individual parents to form children. The Genetic algorithm is applied in this work in order to find optimal cutting parameters, has been carried out in MATLAB 7.6.0 (R2008a).
The Graphical simulation of finding best individuals of cutting parameters for Machining time is shown in Figures 2.

RESULTS AND DISCUSSION

From ANOVA, it is predicted that the considered parameters cutting speed and feed rate are significant for the objective functions Machining time. As the R^2 value of Machining time are greater than 0.8 which ensures the navigation of model through the design space. Machining time decreases considerably with increase in cutting speed and also with increase in Feed rate.

CONCLUSION

This paper presents the findings of an experimental investigation into the effect of Cutting speed, Feed rate on the Machining Time when drilling Magnesium Alloy AZ31B. Minimum machining time can be obtained with maximum cutting speed and maximum feed rate. Genetic Algorithm is best modelling as it learns the best fit of even linear models. From these values, it is easily predictable that the Genetic Algorithm search to find optimal cutting parameters. The Optimal cutting conditions obtained from GA are shown in Table 5.

Table 5: Optimal Cutting Conditions

Objective Function – Minimization		**Cutting Speed (m/min)**	**Feed Rate (mm/rev)**
Machining Time(Sec)	2.539	40	0.174

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