Webology (ISSN: 1735-188X)
Volume 18, Number 6, 2021

# Assessment Of Electrical Process Parameters For Electrical Discharge Machining

**Ruchi Sharma[1] , Irshad Ahamad khilji[2] , Siti Nadiah Binti Mohd Saffe[3] , Mukesh Yadav[4] , Nidhi Tiwari[5]**

[1]Associate Professor , Department of Electronics & Communication Engg. VGU Jaipur.

[2]Faculty of Manufacturing and Mechatronics Engineering Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, Darul Makmur Pahang, Kuantan, 26300

[3]Faculty of Manufacturing and Mechatronics Engineering Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, Darul Makmur Pahang, Kuantan, 26300

[4]Associate Professor ,Department of Electronics & Communication Engg. SAGE University ,Indore.

[5]Associate Professor , Department of Electronics & Communication Engg. SAGE University , Indore.

**Abstract**

Enhancement of electrical process parameter plays a significant role to improve the process efficiency. In electrical discharge machining process, the electrical energy is converted into the thermal energy due to applied electric voltage. This article focuses on the modelling and its effect of process parameters like given voltage and current, duty cycle of pulses and discharge energy on output parameters like MRR, electrode wear rate and finishing of product on surface. In addition, deals with the optimization process and parameters along with electrical process parameter control for EDM. It is noticed that efficacy of machining process can be increased by electrical process parameters, however only few considered for improvement of such parameters

**Keywords:** EDM, Electrical pulse, Power supply, RC supply, ISO power supply.

## 1. Introduction

Electrically conductive materials machined by EDM process, where the thermal energy of spark detaches the material through repeated sequences of electrical discharge between the small gap of an electrode and a workpiece. It is regularly utilized as die in addition to mould assembly industries, aeronautical parts and nuclear instruments at the low cost. Electric Discharge Machining has established its presence, touched on the different subject areas such as use of sporting things, medicinal and clinical instruments, motorized research and development regions. EDM process removes undesirable material in the form of debris and produces the shape of the tool surface as a metal portion by the recurring electrical spark between the tool and the workpiece in the presence of dielectric liquid. In this machining process, workpiece acts as the anode because it relates to the positive terminal, and electrode relates to negative terminal acts as a cathode. The dielectric fluid contains kerosene, transformer oil, distilled water, etc.[1]

The machining method, where the metallic particle is removed as workpiece owed to the controlled wearing away the action utilizing repetitively occurring spark ejection with the discharge current applied by power supply between the tool and workpiece in a small gap 10 –125 μm [2]. Figure 1 depicts the schematic of a simple EDM machine. This Figure shows all the mechanical and electrical path and controlling system for EDM. A small break reserved among the tool and workpiece through a servo control arrangement. Both the electrode and workpiece stay immersed in a dielectric liquid (deionized water) that acts as a catalyst for the machining process

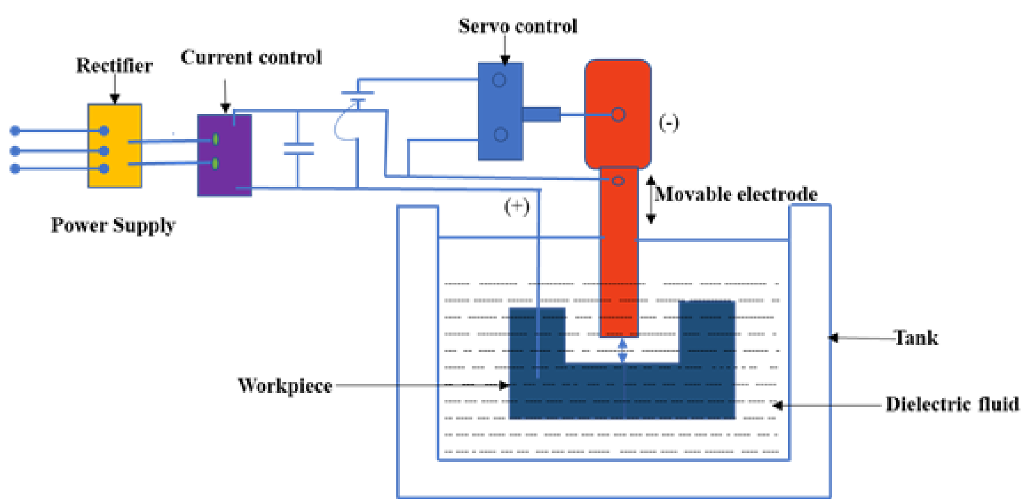


Fig. 1. EDM machine schematic.

In EDM, a potential difference is applied between the tool and workpiece, Both the tool and the work material should be made of electrically conductive materials. A dielectric medium immersed between the tool and the work material. Generally, deionized water or kerosene is used as the dielectric medium. Between the tool and the workpiece, a gap is maintained. An electric field would be established depending upon the applied potential difference and the gap between the tool and workpiece, in general, the tool is connected to the negative terminal of power supply and the workpiece connected to the positive terminal. The electric field established the free electrons on the tool are subject to electrostatic forces between the tool and the job. Electrons emitted from the tool (assumed to be connected to the negative terminal), if the work function or the bonding energy is lower. Such emission of electrons is known as cold emission. The "cold emitted" electrons through the dielectric medium is then accelerated towards the job. Collisions between the electrons and dielectric molecules take place when they gain velocity and energy and start moving towards the job. Such collision may affect in ionization of the dielectric molecule liable upon the work function and energy of the electron. Hence, the electrons get accelerated, more positive ions and electrons would be generated by collisions. At the spark gap, this cyclic process would rise electrons and ions concentration in the dielectric medium between the tool and the job. The matter existing in that channel characterized as "plasma" with high concentration. Such a plasma channel, the electrical resistance would be very less. Thus, suddenly, the flow of many electrons from the tool to the job and ions from the job to the tool will take place. This is the so-called avalanche motion of electrons. Such electrons and ions movement be a spark visually. Thus, electrical energy is dissipated as a spark of thermal energy. The high-speed negatively charged electrons on the work piece and positive ions on the tool. The kinetic energy of the ions and electrons impact on the surface of the job and tool would be converted into heat flux or thermal energy. The intense localized heat flux leads to an extreme instantaneous confined rise in temperature, which would be over 10,000$^{o}$C. Such localized extreme rise in temperature cause material removal. This is due to instant vaporization of the material as well as melting. The melted metal is not entirely removed but only partially. To summarise, the material removal in EDM mainly occurs due to the creation of shock waves as plasma channel collapse owing to the discontinuation of applied potential difference. Usually, the work piece is positive and the tool negative. Thus, the electrons strike the job leading to crater formation due to high temperature, melting and material removal. The positive ions impose on the tool leading to tool wear. In EDM, voltage pulses are created by a generator between the job and the tool. A constant voltage is not applied. Only sparking is desired in EDM than arcing, and arcing leads to localized material elimination at a point whereas sparks get distributed all over the tool surface for uniform distributed material removal under the tool.

## 2. Pulse performance enhancements

Since the power supply is a significant factor for EDM process, generally pulse generator is used for providing DC power supply and for improving the performance and up-gradation of machining process pulse generator is playing an important role, higher energy pulses used for high material remove and lower energy go with a smooth surface.

Various researcher working on pulse generator to improve performance with different pulse rate and using RC and capacitance circuit, Yan and Liu improve the surface quality of metal with pulse

width modulation using a frequency of 4.4. MHz and reduce surface roughness with short duration pulse, Yan and Chiang are developed new power supply for electrical discharge machining using a transistor-controlled power supply with to provide high frequency and lower energy pulse control.
Casanueva et al. used DC to DC Series-parallel resonant converter with high frequency and confirmed that capacitance effect overall impedance.[3]
By using the RC type generator, Johan et al. confirmed the research on surface roughness by using Tungsten carbide by RC generator and compared with transistor type power supply due to lower discharge energy.[4] The summer of research for improving pulse performance on EDM is shown below

Table 1: Pulse supply updating summary

| No | Reference | Type of pulse supply | Finding |
|---|---|---|---|
| 1 | Jahan et al. [4] | RC type Pulse generator | Smooth surface finish due to lower discharge energy distribution. |
| 2 | Han et al. [5] | A modified transistor pulse generator | Used 1 MHz for high MRR, two to three times higher machining speed compare with the conventional RC pulse generator. |
| 3 | Yan and Liu[6] | Fixed pulse Width modulation generator | Generate 4 Mz and short duration pulse control signal to lower surface roughness. Shallow discharge resulted in Improved surface quality |
| 4 | Yan and Chiang[7] | Transistor controlled power supply | Transistor-controlled power supply to provide high frequency and lower energy pulse control |
| **5** | Muthuramalingam and Mohan[8] | Iso current pulse generator | To produce a better surface finish than conventional pulse generators like RC and transistor pulse generator |
| **6** | Han et al. [9] | New transistor type pulse generator | To provide a high erosion rate and 24 times higher remover rate than conventional machining. |
| **7** | Yan and Lai [10] | Excellent finish power supply with high frequencies | To produce lower discharge energy and to lower surface roughness |
| **8** | Muthuramalingam and Mohan[11] | The developed semiconductor-based pulse switching circuit | To provide less energy discharge pulses at finishing level |
| **9** | Casanueva et al. [3] | New EDM impulse generator with high frequencies DC-DC series parallel res | High Impedance due to high capacitance |

converter

### 3. Impact of pulse shape on performance measures

In the EDM process, the response characteristics are due to change in the shape of the generated pulse, which is the central aspect. The average spark energy on the surface is affected by the discharge pulse shape. The machining characteristics like material removal rate, surface quality and electrode are affected by electrical energy and pulse shape, which is shown in figure 2.

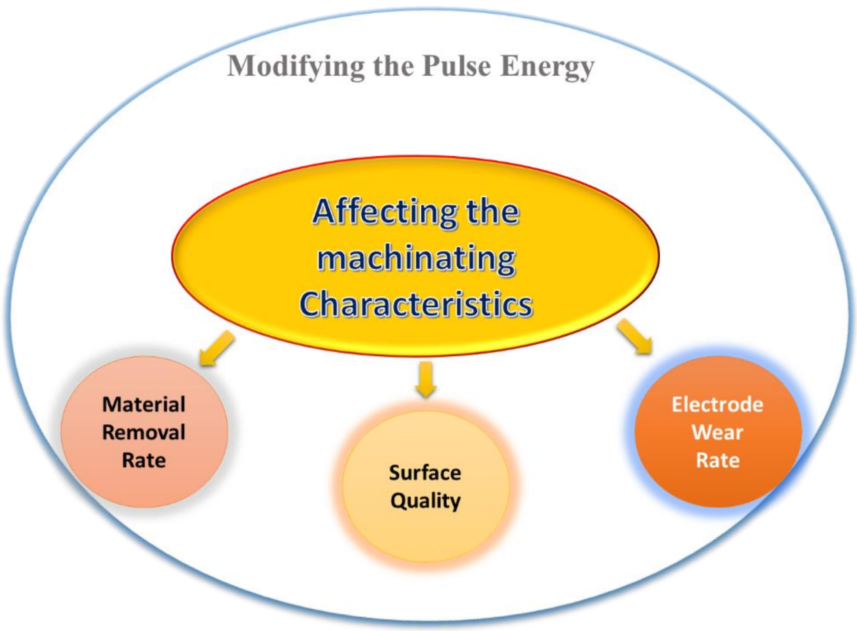


Figure 2: Machining characteristics of Energy supply in the EDM process

Ghoreishi and Tabari described the performance measures like MRR, surface quality and electrode wear rate and average surface roughness affected voltage excitation of pre ignitions of spark pulse.[12] It is confirmed from the result that applying voltage excitation of the pulse provided effective pulse to increase material erosion and surface quality[12]. Tsai and Lu explained the effect of current impulse on machining tungsten carbide and SKD die steel with electrolytic copper tool electrode. From the experiment, it was found that material removal rate and tool wear also affect the energy density[13]. In the EDM process, the influence of discharge current impulse on performance measures was examined by Muthuramalingam and Mohan[8]. The research on the influence of electrical pulse condition was carried out by Son et al. and found that span of pulse affects the material removal rate, tool wear rate and surface roughness. Even the shorter EDM pulse can be efficient to make precision part[14]. The influence of discharge pulse shape on EDM as the material removal mechanism of $Si_3N_4$-TiN was described by Liu et al. [15]. The various forms of discharge pulse-like iso current pulse on the surface texture of Work Piece have been researched and proved for suitable surface topography with uniform discharge energy.

## 4. Electrical parameters that impact on Performance of EDM

Electrical process parameters are an exciting topic for research in the manufacturing field; many researchers experiment to find the influence of electrical paraments especially in EDM process and find that

## 5. Handling and monitoring of EDM process

In EDM process, required response parameter can be obtained by monitoring and controlling the machine process parameters, which can be achieved by observation and measurement process parameters from the expected level by lowering performance measures.

Yan developed the process monitoring recognition and control in the wire electrical discharge machining process by an adaptive control system and noticed that the adjustment of pulse interval of each pulse cycle controlled for wire breaking in EDM process[16]. The roughness of machined surface using wire EDM functions the process parameter by adaptive neuro-fuzzy interference developed by Caydas et al. they found the enhanced surface quality of workpiece from the proposed control system algorithm[17]. An adaptive control system with direct and pre-programmed tool downtime has regulated for better process performance was developed by Han to increase the machining rate by automatic adjustment of spark gap[18]. Latest pulse discrete and control system was developed by Yan and Chien, and they explained the effects of pulse interval, machining feed rate and Work Piece disparity in portions of usual spark Arc and shorts circuit in total spark. Finally, confirm the developed control system lowers the are discharged to obtain stable machining[19]. To analyze the nonlinearity in the EDM process, proportional derivative controller of spark gap between electrode and workpiece designed by Chan and described the nonlinearity lowers the effective discharge[20]. According to Behrens and Ginzel neuro, fuzzy-based gap width controller raised the efficient removal mechanism and proposed the controller achieve an excellent surface finish of the work piece.[21] EDM with high-speed data acquisition and high-frequency response confirmed the lower air gap between tool and workspace enhanced the material removal rate was described by Kao and shih[22] To increase the machine performance of server scanning micro EDM process, ultrasonic linear motor as microdrive and piezoelectric actuators as micro feeding mechanism was utilized with micro or micro dual-feed spindle was reported by Tong et al. [23] Determination and optimization of the process parameters in an automatic method in EDM die sinking process for artificial neural network application was described by Fenggou and Dayong. They concluded the efficient method for enhancing EDM performance by determining automatic current value[24].

## 6. Modelling of EDM process parameters

To aid and analyze the process parameters on machining characteristic in any machining process effects through process parameter modelling.

### 6.1 Hypothetical modelling of EDM process

Tool electrode and workpiece are two electrical conductors distinguished by dielectric medium where EDM positioning can be standard as a capacitor. A plate capacitor model for EDM process was constructed by Liu et al. They describe the relation between energy distribution and process parameters by field electron emission theory. The process efficiency was enhanced by machining time[25].

To predict the park erosion rate in the EDM process and a comprehensive mathematical model was developed by Das and Joshi. They notice a higher pulse duration due to pulse current and plasma radius [26].

Thermal based model determined the material removal rate and average surface roughness as process parameters was developed by salonitis et al. [27].

Even the thermo model for brush electrical discharging alloying process was developed by Spadlo et al. concluded that the material removal rate is directly proportional to the discharge pulses[28].

### 6.2 Optimization process of EDM

Many kinds of research worked on optimization of electric process parameters on the EDM process. Optimization of material removal rate in the EDM process with copper tungsten tool Electrode was described by Marafona and Wykes. It has been proved that a higher current intensity causes greater material removal rate[29]. In the EDM process for machining of precise cylindrical forms on hard and difficult to machine materials by Taguchi robust design method used to optimize the precision and accuracy was reported by Matoorian. The current intensity affects the material removal rate higher[30]. Optimization of electrical process parameters using Taguchi DEAR methodology was described by Muthuramalingam and Mohan[31]. The fuzzy logic analysis, combined with Taguchi methods to optimize the accuracy and precision of the EDM process, was investigated by Tzeng and Chen[32]. Overall performance has been noticed as duty cycle and peak current.

The multiple regression method constitutes the relation between the input and output variables was described by Kuriakose and Shunmugam, to optimize the EDM process parameters, a multi objective optimization method based on non-dominated sorting genetic algorithm was utilized [33]

## 7. Conclusion

The present study discussed Electrical discharge machining electrical parameters contribution and continues evaluation for making EDM as the state-of-the-art machine. Many researchers described the impact of process parameters on performance measures, modelling and optimization concerned in the electro erosion process. The pulse duration and peak current control the performance measures. Low awareness to increase electrical process parameters in terms of pulse modification additive controlling and monitoring the process parameter was reported. Also need to rediscover of hybrid electrical discharge machine that includes electrochemical discharge machining(ECDM)

## 8. **Acknowledgement**

The author is acknowledged to CARIFF lab and Universiti Malaysia Pahang for providing technical and financial support for conduct research through internal grant RDU1903137

## References

[1] A.A. Abdu Aliyu, J. Mohd Rohani, A.M. Abdul Rani, H. Musa, optimization of electrical discharge machining parameters of sisic through response surface methodology, J. Teknol. 79 (2016). https://doi.org/10.11113/jt.v79.7622.

[2] I. Puertas, C.J. Luis, A Study of Optimization of Machining Parameters for Electrical Discharge Machining of Boron Carbide, Mater. Manuf. Process. 19 (2004) 1041–1070. https://doi.org/10.1081/AMP-200035200.

[3] R. Casanueva, F.J. Azcondo, S. Bracho, Series-parallel resonant converter for an EDM power supply, in: J. Mater. Process. Technol., Elsevier, 2004: pp. 172–177. https://doi.org/10.1016/j.jmatprotec.2003.10.038.

[4] M.P. Jahan, Y.S. Wong, M. Rahman, A study on the fine-finish die-sinking micro-EDM of tungsten carbide using different electrode materials, J. Mater. Process. Technol. 209 (2009) 3956–3967. https://doi.org/10.1016/j.jmatprotec.2008.09.015.

[5] F. Han, L. Chen, D. Yu, X. Zhou, Basic study on pulse generator for micro-EDM, Int. J. Adv. Manuf. Technol. 33 (2007) 474–479. https://doi.org/10.1007/s00170-006-0483-9.

[6] M.T. Yan, Y.T. Liu, Design, analysis and experimental study of a high-frequency power supply for finish cut of wire-EDM, Int. J. Mach. Tools Manuf. 49 (2009) 793–796. https://doi.org/10.1016/j.ijmachtools.2009.04.004.

[7] M.T. Yan, T.L. Chiang, Design and experimental study of a power supply for micro-wire EDM, Int. J. Adv. Manuf. Technol. 40 (2009) 1111–1117. https://doi.org/10.1007/s00170-008-1431-7.

[8] T. Muthuramalingam, B. Mohan, Influence of discharge current pulse on machinability in electrical discharge machining, Mater. Manuf. Process. 28 (2013) 375–380. https://doi.org/10.1080/10426914.2012.746700.

[9] F. Han, S. Wachi, M. Kunieda, Improvement of machining characteristics of micro-EDM using transistor type isopulse generator and servo feed control, Precis. Eng. 28 (2004) 378–385. https://doi.org/10.1016/j.precisioneng.2003.11.005.

[10] M.T. Yan, Y.P. Lai, Surface quality improvement of wire-EDM using a fine-finish power supply, Int. J. Mach. Tools Manuf. 47 (2007) 1686–1694. https://doi.org/10.1016/j.ijmachtools.2007.01.006.

[11] T. Muthuramalingam, B. Mohan, Design and fabrication of control system-based ISO pulse generator for electrical discharge machining, Int. J. Mechatronics Manuf. Syst. 6 (2013) 133–143. https://doi.org/10.1504/IJMMS.2013.053823.

[12] M. Ghoreishi, C. Tabari, Investigation into the effect of voltage excitation of pre-ignition spark pulse on the electro-discharge machining (EDM) process, Mater. Manuf. Process. 22 (2007) 833–841. https://doi.org/10.1080/10426910701446812.

[13] Y.Y. Tsai, C.T. Lu, Influence of current impulse on machining characteristics in EDM, in: J. Mech. Sci. Technol., Korean Society of Mechanical Engineers, 2007: pp. 1617–1621. https://doi.org/10.1007/BF03177384.

[14] S.M. Son, H.S. Lim, A.S. Kumar, M. Rahman, Influences of pulsed power condition on the machining properties in micro EDM, J. Mater. Process. Technol. 190 (2007) 73–76. https://doi.org/10.1016/j.jmatprotec.2007.03.108.

[15] K. Liu, D. Reynaerts, B. Lauwers, Influence of the pulse shape on the EDM performance of Si3N4-TiN ceramic composite, CIRP Ann. - Manuf. Technol. 58 (2009) 217–220. https://doi.org/10.1016/j.cirp.2009.03.002.

[16] M.T. Yan, An adaptive control system with self-organizing fuzzy sliding mode control strategy for micro wire-EDM machines, Int. J. Adv. Manuf. Technol. 50 (2010) 315–328. https://doi.org/10.1007/s00170-009-2481-1.

[17] U. Çaydaş, A. Hasçalik, Modeling and analysis of electrode wear and white layer thickness in die-sinking EDM process through response surface methodology, Int. J. Adv. Manuf. Technol. 38 (2008) 1148–1156. https://doi.org/10.1007/s00170-007-1162-1.

[18] M. Zhou, F. Han, Adaptive control for EDM process with a self-tuning regulator, Int. J. Mach. Tools Manuf. 49 (2009) 462–469. https://doi.org/10.1016/j.ijmachtools.2009.01.004.

[19] M.T. Yan, H.T. Chien, Monitoring and control of the micro wire-EDM process, Int. J. Mach. Tools Manuf. 47 (2007) 148–157. https://doi.org/10.1016/j.ijmachtools.2006.02.006.

[20] Y.F. Chang, Mixed H2/H∞ optimization approach to gap control on EDM, Control Eng. Pract. 13 (2005) 95–104. https://doi.org/10.1016/j.conengprac.2004.02.007.

[21] A. Behrens, J. Ginzel, Neuro-fuzzy process control system for sinking EDM, J. Manuf. Process. 5 (2003) 33–39. https://doi.org/10.1016/S1526-6125(03)70038-3.

[22] C.C. Kao, A.J. Shih, Sub-nanosecond monitoring of micro-hole electrical discharge machining pulses and modeling of discharge ringing, Int. J. Mach. Tools Manuf. 46 (2006) 1996–2008. https://doi.org/10.1016/j.ijmachtools.2006.01.008.

[23] H. Tong, Y. Li, Y. Wang, D. Yu, Servo scanning 3D micro-EDM based on macro/micro-dual-feed spindle, Int. J. Mach. Tools Manuf. 48 (2008) 858–869. https://doi.org/10.1016/j.ijmachtools.2007.11.008.

[24] C. Fenggou, Y. Dayong, The study of high efficiency and intelligent optimization system in EDM sinking process, in: J. Mater. Process. Technol., Elsevier, 2004: pp. 83–87. https://doi.org/10.1016/j.jmatprotec.2003.10.059.

[25] S. Liu, Y. Huang, Y. Li, A plate capacitor model of the EDM process based on the field emission theory, Int. J. Mach. Tools Manuf. 51 (2011) 653–659. https://doi.org/10.1016/j.ijmachtools.2011.04.002.

[26] S. Das, S.S. Joshi, Modeling of spark erosion rate in microwire-EDM, Int. J. Adv. Manuf. Technol. 48 (2010) 581–596. https://doi.org/10.1007/s00170-009-2315-1.

[27] K. Salonitis, A. Stournaras, P. Stavropoulos, G. Chryssolouris, Thermal modeling of the material removal rate and surface roughness for die-sinking EDM, Int. J. Adv. Manuf. Technol. 40 (2009) 316–323. https://doi.org/10.1007/s00170-007-1327-y.

[28] S. Spadło, J. Kozak, P. Młynarczy, Mathematical modelling of the electrical discharge mechanical alloying process, in: Procedia CIRP, Elsevier B.V., 2013: pp. 422–426. https://doi.org/10.1016/j.procir.2013.03.031.

[29] J. Marafona, C. Wykes, New method of optimising material removal rate using EDM with copper-tungsten electrodes, Int. J. Mach. Tools Manuf. 40 (2000) 153–164. https://doi.org/10.1016/S0890-6955(99)00062-0.

[30] P. Matoorian, S. Sulaiman, M.M.H.M. Ahmad, An experimental study for optimization of electrical discharge turning (EDT) process, J. Mater. Process. Technol. 204 (2008) 350–356. https://doi.org/10.1016/j.jmatprotec.2007.11.058.

[31] T. Muthuramalingam, B. Mohan, Multi-Response Optimization of Electrical Process Parameters on Machining Characteristics in Electrical Discharge Machining Using Taguchi-Data Envelopment Analysis-Based Ranking Methodology, J. Eng. Technol. 3 (2013) 57. https://doi.org/10.4103/0976-8580.107103.

[32] Y. fong Tzeng, F. chen Chen, Multi-objective optimisation of high-speed electrical discharge machining process using a Taguchi fuzzy-based approach, Mater. Des. 28 (2007) 1159–1168. https://doi.org/10.1016/j.matdes.2006.01.028.

[33] S. Kuriakose, M.S. Shunmugam, Multi-objective optimization of wire-electro discharge machining process by Non-Dominated Sorting Genetic Algorithm, J. Mater. Process. Technol. 170 (2005) 133–141. https://doi.org/10.1016/j.jmatprotec.2005.04.105.