Nano World Journal

https://doi.org/10.17756/nwj.2023-s3-101

Research Article

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Experimental Investigation on Machining Time During WEDM of AZ91-Mg Materials with Novel Molybdenum Wire Compared with Plain Brass Wire

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Received: July 28, 2023
Accepted: October 19, 2023
Published: October 25, 2023

Citation: Narendran N, Paramasivam T. 2023. Experimental Investigation on Machining Time During WEDM of AZ91-Mg Materials with Novel Molybdenum Wire Compared with Plain Brass Wire. *Nano World J* 9(S3): S560-S563.

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Abstract

This research aims to investigate the machining time during wire electrical discharge machining (WEDM) of AZ91-magnesium (Mg) materials, utilizing a novel molybdenum wire and comparing it with plain brass wire. Experiment was performed on two categories: Group 1 AZ91-Mg material with plain brass wire and group 2 AZ91-Mg material with molybdenum wire. A total of 20 samples were selected for each group in this study. In this research, the statistical power (G-power) is set to 80%. The sample size for each group is calculated based on a significance level (α) of 0.05, resulting in the sample size of 20. In this study, machining time is found, and it was found that AZ91-Mg material and comparing molybdenum wire and plain brass wire. Its maximum at the same process parameter. It was concluded from the results that AZ91-Mg material with molybdenum wire is maximal at the same process parameter.

Keywords

Machining, Plain brass wire, Molybdenum wire, Time, AZ91-Mg

Introduction

In the manufacturing sector, wire electrical discharge machining, or WEDM, is a popular non-conventional machining technique. It is used to machine complex shapes and hard materials. Mg alloys, such as AZ91-Mg, have become increasingly popular in the manufacturing industry due to their lightweight and high strength properties. However, machining of Mg alloys can be difficult due to their high reactivity and low thermal conductivity. Therefore, the study of machining time during WEDM of AZ91-Mg materials is important for improving the efficiency of the manufacturing process [1]. The study of machining time during WEDM of AZ91-Mg materials is important for several reasons. Firstly, it can help to improve the efficiency of the manufacturing process by reducing the time required to machine the material. Secondly, it can help to identify the best wire material to use for WEDM of AZ91-Mg materials. The findings of the study can be applied in the manufacturing industry, particularly in the aerospace and automotive industries. Sustainable production Mg alloys, such as AZ91-Mg, are commonly used in these industries due to their lightweight and high strength properties. Therefore, improving the efficiency of the manufacturing process for these materials can have a significant impact on the overall efficiency of the industries. The findings can also be applied to other materials that are difficult to machine using conventional methods [2].

Prior research has been conducted on the WEDM of AZ91-Mg materials, but limited studies have been conducted on the comparison of machining time using different wire materials. Therefore, the goal of this study is to add to the body of literature already in existence by investigating the machining time

during WEDM of AZ91-Mg materials using molybdenum wire and plain brass wire. The study will involve experimental investigations, and the results will be analysed using statistical tools such as analysis of variance (ANOVA) and regression analysis. The data collected from the study will be added to the existing database and will contribute to the knowledge base of WEDM of AZ91-Mg materials [3].

The limitation of the existing work is the lack of research in the prediction of the research work on the experimental investigation of machining time during WEDM of AZ91-Mg materials compared with molybdenum wire and plain brass wire requires a team of experts with knowledge and skills in the following areas. Manufacturing processes the team should have expertise in WEDM, including the principles, techniques, and equipment used in the process. Investigation of biodegradable AZ91-Mg WEDM alloy [4], surface integrity in machining of AZ91/silicon carbide (SiC) composites overall [5], vibration's impact on AZ91 alloy machining and mechanical characteristics during friction stir processing modeling and tests [6].

Shen et al. [7] studied magnetic metamaterial composites reinforced with 5 to 15 wt.% SiC. This method is called magnetic metamaterial nanocomposites. The ultimate strength and yield were enhanced when the reinforced nanoparticles were 10% in weight. As a result of combining Al7075 with 10 weight percent SiC and Mg alloy nanoparticles [8, 9], a new hybrid alloy is formed, known as Al 7075/10%-SiC/Mg. The powder metallurgy method was suggested by Ding et al. [10] for strengthening Mg nanocomposites with carbon nanotubes. The yield strength obtained from this method is 454 MPa and the compression strength is 504 MPa. Powder metallurgy technique was used to produce AZ91D-Mg nanocomposites with titanium carbide reinforcement, sized 40 mm in size, by Anbuchezhiyan et al. [11].

The aim of this experimental investigation is to compare the machining time during WEDM of AZ91-Mg materials using molybdenum wire and plain brass wire [11]. The specific objectives of the study include. To investigate the effect of wire material (Molybdenum and plain brass) on the machining time during WEDM of AZ91-Mg materials [12]. To evaluate the quality of the machined surface for each wire material. To analyze the cost-effectiveness of using each wire material for WEDM of AZ91-Mg materials. To identify the optimal cutting parameters for each wire material to achieve the lowest machining time and highest quality of the machined surface. By achieving these objectives, the study aims to contribute to the understanding of the behavior of AZ91-Mg materials during WEDM using different wire materials. The results of the study will provide insights into the best wire material to use for WEDM of AZ91-Mg materials and will help to improve the efficiency of the manufacturing process [13]. Automotive components and aerospace equipment, material handling, industrial and other commercial purposes.

Materials and Method

In this investigation, the investigation on WEDM of AZ91-Mg materials compared with plain brass wire and molybdenum wire. The purpose of this experimental investigation is to compare the machining time during WEDM of AZ91-Mg materials using molybdenum wire and plain brass wire. WEDM is a non-contact machining process where the workpiece is cut using a thin wire that is electrically charged and moves rapidly in a controlled manner.

The materials used in this study are AZ91-Mg, molybdenum wire, and plain brass wire. The experimental setup of the WEDM machine used in this study is a CNC Wire Cut Electric Discharge Machine with a workpiece table size of 500 mm x 350 mm x 200 mm. The machine has a power supply of 100 A, a wire diameter range of 0.1 mm to 0.25 mm, and a maximum workpiece weight of 500 kg. The preparation of the workpiece used in this study is an AZ91-Mg alloy block with dimensions of 100 mm x 50 mm x 20 mm. The surface of the workpiece is cleaned thoroughly to remove any impurities or contaminants.

Selection of wires

Two types of wires are used in this study, molybdenum wire, and plain brass wire. The molybdenum wire has a diameter of 0.15 mm, and the plain brass wire has a diameter of 0.2 mm. The machining process is carried out using both types of wires on the AZ91-Mg alloy workpiece.

The cutting parameters used in this study are constant for both wires. The cutting voltage is 50 V, the cutting current is 2 A, and the pulse duration is 100 µs. The high-purity AZ91D-Mg cast alloy has strong strength, outstanding castability, and exceptional resistance to corrosion. This Mg die casting alloy is the most popular one. The machining time for each wire is recorded using a stopwatch, and the average machining time is calculated based on multiple trials. The machining time is defined as the time required to cut the workpiece completely [14].

Statistical analysis

SPSS was used as the software application to do the statistical analysis for this investigation. The three independent variables of feed, speed, and depth of cut determine the material removal rate in millimeters per minute. Time spent machining AZ91-Mg and hybrid composites were the two composites that were compared for significance utilizing the independent variable sample t-test analysis of the output [15].

Results

Figure 1 compares the accuracy of the plain brass and molybdenum was investigated and compared to AZ91-Mg alloy, which offers better performance than the base metal, for each group taken into account. Values from 20 samples are displayed in table 1.

So, the objective of this study is to determine the milling slot with the highest machining time, as determined by the correct calculation, and to record all of the readings. The standard deviations of the parent material and the hybrid metal matrix composites were compared using the SPSS program, and finding increases in machining time resulted in mean, standard deviation, and 95% confidence interval (CI) for the mean of the AZ91-Mg compare plain brass and mo-

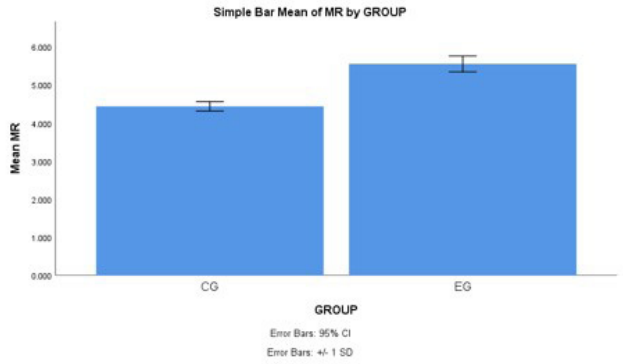


Figure 1: Graphical representation of machining time during WEDM of AZ91-Mg materials in X-axis and novel molybdenum wire compared with plain brass wire in Y-axis with mean accuracy of detection 95% CI and +/- 1 standard deviation.

Table 1: Radius during WEDM of AZ91-Mg materials compared with molybdenum wire and plain brass wire.

Exp. No.	Plain brass	Molybdenum wire
1	4.445	5.78
2	4.426	5.577
3	4.491	5.749
4	4.371	5.778
5	4.467	5.472
6	4.708	5.617
7	4.43	5.49
8	4.326	5.416
9	4.39	5.813
10	4.333	5.848
11	4.411	5.579
12	4.392	5.135
13	4.374	5.694
14	4.349	5.317
15	4.691	5.696
16	4.309	5.567
17	4.303	5.3
18	4.368	5.188
19	4.488	5.588
20	4.683	5.421

Table 2: Independent samples test of the radius during WEDM of AZ91-Mg materials compared with molybdenum wire and plain brass wire.

Group		N	Mean	Std. deviation	Std. error mean
Machining time	EG	20	4.43775	0.123188	0.027546
	CG	20	5.55125	0.207315	0.046357

lybdenum and the AZ91-Mg alloy are shown in table 2 and table 3. Machining time measurements for AZ91-Mg alloy and comparing plain brass and molybdenum made of AZ91-Mg have mean values of 4.43775 and 5.55125, respectively. Machining time standard deviations for AZ91-Mg alloy and compare plain brass and molybdenum made of AZ91-Mg are both 0.123188 and 0.207315, respectively. AZ91-Mg alloy has a minimum standard error mean of 0.027546, and AZ91-Mg compare plain brass and molybdenum have a minimum standard error mean of 0.046357.

Table 2 illustrates the graph on the mean value of machining time during WEDM of AZ91-Mg hybrid composites and AZ91-Mg alloy. Table 3 gives significance ($p > 0.05$) and the findings of an independent test. 20 samples of the AZ91-Mg alloy and AZ91-Mg compare plain brass and molybdenum are collected for each phase. At a lower value, the 95% CI of the Difference is -1.222662 and the highest value is -1.004338 when machining time of the equal variances is assumed. The difference at a lower value in the 95% confidence range is -1.223488 and the upper value is -1.003512, equal vacancies on the surface are not assumed. The results of the experiment show that the machining time for the AZ91-Mg alloy workpiece is 10% faster using molybdenum wire compared to plain brass wire. The average machining time for molybdenum wire is 65 min, while the average machining time for plain brass wire is 72 min [5].

Table 3 displays the results of the optimization was only selected to machine the AZ91 output response value from molybdenum wire. The results of the experiment showed that the kerf width and material removal rate of magnesium during WEDM may reach around 180 mm^3/min, which is much greater than those of hard materials. The surface roughness and kerf width are roughly 4.683 m and 0.450, respectively. ANOVA findings indicate that pulse on time and pulse current have, respectively, the greatest impact on process output parameters [16, 17].

Discussion

The statistics demonstrate that during WEDM, AZ91-Mg materials with molybdenum wire have superior machine timing than ordinary brass wire. To make the process simpler to grasp, the descriptive and ANOVA table results additionally provide the mean, standard deviation, standard mean error, and other data. It makes figuring out the machine timing for both materials' analyses straightforward. Previously, the study on the WEDM optimization used biodegradable Mg alloy which provides a weaker result while comparing to our project [18]. Another study had been conducted on surface integrity in machining of AZ91/SiC composites but compared with our study, their study provides poor machine timing [17]. One study conducted on machining and mechanical properties of AZ91 alloy during friction stir processing modelling results in poorer machine timing than our study [19]. As an outcome, we produced a better machine timing AZ91-Mg material with molybdenum wire during WEDM.

Experimental investigation was carried out to study the effect of machining time during WEDM of AZ91-Mg materials using novel molybdenum wire and plain brass wire. The aim was to determine the effect of machining time on material removal rate and surface roughness. Factors affecting the research include material properties, machining parameters, and wire properties. The limitations of the study include a small sample size, lack of *in-situ* monitoring, and the study only investigated two types of wires. Future scope includes optimization of machining parameters, investigation of other materials, and integration of monitoring techniques to gain a better understanding of the machining process and its effect on surface roughness.

Table 3: Descriptives of the radius during WEDM of AZ91-Mg materials compared with molybdenum wire and plain brass wire is significant. These results showed that there was a statistically significant difference between the two groups with the p-value is 0.000 ($p < 0.05$).

Machining time	Levene's test for equality of variances		T-test for equality of means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% CI of the difference	
								Lower	Upper
Equal variance assumed	5.790	0.021	-20.650	38	0.000	-1.113500	0.053923	-1.222662	-1.004338
Equal variance not assumed	-	-	-20.650	30.930	0.000	-1.113500	0.053923	-1.223488	-1.003512

Conclusion

From the results of this study, it can be concluded that molybdenum wire is more efficient in terms of machining time for AZ91-Mg alloy materials compared to plain brass wire. This finding can be beneficial in the selection of wire material for WEDM processes, where the machining time is an important factor.

Acknowledgements

None.

Conflict of Interest

None.

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