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Electric Discharge Machining of Titanium Grade 2 Alloy and its Parametric Study

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Abstract

The present paper focuses on the electric discharge machining (EDM) of Titanium Grade 2 alloy. The variation in material removal rate (MRR), tool wear rate (TWR), and surface roughness (SR) with the variation of process parameters, for example, current and pulse on time is studied in this paper. Experiments have been carried out as per the Taguchi L_{16} orthogonal array design of experiments (DOE). All the experiments have been carried out using electrolytic copper as tool electrode and hydrocarbon oil as a dielectric fluid. The optimum condition for each response has been evaluated by analyzing the effect of input parameters on the mean of the responses. Analysis of variance (ANOVA) has been performed to study the percentage contribution of each input parameter on the output responses. Highest MRR of 0.0053367 g/min, lowest TWR of 0.0000067 g/min and SR of 2.960 µm has been achieved.

*Keywords:*Electro discharge machining; Ti Grade 2;surface roughness; tool wear rate; material removal rate

1. Introduction

EDM is one of the most widely used non-conventional machining processes which can machine any electrically conductive material regardless of its strength and hardness. Press tools and dies can be manufactured using this machining process. There is no chance of distortion due to stress on the workpiece as there is no physical contact between the electrode and the workpiece [1]. In 1940 by B. R. Lazarenko and N. I. Lazarenko initially employed EDM for stock removal which was established as an elementary die-sinking machine [2]. Nowadays EDM is used in

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all sectors of industry and medicinal use also. As there is no connection between tool and workpiece hence there is no stress on the workpiece and the machining sound also reduces[3].The performance of EDM is mainly described in terms of MRR, TWR, and surface quality. Again the process parameters influence these performance measures. There are two types of process parameters namely, electrical and non-electrical parameters [4]. Electrical parameters include discharge voltage, polarity, discharge current, pulse on time and pulse off time. Non-electrical parameters include tool electrode lift time, flushing pressure, working time, gain and reciprocating speed. EDM being a machining process, MRR is the most important output response of EDM. The efficiency of EDM mainly depends on MRR which reflects the operational speed of production.MRR can be defined in terms of weight or volume of the material removed from the workpiece over the machining time [5,6]. TWR is another important parameter on which efficiency and accuracy of EDM depends on. The surface produced on the workpiece will be erroneous if the TWR is high. TWR is defined as the weight or volume of tool material worn out over the machining time [7,8]. Surface quality plays a vital role in applicability and saleability of a product[9]. In most of the cases, center line average (Ra) is considered as a parameter to evaluate surface quality of an engineering product.

Titanium is a very high strength, low weight ratio, and corrosion resistant material. It has vast use in the field of aerospace, biomedicine, and automobile industries[10,11].Hasçalık and Çaydaş[12]used different types of tool electrode material such as copper, graphite, and aluminum to machine Ti-6AL-4V. They found that MRR, TWR, and surface roughness increased with increase in current value and pulse on time. Wang et al. [13]machined titanium alloy (TC4) in three different types of dielectric fluid such as a compound dielectric fluid, distilled water and kerosene. They observed that compound dielectric fluid has better superior MRR, lesser TWR, and higher surface finish than kerosene.Shabgard and Khosrozadeh[14]studied the machining characteristics of Ti-6Al-4V by mixing CNT powders in the dielectric fluid. They found that MRR reduced initially, but with a high pulse on time and lower current combinations, the MRR increased. TWR decreased for the low pulse on time values. For stable machining conditions, surface roughness in CNT mixed EDM is lower than the conventional EDM and vice versa. Torres et al. [15]studied the machining of TiB_2 using copper electrode in EDM. They observed that current was the main contributing factor for MRR and surface roughness, but for TWR pulse on time was the most important factor.

Literature survey inferred that machinability study of Ti and its alloys by EDM are still in developing stage. This paper aims at the parametric study of electric discharge machining of Ti Grade 2 alloy by varying current and pulse on time. MRR, TWR, and SR have been considered as the response parameters. All the experiments have been done using Taguchi L_{16} orthogonal array. The process parameters which effect MRR, TWR, and SR, are studied by ANOVA.

2. Materials and Methods

The experimentshave been performed in a die sinking EDM (Make: Sparkonix (I) Pvt. Ltd.; Model: S25). Titanium Grade 2 alloy has been used as workpiece material, and electrolytic copper has been used as tool material. The dimension of the workpiece is 25×25mm. The diameter of the tool is 13mm (Fig. 1). The workpiece material has been made into pieces of required dimension from a large plate in a wire electric discharge machine (WEDM). Facing and polishing operationshave been done for flattening the surface of the tool for a better impression on the workpiece. The weight of all the workpieces and the tools have been measured before and after each experiment on a precision analytical balance (Make: Ishida Co. Ltd., Model-DXR220) weight measuring machine. Machined specimens are shown in Fig. 2. Through pilot experiments on the different process parameter values, it has been understood that negative polarity does not yield good machining. Hence all the experiments have been measured in straight polarity. Voltage ranges between 25-30 Volts. Initial and final weights of the tool and workpiece have been measured.MRR and TWR have been calculated by equation (1) and equation (2) respectively.

$$MRR = \frac{W_i - W_f}{t} \qquad (1)$$