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Experimental Investigation of Powder mix EDM using Silicon Dioxide as a Powder additive for Surface Roughness

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Abstract: *Powder mixed EDM (PMEDM) has emerged as one of the advanced techniques in the direction of the enhancement of the capabilities of EDM. Its use is particularly intense when very complex shapes on hard and brittle material with high geometrical and dimensional accuracy are required with increase of machining rate with higher surface finish. In this work, the effect of Silicon Dioxide (SiO2) powder mixing into the dielectric fluid of EDM on machining characteristics of EN-8 has been studied with three input parameters Peak current, pulse on time and concentration of powder. Analysis has been carried out for surface roughness. The result outcome identify the important parameters and their effect on SR of En-8 in the presence of SiO2 in a kerosene dielectric of EDM. Analysis shows that the peak current and pulse on time have higher contribution toward surface roughness.. The experimental result analysis shows 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.*

Keywords-*EDM, PMEDM, Peak current, Pulse on time, Concentration , Surface roughness(SR)*

I. INTRODUCTION

There has been a rapid growth in the development of harder and difficult to machine metals and alloys during the last two decades. Conventional edged tool machining is uneconomical for such materials and the degree of accuracy and surface finish attainable is poor. In view of seriousness of this problem, it was emphasized the need for the development of newer concepts in metal machining. The newer machining that developed is often called 'modern machining processes or 'non-traditional machining process.' In unconventional machining methods, there is no direct contact between the tool and work piece; hence the tool need not to be harder than work piece. Further, in spite of the recent technical advancement, the conventional machining processes are inadequate to produce complex geometries shapes in hard and temperature resistant alloy and die steels. Keeping these requirements into mind, a number of non-conventional methods have been developed.

1.1 WORKING PRINCIPLE OF POWDER MIXED EDM (PMEDM)

Powder mixed EDM (PMEDM) has emerged as one of the advanced techniques in the direction of the enhancement of the capabilities of EDM. In this process, a suitable material in fine powder form (aluminum, chromium, graphite, copper, or silicon carbide, etc.) is mixed into the dielectric fluid of EDM. The spark gap is filled up with additive particles. The added powder significantly affects the performance of EDM process. The electrically conductive powder reduces the insulating strength of the dielectric fluid and increases the spark gap distance between the tool electrode and work piece. As a result, the process becomes more stable, thereby improving machining rate (MR) and surface finish. The principle of PMEDM is shown in Figure 1.1. In this process, the material in powder form is mixed into the dielectric fluid either in the same tank or in a separate tank. When a voltage of 80-320 V is applied to both the electrodes, an electric field in the range 105 to 107 V/m is created. The spark gap is filled up with additive particles, and the gap distance between tool and the work piece increases from 25 µm to 50 µm to many times larger. The powder particles get energized and behave in a zigzag fashion. The grains come close to each other under the parking area and gather in clusters. Under the influence of electric forces, the powder particles

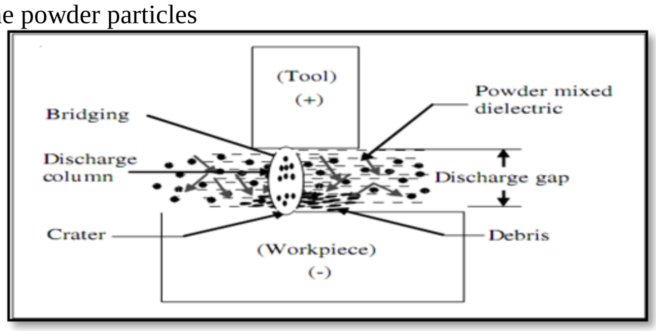


Figure 1.1 Principle of PMEDM process

arrange themselves in the form of chains at different places under the sparking area. The chain formation helps in bridging the gap between both the electrodes. Due to the bridging effect, the gap voltage and insulating strength of the dielectric fluid decreases. The easy short-circuit takes place, which causes early explosion in the gap. As a result, the 'series discharge' starts under the electrode area. Due to the increase in the frequency of discharging, the faster sparking within a discharge takes place, which causes faster erosion from the work piece surface. At the same time, the added powder modifies the plasma channel. The plasma channel gets enlarged. The electric density decreases; hence, sparking is uniformly distributed among the powder particles. As a result, even and more uniform distribution of the discharge takes place, which causes uniform erosion (shallow craters) on the work piece. This results in improvement in surface finish. [4][7]

II. LITERATURE REVIEW

Katshushi Furtutani, Akinori Saneto, Hideki Takezawa, Naotake Mohri, Hidetaka Miyake, have been studied about a surface modification method by electrical discharge machining with a green compact electrode to make tick TiC or WC layer. Titanium alloy powder or tungsten powder was suspended from the green compact electrode and adheres on a work piece by the heat caused by discharge. Research found that TiC layer can be accreted by using a thin electrode to keep the powder concentration high. [1] Zhao W. S., Meng Q. G., Wang Z. L.; have performed experimental research on the machining efficiency and surface roughness of PMEDM in rough machining. Also compared machining efficiency and surface roughness between PM (Powder mix)-EDM and conventional EDM. The result showed that PMEDM machining can clearly improve machining efficiency at the same time surface roughness. Increasing peak current and decreasing pulse width improved the machining efficiency with an increasing rate of 70% without much deterioration of surface finishing. [2] Puertas I, Luis C. J., studied on the machining parameters optimization of electric discharge machining. Peak current, pulse on time and pulse off time are considered as variable input parameters [3] Bansal H.K., Sehijpal Singh, Kumar P. used response surface methodology for the parameters optimization of powder mixed EDM. To avoid the wastage of kerosene oil, a small dielectric circulating system designed and stirring system incorporated to avoid the particle setting. When suitable voltage is applied, the powder particles get energized and behave in zigzag fashion. They have concluded that the silicon powder suspended in the dielectric fluid of EDM affects both MRR and SR. the slope of the curve on the graph indicates that the MRR increases with the increase in the concentration of the silicon powder. The ANOVA suggests that the peak current and concentration are the most important parameters on MRR and SR.[4] Tzeng Yih-fong, Chen Fu-chen, focused on the surface characteristics of electrical discharge machined SKD-11 using powder-suspension dielectric oil. addition of powder leads to an increase in the gap size that subsequently resulted in a reduction in electrical discharge power density and in gas explosive pressure for a single power pulse. It is observed that the effects of particle concentrations on surface are less influential than the discharge current. [5] Biing Hwa Yan, Hsien Chung Tsai, Fuang Yuan Huang investigated the influence of the machining characteristics on pure titanium metals using an electric discharge machining (EDM) with addition of urea into distilled water. Machining performance is measured based on three output parameters including material removal rate, electrode wear and surface roughness. Elemental distribution of nitrogen on the machined surface was qualitatively determined to access the effects on surface modification. The experimental results indicated that the nitrogen elements decomposed from the dielectric that contained urea, migrated to work piece, forming a TiN hard layer and resulting in good wear resistance of the machined surface after EDM.[6] Bansal H.K., Sehipal Singh, Praddep Kumar; have studied the effect of silicon powder mixing into the dielectric fluid of DM on machining characteristics of EDM of AISI D2 die steel. Analysis indicated that the percentage contribution of peak current and powder concentration toward MRR was maximum among the all the parameters.[7] Norliana Mohd Abbas, Daius G. Solomon, Md. Fuad Bahari, have discussed the research trends in EDM on ultrasonic vibration, dry EDM machining, EDM with powder additives techniques and EDM in water in predicting EDM performances. higher efficiency gained by the employment of ultrasonic vibration is mainly attributed to the improvement in dielectric circulation which facilitates the debris removal.[8] The author have investigated for MRR, where PMEDM gives higher MRR[9]

III. EXPERIMENTAL SET-UP

Design of Experiment (DOE) is a powerful technique used for exploring new processes, gaining increased knowledge of existing process and optimizing these processes for achieving world class performance. DOE is an experimental strategy in which effects of multiple factors are studied simultaneously by running tests at various levels of the factors. Here, Experiments were conducted on a Z 50 JM-322 die-sinking EDM machine manufactured by JOEMARS. The existing dielectric circulation system of Z 50 JM-322 EDM machine needs about 200 liters of kerosene in circulation. The dielectric fluid was circulated by pumping system. Fixture is designed to hold the work piece. The machine tank is field up with dielectric fluid i.e. kerosene. EN-8 material is selected as a work piece material because of it's industrial needs that it is widely used in metal forming; forging, squeeze casting and pressure die casting.. Copper electrodes with diameter 15 mm have been selected as a tool. The machining is performed in commercially available kerosene oil. Silicon dioxide powder with 40 µm particle size was added into the kerosene oil.

A series of tests will be 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.

Figure .1.2 Electro Discharge Machine used for performing experiments

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. Chemical composition of EN 8 is given in table 1.1 whereas physical property is in table 1.2. Factors levels with their range selected as per table 1.3

Table 1.1 Chemical composition of EN-8

Composition in %	C	Si	Mn	P	S
	0.390	0.240	0.690	0.027	0.029

Table 1.2 Physical property of EN-8

	Yield strength	Ultimate strength
EN-8	450.79 MPa	694.84 MPa

Table 1.3 Factors with levels value

Factors	Level 1	Level 2	Level 3	Level 4	Level 5
Concentration of powder i.e. SiO_2 (g/lit.)	0	2	4	6	8
Peak current (A)	9	13	17	--	--
Pulse on-time (µs)	25	50	75	--	--

The value of surface roughness at different peak current and different pulse on time in conventional and powder mixed EDM is shown in table 1.4 and 1.5 respectively.

IV. RESULT DISCUSSION

Table 1.4 Experimental results for SR at different peak current and different pulse on time at zero concentration

Sr. No.	**Process Parameter combination**			**SR**
	Powder concentration	**Peak Current**	**Pulse on-time**	
	(g/l)	**A**	**µs**	**µm**
1	0	9	25	1.9
2	0	9	50	2.28
3	0	9	75	2.62
4	0	13	25	3.87
5	0	13	50	3.9
6	0	13	75	4.25

7	0	17	25	5.08
8	0	17	50	5.29
9	0	17	75	6.18

Table 1.5 Experimental results for SR at different peak current and different pulse on time in PMEDM

	0 g/l	2 g/l	4g/l	6 g/l	8 g/l	
9 A	1.9	1.93	2.48	2.56	2.51	**25 µs**
	2.28	2.42	2.94	3.08	3.07	**50 µs**
	2.62	2.86	3.18	3.36	3.43	**75 µs**
13 A	3.87	3.9	4.51	4.62	4.65	**25 µs**
	3.9	3.96	5.13	5.27	5.39	**50 µs**
	4.25	4.38	5.54	5.94	6.02	**75 µs**
17 A	5.08	5.14	6.06	6.54	6.61	**25 µs**
	5.29	5.46	7.68	8.62	8.69	**50 µs**
	6.18	6.41	8.02	9.14	9.23	**75 µs**

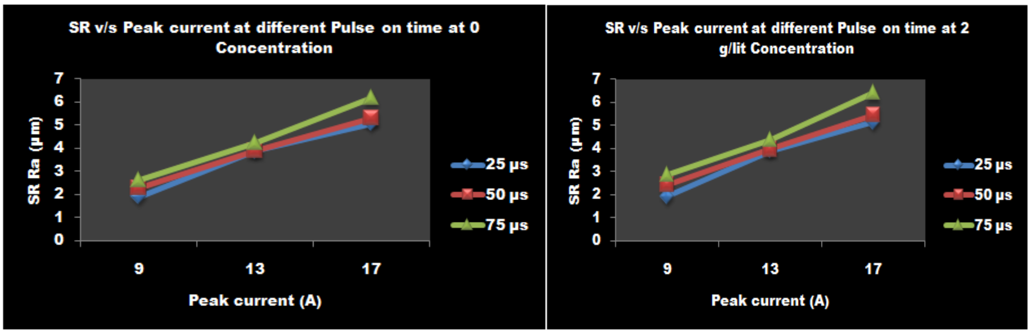
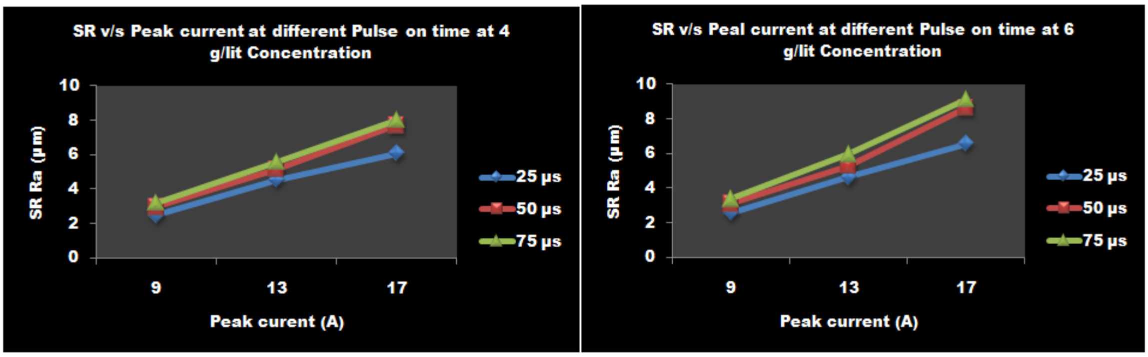


Figure 1.3: SR v/s Peak current at different Pulse on time at zero & 2 g/lit concentration



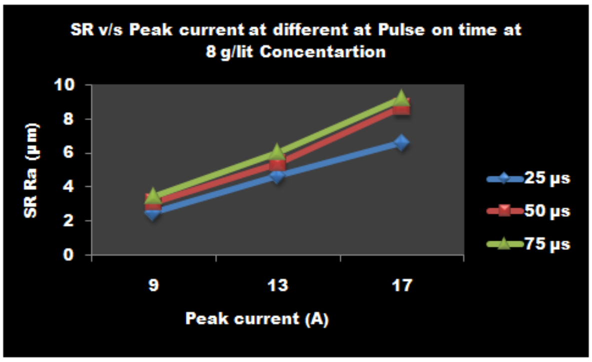


Figure 1.4: SR v/s Peak current at different Pulse on time at 4, 6 & 8 g/lit concentration

Figure 1.3 & 1.4 shows SR v/s peak current at different pulse on time at various concentrations. It is observed that increase in peak current cause the surface quality inferior in EDM as well as in PMEDM. This is due to the reason that increasing peak current increases the discharge energy and the impulsive force which helps to remove more melted material and generating deeper and larger craters, so increasing surface roughness.

It is also analyzed from the graphs that quality of surface decreases as the peak current increases from one level to the next. The surface roughness obtained at 9 A peak current gives good surface finish. At this peak current SR is 1.9 µm obtained.

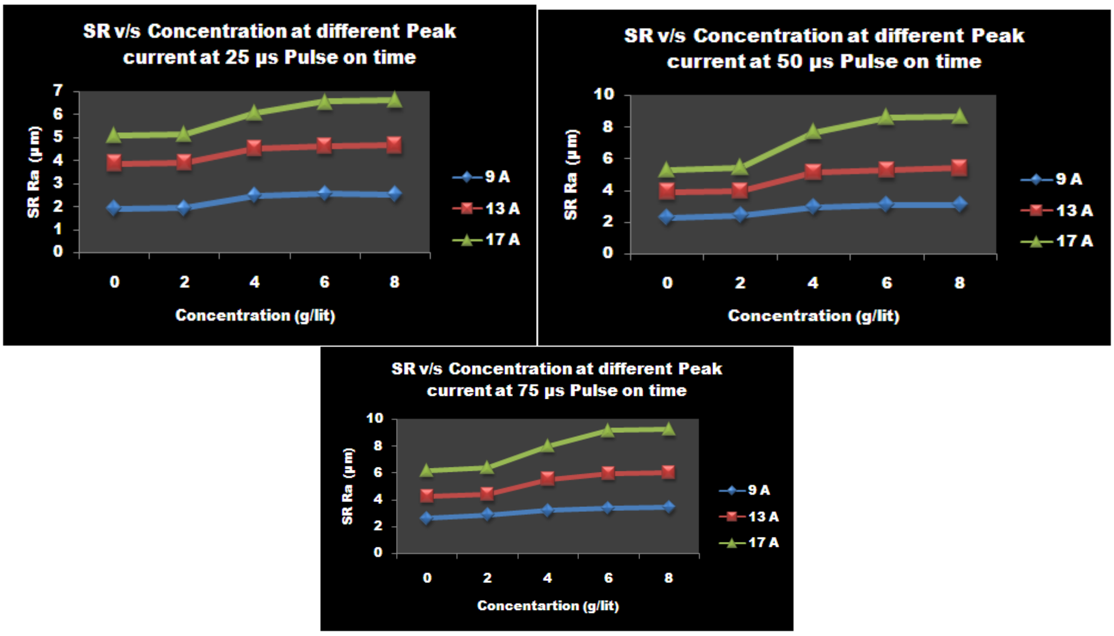


Figure 1.5: SR v/s Concentration at different Peak current at different Pulse on time

Figure 1.5 depicts SR v/s concentration under various peak current with varying the value of pulse on time. Here surface roughness deteriorates as the density of powder in dielectric fluid goes high. This is due to the reason that high additive concentration cause powder setting problem, means with the same dielectric circulation system it is difficult to remove all additive particles from the spark gap which will create hurdle on quality of the surface finish. Here quality of surface of machined work piece at zero concentration vary from 1.9 µm to 5.08 µm with the improvement in peak current from lowest to highest level in a given range. Also surface roughness very from 1.9 µm to 2.62 µm as pulse on time very from 25 µs to 50 µs in conventional EDM process. The same kind of behavior observed in powder mixed EDM.

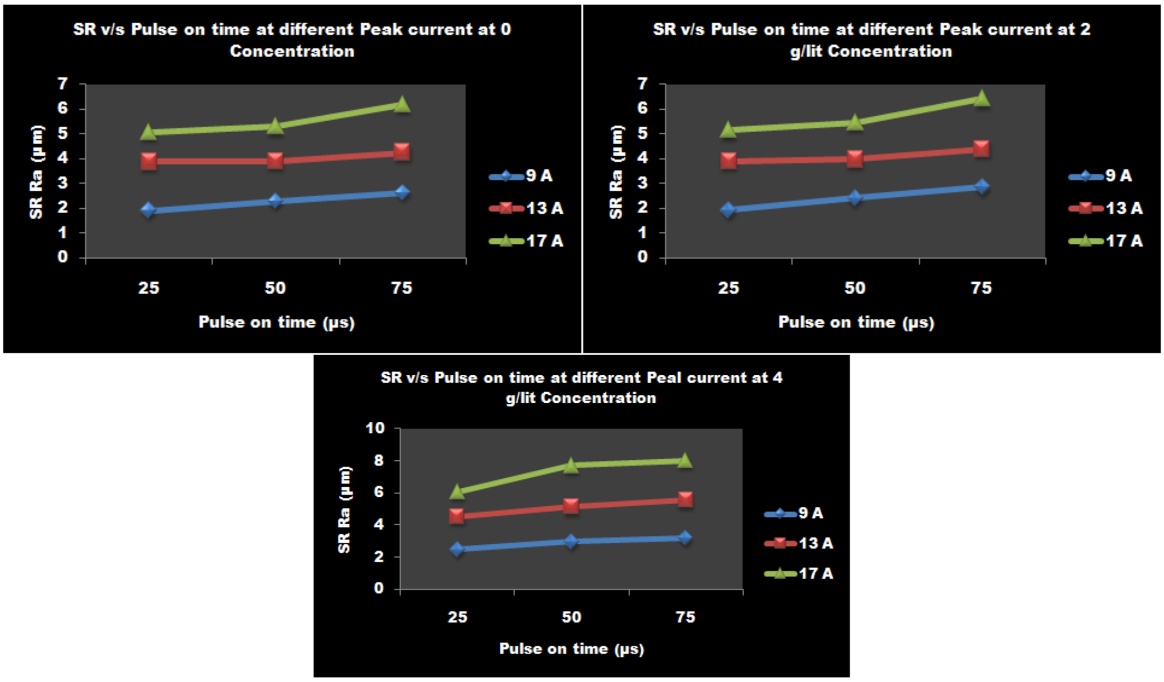


Figure 1.6: SR v/s Pulse on time at different Peak current at zero, 2 g/lit & 4 g/lit Concentration

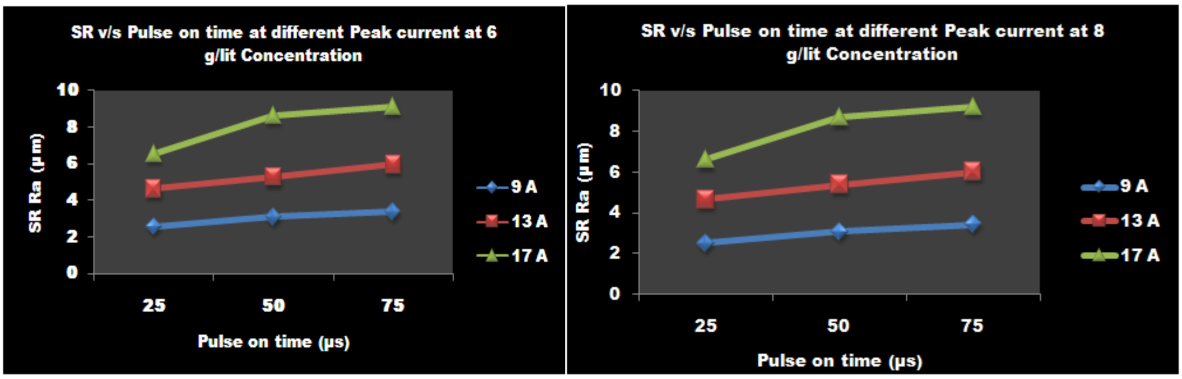


Figure 1.7: SR v/s Pulse on time at different Peak current at 6 & 8 g/lit Concentration

Figure 1.6 and 1.7 shows the graph between Surface Roughness and Pulse on time at different peak current and with varying Concentration. It indicates that as pulse on time goes higher the surface roughness increases; this is due to the reason that with more pulse on time comparatively deep craters are generated and surface finish becomes poor. Also from the graph it is concluded that, as the level of peak current increases surface becomes more and more rough. The lowest surface roughness obtained is 1.9 µm that is at 25 µs pulse on time, 9 A peak current and at zero concentration of silicon dioxide powder in dielectric fluid which shows the case of conventional EDM. Whereas maximum surface roughness obtained is 9.32 µm at 75 µs pulse on time, 17 A peak current and 8 g/lit concentration of SiO2 powder in dielectric fluid.

V. CONCLUSION

Electric discharge machining has been found to be a promising machining technique for obtaining desired dimensional accuracy and intricacy from hard and tough die steels. Powder mixing into dielectric fluid of EDM is one of the innovative developments that ensure better machining rates with good surface finish. The result of present work identifies the significant process parameters and the machining conditions in the presence of silicon dioxide powder in the dielectric fluid. Peak current, concentration of the silicon dioxide powder and pulse on time significantly affects the SR in PMEDM. PMEDM gives poor surface finish, hence when surface finish is only the criteria, 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 this experimental work are:

- Peak current = 9 A, Powder concentration = 0 g/lit and 25 µs pulse on time for better surface quality.

REFERENCES

[1] Katshushi Furtutani, Akinori Saneto, Hideki Takezawa, Naotake Mohri, Hidetaka Miyake, "Accretion of titanium carbide by electric discharge machining with powder suspended in working fluid", Journal of International Societies for Precision Enginering and Nanotechnology, 25 (2001) 138 – 144.

[2] Zhao W.S., Meng Q.G., Wang Z.L., "The application of powder mixed EDM in rough machining", Journal of material Processing Technology 129 (2002) 30-33.

[3] Puertas I, Luis C. J., "A study on the machining parameters optimization of electric discharge machining", Journal of materials Processing Technology, 143 – 144 (2003) 521 – 526.

[4] Kansal H.K., Sehijpal Singh, Kumara P., "Parametric optimization of powder mixed electrical discharge machining by responce surface methodoogy", Journal of Manufacturing Processes, 169 (2005) 427-436.

[5] Tzeng Yih-fong, Chen Fu-chen, "Investigation into some surface characteristics of electrical discharge machined SKD-11 using powder-suspension dielectric oil", Journal of Material Processing Technology, 170 (2005) 385-391.

[6] Biing Hwa Yan, Hsien Chung Tsai, Fuang Yuan Huang, "The effect in EDM of a dielectric of a urea solution in water on modifying the surface of titanium", International Journal of machine Tools & manufacture, 45 (2005) 194 – 200.

[7] Kansal H.K., Sehijpal Singh, Kumara P., "Effect of Silicon Powder mixed EDM on Machining Rate of AISI D2 Die Steel", Journal of Manufacturing Processes, 9 (2007) 13 - 22.

[8] Norliana Mohd Abbas, Daius G. Solomon, Md. Fuad Bahari, "A review on current trends in electrical discharge machining (EDM)", International Journal of Machine Tools & Manufacture 47 (2007) 1214-1228.

[9] R.A. Prajapati, Haresh Patel, Nigam oza, " Experimental Investigation of powder mix EDM using Silicon Dioxide as a Powder additives for Material removal rate", International Journal of Advance Engineering and Research Development(IJAERD) Vol. I, Issue 12, December 2014

