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# MULTI-OBJECTIVE OPTIMIZATION OF EDM PROCESS PARAMETERS WITH COPPER TOOL

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**ABSTRACT**

Optimization is one of the practices used in manufacturing sectors to attain for the best manufacturing situations, which is an essential need for industries towards manufacturing of quality products at lower cost. This methodology uses tool materials such as Copper finding the optimum settings of machine parameters and for combining multiple quality characteristics into one integrated numerical value called Grey relational grade. Taguchi method using $L_9$ orthogonal array based on Taguchi design and observed that which factor is most affected by the Responses of Material Removal Rate (MRR), and Tool Wear Rate (TWR).

**ORIGINAL RESEARCH ARTICLE**

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## 1. INTRODUCTION

EDM has been replacing drilling, milling, grinding and other traditional machining operations and is now a well-established machining option in many manufacturing industries throughout the world. And is capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries.EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive.

A sudden drop of the electric resistance of the previous channel allows that current density reaches very high values producing an increase of ionization and the creation of a powerful magnetic field. The moment spark occurs sufficiently pressure developed between work and tool as a result of which a very high temperature is reached and at such high pressure and temperature that some metal is melted and eroded.

## 2. BACKGROUND STUDY

The power supply generates an electrical potential between the two parts. As the electrode approaches the work piece, dielectric breakdown occurs in the fluid, forming a plasma channel, and a small spark jumps. These sparks usually strike one at a time because it is very unlikely that different locations in the inter-electrode space have the identical local electrical characteristics which would enable a spark to occur simultaneously in all such locations. These sparks happen in huge numbers at seemingly random locations between the electrode and the work piece. Chen et al. [2013] had presented the Taguchi design to analysis the effect of responses on EDM

process with A6061-T6 aluminum alloy. Guleryuz et al. [2013] investigated the effect of EDM parameters on the SR as an alternative method for machining of Al/SiCp metal matrix composites produced using Power Metallurgy (PM) technique. Das et al. [2012] studied the effect of machining parameters on MRR in EDM of EN31 tool steel. The selected control parameters were Ton, Toff, Ip and V with L27 OA based on Taguchi design. Natarajan and Arunachalam [2011] used GRA to optimize multi-performance characteristics of Micro-EDM. They optimized the process parameters for higher MRR, lower TWR and lower OC and verified through a confirmatory experiment. An improvement of 12.88, 14.57 and 6.1% were observed for MRR, TWR and OC respectively. Pradhan [2012] proposed a new combination of RSM, GRA and Principal Component Analysis (PCA) modeling and optimization method for the determination of the optimum process parameters that maximizes MRR without compromising the surface quality in AISI D2 tool steel. The current study focused on Plastic mould steel (P20 tool steel) which is used growing range of Plastic moulds, frames for plastic pressure dies, hydro forming tools. The current study, EDM was carried out on AISI P20 tool steel using three different electrode materials.

## 3. METHODOLOGY

Cylindrical shaped tool electrodes of copper, material with 12 mm diameter is used to on P20 Mould steel. Parameters are design as per L9 Orthogonal Array (OA) based on Taguchi design are used machining parameters like tool material, pulse on time (Ton) from 100 to 300µs, Discharge current (Ip) from 2 to 6Amp., Work time (Tw) from 5 to 15 Second Flushing pressure (F) from 0.2 to 0.4 Kgf/cm$^2$ are taken as variable parameters while other parameters are constant. As per design nine experiments are passed twice and averages of responses are recorded as tool wear and MRR as shown in table 1.

**Table 1** Parameters with responses

| Ton | Ip | Tw | F | T | MRR |
|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0.0246 | 1.8386 |
| 1 | 2 | 2 | 2 | 0.0237 | 2.3977 |
| 1 | 3 | 3 | 3 | 0.0165 | 3.002 |
| 2 | 1 | 2 | 3 | 0.0087 | 4.4056 |
| 2 | 2 | 3 | 1 | 0.0635 | 4.5563 |
| 2 | 3 | 1 | 2 | 0.0212 | 5.145 |
| 3 | 1 | 3 | 2 | 0.938 | 0.6285 |
| 3 | 2 | 1 | 3 | 1.0055 | 0.6242 |
| 3 | 3 | 2 | 1 | 1.061 | 0.6058 |

## 4. RESULT AND DISCUSSION

Besides, it is clearly evident that the other factor does not influence much as compared to Ip. When the pulse on time is increasing the MRR is decreasing, this is due to the fact that with higher Ton, the plasma formed between the Inter electrode gap (Ip) actually hinders the energy transfer and thus reduces MRR. Influence of TWR which indicates the copper tool electrode have higher melting point high tool wear rate, as well as it indicate that Ip is directly proportional to TWR, Because of Ip increases the pulse energy increases and thus more heat energy is produced in the tool work piece interface, leads to increase the melting and evaporation of the electrode. Grey relational analysis is an impacting measurement method in Grey system theory that analyses uncertain relations between one main factor and all the other factors in a given system. For the data analysis of Grey relation analysis process “the higher is MRR and lower is TWR” are the indication of better performances in EDM process. In this section,

the use of orthogonal array with the Grey relational analysis optimization methodology for multi-response optimization is discussed. Finally the Grey Relation Grade (GRG) statistically calculated shown in fig 1.

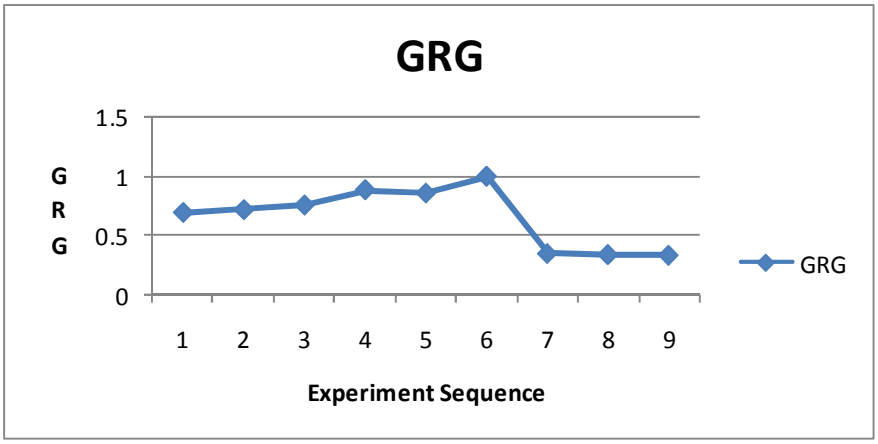


**Fig 1** Optimization Chart

Fundamental step in the DOE, which is a dominant statistical tool aimed at statistically quantifying interactions between independent variables through their methodical modifications to determine their impact on the predicted variables. Main effect plots are shown in fig 2 which is generated on the bases of GRG values with respect to input parametrs. In this graph are shown pulse on time (Ton) from 200µs, Discharge current (Ip) from 4Amp., Work time (Tw) from 5 Sec and Flushing pressure (F) from 0.3Kgf/cm$^2$.

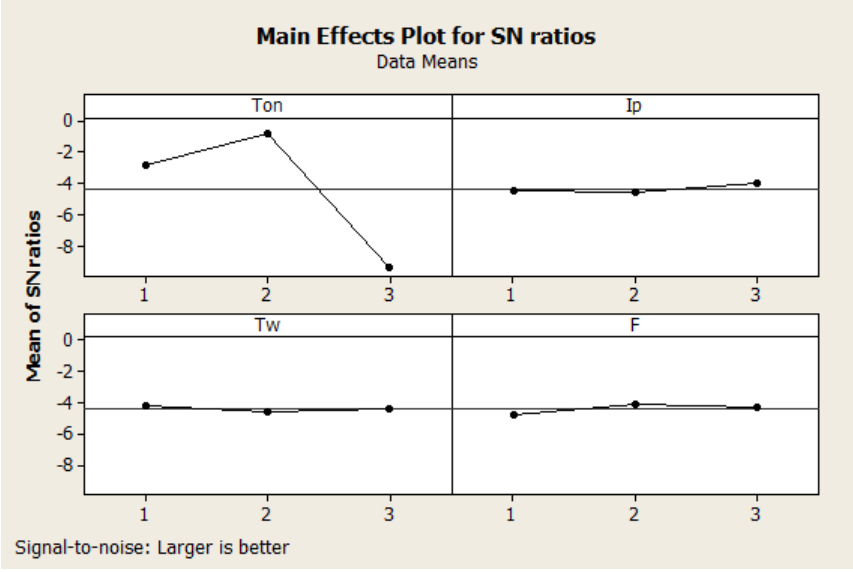


**Fig. 2** main Effect Plot

## 5. CONCLUSION

Tool electrode is gives the highest MRR followed by copper material. Pulse on time is inversely proportional to MRR and directly proportional to the TWR up to maximum value and then if starts to decrease. Grey relation analysis converts multiple optimization characteristics into an optimization which gives factor level of 2,3,1,2 (experiment No 6) are the best parameters. Optimum parameters are shown in table 2.

**Table 2** Optimum Parameters

| Factor | Ton | Tp | Tw | F |
|---|---|---|---|---|
| Level | 2 | 3 | 1 | 2 |

**REFERENCES**

[1].Chen, D., Jhang, J., and Guo, M. (2013). Application of taguchi design method to optimize the electrical discharge machining. Journal of Achievements in Materials and Manufacturing Engineering, 57:76–82.

[2].Das, M., Kumar, K., Barman, T., and Sahoo, P. (2012). Optimization of material removal rate in EDM using taguchi method. Advanced Materials Engineering and Technology, 626:270–274.

[3].Guleryuz, L. F., Ozan, S., Kasman, S., and Ipek, R. (2013). The influence of process parameters of EDM on the surface roughness of aluminum matrix composites reinforced with sic particulates. ActaPhysicaPolonica A, 123(2):421–423.

[4].Natarajan, N. and Arunachalam, R. M. (2011). Optimization of Micro-EDM withmultiple performances characteristics using Taguchi method and Greyrelation analysis. Journal of Scientific and Industrial Research, 70(7):500–505.

[5].Pradhan, M. K. (2012). Determination of optimal parameters with multi response characteristics of EDM by response surface methodology, grey relational analysis and principal component analysis. International Journal of Manufacturing Technology and Management, 26(1-4):56–80.

[6].Singh, S., Maheshwari, S., and Pandey, P. C. (2004c). Some investigations into the electric - discharge machining of hardened tool steel using different electrode materials. Journal of Materials Processing Technology, 149:272–277.

[7].Tsai, H. C., Yan, B. H., and Huang, F. Y. (2003b). EDM performance of Cr/Cu-based composite electrodes. International Journal of Machine Tools and Manufacture, 43:245–252.