Experimental investigation of EDM Process parameters in Machining of 17-4 PH Steel using Taguchi Method

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Abstract

Electrical discharge machining is one of the advanced unconventional machining processes. EDM process is based on thermoelectric energy between the work piece and an electrode. In the present study, the optimal setting of the process parameters of Electric Discharge Machining was determined. The important process parameters that have been selected are peak current, pulse on time, pulse off time and tool lift time with output response as Material Removal Rate and Surface Roughness. L27 Taguchi experimental design was used to conduct the experiments on 17-4 Precipitation Hardening Stainless Steel (PH Steel) with copper tungsten electrode. ANOVA method was used with the help of MINITAB 17 software to analysis the influence of input process parameters on output response. The process parameters were optimized in order to obtain maximum material removal rate and minimum surface roughness by considering the inter action effects of process parameters and the experimental results were validated by confirmation tests. The analysis of Taguchi method reveals that peak current, pulse on time and tool lift time have significantly affected the material removal rate and surface roughness. Surface topography of the machined samples is analyzed using Scanning Electron Microscopy for optimal levels of process parameters

Keywords: copper tungsten electrode; MRR; Taguchi method; PH Steel; SR.

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1. Introduction

Electric Discharge Machining is one of the most extensively used non-conventional material removal process for difficult-to-cut materials. EDM is a thermo-electric process in which material is removed from work piece by erosion effect of series of electric discharges known as sparks between tool and work piece immersed in a dielectric liquid. Physical and metallurgical properties do not create any limitation for the materials to be machined on EDM very popular in machining difficult-to-cut materials. The EDM process has a very strong stochastic nature due to the complicated discharge mechanism that makes optimization difficult.

Literature reports wide experimental and analytical studies on process modeling and optimization of EDM process to improve its accuracy and productivity. Aditya Kumar et al. [1] performed the parametric analysis of wire EDM parameters by taguchi method and developed a mathematical model for simultaneous optimization by hybrid genetic algorithm. Arshad Noor Siddiquee et al. [2] focused on optimizing deep drilling parameters of CNC lathe machine using solid carbide cutting tool on material AISI 321 austenitic stainless steel based on Taguchi method for minimizing surface roughness. Srinivasa Rao et al. [3] studied hybrid method combining grey, fuzzy and Taguchi approaches was implemented for submerged arc welding. S. Assarzadeh et al. [4] modeled and optimized process parameters in EDM of tungsten carbide-cobalt composite using cylindrical copper tool electrodes in planned machining based on statistical Technique Response surface methodology has been used to plan and analyze the experiments. Chen et al. [5] had utilized Taguchi design methodology to optimize the EDM process parameters for the machining of A6061-T6 aluminum alloy. Nikalje et al. [6] used Taguchi method to determine the influence of process parameters and optimization of MDN 300 steel in EDM. Results showed that that the optimal level of the factors for TWR and SR were same but differed from the optimum levels of the factors for MRR and RWR. Kodlinge and Khire [7] had presented detailed investigation on MRR of Tungsten carbide for EDM operation using Kerosene as dielectric medium. Das et al.[8] performed investigation on the effect and optimization of machining parameters on Material Removal Rate in EDM of EN31 tool steel. Observed that the current has the most significant effect on MRR. Dhanabalan et al. [9] described the multi objective optimization based on the orthogonal array with the Grey relational analysis in EDM process ,studied the influence of parameters on the MRR, TWR and SR. S. Gopalakannan et al. [10] investigated the influence of process parameters and their interactions on MRR, EWR and SR of metal matrix composite of aluminum 7075 reinforced with 10 wt. % of B4C. Pragya Shandilya et al [11] optimized the process parameters during machining of SiCp/6061 Al metal matrix composite by wire Electrical discharge machining using response surface methodology and mathematical model have been developed to investigate the kerf, microstructure and surface roughness, concluded that input process parameters play a significant role in the minimization of kerf. Alikbari[12] optimized the process parameters using taguchi method in rotary electric discharge machining of X210CrNi12 alloy material with three copper electrodes: electrode without hole , electrode with one concentric hole and electrode with to symmetric eccentric hole. The tool hole numbers increases MRR, SR, and EWR increases due to the area of the electrode was decreased, and the discharged energy had a higher density and better flushing.

From the above literature study several researches have been research done on the EDM process on various materials but not electrical discharge machining of 17-4 Precipitation Hardening Stainless Steel machined with copper tungsten electrode. In this paper, a EDM process is performed with four controllable process parameters peak current, pulse on time, pulse off time and tool lift time, while machining of the Hardening Stainless steel with copper tungsten tool electrode. Then, the machining conditions have been optimized for high performance machining using the Taguchi method because of its simplicity and it gives a systematic approach to optimize the process parameters.

2. Taguchi’s Signal to Noise (S/N) ratio:

Taguchi design method is to identify the parameter settings which render the quality of the product or process robust to unavoidable variations in external noise. The relative “quality” of a particular parameter design is evaluated using a generic Signal-to-Noise (S/N) ratio. Depending on the particular design problem, different S/N ratios are applicable, including “lower is better” (LB), “nominal is best” (NB), or “higher is better” (HB). S/N ration can be calculated as a logarithmic transformation of loss function and the characteristics selected for MRR and SR are “higher is better” and “Lower is better” as given in equations 1 and 2 respectively. The experimental values and their corresponding S/N ration values for MRR and SR are shown in table 2.
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