Experimental Investigation on Super Alloys using Al7178 Metal Matrix Tools (Aluminum Oxide Materials of Different Weight Percentages 3%, 6%, 9%, 12%) on Electrical Discharge Machining

G. Sravan Kumar[1*], Dr. L. Siva Rama Krishna[2], Dr. S. Gajanana[3]

[*1]Research Scholar, Department of Mechanical Engineering, Osmania University, Hyderabad, India
[2]Professor, Department of Mechanical Engineering, Osmania University, Hyderabad, India
[3]Professor, Department of Mechanical Engineering, MVSR, Hyderabad, India
*Corresponding Author

Received: 03 August 2024/ Revised: 10 August 2024/ Accepted: 16 August 2024/ Published: 31-08-2024

***Abstract*—** *The primary nonferrous metals consist of aluminum, copper, lead, nickel, chromium, manganese, magnesium, titanium, zinc, and alloys like brass. These metals are typically extracted from minerals such as sulfides, carbonates, and silicates. The addition of alloying elements enhances their properties when added in appropriate quantities. Non-ferrous metals are widely utilized due to their favorable characteristics, such as lightweight (e.g. aluminum), high electrical conductivity (e.g. copper), non-magnetism, and corrosion resistance (e.g. zinc). One of the most significant nonferrous alloys is the Al 7178 series alloy, which is commonly used in technical applications. EDM is a method for controlled removal of metal that uses electrical discharge. This process uses an electric spark to erode the workpiece and shape the finished part. Metal removal is accomplished by applying a pulsed charge (ON/OFF) to the workpiece through an electrode using a high-frequency current. The workpiece is subjected to controlled erosion, resulting in the removal of tiny metal fragments. Typically, electrodes made of copper, graphite, and brass are utilized in EDM. The current project investigates the use of the metal matrix material Al7178 (Al2O3-reinforced Al7178) as a tool/electrode for machining the superalloy Superni 90. In this study, aluminum alloy 7178 is utilized as the base metal, Al2O3 is chosen as the reinforcement material, weight fraction 3%, 6%, 9%, 12% as the tool material, and nickel-based alloy as the workpiece being studied. Superni90 has been selected. Material removal rate, surface roughness and tool wear rate in electrical machining discharge. Regression models were developed for MRR and TWR based on experimental data. The Mitutoyo surface roughness measuring machine is utilized to measure the surface roughness of the processed workpiece. The geometric accuracy of the surfaces created on the workpiece is evaluated using MATLab software.*

Keywords*— *Electric discharge machining, Current (I), Voltage(V), Pulse on time (Ton), Pulse off time (Toff), Surface Roughness (SR), Tool Wear Rate (TWR), Material Removal Rate (MRR), % error, Regression models Electrical Conductivity.

I. INTRODUCTION

Modern technology has led to an explosion of lightweight materials, particularly in the realms of aerospace and automobile. The research on new high-strength aluminum alloys is being undertaken by numerous countries and corporations, The aim is to decrease It is crucial to minimize the weight of the materials as much as possible, while still maintaining the stability of mechanics and corrosion resistance for the overall structure, in order to substitute traditional materials such as iron. Numerous modern materials utilized in space exploration, weaponry, and nuclear industries have been produced in the past few years. Due to their increased hardness, toughness, strength, and resistance to heat and wear, these materials cannot be processed using conventional machining methods. The emergence of New Machining Procedures, or Unconventional Machining Procedures, is a direct outcome of the advancement of innovative metal removal techniques. These procedures enable the fabrication of intricate and sophisticated shapes on the workpiece, regardless of the material's strength, hardness, toughness, or brittleness.

These methods are frequently employed for:

- Working with materials that are hard to machine through conventional methods.

- Efficiently producing complex surfaces.
- Additionally, achieving very high surface qualities.

The processes can produce intricate and detailed shapes on the workpiece and are unaffected by the strength, hardness, toughness, or brittleness of the materials. Heat treatment can be used to strengthen Al 7XXX alloys, which are primarily composed of the Zn element. The alloy Al-Zn- Mg, which contains magnesium, is a weldable and high-strength aluminum alloy with excellent thermal deformation characteristics and a broad quenching range. By applying the appropriate heat treatment, it is possible to achieve increased strength, enhanced welding capabilities, and improved corrosion resistance. Incorporating Cu into the Al-Zn-Mg alloy results in the creation of the Al-Zn-Mg-Cu alloy. This alloy demonstrates enhanced strength when compared to Al 2XXX alloys, which is why it is commonly Referred to as an ultra-high-strength aluminum alloy, this material exhibits similar yield and tensile strengths, leading to a remarkably high specific strength. However, its plasticity and high-temperature strength are somewhat lacking. It is best suited for use as a load-bearing structural component at or below room temperature or below 120°C. It is easily processed, provides good corrosion resistance, and exhibits high toughness.

II. EXPERIMENTAL PROCEDURE

2.1 EDM Process:

EDM utilizes spark erosion to burn tiny holes in metal through electrical sparks. In order for the process to work properly, both the workpiece and the electrode need to be conductive materials.

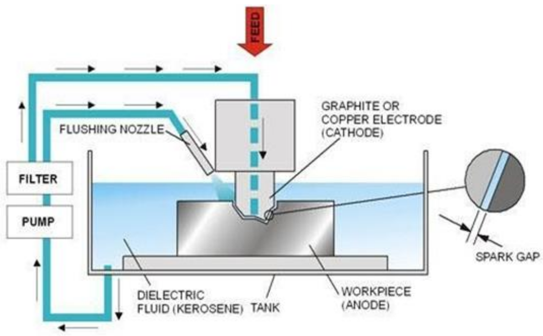

FIGURE 1: EDM Process

The controlled metal-removal technique known as Electrical Discharge Machining (EDM) relies on electric spark erosion to eliminate metal. The workpiece is shaped into the desired form of the final product using an electric spark as the cutting tool in this process. High-frequency current is applied through the electrode to the workpiece in the metal-removal process, involving a pulsating electrical charge.

2.2 Superni90 Super Alloy:

Superalloys are recognized for their outstanding mechanical strength, resistance to creep at elevated temperatures, surface stability, and corrosion and oxidation resistance. These corrosion-resistant super alloys are extensively employed in extreme environments where high heat and corrosion resistance are essential for the integrity of the final product. Sectors like chemical and petrochemical processing, aero-engines, power plants, and oil and gas industries frequently utilize these super alloys. Superalloys with a nickel base are considered a specialized type of high-performance alloys characterized by a significant nickel content. Differences in nickel-based superalloys are usually apparent in the material composition, which is adjusted to create specific properties according to the intended use.

TABLE 1
Properties of Superni90 work material

S. No.	Property	Metric System
1	Density	8.18g/cm^3
2	Melting point Temperature	850°C
3	Tensile Strength	1010MPa
4	Yield Strength	755MPa

FIGURE 1: Superni 90

2.3 Stir Casting:

The stir casting process involves the continuous stirring of the melt, and the aluminum melt surface is exposed to the atmosphere, causing continuous oxidation of the melt. To melt the Al 7178 alloy, a furnace, crucible, blower, coal, and other materials are required. The furnace is heated up to 800°C, while the melting point of Aluminum 7178 is 660°C.

In this study, Aluminum alloy was reinforced with Aluminum Oxide materials at different weight percentages of 3%, 6%, 9%, and 12% of Al2O3. The process was carried out using a Resistance furnace equipped with a stirring system, at a constant speed of 100 rpm and a stirring duration of 10-15 minutes, at a casting temperature was precisely 750±5°C. The mixing equipment was composed of a driving motor capable of generating a rotation speed ranging from 100rpm. Balanced Aluminum 7178 alloys were melted in a graphite crucible, while the Al2O3 particle was preheated in a muffle furnace set at a temperature of 900°C for around one hour to eliminate surface impurities.

The ceramic particle Al2O3 was poured slowly and continuously into the molten metal, which was being stirred at 100 rpm, in order to prepare metal matrix composites through the stir casting method.

FIGURE 2: Process of Stir Casting and Al 7178 MMC's

2.4 Aluminum 7178 Alloy and Machining of MMC's:

Aluminum, the most abundant and widely recognized metal globally, is the second most widely used material after steel. It is commonly utilized for foil and conductor links, but the addition of other elements is crucial for various applications. Aluminum alloy combinations are identified by four digits: the first digit represents a primary alloying component, the second indicates the base composite, and the third and fourth signify individual compounds. Aluminum 7178 alloy has exceptional uses in Aviation field, Automobile sector, and Structural industries. Subsequently in this study, Al 7178 alloy has been chosen for investigation.

After the casting process, the specimen samples are machined on lathe machine. The optimum composition of AL7178 material as electrode and Nickel based Super Alloy - Superni90 for machining investigations and process parameter optimization. The machined specimens of metal matrix composites are shown in figure.

FIGURE 3: Machined Al7178 MMC's

2.5 Surface Roughness (Ra):

The roughness of a surface is a measurement of the texture of a floor, which is determined by deviations in the direction of a surface's normal vector from its perfect form. Large deviations indicate roughness, while small deviations indicate smoothness. Surface metrology typically regards roughness as the high-frequency, short-wavelength features of a surface being assessed. However, in practical applications, understanding both the amplitude and frequency is vital to ensure that a floor is suitable for a specific purpose.

FIGURE 4: Mitutoyo Surface Roughness Tester

2.6 Electrical Discharge Machining (Experimental Process):

(EDM) is an unconventional and non-contact machining operation utilized in industries such as manufacturing, aerospace, automotive, communication, and biotechnology to produce precision products. The method represented in the image is very useful for machining hard and brittle conductive materials because it can melt any electrically conductive substance, regardless of hardness. EDM is a type of thermal machining in which material is removed from the workpiece using thermal energy produced by an electric spark. The tool and the workpiece are skillfully immersed in a dielectric medium, like kerosene, deionized water, or any other suitable fluid. The non-contact nature of the system, combined with nearly force-free machining, facilitates the gentle and precise machining of electrode materials to shape very hard, delicate, or thin work pieces.

III. RESULTS AND DISCUSSION

3.1 Experimentation:

The experiments were performed on EDM, EDM oil is selected as dielectric. The material is selected as Superni90 having dimension of 120mm diameter and 10mm thickness. Aluminum 7178 alloy. With the optimum composition of AL7178 material as electrode and Al7178 with 3% Al_2O_3, 6% Al_2O_3, 9% Al_2O_3, 12% Al_2O_3 and Nickel based Super Alloy - Superni 90 for machining investigations and optimization of process parameters.

FIGURE 5: Working process of EDM machining

3.2 Material Removal Rate (MRR):

MRR is the ratio of the difference of weight of the workpiece material before and after machining to the machining time.

$$MRR = [(W_{wpbm} - W_{wpam})/(t*\rho)]\ mm3/min$$

W_{wpbm} - Weight of workpiece Before machining; W_{wpam} - Weight of workpiece After machining

t - Machining period Time 10min

3.3 Tool Wear Rate (TWR):

Tool Wear Rate (TWR): TWR is the ratio of the difference of weight of the tool before and after machining to the machining time.

$$TWR = [(W_{etbm} – W_{etam})/(t*\rho)]\ mm^3/min$$

W_{etbm} - Weight of electrode Before machining; W_{etam} - Weight of electrode After machining

t - Machining period Time 10minρ – Density of Tool material

3.4 Experimentation on Superni90:

The work material selected for experimental investigation is a super alloy which has wide applications in defence with commercial name as Superni90. The electrode material chosen for machining on work material is Al7178 with 3% Al_2O_3, 6% Al_2O_3, 9% Al_2O_3, 12% Al_2O_3 and the experiment done according to the procedure. Researchers conduct experiments across a wide range of disciplines, usually with the aim of gaining insights into a specific process or system. An experiment involves conducting a trial or a series of trials in which deliberate changes are made to the input variables of a process or system to facilitate the observation and identification of the reasons for changes in the output.

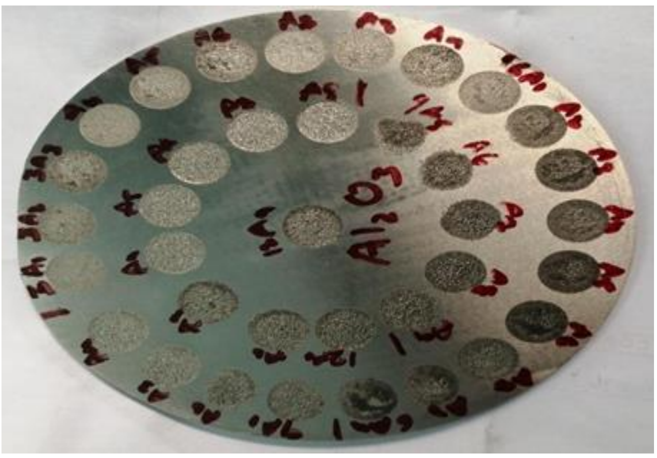

FIGURE 6: Experimentation on Superni90 work material with Aluminium and Al_2O_3 3%, 6%, 9%, 12% as Electrodes on *EDM*

Experiment design is the process of determining the number of trails and running circumstances that are necessary and adequate to solve the problem with the requisite accuracy

3.5 Linear Regression:

The field of image processing is continuously evolving, aiming to enhance images and extract important information through a series of operations. This method of signal processing involves taking an image as input and generating either the image itself or its relevant characteristics as output. Image analysis is crucial for structural characterization of porous substances and has applications in various fields.

The structural properties of media can be represented by statistical and morphology aspects, such as dimensions and shapes, or topological properties. Image processing in MATLAB is used to analyze the trueness of diameter.

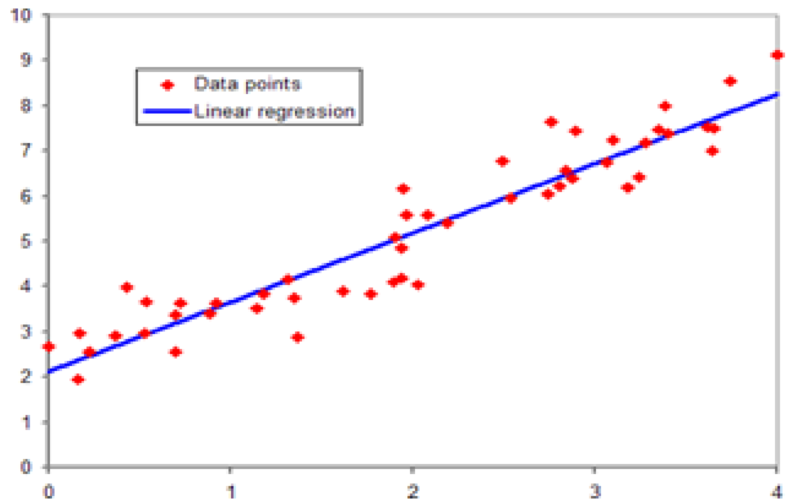

FIGURE 7: Linear Regression

3.6 Results:

The Tool Material is Al7178 with 3% Al2O3, 6% Al2O3, 9% Al2O3, 12% Al2O3 is performed on the workpiece material i.e., Superni90 super alloy on Electrical Discharge Machining process. The obtained values of Material Removal Rate (MRR), Tool Wear Rate (TWR) and Surface Roughness (SR) for the Aluminum alloy Al7178 with 3% Al2O3, 6% Al2O3, 9% Al2O3, 12% Al2O3 Metal matrix composite which is performed on Superni90 super alloy on Electrical Discharge Machining are listed in below table for Al7178 with 3% Al2O3.

3.6.1 Case-1 : Electrode Al7178 + Al2O3 (3%):

Aluminum Oxide with 3% of material removal rate, tool wear rate and surface roughness are compared is shown in figure.

TABLE 2
MRR, TWR & SR of Al7178+ Al2O3 (3%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	TWR (mm^3/min)	SR (µm)
1	4	100	50	30	3.454	0.506	2.581
2	4	450	75	45	1.466	1.265	2.883
3	4	1000	100	60	0.733	1.012	2.973
4	8	100	75	60	1.1	1.518	3.787
5	8	450	100	30	2.2	1.772	2.981
6	8	1000	50	45	0.855	1.265	3.732
7	12	100	100	45	2.078	0.759	3.654
8	12	450	50	60	1.711	3.037	3.048
9	12	1000	75	30	1.222	0.506	3.024

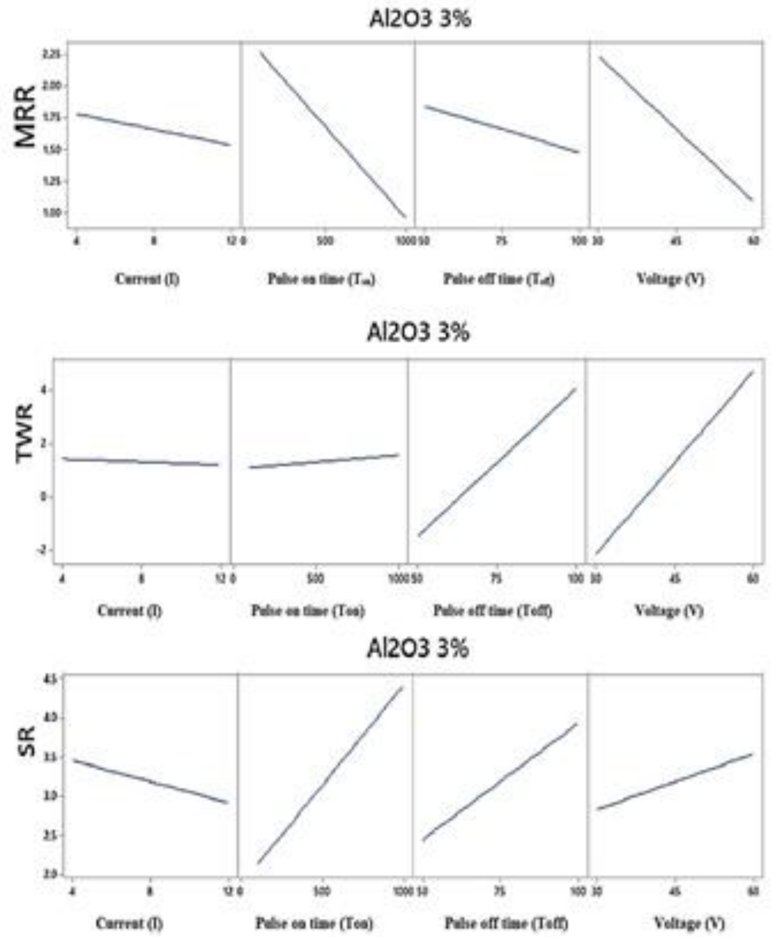

FIGURE 8: Graphical relation among input parameters and MRR, TWR, SR (Al_2O_3 3%)

Aluminum Oxide with 3% of material removal rate, tool wear rate and surface roughness are compared is shown in figure.

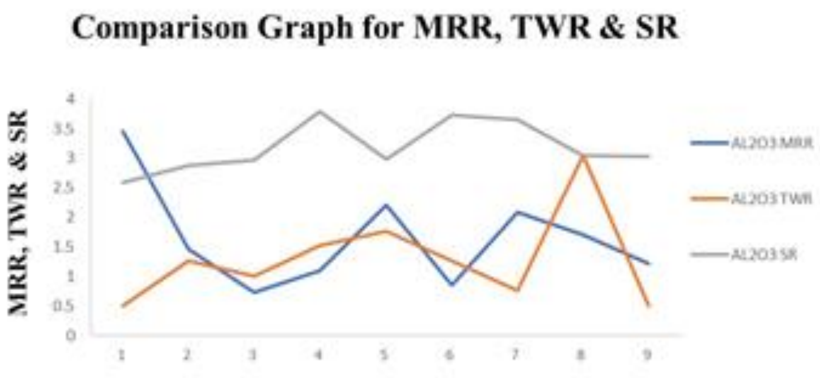

FIGURE 9: Comparison graph for MRR, TWR & SR

For 3% Al_2O_3, the Material Removal Rate is high (3.45mm^3/min), Surface Roughness is less for Trail 1 which is 2.581µm. Hence, the optimum condition for 3% Al_2O_3 is Trail 1 (**Parameters:** current 12amps, pulse on time 1000µs, pulse off time 75µs, voltage 30volts).

Similarly for all the remaining three trails of Al7178 with 3% Al_2O_3, 6% Al_2O_3, 9% Al_2O_3, 12% Al_2O_3 are performed and evaluated.

Geometric Analysis:

The trueness of the diameter is analyzed by imageprocessing in MATLAB.

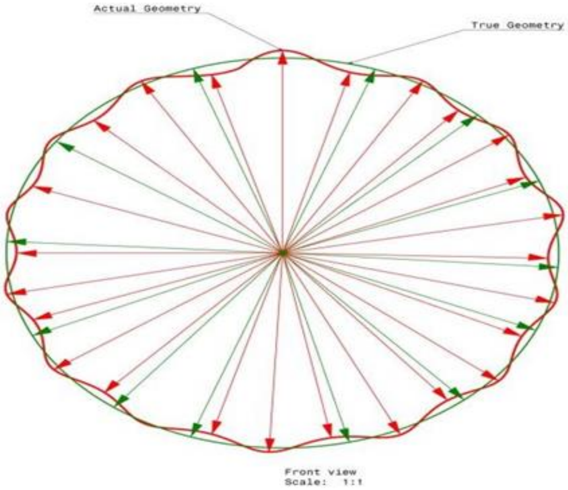

FIGURE 10: 2D image of centroid location

The evaluation of this image processing can be performed using MAT Lab software. The six images which are obtained using MATLab for surface roughness are named as crop image, Black & white, Histogram, Normalized, Normalized Histogram and Binary.

Geometric Analysis (Circularity Accuracy) for Al7178 with 3% Al_2O_3 tool input parameters (V = 30, I = 4, Ton =100, Toff =50) images are obtained for 3% Al_2O_3 for Trails (3A1 to 3A9) by using image processing in MATLab and the percentage error obtained for 3% Al_2O_3 are shown below:

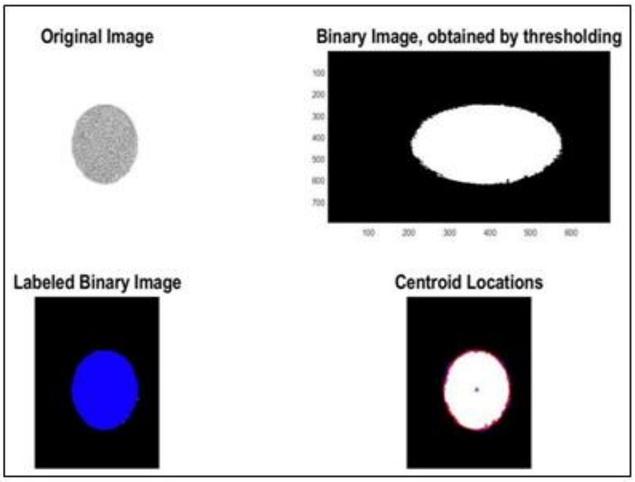

FIGURE 11: 3% Al_2O_3 for Trail 1

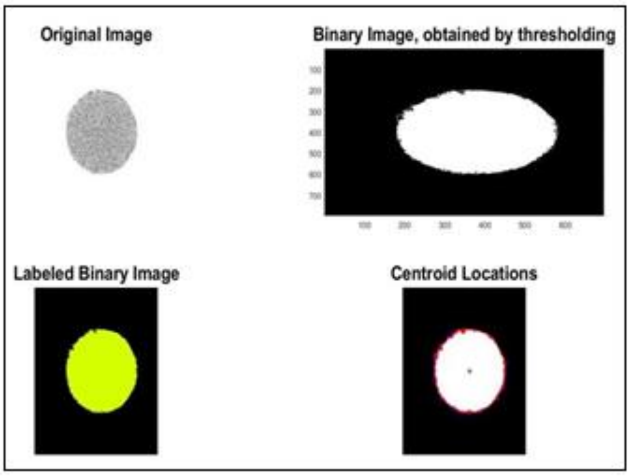

FIGURE 12: 3% Al_2O_3 for Tail 2

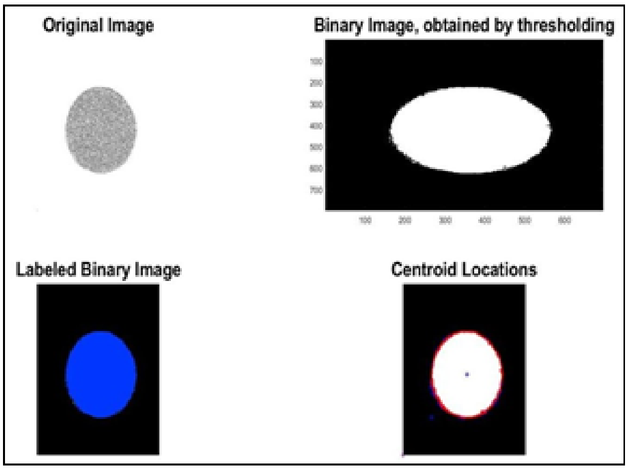

FIGURE 13: 3% Al_2O_3 for Trail 5

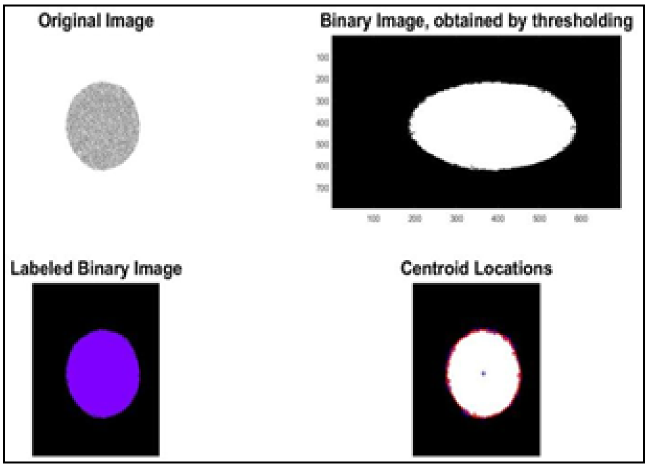

FIGURE 14: 3% Al_2O_3 for Trail 3

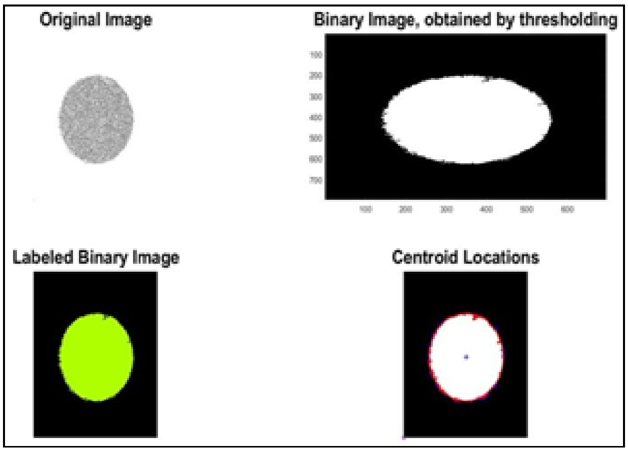

FIGURE 15: 3% Al2O3 for Trail 6

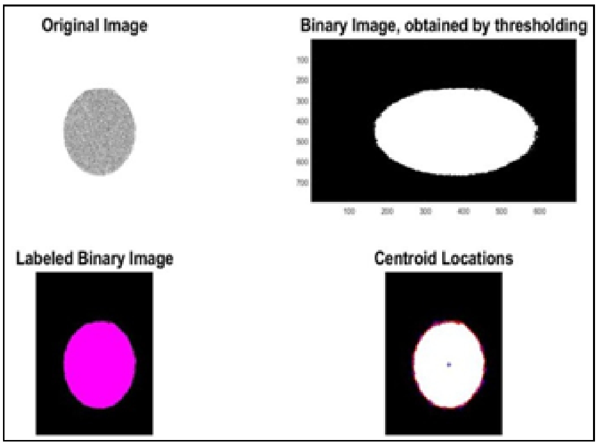

FIGURE 16: 3% Al2O3 for Trail 4

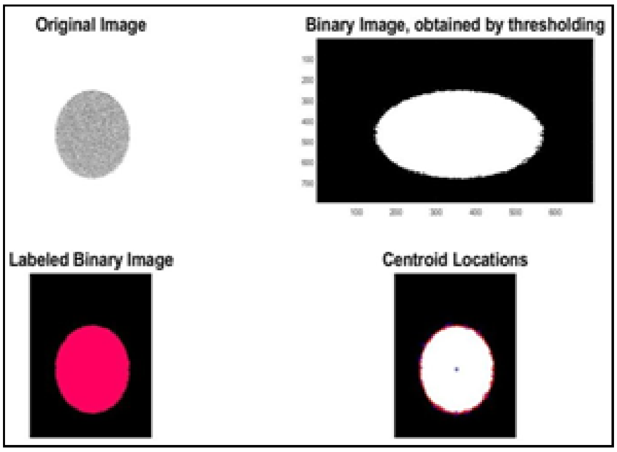

FIGURE 17: 3% Al2O3 for Trail 7

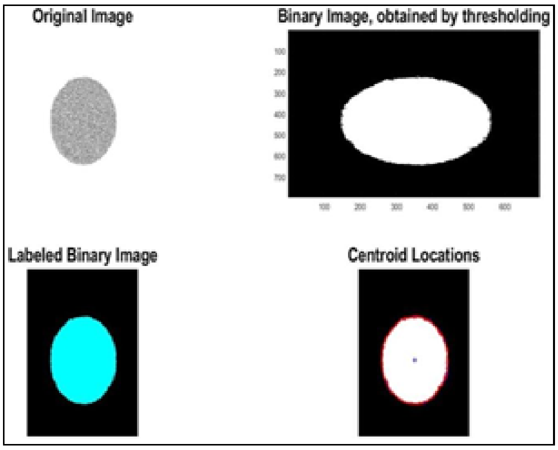

FIGURE 18: 3% Al2O3 for Trail 8

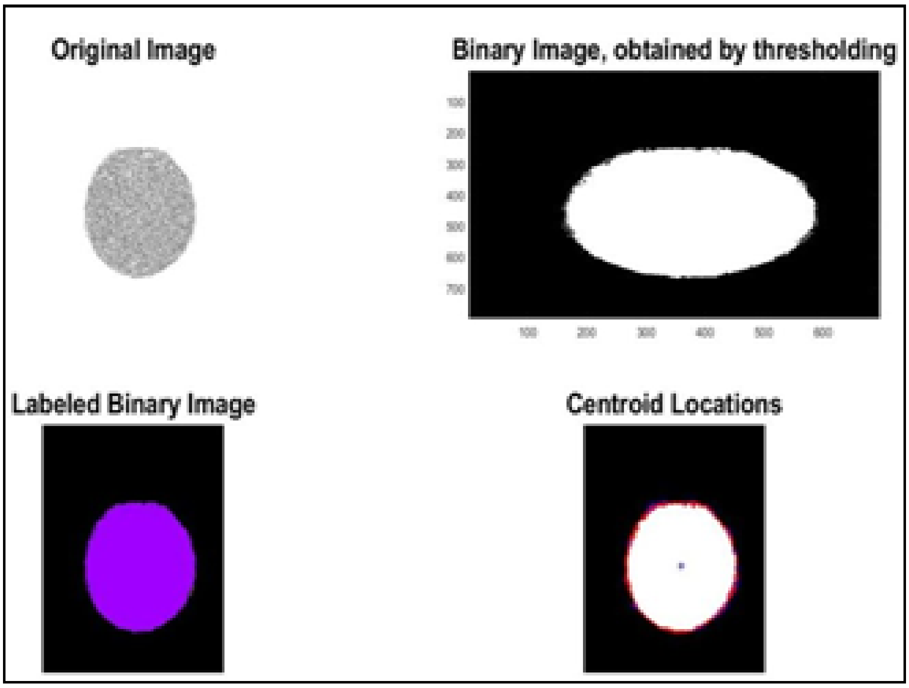

FIGURE 19: 3% Al2O3 for Trail 9

All nine trails of Al7178 with 3% Al_2O_3 are evaluated for Geometric Analysis using MATLab. And Geometric Analysis for Al7178 + Al_2O_3 (3%) is shown below table.

TABLE 3
Geometric Analysis for Al7178 + Al2O3 (3%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	Average Distance (Radius)	% Error	Standard Deviation
1	4	100	50	30	3.454	5.074	1.479	0.086
2	4	450	75	45	1.466	5.08	1.591	0.096
3	4	1000	100	60	0.733	5.119	2.368	0.091
4	8	100	75	60	1.1	4.993	0.125	0.06
5	8	450	100	30	2.2	5.028	0.569	0.068
6	8	1000	50	45	0.855	5.174	3.433	0.117
7	12	100	100	45	2.078	5.023	0.478	0.066
8	12	450	50	60	1.711	5.047	0.939	0.061
9	12	1000	75	30	1.222	5.071	1.415	0.089

3.6.2 Case-2 : Electrode Al7178 + Al2O3 (6%)

TABLE 4
MRR, TWR & S of Al7178+ Al2O3 (6%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	TWR (mm^3/min)	SR (µm)
1	4	100	50	30	0.611	0.253	3.21
2	4	450	75	45	0	0.506	2.577
3	4	1000	100	60	0	0.759	3.452
4	8	100	75	60	0	0.506	3.549
5	8	450	100	30	0.122	0.759	4.123
6	8	1000	50	45	0	0.759	2.398
7	12	100	100	45	0	1.012	3.743
8	12	450	50	60	0	0.506	3.267
9	12	1000	75	30	0	0.759	2.301

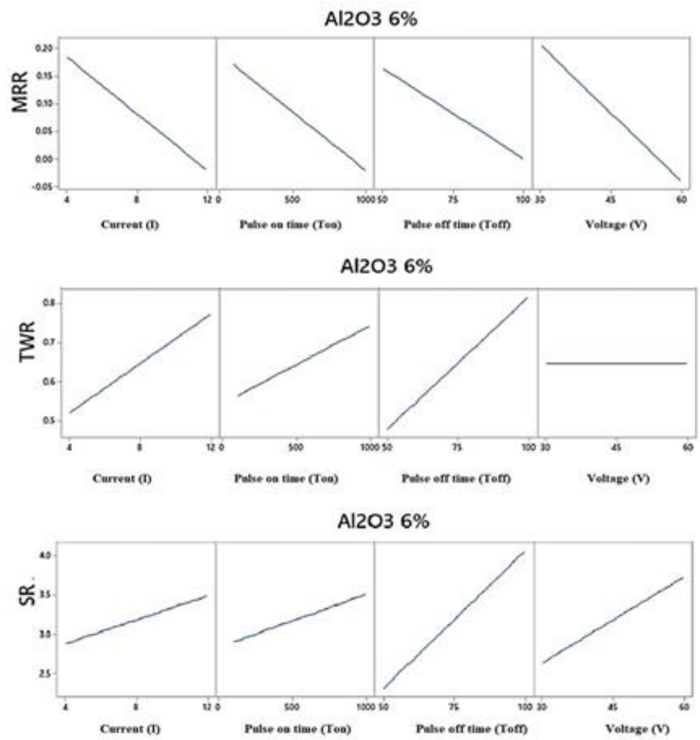

FIGURE 20: Graphical relation among input parameters and MRR, TWR, SR (Al2O3 6%).

Geometric Analysis (Circularity Accuracy) for Al7178 with 6% Al2O3 tool input parameters (V = 30, I = 4, Ton =100, Toff =50) images are obtained for 6% Al2O3 for Trails (6A1 to 6A9) by using image processing in MATLaband the percentage error obtained for 6% Al2O3 are shown below:

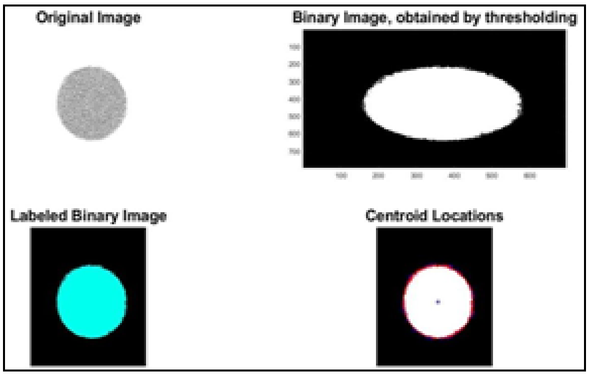

FIGURE 21: 6% Al2O3 for Trail 1

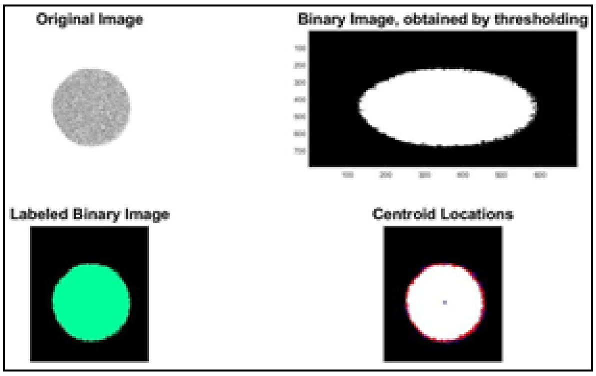

FIGURE 22: 6% Al2O3 for Trail 2

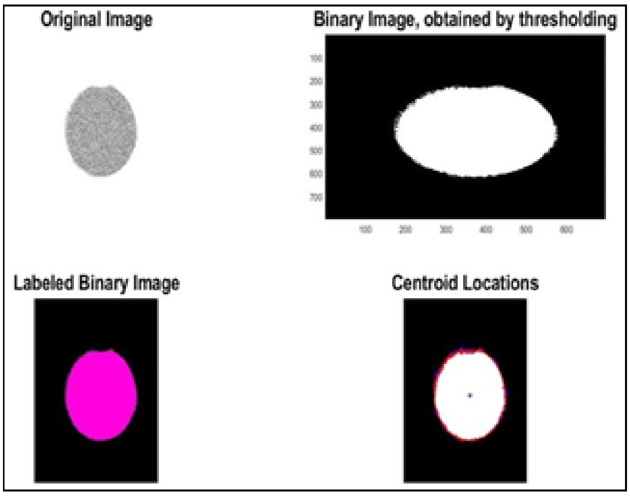

FIGURE 23: 6% Al2O3 for Trail 3

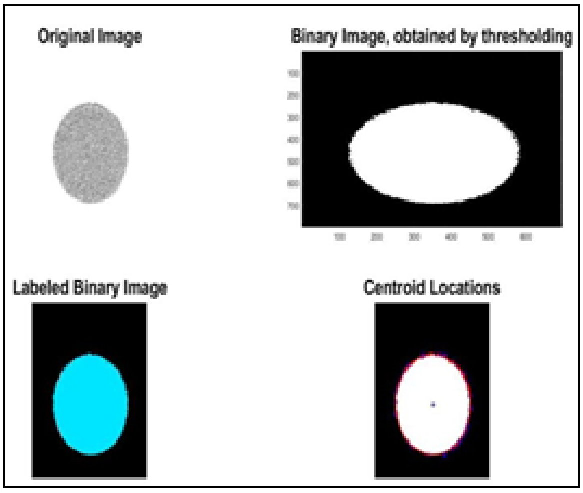

FIGURE 24: 6% Al2O3 for Trail 4

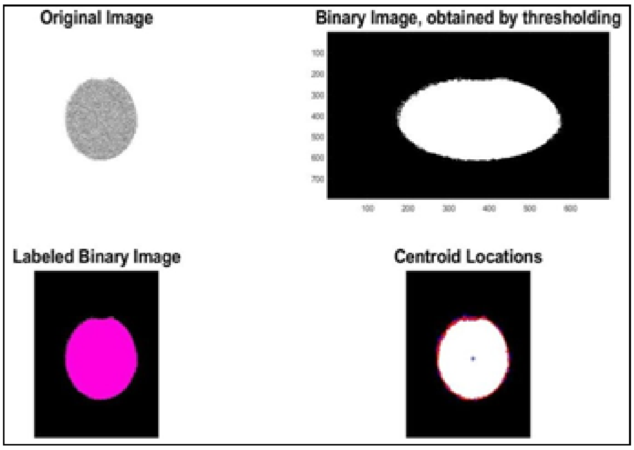

FIGURE 25: 6% Al2O3 for Trail 5

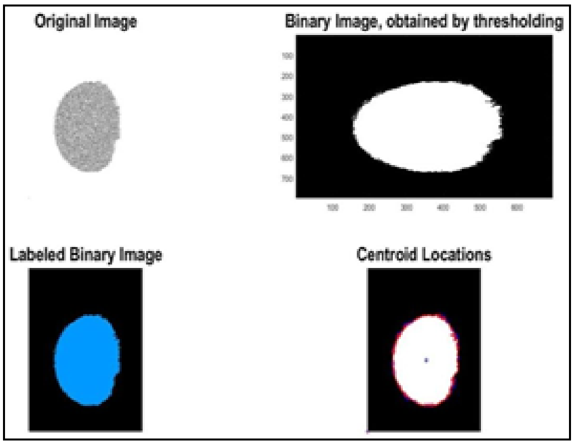

FIGURE 26: 6% Al2O3 for Trail 6

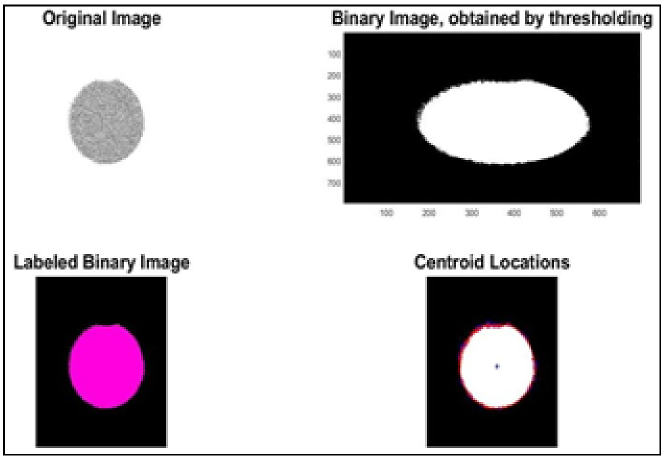

FIGURE 25: 6% Al2O3 for Trail 7

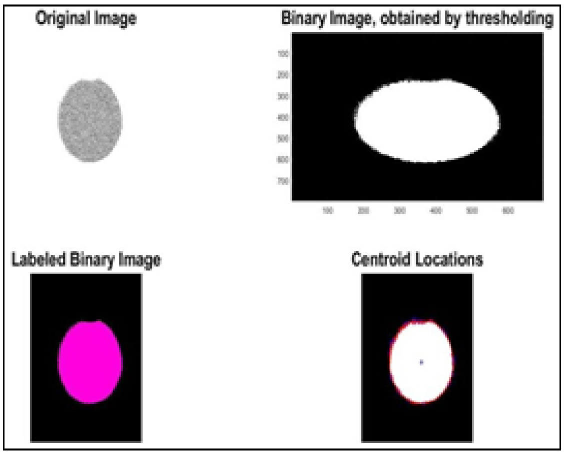

FIGURE 26: 6% Al2O3 for Trail 8

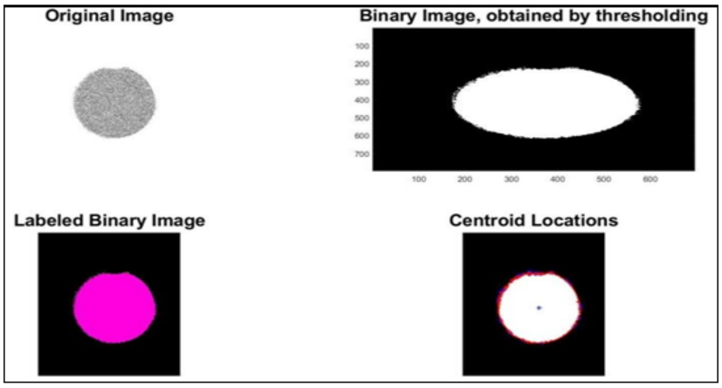

FIGURE 27: 6% Al2O3 for Trail 9

All nine trails of Al7178 with 6% Al2O3 are evaluated for Geometric Analysis using MATLab. And Geometric Analysis Al7178 + Al2O3 (6%) is shown below table:

TABLE 5
Geometric Analysis for Al7178 + Al2O3 (6%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	Average Distance (Radius)	% Error	Standard Deviation
1	4	100	50	30	0.611	5.033	0.672	0.085
2	4	450	75	45	0	5.184	3.631	0.141
3	4	1000	100	60	0	5.055	1.104	0.101
4	8	100	75	60	0	5.06	1.196	0.067
5	8	450	100	30	0.122	5.045	0.908	0.09
6	8	1000	50	45	0	5.063	1.256	0.081
7	12	100	100	45	0	5.058	1.159	0.1
8	12	450	50	60	0	5.031	0.627	0.257
9	12	1000	75	30	0	5.157	3.094	0.148

3.6.3 Case-3: Electrode Al7178 + Al2O3 (9%):

TABLE 6
MRR, TWR & SR of Al7178+ Al2O3 (9%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	TWR (mm^3/min)	SR (µm)
1	4	100	50	30	3.056	10.886	3.917
2	4	450	75	45	0	0	3.774
3	4	1000	100	60	0.122	0.253	2.604
4	8	100	75	60	0.244	0	3.463
5	8	450	100	30	5.012	0.253	1.539
6	8	1000	50	45	0.366	0.253	3.602
7	12	100	100	45	0.122	2.531	3.483
8	12	450	50	60	0	0.759	3.269
9	12	1000	75	30	0.122	0.759	2.951

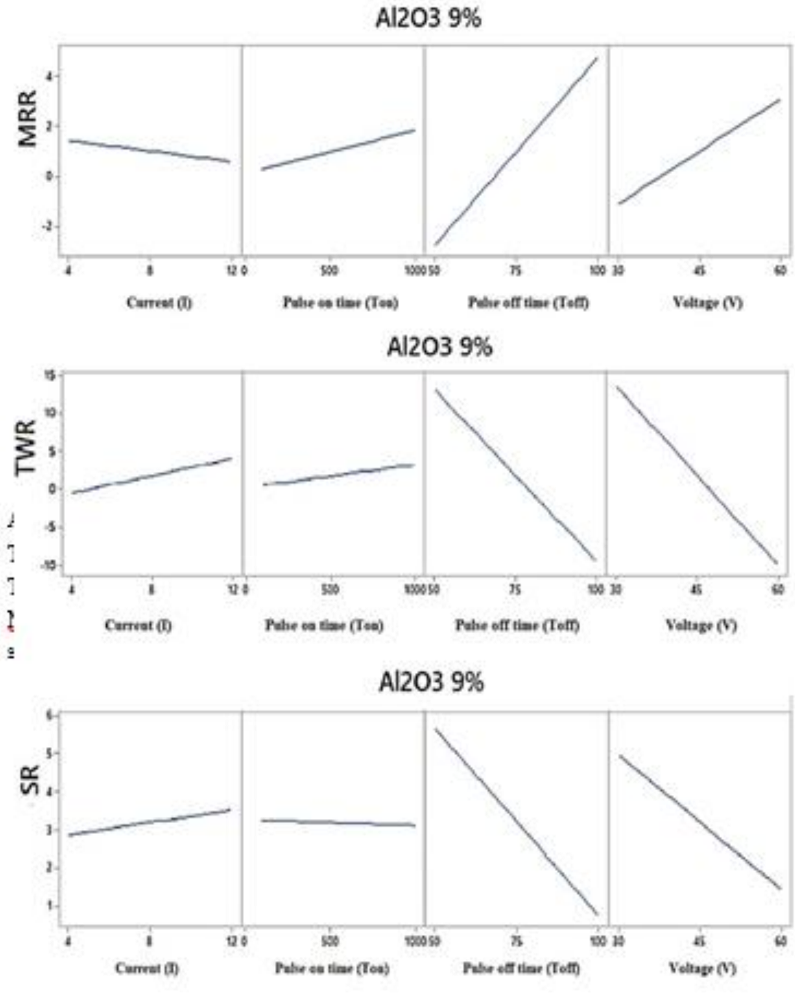

FIGURE 28: Graphical relation among input parameters and MRR, TWR, SR (Al2O3 9%)

Geometric Analysis (Circularity Accuracy) for Al7178 with 9% Al2O3 tool input parameters (V = 30, I = 4, Ton =100, Toff =50) images are obtained for 9% Al2O3 for Trails (9A1 to 9A9) by using image processing in MATLab and the percentage error obtained for 9% Al2O3 are shown below:

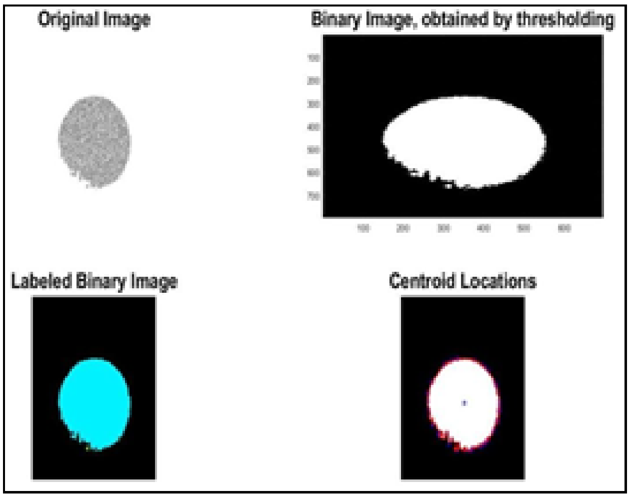

FIGURE 29: 9% Al2O3 for Trail 1

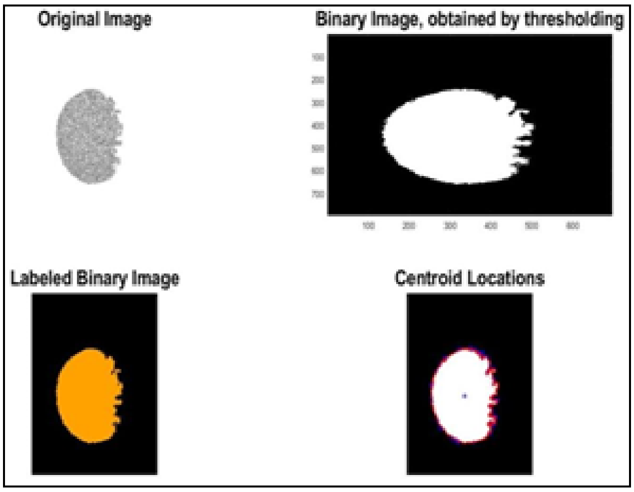

FIGURE 30: 9% Al2O3 for Trail 2

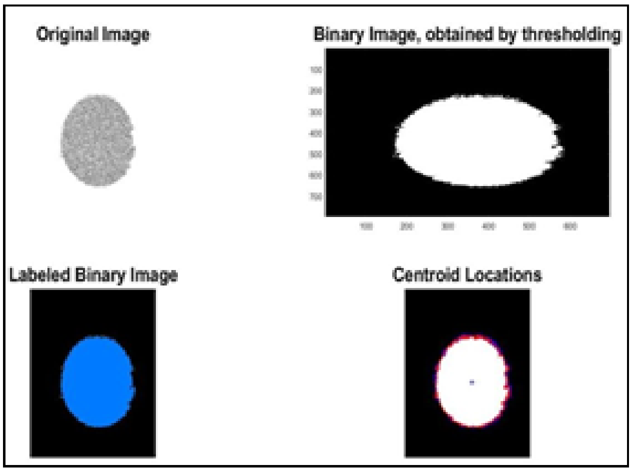

FIGURE 31: 9% Al2O3 for Trail 3

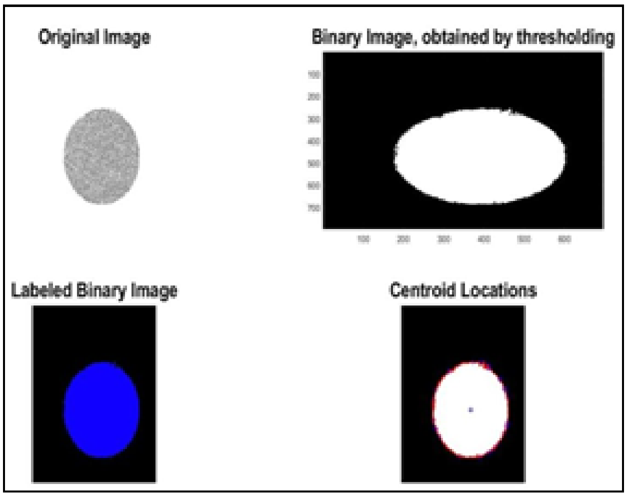

FIGURE 32: 9% Al2O3 for Trail 4

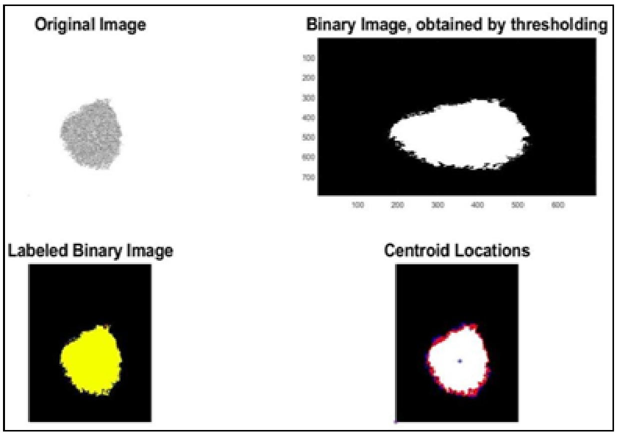

FIGURE 33: 9% Al2O3 for Trail 5

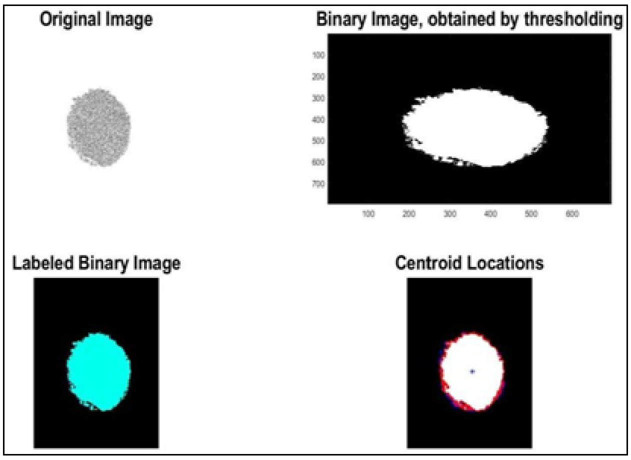

FIGURE 34: 9% Al2O3 for Trail 6

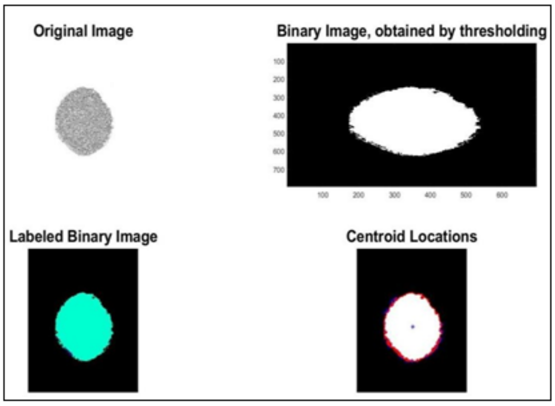

FIGURE 35: 9% Al2O3 for Trail 7

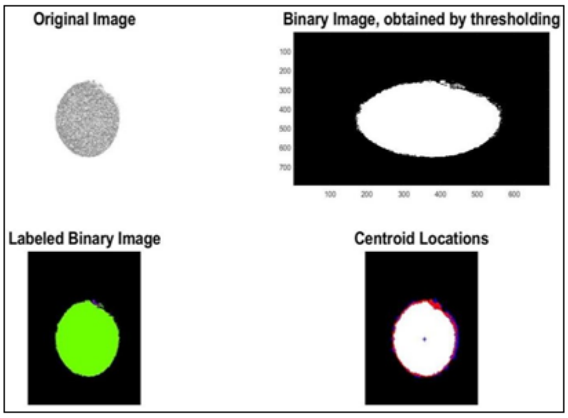

FIGURE 36: 9% Al2O3 for Trail 8

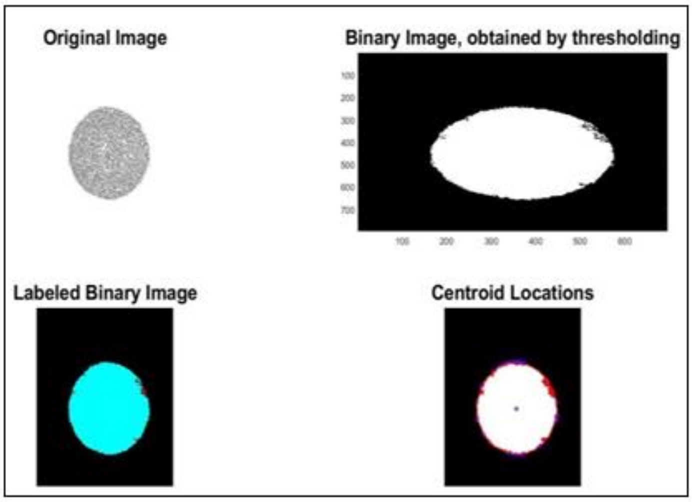

FIGURE 37: 9% Al2O3 for Trail 9

All nine trails of Al7178 with 9% Al2O3 are evaluated for Geometric Analysis using MATLab. And Geometric Analysis for Al7178 + Al2O3 (9%) is shown below table:

TABLE 7
Geometric Analysis for Al7178 + Al2O3 (9%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	Average Distance (Radius)	% Error	Standard Deviation
1	4	100	50	30	3.056	5.294	5.728	0.241
2	4	450	75	45	0	5.211	4.133	0.472
3	4	1000	100	60	0.122	5.189	3.714	0.201
4	8	100	75	60	0.244	4.985	0.3	0.074
5	8	450	100	30	5.012	4.786	4.372	0.351
6	8	1000	50	45	0.366	5.001	0.031	0.245
7	12	100	100	45	0.122	5.069	1.389	0.203
8	12	450	50	60	0	5.129	2.559	0.139
9	12	1000	75	30	0.122	5.124	2.453	0.167

3.6.4 Case-4 : Electrode Al7178 + Al_2O_3 (12%)

TABLE 8
MRR, TWR & SR of Al7178+ Al_2O_3 (12%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) µs	Pulse off time (T_{off}) µs	Voltage (V) Volts	MRR (mm^3/min)	TWR (mm^3/min)	SR (µm)
1	4	100	50	30	0.611	11.139	3.425
2	4	450	75	45	0	0	3.919
3	4	1000	100	60	0.122	0.253	2.386
4	8	100	75	60	0.244	0.253	2.54
5	8	450	100	30	0.122	0	3.331
6	8	1000	50	45	0.611	0.506	2.306
7	12	100	100	45	0.366	0.759	3.727
8	12	450	50	60	0.611	0.759	4.588
9	12	1000	75	30	0.366	0.506	2.803

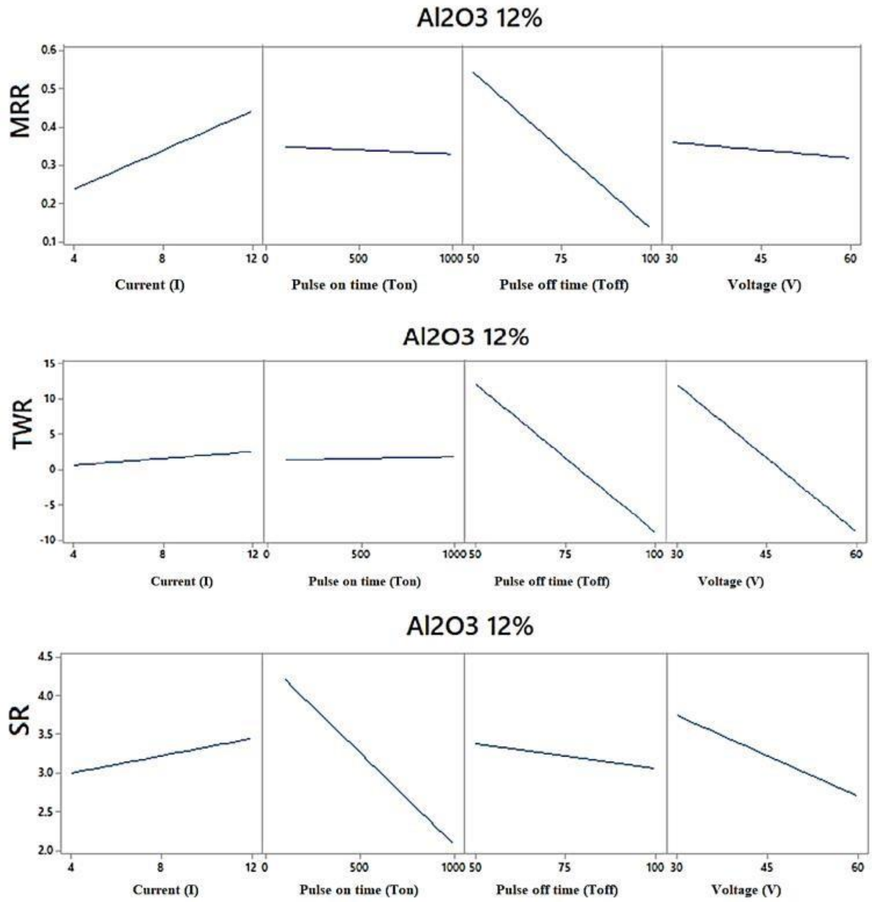

FIGURE 38: Graphical relation among input parameters and MRR, TWR, SR (Al_2O_3 12%)

Geometric Analysis (Circularity Accuracy) for Al7178 with 12% Al_2O_3 tool input parameters (V = 30, I = 4, T_{on} =100, T_{off} =50) images are obtained for 12% Al_2O_3 for Trails (12A1 to 12A9) by using image processing in MATLab the percentage error obtained for 12% Al_2O_3 are shown below:

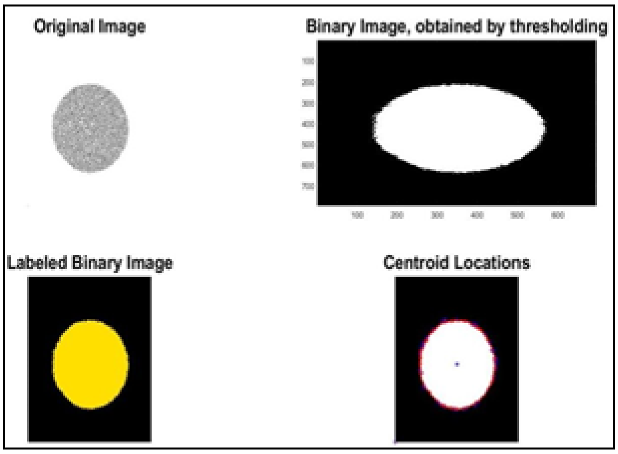

FIGURE 39: 12% Al2O3 for Trail 1

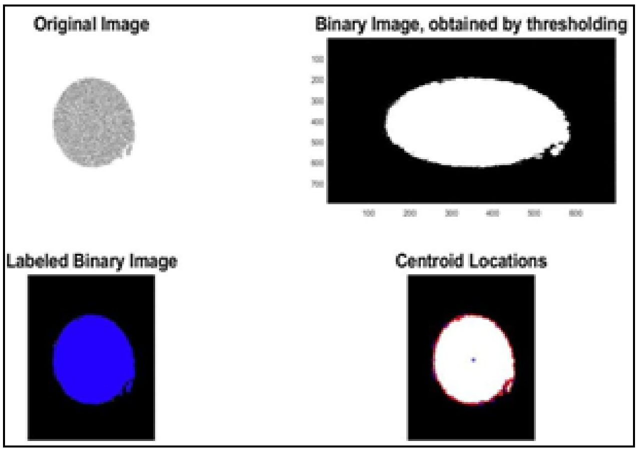

FIGURE 40: 12% Al2O3 for Trail 2

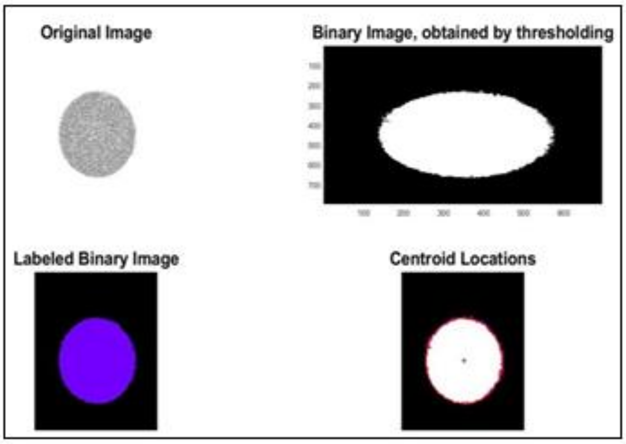

FIGURE 41: 12% Al2O3 for Trail 3

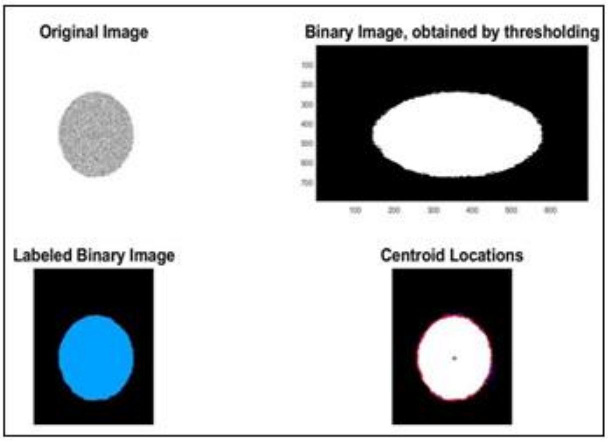

FIGURE 42: 12% Al2O3 for Trail 4

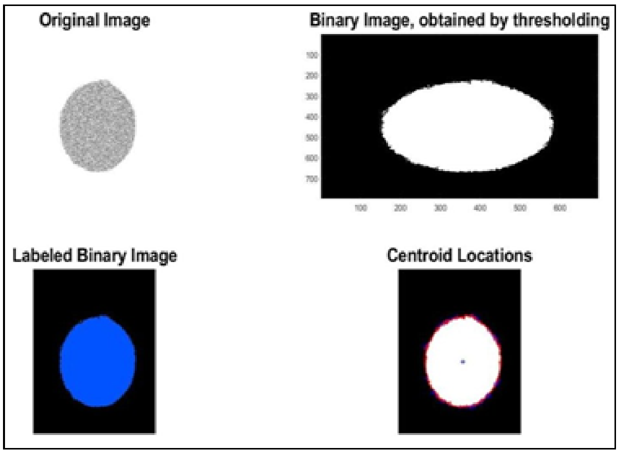

FIGURE 43: 12% Al2O3 for Trail 5

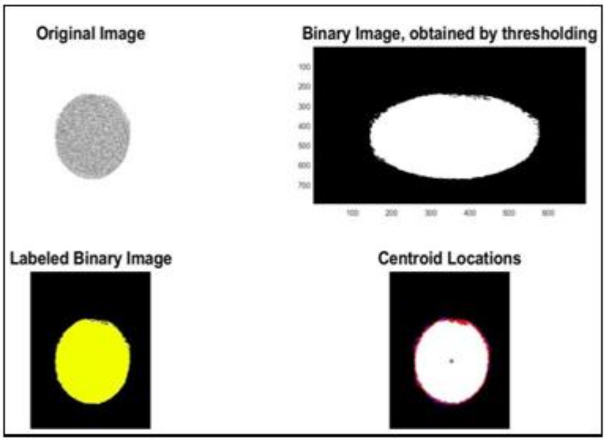

FIGURE 44: 12% Al2O3 for Trail 6

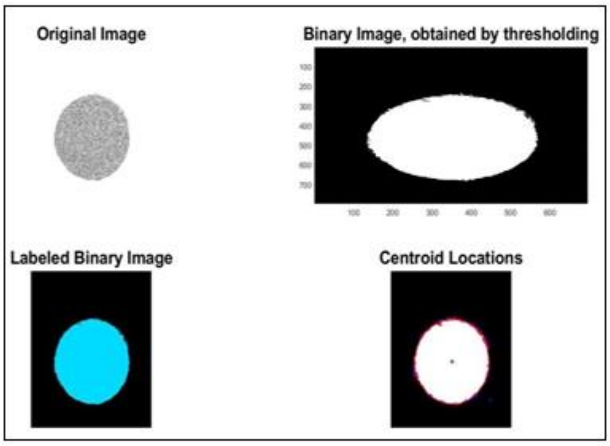

FIGURE 45: 12% Al_2O_3 for Trail 7

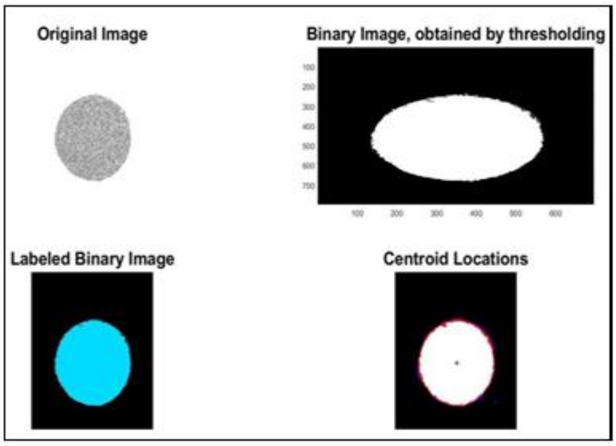

FIGURE 46: 12% Al_2O_3 for Trail 8

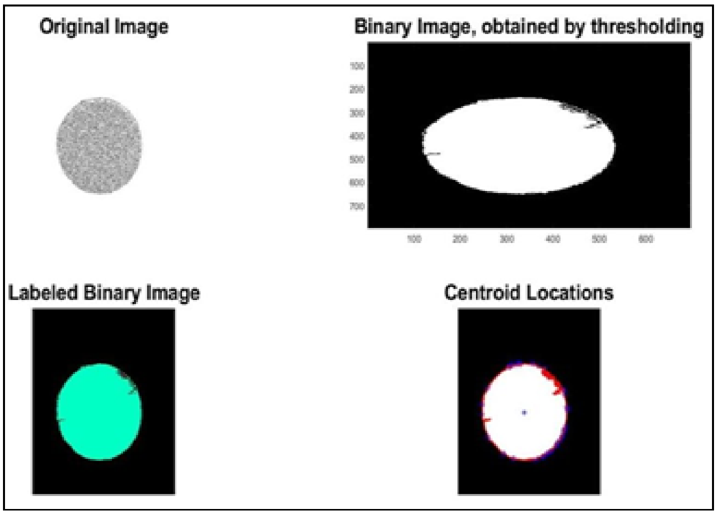

FIGURE 47: 12% Al_2O_3 for Trail 9

All nine trails of Al7178 with 12% Al_2O_3 are evaluated for Geometric Analysis using MATLab. And Geometric Analysis for Al7178 + Al_2O_3 (12%) is shown below table:

TABLE 9
Geometric Analysis for Al7178 + Al_2O_3 (12%)

S.No.	Current (I) Amps	Pulse on time (T_{on}) μs	Pulse off time (T_{off}) μs	Voltage (V) Volts	MRR (mm^3/min)	Average Distance (Radius)	% Error	Standard Deviation
1	4	100	50	30	0.611	5.003	0.065	0.076
2	4	450	75	45	0	4.792	4.232	0.168
3	4	1000	100	60	0.122	5.087	1.735	0.075
4	8	100	75	60	0.244	5.018	0.375	0.067
5	8	450	100	30	0.122	4.941	1.171	0.089
6	8	1000	50	45	0.611	5.103	2.043	0.125
7	12	100	100	45	0.366	5.142	2.803	0.088
8	12	450	50	60	0.611	5.396	7.618	0.229
9	12	1000	75	30	0.366	5.043	0.871	0.078

3.6.5 Consolidated Table & Graph for % error in Geometrical Accuracy:

The consolidated results for percentage error for four cases of Aluminum Oxide 3%, 6%, 9% and 12% are shown in below table:

TABLE 10
Consolidated Table for % error

S.No.	Geometrical Accuracy for different % of Al2O3			
	Al2O3 3%	Al2O3 6%	Al2O3 9%	Al2O3 12%
1	1.479	0.672	5.728	0.065
2	1.591	3.631	4.133	4.232
3	2.368	1.104	3.714	1.735
4	0.125	1.196	0.3	0.375
5	0.569	0.908	4.372	1.171
6	3.433	1.256	0.031	2.043
7	0.478	1.159	1.389	2.803
8	0.939	0.627	2.559	7.618
9	1.415	3.094	2.453	0.871

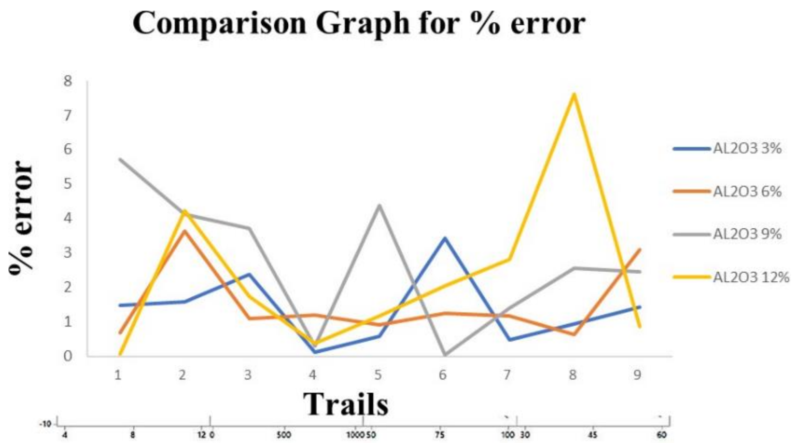

FIGURE 48: Consolidated graph for percentage error for four cases of Aluminum Oxide 3%, 6%, 9% and 12%

After performing the nine trails of four cases of Al7178 + Al2O3 3%, Al2O3 6%, Al2O3 9% and Al2O3 12% the higher percentage error is obtained at Al2O3 9% in trail 1 i.e., 5.728 and the lower percentage error is obtained at Al2O3 12%in trail 1 i.e., 0.065 by using MATLab and the comparison graph for percentage error for four cases of Aluminum Oxide3%, 6%, 9% and 12% are shown in figure.

The comparison graph for MRR, TWR, SR and percentageerror for 3% Aluminum Oxide (3% Al2O3) is shown in figure:

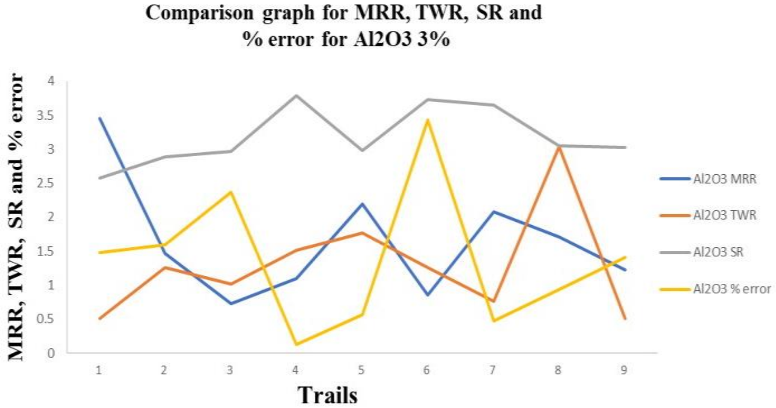

FIGURE 49: Comparison graph for MRR, TWR, SR and % errorfor Al2O3 3%

Higher Material Removal Rate is happens at higher current which in turn causing higher Roughness and all higher percentage error in geometry. The optimized condition for lower Roughness, lower TWR, lower Geometrical error and higher MRR is at Trail 1 (Parameters: current 4amps, pulse on time 100µs, pulse off time 50µs, voltage 30volts).

IV. CONCLUSION

From the experimental data and results obtained from the analysis the following conclusions may be drawn.

From the experimentation Al2O3 3% is found to be the optimum solution from all the cases (Al2O3 3%, Al2O3 6%, Al2O3 9% & Al2O3 12%)

- For 3% Al2O3, the Material Removal Rate is high (3.45 mm3/min), Surface Roughness is less in Trail 1 which is 3.955µm. Hence, the optimum condition for 3% Al2O3 is in Trail 1 (Parameters: current 4amps, pulse on time 100µs, pulse off time 50µs, voltage 30volts).
- The optimized condition for lower Roughness, lower TWR, lower Geometrical error and higher MRR is in Trail 5 (Parameters: current 8amps, pulse on time 450µs, pulse off time 75µs, voltage 45volts).
- The main input parameter influencing the responsesis current and its optimum value is 8amps.

FUTURE SCOPE

Aluminum Oxide (Al2O3) tool with Kerosene and Nano Fluidblend as a Dielectric.

ACKNOWLEDGMENT

The success of my project is a result of the hard work and technical expertise of many individuals, and I am grateful for their contributions. I would like to express my deep appreciation to my supervisor, **Dr. L. Siva Rama Krishna**, Professor & Department of Mechanical Engineering, Osmania University, for his guidance and suggestions throughout the project. I would like to express my deep appreciation to my co-supervisor, **Dr. S. Gajanana**, Professor & Dean of the Department of Mechanical Engineering, MVSR, for his guidance and suggestions throughout the project.

REFERENCES

[1] H.M. Zawa, J.Y.H. Fuhb, A.Y.C. Neeb& L. Lub, Formation of a new EDM electrode material using sintering techniques. https://doi.org/10.1016/S0924- 0136(99)00054-0

[2] Z.Y.Yu, J.Kozak & K.P. Rajurkar, Modelling and Simulation of Micro EDM Process.

[3] M.Rozenek, J.Kozak, L.Dąbrowski & K.Łubkowski, Electrical discharge machining characteristics of metal matrix composites.

[4] K. M. Patel, Pulak M. Pandey & P. Venkateswara Rao, Determination of an Optimum Parametric Combination Using a Surface Roughness Prediction Model for EDM of Al2O3/Al2O3w/TiC

[5] https://doi.org/10.1080/10426910902769319

[6] M.R.Shabgard & R.M.Shotorbani, Mathematical Modeling of Machining Parameters in Electrical Discharge Machining of FW4 Welded Steel.

[7] Sanjeev Kumar, Rupinder Singh, T.P. Singh& B.L. Sethi, Surface modification by electrical discharge machining: A review. https://doi.org/10.1016/j.jmatprotec.2008.09.032

[8] Kuldeep Ojha, R. K. Garg & K. K. Singh, MRR Improvement in Sinking Electrical DischargeMachining: A Review.

[9] Sharanjit Singh & Arvind Bhardwaj, Review to EDM by Using Water and Powder- Mixed Dielectric Fluid.

[10] E. Weingärtnera, F. Kustera& K. Wegenera, Modeling and simulation of electrical discharge machining. http://dx.doi.org/10.1016/j.procir.2012.05.043.