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Obtaining the Output Parameters for Different Powder Concentrationin PMEDM

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Abstract:*Now-a-days many industries are working to find out the best metal alloys to obtain the optimized outputs for their products all the time. Out of all the available, Titanium alloy is one which is extensively used in many industrial applications because of its positive characteristics like corrosive resistance, fracture resistance and high strength to weight ratio and so on. It is quite necessary to know the better concentration of powder concentration which is to be mixed in the dielectric fluid when working on the aluminium alloy before going to fix the values in the levels of the parameter. In this paper more than 30 trails were performed to determine MRR, SR and TWR.*

Keywords-MRR, SR, TWR, PM-EDM & PC

I. INTRODUCTION

PMEDM is the advanced type of usage of the conventional EDM. In Powder Mixed EDM suitable material in the powder form will be mixed into the dielectric fluid in tank. For better circulation of the dielectric fluid a stirring system is used. The constant reuse of powder in the dielectric fluid can be done by the special circulation system. Various powders of particle can be added into the dielectric fluid. spark gap provided by the additives particles. The powder particles of the material get energized & behave like a zigzag way manner. under the sparking zone, the particles of the material powder comes close to each other & arrange themselves in the form of chain like structure between the workpiece surface & tool electrode. The interlocking between the different powder particles occurs in the direction of flow current. The chain formation helps in bridging the discharge gap between the electrodes. Because of bridging effect, the insulating strength of the dielectric fluid decreases resulting in easy short circuit. This causes early explosion in the gap and series discharge' starts under the electrode area.

II. WORKING PRINCIPAL

When voltage is applied the powder particles become energized and behave in a zigzag fashion. These charged particles are accelerated due to the electric field and act as conductors promoting breakdown in the gap. This increases the spark gap between tool and the work piece. Under the sparking area, these particles come close to each other and arrange themselves in the form of chain like structures. The interlocking between the powder particles occurs in the direction of flow of current. The chain formation helps in bridging the discharge gap between the electrodes. Because of bridging effect, the insulating strength of the dielectric fluid decreases resulting in easy short circuit. This causes early explosion in the gap and series discharge' starts under the electrode area. The faster sparking within a discharge causes faster erosion from the work piece surface and hence the material removal rate increases.

III. PARAMETERS

Parameters of this machine are mainly classified into two categories i.e. Process Parameters &Performance Parameters

Process Parameters: The process parameters in EDM are used to control the performance measures of the machining process. Process parameters are generally controllable machining input factors that determine the conditions in which machining is carried out. These machining conditions will affect the process performance result, which are gauged using various performance measures.

Electrical Parameters

Polarity: Polarity of the electrode can be either positive or negative

Supply voltage: The input voltage applied across the tool electrode and workpiece is called the supply or open circuit voltage.

Discharge voltage: This is the electrical energy that is available for material removal. The magnitude of Em is calculated from measured pulse on time, discharge voltage and discharge current values.

Discharge Current: The discharge current is a measure of the amount of electrical charges flowing between the tool and workpiece electrode. As the flow of electrical charges is the heating mechanism in electro-thermal erosion,
Gap Voltage: The pre-set gap-voltage determines the width of the spark gap between the leading edge of the electrode and the workpiece. High voltage settings increase the gap and hence the flushing and machining. However when using graphite electrodes, high open gap voltage drastically increases the electrode wear.
Peak Current: This is the amount of power used in discharge machining, measured in units of amperage, and is the most important machining parameter in EDM.During each on-time pulse, the current increases until it reaches a pre-set level, which is expressed as the peak current. In both die-sinking and wire-EDM applications, the maximum amount of amperage is governed by the surface area of the cut. Higher amperage is used in roughing operations and in cavities or details with large surface areas. Higher currents will improve MRR, but at the cost of surface finish and tool wear. This is all more important in EDM because the machined cavity is a replica of tool electrode and excessive wear will hamper the accuracy of machining.
Average Current: Peak current is the maximum current available for each pulse from the power supply/generator. Average current is the average of the amperage in the spark gap measured over a complete cycle. It is calculated by multiplying peak current by duty factor.
Pulse on Time: The pulse on time represents the duration of discharge and is the time during which the electrode material is heated by the high temperature plasma channel. Material removal is directly proportional to the amount of energy applied during this on-time .A longer pulse on time will increase the discharge energy.
Pulse off time: The pulse off time represents the duration when no discharge exists and the dielectric is allowed to deionise and recover its insulating properties. A longer pulse off time improves machining stabilityas arcing is eliminated.
Pulse Frequency: Pulse frequency is the number of cycles produced across the gap in one second. The higher the frequency, finer is the surface finish that can be obtained.
Pulse waveform: The pulse shape is normally rectangular, but generators with other pulse shapes have also been developed.
Electrode Gap: It is the distance between the electrode and the part during the process of EDM. An electro-mechanical and hydraulic systems are used to respond to average gap voltage. To obtain good performance and gap stability a suitable gap should be maintained. For the reaction speed, it must obtain a high speed so that it can respond to short circuits or even open gap circuits. Gap width is not measured directly, but can be inferred from the average gap voltage.
Duty Factor: Duty factor is a percentage of the pulse duration relative to the total cycle time. Generally, a higher duty factor means increased cutting efficiency

Performance Parameters
These parameters measure the various process performances of EDM results. Performance parameters classified into following Categories.

1. Material removal Rate: The Material removal rate is expressed as the weight of material removed from work piece over a period of machining time in minutes
2. Tool wear Rate: The TWR is calculated by using the weight loss from the tool divided by the time of machining.
3. Relative Wear Ratio: WR is the ratio of TWR/MRR and is used as a performance measure for quantifying tool-work piece material combination pairs since different material combinations gives rise to different TWR and MRR values. A material combination pair with the lowest WR indicates that the tool-work piece material combination gives the optimal TWR and MRR condition. The relative wear ratio of the work piece and tool is expressed.
4. Surface Roughness: It is the classification of surface parameter used to describe an amplitude feature, which translates to roughness of the surface finish. Of the many parameters available to quantify SR, the most commonly used in EDM are arithmetical mean surface roughness, maximum peak-to valley surface roughness and root mean square surface roughness.
5. Surface quality: Surface quality is a broad performance measure used to describe the condition of the machined surface. It comprises components such as surface roughness, extent of heat affected zone, recast layer thickness and micro-crack density.
6. Heat affected Zone: It refers to the region of a work piece that did not melt during electrical discharge but has experienced a phase transformation, similar to that of heat treatment processes, after being subjected to the high temperatures of electrical discharge.
7. Recast layer Thickness: The recast layer refers to the region of re-solidified molten material occurring as the top most layer of the machined surface. The recast layer is usually located above the heat affected zone.

IV. FUNCTIONS OF DI-ELECTRIC FLUID

The dielectric fluid in an EDM serves a number of functions. The dielectric oil acts as a medium through which controlled electrical discharges occur.Cool the section that was heated by the discharging effect. Flush the eroded particles from the machining gap. Provide insulation between the electrode and the workpiece. The dielectric oil acts as a medium used to carry away the solidified EDM debris from the discharge gap to thefilter system.The dielectric oil acts as a heat transfer medium to absorb and carry away the heat generated by the discharges from both the electrode and the workpiece

Types of dielectric fluid

Mineral Oils
Kerosene
Transformer Oil
EDM Oils
Synthetic oil

Properties & Characteristics of Dielectric Fluid

Viscosity is the property that describes a fluids resistance to flow.
The flash point for commonly used EDM dielectric oils ranges from 160º F to 255º F. Obviously for reasons of safety, the higher the flash point the better. The oil temperature at which ignition of the resulting vapor occurs is the Flash Point.
Oxidation Stability is a measure of the dielectric fluids tendency to react with oxygen.
Volatility is a measure of the tendency of a dielectric fluid to vaporize.
Acid Number is used to quantify the amount of acid present in a sample of dielectric oil.
Excessive levels of acid in dielectric oil could lead to corrosion in the dielectric system. The acid number is expressed in units of mg KOH/g, or the amount of Sodium Hydroxide necessary to neutralize the acid present in an oil sample.

V. LITERATURE SURVEY

KuldeepOjha a et (1)have worked on material removal rate (MRR) and tool wear rate (TWR) study on the powder mixed electrical discharge machining (PMEDM) of EN-8 steel and using Response surface methodology (RSM) analysed the experiments. Peak current, pulse on time, diameter of electrode and concentration of chromium powder added into dielectric fluid of EDM were chosen as process parameters to study the PMEDM performance in terms of MRR and TWR. Experiments have been performed on newly designed experimental setup developed in laboratory. Their research work adds valuable data regarding PMEDM process. They have ended by more work piece/ powder/ electrode materials/ experimental settings combinations are needed to be investigated further for much validation of the process.

M Prabuet (2) have done experimental investigation on effect of graphite powder suspended dielectric in electric in EDM of Al-TiB2 composites. The experiments were conducted on ELEKTRAPULS spark erosion machine. Their objective is to find the effect of parameters viz, current, pulse ON-time, flushing pressure and vibration As a result, the process becomes more stable thereby improving Material Removal Rate (MRR) and reducing Tool Wear Rate (TWR). The EDM set-up is used in their experimental study is M100 model die sinking EDM machine manufactured by Electronica Machine Tools. The Parameters and their settings are in L16 orthogonal array. It uses Kerosene as the dielectric fluid. TWR slightly increases with increasing the Current. When comparing the TWR of with powder and without powder the TWR obtained for with powder is found higher.

Shriram Y. Kaldhoneet (3) have studied the influence of operating parameters of tungsten carbide on the machining characteristics such as material removal rate. The effectiveness of PMEDM process with tungsten carbide, WC-Co is evaluated in terms of the material removal rate. They have observed that copper tungsten is most suitable for use as the tool electrode in EDM of WC-Co; better machining performance is obtained generally with the electrode as the negative and the work piece as positive. They have concluded that The MRR and TWR are mainly affected by the current and powder. With mixing of silicon carbide powder MRR can be increased by 90%. Current, Pulse on time, work piece material, Powder type and Flushing Pressure significantly affect MRR. The maximum MRR is produced at 8 g/l of SiC powder for Flushing pressure 1.5 Kg/cm2.

M. A. Razak et (4) have done experiments on improving EDM efficiency with silicon carbide powder mixed dielectric fluid PMEDM works gradually at low pulse energy and distributes evenly the powder in machining area. PMEDM may lead to improve machined part surface finish, improve material removal rate (MRR) and reduce tool wear rate (TWR). Further investigations on powder concentration and powder particles size for silicon carbide (SiC) PMEDM are proposed to conduct. Number of experiments were conducted is based on Taguchi orthogonal array with three level and two factors. The outcomes obtained were capable to increase MRR, improve surface finish, reduce TWR, reduce machining time and reduce machining cost. The objectives of their research work are: To investigate the influence of PMEDM in machining premium stainless mold steel material in terms of MRR, TWR and Ra. Their results have given information on: The influence of PMEDM in machining Stavax material in terms of MRR, TWR and Ra. The optimum powder concentration and size of powder particles to achieve the highest efficiency of EDM

G. Bharath Reddy et (5) presented the outcomes of an experimental analysis carried out to study the effect of micro-sized metal powders, when they are mixed to the dielectric fluid, during Electric Discharge Machining (EDM) of different steels. The work piece material, peak current, pulse on time, duty factor, gap voltage and mixing of fine metal powders(copper and aluminium) in dielectric fluid are taken as process input parameters. Material removal rate and Surface Roughness were taken as output parameters to measure the process efficiency. Powder Mixed EDM makes discharge collapse easier, increases the discharge gaps and expands the discharge channel, and finally forms uniformly distributed large and shallow craters on the work piece.

R.A.Prajapatiet (6) experimented the effect of Silicon Dioxide (SiO2) powder mixing into the dielectric fluid of EDM on machining characteristics of EN-8 with three input parameters Peak current, pulse on time and concentration of powder. Analysis was carried out for surface roughness. The result outcomes identified the important parameters and their effect on SR of En-8 in the presence of SiO2 in a kerosene dielectric of EDM. Analysis was showed that the peak current and pulse on time have higher contribution toward surface roughness. They have concluded that PMEDM is not preferable. Peak current and pulse on time are the most influential parameters for reducing surface quality. The optimum levels of various process parameters obtained in their experimental work are: Peak current = 9 A, Powder concentration = 0 g/lit and 25 µs pulse on time for better surface quality

VedParkashet (7) have conducted the experiments on the effect of powder mixed dielectric on tool wear rate (TWR) in EDM has been observed. Experiments were designed using Taguchi method and appropriate Orthogonal Array and experiments have been performed as per the set of experiments designed in the orthogonal array. Signal to Noise ratios are also calculated to analyze the effect of PMEDM more accurately. They have concluded that the PMEDM (Powder Mixed Electric Discharge Machining) has significant effect on the tool wear rate. The Tool Wear Rate is higher with Copper as an additive and less when Graphite is used in dielectric. As current is directly proportional to discharge energy and pulse on-time. With increase in current and pulse on-time, tool wear rate also increases.

Gurule N. B. et (8) experimented the effect of tool rotation on mrr during powder mixed EDM of die steel They have concluded that Current, on time, tool material, tool rpm and powder concentration significantly affect MRR. The suspension of Al powder into dielectric enhances MRR. The maximum MRR is produced at 4 g/l of Al powder, 900 tool rpm with Cu tool. Flushing shows least effect on MRR. Finally, it was concluded that Al powder and rotary tool have impact to great extent on the MRR of die steel. Their study shows future scope and potential for the improvements in the EDM field.

AbhishekAbrol et (9) studied the effect of chromium powder mixed dielectric fluid on machining characteristics of AISI D2 die steel has been studied. Peak current, pulse on time, pulse off time, concentration of powder are the process parameters. The process performance is measured in terms of material removal rate (MRR), tool wear rate (TWR) and surface roughness (SR). The research outcome will identify the important process parameters that maximize MRR, minimize TWR and SR. The design of experiment was undertaken using Taguchi method. Both the performance data show an increasing pattern with increase in current for any other parameter. Surface roughness is mainly affected by the pulse-off time as per the main effects plot for SR. Surface Roughness is higher with the increase in pulse-off time.

Nimo Singh Khundrakpamet (10) have studied the effect of polarity on Different EDM (EDM, Dry-EDM and Powder Mixed EDM) has been studied in different polarity and dielectric mediums. It was observed experimentally that increase in tool hole diameter increase Material Removal Rate (MRR) and Tool Wear Rate (TWR). Dry-EDM has negligible TWR. In reverse polarity MRR is very low except Dry-EDM. They have concluded that increase in tool hole diameter increase both MRR &TWR. The dry EDM gives negligible tool wear rate. Tool Hole Diameter has more effective on dry EDM in both the polarity. Their Experiment is more suggested to study different powder mixed to dielectric medium for better MRR and TWR.

Mahendra G. Rathiet (11) experimented the Effect of Powder Mixed dielectric in EDM of Inconel 718. The effect of various powder mixed in dielectric is studied input parameters like Duty cycles, current, pulse on time and powder media in that Silicon carbide, Aluminium oxide, Graphite powder used. An analysis of variance (ANOVA) is used to present the influence of process parameters on material removal rate, tool wear rate. Results obtained by Taguchi method and by ANOVA method, are compared and found that they match closely with each other. As the MRR is depends mostly on current. Current carrying capacity of any material depends on it electric conductivity. Here Graphite is having highest electric conductivity than Aluminium oxide and Silicon carbide and therefore MRR is higher in case of Graphite powder.

MarekRozeneket (12) The EDM characteristics obtained using hydrocarbon dielectric (kerosene) and mixture deionized water with abrasive powder have been compared. The relationship between surface roughness parameters, material removal rate and operating parameters of EDM have been determined for different kind of powder and its concentration in kerosene/water. The investigation results were showed that there are chances for replacing the conventional dielectric with water and that would imply considerable economic and ecology advantages. The investigation results were showed that there are chances for replacing the conventional dielectric with powder suspended deionized water and that would imply considerable economic and ecology advantages.

B Govindharajanet (13) focused on performance of nickel mixed with kerosene as dielectric medium in electrical discharge machining of Monel 400TM. The optimum range of nickel powder, Graphite powder 6g mixes with the dielectric medium of kerosene servotherm (75:25) were developed experimentally. They have concluded that the experimentally observed performance of kerosene-servotherm of different proportion of nickel powder found that better machining output in EDM of Monel 400TM. The surface smoothness and diameteral accuracy reported by kerosene servotherm of 8g nickel mixed dielectric medium gives better result. After than drawn all graphs which shows the optimum proportion mixture of nickel powder influences the MRR, TWR and OC.8, 6g of nickel and graphite powders are mixed with kerosene-servotherm (75:25) gives better results of MRR, TWR and OC.

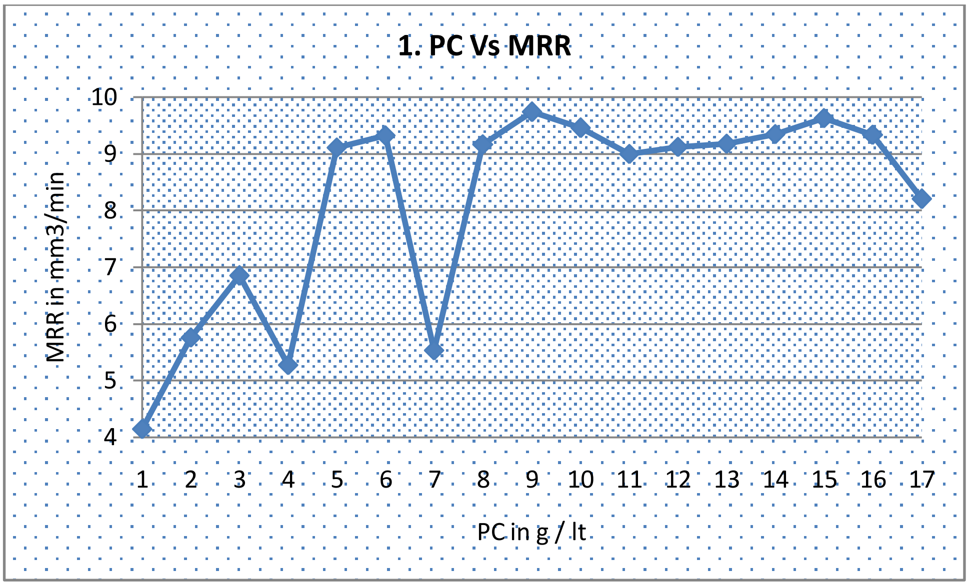
KuldeepOjha et (14) have presented parametric optimization for material removal rate (MRR) and tool wear rate (TWR) study on the powder mixed electrical discharge machining (PMEDM) of EN-8 steel has been carried out. Response surface methodology (RSM) has been used to plan and analyse the experiments. Average current, duty cycle, angle of electrode and concentration of chromium powder added into dielectric fluid of EDM were chosen as process parameters to study the PMEDM performance in terms of MRR and TWR. Experiments have been performed on newly designed experimental setup developed in laboratory. They have concluded that the quantitative analysis of machinability of EN-8 steel in PMEDM process was carried out.

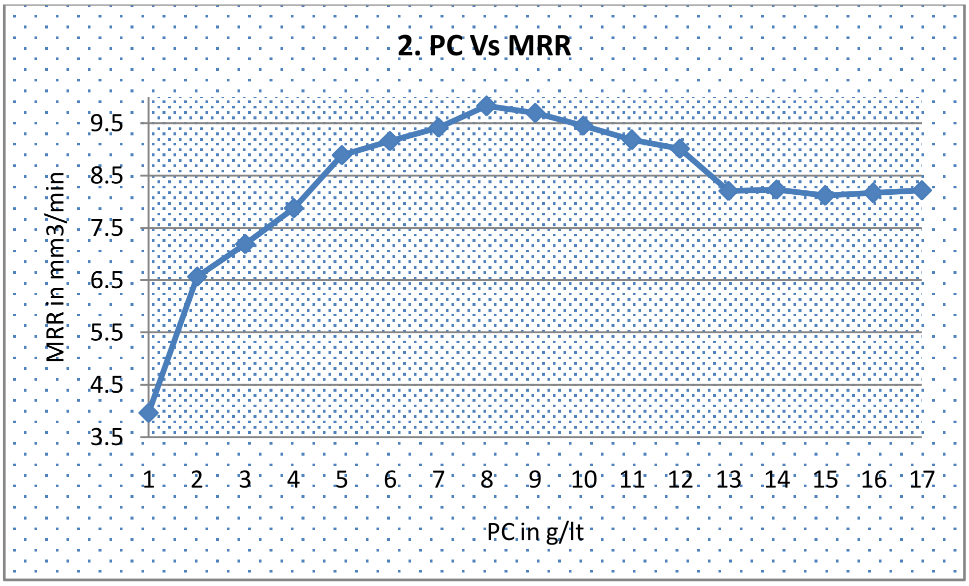
VI. EXPERIMENTATION

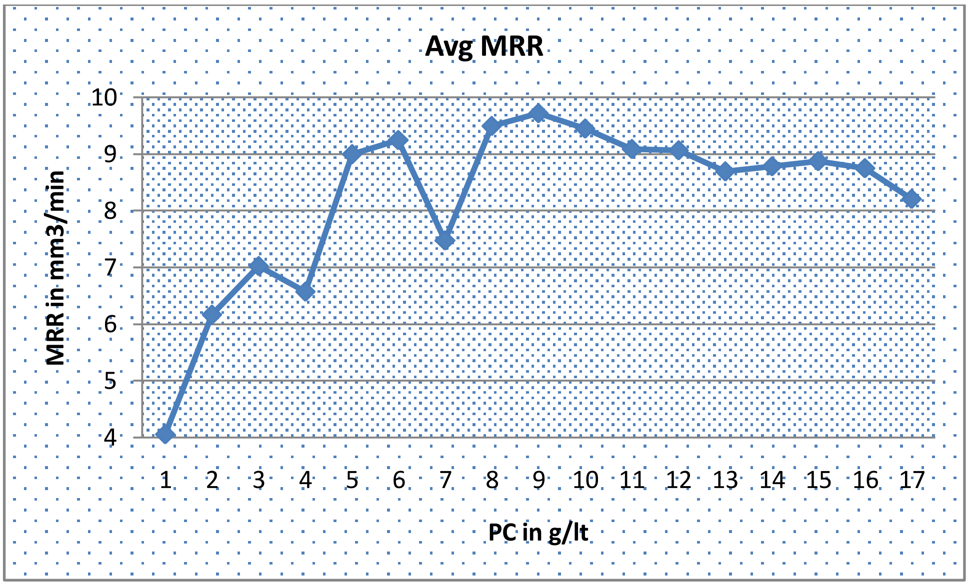
Some of the experiments have been conducted to find out the quantum of the best concentration which is to be mixed up to get the better results to proceed towards the main experimentation. As a part of it, it is being selected to conduct experiments with 1 gram powder as incremental factor starting with 1 gram till 17 grams. Firstly it was tested to find out the Material removal rate in more than 30 experiments for which two trials were performed for each experiment. Then the values of the MRR in two trials were shown in the following table along with the average value of the each concentration.

PC (in Grams)	**MRR**		**Avg MRR**
	Trial1	**Trial2**	
1	4.143	3.9673	4.05515
2	5.761	6.564	6.1625
3	6.85	7.19	7.02
4	5.27	7.88	6.575
5	9.1089	8.8916	9.00025
6	9.3241	9.1652	9.24465
7	5.5338	9.417	7.4754
8	9.1726	9.8272	9.4999
9	9.7392	9.7016	9.7204
10	9.4563	9.4538	9.45505
11	9.004	9.18	9.092
12	9.1231	9.0142	9.06865
13	9.1828	8.21	8.6964
14	9.3452	8.234	8.7896
15	9.6294	8.115	8.8722
16	9.3412	8.165	8.7531
17	8.2031	8.224	8.21355

Graphs are being drawn between the powder concentration and material removal rate for the values obtained in two trails and the average of it even. The following figures shows the same



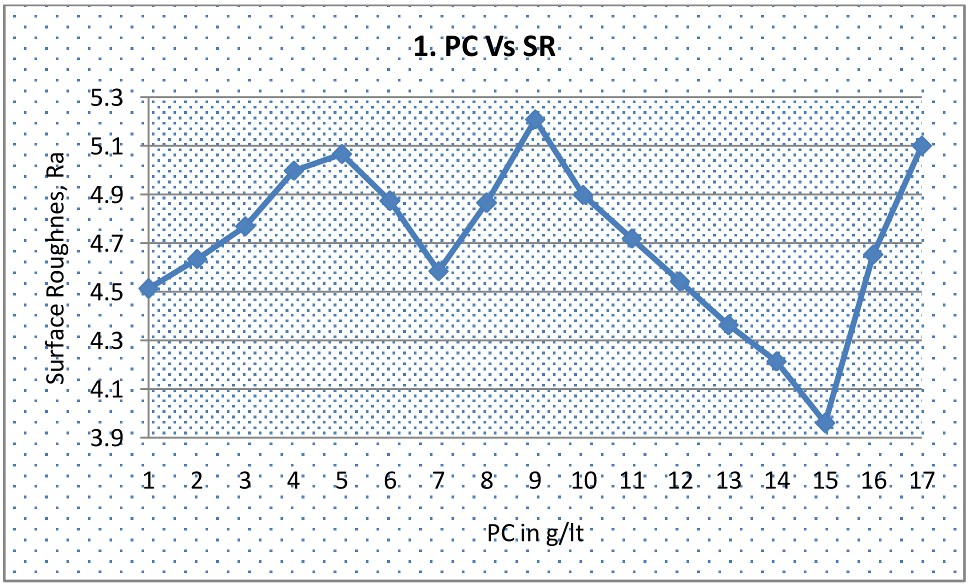


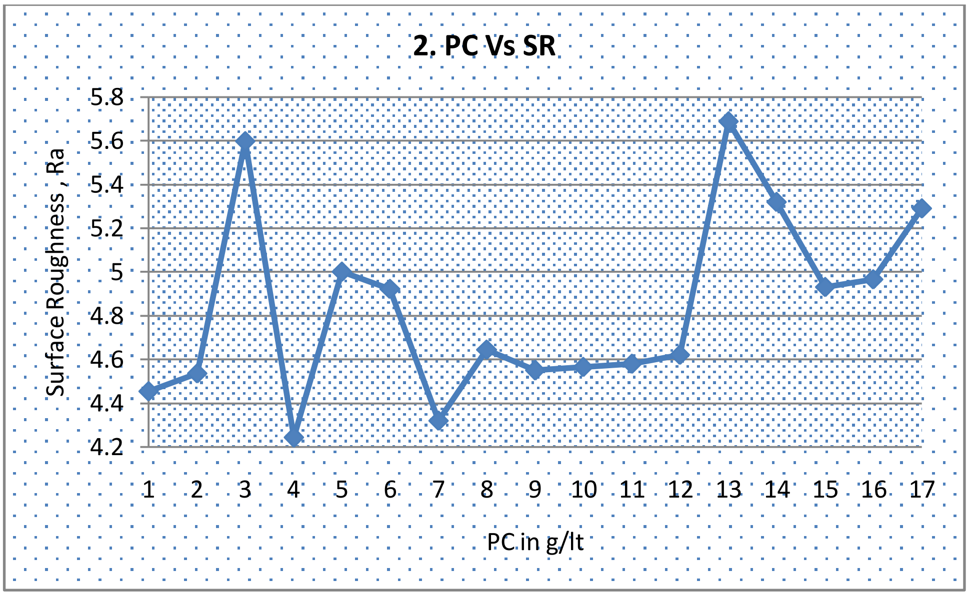


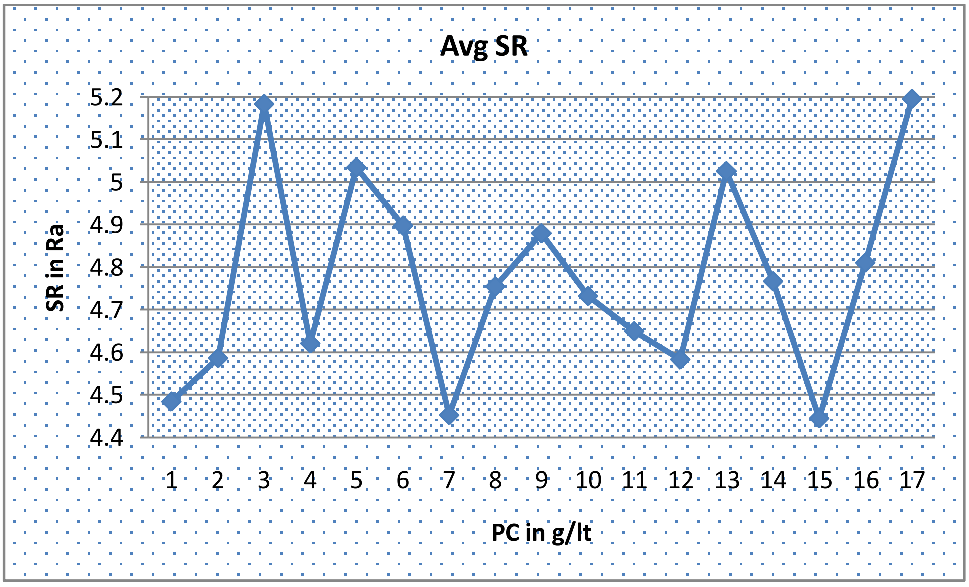
Secondly, the surface roughness was measured in two different trails with the variation of the powder concentration right from 1 gram / litre to 17 grams / litre. The following table exhibits the same along with the average value of surface roughness followed by the graphs between the quantum of the powder concentration and the surface rough ness in three diagrams indicates the trail 1, trial 2 and average values respectively

PC (In grams)	SR		Avg SR
	Trial1	Trial2	
1	4.512	4.457	4.4845
2	4.634	4.539	4.5865
3	4.768	5.6	5.184
4	4.999	4.244	4.6215
5	5.067	5.003	5.035
6	4.873	4.924	4.8985
7	4.585	4.321	4.453
8	4.865	4.645	4.755
9	5.209	4.551	4.88
10	4.897	4.568	4.7325
11	4.7181	4.582	4.65005
12	4.5426	4.623	4.5828
13	4.362	5.691	5.0265
14	4.213	5.321	4.767
15	3.9591	4.932	4.44555
16	4.6541	4.967	4.81055
17	5.1	5.293	5.1965

Graphs are being drawn between the powder concentration and surface roughness for the values obtained in two trails and the average of it even. The following figures shows the same





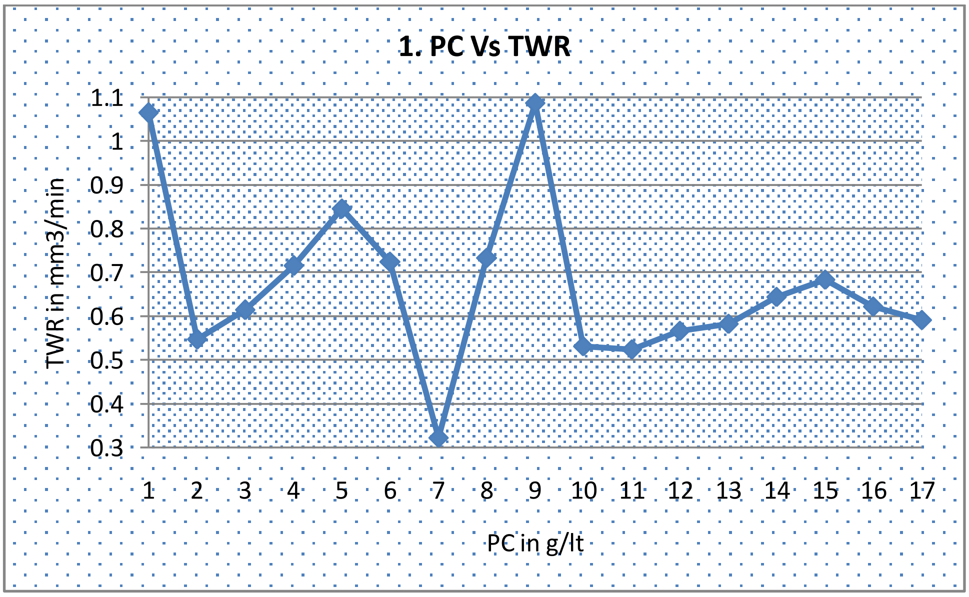


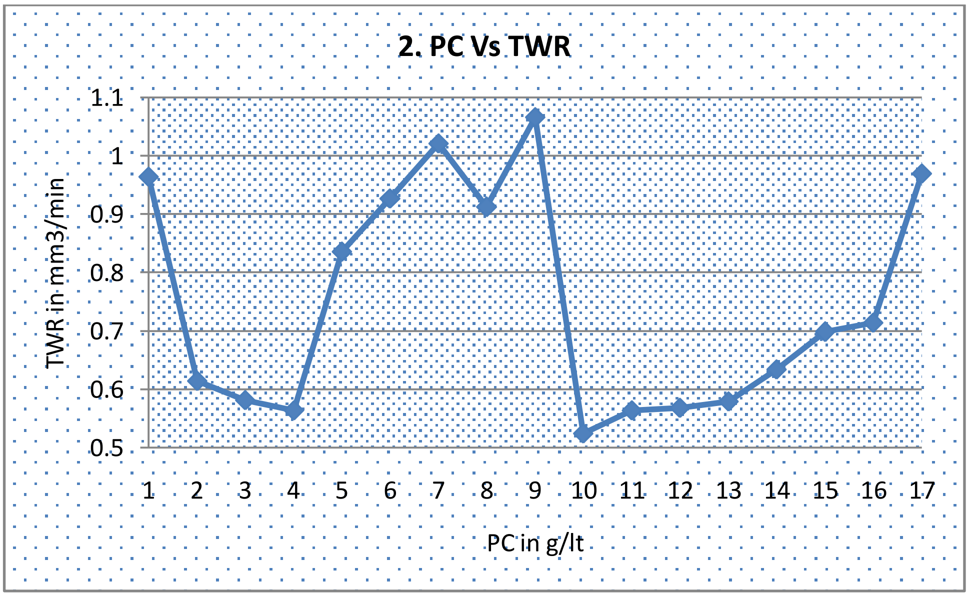
Lastly, the third parameter of the PMEDM is tool wear rate is obtained for the same number of experiments for the same powder concentration variations. The table given below shows the three values i.e. trial1, trial2 and average value of tool wear rate followed by the three graphs between the powder concentration and tool wear rate for the three values respectively

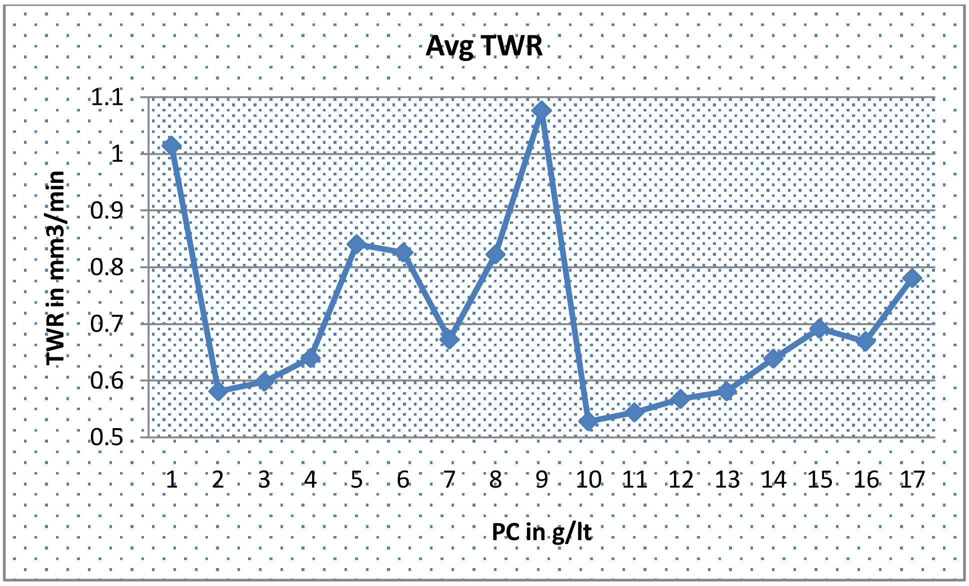
Powder Concentration (In Grams)	TWR		Avg TWR
	Trial1	Trial2	
1	1.0648	0.9646	1.0147
2	0.5472	0.6145	0.58085
3	0.6144	0.5819	0.59815
4	0.7154	0.5638	0.6396
5	0.8462	0.8363	0.84125
6	0.7245	0.9275	0.826
7	0.323	1.0218	0.6724
8	0.734	0.9123	0.82315
9	1.087	1.0667	1.07685
10	0.532	0.5247	0.52835

11	0.524	0.5645	0.54425
12	0.567	0.5687	0.56785
13	0.5825	0.5796	0.58105
14	0.6438	0.6342	0.639
15	0.684	0.6985	0.69125
16	0.623	0.7142	0.6686
17	0.592	0.97	0.781

Graphs are being drawn between the powder concentration and tool wear rate for the values obtained in two trails and the average of it even. The following figures shows the same







VII. CONCLUSION

As per the requirement 34 experiments were conducted to find out the each parameter. In the three machining parameter values are obtained when the concentration of the powder is taken as 1-17g/lt at Discharge current – 20 amp, Pulse on time – 65 micro seconds and Pulse off time – 36 micro seconds.Average of each concentration has been calculated and then the relevant graphs were plotted.

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