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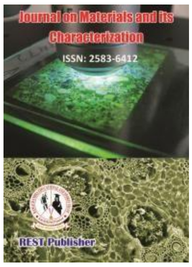

Recent Research in Wire Cut Electrical Discharge Machining Process

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Abstract: *A product's shape and size are developed through the manufacturing process, which is essential to all sectors. With its unique thermal machining technique, Wire Cut Electrical Discharge Machining (WEDM), items with sharp edges and varied hardness that prove challenging to produce using conventional machining methods can be precisely machined. Utilizing the widely used non-contact material removal technique, the practical technology of the WEDM process is based on the typical EDM sparking phenomenon. When the process was first introduced, WEDM has developed from a crude way to make tools and dies to the best way to produce micro-scale parts with the highest level of surface finish quality and dimensional accuracy. This paper reviews the extensive amount of research done from the EDM process to the development of the WEDM. It reports on the WEDM research that involves optimizing the process parameters and examining the impact of various factors on productivity and machining performance. The impact of multiple WEDM process input parameters, including wire speed, peak current, pulse on and off times, and peak on material removal rate (MRR), surface roughness (Ra), and micro structural analysis, on various process output responses is reviewed in this study.*
Keywords: *Wire Cut Electrical Discharge Machining, Conventional machining, Output Responses.*

1. INTRODUCTION

The extensively utilized non-traditional material removal method known as wire electrical discharge machining (WEDM) is used to make components with complicated forms and profiles. An electrode is used to initiate the sparking process in the traditional EDM method, and this modification is thought to be unique. The manufacturing sector was first exposed to WEDM in the late 1960s. Seeking a way to replace the machine electrode used in EDM led to the creation of the procedure. The optical line follower system was developed by D.H. Dulebohn in 1974 to automatically manage the geometry of the component that the WEDM process would produce. Its popularity began to rapidly rise by 1975 as the industry became more aware of the procedure and its potential. The machining process did not significantly evolve until the end of the 1970s with the introduction of computer numerical control (CNC) systems into WEDM.As a result, because wire had to flow through the component to be machined, the vast capabilities of the WEDM process were heavily utilized for any through-hole machining.

Only copper and brass wire options were available for the initial WEDM machine, which operated simply and without any complications. In order to change WEDM's cutting speed and overall capabilities, numerous studies were conducted alone. A lot of attempts have been made in the last few decades to use Wire EDM technology to meet different production needs, particularly in the precision mold and die sector. Through advancements in several WEDM areas, including quality, accuracy, precision, and operation, wire EDM productivity and efficiency have increased. Welding and extrusion tools, dies, fixtures, gauges, prototypes, aviation and medical parts, and wheel form tools are among the common uses of WEDM. It can create any electrically conductive material, regardless of hardness, ranging from extremely uncommon space-age alloys like has alloy, inconel, titanium, carbide, polycrystalline diamond compacts, and conductive ceramics to more widely used materials like steel, aluminum, copper, and graphite. The wire does not make direct contact with the work item, unlike grinding wheels and milling cutters, therefore no force is exerted to it. Workpiece distortion or damage can be prevented by using minimal clamping pressure to secure small, delicate, and delicate parts.

WEDM: A succession of sparks between the work piece and the wire electrode (tool) remove material inthe thermo-electric WEDM process. Immersing the part and wire in a dielectric (electrically non-conducting) fluid—typically deionized water—also serves as a coolant and washes away the dirt. On a wire EDM, the Spark Theory is essentially the same as the vertical EDM process. In wire EDM, a precisely positioned moving wire (the electrode) and the workpiece produce a series of electrical discharges (sparks) that mill the conductive materials. An insulated dielectric fluid (water) is used to discharge high frequency pulses of either direct current or alternating current with a tiny spark gap from the wire to the work piece.

2. LITERATURE REVIEW

The literature presents research results on several materials' wire-cut electro discharge machining. Using various tools, experiment design, and statistical optimization techniques, the majority of the work is reported to investigate parameters such as pulse on time, pulse off time, servo voltage, wire tension, wire speed, and surface roughness, material removal rate (MRR), and kerf width.

Arulselvan Subburaj et al ,revealed that iron, nickel, and chromium are the three primary elements of Inconel 825 alloy. It is very resistant to corrosion and presents a challenge for machining. We finished the experiments with an EXCETEK V650 WEDM machine. The tool electrode was 0.25 mm diameter copper wire, with deionized water serving as the dielectric fluid. Four input parameters were used for optimization: wire tension (WT), taper angle (TA), pulse-on time (Ton), and pulse-off time (Toff). Three levels of input factor consideration were applied in the experiment design, which was framed by RSM (central composite design). A measurement was made of the response parameter.[1]

L. Selvarajan and K. Venkataramanan showed the MoSi2-SiC and Si3N4-TiN conductive ceramic composites' surface shape and drilled hole precision on EDMed surfaces. Silicon Nitride-Titanium Nitride (Si3N4-TiN) and intermetallic ceramic composite (MoSi2-SiC) were the two conductive ceramic composites that were cut using electro-discharge machining (EDM). Measuring key performance metrics and recording the geometrical characteristics of the machined hole were crucial aspects of the EDM process. Comparison is made between the two conductive ceramic composites' machining properties, which include current, spark on time, spark off time, and dielectric pressure.[2]

XinyuYang et al, gave a presentation on the study of the core loss for amorphous alloys after wire-cut electric discharge machining, including the mechanism of degradation and high-precision modeling. Through an analysis of the domain width and nano-mechanical characteristics fluctuation in the magnetic domain distribution, this work suggests that the range of performance degradation for AA ribbons processed by W-EDM is within 1 mm of the edge. This work offers a mechanism for the electrochemical corrosion-based property deterioration of W-EDM-processed AA ribbons by comparing the microscopic morphology and chemical composition changes in the affected and the unaffected area. Finally, based on the partition of the affected area, a modified loss model for W-EDM-processed AAs is constructed. [3].

L. Selvarajan and K. Venkataramanan demonstrated the topography on EDMed surfaces and precisely drilled holes in the Si3N4–TiN conductive ceramic composites. In this study, drilling a 5 mm hole in a Si3N4–TiN conductive ceramic composite is difficult, especially when trying to find a relationship between parameters for EDM machining such as current, pulse on-time, pulse off-time, dielectric pressure, and spark gap, and parameters for performance such as Material Removal Rate, Electrode Wear Rate, Average Surface Roughness, and geometrical tolerances like Circularity, Perpendicularity, and Cylindricity. According to the experimental results, a surface machined with a copper electrode can have a good surface quality, better machining accuracy, closer geometrical tolerances, and fewer anomalies.[4]

L. Selvarajana et al, presented the regression analysis and fuzzy logic optimization were used to assess the EDM machining parameters for Si3N4-TiN ceramic composites. The objective of the venture was to concentrate on the analysis of the effects of metal removal rate (MRR) and electrode wear rate (EWR), for example, input spark on time (Son), current (Ip), spark off time (Soff), spark gap, and dielectric pressure. This was due to the working parameters of EDM for machining silicon nitride-titanium nitride in the machining qualities with copper electrode. Next, using Taguchi analysis of several plots, including Mean effect plots, Interaction plots, and contour plots, performance factors are investigated in relation to various process elements. Several answers are combined using regression analysis and fuzzy logic to create a single trademark record known as the Multi Response Performance Index (MRPI).[5]

L. Selvarajan and K. Venkataramanan provided the paper Surface Morphology Assessments in Intermetallic Ceramic Composite Surfaces (EDMed $MoSi_2$-SiC). Machining a 5 mm hole in molybdenum disilicide-silicon carbide is challenging because to its extreme rigidity and resistance. The effectiveness of Electrical Discharge Machining (EDM) was evaluated using standard metrics such as wear ratio, material removal rate, electrode wear rate, average surface roughness, and geometrical tolerances. Notably, this study piece analyzes in depth the melting and evaporation mechanism of metal removal as well as the topography of the machined surface using an EDS and XRD report, machined electrodes, and WEDM machined brass wire.[6]

L. Selvarajan et al, examined the $MoSi_2$-SiC ceramic composites using die-sinking and rotary EDM surface and subsurface investigation. The area fraction yield for porosity, according to the study, varied from 8.18% to 12.922% when utilizing rotary EDM, but only from 2.33% to 8.10% when utilizing die-sinking EDM. The EDAX states that excessive gas production is what causes a composite's spongy exterior. Rotary EDM produced good surfaces but produced a thinner and less uniform recast layer even if the tool's circular action sweeps the resolidified particles away.[7]

L. Selvarajan et al, discussed the evaluation of surface morphology using TLBOMRA for EDD machining settings for Si_3N_4-TiN. Investigation of Si_3N_4-TiN ceramic composites using electrical discharge drilling (EDD) is done in this work. The performance features of the brass electrode were evaluated through 25 experimental trials conducted based on process parameters. 90% accuracy is demonstrated by the validated results of multiple regression analysis (MRA), which is used to create prediction models. The simultaneous optimization of all replies is achieved by utilizing an integrated teaching-learning-based optimization (TLBO) and MRA.[8]

L. Selvarajan et al,discussed the examination of micro-structural and geometrical tolerances, as well as the Mo-Jaya algorithm's Pareto optimal solution for Si_3N_4-TiN rotary EDM optimization. The material removal rate, electrode wear rate, surface roughness, cylindricity, perpendicularity, top and bottom radial overcuts, and run out are a few of the variables that are taken into consideration. The reactions that resulted from validating various parameter combinations through experimentation were studied. The effects ofspecific parameters are examined using regression analysis and mean effects analysis. By optimizing the responses simultaneously, multi-objective Jaya optimization helps to understand the instantaneous behavior of the replies. Three-dimensional charts illustrating the results of the multiobjective problem each display the Pareto optimal solution.[9]

L. Selvarajan et al displayed the Pareto front visualization and simultaneous multi-response Jaya optimization for EDM drilling of $MoSi_2$-SiC composites. The $MoSi_2$-SiCintermetallic ceramic composite's EDM is examined in this work. Three factors influence the quality of a spark: dielectric pressure (DP), spark gap voltage (Sv), and spark gap speed (v). It is possible to measure a wide range of performance indicators, including circularity, cylindricality, overcut, surface roughness, and material removal rate. Mo-Jaya, or multi-objective, analysis might be used to maximize a variety of performance metrics by treating each potential answer as a distinct target.[10]

Y Kumarswamy et al, described how to use AISI 308 to optimize the wire EDM process parameters and analyze the welding properties of tig welding connections. In addition to analyzing the welding properties of Tungsten Inert Gas (TIG) welded joints made of the same material, the research project attempts to optimize the wire cut EDM process parameters for AISI 308 steel. Finding the ideal mix of process variables that would result in the maximum material removal rate, lowest wear rate, and best material tensile characteristics is the goal of the study.[11]

Manisha Priyadarshini et al, discussed the impact of gray relational optimization of process parameters on the tribological properties and surface features of AISI P20 tool steel that has been annealed and processed using wire EDM. This research uses grey relational analysis to investigate the changes in the workpiece's surface and subsurface tribology caused by the initial and optimized wire-electro discharge machine parametric configuration during sub-cooled AISI P20 tool steel machining. It is found that the best parametric configuration for utilizing grey relational analysis to increase surface roughness, kerf width, and cutting speed results in a thicker recast layer, which enhances component quality and productivity. The surface machined with an optimal parametric setting yields higher wear resistance, according to the wear test results.[12]

M. Veeranjaneyulu et al ,shown how the thickness of the work piece affected the MRR and surface roughness responses in the AL6063-T6 alloy's wire-edge electronic data milling.L8-Orthogonal array of Taguchi method was used to accomplish the procedure on aluminum alloy AL6063-T6. Surface roughness (Ra) and Material Removal Rate (MRR) are the quantifying responses, and the input parameters are workpiece thickness (w/p-t), pulse on time (Ton), pulse off time (Toff), wire tension (WT), wire feed (WF), and dielectric flushing pressure (WP). [13].

Selvarajan Let al, described the use of RSM and regression equations to experimentally investigate and optimize the MoSi2 SiC intermetallic ceramic composite's EDM performance metrics.The sparking characteristics of MoSi2-SiC intermetallic composites, which are used in aerostructures and high-temperature structural environmental applications, consist of input process parameters like current (I), pulse-of-time (Tof), spark-gap voltage (Sv), pulse-on time (Ton), and speed when conducting an EDM process on them. In order to assess several EDM output performances, such as material removal rate (MRR), surface roughness (Ra), wear ratio (WR), electrode wear rate (EWR), and taper angle, the Taguchi L25orthogonal array with DOE was utilized.[14]

L.Selvarajan,R et al, reported the results of an experimental examination into the recasting layer and surface morphology of Si3N4-TiN composites that were machined using rotary EDM and die-sinking.Since Si3N4-TiN composites have excellent mechanical and thermal properties, they are widely used in manufacturing. On the other hand, due to their higher strength and hardness, they place a great deal of demand on machines that operate using conventional methods. An effective alternative to electrical erosion machining for Si3N4-TiN composites is electrical discharge machining. On the other hand, not much research has been done on the surface properties and machinability of electrical discharge machining composite materials.[15]

Uzair Khaleequz Zaman et al, outlined the Taguchi design of experiments for the optimization of the wire electric discharge machining (WEDM) process parameters for AISI 1045 medium carbon steel. Because it is a high-solidity steel with excellent formability, welding, and maximum hardness, AISI 1045 medium carbon steel—which is produced in China by Shandong Zhong Tong Boda Iron and Steel Co., Ltd., Liaocheng—was used for the experiments in this paper. Both in its standardized and molten states, AISI 1045 exhibits sway characteristics. In addition, AISI 1045 medium carbon steel provides the best formability when heated or standardized. A variety of operations can be carried out on AISI 1045 steel using the proper feeds, tool kinds, and speeds, depending on the manufacturer's recommendations.[16]

Rajusing Rathod et al, provided an overview of the titanium alloy performance evaluation using electric discharge machining. Titanium alloy is a noncorrosive material with exceptional mechanical qualities, high specific resistance, and good machining performance. It can also tolerate high temperatures. For aerospace, marine, biomedical, and industrial applications, this alloy is the best option. However, because titanium alloy has a low elastic elasticity, is very chemically reactive, and poor heat conductivity, it is considered a difficult-to-cut material. When machining titanium alloy using traditional techniques, rapid tool wear is seen.[17]

Jatinder Kumar et al, explained the TOPSIS: Processing and Characterizations Optimization of Wire-EDM Process Parameters for Al-Mg-0.6Si-0.35Fe/15%RHA/5%Cu Hybrid Metal Matrix Composite.In the present experimental work, the ideal wire-EDM processing factor set for a new hybrid aluminum matrix composite, Al-Mg-0.6Si-0.35Fe/15%RHA/5%Cu, is being investigated. According to normal testing procedures, the composite shows 64.2 HRB hardness, 104.6 MPa tensile strength, and 4.8 joules of impact energy. Utilizing a stir casting method, composite is created for this. According to Taguchi's L27 OA, the tests are carried out to investigate how processing variables affect the material removal rate (MRR), radial overcut (ROC), and surface roughness (Ra).[18]

3. SELECTION OF MATERIALS

Kaki Venkata Rao et at, published the paper Online modeling and monitoring of aerosol emissions, surface roughness, and power consumption in wire-cut electric discharge machining of Ti 6Al 4 V.Using the grey theory GM(1,N), this work provided a unique data-based grey online modeling and monitoring system for the surface roughness, aerosol emissions, and power consumption in wire cut electrical discharge machining of Ti-6Al-4 V. For modeling and monitoring, the suggested methodology requires a relatively small number of data samples and requires no training time. When the neural network-developed system and the gray online modeling and monitoring system were compared, the grey online modeling and monitoring system performed better with less training models.[19]

Jinglan Guo, presented the paper titled "Experiments of Ti6Al4V manufactured by lowspeed wire cut electrical discharge machining and electrical parameter optimization" is available for viewing. This study examines the impacts of electrical factors on the surface roughness, kerf width, and cutting speed of TC4 specimens based on orthogonal experiments, with a particular focus on LS-WEDM machining of titanium alloy A. Utilizing the response surface method and grey correlation method, five electrical parameters are tuned.The machining settings detailed in this paper have a significant impact on cutting speed, kerf breadth, and surface roughness due to peak current.[20]

ElangoNatarajan et al , gave the presentation on "Gorilla Troops Optimizer." used in conjunction with ANFIS for aluminum alloy wire cut EDM.Resources. Because aluminum 7075 alloy is the best material for structural applications in the transportation, aerospace, marine, and defense industries, it was the material of choice for this study. The mechanical characteristics and weight-strength ratio of aluminum alloysare well-known. The dimensional accuracy is not consistently achieved when milling this alloy with a traditional machining method. Through the search for the ideal machining settings that may produce the best (i.e., lowest) surface finish, the Gorilla Troops Optimizer (GTO), an emerging metaheuristic algorithm, was to be used in this study to tackle the WEDM machining problem.[21]

Sathishkumar Seshaiah et al, displayed the Response Surface Methodology's optimization of the Material Removal Rate and Surface Roughness of Stainless Steel 304 Wire Cut EDM. stainless steel with grade 304. Stainless steel that is most widely used is SAE 304, also referred to as A2 stainless steel (which is not to be confused with stainless steel tool) or stainless steel (18/8), standard 1.4301. Chromium (normally 18%) and nickel (usually 8%) are the two main noniron constituents of steel. Austenite makes up its steel. Not very electrically or thermally conductive, it is also nonmagnetic. Its superior corrosion resistance over regular steel and ease of molding into various shapes make it a widely utilized material. Textiles, screws, and other industrial and domestic objects are constructed of stainless steel 304.[22]

Boopathi Sampath and Sureshkumar Myilsamyare released the paper, "Experimental Study of Near-dry Wire-cut Oxygen-mist Cryogenically Cooled Electrical Discharge Machining Process." This work describes the new oxygen-mist near-dry wire-cut electrical discharge machining (NDWEDM) technique for cutting Inconel 718 alloy material using a cryogenically cooled (low-temperature nitrogen gas) wire tool. For response characteristics such wire wear ratio (WWR) and material removal rate (MRR), the controllable variables are the current, pulse width, pulse interval, and flow rate. To gather data from trials, the Box-Behnken approach is utilized in the design of the experiments. The sequential sum of the square test was used to create the mathematical models for each response utilizing substantial individual, interaction, and quadratic variables.[23]

Timur Rizovich Ablyaz et al , presented the study paper Analysis of Wire-Cut Electro Discharge Machining of Polymer Composite Materials was presented. The examination of wire-cut electro-discharge machining (WIRE-EDM) of polymer composite material (PCM) is presented in this work. Using titanium plates (layers) sandwiched on the PC and measuring 1 mm thick, the workpiece's conductivity is increased. The outcomes showed that the cut-width accuracy of PCM is highly dependent on voltage and pulse duration. In addition, a theoretical model for machining is created, which shows effectiveness within an acceptable range. Recently, it has been thought that substituting composite material for metallic machine parts could be a viable solution to a number of problems, such as expensive metal, rusting, and component weight.[24]

Thanikodi Sathish et al, delivered the paper on the synthesis, mechanical property characterization, and wire-cut EDM process parameter analysis in AZ61 magnesium alloy +B4C + SiC. A unique technique for cutting various materials using electrical energy application and wire electrode movement is called Wire Cut Electric Discharge cutting (WCEDM). This experiment used an AZ61 magnesium alloy that was reinforced with silicon carbide and boron carbide at varying percentages. The stir casting process was used to make the plate. By using Wire Cut Electric Discharge Machining (WCEDM) to extract the specimens from the casted AZ61 magnesium alloy composites, surface roughness values and material removal rate were creatively determined.[25]

Sampath Boopathia et al, presented the work titled "An Experimental Study of a Near-Dry Wire-Cut Electrical Discharge Machining Process Using Water-Air-Mist Fluid." This work describes the use of a molybdenum wire tool in water-mist wire-cut electrical discharge machining (WEDM) to cut Inconel 600 alloy. In the plasma zone, a little amount of compressed air combined with tap water (water-mist) was utilized as the dielectric insulating medium. In order to forecast the cutting speed (CS) and surface irregularity (SI), a new experimental setup has been created to perform the near-dry WEDM using input parameters of the current (K), pulse-duration (PD), pulse-pause time (PP), and flow rate (FR) of mixed tap water.[26]

RM sakthi Sadhasivam and K Ramanathan presented a study on the use of the Topsis approach in Wirecut-EDM to analyze stir-cast aluminum matrix composite and investigate its parametric effects. Due to its excellent parent and inherent mechanical qualities, aluminum matrix composites are now the most promising substitutes for a wide range of structural and industrial applications. In this work, stir cast Al6061 matrix reinforced with a sample of 6 weight percent zinc oxide particles is machined using wire-cut electro discharge machining. The effects of input parameters like voltage, wire feed rate, and pulse duration are examined in relation to the responses of MRR and surface roughness.[27]

4. FABRICATION METHODS

Ming Zhang* et al, are presented The work Multi-channel discharge characteristics cutting via ultra-fine wire-EDM is offered by Ming Zhang . Comparing the continuous discharge waveforms of two different types of wire electrodes allowed researchers to better understand how the ultra-fine and conventional diameter wires varied in terms of their discharge characteristics. In the discharge waveform cut by ultra-fine wire, it was discovered that there was a multichannel discharge phenomenon. The potential difference between the ultra-fine wire and the workpiece increased linearly along the wire's axis, which may be explained by the fact that the formation of a discharge equivalent circuit model and the simulation analys is of the electrostatic field made it simple for multi-channel discharge phenomena to occur. Moreover, etching materials such as metal particles will warp the electrical.[28]

S. Boopathi and Suresh kumar Myilsamy are presented a study on surface roughness and material removal rate related to near-dry wire electrical discharge machining. The investigations on the effects of wire speed, material thickness, gap voltage, and pulse-off duration on Material Removal Rate (MRR) and Surface Roughness (SR) were conducted using near-dry wire electrical discharge machining (NDWEDM), as described in this paper. Since measuring tools, dies, and punches are employed in more production processes, AISI-D3 tool steel has been used for the testing. Hydrogen gas was mixed with water, which was employed as the dielectric fluid, to study the NDWEDM of AISI-D3 tool steel. In this work, the machining characteristics are improved by accounting for current, pulse on time, oxygen-mist.[29]

Boopathi Sampatha et al, are showcased The work is titled "Exploratory investigation and multi-objective optimization of cryogenically cooled near-dry wire-cut EDM using TOPSIS approach." The goal of this work is to increase environmentally friendly production by using a cryogenically cooled molybdenum wire as a tool in wire-cut electrical discharge machining (WEDM). Compressed air is mixed with a small amount of water to act as a dielectric medium in the cryogenically cooled near-dry WEDM process. Using a nitrogen gas-cooled wire cutter, the Inconel 718 alloy workpiece can be cut with enough electrical conductivity and without the wire breaking. Preliminary experiments were conducted to evaluate wet, dry, cryogenically cooled near-dry, and near-dry WEDM processes. It was discovered that cryogenic cooled near-dry WEDM outperformed dry, near-dry WEDM, with the exception of the wet process.[30]

Yasir Nawaz et al, are presented Parametric optimization of material removal rate, surface roughness, and kerf breadth in high-speed wire electric discharge machining (HS-WEDM) of DC53 die steel is the title of the article. In this study, pulse on time is the most important factor for kerf breadth, but current intensity is the most important component for material removal rate and surface roughness. While all elements are significant for material removal rate, wire speed has no effect on surface roughness or kerf width. Improvement of the replies can be achieved by utilizing the ideal value of variables.[31].

A.Muniappan et al, are presented the paper entitled "Utilization of ANN modeling approach for surface quality enhancement in wire EDM machining of magnesium alloy." The work piece needed for machining was a magnesium mix alloy, and this study discusses improving surface quality by exhibiting different device settings utilizing ANN modeling for wire EDM technique. The exploratory game plan took into account several machining factors, such as wire feed, voltage, and pulse on/off times. Response Surface Methodology (RSM) was utilized to organize the experiment, and Central Composite Design (CCD) was applied. ANN modeling predicted surface quality. To enhance the approach parameters for surface quality, various enlistment constraints were employed. The best assortment was 4.3%, and the predicted qualities were unusually close to the test regard.[32]

Makarand M Kanea et al, presented the paper entitled Experiments with Miniature Wire EDM for Silicon. While WEDM is thought to be a good substitute for semiconductor ingot slicing, most research focuses on using commercially available WEDM and determining the ideal set of parameters. This paper talks on the invention of mini WEDM, a silicon slicing tool that is easily customizable. Such a device is useful for two purposes: first, it may be used to comprehend the fundamentals of sparking between a metallic wire and a semiconductor workpiece; second, it can be used to find the ideal conditions for cutting semiconductor workpieces. In order to do this, the design of the mini-WEDM and several sub-assemblies are presented in this work. A brief explanation of the pulse generator's operation is provided, along with a circuit schematic that illustrates its topology. [33]

Gurusamy Selvakumaret al, are presented The research examines the topic of investigating corner correctness in AISI D3 tool steel wire cut EDM. The tool and die producing industries use AISI D3 steel extensively. The only method that can machine ultra-precision dies with the necessary surface finish and corner accuracy is the WEDM technique. It is well recognized that the issues with the WEDM process are related to wire deflection and rupture.

Taguchi's L-27 orthogonal array served as the basis for the studies. We looked examined how the process responses, like area removal rate (ARR), surface roughness (Ra), and corner error (CE), were affected by the control parameters, which included workpiece thickness, flushing nozzle height, corner angle, pulse on time, pulse off time, peak current, and wire tension.[34]

M. Chaitanya reddy and K. Venkata rao are presented An overview of main study areas in wire-cut EDM on various materials is the title of the paper. As a result, numerous researchers have conducted various experiments to improve WEDM technique performance. It was found that the wire condition had a greater impact on machining performance. The precision of the cutting is at issue in this performance. Monitoring machining parameters such peak current, pulse on time, open circuit voltage, wire feed rate, dielectric flow rate, etc. is necessary to maintain good wire condition. Therefore, in order to choose the best process parameters for high performance in machining, it is necessary to look into how the factors affect the characteristics of machining. This article's primary objective is to highlight key research findings on WEDM.[35]

Abu Qudeiri et al, the study's title is provided the Principles and Features of Various EDM Processes in Tool and Die Steel Machining. The impact of process factors on performance parameters was also investigated using the Taguchi method. For example, one study looked at the effect of wire EDM process settings for typical SR during the machining of powder metallurgical cold-worked tool steel, VANADIS 4e. The Taguchi technique was used in the study to determine the optimal SR. Process characteristics considered in this experiment included wire tension, water pressure, servo voltage, peak current, and pulse-on and pulse-off periods. A different study used the Taguchi and fuzzy TOPSIS (technology for order preference by simulation of ideal solution) methodologies to address multi-response parameter optimization problems.[36]

Neeraj Ahuja et al. presented the study on the experimental investigation and optimization of wire electrical discharge machining for biodegradable magnesium alloy surface characteristics and corrosion rate. The spark-on time (Ton), spark-off time (Toff), servo voltage (SV), and wire feed rate (WF) are four important Wire EDM process parameters that were selected as input variables for this study. After conducting trial trials, the lower and upper working limits of the four input variables were determined. Three leveled values for the selected parameters are displayed in Table 1. While the exact values of Ton and Toff are uncontrollable, their values can be managed in terms of machine units (mu). Thirty numbers of tests were conducted in accordance with the FCCCD. Regression analysis and experiment design are used in the modelling.[37]

5. EXPERIMENTAL WORK AND RESULTS

M. Subrahmanyam and T. Nancharaiah presented about This paper examines the effects of machining parameters, such as discharge current, pulse on time and voltage, on material removal rate (MRR) and surface roughness (SR) of Inconel 625 machined work piece using brass wire tool using Taguchi method. The study employs Taguchi's approach to optimize process parameters in wire-cut EDM of Inconel 625. It is now acknowledged that one essential non-conventional thermoelectric machining technique for processing electrically conductive materials is wire electric discharge machining. The overall EDM process and the material removal method are the same. With the aid of a generator, electric sparks that have been set up and controlled perform the cutting. The work piece is not completely touched by the wire electrode, which produces the allowable voltage of electric charge.[38].

Rongxian Qiu et al, presented the paper. High-speed wire electrical discharge machining is utilized to produce extremely hydrophobic surfaces for magnesium alloys that exhibit exceptional resistance to corrosion and wear. Zhou and colleagues introduced a novel technique to create micro- and nano structured surfaces by modeling the growing process of grass. Stearic acid modification of the surface resulted in exceptional super hydrophobicity, wear resistance, and corrosion resistance, with a WCA of 163°. The usage of most current technologies is severely limited in actual industries due to their numerous inherent flaws, which include costly equipment requirements, intricate multistep treatments, laborious chemical treatments, and low efficiency. Consequently, it is important to conduct thorough research into creating a novel technique that produces a super hydrophobic magnesium alloy surface with high corrosion and wear resistance. A surface created with high-speed wiring[39].

Ashwin Polishetty presented about In the past ten years, AM printers and materials have advanced quickly, as shown in the research Evaluating Optimal Parameters for Machining Selective Laser Melting Titanium Alloy Using Wire Cut Electrical Discharge Machining. The advantages of AM over conventional techniques are highlighted by Huang et al. (2013) in relation to direct kitting, material efficiency, and production flexibility. These benefits make AM a viable substitute for traditional complex structure manufacturing (Mellor, Hao, & Zhang, 2014). With the quick development of material and manufacturing technology, additive manufacturing (AM) has transitioned from applications for prototyping to the actual production of parts. R. Material formation follows the same path as laser beam scanning. Each cross-section of the material is filled sequentially with long, molten powder lines.[40].

Luochen Liu et al, presented about the manuscript investigation into silicon crystal power sources using wire-cut electrical discharge machining and constant discharge probability pulses.WEDM is an unusual machining technique that is typically used to accurately cut a wide range of forms. The technique's low cutting speed is a disadvantage when compared to other cutting methods. However, achieving accuracy with efficient cutting is the main objective of the WEDM approach. In order to improve the performances in the WEDM approach, numerous researchers have conducted various experiments. The wire condition was shown to have a greater impact on machining performance. This performance involves cutting with accuracy. Maintaining good wire condition requires keeping an eye on machining factors such peak current, timely pulses, open circuit voltage, and wire [41].

K. Chockalingam et al, presented about the study on material subtraction of AISI T-15-HSS by wire cut electrical discharge machining (CNC-wire cut EDM), which is grounded in Taguchi gray relational analysis. Voltage, current, and CNC motion are all managed by PI controllers. With the Texas Instruments TMS320F28069 Controller, the control schemes are put into practice. We provide fm, Dm, Iref, Vref, and the gains of the PI controller to the WEDM master control. To manage the pulse generator and the CNC system, the PI controllers respond to feedback signals. Using WEDM, the ideal electrical parameters for silicon cutting are determined. The conclusions are only applicable to the specific set of process parameters and components, so the impact of such efforts is likewise constrained.[42].

Carmita Camposeco-Negrete presented about the document robust design and desirable strategy for the prediction and optimization of machining time and surface roughness of AISI O1 tool steel in wire-cut EDM. Process variables influencing the WEDM's performance through MRR and Ra. The Taguchi method of experiment design employs a set of statistical and mathematical tools to establish a relationship between the input and response variables. Instead, a timely pulse increases the rate of material removal. The surface roughness was positively impacted by the pulse off time. It is determined that surface roughness and material removal rate rise with timely pulses. A specialized thermal machining technique called wire electrical discharge machining (WEDM) can precisely machine objects made of hard materials. [43].

D. Devarasiddappa et al, discussed the work Optimizing MRR of Ti6Al4V Alloy for Sustainable Production with Modified Teaching Learning Based Optimization by Using Wire-cut EDM.Ti-alloy Ti6Al4V is extensively studied and used in many different engineering applications. This work employs the modified teaching-learning based optimization (M-TLBO) method to maximize the material removal rate (MRR) in Ti6Al4V alloy WEDM, with an emphasis on the economic aspects of sustainable production. To identify global optima for MRR maximization, a novel fitness curve fitting method is presented. The Taguchi L16 OA is used for WEDM research. Under optimal cutting conditions, MRR is shown to have increased by 27.51% relative to its initial maximum value.[44]

Dwaipayan De et al, presented about the parametric study for sintered titanium wire-cut electrical discharge machining. For the experiment, orthogonal array L27 was chosen using the Taguchi method.Its success and popularity stem from its ability to produce a variety of extremely hard-to-machine components, such as those made of titanium, tungsten carbide, Inconel, and other materials. It also offers a platform for producing intricate, complex shapes that are frequently impossible to machine using conventional machining techniques. Although pure sintered titanium has several uses in aerospace and bio-plant components, its extremely high specific strength, resistance to abrasion, and corrosion make it extremely difficult to machine using traditional methods. WEDM on pure sintered titanium is investigated in this paper.[45]

Sumeet Goyal et al, presented about the article Wire Cut EDM Process Parameter Optimization for Stainless Steel-316. Tilekar et al. (2014) used the Taguchi approach to study process optimization parameters for mild steel and aluminium. Surface roughness and Kerf width were determined using the following process parameters: wire feed 75, 80, 85 (mm/s), input current 1, 2, 3 (A), pulse on time 25, 32, 39 (µs), pulse off time 6, 8, 10 (µs), and so on [3]. Using the single objective Taguchi approach and the multi-objective grey relation grade, Durairaj et al. (2013) examined the impact of process factors on stainless steel (SS304). Wire feed, gap voltage, pulse on time, and pulse off time were the parameters chosen for the experiment [4]. Using Taguchi-based Grey Relational Analysis, Khan et al. (2014) investigated the process parameters on stainless [46]

Dhruv Bhatta and Ashish Goyalb presented the article titled "Multi-objective optimization of wire EDM machining parameters for AISI-304." Taguchi's L27 orthogonal array was used in the current experimental effort to optimize six machining parameters: wire tension, spark gap, gap voltage, wire speed, and pulse on/off time.

Material Removal Rate (MRR) and Surface Roughness (SR) were the experiment's responses, which were analyzed using the Design of Experiment (DOE) and Grey Relational Analysis (GRA) procedures. This approach is unique in that it applies both GRA and DOE to find the best individual solutions for MRR and SR. Every industry wants to produce high-quality goods with minimal input costs, and input parameter optimization can help them do this.[47].

Somvir Singh Nain et al, presented aboutthe manuscript modeling and analysis for the wire-cut electric discharge machining of Udimet-L605 to assess its machinability. the impact of explanatory factors in WEDM with the utility notion integrated into the Taguchi technique. To increase the injection molding pace, Dangayach and Guglani (2015) used the Taguchi technique and Moldflow software. Prior to now, the SVM was primarily used in the statistics (Liu et al., 2006) and civil engineering (Pal et al., 2010) domains. It has recently been used in mechanical engineering. In order to model and optimize the process parameters in WEDM, Zhang et al. (2010) used genetic and SVM algorithms. SVM modeling was used in the steel-making process by Laha et al. (2015).[48]

Rusdi Nur, et al, presented about the impact of wire speed and current on surface roughness during straight gear production utilizing the wire-cut EDM process is discussed in the study. A traditional machine that is frequently utilized in a variety of study objects is the wire cut machine. There has previously been research on the establishment of cutting cut settings on straight gears. A study was carried out by Tosun et al. to investigate the impact of cutting parameters on surface roughness on wire-cut steel workpiece SAE 4140. This study found that the length of the pulse, the open circuit voltage, and the wire speed all significantly influence the surface roughness. A finer cutting surface might lead to an increase in the dielectric fluid pressure. The machining parameters of cutting speed, surface finish, and dimensional deviation were optimized by Sarkar et al. during the wire-cut process. [49]

Tran Thi Hong ry al, presented The paper focuses on how process parameters affect surface roughness in 9CRSI tool steel during wire-cut EDM. With a variety of work materials and numerous goals, the ideal process parameters in WEDM were examined. Using the Grey relational theory and Taguchi technique, Durairaj identified the ideal process parameters for wire cut EDM of stainless steel SS304. In order to achieve the lowest possible surface roughness and the highest possible rate of volumetric material removal when cutting molybdenum wire, Ugrasen looked into the effects of several process variables. The ideal input variables for brass machining were determined by Parameswara and Sarcar. Furthermore, finding the best process parameters for WEDM has been the subject of numerous studies. Furthermore, many techniques have been employed to investigate the wire-cut EDM process. They were genetic, and they were experimental. [50]

6. CONCLUSION

The literature investigation indicates that a parametric analysis of the near-dry WEDM process has been performed using an oxygen-mist dielectric fluid, based on experimental results. To summarize, this review study has extensively investigated the assessment and enhancement of process parameters in Wire Cut Electrical Discharge Machining (WEDM), specifically pertaining to Inconel 625, a challenging-to-machine material recognized for its exceptional strength and resistance to corrosion. Numerous process parameters, such as discharge current, pulse-on time, pulse-off time, wire tension, flushing conditions, and dielectric fluid characteristics, are demonstrated to have a substantial influence on the performance of WEDM for Inconel 625.The highest MRR and shortest SR could be reached at the maximum flow rate due to the quick debris clearance and high oxygen-mist velocity. The spark transmission between the wire and the workpiece is disturbed at the extraordinarily high oxygen-mist flow rate. Various optimization strategies, such as the Taguchi method, artificial neural networks (ANN), hybrid approaches, response surface methodology (RSM), genetic algorithms, and genetic algorithms, have been employed to enhance WEDM performance. Several goals are considered in these approaches, including as tool wear, surface roughness, and material removal rate. To summarize, this research compiles the most recent state-of-the-art information on the assessment and WEDM process parameter optimization for Inconel 625.It offers a useful resource for researchers and practitioners looking to improve the effectiveness, caliber, and sustainability of WEDM operations in the machining of difficult materials like Inconel 625 by combining insights from a variety of studies. Even with these tremendous advances, there is still room for more research, especially in the areas of combining new process parameters, in corporating sophisticated modeling and simulation methods, and looking into cutting edge technologies like additive manufacturing and WEDM for Inconel 625.By using alternative dielectric fluids, this work could be expanded to improve the near dry WEDM performance.

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