Chapter 4

Optimization of Surface Roughness Parameters by Different Multi-Response Optimization Techniques During Electro-Discharge Machining of Titanium Alloy

Anshuman Kumar Sahu
National Institute of Technology Rourkela, India

Siba Sankar Mahapatra
National Institute of Technology Rourkela, India

ABSTRACT

In this chapter, the EDM process is performed by taking titanium alloy as work piece and AlSiMg prepared by selective laser sintering (SLS) process as tool electrode along with copper and graphite. The EDM is performed by varying different process parameters like voltage (V), discharge current (Ip), duty cycle (τ), and pulse-on-time (Ton). The surface roughness parameters like Ra, Rt, and Rz are measured by the use of surface roughness measurement machine. To reduce the number of experiments, design of experiment (DOE) approach like Taguchi’s L27 orthogonal array has been used. The surface properties of the EDM specimen are optimized by desirability function approach, TOPSIS and VIKOR method, and the best parametric setting is reported for the EDM process. All the optimization techniques convergence to the same optimal parametric setting. The type of tool is the most significant parameter followed by discharge current and voltage. Better surface finish of EDM specimen is produced with lower level of parametric setting along with the use of AlSiMg RP electrode during EDM.

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INTRODUCTION

Now-a-days, Electro-discharge machining (EDM) is a widely used non-conventional machining process due to its applications to produce complex, intrinsic cavity with excellent surface finish components, which can be used in automobile, chemical, aerospace, biomedical, tool and die industries. In EDM process, both work piece and tool electrode are submerge inside a dielectric fluid. During machining, a spark channel is generate in between the electrode and work piece gap with generation of very high temperature of around 10000°C. This high temperature is sufficient to melt and vaporizes tiny amount of material from the work piece surface that leads to the material removal from the work piece surface. The use of EDM process is required to machine difficult to machine materials, which required accurate dimensions and excellent surface finish to meet its requirement in industries. Titanium and its alloys are used in biomedical industries like tooth implants and biomedical instrumentation and aerospace due to its properties like high strength to weight ratio, high corrosion and erosion resistance and good strength in wide range of temperature variation. To meet its requirement in industries, the parts produced must be excellent surface (Sahu, Mohanty, & Sahoo, 2017). To study the surface properties of the machined surfaces three characteristics are taken for analysis like average roughness (Ra), maximum height of the profile (Rt) and average height of the profile (Rz). To achieve excellent surface finish the performance of three different tool electrodes are studied. Here AlSiMg tool electrode prepared via selective laser sintering (SLS) process along with conventional copper and graphite electrodes are used. The SLS process is an additive manufacturing (AM) technique used the powder fused based techniques. Here, the laser fuses powder layers and produced three-dimensional components layer by layer. This SLS process also able to produce complex intrinsic tool electrode with less time (Durr, Pilz, & Eleser, 1999). Therefore, the performance of the SLS tool electrodes is studied as compare to copper and graphite electrode with consideration to the surface characteristics of the EDM machined surfaces.

BACKGROUND

Pradhan et al. have analyzed the average surface roughness of the EDMed surface by neural network models during EDM of AISI D2 steel work piece material (Pradhan, Das, & Biswas, 2009). Similarly, the surface properties like Ra, Rt and Rz are measured. The best optimal parametric setting is found out by using optimization techniques like VIKOR based Harmony search algorithm and desirability function approach to get excellent surface finish during electrical discharge coating and electrical discharge machining of AISI 1040 stainless steel and Nitinol respectively (Sahu, Mahapatra, & Chatterjee, 2017; Sahu, Chatterjee, Nayak, & Mahapatra, 2017). SLS process is use to prepare EDM electrode and the surface characteristics performance of the machined surface is studied during EDM process by taking Nitinol as work piece material (Sahu, Chatterjee, Nayak, & Mahapatra, 2017). Arthur at al. have used epoxy with silver paint and copper coating electrode prepared by rapid prototype process during machining of hardened tool steel to study the EDM performance of the electrodes. The thin-coated SL tool were rupture during machining where coating thickness is less than 180µm. However, electrode can used for semi-roughing or for finishing operations (Arthur et al., 2007). Different researchers have used SLS process to prepared EDM tool electrodes of different composition like bronze-nickel with copper phosphite, steel, phosphate and polyester as binder (Durr, Pilz, & Eleser, 1999; Zhao, Li, Zhang, Yu, & Zhang, 2003). Similarly, some other rapid tooling process are adopted to prepare EDM electrodes.