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An analysis of mechanical properties and optimization of EDM process parameters of Al 4032 alloy reinforced with Zrb_2 and Tib_2 in-situ composites

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ABSTRACT

In the present study, the new engineered metal matrix composites (MMC) Aluminum 4032 is reinforced with reinforcement particles Zrb_2 and Tib_2 in various Wt. % (0,2,4,6,8) at room temperature through the stir casting method. The reinforcement particles Zrb_2 (Zirconium Boride) and Tib_2 (Titanium Boride) influences the mechanical property and parameters such as material removal rate, tool wear rate and depth in EDM machining process. Initially, the mechanical property such as tensile, compressive and hardness value has been measured for the Al 4032 composite alloy and it proves that increase in mechanical strength is due to the increase in reinforcement particles. Electrical discharge machining (EDM) is carried out on the composite alloy Al 4032 with tool as copper electrode where input parameters such as Pulse ON, (μS) Pulse OFF (μS) Current (Amps) is provided initially to set up the machining process. To identify the optimize process parameter in EDM machining process which influence to obtain minimum material removal rate (MRR), tool wear rate (TWR) and depth (Depth), the Taguchi L_{25} orthogonal array is used. The analysis of variance (ANOVA) was used to investigate the percentage of contribution by each parameter. The variation of current (amps), Pulse ON, Pulse OFF of the Al 4032 composite have been measured with the function of three parameter such as MRR, TWR and depth.

1. Introduction

The property such as low density, high specific strength and specific stiffness are in-corporatized in metal matrix composites. The metal matrix composites are good resistance to abrasion, temperature and impact as well as good shock absorption, good dimensional stability and casting. These advantages contribute to the wide acceptance of aluminum matrix composites in high-technology structural and functional applications in fields such as mining, aerospace, automotive, defense, electronic industries, sports and recreation [1,2]. MMC's have to chemically and physically distinct phases. Which are distributed to provide properties which are not obtainable either of the individual phases [3]. MMC's are produced in a different way of conventional metal alloying. These composites are produced by combining two preexisting constituents [4]. In this investigation, the reinforced particles such as Zrb_2 and Tib_2 in various Wt. % (0,2,4,6,8) is mixed with the matrix alloy Al 4032 to form composite alloy through in-situ process. The reinforced particles Zrb_2 and Tib_2 are formed by the mixing of three salts such as of K_2ZrF_6, k_2TiF_6 and KBF_4. These particles posses high reinforcement for composites has both physical and mechanical strength. Here electrical discharge machining (EDM) is used to drill hole on the upper surface of the specimen. In total, around twenty five specimens are made in desired shape and size of copper electrode is used to conduct this experiment. The mechanical property such tensile, compressive and hardness value has been measured by conducting various test according to the ASTM standards. The input parameter assigned in EDM process such as Pulse ON, (μS) Pulse OFF (μS), Current (Amps) is used to measure the output parameter such as material removal rate (MRR), tool wear rate (TWR) and depth (Depth) with function of composites in various Wt. %. The Taguchi L_{25} orthogonal array has been used to identify

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the most influential process parameter and find out the minimum MRR, TWR and Depth value for the composite alloy Al 4032. The Analysis of variance (ANOVA) is used to obtain the total percentage of contribution of each parameter in MRR, TWR and Depth. The variation of current (amps), Pulse ON, Pulse OFF of the Al 4032 composite alloy is measured as a function of MRR (g/min), TWR (g/min) and Depth (g/min) in composite alloy with various Wt. % of reinforcement.

2. Experimental details

2.1. Material selection

In this investigation, the matrix material Al 4032 is considered as the base material were combined with reinforcement particles such as Zrb_2 and Tib_2 in various Wt. % to form the Al 4032 composite alloy. The reinforcement particle such as Zrb_2 and Tib_2 are initially formed separately by mixing of three salts such as K_2ZrF_6, k_2TiF_6 and KBF_4 in appropriate Wt. %. The composite alloy Al 4032 is made by adding the Al 4032 matrix material with reinforcement particles in various Wt. % (0,2,4,6,8) to form a five different set of work pieces. The chemical composition of Al 4032 alloy with various Wt. % is shown in the Table 1. The matrix material Al 4032 is mixed with the reinforcement particles Zrb_2 and Tib_2 to expose the strength of mechanical properties of in-situ composites in various weight percentages from its standard consideration.

2.2. Work piece design

The stir casting method is used in this study to prepare the work piece for this experiment. The work piece is prepared by the mixing of matrix alloy Al 4032 with reinforcement particles such as Zrb_2 and Tib_2 in various Wt. % (0,2,4,6,8). The work piece made up of Aluminum 4032 with reinforcement particle is shown in Fig. 1. In the process of stir casting method, it poses a crucible made up of graphite, in which the matrix material Al 4032 is taken along with the reinforcement particles in various Wt. % (0,2,4,6,8) is poured in to and heated to a temperature of 850 °C, which forms an molten metal. This molten metal is stirred well to make the particles to distribute even in all above the surface with an aid of stirrer. The chemical reaction between the inorganic salts and the molten Al took place to form in situ particulates [5]. Finally, the molten metal is transferred in to the mold is made in the shape of cylindrical with diameter of 10 mm and length of 25 mm. This mold is done to parch and the work piece is detached to obtain desired shape and size through turning and facing operations.

2.3. EDM machining process

The EDM is a manufacturing method where a work piece is made in accurate shape and size through electric discharge sparks. In this study, the twenty five specimens are considered with size of diameter 10 mm and length 25 mm for the EDM process. The process is carried out in an AC power supply of 415 V and kerosene is considered as a di-electric fluid as it posses low chemical reactivity. The electric discharge machine along with setup is shown in Fig. 2. The copper electrode is used as tool for this process shown in Fig. 3 and the Table 2 show the properties of tool – copper

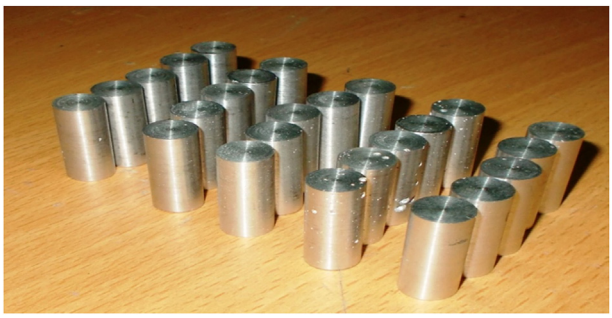

Fig. 1. Work piece made up of Aluminum 4032 composite alloy.

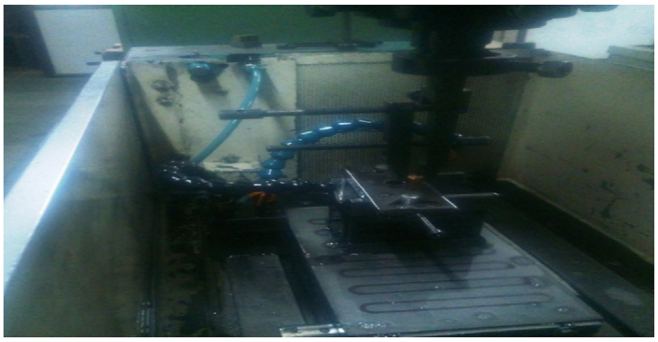

Fig. 2. EDM machine setup.

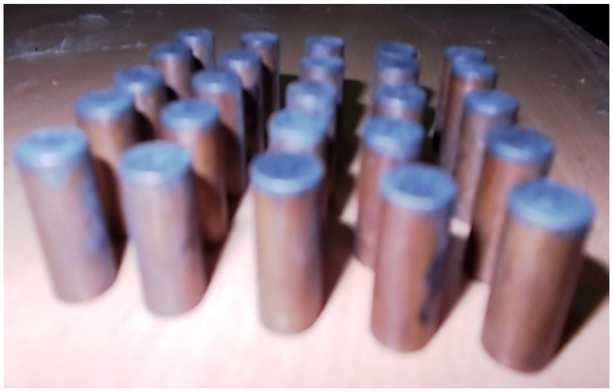

Fig. 3. Tool – copper electrode.

Table 2
Shows the properties of electrode material.

S. No	Properties	Value
1	Melting point (°C)	1083
2	Elastic modulus(E) (N/mm^2)	1.23×10^5
3	Poisson's ratio	0.26
4	Density (gm/cm^3)	8.9

Table 1
Chemical composition of Al 4032 alloy in Wt. %.

Element	Si	Cu	Mg	Ni	Fe	Cr	Zn	Al
Wt%	11–13.5	0.5–1.3	0.8–1.3	0.5–1.3	1.0 max	0.10 max	0.25 max	Bal