Journal Of Harmonized Research (JOHR)

Journal Of Harmonized Research in Engineering
4(1), 2016, 01-05

ISSN 2347 – 7393

Original Research Article

MULTI-OBJECTIVE OPTIMIZATION OF MACHINING PARAMETERS USING GREY TAGUCHI METHOD

Amar Nath, S.P.Shrivas, A K Khandelwal

Chouksey Engineering College, Bilaspur

Abstract - In this research, a distinct combination of Taguchi method, Gray Relational Analysis (GRA) with an experimental investigation was conducted to determine the main machining parameters which contribute to material removal rate (MRR) and surface roughness (SR) in wire-EDM of mild steel. In WEDM operations, Proper selection of process parameters is essential to obtain good surface finish and higher MRR. In setting the machining parameters, particularly in rough cutting operation, the goal is - the maximization of MRR, minimization of SR or increasing the quality. In this experiment using the selected control parameters are discharge current, pulse on time, pulse off time and servo feed setting. The four control parameters each are three level means L_{27} orthogonal array based on Taguchi design is selected for this analysis. The relatively significant parameters were determined by Analysis of Variance (ANOVA). The variation of output responses with process parameters were mathematically modeled by using non-linear regression analysis. The models were checked for their adequacy.The optimal parameter setting for maximum MRR and minimum SR was obtained by Gray Relational analysis.

Keywords: Material removal rate (MRR), Surface roughness (SR), ANOVA, Taguchi Design, Grey Relation Analysis (GRA).

Introduction: The non-traditional manufacturing process of wire-electrical discharge machining (WEDM) possesses many advantages over traditional machining during the manufacture of Mild Steel parts.WEDM is mostly used to cut difficult-to-machine materials and high asset temperature resistant alloys. It is the most widely and effectively useful machining process for various work piece materials [1].

With a view to alleviate this trouble, various surveys have been carried out by several researchers for improving selection of optimal parametric values for the MRR, Surface Finish [2–6]. However, the problem of selection of

For Correspondence:
anamarnath494@gmail.com
Received on: December 2015
Accepted after revision: January 2016

machining parameters is not fully depending on machine controls rather material dependent. To advance manufacturing processes with single performance characteristic, the optimal selection of control parameters Taguchi method has been widely adopted. Traditional Taguchi method cannot solve multi-objective optimization problems. To overcome this, the Taguchi method together with Grey relational analysis (GRA) has a wide area of application in manufacturing processes and other optimization process[7– 12].

The objective of the present work is an attempt to finding feasibility of machining Mild Steel using copper electrode wire. The machining parameter selected for discharge current, pulse on time, pulse off time and servo feed using L_{27} orthogonal array based on Taguchi design approach analyzing the responses MRR and SR.

Experimentation: Wire EDM machine puts impulse voltage between electrode wire and workpiece through impulse source, controlled by servo system, to get a certain gap, and realize impulse discharging in the working liquid between electrode wire and workpiece. Numerous tiny holes appear due to erosion of impulse discharging, and therefore get the needed shape of workpiece (Shown in Fig. 1).

For this experiment the whole work can be down by Wire Electric Discharge Machining, model Electronica EZEECUT-WEDM with servo-head (constant gap) and positive polarity for electrode was used to conduct the experiments. Distil water as a dielectric fluid, with side flushing of copper tool.Experiments were conducted with positive polarity of electrode.

Fig 1. Wire Electric Discharge Machining

Taguchi Design Experiments in Minitab: Taguchi designs provide a powerful and efficient method for designing products that operate consistently and optimally over a variety of conditions. Taguchi proposed several approaches to experimental designs that are sometimes called "Taguchi Methods." These methods utilize two, three, four, five, and mixed-level fractional factorial designs. Taguchi refers to experimental design as "off-line quality control" because it is a method of ensuring good performance in the design stage of products or processes. In the experiment using four factors and each are three levels then total number of experiments to be conducted is 27. In this study, an L_{27} OA based on Taguchi design are used machining parameters like discharge current, pulse on time, pulse off time and servo feed setting were varied to conduct 27 different experiments and the measurements weights of the work piece were taken for calculation of MRR. Minitab software was used to analysis the findings.

The levels of experiment parameters are like discharge current, pulse on time, pulse off time and servo feed setting shown in Table 1 and the Response are depicted in Table 2.

Table 1 Machining parameter and their levels

Parameters	**unit**	**Level 1**	**Level 2**	**Level3**
Ip (Discharge Current)	A	13	18	23
T_{on} (pulse on time)	(µs)	100	112	118
T_{off} (pulse off time)	(µs)	20	30	40
SF (Servo Feed)	(mm/µ)	500	1300	2000

Results and Discussions: In This chapter are related about influences of MRR and SR in WEDM and finding the result which factors discharge current, pulse on time, pulse off time and servo feed of Copper tool, is most with mild steel workpiece important with help of orthogonal array based on Taguchi L_{27} design.

Optimization by Gray relation analyses

In Gray relational analysis, multiple performances can be unified to a single response, *i.e.* Gray relational grade in Table 2 (observation table)are used to calculated the normalised MRR and SR. These normalised values are used to calculate GRC's for both the responses using Equation 1 and 2. Subsequently, GRG is evaluated from GRG's for each experimental run. According to GRG rules, all the experimental run are related to higher is better policy". The experimental run verse GRG plot is shown inFig 2. It is the Pareto graph of GRGs and the run numbers **27** are having the three highest GRG values.

In addition, the mean of the GRG for each level of the EDM parameters, and the total mean of GRG is summarised in Table 1 for each factor levels. The higher value of GRG means comparability sequence has a stronger correlation to the reference sequence. Fig. 2 represents graphically in main effect plot for GRG and this graph exposes that the optimal WEDM parameter i.e. Ip =23A, T_{on} = 112μs, T_{off} = 40 μs, and SF =1300 mm/μ. The significance of the factors on overall quality characteristics of the WEDM process has also been evaluated quantitatively with ANOVA for GRG. as a result, the combined effect of *Ip* on GRG in insignificant.

Table 2 Grey relation analysis response table

Run	MRR	SR	N MRR	N SR	GRC MRR	GRC SR	GRG	Ranking
1	0.0040	0.78	0.001	0.759	0.334	0.675	0.504	11
2	0.0049	0.66	0.003	0.847	0.334	0.765	0.550	7
3	0.0210	0.84	0.023	0.715	0.339	0.637	0.488	13
4	0.0029	0.95	0.000	0.635	0.333	0.578	0.456	21
5	0.0142	0.45	0.014	1.000	0.337	1.000	0.668	3
6	0.2084	0.85	0.262	0.708	0.404	0.631	0.518	10
7	0.0264	1.082	0.030	0.539	0.340	0.520	0.430	24
8	0.0793	1.195	0.097	0.456	0.356	0.479	0.418	27
9	0.0553	0.98	0.067	0.613	0.349	0.564	0.456	20
10	0.1198	1.05	0.149	0.562	0.370	0.533	0.452	22
11	0.1460	1.01	0.182	0.591	0.379	0.550	0.465	19
12	0.0935	1.03	0.115	0.577	0.361	0.542	0.451	23
13	0.0322	0.93	0.037	0.650	0.342	0.588	0.465	18
14	0.2250	1.04	0.283	0.569	0.411	0.537	0.474	16
15	0.2171	1	0.273	0.599	0.408	0.555	0.481	14
16	0.2250	1.3	0.283	0.380	0.411	0.446	0.429	25
17	0.0751	0.95	0.092	0.635	0.355	0.578	0.467	17
18	0.5385	0.93	0.683	0.650	0.612	0.588	0.600	5
19	0.5000	1.22	0.634	0.438	0.577	0.471	0.524	9
20	0.2593	1.37	0.327	0.328	0.426	0.427	0.426	26
21	0.3145	1	0.397	0.599	0.453	0.555	0.504	12
22	0.5472	1.137	0.694	0.499	0.620	0.499	0.560	6
23	0.5510	1.82	0.699	0.000	0.624	0.333	0.479	15
24	0.7872	1.71	1.000	0.080	1.000	0.352	0.676	2
25	0.4119	1.03	0.522	0.577	0.511	0.542	0.526	8
26	0.5510	0.91	0.699	0.664	0.624	0.598	0.611	4
27	0.7872	1.03	1.000	0.577	1.000	0.542	0.771	1

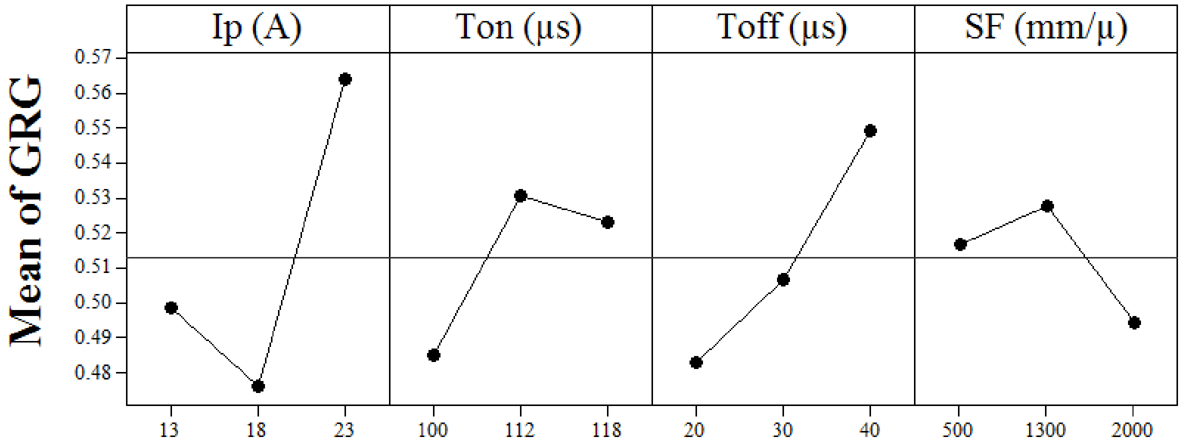

Fig. 2 Main effect plots for GRG

Conclusions: L_{27} OA based Taguchi design was used to study MRR and SR on Mild tool steel with sideimpulse flushing. MRR is affected by T_{on} and T_{off}. It decreases and slightly increases with $T_{on.}$

The following conclusions are described.

- Finding the result of MRR discharge current is most influencing factor and then pulse duration time and the last is pulse off time than servo feed. MRR increased with the discharge current (IP).
- In the case of surface roughness the most important factor of discharge current then pulse on time, pulse off time and other factors are not important as compare to this factors.
- Gray relation analysis was adopted to optimize the WEDM process with multiple performance characteristics, i. e., MRR and SR. The optimal EDM parameter settings were found to be ***Ip =23A, T_{on} = 112μs, T_{off} = 40 μs and SF =1300 mm/μ***for maximum MRR and minimum SR

References

[1]. R.Snoeys, F. Staelens and W. Dekeyser, Current trends in nonconventional material removal processes. CIRP Annals – Manufacturing Technology, 35(2):467–480 (1986).

[2] D.Scott, , S. Boyna, and K.P. Rajurkar,. Analysis and optimization of parameter combinations in WEDM. Int. J. Prod. Res, 29, 2189–2207 (1991).

[3] Y.S.Tarng,, S.C.Ma and L.K.Chung , Determination of optimal cutting parameters in wire electrical discharge machining, Int. J. Machine Tools Manuf, 35, 1693–1701(1995).

[4] Y.S.Liao, , J.T.Huang, and H.C.Su , A study on the machining-parameters optimization of wire electrical discharge machining, J. Mater. Process. Technol, 71, 487–493(1997).

[5] T.A. Spedding, and Z.O. Wang , Parametric optimization and surface characterization of wire electrical discharge machining process. Precision Eng, 20, 5–15 (1997).

[6] C.Y. Ho, and Z.C Lin, , Analysis and application of grey relation and ANOVA in chemical mechanical polishing process parameters, Int. J. Adv Manuf. Technol.,21, 10–14, (2003)

[7] M.Shajan, , M.Kamal, and M.S.Shunmugam, Data Mining applied to Wire-EDM process, J. Mater. Process. Technol, 142 ,182– 189(2003).

[8] Tosun, N.,. Determination of optimum parameters for multiperformance characteristics in drilling by using grey relational analysis. Int,.J. Adv. Manuf. Technol., 28, 450–455. 2006

[9] Chang, C.K. and Lu, H.S.,. Design optimization of cutting parameters for side milling operations with multiple performance characteristics, Int. J. Adv. Manuf. Technol., 32, 18–26. (2007)

[10] L.K Pan, C.C.Wang, S.L.Wei, and H.F Sher, Optimizing multiple quality characteristics [11] J Kopac, and P.Krajnik, ,Robust design of flank milling parameters based on grey-Taguchi method, J. Mater. Process. Technol., 191, 400–403, (2007)

[12] A.Noorul Haq, , P.Marimuthu, and R.Jeyapaul , Multi response optimization of machining parameters of drilling Al/SiC metal matrix composite using grey relational analysis in the Taguchi method, Int. J. Adv. Manuf. Technol., 37, 250–255(2008).

[13]. Ghoreishi, M. and Tabari, C. (2007). Investigation into the effect of voltage excitation of pre-ignition spark pulse on the Electro-Discharge Machining (EDM) process. Materials and Manufacturing Processes, 22(7):833–841.

[14]. Kung, K. Y., Horng, J. T., and Chiang, K. T. (2009). Material removal rate and electrode wear ratio study on the powder mixed Electrical Discharge Machining's of cobalt-bonded tungsten carbide. International Journal of Advanced Manufacturing Technology, 40(1-2):95-104.

[15]. Saha, S. K. and Choudhury, S. K. (2009). Experimental investigation and empirical modeling of the dry Electric Discharge Machining process. International Journal of Machine Tools and Manufacture, 49(3-4):297–308.