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Determination of Best Concentration of Powder to Be Mixed in Di-Electric Fluid of PMEDM

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Abstract:

Titanium alloy is extensively used in many industrial applications because of its corrosive resistance, fracture resistance and high strength to weight ratio and so many other advantages. It is quite necessary to know the best 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 a total of 34 trails were performed on titanium alloy on MRR, SR and TWR to find out the better concentration.

Keywords: PMEDM, MRR, SR, TWR &PC

I. INTRODUCTION-POWDER MIXED 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 that can be added into the dielectric fluid include Aluminium,graphite, copper, chromium, and Silicon carbide etc. spark gap provided by the additives particles. When the voltage applied between the tool electrode and workpiece are 80-320V with the gap of 25-50µm & electric field range 105- 107 V/m was created. 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. The faster sparking within a discharge causes faster erosion from the work piece surface and hence the material removal rate increases.

II. MAJOR COMPONENTS

Power supply: It transform the alternating current from the main utility supply into the pulse direct currentrequired to produce the spark discharge at the machining gap.
Pulse Generator & Control Unit: This unit is responsible for supplying pulses at a certain voltage and current for specific amount of time. The power supply control the amount of energy consumed. The control unit is control the all function of the machining for example of Ton, Ip, duty cycle, putting the values and maintain the work piece the tool gap.
The servo system: It is provided to maintain the pre-determined gap. It senses the gap voltage and compares it with the present value and the different in voltage is then used to control the movement of servo motor to adjust the gap.
Tool holder: The tool holder holds the tool with the process of machining.
Circulating Pump: Circulation of powder mixed dielectric.
Electrode: The EDM electrode is the tool that determines the shape of the cavity to be produced.
Permanent magnet: Magnetic forces are used to separate the debris from the dielectric fluid.
Machining Tank: The system consists of a transparent bath-like container, called the machining tank.

III. WORKING PRINCIPLE OF PMEDM

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.

IV. PARAMETERS OF PM-EDM

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.

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Electrical Parameters

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

Straight polarity: Electrode (-) & workpiece (+)

Reverse polarity: Electrode (+) & workpiece (-)

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

Non-Electrical Parameters

Nozzle flushing: Flushing is defined as the correct circulation of dielectric solution between the electrodes and workpiece. Suitable flushing conditions are essential to obtain the highest machining efficiency. The sinker EDM process has primarily used oil for the dielectric fluid. Flushing system mainly two type i.e., Normal flow & Reverse flow

Powder Based Parameters

Powder type

The powder added into the dielectric fluid could increase the MRR and decrease the tool wear rate (TWR) and improve the surface quality of the work quite clearly. But the different powders would have different impact on the output characteristics of the EDM process. Some kinds of inorganic oxide powders cannot disperse uniformly and persistently in kerosene, concentrate and precipitate quickly, so they do not play a good role in improving the MRR, decreasing the SR and TWR. A powder which can be suspended into dielectric fluid of EDM must have following properties:-

It should be electrical conductive in nature.

It must be non-magnetic in nature.

It must have good suspension capabilities.

It should have good thermal conductivities.

It should be in toxic and odor-less.

Concentration of added powder

Addition of appropriate amount of powder into dielectric fluid plays a very important role on MRR, TWR and SR. The material removal depth reached the maximum value at appropriate concentration. Further increase or decrease in the concentration of the added powder would decrease the MRR.

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Mesh size of powders

The size of the powder particles affects the PMEDM performance. A large diameter of the powder particle increases the gap but simultaneously decreases the MRR and then increases the SR.

Electrical properties of powders

The electrical conductivity of the added Powder directly affects EDM performance. This is because the added powder increases the Conductivity of the dielectric fluid and results in the extension of the gap distance.

Powder conductivity

Powder density

Electrode Based Parameters

Electrode material: EDM electrode materials need to have properties that easily allow charge and yet resist the erosion that the EDM process encourages and stimulates in the metals it machines. Alloys have properties which provide different advantages based on the needs of the application.

Brass is an alloy of copper and zinc. Brass materials are used to form EDM wire and small tubular electrodes. Brass does not resist wear as well as copper or tungsten, but is much easier to machine and can be die-cast or extruded for specialized applications. EDM wire does not need to provide wear or arc erosion resistance since new wire is fed continuously during the EDM wiring cutting process.

Copper and copper alloys have better EDM wear resistance than brass, but are more difficult to machine than either brass or graphite. It is also more expensive than graphite. Copper is, however, a common base material because it is highly conductive and strong. It is useful in the EDM machining of tungsten carbide, or in applications requiring a fine finish.

Copper tungsten materials are composites of tungsten and copper. They are produced using powder metallurgy processes. Copper tungsten is very expensive compared to other electrode materials, but is useful for making deep slots under poor flushing conditions and in the EDM machining of tungsten carbide. Copper tungsten materials are also used in resistance welding electrodes and some circuit breaker applications

Graphite provides a cleaning action at low speeds. Carbon graphite was one of the first brush material grades developed and is found in many older motors and generators. It has an amorphous structure.

Molybdenum is used for making EDM wire. It is the wire of choice for small slot work and for applications requiring exceptionally small corner radii. Molybdenum exhibits high tensile strength and good conductivity,making it ideal where small diameter wire is needed for demanding applications.

Silver tungsten material is tungsten carbide particles dispersed in a matrix of silver. Silver offers high electrical conductivity and tungsten provides excellent erosion resistance and good anti-welding characteristics in high-power applications. This composite is thus the perfect choice for EDM electrode applications wheremaximizing conductivity is crucial.

Tellurium copper is useful in EDM machining applications requiring a fine finish. Tellurium copper has a machinability that is similar to brass and better than pure copper.

Electrode Shape& size: The performance of die sinking EDM due to the shape configuration of the electrode. The effect of electrode shape on material removal rate (MRR), electrode wear rate (EWR), wear ratio (WR), and average surface roughness (Ra) has been investigated for mild steel work material and copper electrode. The shapes of the electrodes were round, square, triangular, and diamond of constant cross-sectional area of 64 mm^2.

Electrode Properties:

High electrical conductivity – electrons are cold emitted more easily and there is less bulk electrical heating.

High thermal conductivity – for the same heat load, the local temperature rise would be less due to faster heat conducted to the bulk of the tool and thus less tool wear.

Higher density – for the same heat load and same tool wear by weight there would be less volume removal or tool wear and thus less dimensional loss or inaccuracy.

High melting point – high melting point leads to fewer tools wear due to less tool material melting for the same heat load. Easy to manufacture.Less in cost

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 workpiece 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-workpiece 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-workpiece material combination gives the optimal TWR and MRR condition. The relative wear ratio of the workpiece 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-tovalley surface roughness and root mean square surface roughness. The Surface Roughness of the workpiece can be expressed in different ways like,

a. Arithmetic average
b. Average peak to valley height
c. Peak roughness etc.

Defined as the arithmetic average roughness of the deviations of the roughness profile from the central line along the measurement

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 usuallylocated above the heat affected zone.

V. LITERATURE SURVEY

F.Q.Huaet (1) conducted experiments on surface properties of SiCp/Al with moderate fraction of Sic particle reinforced Al matrix composites in EDM and PMEDM using Environment scanning electron microscope. They have found that the surface properties are improved greatly in PMEDM than EDM as its surface roughness decreased about 31.5% and is better in corrosion resistance and wear resistance is twice of EDM. Finally they have also mentioned that the PMEDM is having promising applications in metal matrix composites machining field

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. The primary benefit of using kerosene is that it has very low viscosity and gets flushed away easily. The selected work piece material is Al-TiB2 composites. Each experiment was performed for fixed time period using brass as an electrode. Input process parameters are current, pulse on time and flushing pressure. The material removal rate and tool wear rate are evaluated by using an electronic balance machine. They have concluded that this work evaluates the feasibility of machining Al-TiB2MMC with graphite powder suspended dielectric fluid. MRR was found higher for larger Current. When comparing the MRR of with powder and without powder the MRR obtained for with powder is found higher. 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. Increase in MRR was found on increasing Pulse ON-time. TWR increases with the increases in pulse ON-time.

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. In their work, a study was carried out on the influence of the parameters such peak current, Duty factor, pulse on time , work piece material, powder type , powder concentration and flushing pressure. Taguchi methodology has been adopted to plan and analyze the experimental results. Experiments have been performed on newly designed experimental setup. In their study seven factors with three levels are investigated using Orthogonal Array (OA) L27.Material removal rate (MRR) in their experiment was calculated by using mathematical method. The result of their experiment then was collected and analyzed using MINITAB 16 software. The recommended best parametric settings have been verified by conducting confirmation experiments for MRR. From their experimental study it is found that addition of Silicon carbide powder enhances machining rate drastically with slightly increase in Tool wear rate. 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. Duty factor shows least effect on MRR. Finally, it was concluded that SiC powder and Current have impact to great extent on the MRR of Tungsten Carbide

R.A.Prajapatiet (4) 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. The experimental result analysis showed EDM with zero concentration gives better surface finish rather than PMEDM. Better surface quality obtained at Peak current (9A), Powder concentration = 0 g/lit and 25 μs pulse on time. A series of tests were conducted in order to compare EDM conventional process performance with powder mixed dielectric EDM performance on widely used industrial material EN-8. Based on literature survey three parameters are considered as critical input parameters (1) Peak current (2) Pulse on-time (3) Concentration of powder. Surface roughness measured for each experiment with setting process parameters. 45 work piece of EN 8 of size 50 mm X 30 mm X 6 mm are being produced for experimental work with copper electrode. 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 (5) 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. The TWR is 3.685gms/µsec. When no additive is mixed in kerosene dielectric medium and this TWR decreases to 3.315gms/µsec. When Copper powder is mixed with dielectric medium and it again decreased to 2.5185gms/µsec. When Graphite powder is mixed with the dielectric medium. As it is known that lesser the TWR means higher the Tool Life, so it is clear that Tool life increases with the addition of Graphite powder in the dielectric medium.

Gurule N. B. et (6) 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.

Nimo Singh Khundrakpamet (7) 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 (8) 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. Machining characteristics measured in terms of Material removal rate, tool wear rate. To obtain the optimal process parameter combination, optimization is carried out by the Signal-to-Noise (S/N) ratio analysis of Taguchi method using L18 Orthogonal Array. 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. As well as TWR is less. They have concluded that The Maximum MRR is obtained at a high peak current of 18 A, a moderate Ton of 5µs, duty cycle 85% and Graphite as powder media. Low TWR is achieved at a current of 12 A, a moderate Ton of 20 µs, duty cycle 90% and SiC as powder media.

MarekRozeneket (9) 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. A copper cylinder of 20 mm in diameter has been used as a tool electrode; the hole has been made in the cylinder in order to pump dielectric into to area of machining. The tool steel NC6, in compliance with Polish Standard, was used as a workpiece. To determine of basic EDM relationships between input parameters such as pulse current, on-time, duty factor, and output parameters namely material removal rate (MRR) and surface roughness (Ra, Rz), factorial design and multiple regression analysis have been used. First series of experiments were carried out using kerosene and kerosene/powder mixture as dielectric and second series with using deionized water and deionized water/powder mixture. During machining negative and positive polarity of tool electrode was used for investigation of polarity effect, it is an especially important when water-based dielectric is used. They have concluded that application of powder in the dielectric lead to reduce surface roughness. 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 (10) 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. It was reported slightly more material removal rate, very low tool wear rate, better dimensional accuracy and good surface finsh in Monel 400TM. 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 (11) 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. Most important parameters affecting selected performance measures have been identified and effects of their variations have been observed. They have concluded that the quantitative analysis of machinability of EN-8 steel in PMEDM process has been carried out. Chromium powder particles are mixed in EDM dielectric fluid. RSM has been applied for analysis. Optimum results have been found as suggested by software.

Nimo Singh KhundrakpamÅet (12) presented a Central Composite Design (CCD) for combination of variables and Response Surface Method (RSM) have been used to explore the influence of process parameter such as; peak current, powder concentration and tool diameter on the Material Removal Rate (MRR) on EN-8 steel. Analysis Of Variance (ANOVA) at 95% level of significance was performed to obtain the significant coefficients. Significant process parameters have been identified and optimum process conditions have been obtained. A confirmation experiments has been conducted and verified optimal conditions. Percentage errors are predicted and an actual value for developed models was found within 5%. They have concluded that the powder concentration have more significant effect on MRR. The adequacy of the developed models was checked by performing confirmation runs. The variation in prediction errors for MRR was found within ±5.5%. It was concluded that the model is valid to predict the machining responses within the experimental region.

VI. EXPERIMENTATION

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. It was tested to find out the Material removal rate, Surface Roughness & Tool Wear Rate in 17 experiments for which two trials were performed for each experiment. Then the values of the MRR, SR & TWR in two trials were shown in the following table along with the average value of the each concentration.

*PC	MRR		Avg MRR	SR		Avg SR	TWR		Avg TWR
	Trial1	Trial2		Trial1	Trial2		Trial1	Trial2	
1	4.143	3.9673	4.05515	4.512	4.457	4.4845	1.0648	0.9646	1.0147
2	5.761	6.564	6.1625	4.634	4.539	4.5865	0.5472	0.6145	0.58085
3	6.85	7.19	7.02	4.768	5.6	5.184	0.6144	0.5819	0.59815
4	5.27	7.88	6.575	4.999	4.244	4.6215	0.7154	0.5638	0.6396
5	9.1089	8.8916	9.00025	5.067	5.003	5.035	0.8462	0.8363	0.84125
6	9.3241	9.1652	9.24465	4.873	4.924	4.8985	0.7245	0.9275	0.826
7	5.5338	9.417	7.4754	4.585	4.321	4.453	0.323	1.0218	0.6724
8	9.1726	9.8272	9.4999	4.865	4.645	4.755	0.734	0.9123	0.82315
9	9.7392	9.7016	9.7204	5.209	4.551	4.88	1.087	1.0667	1.07685
10	9.4563	9.4538	9.45505	4.897	4.568	4.7325	0.532	0.5247	0.52835
11	9.004	9.18	9.092	4.7181	4.582	4.65005	0.524	0.5645	0.54425
12	9.1231	9.0142	9.06865	4.5426	4.623	4.5828	0.567	0.5687	0.56785
13	9.1828	8.21	8.6964	4.362	5.691	5.0265	0.5825	0.5796	0.58105
14	9.3452	8.234	8.7896	4.213	5.321	4.767	0.6438	0.6342	0.639
15	9.6294	8.115	8.8722	3.9591	4.932	4.44555	0.684	0.6985	0.69125
16	9.3412	8.165	8.7531	4.6541	4.967	4.81055	0.623	0.7142	0.6686
17	8.2031	8.224	8.21355	5.1	5.293	5.1965	0.592	0.97	0.781

*PC-Powder Concentration in g/lt

VII. CONCLUSION

In the three machining values it is found that the average of the best and second best together and it is found as 10. Then the possible levels (3) within the prescribed number of experiments (17) are being decided that 5, 10 and 15 g/lt.

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