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Surface Texture of Titanium 31 and H.S.S using Micro EDM Drill and Wire EDM

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Abstract: ***Micro EDM Drill is variant EDM processes in a situation where it employs water as a dielectric fluid, with pressure flushing and rotating nanotube electrode. This paper brings out the relative features of work pieces i.e., H.S.S and Titanium 31 about their surface roughness with Talysurf, as well as Surfaces Texture with Scanning Electronic Microscope (SEM analysis).Thus the results are evaluated for Ra (Surface Roughness), Rsk (Surface Skewness) and Rku (Surface Kutosis).***

Keywords: ***Titanium 31, (H.S.S) High Speed Steel, Micro Electro Discharge Machining Drill (Micro EDMD), SEM, Ra, Rsk, Rku***

I. INTRODUCTION

The EDM is widely applied for machining unusual materials and intricate shape. In wire cut EDM etc drilling micro holes of 0.3 to 3.0 mm, run away holes in die and pneumatic valves are difficult. In the variant EDM process it consists of a low energy pulse, water dielectric and a spark gap, flushing with pressure through a nano pipe electrode which is assisted by Taylor coquette flow the dielectric from rotation of the electrode. This shows setup in the Figure 1.

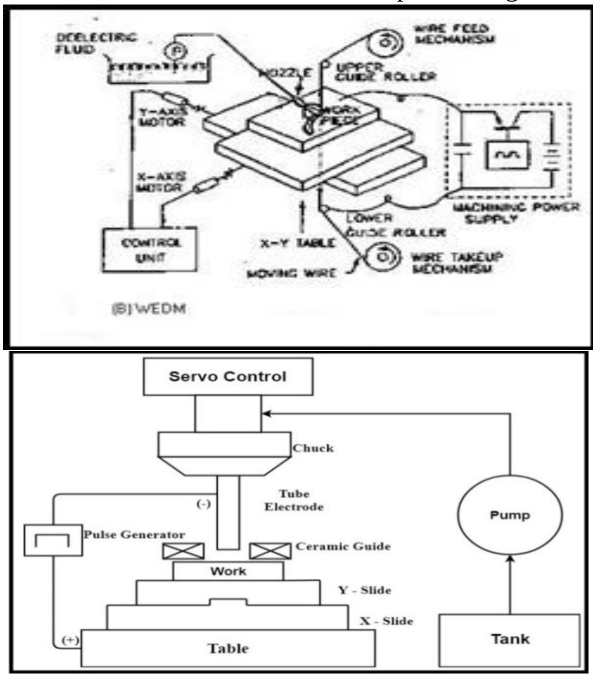

Figure 1 Schematic Representation of WEDM and Micro EDM

Assembly of ceramic guide is mounted as electrode. The nano - tube Tool and workpiece form a pair of electrodes with electrode negative with uniform gap of few scores of microns. Therefore wearing away occurs by elevated frequency sparks trigger by square pulse generator. Dielectric medium as distilled water is employed in place of customary kerosene pulse generator.In conventional EDM it is diverse designed for machining small holes due to reduced erosion rates, get thinner and massive are typical harms [1, 2]. At common short circuits as of spark gap contamination by wearing down debris. [3] Water as dielectric medium is used efficiently which results in smallest spark gaps [4], fastest solidification of eroded particles before they combine to form larger size debris [5, 6]. The viscosity is superior due to flushing action. The key benefit of micro EDM drill is to machine small holes by way of very small forces. The forces are small due to tool and workpiece interface which perform keen approach in contact throughout the machining process. This provides advantage to both tool and workpiece. Additional return of micro EDM drill includes low down - elevated feature ratio, setup cost and enhanced precision with great plan freedom. In addition micro EDM drill is contactless MRR thereby eliminate mechanical pressure vibration and chatter troubles during machining. Micro EDM is extremely efficient to machine any kind of micro holes by means of elevated aspect ratio.

II. EXPERIMENT PLAN

Narrative assessment has been performed in the direction to discover but not in machining parameters which affect the surface roughness of WEDM process. While machining parameters wire feed. Speed, pulse on time, wire tension, delay time and ignition current strengthen be chosen for testing. The experiment be intended according to Taguchi's L16 $(4)^4$. Trial is conduct with WEDM machine manufactured by charmilles technologies. A 0.25mm diameter zinc coated brass wire is selected as tool electrode. Titanium 31 and H S S material of 10 mm width are taken as work material. A talysurf on 0.8 mm cut off significance considered the surface roughness of every specimen. Table 1 illustrates the chosen machining parameter for the testing. The Work pieces are prepared on the Electron Discharge Machine Rapid drill and Wire EDM.

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A. Input factors

Work piece materials of Titanium 31 and H.S.S, electrode brass tube of 1mm and 3mm diameter, pulse current 3 Amps and 6 Amps, pulse on times 6 and 10, pulse off times 4 and 7 (dial positions with increasing order) pulse voltage (100 V) and flush pressure (100 bar) were kept uniform [4].

B. Output factors and Inference mode

Roundness error of 3D-cmm, are observed at the top and base of the hole and the taper. Surface finishes using Talysurf, Topological surface and SEM. Scanning Electron Microscope

III. RESULTS AND DISCUSSION

A. Surface Characteristics

The outcome of surface roughness are planned in Table 1

Table I Surface Roughness (Ra) (μm) range in Micro EDM Drill and WEDM

Process	Materials			
	Titanium 31		H.S.S	
	Speed (Low)	Speed (High)	Speed (Low)	Speed (High)
Micro EDM	0.936	1.640	1.807	1.962
WEDM	1.609	1.728	2.109	2.781

The finding are predictable but demonstrative surface roughness in titanium 31 compare to H.S.S, and sizeable fluctuations of Ra values were observed along Titanium 31 surface. The attributed of non-uniform attrition occurring to spark discharge is due to short circuit current surge. The eroded surfaces in Titanium 31 were very smooth with good appearance compared to H.S.S, The surface finish and geometric accuracy of Titanium 31 surfaces have significant advantage and lower to H.S.S surfaces.

It is high energy of spark discharge produce melt on the spot of its impingement and atomization of fluid metal by flash forces and growing gas. However erosion rates within Titanium 31 are so high that elevated energy pulses and flash unaided might not be the cause other than short circuits among electrode and work peace by means of current surge. The usual spark discharge key quantity of melt metal is retained and a minute part is detached since atomized droplet.While the unstable forces of short circuits give a good deal of higher removal and lesser preservation of melt metal. The mark wants further explosion in the wearing down mechanism of Titanium 31 and H.S.S. using micro EDM drill.

B. Textural study

The worn surface of work materials H.S.S besides Titanium 31 from Micro EDM and WEDM are revealed in the SEM photographs of Figure 2 and 3.

Therefore erosive effect of sparks is considerable in similarity of Sparking is a continuous local spark discharges; hence fourth articulate sparks will be employed. The tool electrodes are anode within Micro EDM drill. The emblematic occurrence of passivating film pattern on anode and evaluation of hydrogen on cathode are in favour of gaseous bridge of spark gap and also ionization for sparks channel formation involve the type of polarity.

It is the erosion in each case appears elevated quenching effect of circulate fluid prevent vaporization. There is sizeable retained metal which appear to contain resoldified at spark zone. The reduction is extensive in Micro EDM Drill owing is soaring quench result in water based electrolyte.

This gives eroded surface of Titinium31and H.S.S show distinctive form associated along with EDM [4] like burst blisters from dissolve gas, pock marks plus craters after expulsion of melt metal since spark energy. This removal to be superior in Micro EDM Drill owing to superior since water based electrolyte which also promote the oxidation tendency of Titanium 31 in (Figure 2 d, e, f).

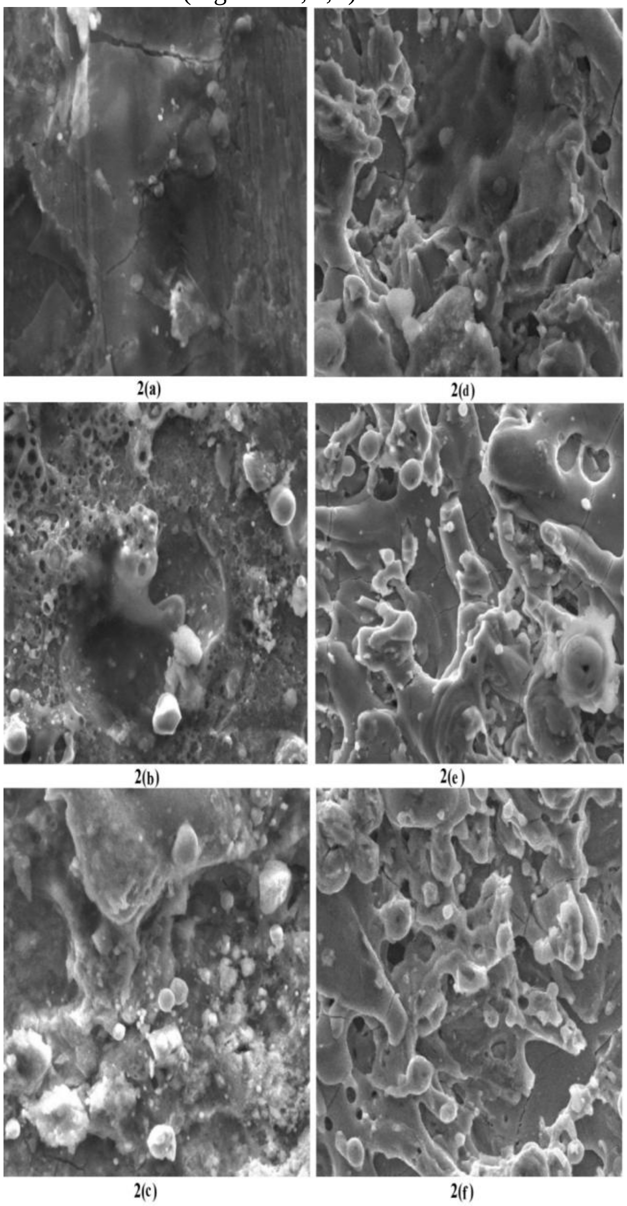

Figure 2 SEM photographs 2 (a, b, c) of H.S.S and 2(d, e, f) Titanium 31 Micro EDM Drill

Unlike precipitation of H S S which remains hard after quenching and hardened, this shows the formation white layer in Fig. 2 (b) and (c) where as in Fig. 2 (a)

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visualizes more carbon content at various speeds. In Fig. 2 (d) that is titanium 31 carbon content is more and shows wide spread of grain structure but in Fig. 2 (e) and (f) the carbon content is less and the grain structure is closely packed.

The SEM analysis show schematically within Fig. 3 (a) (b) and (c) and Fig. 3 (d) (e) and (f) results are arbitrarily "high" and "low" speed. In practice, intermediate speed usually permits and result is good in Fig. 3 (a) (b) of H S S and 3 (d) (e) in Titanium 31, whereas in Fig 3 (c) and 3 (f) shows cracks and white layer deposit.

Table 2 Machining Parameters, range and levels.

Sl. No	Parameters	Symbol	Range	Level (Pass)			
				1	2	3	4
1	Pulse on time	A	1-9	1	3	7	9
2	Pulse off time	B	1-9	1	3	7	9

The Ra surface roughness Rsk Skewness, Rku Kurtosis be obtain by means of Talysurf Instrument with surface roughness (Ra) graphs are taken, the best results are presented in this paper, of Titanium 31 and H S S in Table 3 & 4.

Table 3 Surface Roughness for H SS Wire EDM

Sl. No	A µ sec	B µ sec	R_a µ m	R_{sk} µ m	R_{ku} µ m	Speed mm/min
1	1	1	3.2678	0.2133	2.8718	2.456
2	3	1	3.2976	0.2436	2.8691	2.347
3	7	1	3.2764	0.2314	2.8115	2.236
4	9	1	3.2981	0.2174	2.8016	2.178
5	1	3	3.1064	0.2186	2.7341	2.109
6	3	3	3.1578	0.2256	2.6542	2.119
7	7	3	3.2679	0.2387	2.5616	2.436
8	9	3	3.2198	0.2468	2.5781	2.379
9	1	7	4.0118	0.2369	2.5014	2.405
10	3	7	4.1268	0.2101	2.6718	2.679
11	7	7	3.5213	0.2618	2.8179	2.346
12	9	7	3.5116	0.2676	2.8201	2.647
13	1	9	3.5078	0.2610	2.7541	2.566
14	3	9	3.4798	0.2578	2.7871	2.610
15	7	9	3.2768	0.2416	2.8178	2.781
16	9	9	3.2579	0.2478	2.8068	2.699
Total	80	80	54.5856	3.8200	43.8590	38.993
Average	5	5	3.4116	0.2388	2.7412	2.437

Erosion rates and roughness Ra are listed in Table 3 and Table 4 and roughness profiles of Titanium 31 and H S S are exposed within Figure 2(a), 1(b) and 1(c) and Fig 3(a), 2(b) & 2(c) respectively. The result is since likely but show considerately elevated erosion rates and surface roughness as revealed in Figure 2 compared to Figure 3 Considerable fluctuations in choice of Ra was observed surfaces. The results are attributed to non-uniform erosion owing to arc discharges as well as short circuit current surge. The preceding section explained the reasons of the theory. The worn surfaces in H S S were extremely uneven amid poor look, compare to Titanium which are extremely rough with extensive burrs. It is the surface finish and geometric accuracy of WEDM surfaces.

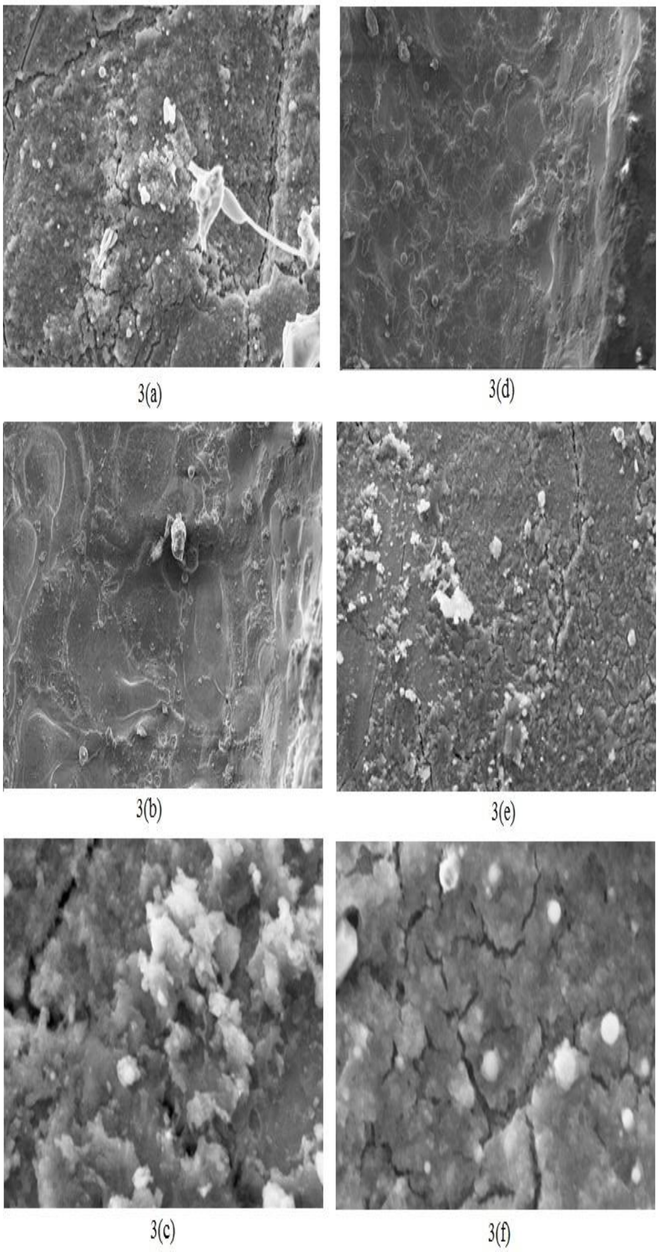

Figure 3 SEM photographs 3 (a, b, c) of H.S.S and 3(d, e, f) Titanium 31 Wire EDM

Table 4 Surface Roughness for Titanium 31 for WIRE EDM

Sl. No	A µ se	B µ sec	R_a µ m	R_{sk} µ m	R_{ku} µ m	Speed mm/min

	c					
1	1	1	0.925	0.9417	1.405	1.669
2	3	1	0.917	0.9517	1.526	1.609
3	7	1	0.987	0.9567	1.559	1.617
4	9	1	0.981	0.9674	1.578	1.628
5	1	3	0.918	0.9561	1.563	1.709
6	3	3	0.926	0.9489	1.573	1.699
7	7	3	0.937	0.9603	1.548	1.728
8	9	3	1.089	0.9899	1.601	1.683
9	1	7	1.001	0.9738	1.599	1.691
10	3	7	1.063	0.9627	1.536	1.683
11	7	7	0.989	0.9579	1.563	1.626
12	9	7	0.945	0.9368	1.514	1.673
13	1	9	0.991	0.9458	1.511	1.645
14	3	9	0.945	0.9601	1.517	1.620
15	7	9	1.006	0.9473	1.563	1.681
16	9	9	1.018	0.9563	1.513	1.672
Tot al	8 0	80	15.638	15.313 4	24.66 9	26.633
Av era ge	5	5	0.9773	0.9570	1.541 8	1.6645

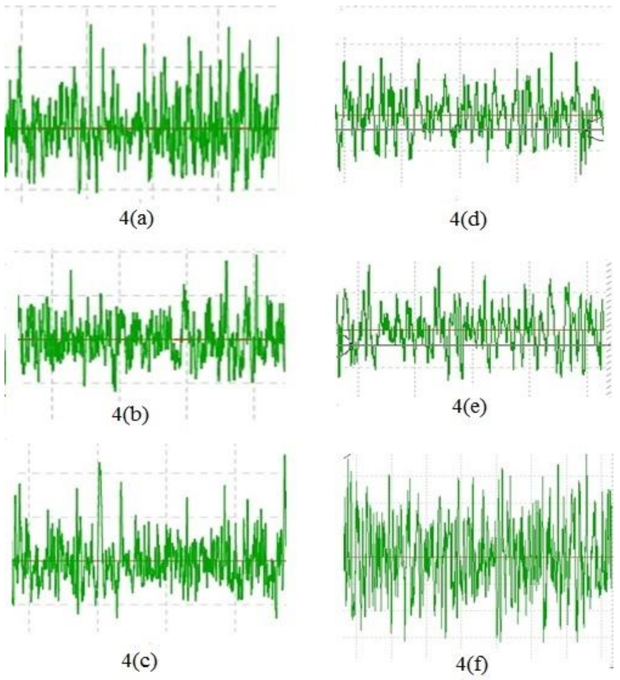

Figure 4 Surface Profile Ra 4 (a, b, c) of H.S.S and 4(d, e, f) Titanium 31 Wire EDM

The method of wearing away bears considerable similarity of EDM. The wearing down rates in WEDM that low energy pulses and arcing unaided may not be cause but also short circuits among electrode and work with current surge. The normal arc discharge chief quantity of melt metal is retained and only minute parts get detached when atomized droplets.

Table 5 Experimental design for H.S.S for MICRO EDM DRILL

Sl. No	A µ se c	B µ sec	R_a µ m	R_{sk} µ m	R_{ku} µ m	Speed mm/ min
1	1	1	2.660	0.2356	2.8418	1.845
2	3	1	2.745	0.2643	2.8521	1.946
3	7	1	2.008	0.2458	2.8551	1.866
4	9	1	1.895	0.2254	2.8201	1.807
5	1	3	2.454	0.2239	2.7526	1.908
6	3	3	2.324	0.2245	2.6252	1.962
7	7	3	1.466	0.2658	2.5542	1.833
8	9	3	1.108	0.2478	2.5418	1.834
9	1	7	1.245	0.2486	2.5015	1.844
10	3	7	1.306	0.2125	2.6451	1.856
11	7	7	1.346	0.2548	2.8428	1.840
12	9	7	1.464	0.2264	2.8284	1.843
13	1	9	2.100	0.26 32	2.7251	1.836
14	3	9	2.147	0.2556	2.8171	1.932
15	7	9	1.955	0.2256	2.8278	1.944
16	9	9	1.986	0.2588	2.8543	1.868
Tot al	80	80	30.20 9	3.8786	43.8850	29.964
Av era ge	5	5	1.888	0.2424	2.7428	1.873

Table 6: Experimental design for Titanium 31 for MICRO EDM DRILL

Sl . N o	A µ sec	B µ sec	R_a µ m	R_{sk} µ m	R_{ku} µ m	Speed mm/ min
1	1	1	1.804	0.9354	1.452	1.640
2	3	1	1.665	0.9586	1.425	1.543
3	7	1	1.060	0.9765	1.562	1.548
4	9	1	1.006	0.9548	1.575	1.499
5	1	3	1.768	0.9625	1.545	1.467
6	3	3	1.456	0.9842	1.585	1.489
7	7	3	1.398	0.9702	1.532	1.463
8	9	3	1.387	0.9844	1.652	0.987
9	1	7	0.946	0.9789	1.611	0.948
10	3	7	0.956	0.9782	1.545	0.936
11	7	7	0.988	0.9648	1.536	0.944
12	9	7	0.974	0.9246	1.541	0.942
13	1	9	1.179	0.9325	1.521	0.952
14	3	9	1.180	0.9562	1.548	1.400
15	7	9	1.199	0.9745	1.525	1.501
16	9	9	1.204	0.9325	1.524	1.581
T ot al	80	80	20.170	15.3688	24.679	20.840
A ve ra ge	5	5	1.260	0.9605	1.5424	1.302

The short circuits give to a large extent poorer expulsion and lesser retention of melt metal. The wearing away method in WEDM wants more exploration.

A different attractive and clear study gives lesser erosion rates in H S S compare to Titanium 31 in of WEDM. Therefore reason, lesser thermal and electrical conductivity of Titanium 31 ensuing in lesser energy concentration. Therefore past possibilities can act on minor share of pulse energy and reduced compatibility among the electrode. The lesser wearing away rates through declining pulse current have the noticeable cause of lesser pulse energies.

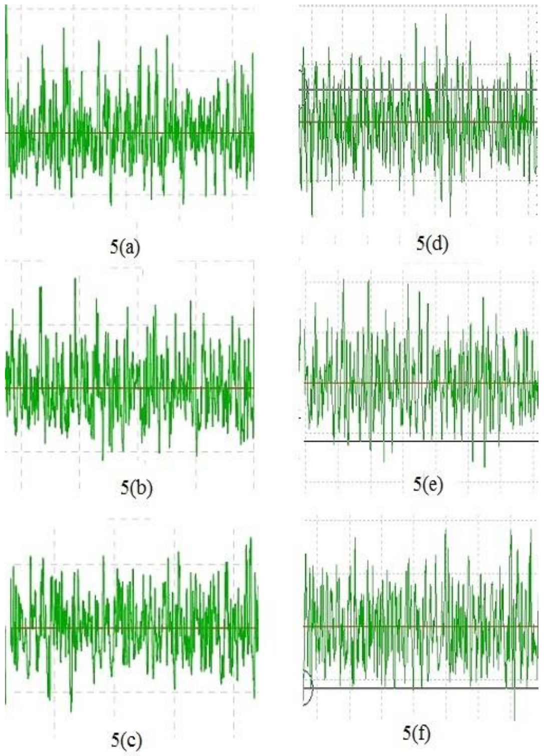

Figure 5 Surface Profile Ra 5(a, b, c) of H.S.S and 5(d, e, f) Titanium 31 Micro EDM Drill

IV. CONCLUSIONS

- Micro EDM Drill has considerably lower erosion charge for drilling micro holes.
- The H.S.S and Titanium 31 leads erosion rates of high thermal and also electrical conductive.
- Surface indiscretions follow normal pattern alike near that of erosion rates.
- Significant reserved metal which resoldified exhibits typical features of spark erosion in the form of gas pockets.
- The quenching effect of water as working fluid of Micro EDM Drill on Titanium 31 result irregular debris which sticks together and appears in sludge form. H S S by means of elevated thermal and electrical conductivity show lower wearing away rates compare to Titanium 31.
- Lower wearing away rate with declining current is compliance to assumption of electrical method of machining.
- Surface roughness's too have alike inclination as wearing away rate within the two material H S S and Titanium 31.

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