Experimental Investigation on Nickel Aluminium Alloy by Electric Discharge Machine

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Abstract: *Advanced structural ceramics, such as Silicon Carbide (Sic), Silicon Nitride (Si_3N_4), Alumina (Al_2O_3) and Zirconia (ZrO_2) are attractive materials for many applications ranging from aero engines to dental restoration and is possible due to high hardness and strength, wear resistance, resistance to chemical degradation and low density. Various applications of these ceramic materials demand shaping to a high degree of surface finish and dimensional accuracy. These materials difficult to machine because of high hardness and abrasive nature of reinforcingelements like alumina particles. In this study, homogenized (4%, 6%, and 8%) by weight of alumina aluminum metal matrix composite materials were fabricated and selected as work piece for experimental investigations of surface roughness and metal removal rate.*

Among the machining processes used for shaping advanced ceramics, grinding is the most widely used machining process as it gives reasonably good rate of material removal. However, the high cost of diamond grinding and difficulty in machining complex shapes and 3D surfaces have promoted research into alternative methods of ceramics machining like ultrasonic machining, abrasive water jet machining, electrical discharge machining and laser beam machining.

Electrical-discharge machining (EDM) is an unconventional, non-contact type machining process where metal removal is based on thermal principles. In this process, the material removalmechanism is based on the conversion of electrical energy into thermal energy through a series of discrete electrical discharges that occur between the electrode and work piece immersed in an insulating dielectric liquid. The concentrated heat of spark generates a channel of plasma between the cathode and anode at a temperature in the range of 8000 to 12,000 °C, initializing a substantial amount of heating and melting of material at the surface of each pole. When the direct current supply is turned off and the potential reaches above the breakthrough voltage of dielectric, the plasma channel breaks down. This causes a sudden reduction in the temperature Allowing the circulating dielectric fluid to implore the plasma channel and flush the molten material from the pole surfaces in the form of microscopic debris.

EDM does not make direct contact between the electrode and the work piece whereby it caneliminate mechanical stresses chatter and vibration problems of conventional machining. Despite all the advantages, the EDM process is not free from drawbacks. In EDM, the tool wear problem is very critical since the tool shape degeneration directly affects the final shape of the die cavity. The machinability of a material is a factor of its thermal and electrical properties in EDM.

Material's electrical resistivity is dependent on its temperature. In addition, the cost of a part manufactured by the EDM is determined mainly by the tool cost, which consists of the raw material cost of the tool, the tool production cost and the number of tools required for operation. In most of the EDM operations, the contribution of the tool cost to the total operation cost ismore than 70%. It is also known that during the cut by EDM the material removal rate (MRR)decreases, which is due to process instability. However, the decrease of MRR is due to thechange of metallurgic constituent in the machining zone. The quality of the surface machinedplays an important factor in evaluating the productivity. Surface Roughness is a significantdesign factor which has a considerable influence on properties such as fatigue, strength, andwears resistance. It is one of the most important measures also in machining operations. It is,therefore, imperative to target for good surface finish. Other drawbacks include difficulty inreproducing sharp corners on the work piece due to electrode wear, surface and subsurfacedamage and creation of thin and brittle heat-affected zone.

This work has attempted to overcome some of the drawbacks of the EDM process. It hasbeen observed that the rapid electrode wear can be reduced and better surface quality obtained by An efficient cooling strategy. The present work correlates the inter-relationships of various EDM machining parameters namely discharge current, pulse-on time, duty cycle and gap voltage on the material removal rate (MRR) and surface roughness (SR) in EDM process using c). Regression models have been developed to predict MRR and SR by correlating the inputparameters. The significance of EDM parameters on the selected responses has been evaluated using Taguchi Method with copper electrode. Confirmation experiments were also conducted at various test conditions to show that the developed models for EDM process can predict MRRand SR values accurately within 94% confidence interval an attempt has been made to optimize the EDM conditions to obtain maximum MRR and minimum SR. A trust-region based optimization method has been used to obtain optimum solution.

The objective of this research study is to investigate the optimal Process parameters of Electric Discharge Machining on Nickel aluminum composite work piece with copper as a tool electrode. The effect of various process parameters on machining performance is investigated in this study. The input parameters considered are impulse current, Pulse on timeand pulse off time, voltage gap are used for experimental work and their effect on Material Removal Rate, Tool and Surface Roughness. The Central competitive method is used to formulate the experimental layout,

Taguchi Method is used to analysis the effect of input process Parameters on the machining characteristics and finds the optimal Process parameters of Electric Discharge Machining. The results of the Present work reveal that proper selection of input parameters will play a significant role in Electric Discharge Machining.

1. INTRODUCTION

1.1. Overview of composite materials

Composite materials have been termed as the 'materials of the future' in 1970s when theywere introduced in engineering applications. Composite material is a materials system composedof two or more dissimilar constituents, differing in forms, insoluble in each other, physically distinct and chemically inhomogeneous. Each of the various components retains its identity in the composite and maintains its characteristic structure and properties. These are recognizable interfaces between the materials. The resulting product possesses properties much differed from the properties of constituents materials, also referred as composites. Metal matrix composite (MMC) are widely used composite materials in aerospace, automotive, electronics and medical industries. They have outstanding mechanical properties like high strength, low weight, low ductility, high wear resistance, high thermal conductivity and low thermal expansion. These desired properties are mainly manipulated by matrix, the reinforcement element and the interface.

Aluminum-based Ni-Al particle reinforced MMC material have become useful engineering materials due to their properties such as low weight, heat-resistant, wear-resistant and low cost. These are found in various engineering applications such as cylinder block liners, vehicle drive shafts, automotive pistons, bicycle frames etc. These materials are known as the difficult-to-machine materials, because of the hardness and abrasive nature of reinforcement element like nickel particle. These composites can be produced through a number of routes including melt processing and powder metallurgy. Compared with powder metallurgy, melt processing has some important ad vantages, e.g. better matrix particle bonding, easier control of matrix structure, simplicity, low cost of processing. There are many types of composite materials and several methods of classifying them. One such method is based on geometry and consists of three distinct families: laminar or layered composites, particulate composites, and fiber- reinforced composite.

1.2. Electro-Discharge Machining (EDM)

Electrical discharge machining (EDM) is a non-traditional manufacturing process wherethe material is removed by a succession of electrical discharges, which occur between the electrode and the work piece. These are submersed in a dielectric liquid such as kerosene or de- ionized water. The electrical discharge machining process is widely used in the aerospace, automobile and molds industries to machine hard metals and its alloys.

1.2.1. Types of EDM

- Die Sinker EDM
- Wire Cut EDM
- Drill EDM
- Disintrigated EDM

1.3. EDM Basic and Principle

In electrical machining processes, electrical energy is used directly to cut the material to final shape and size. Efforts are made to utilize whole of the energy by apply it at the exact spot where the operation is to be carried out. Another advantage of these methods is that no complicated fixtures are needed for holing the job and even very thin jobs can be machined to the desired dimensions and shape.

2. LITERATURE REVIEW

The review presented in this section is based on current EDM research trends. Few researches have been investigated in areas discussed.

Lokesh Upadhyay et al. [1] have been concluded that microstructure of MMC’s indicates the homogenous mixture of the alumina in the composite. Surface roughness increases with the process variables except the speed, speed made adverse effect on surface roughness. MRR increases with the process parameters except the concentration of reinforced particles due to presence of hard ceramic particles.

Lokesh Upadhyay et al. [2] have studied surface finish increases as the cutting speed icreases. With increase in reinforcement ratio the hardness and tensile strength of composite material found to be increased.

Pradhan et al. [3] have studied three different parameters namely pulse current, discharge time and pulse time and pause time for EDM process of AISI D2 steel using response surface method. It was found that all the three machining parameters and some of their interactions have significant effect on MRR.

Ryota Toshimitsu et al. [4] have studied a new EDM surface finishing method using chromium powder mixed fluid was proposed and the finished surface characteristics were experimentally discussed.

Syed, Palaniyandi et al [5] worked on addition of aluminium metal powered I distilled water resulted in high MRR, good surface finish and minimum white layer thickness when compared with pure distilled water.

Singh et al[6] investigated that negative polarity of tool electrode is desirable lowering of surface roughness and addition of powder particles I dielectric fluid decreases surface roughness of specimen in EDM process.

Rozeek et al. [7] was found that application of powder I the dielectric lead to reduce surface roughness. The investigation result showed that there were chances for replacing the conventional dielectric powder suspended deionized water and that would imply considerable economic and ecology advantages.

Biswas et al. [8] investigated that surface roughness is directly proportional to linear effect of pulse current and pulse on time.

Singh et al. [9] concluded that dry EDM have several advantages such as low tool electrode wearratio, better surface roughness and waste from the dielectric liquid as in case of EDM with oil. Mohd. Abbas et al[10] reviewed the research trends in EDM on ultrasonic vibration, dry EDM machining, EDM with powder additives, EDM in water and modeling techniques in predicting EDM performances is presented.

Kansal et al. [11] developed a axis symmetric two dimensional thermal model to predict the several aspects of the PMEDM using FEM.

Kiyak.M. et al.[12] explained surface roughness increased with increasing pulse current and pulsetime. Work piece surface roughness would be increase due to wear rate on electrode.

Afazov et al [13] determined stable cutting conditions for corresponding cutting tools with specific geometries was essential for achieving precision micro- milling with high surface quality.

Kansal et al[14] have studied that peak current concentration of the silicon powder pulse- on time and gain significantly affect the MRR in PMEDM.

Kendal.J. et al. [15]investigated the surface integrity induced by the AFM process on hardened tool steel AISI D2.

Liquing et al[16] proposed two new dry EDM techniques, namely oxygen- mixed dry EDM and dry EDM with cryogenically cooled work piece with the objective of increasing MRR and surface integrity.

Kolke et al[17] studied the possible productivities, tool wear and surface qualities in processing gamma titanium aluminides with the help of Sinking EDM.

Tomadi. S.H. et al[18] investigated the condition of parameters, main effect and the significance of individual parameter to surface roughness, material rate and electrode wear of material.

Choudhary Suraj et al[19] concluded that copper electrode showed the highest MRR while the brass electrode showed the least MRR. For lowest value of pulse-on time the MRR is low. Atcurrent 30 A the MRR is highest.

Bikramjit Singh et al[20] concluded that adding SiC and Aluminium powder into Kerosene oil increased the gap distance, resulting in higher MRR and depth.

3. METHODLOGY

The recent advancement in various technological field demands the development and use of new materials, which can sustain external loads at extremely high temperatures and corrosive environments. The use of thermoelectric source of energy in developing the nontraditionaltechniques has greatly helped in achieving an economic machining of extremely low machinability materials and jobs with complex geometries. There are many processes in which metal removal is based on thermal principles and Electrical Discharge Machining (EDM) is one of them EDM is a process that is based on removing material from a conducting work piece by means of a series of repeated electrical discharges between tool electrode (cathode) and the work piece (anode) in the presence of a dielectric fluid. The electrode is moved towards the work pieceby servo controlled feed until the gap is small enough in the range of 10 - 100 μm so that the applied voltage ionizes the dielectric. Short duration discharges are generated in a liquid dielectric gap. The material is removed with the erosive effect of the electrical discharges from tool and work piece. Thermal energy generates a channel of plasma between the cathode and anode at a temperature in the range of 8000 to 20000°C initializing a substantial amount of heating and melting of material at the surface of each pole. When the pulsating direct current supply of approximately 20000–30000 Hz is turned off, the plasma channel breaks down. This causes a sudden reduction in the temperature allowing the circulating dielectric fluid to implore the plasma channel and flush the molten material from the pole surfaces in the form of microscopic debris. EDM does not make direct contact between the electrode and the work piece whereby it can eliminate mechanical stresses chatter and vibration problems during machining. Although this does not mean that induced stresses and metallurgical effects on the work piece are necessarily absent.

EDM has been widely accepted by the metal cutting industries for the machining of heat treated tool steel, high strength alloys and carbides. EDM is also capable of machining ultra-hard tool materials such as polycrystalline diamond, CVD diamond; PVD coated cemented carbide and conducting ceramics. The development of different modern composite materials in the last decade has led to an expansion of EDM applications. Its unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been its distinctive advantage in the manufacture of mold, die, automotive, aerospace and surgical components. The volume of material removed per discharge is typically in the range of 10-6–10-4 mm3 and the material removal rate (MRR) is usually between 2 and 400 mm3/min. The surface finish produced by the EDM process consists of a multitude of small craters randomly distributed all over the machined face. Typical surface finish range is about 1.002 to 3.2 μm, although there are claims of 0.05 to 0.1 μm also. Normal tolerances of about ± 25 μm are obtainable by proper selection of process variables. The two most widely used types of EDM are die sinking EDM and wire EDM (WEDM). Die sinking EDM is widely used in the mold making industries. The advent of computer numerical control (CNC) in EDM brought tremendous advances in improving the efficiency of the machining operation.
Manufacturing of Ni-Al composite

The Ni-Al reinforced Al composite was produced by sand casting in foundry shop. The dimensions of final product were 45mm in diameter and 300mm length. In order to obtain matrix material at the beginning phase of the production, 99.9% pure aluminum was melted in the crucible at 700°C in muffle furnace. Then the nickel was added in the crucible and steered continuously. In order to increase wetting capability of reinforcement, 2% of Mg was added. In our experiment three types of nickel particles reinforced metal matrix composites were casted. In the first type 15% by weight nickel and remaining aluminum and could able to mix 4% by weightalumina in the final cast product. In type second 20% by weight nickel and remaining aluminum and could able to mix 6% by weight nickel in the final cast product. In third type 25% by weight nickel and remaining aluminum and could able to mix 8% by weight nickel in the final cast product. The dimension of work piece was 30 mm x 30 mm x 10 mm.

Fig 3.1:- Work piece of composite

3.1. Characterization of work piece material

Hardness, tensile strength and scanning electron microscope images have been characterized of work piece material. Hardness of composite is tested on the Rockwell hardness testing machine .The model of machine is Fine Engineering industries, S No. NR S. and pressure imposed capacity is 50kgf, 100kgf, 150kgf.

We had applied 100kgf at B scale 1/16’’ ball penetration, of pressure on our three specimens of 15%, 20% &25% by weight in nickel particles reinforced aluminum metal matrix composite. Tensile strength of composite specimen is measured by universal testing machine.The maximum capacity of our UTM is 40,000 Kgf. When the composite specimens obtained from casting, their microstructure of 4%, 6%, and 8% will examined with the scanning electron microscope (SEM). The scanning electron microscope (SEM) is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern.

3.2. Selection of process parameters

It is necessary to choose a reasonable set of factors to be varied in the experiment. The performance of EDM of nickel Aluminum composites are governed by a large number of interactive variables. The variables can be classified as electrical parameters, non-electrical parameters, electrode based parameters and work piece material based parameters. Review of literature revealed that among all the factors, discharge parameters such as discharge current, pulse-on time, and duty cycle and gap voltage have most significant influence on the EDM performance. Therefore, it has been decided that these four factors be chosen for the present study.

The experiments have been conducted keeping the four factors at various levels. The range of each factor has been selected based on the review of past literature and preliminary experiments conducted by using one variable at a time approach. The range of the discharge current, pulse-on time, duty cycle and gap voltage have been selected as 3 to 7 A, 100 to 500 µs,
0.60 to 0.84 and 50 to 70 V respectively. When the current was kept below 3A, it was observed that

MRR was insignificant and when current more than 7A was selected, it resulted in very rough surface necessitating the selection of the values at an intermediate. The range selected for the pulse-on time is commonly used in EDM process. The range selected for the duty cycle covers a wide range of duty cycle. Whereas the range of gap voltage selected is in accordance to that available on the machine used for the experimentation.

Table 3.5:- The process parameters with ranges have been given

FACTORS	UNITS	RANGE
Discharge Current (IP)	A	5, 6, 7
Pulse On Time (Ton)	Ms	270, 320, 370
Duty Cycle (DC)	DC	0.75, 0.78, 0.81
Gap Voltage (Vg)	V	60, 65, 70

The first order model is acceptable over a narrow range of variables, therefore the experiments are conducted to obtain second order model. In this RS method the design parameter are selected on the following method.

DC=TON/(TON+TOFF).
For the designing this parameter is necessary to fulfill the following equation.
DC (TON+OFF) =Ton.
The all the designing parameter must fulfill this equation.
Central composite design (CCD) is the most popular class of second order designssuggested by Box and Wilson. A design is rotatable if the variance of the response is constant forall variables at a given distance from the design Centre. The rotatable central composite design would be nearly orthogonal if the number of center points is about five. Central composite rotatable design (CCRD) is capable of predicting independent, quadratic and interaction effects of different parameters on the responses. Total 31 experiments (16 factorial runs, 8 axial runs, 7 central points) have been carried out at five levels.

Table 3.6:- The process parameters with levels.

Factors	Units	Levels				
		-2	-1	0	1	2
Discharge Current	A	3	4	5	6	7
Pulse-on time	(µs)	220	270	320	370	420
Duty cycle		0.72	0.75	0.78	0.81	0.84
Gap voltage	(V)	55	60	65	70	75

3.3. TAGUCHI METHOD

3.3.1. Introduction

Taguchi method is a statistical method developed by Taguchi .And initially it was developed for improving the quality of goods manufactured (manufacturing process development), later its application was expanded to many other fields in Engineering, such as Biotechnology etc. Professional statisticians have acknowledged Taguchi‘s efforts especially in the development of designs for studying variation. Success in achieving the desired results involves a careful selection of process parameters and bi furcating them into control and noise factors. Selectionof control factors must be made such that it nullifies the effect of noise factors. Taguchi Methodinvolves identification of proper control factors to obtain the optimum results of the process. Orthogonal Arrays (OA) are used to conduct a set of experiments. Results of these experiments are used to analyses the data and predict the quality of components produced. Here, an attempt has been made to demonstrate the application of Taguchi‘s Method to improve the surface finish characteristics of faced components that were processed on a lathe machine. Surface roughness is a measure of the smoothness of a products surface and it is a factor that has a high influence on the manufacturing cost. Surface finish also affects the life of any product andhence it is desirable to obtain higher grades of surface finish at minimum cost.

3.3.2 Selection of Orthogonal Array

To select an appropriate orthogonal array for conducting the experiments, the degrees of freedom are to be computed. The same is given below: Degrees of Freedom: 1 for Mean Value and 8= (2x4), two each for the remaining factors Total Degrees of Freedom: 9 The most suitable orthogonal array for experimentation is L9 array as shown in Table 4.3. Therefore, a total nine experiments are to be carried out.

Table 3.7 Orthogonal Array (OA) L9

Experiment no.	IP	TON	DC	% of Ni	
1	1	1	1	1	
2	1	2	2	2	
3	1	3	3	3	
4	2	1	3	3	
5	2	2	1	1	
6	2	3	2	2	
7	3	1	2	2	
8	3	2	3	3	
9	3	3	1	1	

In this Taguchi method the design parameter are selected on the following method.

DC=TON /(TON+TOFF).

By using Orthogonal Array (OA) L9 we make the process parameters with levels which isgiven below in the table 3.6

Table 3.8:- The process parameters with levels.

Factors	Units	Levels		
0	1	2		
Discharge	A	5	6	7
Current				
Pulse-on time	(μs)	270	320	370
Duty cycle		0.75	0.78	0.81
% of Ni		15	2	25

Table 3.9:- The parameters filled in orthogonal array should look like this

Experiment no.	IP	TON	DC	% of Ni
1	4	45	0.75	15
2	4	50	0.78	20
3	4	55	0.81	25
4	5	45	0.81	25
5	5	50	0.75	15
6	5	55	0.78	20
7	6	45	0.78	20
8	6	50	0.81	25
9	6	55	0.75	15

Fig. 3.2:- Experimental Setup

4. RESULT AND DISCUSSION

4.1. Experimentation on EDM with EDM oil as Di-Electric fluid Medium

Die sinking EDM experiments have been carried out on EDM machine (Model Spark nix,India). In all the experiment, Nickel reinforced aluminum composites of 8% composition of Nickel powder used because its tensile strength and hardness value was better than other two composites. In all the experiments, EDM oil has been used as dielectric medium. Total 18 experiments have been performed using CCRD with independent variables at 5 different levels. Machining time for each work piece in the experiments has been kept 60 minutes.

After EDM, Nickel reinforced aluminum composites (8%) samples have been cleaned with acetone. A high precision electronic weighing balance with least count 0.01 mg has been used to measure the weight loss of work piece and electrodes after each experiment. The surface finish after machining was measured using Talysurf 6 (Rank Taylor Hobson, England). Atraverse length of 3 mm with a cut-off evaluation length of 2 mm was used. The Centre line average value of the surface roughness (SR) is the most widely used surface roughness parameter in industry, was selected in this study. Each sample was measured three times and the average was taken as the response. Measurement of out of roundness of the electrode was performed before and after machining so as to determine the actual change in the shape of the electrode. This measurement was performed on Carl Zeiss Coordinate Measuring Machine and Calypso software. The change in roundness of the tool has been considered as the response in the study torepresent the shape of the tool.

MRR has been defined, as the ratio of the wear weight of work piece to the machining time.

$$\text{MRR} = \frac{\text{(Initial Volume – Final Volume)}}{\text{Time taken during turning}}$$

Table 4.1: Design for Experiments

Exp. No	IP	TON	DC	%Ni	MMR	SR
1	4	270	0.75	15	.0266	1.3945
2	4	320	0.78	20	.0385	1.2435
3	4	370	0.81	25	.0695	1.5898
4	5	270	0.78	25	.0573	1.896
5	5	320	0.81	15	.0411	0.9578
6	5	370	0.75	20	.1120	1.7356
7	6	270	0.81	20	.1266	1.9486
8	6	320	0.75	25	.1130	2.0236
9	6	370	0.78	15	.1331	2.0856

4.2. Analyzing Experimental data for MRR

Conducting three trails for each experiment, the data below was collected. Compute the SN ratio for each experiment for the target value case, create a response chart, and determine the parameters that have the highest and lowest effect on the processor yield.

Table 4.2:- Experimental data

Exp. No.	IP	TON	DC	%AL2O3	TRIAL 1	TRAIL 2	MEAN
1	4	270	0.75	15	0.0276	0.0257	0.0266
2	4	320	0.78	20	0.0425	0.0346	0.0385
3	4	370	0.81	25	0.0612	0.0781	0.0696
4	5	270	0.78	25	0.0339	0.0807	0.0573
5	5	320	0.81	15	0.0459	0.0363	0.0411
6	5	370	0.75	20	0.0857	0.1384	0.1120
7	6	270	0.81	20	0.1176	0.1357	0.1266
8	6	320	0.75	25	0.0625	0.1636	0.1130
9	6	370	0.78	15	0.1538	0.1125	0.1331

Shown below is the calculation and tabulation of the SN ratio. $Sm1 = (0.0269+0.0257)^2 \div 2 = 0.001383$

$St1 = (0.0269)^2 + (0.0257)^2 = .6677$

$Se1 = St1 - Sm1 = .6535$ $Ve1 = Se1 / (N-1) = .06535$

$SN1 = 10\log(1/N)(Sm1-Ve1)$

Ve1
SN1 = .00418
Similarly, SN2 = .00147
SN3 = .00478
SN5 = .00166
SN6 = .01186
SN7 = .01596
SN8 = .01022
SN9 = .01729

Table 4.3: Trial table

Exp.	IP	TON	DC	%Ni	TRIAL	TRAIL 2	MEAN	SN
No.					1			
1	1	1	1	1	0.0276	0.0257	0.02665	.00418
2	1	2	2	2	0.0425	0.0346	0.03855	.00147
3	1	3	3	3	0.0612	0.0781	0.06965	.00478
4	2	1	2	3	0.0339	0.0807	0.0573	.00273
5	2	2	3	1	0.0459	0.0363	0.0411	.00166
6	2	3	1	2	0.0857	0.1384	0.1120	.01186
7	3	1	3	2	0.1157	0.1357	0.1266	.01596
8	3	2	1	3	0.0625	0.1636	0.1130	.01022
9	3	3	2	1	0.1538	0.1125	0.1331	.01729

Shown below is the response table. This table was created by calculating an average SN valuefor each factor

Table 4.4: Response table

Exp. No.	IP	TON	DC	%Ni	SN
1	1	1	1	1	.00418
2	1	2	2	2	.00147
3	1	3	3	3	.00478
4	2	1	2	3	.00273
5	2	2	3	1	.00166
6	2	3	1	2	.01186
7	3	1	3	2	.01596
8	3	2	1	3	.01022
9	3	3	2	1	.01729

A sample calculation is shown for Factor IP (Discharge current). SN1= (.00418+.00147+.00478)/3 = .003476
SN2= (.00273+.00166+.01186)/3 = .00541SN3= (.01596+.01022+.01729)/3 =.01449
The effect of this factor is then calculated by determining the range:
=Max-Min=.01449-.00347=.01102

Table 4.5:-Confirmation Experiment of MRR

LEVEL	%Ni	DC	TON	IP
1	17.28	13.65	16.25	.00347
2	16.07	17.89	13.14	.00541
3	14.69	16.50	18.65	.01449
	2.58	4.24	5.51	.01102
Rank	4	3	2	1

It can be seen that % Ni has the largest effect on the processor yield and that impulse current has the smallest effect on the processor yield. Due to increases the %Ni and material removalrate increases. Due to the vibrational effect of tool and on increases the %Ni the abrasive particle provide better effect.

4.3. Analyzing Experimental data for SR

Conducting three trails for each experiment, the data below was collected. Compute the SN ratio for each experiment for the target value case, create a response chart, and determine the parameters that have the highest and lowest effect on the processor yield.

Table 4.6: Table for conducting three trails

Exp.	IP	TON	DC	%Ni	TRIAL	TRAIL	MEAN
No.					1	2	
1	4	270	0.75	15	1.494	1.140	1.317
2	4	320	0.78	20	1.163	1.237	1.200
3	4	370	0.81	25	1.869	1.719	1.794
4	5	270	0.78	25	1.475	1.595	1.535
5	5	320	0.81	15	1.697	1.877	1.787
6	5	370	0.75	20	1.125	0.965	1.045
7	6	270	0.81	20	1.866	1.910	1.888
8	6	320	0.75	25	1.023	1.303	1.163
9	6	370	0.78	15	1.754	1.785	1.769

Shown below is the calculation and tabulation of the SN ratio.$Sm1 = (1.494+1.140)^2 \div 2 = 3.4689$

$St1 = 1.494^2+1.140^2 = 3.5316$

$Se1 = St1 - Sm1 = .06273$ $Ve1 = Se1 / (N-1) = 0.06273$

SN1= 10 log (1/N)(Sm1-Ve1)

Ve1

SN1 = 10.25

Similarly, SN2 = 12.45

SN3 = 24.88

SN4 = 9.33

SN5 = 17.93

SN6 = 15.96

SN7 = 16.19

SN8 = 10.53
SN9 = 19.49

Table 4.7: Table for SN value

Exp. No.	IP	TON	DC	%Ni	TRIAL 1	TRAIL 2	MEAN	SN
1	1	1	1	1	1.494	1.140	1.317	10.25
2	1	2	2	2	1.163	0.237	1.200	12.45
3	1	3	3	3	1.863	1.719	1.794	24.88
4	2	1	2	3	0. 475	0.595	0.535	9.33
5	2	2	3	1	1.697	1.877	1.787	17.93
6	2	3	1	2	1.125	0.965	1.045	15.96
7	3	1	3	2	1.866	1.910	1.888	16.19
8	3	2	1	3	1.023	1.303	1.163	10.53
9	3	3	2	1	1.754	1.785	1.769	19.49

Shown below is the response table. This table was created by calculating an average SNvalue for each factor.

Table 4.8: Response table created by an average SN Value for each factor

Exp. No.	IP	TON	DC	%Ni	SN
1	1	1	1	1	10.25
2	1	2	2	2	12.45
3	1	3	3	3	24.88
4	2	1	2	3	9.33
5	2	2	3	1	17.93
6	2	3	1	2	15.96
7	3	1	3	2	16.19
8	3	2	1	3	10.53
9	3	3	2	1	19.49

A sample calculation is shown for Factor IP (Discharge current).SN1= (10.25+12.45=24.88)/3 =18.36 SN2= (9.33+17.93+15.96)/3 = 14.40 SN3= (16.19+10.53+19.49)/3 = 15.40
The effect of this factor is then calculated by determining the range:
=Max-Min=18.36-14.40= 3.96

Table 4.9: -Confirmation Experiment of SR

LEVEL				
	%Ni	IP	DC	TON
1	18.39	18.36	14.34	14.42
2	14.86	14.40	13.75	13.63
3	14.91	15.40	19.66	20.11
	3.53	3.96	5.91	6.48
Rank	4	3	2	1

It can be seen that %Ni has the largest effect on the processor yield and that Pulse ON Time has the smallest effect on the processor yield. Due to the increase of abrasive particle provide better cleaning cutting of piece.

5. CONCLUSIONS AND FUTURE SCOPE

5.1. CONCLUSION

- In this work, EDM has been successfully performed on nickel reinforced aluminum composite material. Statistical models have been developed for predicting MRR and SR in EDM by correlating the input parameters, namely, discharge current, pulse-on time, duty cycle, and % of Ni. In EDM process, significant parameters have been identified and Taguchi was used to establish the adequacy of the model.
- It has been observed that MRR is significantly affected by discharge current, pulse-on time and duty cycle. It has been found that MRR increases with the increase in discharge current. It is also observed that MRR decreases with the increase in pulse-on time initially but after a certain value of pulse-on time, MRR increases. MRR is found to be increasing with an increase in the duty cycle. The second order model developed for SR is statistically significant. It has been observed that discharge current and pulse-on time are significant parameters affecting SR. It has been observed that SR increases with increase in discharge current. An increase in pulse-on time increases the SR.

5.2. SCOPE FOR THE FUTURE WORK

The work presented in this thesis may be extended further in the following ways:

- In place of Nickel reinforced Aluminum composite, investigate another composite such as AL Sic, Silicon Carbide (SiC), Silicon Nitride (Si_3N_4), etc. on EDM with different types of di- electric fluids.
- We use dielectric fluid in place of Silicon oil and the MRR because due to the abrasive particle it provides better cleaning of cutting pieces. This process we will study in our future investigation.
- We also think how to improve the MRR then we decided to design and construct the Rotational types electrode holder, this types of holder arrangement we are construct and also check it .at the same times the MRR is increases more due to vibration effect .and surface finishing is not affected more but it is also maintained that.

REFRENCES

[1] Lokesh Upadhyay, Puneet Bansal, " Experimetal Ivestigation To Study Tool Wear During Turning of Alumina Reiforced Aluminium Composites". SciVerse ScienceDirect, Procedia Engineering 51 (2013) 818-827.

[2] Lokesh Upadhyay, Puneet Bansal, " Effect of Turning Parameter on Tool Wear, Surface Roughness and Metal Removal Rate of Aluminium Reinforced Aluminium Composite". ScienceDirect, Procedia Technology 23 (2016) 304-310.

[3] Mohan Kumar Pradhan, Chandan Kumar Biswas, 2008, "Modelling of machining parameters for MRR in EDM using response surface methodology". Proceedings of NCMSTA'08 Conference.

[4] Royata Toshimitsu, Akira Okada, Ryoji Kitada and Yasuhiro Okamoto, 18th CIRP Conference on Electro Physical and Chemical Machining (ISEM XVIII), Procedia CIRP 4(2016) 231-235.

[5] Khalid Hussain Syed, Kuppan Palaiyandi, "Performance of electric discharge machining using aluminium powder suspended distilled water", journal of Turkish J. Eng. Env. Sci. 36(2012), 195-207.

[6] Gurjeet Singh, Paramjit Singh, Gaurav Tejpal, Baljinder Singh, "Effect of machining parameters on surface roughness of H13 steel I EDM process using powder mixed fluid" , International Journal of Advace Egieerig Research and Studies, E-ISSN2249-8947.

[7] Marek Rozeek, Jerzy Kozak and Lucja Dabrowski, Warsaw University of Technnology, POLAND, "Electrical Discharge Machining I Dielectric Powder Media".

[8] M.K. Pradhan and C.K.Biswas, "Modelling and Analysis of process parameters on Surface Roughness in EDM of AISI D2 tool Steel by RSM approach", World Academy of Science , Engineering and Technology 33 2009.

[9] Narlianan Mohd. Abbas, Darius G. Solomon, Md. Faud Bahari, "A review o current research trends in EDM", Iternational Journal of Machine Tools and Manufacture 47(2007) 1214-1228.

[10] H.K.Kansal, Sehijpal Singh, Pradeep Kumar, " Numerical Simulatio of Powder Mixed EDM(PMEDM) using finite element methods"' Science Direct, Mathematical and Computer Modellig 47(2008)1217-1237.

[10] M. Kiyak, O. Cakir," Examination of machining parameters o surface roughness in EDM toolsteel", Journal of Materials Processing Techology 191(2007) 141-144.

[11] S.M. Afazou, D Zbedski, S.M. Ratchev, J. Sehgal,S.Liu," Effect of micro- milling conditions on the cutting forces and process stability", Journal of Materials Processing Technology 213(2013) 671-684.

[12] H.K. Kansal, Sehijpal Singh, Pradeep Kumar, "Effect of Silicon Powdered Mixed EDM on Machining Rateof AISI D2 Die Steel", Journal of Manufacturing Processes Vol. 91 No.1 (2007).

[13] J. Kenda, F. Pusavec, G.Kermouche, J.Kopac," Surface Integrity in Abrasive Flow Machining of Hardened Tool Steel AISI D2"' SciVerse Science Direct Procedia Engineering 19(2011) 172-177.

[14] "L.Liquing, S. Yingjie," Study of Dry EDM with oxygen mixed and cryogenic cooling approaches", Science Direct Procedia CIRP6 (2013) 344-350.

[15] "Experimental Investigation on Sinking EDM of Seal Slots I Gamma-TiAl", by F. Kolke, MHolsten,

[16] L. Hengen, A. Klink, Science Direct Procedia CIRP 24(2014) 92-96.

[17] "Analysis of MRR and SR with different electrodes for SS 316 o Die Sinking EDM using Taguchi Technique", by Suraj Chaudhary, Krishan Kant and Pravi Saini, Global Journals of Research I Engineering Issue3 Version 1.0(2013).

[18] Bikramjeet Singh, Chandan Deep Sigh, Jasvinder Singh. " Improving the Process Capabilities of EDM", IJETCAS.

[19] S.H.Tomadi, M.A.Hassen, Zhamedon, IAENG R.Daud, A.G.Khalid, "Aalysis of the Influence of EDM Parameters on Surface Parameters o Surface Quality Material Removal Rate Electrode Wear of Tunsten carbide", IMECS, March 18-20 2009, HongKong.