Influences and Optimization of Electrical Discharge Machining Parameters for Improving form Tolerances of Micro Hole on SiC Conductive Ceramic Composite

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Abstract

Advanced Ceramics find wide range of industrial applications. Cutting of advanced ceramic (SiC) is very difficult using conventional machining methods due to its low fracture toughness. In the past few years, researchers have claimed successful machining of ceramic composites using EDM process. Furthermore, increasing trend, necessity of miniaturization, micro components in MEMS and semiconductor industry, micro mould and dies, furnace, micro injection, stamping, fuel nozzles, micro probes, photo-masks and micro tools. etc, have demanded the development of micro-machining methods for advanced ceramics. Therefore, this research was focused on micro hole drilling-EDM of SiC. The optimization of micro drilling in electrical discharge machining process parameters of SiC to improve the multiple performance characteristics such as, high material removal rate, low electrode wear ,surface finish and accurate over cut was investigated and optimized by the Grey-Taguchi method. The influences of peak current, pulse on-time, pulse off-time and spark gap on electrode wear (EW), material removal rate (MRR), circularity(CIR), taper ratio(TR) and overcut (OC) in the micro drilling operation using EDM of SiC were analyzed. The experimental results show that high MRR, low TWR, accurate OC, better CIR, better TR under the micro drilling electrical discharge machining. Hence, it is clearly shown that multiple performance characteristics can be improved by using the Grey-Taguchi method.

Keyword- Sink EDM; electrode wear; material removal rate; over cut; CIR, TR, Grey-Taguchi method

I. INTRODUCTION

SiC based composites are well-recognized engineering materials for high temperature applications. Due to their high strength, low density, fracture toughness good electrical conductivity and high hardness, silicon-based composites are used in heat exchangers, non-ferrous molten metal handling, gas turbine components, wear-resistant components, and aircraft engines, among other applications. Because these materials have high hardness, conventional machining processes for the production of complex shapes are extremely difficult and expensive because machining may cause cracks on the exterior parts of the working materials. Thus, it is more suitable to select a non-traditional machining process for these experiments. EDM is a widely used non-traditional machining process that maintains good dimensional tolerance in electrically conductive materials despite the high strength and hardness of the materials. To incorporate better wear properties, electrically conductive particles, such as TiC, TiN, ZrB2, and TiB2, are reinforced with a Si3N4 matrix. The machine should work effectively on conductive electrical pieces regardless of their mechanical properties and shape spark eroding processes [1-4]. Sanchez et al. [5] developed optimum electro discharge machining technology for advanced ceramics and EDM proves its feasibility for the optimum machining of ceramics. The ceramic composites are manufactured by a hot pressing technique and the high-temperature sintering of powder metallurgy [6]. The ceramic composites should possess good electrical conductivity for their machining by the EDM. Recently, various special processes have been used to manufacture conductive ceramic-based composites [7]. Ahmad and Sueyoshi studied the outcome of the mechanical and electrical possession of silicon nitride and titanium nitride composites [2, 5, 8]. Their research used a hot pressing technique between 1250°C and 1350°C to prepare the experimental composites. Drawin et al. [9] used the same preparation technique as Ahmad and Sueyoshi. The research by Darwin et al. also incorporates the addition of silicon nitride composites to improve the MRR during the spark eroding process. The above mentioned research also demonstrated that conductive ceramic-based composites are being manufactured and used for an increasing number of applications. As an attempt to determine the most suitable electrode material, Muttamara et al. [10] used Cu, Cu-W and Ag-W as materials for the micro-EDM and suggested the Cu electrode as having the highest MRR, followed by the CuW and AgW electrodes. Dey et al. [11] also suggested that copper electrodes are suitable for achieving a high metal removal rate pertaining to the electrical discharge while machining ceramics.

Recently, the Taguchi technique has been used as an experimental methodology to minimize the number of trials based on experimental design. Precisely, an orthogonal array and the grey relational analysis are employed to achieve the optimal parameter combinations [12, 13]. Additionally, the Taguchi grey relational analysis (TGRA) and ANOVA are used to analyze the importance of machining parameters [3, 8]. Chiabert et al. [14] reviewed the current geometric tolerance theories and algorithms for inspection data analysis. In manufacturing engineering, EDM is becoming a vital process in the recent scenario due to the evolving trend of micro- and nano- applications. Therefore, precision components with good form tolerances are needed in EDM manufacturing. This experimental work focuses on analyzing the application of conventional EDM on micro scale feature machining, in silicon Carbide composites. A literature research indicated that few appreciable experimental works have been completed in this field. Moreover, form and orientation tolerances are relevant responses in non-conventional machining processes, such as EDM [15-22]. This article presents to optimize the EDM process parameters to improve the MRR, TWR, CIR, Dilation of hole, TR. Hyun-Kyu Yooa, Ji-HyeKoa, As the unit discharge energy increased, the debris size and its standard deviation for YN-SiC increased, while those of SUS304 decreased [23]. Mustafa Ay & Ulaş Çaydaş, studied micro-electrical discharge machining (EDM) drilling process of Inconel 718 nickel-based Super alloy with multi performance characteristics The hole taper ratio (Ht) and hole dilation (Hd) were the measured performances [24].Krishna Kumar Saxenaa, n, Anand Suman Srivastava b analyzed that Micro EDM operation process parameters (Voltage, Capacitance and Threshold) affect the Surface Roughness, MRR, TWR and ROC significantly [25].

Hence, the process can be applied to close tolerance components, such as tools, dies, mould and press work operations, due to the improvement in the above response parameters. For example, in the application of extrusion die for manufacturing hard steel product, this extrusion die that are made by an EDM, which needs for circularity, over cut and taper ratio to accurate size and shape.

II. MATERIALS AND METHODS

The machine used for this work was the OSCARMAX spark EDM. Feed in the vertical direction was controlled by a servo drive. The dielectric fluid was the EDM oil solution, and the electrode suction flushing method was used. Removal of the debris generated during the machining process was required to maintain smooth processing during the electrical discharge machining; thus, a solid electrode was selected. Table.1 shows the operating conditions of the EDM machine (Model no: SD325-ZNC) shown in Fig.1, which is used to machine the composite material.

Working conditions	*Description*
Electrode material	*Electrode material Chromium Zirconium copper*
Electrode Diameter	*Ø 700 µm, length – 40 mm*
Shape of Tool Electrode	*Cylindrical shape*
Electrode polarity	*-ve*
Work piece polarity	*+ve*
work material type	*Silicon carbide*
Work piece material size	*Ø50 mm, thickness-2 mm*
Type of current	*DC Power Supply*
Dielectric fluid	*EDM oil*

Table 1: EDM operating conditions

A. Process Variables and their Levels of Spark EDM

Symbol	*Parameter*	*Units*	*Level*	*Level 2*	*Level 3*
A	*Current*	*A*	*5*	*4*	*2*
B	*Pulse On time*	*µs*	*15*	*10*	*6*
C	*Pulse off time*	*µs*	*22*	*15*	*10*
D	*Dielectric pressure*	*Kg/cm^2*	*15*	*16*	*17*

Fig. 1: OSCARMAX Spark EDM machine

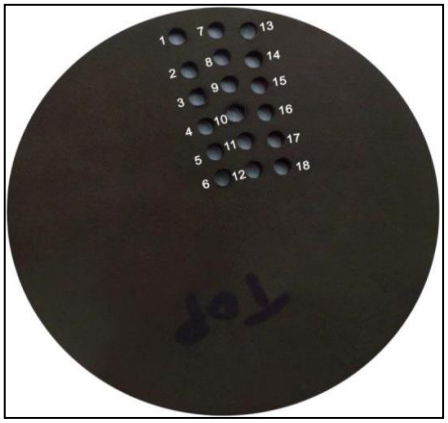

Fig. 2: shows micro holes in machined work piece

The work piece material was hot-pressed SiC, a composite-grade developed as an electrically conductive ceramic. The work piece was a disc with a 50 mm diameter and 2 mm thickness. A copper-based electrode composed of Cr–Zr – Cu in the form of a rod with a 0.7 mm diameter and a 100 mm length was used to achieve a higher MRR [10]. Taguchi developed a method for DOE that reduces the number of experiments and analyses required to achieve proper outcomes [15–20]. In this work, SiC can be considered a specimen material. Being a powerful tool in parameter design, the experiment is designed using the Taguchi method. The MRR was calculated based on the weight difference of the work piece before and after undergoing the EDM process. The weights of the electrode and work specimen were measured using electronic weighing machine.
The MRR was determined using Equation (1).

$$MRR\ (g/min) = \frac{Va - Vb}{t} \quad (1)$$

Where Vjb - weight of the specimen material before eroding (g),Vja – weight of the specimen material after eroding (g),
Similarly, the TWR was determined using Equation (2)

$$TWR\ (g/min) = \frac{V\,tb - V\,ta}{t} \quad (2)$$

Where V tb - weight of the electrode before eroding (g), Vta- weight of the electrode after eroding (g), t- Machining time (min).

B. Calculation of Circularity

Circularity is defined as a condition of a surface of revolution (sphere, cone, and cylinder) where all points of the surface intersected by any plane perpendicular to a common axis (cone, cylinder) or passing through a common centre (sphere) are equidistant from the axis of the centre. The form tolerances and orientation tolerances were measured by Optical Profile Projector, model ZEISS Contoura G2, with an accuracy of 4.5µm. At least four measurements of circularity were taken for each hole and average (Fig. 1a). The circularity of drilled holes was calculated in terms of circularity (ΔC) by using the formula

$$\Delta C = (D_i - De) + \text{----} (D_n - De) / 4$$

Where, i= 1,2,.. 4, n is the number of measurement.

1) Specification of optical Profile Projector

2) Specifications:

- Models : V30 Profile Projector
- Variable Intensity :24Vxl50W
- Magnifications :10X,20X.25X.SOX,lOOx
- Dual Xenphot Light Source :24Vxl50W
- MagnificationAccuracyContour:0.05%
- Surface :0.10%
- Screen : 360mm Dia
- Rotation : 360º

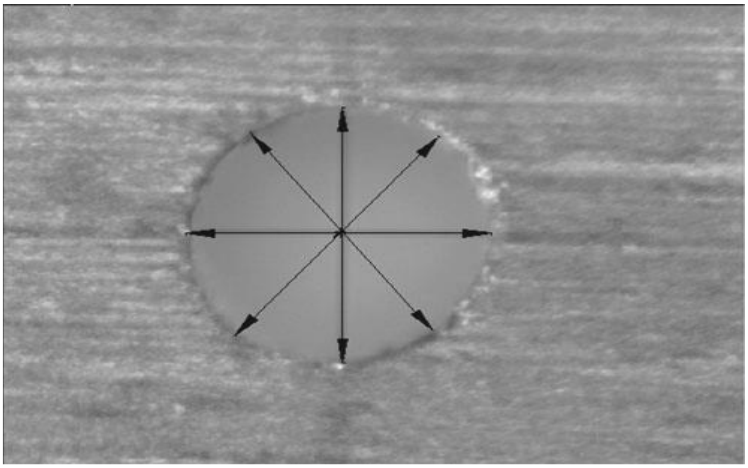

Fig. 1: a) Dimension were measured using optical profile projector

The dilation of holes (OC) was determined by the following equation:
Dilation of hole (Over Cut) = D_{max}- De
Where De is the original electrode diameter.

3) Image Scanned By Optical Profile Projector

Measurement at Entrance

Measurement at Exit

In EDM drilling, entry hole diameter is normally larger than exit hole diameter and thus the drilled holes are generally positively tapered.
The hole taper ratio (Ht) was calculated by using following formula:
Taper Ratio = $D_{entrance} - D_{exit}$ / 2x thickness of material
Where, D entrance is the hole entrance diameter,
D exit is the hole exit diameter and t is the thickness of the material.
L18 Orthogonal array with factors and responses.

Ex.no	*Process parameter-Input parameter*				*Output parameter*				
	Current	*Pulse On time*	*Pulse off time*	*Dielectric pressure*	*MRR*	*TWR*	*Circularity (CIR)*	*Over Cut (Dilation)*	*taper ratio (TR)*
	A	*μs*	*μs*	*Kg/cm²*	*g/min*	*g/min*	*mm*	*mm*	*mm*
	5	*15*	*22*	*15*	*0.0036*	*0.0003*	*0.007*	*0.023*	*0.065*
	5	*10*	*15*	*16*	*0.0068*	*0.0011*	*0.025*	*0.031*	*0.055*
	5	*6*	*10*	*17*	*0.0185*	*0.0011*	*0.016*	*0.028*	*0.214*
	4	*15*	*22*	*16*	*0.0043*	*0.0004*	*0.009*	*0.023*	*0.047*
	4	*10*	*15*	*17*	*0.0050*	*0.0008*	*0.013*	*0.025*	*0.038*
	4	*6*	*10*	*15*	*0.0045*	*0.0006*	*0.011*	*0.018*	*0.092*
	2	*15*	*22*	*17*	*0.0069*	*0.0012*	*0.007*	*0.026*	*0.210*
	2	*10*	*15*	*15*	*0.0037*	*0.0003*	*0.010*	*0.019*	*0.125*
	2	*6*	*10*	*16*	*0.0021*	*0.0001*	*0.006*	*0.008*	*0.055*
	5	*15*	*22*	*16*	*0.0052*	*0.0009*	*0.019*	*0.026*	*0.045*
	5	*10*	*15*	*17*	*0.0059*	*0.0007*	*0.020*	*0.032*	*0.055*
	5	*6*	*10*	*15*	*0.0047*	*0.0013*	*0.004*	*0.050*	*0.098*
	4	*15*	*22*	*15*	*0.0058*	*0.0012*	*0.006*	*0.058*	*0.148*
	4	*10*	*15*	*16*	*0.0054*	*0.0008*	*0.007*	*0.030*	*0.180*
	4	*6*	*10*	*17*	*0.0029*	*0.0001*	*0.010*	*0.036*	*0.298*
	2	*15*	*22*	*17*	*0.0038*	*0.0008*	*0.009*	*0.022*	*0.598*
	2	*10*	*15*	*15*	*0.0023*	*0.0001*	*0.008*	*0.038*	*0.039*
	2	*6*	*10*	*16*	*0.0038*	*0.0004*	*0.002*	*0.010*	*0.175*

III. RESULTS AND DISCUSSION

The signal-to-noise (S/N) ratio for the relating experimental results is calculated via Equations (3) and (4).
A higher S/N ratio is better:

$$S / N \text{ ratio } (\eta) = -10 \log_{10} (1/n) \sum 1/ y_{ij}^{2} \quad \text{---------- (3)}$$

Where, η = the resultant S/N ratio, n = the number of replications, k = number of experiments and y_{ij} = the observed response value, where i = 1, 2, ..., n and j = 1, 2, ..., k. i is the response value in the jth experiment. i=number of responses and j=number of experiments. In this research, a higher MRR is advantageous. Therefore, Equation (3) is used to calculate the S/N ratio values of the MRR.
A lower S/N ratio is better:

$$S / N \text{ ratio } (\eta) = -10 \log_{10} (1/n) \sum y_{ij}^{2} \quad \text{---------- (4)}$$

Where, η = the resultant S/N ratio, n = the number of replications, and yij = the observed response value, where i = 1, 2,..., n and j = 1, 2, ..., k., i is the response value in the jth experiment. i=number of responses and j=number of experiments. Therefore, Equation (4) is used to evaluate the S/N ratio values of the experimental results. Normalization of the experimental data for each response is completed. Normalization is often considered a transformation that is carried out by individual data that is entered and can be circulated and measured by a greater analysis, where yij is normalized as Xij ($0 \leq Xij \leq 1$) by applying the equation. The normalization prevents the impact of choosing various components to decrease the variables and is mandatory in standardizing data when examining it with either Grey theory or another technique. Making an assessment of an array approximate to 1 can be deducted from the value of the same array. The receptiveness of the standard method in the outcome is also analyzed because the method of normalization changes the grades. Thus, the S/N ratio must be considered while normalizing the data in a GRA.

$Y_{ij} - \min y_{ij}$ (i= 1,2,…… n).

---------- S/N ratio in which a higher value is better (5) $\max Y_{ij}$(i= 1,2,…… n) $- \min y_{ij}$ (i= 1,2,…… n)

$= \max Y_{ij}$(i= 1,2,…… n)$- Y_{ij}$

---------- S/N ratio in which a lower value is better (6)

$\max Y_{ij}$(i= 1,2,…… n)$- \min y_{ij}$ (i= 1,2,…… n)

In this work, to maximize the performance characteristics, the normalized values of the experimental results are obtained by Equation (5) and by minimizing the performance characteristics in Equation (6). The results are given in Table 4.

S.No	*S/N Ratio*					*Normalising*				
	MRR	*TWR*	*CIR*	*OC*	*TR*	*MRR*	*TWR*	*CIR*	*Dilation*	*TR*
	-8.82799	*71.1067*	*38.4164*	*32.7654*	*23.7417*	*0.2532*	*0.4489*	*0.7094*	*0.5331*	*0.1948*
	-43.2962	*59.5545*	*32.0412*	*30.1728*	*25.1927*	*0.5447*	*0.9178*	*1.0000*	*0.6838*	*0.1342*
	-34.6555	*59.1617*	*35.9176*	*31.0568*	*13.3917*	*1.0000*	*0.9337*	*0.8233*	*0.6324*	*0.6271*
	-47.2735	*66.9791*	*34.4249*	*32.7654*	*26.5580*	*0.3351*	*0.6165*	*0.8913*	*0.5331*	*0.0771*

	-46.0452	*61.6082*	*37.7211*	*32.0412*	*28.4043*	*0.3999*	*0.8344*	*0.7411*	*0.5752*	*0.0000*
	-46.9980	*63.9000*	*39.1721*	*34.8945*	*20.7242*	*0.3496*	*0.7414*	*0.6750*	*0.4094*	*0.3208*
	-43.2853	*58.0925*	*43.0980*	*31.7005*	*13.5556*	*0.5453*	*0.9771*	*0.4960*	*0.5950*	*0.6203*
	-48.7061	*70.9850*	*40.0000*	*34.4249*	*18.0618*	*0.2596*	*0.4539*	*0.6372*	*0.4366*	*0.4320*
	-53.6336	*76.8609*	*44.4370*	*41.9382*	*25.1927*	*0.0000*	*0.2154*	*0.4350*	*0.0000*	*0.1342*
	-45.7516	*61.3146*	*34.4249*	*31.7005*	*26.9357*	*0.4153*	*0.8464*	*0.8913*	*0.5950*	*0.0613*
	-44.6150	*63.2034*	*33.9794*	*29.8970*	*25.1927*	*0.4752*	*0.7697*	*0.9117*	*0.6998*	*0.1342*
	-46.4725	*57.5293*	*47.9588*	*24.7314*	*20.1755*	*0.3773*	*1.0000*	*0.2744*	*1.0000*	*0.3438*
	-44.7223	*58.7017*	*44.4370*	*34.4249*	*16.5948*	*0.4696*	*0.9524*	*0.4350*	*0.4366*	*0.4933*
	-45.3314	*62.2333*	*43.0980*	*30.4576*	*14.8945*	*0.4375*	*0.8091*	*0.4960*	*0.6672*	*0.5644*
	-50.6069	*78.9064*	*40.0000*	*28.8739*	*10.5157*	*0.1595*	*0.1323*	*0.6372*	*0.7593*	*0.7473*
	-48.5010	*62.1859*	*40.9151*	*33.1515*	*4.4660*	*0.2704*	*0.8110*	*0.5955*	*0.5107*	*1.0000*
	-52.9193	*82.1672*	*41.9382*	*28.4043*	*28.1787*	*0.0376*	*0.0000*	*0.5489*	*0.7865*	*0.0094*
	-48.3184	*68.3184*	*53.9794*	*40.0000*	*15.1392*	*0.2801*	*0.5621*	*0.0000*	*0.1126*	*0.5541*

Table 4: S/N ratio values and normalized S/N ratio values

Calculate the grey relational coefficient (GRC) in the normalization experimental results.

$$\gamma\, y\, k\, ,\, y\, k = \Delta\min + \xi\, \Delta\, \max$$

$$\text{---------- (7)}$$

$$V\, oj + \xi\, \Delta\, \max$$

The defined range of $0 \leq \xi \leq 1$ determines the differentiated coefficient. The GRG is determined using the following equation:

$$\text{ɤ}_j = 1/k \sum_{i=1}^{m} y\, ij \text{ ---------- (8)}$$

Where ɤ_j = the grey relation rank for the j^{th} test and k = the number of output parameters. The values for the grey rank provided in Table 5 are plotted at Fig. 5.

Ex.No	*Grey relational Co-efficient*					*Grey grade*	*Rank*
	MRR	*TWR*	*CIR*	*OC*	*TR*		
	0.4010	*0.4757*	*0.6324*	*0.5171*	*0.3831*	*0.4819*	*14*
	0.5234	*0.8588*	*1.0000*	*0.6126*	*0.3661*	*0.6722*	*2*
	1.0000	*0.8830*	*0.7389*	*0.5763*	*0.5728*	*0.7542*	*1*
	0.4292	*0.5659*	*0.8215*	*0.5171*	*0.3514*	*0.5370*	*11*
	0.4545	*0.7513*	*0.6588*	*0.5406*	*0.3333*	*0.5477*	*10*
	0.4346	*0.6591*	*0.606*	*0.4584*	*0.424*	*0.5165*	*13*
	0.5237	*0.9563*	*0.498*	*0.5525*	*0.5684*	*0.6198*	*5*
	0.4031	*0.4779*	*0.5795*	*0.4702*	*0.4682*	*0.4798*	*15*
	0.3333	*0.3892*	*0.4695*	*0.3333*	*0.3661*	*0.3783*	*18*
	0.4610	*0.7650*	*0.8215*	*0.5525*	*0.3475*	*0.5895*	*7*
	0.4879	*0.6847*	*0.8498*	*0.6248*	*0.3661*	*0.6027*	*6*
	0.4454	*1.0000*	*0.408*	*1.0000*	*0.4324*	*0.6572*	*3*
	0.4852	*0.9131*	*.4695*	*00.4702*	*0.4967*	*0.5669*	*8*
	0.4706	*0.7237*	*0.498*	*0.6004*	*0.5344*	*0.5654*	*9*
	0.3730	*0.3656*	*0.5795*	*0.675*	*0.6643*	*0.5315*	*12*
	0.4067	*0.7257*	*0.5528*	*0.5054*	*1.0000*	*0.6381*	*4*
	0.3419	*0.3333*	*0.5257*	*0.7008*	*0.3354*	*0.4474*	*16*
	0.4099	*0.5331*	*0.3333*	*0.3604*	*0.5286*	*0.4331*	*17*

Table 5: computing the grey relational rank values by the GRA.

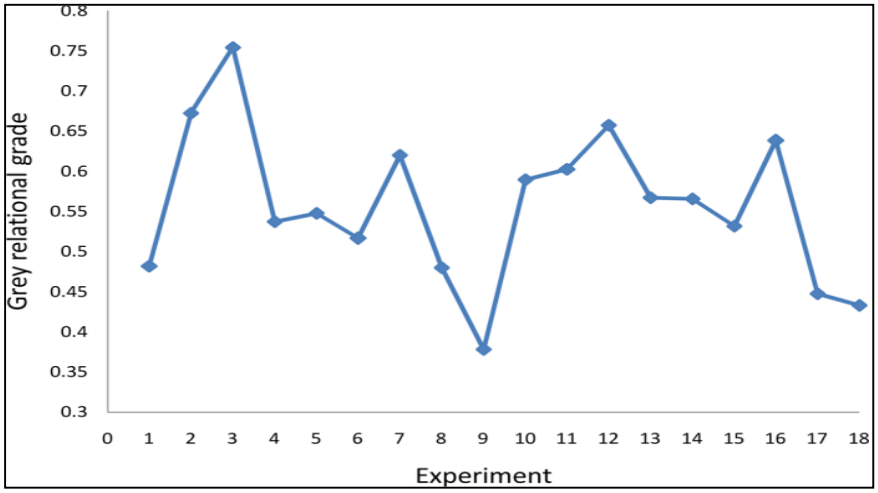

Fig. 5:

Considering the maximization of the grey rank values (Table 6 and Fig. 6), the optimal parameter conditions, A1B1C3D3 are obtained.

Symbol	*Parameter*	*1*	*2*	*3*	*Optimum Level*	*Max-Min*	*Rank*
A	*Current*	*0.5888*	*0.5813*	*0.4744*	*1*	*0.1144*	*1*
B	*Pulse on time*	*0.6013*	*0.5038*	*0.5439*	*1*	*0.0975*	*2*
C	*Pulse off time*	*0.5456*	*0.5375*	*0.5598*	*3*	*0.0223*	*4*
D	*Dielectric pressure*	*0.5081*	*0.5524*	*0.5899*	*3*	*0.0818*	*3*

Table 6: Performance table of the grey relation rank.

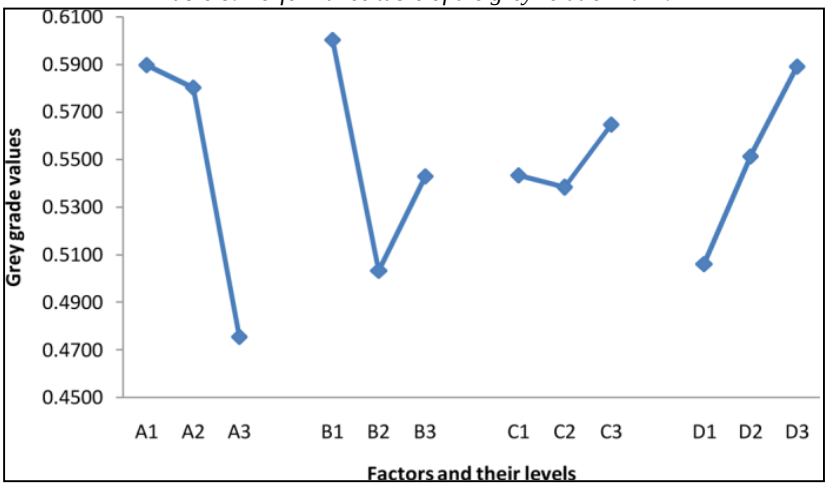

Fig. 6: Response graph of the grey relation rank.

ANOVA is performed to identify the significant parameters. This variance analysis is conducted by a static process that analyses the output in specific parameters. The output of the ANOVA determines the impact of the consequences on each parameter. The Taguchi method is incapable of scrutinizing the results for every parameter of the method; therefore, a particular percentage of the ANOVA is utilized to obtain a balanced outcome. When the F value is large, a change in the eroding parameters plays a vital role in the results. The ANOVA of the GRG is presented in Table 7. The current, pulse on time, and dielectric pressure are identified as significant parameters that affect the GRG in Fig. 7.

Symbol	*Parameter*	*SS*	*DOF*	*MS*	*F-cal*	*% Contribution*	*Rank*
A	*Current*	*0.0464*	*2*	*0.0232*	*17.8500*	*33.50*	*1*
B	*Pulse on time*	*0.0389*	*2*	*0.0194*	*14.9230*	*28.08*	*2*
C	*Pulse off time*	*0.0039*	*2*	*0.0020*	*1.5385*	*3.00*	*4*
D	*Dielectric pressure*	*0.0379*	*2*	*0.0189*	*14.5400*	*27.34*	*3*
Error		*0.0114*	*9*	*0.0013*		*8.23*	
Total		*0.1385*	*17*				

Table 7: Significance of the spark eroding parameters as obtained through ANOVA.

SS-Sum of Square, DOF-Degrees of freedom, MS-Mean Square, %-Percentage

	Machining Parameters in 2 trial	*Optimal machining Parameter in 2 trial*	
		Prediction	*Experiment*
Setting Level	*A1B3C3D3*	*A1B1C3D3*	*A1B1C3D3*
Material removal rate (g/min)	*0.0185*	-	*0.0250*
Tool wear rate(g/min)	*0.0011*	-	*0.0010*
Circularity (mm)	*0.016*	-	*0.012*
Dilation (mm)	*0.028*	-	*0.015*
Taper Ratio (mm)	*0.214*	-	*0.210*
Grey relational grade	*0.7542*	-	*0.7675*

Table 8: Results of the validation experiment.

Improvement of the Grey relational grade 0.0133

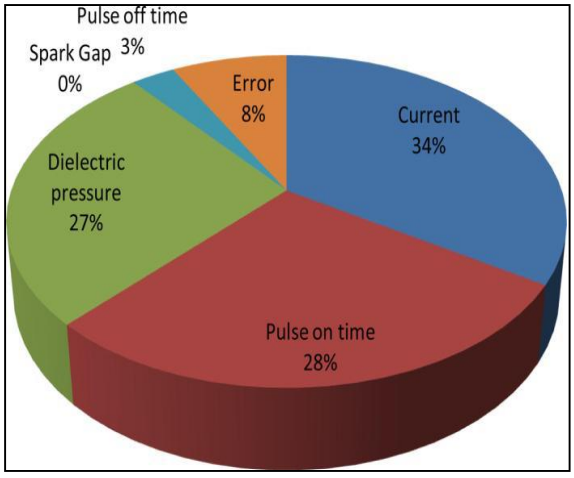

Fig. 7: Proportional values of the contributing factors by ANOVA

The optimum condition is computed. A selected optimum level of the input parameters to forecast and validate a confirmatory characteristic uses the ideal level of design parameters. The expected S/N ratio constitutes the ideal values of the design parameters.

$$\hat{\eta} = \eta_m + \sum_{i=1}^{m} \eta - \eta_m \quad \text{---------- (9)}$$

In this equation, η_m = the average S/N ratio, η = the mean S/N ratio relating to the i^{th} important parameter on j^{th} level and q= number of important parameters.

The grey relational grade (GRG) is estimated by applying Equation (9), and the optimum combinations of the eroding parameters related to various response characteristics are determined. A validation experiment is executed using the spark EDM to verify and enhance the performance characteristics of ceramic composites. Furthermore, the GRG for several response optimizations completed in the spark eroding process is enhanced between 0.7542 and 0.7675. Therefore, the outcome is confirmed by the optimization of the EDM parameters using the GRA.

IV. CONCLUSIONS

This study proposes an optimization procedure for the spark eroding process of a SiC ceramic composite based on the GRA of the Taguchi method. The optimal process parameters are attained by the GRG for multi-response optimization.

1) Factor A (current), factor B (pulse on time) and factor E (dielectric pressure) contribute 33.50%, 28.08% and 27.34%, respectively, to the ANOVA. The above factors are recognized as the most significant parameters affecting the accuracy and precision of the spark EDM process.
2) The appropriate combination of the results is obtained by the factor level settings, A1B1C3D3, which resemble the 3rd experimental parametric combination.
3) Furthermore, this technique improves the target output performance parameters with relation to the MRR, TWR, Circularity (mm), Over cut(Dilation of hole), Taper Ratio by applying the optimum level of input parameters, such as the current (I), pulse on time (Ton), pulse off time (T off) and dielectric pressure (DP).
4) The experiment is conducted within the optimum settings and results in a significant improvement in this process. The verification experiment shows that the responses of the spark erosion process can be efficiently improved.

5) Micro features on SiC ceramic composite using conventional sink EDM is successfully achieved with the satisfied form quality.

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