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EXPERIMENTAL STUDY AND THERMAL MODEL DEVELOPMENT OF DRY PROCESS

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Abstract - The principle of dry and near dry EDM process and its applications is discussed briefly in preceding content. In this content, making of experimental setup is discussed broadly since it required to make extra attachment to the conventional EDM for DEDM and NDEDM process. Each attachment and its function are discussed briefly since which effects on performance of EDM and it reflects during measurement of response variable.

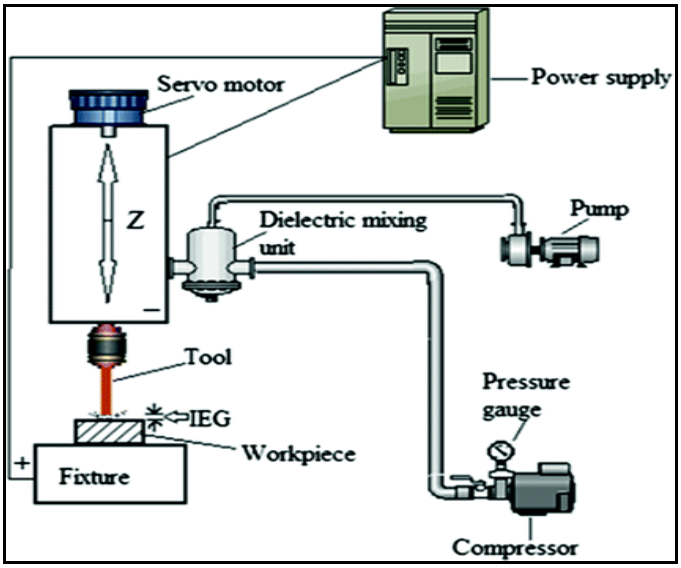
Key Words: Dry Process, EDM, Manufacturing, Electrodes, Control Unit, Lubrication.

1.INTRODUCTION

- The important aspect is that they satisfy the demands of today's industry, but the major problem is that it is very difficult to machine the newly developed materials. So, in order to manipulate them, newer machining methods have been developed.

- These methods are more efficient than the conventional ones. Electric discharge machining (EDM) is one of the most widely used methods among the new techniques. EDM has been employed to effect/change the surface properties such as roughness and hardness of the material By Varying the EDM process such as conventional EDM, dry EDM, and PMEDM Research in the process of PMEDM is going on since last 20 years but still the process is in laboratories, it is not being used for commercial applications.

- Secondly major application of EDM is for manufacturing dies. In dies surface quality is the most important factor as it reduces the machining allowances to be kept on the components manufacturing usin9g that die.



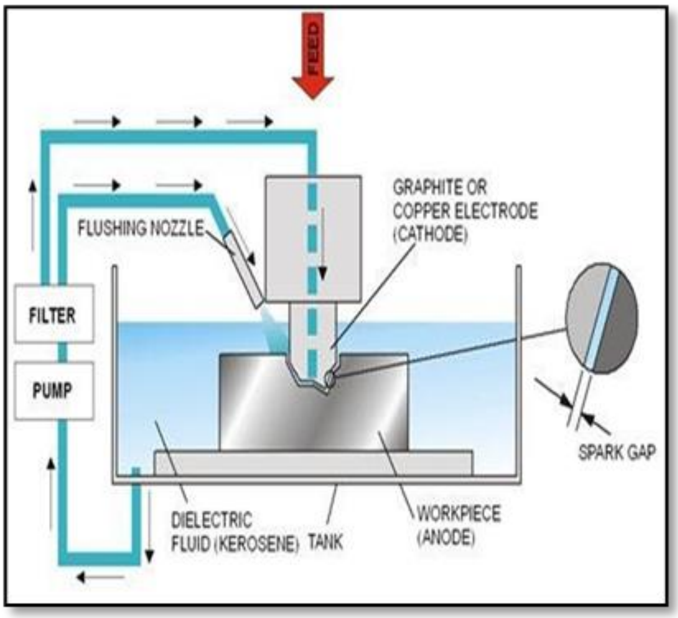
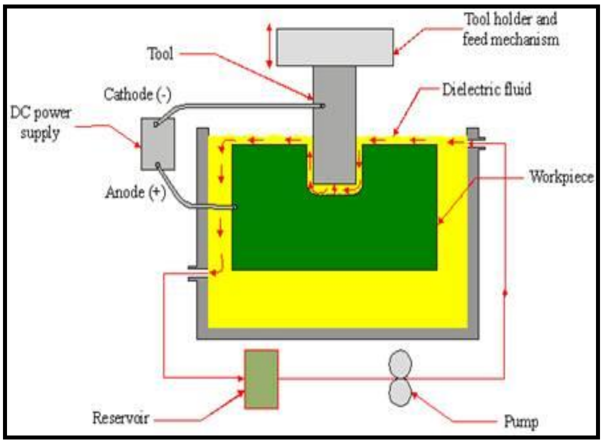
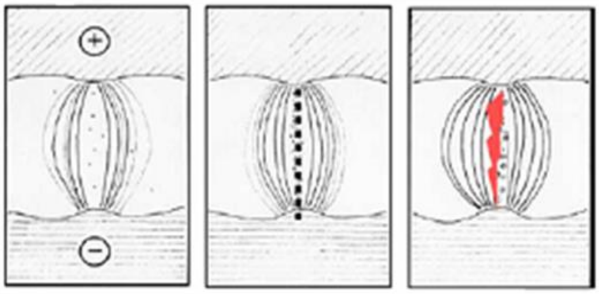


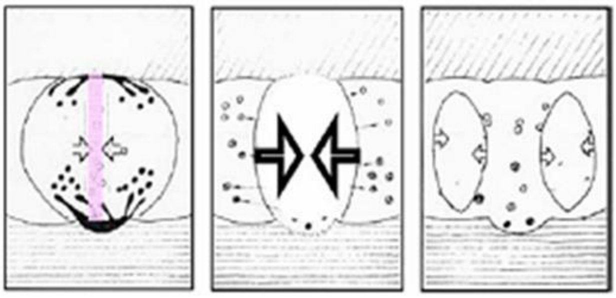
Fig: Electric Discharge Machine

Properties Medium	Thermal Conductivity	Specific heat capacity	Dielectric Strength	Dynamic Viscosity	Density
	W/m-K	J/g-K	(MV/m)	g/m-s	g/L
Kerosene	0.149	2.16	14-22	1.64	0.82
Deionized water	0.606	4.19	13	0.92	1
Air	0.026	1.04	3	0.019	1.2
Oxygen gas	0.026	0.92	-	0.019	1.429

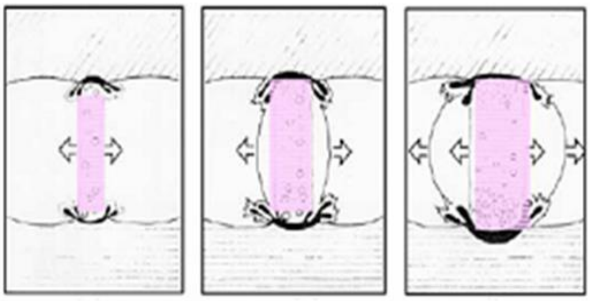




Phases of a Discharge during EDM: Preparation Phase



Phases of Discharge during EDM: Interval Phase



Phases of Discharge during EDM: Discharge Phase

Taguchi Method-Based Design of Experiments

One simple and well-known method for optimization is trial and error approach. This method has a simple concept but is not practical for the complex systems with many parameters. In order to solve the problem, Taguchi's method was developed based on the concept of the orthogonal arrays (OA), which can significantly reduce the number of trials required in an optimization procedure. It is the one of the most powerful DoE methods for analyzing of experiments. It is regarded as the foremost proponent of robust parameter design, which is an engineering method for product or process design that focuses on minimizing variation and / or sensitivity to noise. When used properly, Taguchi designs provide a powerful and efficient method for designing products that operate consistently and optimally over a variety of conditions. In robust parameter design, the primary goal is to find factor settings that minimize response variation, while adjusting (or keeping) the process on target. When the factors affecting variation have been determined, it could be used to find settings for controllable factors that will either reduce the variation, make the product insensitive to changes in uncontrollable (noise) factors, or both. It is widely recognized in many fields particularly in development of new products and processes in quality control.

Taguchi method- based design of experiments involved following steps.

Definition of the problem

A brief statement of the problem under investigation is "Experimental investigation of dry and near dry EDM process"

Identification of the noise factors

The environment in which experiments are performed is the main external source of variation of performance of EDM process. Some examples of the environmental noise factors are temperature, vibrations and human error in operating the process.

Selection of the response variables

In any process, the response variables need to be chosen so that they provide useful information about the performance of the process under study. The response variables chosen for study are SR, heat affected zone, Micro hardness and metal recast layer by visual inspection.

Selection of the process parameters and their levels

The process parameters can be divided in to two categories i.e., electrical and non-electrical parameters {refer figure}. Major electrical parameters are gap voltage, peak current and pulse on time. Non electrical EDM process parameter is air pressure.

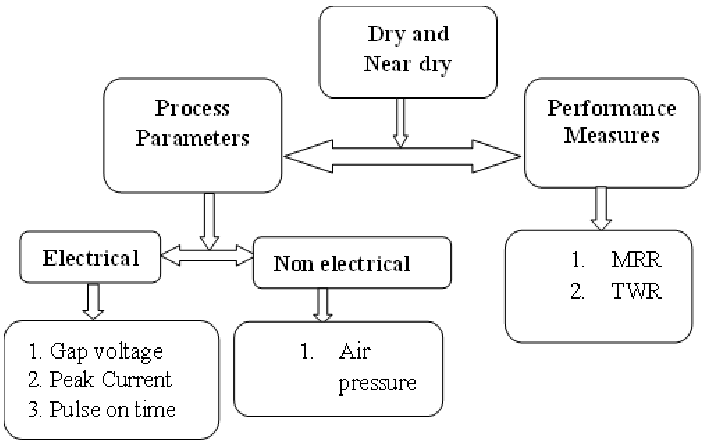


Figure: Process Parameters and Performance Measures

Collection of Electrodes after Dry EDM Process.

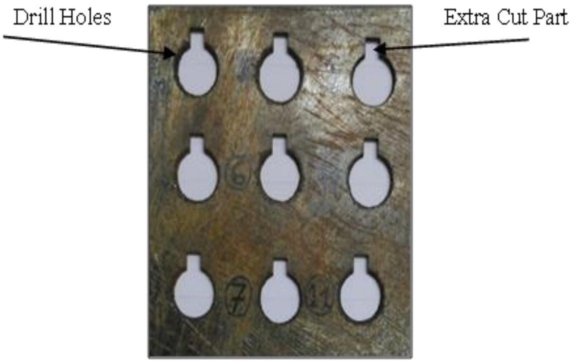


Figure: Dry EDM Machined Plate

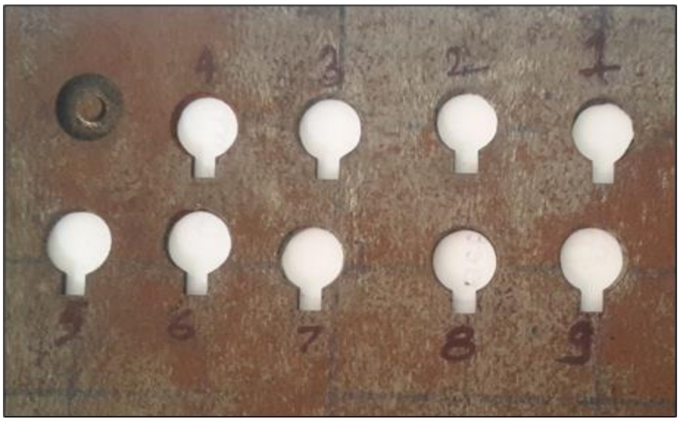
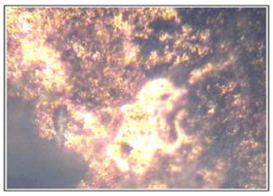
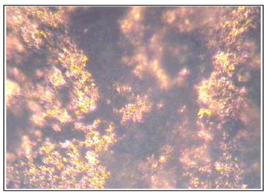


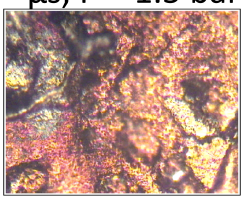
Figure: Near dry EDM Machined Plat



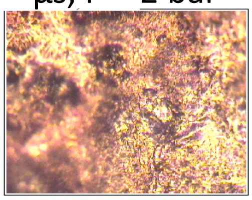
I = 15 A, POT = 200 µs, P = 1.5 bar



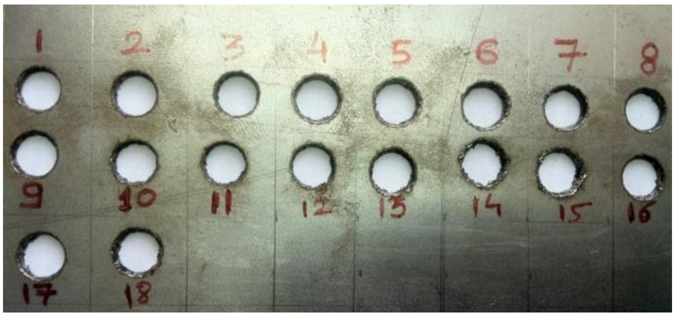
I = 15 A, POT = 200 µs, P = 2 bar



I = 16 A, POT = 50 µs, P = 1.5 bar



I = 16 A, POT = 50 µs, P = 1 bar



Drills as per L_{18} orthogonal array by Dry EDM.

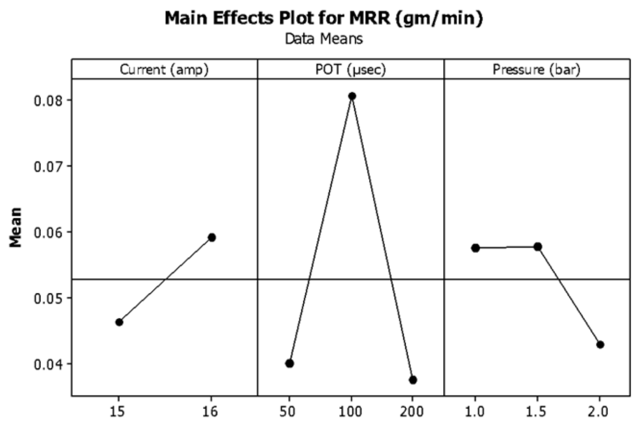
Expt.no.	Current	POT (µs)	Pressure (bar)	MRR (gm/min)	TWR (gm/min)	SRµmRa
1	15	50	1	0.0392	0.0000	3.2
2	15	50	1.5	0.0205	0.0000	4.2
3	15	50	2	0.0270	0.0000	3.6
4	15	100	1	0.0588	0.0000	4.6
5	15	100	1.5	0.0632	0.0000	4
6	15	100	2	0.0698	0.0000	3.6
7	15	200	1	0.0542	-0.0005	4.6
8	15	200	1.5	0.0623	-0.0011	3.6
9	15	200	2	0.0231	-0.0017	3.8
10	16	50	1	0.0484	0.0012	4.6
11	16	50	1.5	0.0335	0.0011	4.8
12	16	50	2	0.0718	0.0012	5.2
13	16	100	1	0.0757	0.0013	3.8
14	16	100	1.5	0.1080	0.0022	4.4
15	16	100	2	0.1092	0.0022	4.6
16	16	200	1	0.0249	0.0000	4.2
17	16	200	1.5	0.0209	0.0000	4.4
18	16	200	2	0.0408	0.0000	4.4

Table: Experimental L_{18} Orthogonal Array for Final Experiments.

Workpiece material	**: Mild Steel.**
Tool type	: Electrode (Copper).
Dielectric	: Oxygen gas.
Design of Experiments	: Taguchi method.

ANOVA for Material Removal Rate (MRR):

ANOVA (Analysis of Variance) for MRR has given in Table. From ANOVA table we found that, pulse on time is most significant parameter for the higher material removal rate at 99% confidence level. We can say that current also a significant parameter for higher material removal rate at 80% confidence level. The remaining parameter, dielectric pressure (oxygen gas pressure) is non-significant parameter for material removal rate.



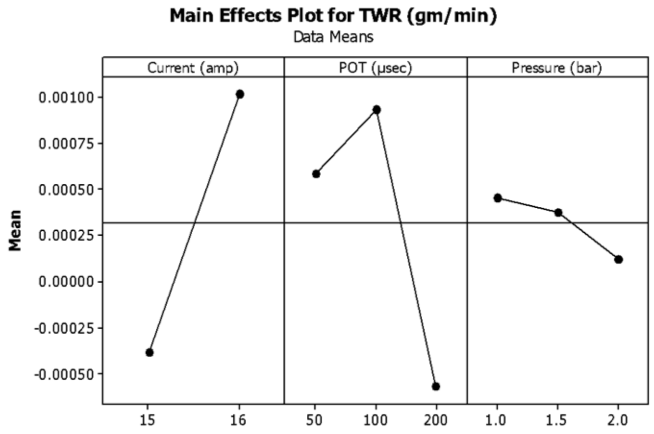
Source	DF	SS	MS	F ratio	P value	Contribution (%)
Current	1	0.0007361	0.0007361	2.15	0.168	5.77
POT (µsec)	2	0.0070405	0.0035203	10.29	0.002	55.24
Pressure(bar)	2	0.0008632	0.0004316	1.26	0.318	6.77
Error	12	0.0041034	0.0003419			32.20
Total	17	0.0127433				

S=0.0184919 R-Sq=67.80% R-Sq(adj)=54.38%

ANOVA for MRR

ANOVA for Tool Wear Rate (TWR):

ANOVA for TWR is given in Table. From the results we found that, current and pulse on time are most significant parameter for TWR but remaining parameter dielectric pressure is non-significant parameter for TWR



Source	DF	SS	MS	F ratio	P value	Contribution (%)
Current	1	0.0000087	0.0000087	74.00	0.000	48.60
POT (µsec)	2	0.0000074	0.0000037	31.45	0.000	41.34
Pressure(bar)	2	0.0000004	0.0000002	1.52	0.257	2.23
Error	12	0.0000014	0.0000001			7.82
Total	17	0.0000179				

S=0.000343329 R-Sq=92.10% R-Sq(adj)=88.81%

ANOVA for TWR

The experimentation is performed for dry EDM process using compressed air as dielectric medium. The experimental working phase is shown. The experimentation for DEDM is carried out to drill holes on spring steel material. The DoE of process parameters are shown. In case of dry EDM only compressed air is passed through the hollow electrode with a pressure of 0.5, 1 and 1.5 bar.

Figure: Working phase

Working tank with work holding device:

The working tank and fixture for holding the workpiece is shown in fig. All the distilled water is kept in the working tank and which is used to supply the fluid during the process of machining. The minimum quantity lubrication (MQL) is connected with tank which makes the mist flow of dielectric for use of near dry EDM process. The fixture is also shown which holds the workpiece properly. The working tank is mounted on table which reciprocates in X-Y direction this movement is provided manually.

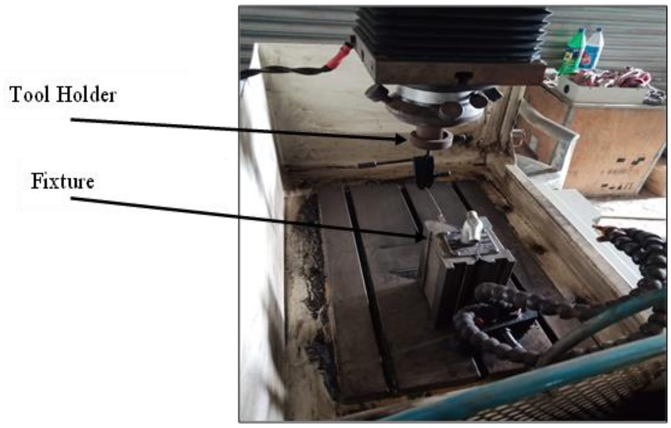
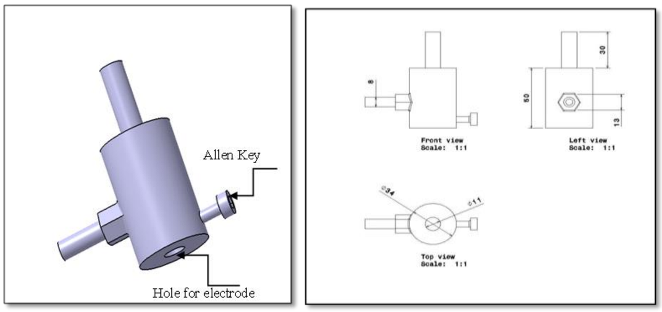


Figure: Tank and fixture

Tool holder modelling & details

To hold the tool and provide the leak free entry of mist flow and gas from MQL to workpiece is a function of the tool holder. It is an important part of external attachments of machine. The tool holder is a hollow cylindrical part and it is fitted in collet chuck of spindle. To fit the electrode, tool holder has internal threads and the tool as external threads so they are tight with each other.



(a) (b)

Figure: (a) Modelling of Tool Holder and (b) Drawing of Tool Holder

PROPOSED WORK:

In current research work following are the objectives:

I. To study the effect of the surface properties with respect to dry EDM.
II. To study the effect of dry EDM on MRR as well as TWR.
III. Simulation of experimental result.

OBJECTIVE:

1. Development of dry EDM setup.
2. Identification of response variables such as tool wear rate (TWR) material removal rate (MRR).
3. Analysis of response variables using Minitab software.
4. Optimization of multiple response variables using Grey relational analysis.

METHODOLOGY:

In order to fulfill the objectives, following methodology is adopted:

Phase I: Data collection regarding to the dry EDM.
Phase II: The current work aims to develop dry EDM setup.
Phase III: The parametric analysis will be taken place by conducting a set of experiments using oxygen gas as a dielectric.
Phase IV: Design of experiments using Taguchi method.
Phase V: Analysis of response variables And Optimization of multiple response variables using GRA.

POSSIBLE OUTCOMES:

1. It satisfactory shows the improvement in surface roughness (SR).
2. It shows the lower tool wear rate (TWR) in machining processes
3. Improvement in MRR and Optimized TWR.
4. Improvement in surface quality and topography.
5. Improvement in Production Rate.

CONCLUSIONS AND FUTURE SCOPE:

Present dissertation work has performed for drilling operation by dry EDM process. The experiments were performed using Taguchi method of design of experiments. Analysis was carried out using Minitab16 software. The final experiments were performed on bright mild steel work material, for three response variables such as MRR, TWR and SR. Three process parameters were selected such as current, pulse on time and dielectric pressure.

In this work, experimental evaluation of dry electrical discharge drilling was carried out. This study has revealed various characteristics of dry EDM process by measurement of MRR, TWR and SR.

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