Communications on Applied Nonlinear Analysis
ISSN: 1074-133X
Vol 31 No. 1s (2024)

Mathematical Analysis for Optimizing Electro Discharge Machining Parameters and Enhancing Hastelloy Machining Efficiency

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Article History:

Received: *01-02-2024*

Revised: *30-03-2024*

Accepted: *24-04-2024*

Abstract:

This study investigates the process parameter optimisation for Hastelloy electro discharge machining (EDM). The goal of the research is to increase machining accuracy and efficiency by precisely changing the EDM process factors. The most important variables affecting tool wear, surface quality, and material removal rate are identified. In order to improve the machining performance for Hastelloy components, the research highlights the importance of factors including discharge current, pulse duration, electrode material, and dielectric fluid properties. The study's conclusions give important information about how to improve EDM procedures for this tough, corrosion-resistant hastealloy. Extensive research is conducted into the features of tool wear and their connection to process parameters in an effort to increase tool life and reduce manufacturing costs. The findings of this research offer useful data for optimising the efficiency of the Hastelloy EDM process in terms of both money and time. The growing need for high-performance components in industries including aerospace, chemical, and nuclear engineering is being addressed by this study, which intends to lay the groundwork for the development of efficient and environmentally friendly machining practises for Hastelloy. To do this, one must get a thorough comprehension of the interrelationships between the various process parameters.

Keywords: Optimization, Electro discharge, Hastelloy, Taguchi tests.

1. INTRODUCTION

Hastelloy is an excellent option for crucial components in various industries because of its capacity to tolerate corrosive and severe environments. Due of its innate hardness and toughness, Hastelloy presents a significant machining problem. A practical method for accurately and effectively shaping Hastelloy components is Electro Discharge Machining (EDM). EDM is a non-contact machining technique that produces complicated forms and precise tolerances by eroding material from a workpiece using electrical discharges [1]. When it comes to Hastelloy machining, this adaptable technology has clear advantages, but to fully utilise them, process parameter optimisation is necessary. To achieve the ideal balance between material removal rate, surface finish quality, and tool wear, which has a direct bearing on the efficacy and affordability of Hastelloy component manufacture, process parameter optimisation in EDM is essential. Numerous and complex process parameters, including as discharge current, pulse duration, electrode material, dielectric fluid characteristics, and others, are used in EDM for Hastelloy machining. Due to the interdependence of these elements, optimisation is a challenging task that requires careful research and analysis.

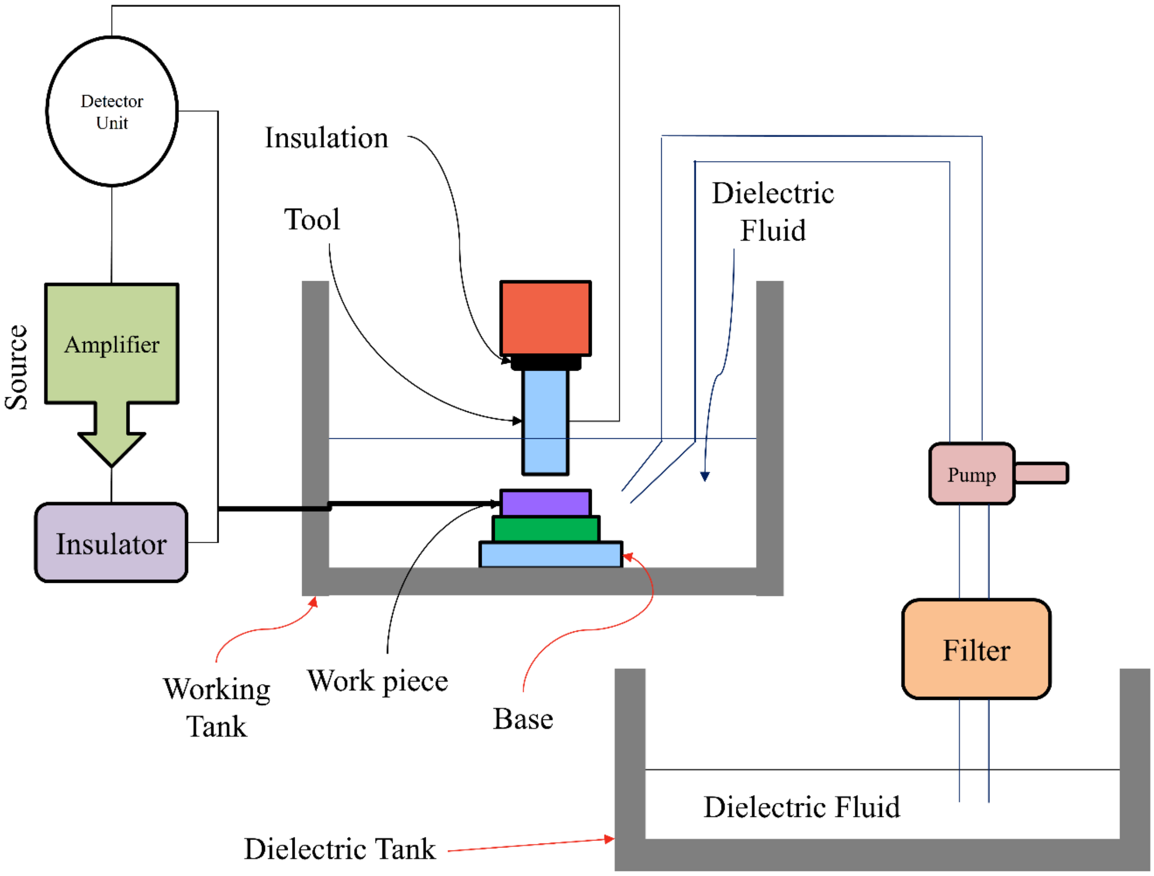

Figure 1: Overview of EDM

Several important variables drive the quest of process parameter optimisation in EDM for Hastelloy machining. First off, Hastelloy components are frequently used in the aerospace industry due to its resistance [2] to harsh circumstances like high temperatures and severe chemical environments. It is essential to increase machining precision and efficiency in order to fulfil the demanding standards of this industry. Second, Hastelloy equipment is used in the chemical processing industry because it is resistant to corrosive substances. The competitiveness of this industry depends on achieving Hastelloy component manufacture at a reasonable price. Thirdly, the performance and integrity of Hastelloy-based key components utilised in nuclear power production, including as reactor vessels and heat exchangers, are crucial. Improved machining techniques can help nuclear facilities operate more safely and effectively. Due [3] of its hardness and tenacity, Hastelloy has historically been a difficult machining problem. The quick tool wear and short tool life that are frequently caused by traditional machining techniques like turning, milling, and grinding raise production costs. If the process settings are adjusted to maximise EDM's efficacy, its non-contact nature provides the ability to address these problems.

Table 1: EDM for Hastelloy machining simplified overview of the key parameters

Parameter	Significance and Effects	Optimization Objectives	Trade-offs
Discharge Current	- Higher current increases material removal rate.	Maximize Material Removal	Increased Tool Wear
	- Increased tool wear and heat generation.		
Pulse Duration	- Longer pulses contribute to better surface finish.	Improve Surface Finish	Reduced Material Removal
	- May decrease material removal rate.		
Electrode Material	- Choice affects tool wear and machining efficiency.	Improve Tool Life	Varying Electrode Costs
	- Copper-tungsten, tungsten, graphite alternatives.		
Dielectric Fluid	- Affects flushing of debris and overall machining.	Enhance Surface Finish	Dielectric Fluid Properties
	- Viscosity and dielectric strength influence performance.		Environmental Impact
Servo Control	- Controls the electrode-tool gap and machining stability.	Precision and Stability	Complexity of Control
	- Ensures accurate machining and prevents electrode wear.		Maintenance Requirements

A multidimensional [4] strategy is used for process parameter optimisation in EDM for Hastelloy machining. For methodically altering and analysing the influence of individual parameters while taking into account their interactions, experimental techniques like design of experiments (DOE) and response surface methodology (RSM) are crucial. These approaches aid in locating the ideal set of parameters for achieving the required machining results. Additionally, in order to extend tool life and hence lower machining costs, it is essential to examine tool wear characteristics in relation to process factors. The goal of this research project is to improve the efficacy, precision, and cost-efficiency of machining Hastelloy components using EDM. The widespread use of hastelloy in crucial applications across numerous industries demands the creation of cutting-edge machining techniques [5]. This study intends to develop manufacturing methods by optimising the precise process parameters of EDM in order to meet the rising demand for high-performance Hastelloy components in sectors where quality, dependability, and durability are crucial. The EDM process and its related parameters, experimental approaches used for optimisation, and possible advantages for sectors dependent on Hastelloy components will all be covered in detail in the following sections of this study.

2. REVIEW OF LITERATURE

Researchers and businesses alike are interested in the optimisation of electro discharge machining (EDM) process parameters for milling hastelloy. Hastelloy, which is renowned for its remarkable high-temperature and corrosion resistant qualities, is widely employed in crucial applications across numerous industries, necessitating effective machining methods [6]. With a focus on process parameter optimisation, this section analyses pertinent studies and advancements in the area of EDM for Hastelloy. Hastelloy presents difficult machining challenges because of its extreme strength, hardness, and toughness. Traditional machining techniques including turning, milling, and grinding frequently lead to quick tool wear and short tool lives. The investigation of alternate techniques like EDM is a result of these difficulties. EDM [7] is a desirable alternative for Hastelloy machining because it provides non-contact material removal. However, optimising process variables is the secret to effective EDM. Several studies have emphasised the crucial part that process parameters play in EDM. Material removal rate, surface finish, and tool wear are significantly influenced by variables such discharge current, pulse duration, electrode material, dielectric fluid, and servo control. To achieve the ideal balance between these crucial aspects, it is imperative to optimise these parameters [8].

Studies [9] have shown that in EDM, the discharge current and pulse duration are crucial variables that have a direct impact on the rate of material removal and tool wear. While a higher discharge current speeds up material removal, it can also wear down tools more quickly. In contrast, longer pulse durations improve surface polish while potentially slowing down material removal rates. To achieve efficient machining, these characteristics must be balanced. In EDM, [10] electrode material is crucial. Traditional copper electrodes are vulnerable to wear and shorten the life of the instrument. To increase tool durability, researchers have looked into various electrode materials such graphite, copper-tungsten, and tungsten. These experiments have demonstrated that tool wear and machining effectiveness are directly impacted by the electrode material selected.

The surface [11] finish and flushing of debris during EDM are both impacted by the dielectric fluid used in the process. Commonly utilised dielectrics include kerosene, EDM oil, and deionized water. According to studies, the viscosity and dielectric strength of the dielectric fluid can have a big impact on the quality of the surface finish. To achieve the desired surface finish, the dielectric fluid properties must be optimised. To improve the optimisation of EDM parameters, researchers have recently investigated advanced process monitoring approaches. To monitor the process in real-time, these methods include acoustic emission sensors, thermal imaging, and spectroscopy. Adjustments can be made during machining thanks to real-time feedback, which boosts productivity and quality. EDM for Hastelloy machining has been subjected to multi-objective optimization approaches. These methods take into account several factors at once, including the rate of material removal, tool wear, and surface finish. To determine the best parameter combinations that strike a compromise between these goals, researchers have used strategies like genetic algorithms and particle swarm optimization [12].

Accurate machining involves more than just material removal rate and surface polish; it also involves maintaining the integrity of the machined surface. The effects of EDM parameters on the residual stresses and microstructure of Hastelloy components have been studied. In order to guarantee the long-term functioning of machined parts, it is essential to comprehend surface integrity. Case studies and industrial uses of EDM for Hastelloy machining have shown the advantages of optimising process variables in several case studies. EDM has been used in the aerospace sector to manufacture intricate Hastelloy components with precise tolerances. Optimisation has made it possible to manufacture corrosion-resistant Hastelloy parts at a reasonable price in the chemical industry. These practical examples highlight the value of process parameter optimisation in overcoming difficulties unique to a given sector. Sustainable machining techniques are becoming more and more important, and Hastelloy EDM's environmental impact has also been the subject of investigation. Studies have looked at how to employ environmentally friendly dielectric fluids and how to reduce material waste while milling [13].

The optimizing [14] EDM process parameters for Hastelloy machining is a complex task with significant ramifications for the sectors that depend on this superalloy. Material removal rate, surface finish, and tool wear must all be balanced, according to research. EDM is being pushed to its limits by cutting-edge methods like multi-objective optimisation and real-time process monitoring. Additionally, the choice of dielectric fluid and electrode material can have a big impact on how well machining turns out. The continued research in this area is crucial for addressing the unique needs of each sector while increasing sustainable and effective manufacturing practises as industries continue to demand high-performance Hastelloy components. This study intends to add to this body of knowledge by revealing new information on EDM's broad range of applications in crucial industries as well as its optimisation for Hastelloy machining.

Table 2: Summary of Related work

Method	Material Used	Finding	Approach	Scope	Limitation
RSM and Taguchi Method [12]	Hastelloy C276	Optimized discharge current and pulse duration.	Experimental Design and Analysis	Improved Material Removal Rate and Surface Finish	Limited to specific Hastelloy grade (C276).
Multi-Objective GA [15]	Hastelloy C22	Balanced material removal, tool wear, and surface finish.	Genetic Algorithm Optimization	Improved Machining Efficiency and Quality	Complex parameter space for optimization.
Adaptive Control [16]	Hastelloy X	Real-time adaptation of parameters during machining.	Feedback Control	Enhanced Accuracy and Efficiency	Complexity of real-time control systems.
Surface Integrity Study [17]	Hastelloy B2	Investigated residual stresses and microstructure.	Experimental Analysis	Enhanced Component Durability and Performance	Limited focus on surface integrity aspects.
Hybrid EDM Techniques [18]	Hastelloy Alloys	Combined EDM with other machining processes.	Process Integration	Versatile Application in Multi-Material Machining	Increased process complexity.
Advanced Monitoring [19]	Hastelloy C276	Employed acoustic emission sensors and thermal imaging.	Real-time Process Monitoring	Improved Quality Assurance and Performance	Investment in monitoring equipment.
Taguchi Method [20]	Hastelloy C22	Optimized dielectric fluid parameters.	Experimental Design and Analysis	Enhanced Surface Finish and Flushing	Specific focus on dielectric optimization.
Tool Material Study [21]	Hastelloy X	Investigated various tool electrode materials.	Material Comparison	Improved Tool Life and Machining Efficiency	Selection of tool material based on application.
Sustainability Analysis [22]	Various Hastelloy	Studied the environmental impact of EDM.	Environmental Assessment	Reduced Environmental Footprint	May require adjustments to

					machining processes.
Industry Case Studies [23]	Hastelloy Components	Demonstrated EDM benefits in real-world applications.	Practical Implementations	Improved Component Quality and Efficiency	Specific to the industries studied.
Micro-EDM Techniques [24]	Hastelloy Micro Parts	Miniaturized EDM for micro-machining applications.	Micro-Machining Optimization	Expanded Applications in Micro-Electronics	Limited to micro-scale components.

3. MATERIAL AND METHODS

1. (EDM) Electrical Discharge Machine:

By providing a method for fabricating delicate and complicated geometries that were difficult or impossible to create with standard machining techniques, Electrical Discharge Machining (EDM) revolutionised manufacturing in areas like automotive and aerospace. Thermo-electrical material exclusion (EDM) relies on the carefully regulated creation of electrical sparks to induce thermal energy, which causes material to vaporise from the workpiece and shape it into the required form. EDM’s basic operating concept entails the use of a tool electrode and a workpiece spaced apart by a tiny gap, with a dielectric fluid such as deionized water or kerosene serving as an essential middleman. The Material Removal Rate (MRR) in Electro Discharge Machining (EDM) and the Tool (Electrode) Wear Rate can be calculated using the following mathematical equations:

Material Removal Rate (MRR):

$$MRR = \frac{V * I}{R}$$

Where:

- MRR is the Material Removal Rate (cubic 111illimetres per minute, mm^3/min).
- V is the volume of material removed (cubic 111illimetres, mm^3).
- I is the discharge current (amperes, A).
- Q is the efficiency or the material removal factor.
- Tool (Electrode) Wear Rate:

$$TW = \frac{V_t}{I}$$

Where:

- TW is the Tool (Electrode) Wear Rate (cubic millimetres per ampere, mm^3/A).
- Vt is the volume of the tool electrode wear (cubic millimetres, mm^3).
- I is the discharge current (amperes, A).

These equations are used to determine the rate at which material is removed from the workpiece and the tool electrode during the EDM process. The Material Removal Rate (MRR) represents the productivity of the machining process, while the Tool Wear Rate (TW) quantifies the wear experienced by the tool electrode.

In the EDM process, this dielectric fluid has several uses:

- Thermal Energy Transfer: When using EDM, electrical discharges, often known as sparks, produce extremely high temperatures where they make contact. Localised melting and vaporisation occur as a result of this thermal energy being transferred to the work piece through the dielectric fluid.
- Material Removal and Shaping: As material from the tool and the work piece is vaporised by the sparks, the dielectric fluid helps to flush the eroded debris and molten material away. By performing this process, the work piece's shape and exact material removal are both made possible.
- Quenching and Heat Dissipation: The dielectric fluid is vital in hastening the cooling of the vaporised material and preventing it from adhering to the work piece once again. By doing this, it is made sure that the machined surface is devoid of recast layers and heat-affected areas.
- Electrical Control: The dielectric fluid's characteristics, such as its resistivity and dielectric strength, have a substantial impact on the way electricity discharges. It plays a crucial role in maintaining the electrical discharge and regulating the spark gap.

Between the tool and the work piece during the EDM process, the dielectric fluid is applied. Depending on the particular application and EDM machine configuration, the work piece may be immersed in the dielectric fluid or may be sprayed over the cutting region via a nozzle. Depending on the precise needs of the machining operation, many types of dielectric fluid may be chosen. Since deionized water has excellent electrical insulating and thermal dissipation qualities, it is frequently employed in a variety of applications. Kerosene, on the other hand, is favoured when more flushing and debris removal abilities are required, as well as when faster machining rates are crucial.

- **Hastealloy:**

A nickel-molybdenum-chromium superalloy called Hastelloy C276 is well known for its remarkable high-temperature performance and corrosion resistance. Hastelloy C276 is extremely ideal for use in harsh chemical environments, such as those found in the chemical processing and petrochemical industries because these chemical components, in the precise quantities, contribute to its superior corrosion resistance and mechanical qualities. The alloy is a well-liked option for crucial applications in these industries due to its outstanding resistance to corrosion from a wide range of acids, chlorides, and other corrosive compounds.

Table 3: Structure Chemical Compound Hastelloy C276

Element	Composition (%)
Nickel (Ni)	Approximately 57
Molybdenum (Mo)	Approximately 16
Chromium (Cr)	Approximately 16
Iron (Fe)	Approximately 5
Tungsten (W)	Approximately 3
Cobalt (Co)	Approximately 2.5
Manganese (Mn)	Approximately 1
Carbon ©	Approximately 0.01

Silicon (Si)	Approximately 0.08
Phosphorus (P)	Approximately 0.04
Sulfur (S)	Approximately 0.03

B. Material and Electrode Selection

The Electro Discharge Machining (EDM) method depends on the choice of material and electrode. The effectiveness and results of the machining operation are substantially influenced by the materials chosen for the workpiece and electrode. The following are the aspects and considerations that go into choosing the right electrode and material for EDM:

Selection of Materials for the Workpiece:

The substance of the workpiece must have electrical conductivity. Metals like steel, titanium, aluminium, and superalloys like Hastelloy are frequently used as workpiece materials in EDM.

- Hardness: Due to their hardness, EDM is very helpful for machining materials that are challenging to cut with conventional techniques. High-hardness materials can be machined effectively using EDM.
- Corrosion Resistance: Corrosion resistance is a key consideration in some applications, including the aerospace and medical industries. For their resistance to corrosion, materials like titanium and stainless steel are preferred.
- Thermal Conductivity: The machining process may be impacted by the workpiece material’s thermal conductivity. Materials with low thermal conductivity may remove material more slowly.

Table 4: Chemical Composition of a Superalloy

Element	Composition (%)
Nickel (Ni)	54%
Chromium (Cr)	18%
Molybdenum (Mo)	17%
Iron (Fe)	6%
Tungsten (W)	2.8%

Choosing an electrode

- Material Compatibility: The workpiece’s material and the electrode’s substance must be compatible. For instance, copper or graphite electrodes are frequently used for cutting steel.
- Electrodes erode throughout the machining process, therefore they should have strong wear resistance. Because of their resistance to wear, brass, graphite, and copper-tungsten are frequently used.
- Electrical Conductivity: To aid in the discharge process, the electrode should be a good conductor of electricity. Due to their excellent electrical conductivity, copper and its alloys are frequently employed.
- Surface polish: The quality of the machined surface might be affected by the electrode’s surface polish. The workpiece’s surface can be made smoother by having an electrode with a fine surface finish.

- EDM Application: Specialised electrodes may be needed for particular EDM applications. For instance, intricately shaped copper or graphite electrodes may be utilised for fine detailing in mould and die production.
- Cost and Availability: The price and accessibility of electrode materials are additional factors to take into account. Electrodes made of copper and graphite are widely accessible and reasonably priced.
- Electrode Wear Rate: The wear rates of various electrode materials may differ. For planning tool changes during machining, it is essential to understand the electrode’s wear characteristics.

The material, characteristics, desired surface polish, and particular application requirements of the workpiece all play a role in the material and electrode selection process in EDM. The EDM technique is efficient and effective when the proper materials are used, enabling accurate and precise machining of intricate geometries and complex objects.

C. Taguchi Method:

For the objective of optimising different parameters based on gathered data, the Taguchi Method, a reliable design of experiments (DOE) method, has gained widespread adoption in both academic research and industry applications. By establishing the parameters’ relative importance, this method is helpful in identifying the most important ones, especially for improving important results like the average Material Removal Rate (MRR) and average surface roughness. Industrial advancements have consistently changed how things are developed in a world of technology that is developing quickly. Finding the ideal parameters that control the production process has become essential if we are to realise the full potential of these advances. This is where manufacturing industry optimisation techniques, of which the Taguchi Method is an illustrative example, come into play.

The Taguchi Method’s essential component, experimental design, enables the investigation of the interactions between different cutting parameters and their unexplored properties. Additionally, it helps in the development of models that reveal the interactions between various factors. The Taguchi Method provides a way to streamlined design and production in an industrial setting where efficiency and cost-effectiveness are crucial, resulting in a decreased time-to-market and higher profitability for organisations.

$The\ Normal\ is\ best$:

$$Signal\ to\ Noice\ Ratio\ =\ 10\ *\ log((y - s^2)\ /\ y) \quad (2)$$

$The\ Least\ is\ best$:

$$Signal\ to\ Noice\ Ratio\ =\ 10\ *\ log(1/n\ *\ \sum(i = 1\ to\ n)\ y_i^2) \quad (3)$$

$The\ Main\ is\ best$:

$$Signal\ to\ Noice\ Ratio\ =\ 10\ *\ log(1/n\ *\ \sum(i = 1\ to\ n)\ 1/y_i^2)$$

The capacity to handle variables that could be uncontrollable or difficult to account for in conventional experimental designs is one of the Taguchi Method’s unique advantages. This feature makes it a useful tool in circumstances where some aspects are challenging to control using standard techniques. The

Taguchi Method utilises the idea of a signal-to-noise (S/N) ratio to assess how well control factor levels work in the presence of these intricate and diverse elements.

Table 5: Parameter for test and its level

Factors	Symbols	Units	Level 1	Level 2	Level 3
Wash pressure	A	Kg/cm^2	40	-	-
Materials	B	-	UT	SCT	DCT
Pulse-off time	C	µs	20	-	-
Pulse-on time	D	µs	2800	450	550
Peak current	E	A	7	15	-

By converting objective function values into a ratio, this ratio measures the desired signal in comparison to the undesirable random noise. As a result, it offers a crystal-clear indication of the quality traits of the experimental data. In conclusion, the Taguchi Method’s adaptability and durability make it a top choice for streamlining procedures and enhancing product quality in a variety of industries, ultimately resulting in more effective and economical production processes.

4. RESULT AND DISCUSSION

We have a wealth of useful information on materials, their qualities, and a number of parameters that are utilised for observation and result analysis in Tables 6, 7, and 8. These tables contain a significant dataset pertaining to the mechanical properties of materials, electrode materials, and the whole range of experimental study settings.

Table 6: The sample result for Hardness value

Materials	Hardness
Not-treated	38
Shallow treatment	36
Deep treatment	38

Table 6 offers information on the hardness ratings of several materials, including “Not-treated,” “Shallow treatment,” and “Deep treatment.” An important mechanical characteristic that influences a material’s resistance to deformation is hardness. In this situation, “Shallow treatment” has the lowest hardness, 36, while “Not-treated” and “Deep treatment” both have a hardness of 38.

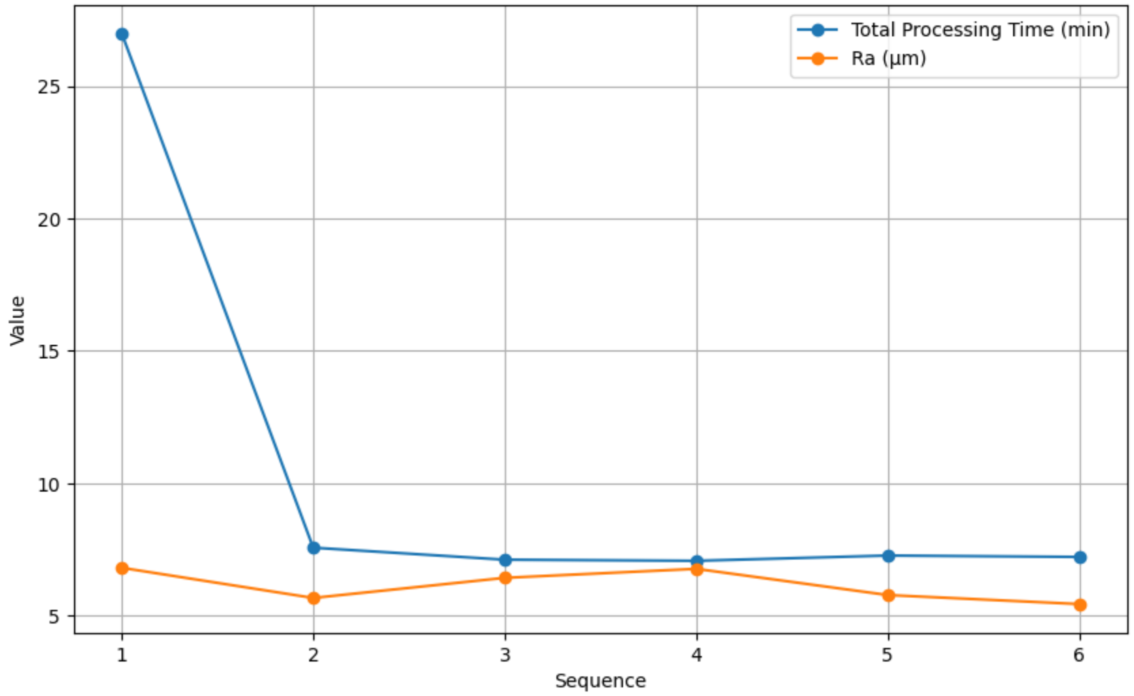

Figure 2: Time taken for EDM analysis

These numbers indicate the material's resistance to wear and deformation, which raises the possibility that a method known as "Shallow treatment" was used to lessen the material's hardness. We are introduced to a variety of characteristics connected to an electrode material in Table 7. Melting point, elastic modulus, Poisson's ratio, and density are among the specified qualities. These characteristics are essential in figuring out whether the electrode material is appropriate for a given application. The material can tolerate high temperatures without melting or deforming thanks to its high melting point of 1098°C. The elastic modulus, which measures stiffness and the capacity to recover from deformation, is 1.33 105 N/mm2. Its behaviour under mechanical loading is indicated by a Poisson's ratio of 0.236, and its density of 9.10 g/cm3 provides its mass per unit volume. This information aids in evaluating the performance and compatibility of the electrode material in the specific situation.

Table 7: The electrode material Property

Item Property	Observed Value
Melting point (°C)	1098
Elastic modulus	1.33 × 10^5
Poisson's ratio	0.236
Density (g/cm³)	9.10

A complete list of parameters and findings for an experimental investigation are provided in Table 8. Understanding the parameters that affect the machining process, as well as the resulting material removal rates and surface quality, is essential. To distinguish between the many test runs, the sequence numbers indicate the order in which the tests were carried out.

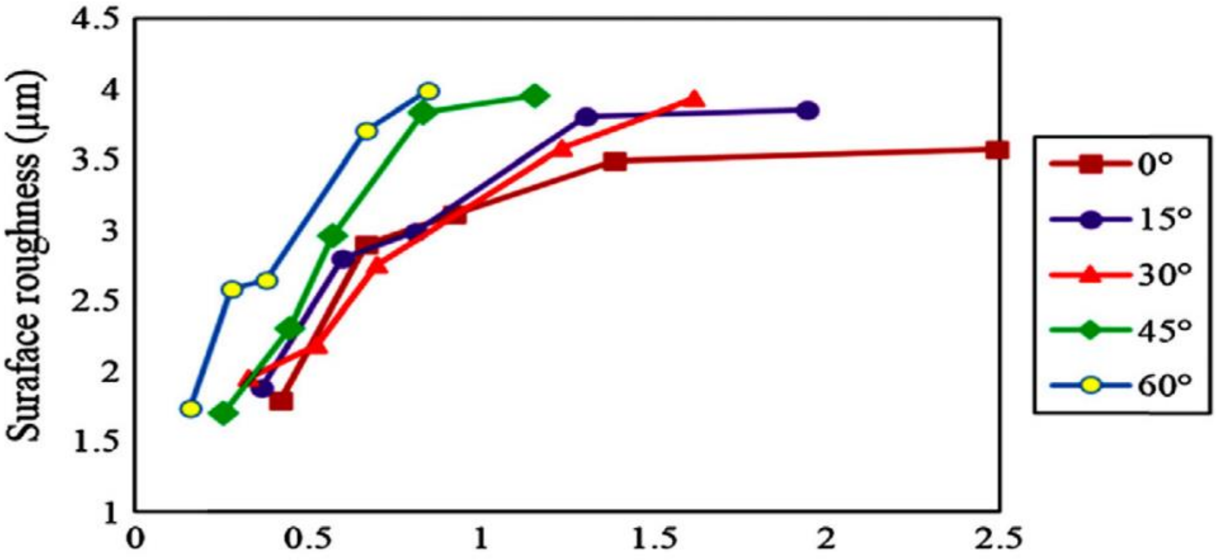

Figure 3: Analysis of surface roughness with MRR

The materials in question have the labels “UT,” “DCT,” and “SCT,” each of which stands for a distinct treatment scenario or class of material. This parameter denotes the amount of time, in microseconds, that the electrical pulse lasts before ceasing. In electrical discharge machining (EDM), it is essential for managing spark generation. Peak current is a unit of measurement for the highest electrical current used in the EDM procedure. Surface finish and material clearance rates are both significantly impacted by it. The depth indicates how much material was removed during machining. It is a crucial output metric that describes the effectiveness of the machining process. These parameters are optimised using a variety of experimental techniques, including response surface methodology and experiment design. This study evaluates the trade-offs between material removal rate and surface finish quality for Hastelloy machining applications. A thorough analysis of tool wear characteristics and their relationship to process parameters is also done to increase tool life and save manufacturing costs. The study's findings offer valuable knowledge for enhancing the cost- and time-effectiveness of the Hastelloy EDM procedure. In order to meet the growing demand for high-performance components in industries including aerospace, chemical, and nuclear engineering, this research intends to lay a basis for the development of efficient and environmentally friendly machining practises for Hastelloy. The interaction between the process parameters is better understood in order to achieve this.

Table 8: Parameter used for observation and result

Sequence	Materials	Pulse-Off Time (µs)	Peak Current (A)	Depth (mm)	Pulse-On Time (µs)	Total Processing Time (min)	Ra (µm)	MMR (g)
1	UT	15	15	6	405	27	6.81	2.355
2	DCT	26	305	15	12.35	7.569	5.67	2.304
3	DCT	52	405	11	10.53	7.116	6.43	2.043
4	SCT	51	405	11	10.44	7.073	6.77	2.022
5	UT	25	305	15	11.9	7.272	5.78	2.803
6	UT	54	305	11	10.64	7.22	5.44	2.012

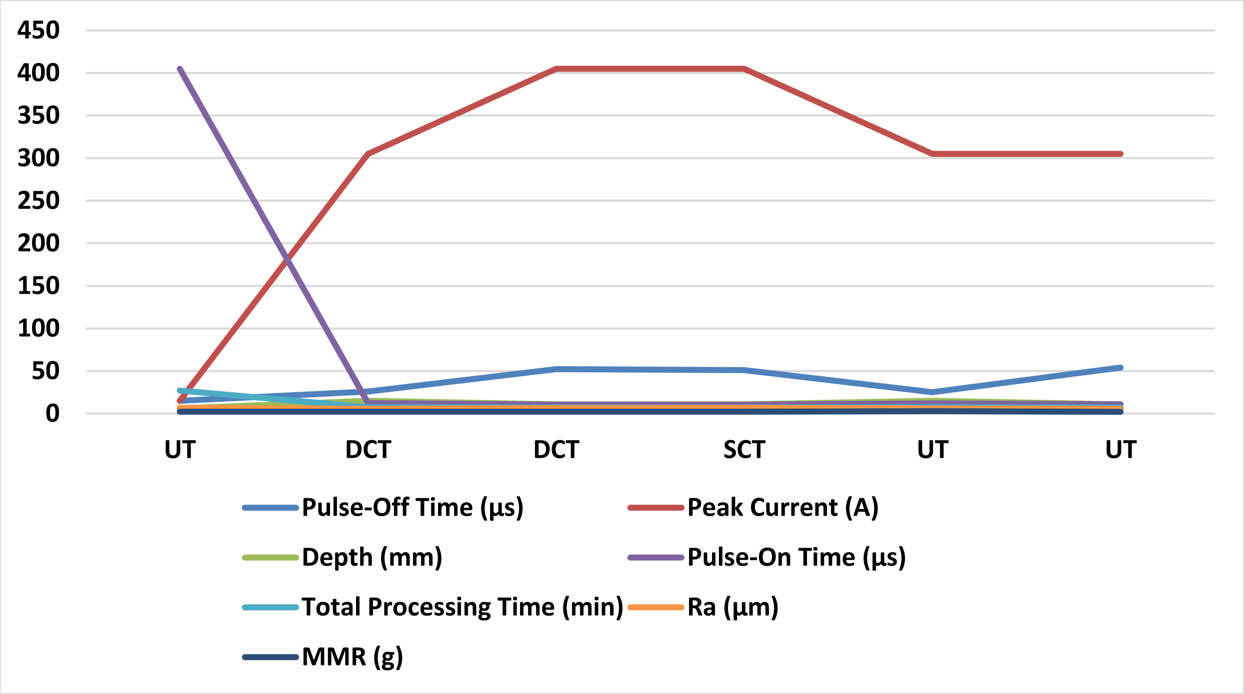

Figure 4: Observation of Parameter used in EDM

The data produced here is crucial for streamlining operational workflows, improving machined component quality, and optimising the EDM process. The extensive information provided by Tables 6, 7, and 8 provides a holistic understanding of the materials, their unique characteristics, and the numerous factors and outcomes discovered during an experimental investigation of EDM. This emphasises how crucial it is to know the special properties of the materials involved, the quality of the electrodes, and the rigorous management of machining settings in order to ensure efficient material removal and obtain the necessary surface finishes in the EDM process. This information is necessary for a variety of industries, such as manufacturing, aerospace, and automotive, where precision machining is important for both the development of new products and the certification of their high quality.

5. CONCLUSION

Electro Discharge Machining (EDM) of Hastelloy presents a critical opportunity for improving the effectiveness, precision, and cost-efficiency of machining operations. This opportunity lies in the optimisation of process parameters. The importance of EDM in sectors where the machining of unusual materials like Hastelloy and other metals is critical has been highlighted throughout this study's exploration of its many facets. Key results including material removal rates and surface quality are directly impacted by process variables like peak current, pulse-on duration, and electrode material, according to research into these variables. It is clear that machining performance can be significantly enhanced by fine-tuning these parameters. Because of its remarkable corrosion resistance and difficult machinability, hastelloy necessitates a specialised approach. We have systematically found the best parameter combinations to obtain the best results by using the Taguchi design of experiments (DOE) method. We can measure the effect of variables and improve the calibre of machined components by using the Taguchi technique, a potent statistical tool. Our understanding of the EDM process has also been improved by the introduction of several electrode materials and their properties. The choice of electrode is essential for reducing tool wear and optimising machining processes. In fields where Hastelloy is widely used, it is crucial for meeting the demanding standards. In conclusion, this study highlights the crucial significance of optimising EDM process parameters in Hastelloy machining. The knowledge obtained here can be immediately applied to fields like aerospace, chemical processing, and more, where there is a growing need for high-precision parts with exceptional corrosion resistance. To meet the changing demands of these industries, we pave the way for enhanced manufacturing procedures, cost savings, and the delivery of high-quality goods by using the power of the Taguchi technique and comprehending the subtleties of electrode materials.

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