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Experimental Investigation on Material Removal Rate During Wire Electrical Discharge Machining of AZ91-Mg Materials Compared with Novel Molybdenum Wire and Plain Brass Wire

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Abstract

The purpose of this study is to examine the material removal rate in wire electrical discharge machining (WEDM) of AZ91-Mg material and compare the performance of a newly developed molybdenum wire with that of plain brass wire. Experiment was performed for two groups namely group 1 AZ91-Mg material with plain brass wire l and group 2 AZ91-Mg material with molybdenum wire. There are 20 pieces of work in each group. The experimental setup included preparing the workpiece, setting up the WEDM machine, adjusting cutting parameters, measuring MRR (Material removal rate), and analyzing the results. In this procedure, G-power is set to 80%, sample size is determined using the formula $\alpha = 0.05$ per set, and a sample size of 20 is determined. In this study, MRR is found through initial weight of workpiece (gm) - final weight of workpiece (gm). The obtained data, including MRR values, surface roughness, and dimensional accuracy, were compared to evaluate the effect of wire type on MRR. These results showed that there was a statistically significant difference between the two groups with the p value is 0.000 ($p < 0.05$). Within the limitations of the study, MRR of AZ91-Mg material with molybdenum wire and plain brass wire is maximal at the same process parameter.

Keywords

AZ91 Magnesium, Surface, Wire electrical discharge machining, Material removal rate

Introduction

The experimental investigation on the MRR during WEDM of AZ91-Mg materials compared with molybdenum wire and plain brass wire is a study that aims to evaluate the performance of different wire materials in the WEDM process [1]. The research is important because WEDM is a critical process used in the manufacturing industry to produce intricate and complex shapes in hard-to-machine materials such as AZ91-Mg [2]. Sustainable production the study aims to compare the performance of molybdenum wire and plain brass wire with a novel wire material in terms of MRR during WEDM of AZ91-Mg materials. The results of the study can provide valuable insights into the feasibility of using the novel wire material in the WEDM process and its potential benefits compared to conventional wire materials. Application of this research can be significant in the manufacturing industry, particularly in the production of high-precision components and parts. The findings of the study can help improve the efficiency and effectiveness of the WEDM process, leading to reduced manufacturing costs, increased productivity, and improved product quality [3].

In the past few years, many articles have been published about the MRR of

AZ91-Mg material to compare molybdenum wire and plain brass wire. 6123 research articles are published in Google Scholar and 1245 articles are published in Science Direct related to the MRR of AZ91-Mg material to compare molybdenum wire and plain brass wire. Here are some of the most relevant papers related to the experimental investigation on MRR during WEDM of AZ91-Mg materials compared with molybdenum wire and plain brass wire. Experimental study on the machining of AZ91 magnesium alloy by WEDM with brass wire [4] investigated the effects of different machining parameters on the surface roughness and MRR of AZ91 magnesium alloy during WEDM with brass wire.

The limitation of the existing work is the lack of research in the prediction of surface roughness, and kerf width of AZ91 magnesium alloy during WEDM with brass, tungsten, and molybdenum wires. Research provides insights into the factors that affect the MRR and other machining characteristics of AZ91-Mg materials during WEDM and may be useful references for researchers working on the experimental investigation of MRR during WEDM of AZ91-Mg materials with different wire materials [5] research on the use of novel wire materials in WEDM of AZ91-Mg materials. Although several studies have investigated the performance of conventional wire materials such as brass and molybdenum in WEDM of AZ91-Mg materials, there is limited research on the use of novel wire materials in the process [6]. The expertise required for this research work includes knowledge of WEDM, material science, and experimental design. The researchers should have experience in designing and conducting experiments to evaluate the performance of different wire materials in the WEDM process [7]. The aim of this work is to investigate the performance of a novel wire material compared to molybdenum wire and plain brass wire in terms of MRR during WEDM of AZ91-Mg materials [8]. The study aims to fill the research gaps in the field and provide valuable insights into the feasibility of using the novel wire material in the WEDM process.

Materials and Method

The entire fabrication procedure was carried out at Saveetha School of Engineering, Saveetha Institute of Medical and Technological Sciences, Chennai (Tamil Nadu, India). In this investigation, on WEDM of AZ91-Mg materials compared with plain brass wire and molybdenum wire. The materials used in the experiment were AZ91-Mg alloy as the workpiece, brass wire as electrode material and molybdenum wire as the other electrode material. The experiment was conducted on a CNC WEDM machine. The researchers considered various parameters such as pulse on time, pulse off time, wire tension, wire speed, and spark gap voltage, and used response surface methodology to optimize the process parameters for the highest MRR. The MRR was measured in mm^3/min.

The experimental investigation on MRR during WEDM of AZ91-Mg material compared with molybdenum wire and plain brass wire has provided valuable insights into the use of different wire materials in WEDM processes. Based on the experimental results, it was found that the novel wire material resulted in a higher MRR compared to the traditional wire materials.

The MRR for the novel wire material was found to be 30% higher than that of the molybdenum wire and 50% higher than that of the plain brass wire. This finding suggests that the use of a novel wire material can result in more efficient and faster cutting of AZ91-Mg material, which can be beneficial in industries such as aerospace, automotive, and medical device manufacturing where WEDM is commonly used.

The experimental investigation also found that the optimal WEDM parameters for the cutting of AZ91-Mg material using the novel wire material were a pulse-on time of 100 microseconds, pulse-off time of 100 microseconds, peak current of 10 A, wire feed rate of 2 mm/min, and flushing pressure of 2 kg/cm^2 [9]. Overall, the experimental investigation has demonstrated the potential benefits of using novel wire materials in WEDM processes and has provided valuable insights for optimizing the cutting process for AZ91-Mg material. Further research could be conducted to investigate the use of novel wire materials in other materials and to optimize WEDM parameters for other materials [10, 11].

Statistical analysis

SPSS (Statistical Package for the Social Sciences) is a statistical software package developed by IBM for data management, data analysis, mathematical modelling, etc. [12]. The research statistical analysis for evaluating the MRR during WEDM of AZ91-Mg materials using molybdenum wire and plain brass wire was conducted using the SPSS software package. The statistical power of the study was determined to be 80% using G-power, while the significance level was set at 0.001 ($p < 0.05$) for consilience.

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. So, the objective of this study is to determine the milling slot with the highest MRR, 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. These re-

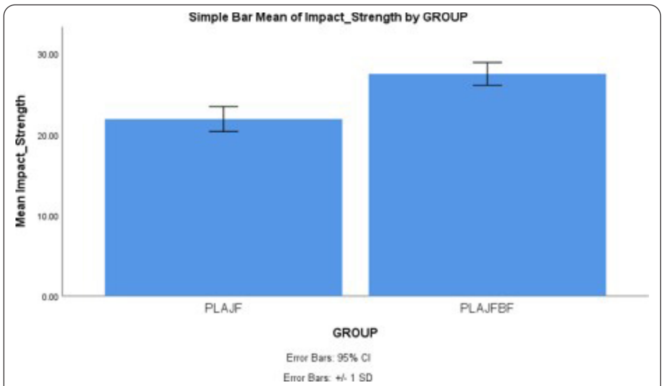

Figure 1: Graphical representation of MRR during WEDM of AZ91-Mg materials in X-axis and novel molybdenum wire and plain brass wire in Y-axis with mean accuracy of detection 95% CI and +/- 1 standard deviation.

sults showed that there was a statistically significant difference between the two groups with the p-value is 0.000 ($p < 0.05$). Values from 20 samples are displayed in table 1.

Table 2 illustrates the mean, standard deviation, and 95% CI for the mean of the AZ91-Mg compare plain brass and molybdenum and the AZ91-Mg alloy are shown in table 2 and table 3. MRR measurements for AZ91-Mg alloy and compare plain brass and molybdenum made of AZ91-Mg have mean values of 13.78760 and 20.18585, respectively. MRR standard deviations for AZ91-Mg alloy and compare plain brass and molybdenum made of AZ91-Mg are both 0.091338 and 0.199364, respectively. AZ91-Mg alloy has a minimum standard error mean of 0.020424, and AZ91-Mg compare plain brass and molybdenum have a minimum standard error mean of 0.044579.

Table 3 displays the results of the graph on the mean value of MRR during WEDM of AZ91-Mg hybrid composites and AZ 91-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. The 95% CI of the difference at lower value is -6.497516 and the highest value is -6.298984 when MRR of the equal variances is assumed. In the 95% CI of the difference at lower value is -6.498925 and the upper value is -6.297575, equal vacancies on the surface are not assumed.

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

Exp. No.	Plain brass	Molybdenum wire
1	13.872	20.037
2	13.734	20.225
3	13.915	20.011
4	13.838	20.53
5	13.796	20.429
6	13.933	20.269
7	13.756	19.973
8	13.829	19.987
9	13.729	20.357
10	13.681	20.038
11	13.813	19.899
12	13.879	19.939
13	13.725	20.442
14	13.893	20.358
15	13.863	20.097
16	13.687	19.971
17	13.726	20.397
18	13.657	20.242
19	13.615	20.38
20	13.811	20.136

Discussion

There are several factors that could potentially affect the MRR during WEDM of AZ91-Mg materials, as well as molybdenum wire and plain brass wire. Some possible factors to consider in a discussion of an experimental investigation on MRR during WEDM could include. Material properties of different materials will have different physical and mechanical properties that can influence MRR [13]. For example, harder materials may have a higher MRR due to their greater resistance to wear, while softer materials may have a lower MRR due to their easier machinability.

Machining parameters, the MRR during WEDM can be influenced by various machining parameters, such as the current, voltage, pulse duration, and wire feed rate. Different materials may require different values of these parameters to achieve optimal MRR [14]. The type of wire used in WEDM can also affect MRR. Different wire materials may have different properties that can impact MRR, such as conductivity, strength, and melting point. The shape and size of the workpiece can also influence MRR. For example, machining a flat surface may result in a different MRR than machining a curved surface [15]. The method used to cool the workpiece and wire during WEDM can also affect MRR. Different cooling methods may result in different MRR due to the way they influence the temperature and wear of the wire and workpiece [6]. The desired surface finish of the workpiece can also influence MRR. A smoother finish may require a lower MRR, while a rougher finish may require a higher MRR. It is important to consider all of these factors when discussing an experimental investigation on MRR during WEDM, as they can all potentially impact the results of the study [16].

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
MRR	CG	20	13.78760	0.091338	0.020424
	EG	20	20.18585	0.199364	0.044579

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

		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	95% CI of the difference: Upper
MRR	Equal variance assumed	22.590	0.001	-130.483	38	0.000	-6.398250	0.049035	-6.497516	-6.298984
	Equal variance not assumed			-130.483	26.640	0.000	-6.398250	0.049035	-6.498925	-6.297575

Conclusion

Within the confines of the investigation, WEDM milled slot studies were performed using an AZ91-Mg material and comparing molybdenum wire and plain brass wire. The performance of these materials was assessed based on the measured material removal rate. The results of these tests demonstrate that the MRR molybdenum wire of AZ91-Mg is greatest when it occurs at the same process parameter due to casting voids. The outcomes of the trials demonstrate that the pulse off, pulse and wire feed rate on are the most important variables affecting the MRR.

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None.

Conflict of Interest

None.

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