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Study the impact of process parameters and electrode material on wire electric discharge machining performances

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Abstract

Wire electric discharge machining (WEDM) is an advance manufacturing process for machining hard materials. The machining efficiency and productivity of WEDM not only depends on machining parameters but also improved by proper selection of electrode material. In this investigation brass wire and silver coated brass wire are selected as electrode material to evaluate the influence of wire material on WEDM machining performances. From analysis of variance, it was reveals that pulse on time, servo voltage is one of the dominant parameters. Machining with silver coated brass wire found to be best alternative of brass wire on the Maraging steel 300.

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Keywords: WEDM; brass wire; silver coated wire; WC; SR; surface morphology.

1. Introduction

WEDM is a versatile advance manufacturing technology for the production of precision micro elements with complicated shapes and multidimensional profiles by using a thin wire as electrode of diameter varying (0.1-0.3) mm [1,2]. The wire electrode is mainly made of copper, brass, molybdenum, tungsten, zinc coated brass etc. [3]. Wire-cut machining used thermoelectric energy to remove unwanted material from the surface of work piece. The cutting operation is performed due to uninterrupted sparks generated between the tool and work piece [4]. There is

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no physical contact between wire electrode and work piece. Thus eliminates the chance of generating stress between two electrodes [5]. The WEDM process is capable to machine high strength, temperature resistive material without any geometrical error. It has many applications in aerospace, nuclear, automotive industry, tooling and die making industry [6]. In conventional cutting production of an intricate shape in hard to machine materials is difficult phenomena [7]. Therefore, advance nonconventional machining processes like WEDM are effectively employed as an alternative process to overcome this problem. Due to increasing demand for machining advanced high strength materials, WEDM play a significant role in this area. Previous studies also discussed the machinability of WEDM process in different field of manufacturing which display good machinability compared to the conventional machining process. Saha et al [8] studied the impact of WEDM control parameters on material removal rate, surface roughness, machining time during machining nanostructured hard facing alloy with brass and zinc coated brass wire electrode. It was also detected that pulse time and servo voltage shows major effect on machining performance of zinc coated brass wire and brass wire respectively. Manjaiah et al [9] implemented experiments on WEDM of Ti50Ni45Cu5 shape memory alloy to study performance characteristics behavior. They found that recast layer, craters, micro cracks, voids were increased on the machine surface due to current and pulse on time. Shakeri et al [10] discussed the WEDM of cementation alloy steel. The study evidently indicates that pulse current (IP) and frequency were the parameters that affect performance characteristics of WEDM most significantly. Zhang et al [11] examined thickness of white layer and crack density on the machined surface of tungsten tool YG15 after WEDM process. Results confirmed that surface roughness along with crack density trends to increase due to combined effect of high pulse current and pulse on time. Aggarwal et al [12] investigated the correlation between process parameters and surface roughness of wire cut machined surface by using zinc coated brass wire. It was detected that roughness rises with increasing pulse on time. It also dropped with increasing value of spark gap voltage. Prasad et al [13] developed a relationship between process variables and wire wear ratio. Author found that wire wear ratio increases with increasing pulse on time (T_{on}), pulse off time (T_{off}), wire feed (WF). Using scanning electron microscopy (SEM) analysis of micro WEDM machining surface of Ti-6Al-4V, kuriachen et al [14] et al confirmed that larger craters were generated on the machined surface which decreases the surface finish due to high discharge energy intense spark occur at the machining zone that erodes the material from the surface frequently.

Even though many works are discussed to show WEDM capabilities of machining complex and contour profile for different application field, the surface quality of Maraging steel 300 is poorly studied. Effect of tool material on the performance characteristics of WEDM is also need to be discussed. Due to high requirements of excellence quality in aerospace and aircraft components, it is essential to determine WEDM performance during machining of Maraging steel 300. The present investigation reports the impact of several process parameters such as T_{on} , T_{off}, IP, SV, wire tension (WT) and wire material (brass wire and silver coated brass wire) on WEDM performance characteristics including surface roughness (R_a), wire consumption (WC) and surface metallographic changes.

2. Experimental Details

The experiments were performed on “ELECTRONICA SPRINGCUT WEDM”. Various process parameters such as pulse on time, pulse off time, peak current, servo voltage, wire tension were selected for this investigation. Their levels and range are shown in Table 3. A number of experimental trials have been conducted to select the range of process parameters for these experiments. After that experimental design was planned using Taguchi L25 L27orthogonal array (presented in Table 4) for this current approach. The Taguchi approach is used to reduce the number of runs, overall experimental time and the influence of nuisance factors. This method helped to evaluate the influence of machining parameters on machining performance such as surface roughness and wire consumption. Each experiment was simulated twice to reduce the experimental error. Depending on machine performance, few control parameters were kept constant during whole machining process such as wire running speed (4.0 m/min), servo feed (1020 machine unit), wire guides distance (30 mm), flushing pressure (10.0 L/min). The standard brass wire and silver coated brass wire of same diameter (0.25mm) were used as wire electrode to evaluate the effect of tool material on machining performance which also finally justified by analyze the image, obtain from scanning electron microscope (SEM) and Energy Dispersive X-Ray analysis (EDX) analysis.