Measurement 58 (2014) 495–502

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Application of Taguchi-grey multi responses optimization on process parameters in electro erosion

T. Muthuramalingam [a,*], B. Mohan [b]

[a] Department of Mechatronics Engineering, SRM University, Kattankulathur, India
[b] Department of Mechanical Engineering, Anna University, Chennai, India

ARTICLE INFO

Article history:
Received 3 April 2014
Received in revised form 4 September 2014
Accepted 11 September 2014
Available online 19 September 2014

Keywords:
Current
Duration
EDM
Optimization
Spark
Taguchi

ABSTRACT

Convention Taguchi method deals with only single response optimization problems. Since the electrical discharge machining process involved with many response parameters, Taguchi method alone cannot help to obtain optimal process parameters in such process. In the present work, an endeavor has been made to derive optimal combination of electrical process parameters in electro erosion process using grey relational analysis with Taguchi method. This multi response optimization of the electrical discharge machining process has been conducted with AISI 202 stainless steel with different tool electrodes such as copper, brass and tungsten carbide. Gap voltage, discharge current and duty factor have been used as electrical excitation parameters with different process levels. Taguchi L_{27} orthogonal table has been assigned for conducting experiments with the consideration of interactions among the input electrical process parameters. Material removal rate, electrode wear rate and surface roughness have been selected as response parameters. From the experimental results, it has been found that the electrical conductivity of the tool electrode has the most influencing nature on the machining characteristics in EDM process. The optimal combination of the input process parameters has been obtained using Taguchi-grey relational analysis.

1. Introduction

1.1. Electro erosion process

Electro erosion process or electrical discharge machining (EDM) is removing material from the work piece by thermal erosion owing to the spark energy happened between two conductors. The ionization of dielectric medium has the important role in such process. Ho and Newman narrated about the mechanism involved in thermal erosion process [1]. This process can create crater in any conducting material by thermal energy irrespective of hardness of the material. This causes less tool wear than the conventional manufacturing processes. In this process, two conductors i.e. tool and workpiece are separated by an isolating region called the dielectric medium. With the presence of the dielectric medium, the material is removed by producing precisely controlled electrical discharges occurring between the tool and the work piece. The tool electrode does not make contact with the work piece and it is separated by the distance required for electrical discharge sparking, known as 'spark gap'. The number of sparks depends on the DC pulse frequency [2]. The air gap is filled by the dielectric medium. Whenever the spark gap is sufficient to ionize the dielectric medium, there is an electricity flow in a closest point between tool and work piece. The electrically conductive tool materials such as graphite, copper, brass, tungsten carbide and copper

* Corresponding author. Tel.: +91 44 22516155.
E-mail addresses: muthu1060@gmail.com (T. Muthuramalingam), mohan@mitindia.edu (B. Mohan).

http://dx.doi.org/10.1016/j.measurement.2014.09.029
0263-2241/

Table 1
Chemical composition of AISI 202 stainless steel.

Elements	C	Si	Cu	Mn	P	S	Mo	Cr	Sn	Ni	W	Al	Ti	Fe
% Composition	0.05	0.35	1.93	8.76	0.03	0.011	0.22	16.04	0.09	1.56	0.17	0.07	0.011	Remain

tungsten can be utilized as the tool electrodes in electrical discharge machining process [3]. A controlled DC pulse (30–100 V) is applied between tool and workpiece separated by small air gap (0.002–2 mm) with high frequency (100 kHz–10 MHz) [4]. When the dielectric medium reaches its breakdown voltage, the ionization effect occurs in the air gap. This ionization produces a initiation of spark between tool and workpiece. It leads to dissipation of higher amount of heat in terms of 8000–12000 °C. Because of this higher thermal energy, the material is melted and vaporized. The melted material in the air gap can be removed by the flushing process.

1.2. Importance of multi response optimization in electro erosion process

Due to the random nature of such machining process, it is very essential to optimize the process parameters in EDM process. Conventional Taguchi method deals with single response optimization only. It may give different set of optimal combinations for multiple responses. It is needed to introduce multi response optimization technique in the process. In this approach, the multiple responses can be converted into single normalized response. Then it is easy to obtain the optimal set of process parameters. Lin et al. discussed about need of optimizing non linear machining process [5]. Lin et al. explained about the methodology for finding influencing process parameters with Taguchi method while machining high speed steel [6]. Panda proposed the innovative modeling of electro erosion process [7]. Mukherjee and Chakraborty depicted the biogeography based optimization algorithm for selecting thermal erosion process parameters [8]. Chakravorty et al. discussed about need of optimizing the electrical process parameters involved in EDM process [9]. Panda and Yadava explained about the multi response optimization in chemical spark erosion process using genetic algorithm [10]. Jailani et al. obtained the optimal set of sintering parameters in grinding process using Taguchi method with grey technique [11]. Patel et al. applied the response surface methodology technique in machining process for optimization purpose [12]. Meena and Azad discussed about grey relational analysis in thermal erosion process [13]. Somashekhar et al. described about the optimization technique in EDM process using artificial intelligence and genetic techniques [14].

From the above literatures, it is clearly understood that only multi response optimization technique can give better optimal set of process parameters [15]. It is very clear that only few researches have been carried out in EDM process for optimizing electrical process parameters. While reviewing the literatures, it has been also found that interactions have not been taken into account, in case of electrical parameters optimization in EDM process. Since

Table 2
Orthogonal table L_{27} for responses.

Trial no.	Voltage (V)	Current (A)	Duty factor	Tool	MRR (mm^3/min)	SR (μm)	EWR (mm^3/min)
1.	40	9	0.4	WC	0.783	0.326	0.0157
2.	40	9	0.6	Br	4.896	3.724	1.3219
3.	40	9	0.8	Cu	8.097	5.286	0.9716
4.	40	12	0.4	Br	4.673	5.523	1.2617
5.	40	12	0.6	Cu	8.811	5.604	1.0573
6.	40	12	0.8	WC	0.971	0.725	0.0194
7.	40	15	0.4	Cu	7.142	5.124	0.857
8.	40	15	0.6	WC	0.982	0.731	0.0196
9.	40	15	0.8	Br	6.562	12.458	1.7717
10.	60	9	0.4	Br	4.328	3.789	1.1686
11.	60	9	0.6	Cu	8.323	4.464	0.9988
12.	60	9	0.8	WC	1.157	0.618	0.0231
13.	60	12	0.4	Cu	7.566	3.592	0.9079
14.	60	12	0.6	WC	1.128	0.674	0.226
15.	60	12	0.8	Br	8.862	10.235	2.3927
16.	60	15	0.4	WC	0.973	0.595	0.0195
17.	60	15	0.6	Br	7.769	10.357	2.0976
18.	60	15	0.8	Cu	15.485	10.562	1.85282
19.	70	9	0.4	Cu	9.363	3.125	1.1236
20.	70	9	0.6	WC	1.111	0.595	0.0222
21.	70	9	0.8	Br	10.647	8.934	2.8747
22.	70	12	0.4	WC	1.135	0.484	0.0227
23.	70	12	0.6	Br	8.453	8.128	2.2823
24.	70	12	0.8	Cu	16.621	8.159	1.9945
25.	70	15	0.4	Br	7.865	7.653	2.1236
26.	70	15	0.6	Cu	13.803	8.364	1.6564
27.	70	15	0.8	WC	1.568	0.905	0.0314