International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 04 | April - 2021 ISSN: 2582-3930

Review on Electro Discharge machining (EDM) Process Parameters Optimization of A2 Steel

Vijay M. Bankar[1], Dr. S. A. Patil[2]

[1]*PG Student Mechanical Engineering Department,*
Government Engineering College, Aurangabad.
[2]*Asso. Prof., Mechanical Engineering Department,*
Government Engineering College, Aurangabad

Abstract-Electrical discharge machining (EDM) is one of the earliest non-traditional machining processes. EDM is a thermal process in which rapid and continuous spark is discharged between electrically conductive work piece and electrode in dielectric medium.It is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes.Electrical Discharge Machining performance is generally evaluated on the basis of Material Removal Rate (MRR), Tool Wear Rate (TWR), Relative Wear Ratio (RWR) and Surface Roughness (SR). The important EDM machining parameters affecting to the performance measures of the process are discharge current, pulse on time, pulse off time, arc gap, and duty cycle. A considerable amount of work has been reported by the researchers on the measurement of EDM performance on the basis of MRR, TWR, RWR, and SR for various materials.Previous researchers working in the area of EDM have extensively analyzed the machining performance throughexperimental study, modeling, and simulation and also by theoretical analysis. This article discusses the significant summary of the work performed by earlier researchers through a detailed literature survey.This new research shares the same objectives of achieving more efficient metal removal rate reduction in tool wear and improved surface quality.This paper reviews the research work carried out from the inception to the development of electric Discharge Machining and optimization Technique used in the Electric Discharge Machining research field.

Keywords: Electro discharge machining (EDM), Process parameters, Performance parameters, Optimization.

I.INTRODUCTION

In the present-day scenario, there has been incessant growth of accessibility and application of difficult-to machine materials. Various nontraditional approaches have been explored and adopted to machine these materials. Electrical discharge machining (EDM) is one of the suitable processes broadly applied for the machining of electrically conductive materials regardless of its hardness,strength, etc. In this machining process, combined electrical and thermal energy is used in terms of controlled erosion through a sequence of electrical spark generation to remove the material from specimen. The cornerstone of this EDM process was laid in 1770, whenDr. Joseph Priestly revealed the continuous erosive resultsobtained from the series of sparks. It was primarily presented by Dr. B.R. Lazarenko and Dr. N.I. Lazarenkoin 1943, in which spark generator used was recognized as the Lazarenko circuit. Later on in 1950, Lazarenkodeveloped EDM system having power supply controlled with resistance–capacitance (RC) circuit. Afterward, in 1960, the modified EDM was the combination of pulse and solid-state generators that not only reduced earlier difficulties using weak electrode but also originated orbiting systems. The EDM developed in the 1970s used less number of electrodes to create cavities. In 1980, a computer-assisted EDM called computer numerical controlled EDM was invented in the United States. Since then, EDM process has attracted worldwide attention as a technique to machine various advanced conductive materials such as carbide, composite, and ceramics. It is also used for the manufacturing of mould, die, automotive parts, aerospace parts, surgical apparatus, etc. Due to noncontact surface between the specimen and the tool, thin and fragile samples could be machined without damage. Keeping the potential utility of this process in consideration, there is burgeoning requirement of summarized literature at one place wherein description of essential machining parameters along with the current trends wouldbe discussed. Therefore, this article is an attempt to serve the aforementioned purpose and presents a systematic review on the machining parameters for efficient EDM performance. In nutshell, the article reviews the work performed on the measurement of various EDM performance and EDM operating parameters, along with the review on the current state-of-the-art work on EDM-based research as the concluding part of this article.

II.THE TECHNOLOGY AND PROCESS MECHANISM OF EDM

It is also called cavity-type EDM or volume EDM. It consists of an electrode and work piece submerged in an insulating liquid, such as, more typically, oil, or, less frequently, other dielectric fluids. The electrode and work piece are connected to a suitable power supply. The power supply generates an electrical voltage between the two parts. As the electrode approaches the work piece, the dielectric breakdown occurs in the fluid, which forms a plasma channel and small spark jumps. These jumping sparks usually strike on one at a time. The sinker EDM process uses an electrically charged electrode that is configured to a specific geometry to burn the electrode's geometry into a metal component. EDM has a controlled removal of metal through the electric spark erosion is used to extract the metal. In the process, the cutting tool to cut an electrical spark (Erode) finished work piece part production to the desired size as is used. The process of removing metal electrode to the work piece through a pulsing (on / off) of the high frequency current is performed by applying electrical charge. This removes the metal work piece at a controlled rate (impaired) is very small. This process is commonly used in dies and tool manufacturing. A schematic diagram of a sinker EDM is shown in Figure 1

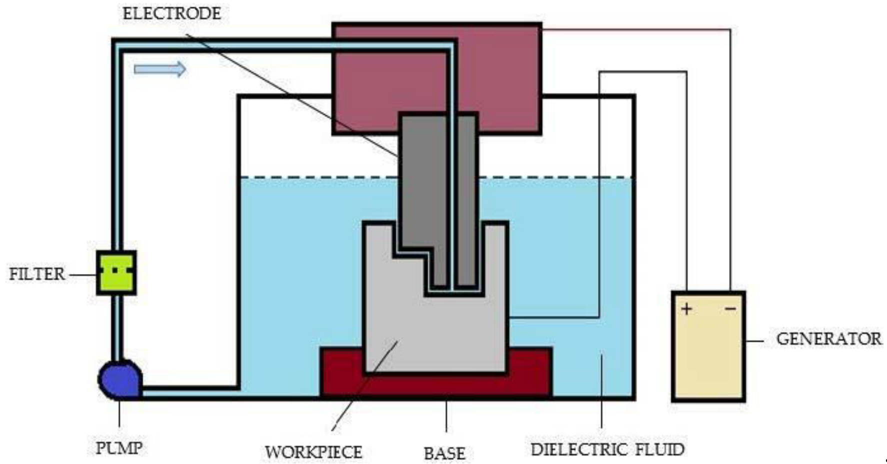

Figure1. Schematic diagram of sinker EDM.

Application of EDM:

1) The EDM process is most widely used by the mould-making tool and die industries, but is becoming a common method of making prototype and production parts, especially in the aerospace, automobile and electronics industries in which production quantities are relatively low.
2) It is used to machine extremely hard materials that are difficult to machine like alloys, tool steels, tungsten carbides etc.
3) It is used for forging, extrusion, wire drawing, thread cutting.
4) It is used for drilling of curved holes.
5) It is used for internal thread cutting and helical gear cutting.
6) It is used for machining sharp edges and corners that cannot be machined effectively by other machining processes.
7) Higher Tolerance limits can be obtained in EDM machining. Hence areas that require higher surface accuracy use the EDM machining process.
8) Ceramic materials that are difficult to machine can be machined by the EDM machining process.
9) Electric Discharge Machining has also made its presence felt in the new fields such as sports, medical and surgical, instruments, optical, including automotive R&D areas.
10) It is a promising technique to meet increasing demands for smaller components usually highly complicated, multifunctional parts used in the field of micro-electronics.

Advantages of EDM:

1) Any material that is electrically conductive can be cut using the EDM process.
2) Hardened workpieces can be machined eliminating the deformation caused by heat treatment.
3) X, Y, and Z axes movements allow for the programming of complex profiles using simple electrode.
4) Complex dies sections and molds can be produced accurately, faster, and at lower costs. Due to the modern NC control systems on die sinking machines, even more complicated work pieces can be machined.

5) The high degree of automation and the use of tool and work piece changers allow the machines to work unattended for overnight or during the weekends
6) Forces are produced by the EDM-process and that, as already mentioned, flushing and hydraulic forces may become large for some work piece geometry. The large cutting forces of the mechanical materials removal processes, however, remain absent.
7) Thin fragile sections such as webs or fins can be easily machined without deforming the part.
Optimization of Process Parameters in Die Sinking EDM- A Review

Limitation of EDM:

1) Both the material the tool and work piece material has to be electrical conductivity property. Because of this property creation of electric discharges is possible.
2) Sometimes the wear rate on the electrode or tool is higher which requires use of more than one tool to finish the machining
on the work piece.
3) Sometimes the measurement of thin gap between the tool and work piece is not easily predictable especially in case of complex geometries which demands the flushing method to be differ from the simple one.
4) Optimum machining settings of the EDM process largely are influenced by on the grouping of the tool and work piece. EDM manufacturers only fund these settings of the required material combination. Therefore skill personnel required to develop his own technology.
5) In case of die sinking EDM the cavity formed on the work piece with low metal removal rate. In case of wire-cut EDM only outline of the required shape on the work piece has to be machined. Therefore EDM is limited to small production applications.

III. SOME MACHINING PARAMETERS OF EDM

Parameters of Dry EDM mainly classified into two categories: process parameters & performance Parameters.

Process Parameters:

The process parameters in EDM are used to control the performance measures of the machining process.

1) Spark On-Time (Pulse Time or Ton): It is the duration of time expressed in micro seconds in whom the peak current is ready to flow in every cycle. This is the time in which energy removes the metallic particles from the work piece. This energy is really controlled by the peak current and the length of the on-time.
2) Spark Off-Time (Pause Time or Toff):It is the period of time expressed in micro seconds between the two pulses on time. This time permits the melted particle tocoagulate on to the work piece and to be wash away by flushing method of the arc gap.
3) Arc Gap:It is gap between the electrode and work piece in which the spark generate for eroding the metal from the work piece. It is verythin gap in the range of 10 – 125 μm.
4) Discharge Current (IP):Current is measured in ampere (A). Discharge current is responsible directly for material removal. It contains energy for meltingand evaporation.
5) Duty Cycle (τ):It is a percentage of the on-time relative to the total cycle time. This parameter is calculated by dividing the on-time by the totalcycle time (on-time pulse off-time).

6) Voltage (V):It is a potential that can be measure by volt it is also effect to the materialremoval rate and allowed to per cycle. Voltage is givenby in this experiment is 50 V.
7) Diameter of Electrode (D):It is the diameter of electrode or tool material. Diameter of tool is one factor considered on machining. This experiment 10 mmtool diameter is utilized.
8) Over Cut:It is a clearance per side between the electrode and the workpiece after the marching operation.

Performance Parameters:

These parameters measure the various process performances of EDM results.

1) Material Removal Rate (MRR):MRR is a performance measure for the erosion rate of the workpiece and is typically used to quantify the speed at which machiningis carried out. It is expressed as the volumetric amount of workpiece material removed per unit time.
2) Tool Wear Rate (TWR):TWR is a performance measure for the erosion rate of the tool electrode and is a factor commonly taken into account whenconsidering the geometrical accuracy of the machined feature. It is expressed as the volumetric amount of tool electrode materialRemoved per unit time.
3) Surface Quality (SQ):Surface quality is a broad performance measure used to describe the condition of the machined surface. It comprises componentssuch as surface roughness (SR), extent of heat affected zone (HAZ), recast layer thickness and micro-crack density.

IV. MATERIAL SELECTIONS

A2 Steel material is used as work piece in this research work. Size available in round, flat and square shape. The application of this material mainly used in mould and dies making, aerospace and automotive industries Literature study indicates that research can be conducted to evaluate effect of process parameters like pulse on time, current and voltage of EDM on MMR and TWR.

- Superior strength & toughness
- Corrosion resistant
- Withstand extreme temperature
- Capable of being fabricated into a variety of parts

C	Si	Mn	P	S	Cr	Mo	V
0.95-1.05	0.10-0.40	0.40-0.80	0.030max	0.030max	4.80-5.50	0.90-1.20	0.15-0.35

Fig.1 Chemical composition

Fig.2 A2 Steel

V. REVIEW ON OPTIMIZATION OF PROCESS PARAMETERS

The specific analysis is performed in the different areas as discussed by this review paper

Author & Year	Contribution	Process Parameters	Response parameters	Workpiece material	Remark
PhanHuu (2017)	Exp Investigation of SR of SKD11 Die Steel during Die-Sinking EDM Process using Copper Electrode	Voltage, Current, pulse on time	SR	SKD11 Die Steel	In this study, the influence of the most significant factors on SR has been studied.
JadiLaxman (2014)	Optimization of Electric Discharge Machining Process Parameters Using Taguchi Technique	Pulse on time, pulse off time, current , Tool LIFT time	MRR, SR, TWR	Titanium super alloy	From results show that, Increase in peak current causes MRR, TWR and SR to increases continuously. Increase in pulse on time causes MRR, TWR to increase and SR to decrease.
Mahendra U Gaikwad (2019)	Process Parameters Optimization Using Jaya Algorithm During Edm Machining Of Niti60 Alloy	Voltage, Current, on time, off time	MRR, SR	Niti60 Alloy	It is reported that increase in current leads to increase the MRR but hampers SR So for SR less value of current is desirable
SeepalaKiran(2016)	Experimental Investigation to Optimize Process Parameters Using Copper Electrodes in Die Sinking EDM Process Machining P20 Steel	Pulse on time, pulse off time, spark gap. current	MRR, TWR, SR	P20 Steel	In this study take different electrode shapes round and hexagonal are taken for experimentation. Material removal rate is more for hexagonal Electrode, Tool wear rate is less for round electrode, Surface roughness is less for round electrode
Nadeem Faisal (2018)	Optimization of Machine Process Parameters in EDM for EN 31 Using Evolutionary Optimization Techniques	Pulse on time, pulse off time, voltage, current	MRR, SR	EN 31	Better optimized value were obtain like greater MRR and less SR was main goal of whole experiment.
J. Jeykrishnan (2016)	Parameter Optimization of Electro-Discharge Machining (EDM)	Current, pulse on time, pulse off time	MRR	AISI D2 Die Steel	From this study conclude that, MRR was increased when pulse on time and current increased.

	in AISI D2 Die Steel				
D.Vinoth Kumar (2016)	Experimental Investigation of Process Parameters in EDM for Incoloy 600 Using Taguchi	Pulse on time, pulse off time, current	MRR, TWR	Incoloy 600	According to Annova, most significant factor and contribution of pulse on time for MRR and TWR
Jaganathan Pa, (2016)	Machining Parameters Optimization of EDM Process Using Taguchi Method	Applied voltage, pulse on time, pulse off time	MRR, SR	EN31	Factors like Voltage, Pulse width and Speed have been found to play a significant role for MRR and surface roughness. Taguchi's method is used to obtain optimum parameters combination for maximization of MRR and minimization of Ra
Dr.T.Vijaya Babu (2016	Investigation of Process Parameters Optimization in Die - Sinking Edm to Improve Process Performance Using Taguchi Technique	Pulse on time, off time, current, servo voltage, Servo Feed	SR	M300 steel	From the results, it was found that voltage, current and pulse on time has been found to play significant role in EDM operations
M.M. Bahgat (2019)	Influence of process parameters in electrical discharge machining on H13 die steel	Pulse on time, electrode material, current		H13 die steel	ANOVA of the obtained data shows that according to significance, the peak current is the most important factor affecting both MRR and SR
Ch.MaheswaraRao (2019)	Effect and Optimization of EDM Process Parameters on Surface Roughness for En41 Steel	Pulse on time, off time, wire tension, feed rate	SR	En41 Steel	From ANOVA results, the wire feed rate is the most significant parameterfollowed by wire tension and pulse time off. Pulse on time has theleast significance among all the process parameters in effecting the surface roughness.
Vikas (2013)	Effect and Optimization of Machine Process Parameters on Material Removal Rate in	Pulse on time, pulse off time, discharge current, gap voltage	MRR	EN41 Steel	Results found that the Input current has highest impact over the MRR followed by pulse off time and voltage. The MRR rate increased greatly with

	EDM for EN41 Material Using Taguchi				an increase in the discharge current. However, the impact of Pulse on time was the least
Niraj Kumar Ohdar (2017)	Optimization of EDM process parameters using	Peak current, spark on time, spark off time, flushing pressure	MRR, TWR	Die Mild steel	For MRR, the most significant factor is found to be pulse on time followed by pulse off time. For TWR, the most significant factor is found to be peak current followed by pulse on time.
J.Jeevamalar (2015)	Optimization of EDM Process Parameters Taguchi Method with Copper Electrode using Taguchi Method	Pulse on time, off time, current	MRR, SR, TWR	OHNS	We can conclude from this project work that by using the Taguchi design to maximize the MRR, TW and SR

VI.CONCLUSION

- The experiments were carried out and on the basis of comparison with the results & the analysis, it was concluded that the predicted values match the experimental values reasonably well for MRR, TWR and SR.
- The key parameters affecting the Material Removal Rate, Tool Wear Rate, Surface Roughness, over cut are identified as the Discharge Current, Pulse on time, Pulse off time, Spark gap, flushing pressure of electrolyte, tool geometry, electrode material from the literature available.
- The coefficients and power indices of the model suggests that pulse on-time and thermo-physical properties such as coefficient of thermal expansion, thermal diffusivity and melting point temperature are significant parameters on MRR.
- Ton higher will be the energy applied and spark there by generating more amount of heat energy during this period. MRR is directly proportional to the amount of energy applied during Ton. Higher the value of Ton, higher will be the energy produced and this will lead to the generation of more heat energy.
- Kerosene and some commercial EDM oils are most used as a dielectric fluids because of their high flash point. Deionized water was also used depending on the workpiece or when carbide formation on the machined surface had to be avoided.

- From the literature study it is found that, many researcher conducted study on the pulse time, current and voltage which are affecting on material removal rate and surface finish.
- In the literature it was also noted that with the different electrode material different performance was measure. Copper, graphite, steel, tungsten, aluminum electrode material was widely used in present scenario.
- The optimization techniques used by various researchers with different techniques are Taguchi method, RSM, Algorithm were mentioned in the review.

VII. REFERENCES

1. IndhuSekaran.N, ArunPothilingam S, Dinesh S, J Jefferson Lazer C, Jegatheesan S "Experimental Investigation and Optimization of Machining Parameters in Electrical Discharge Machining" International Journal of Innovative Research in Science, Engineering and Technology Vol. 5, Special Issue 8, May 2016 ISSN(Online) : 2319-8753
2. Parameters Using Taguchi Method with Graphite Electrode" International Journal of Engineering Trends and Technology (IJETT) Volume 7 Number 2- Jan 2014 ISSN: 2231-5381
3. Suresh Kumar Gurjar "Optimization of MRR and TWR on EDM by using Taguchi's method and ANOVA Die" International Journal for Innovative Research in Science & Technology IJIRST Volume 2 | Issue 03 | August 2015 ISSN (online): 2349-6010
4. Kapil Banker, UjjvalPrajapati, JaiminPrajapati, ParasModi, "Parameter optimization of Electro Discharge Machine of AISI 304 Steel by using Taguchi Method" International Journal of Application or Innovation in Engineering & Management(IJAIEM) Volume 3, Issue 8, August 2014 ISSN 2319 – 4847
5. Raghuraman S, Thiruppathi K, Panneerselvam T, Santosh S "Optimization of EDM parameters using Taguchi method and grey relational analysis for mild
6. steel is 2026" International Journal of Innovative Research in Science, Engineering and Technology (IJRSET) Vol. 2, Issue 7, July 2013 ISSN: 2319-8753
7. J. Laxman, Dr. K. Guru Raj "Optimization of EDM Process Parameters on Titanium Super Alloys Basedon the Grey Relational Analysis" International Journal of Engineering Research Volume No.3, Issue No.5, pp : 344-348 ISSN:2319-6890
8. Shahul Backer, Cijo Mathew, Sunny K. George "Optimization of MRR and TWR on EDM by Using Taguchi's Method and ANOVA" International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163(2014).
9. S N Panda AND A K Pattanaik "parametric optimization of EDM process by using Taguchi based grey relational analysis for mild steel is 1018" International Interdisciplinary Conference On Engineering Science & Management Held ISBN: 9788193137383(2014)
10. J.S. Soni, G. Chakraverti, "Experimental investigation of migration of material during EDM of die Steel (T215Cr12),. pp.51-58.
11. Koshy George, P.K. Philip and Geddam A, "Hardening of surface layers using electrical discharge techniques," Proc. Conf. 11th AIMTDR, IIT, MADRAS, 1981, p. 315.
12. A. Gandadhar ,M.S. Shunmugam and P.K Philip, "Surface modification in electro discharge techniques with a powder compact tool electrode," Wear, Vol. 143,No 1,1991, p.45.
13. O.A. Abu Zied, "The role of voltage pulse off-time in the electro discharge machined AISI T 1 high- speed steel," J. of Mat Process Technol. 61, 1996, pp.287-291.
14. L.C. Lee, L.C. Lim, V. Narayanan and V.C Venkatesh,"Quantification of surface damage of tool steel after EDM," Vol. 28, No 4, 1988, pp. 359- 372.
15. S.H. Lee, X.P. Li, "Study of the effect of machining parameters on the machining characteristics in electric discharge machining of tungsten carbide," Journal of Matl. Processing Technology, 115, 2001, pp.344-358.

16. L.C. Lim, L.C. Lee, Y.S. Wong , H.H Lu, "Solidification microstructure of electro discharged machined surface of tool steels," Mater. Sci. Technol,7, 1991, pp. 239-248.
17. J.P. Kruth, L. Stevens, L. Froyen, B. Lauwers, "Study of the white layer of a surface machined by die- sinking electro discharge machining," Ann.CIRP, 44, 1,1995, pp. 169-172.
G. Krishna MohanaRao,"Influence of the machining parameters on electric discharging machining of maraging steels," Proceeding of the world congress of engineering, vol.II, pp.978-988, July 2018.
18. A. M. Nikalje, "Influence of parameters and optimization of EDM performance measures on MDN 300 steel using Taguchi method," International journal of manufacturing technology, vol.69, pp. 41-49
19. J. C. Rebolo,"An experimental study on electro discharge machining and polishing of high strength copper-berlliyum alloys, "Journals of material processing technology,vol.103, pp. 389-397,Dec 2010.
20. S. H. Lee," Study of the effect of machining parameters on the machining characteristics in electrical discharge machining of tungsten carbide," Journal of material processing technology,vol.115, pp. 344-358,Sep 2015.
21. I. Peuratos,"Analysis of the influence of EDM parameters on the surface quality, MRR and EW of WC-Co," Journals of material processing technology,vol.153,pp.1026-1032,2004.
22. M. Kiyak, "Examination of machining parameter on surface roughness in EDM of tool steel," Journals of material processing technology, vol.191, pp.141-144, 2017. .