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Electrical discharge machining of ceramic coated Titanium alloy in Association with Ultrasonic Machining

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Abstract- The hybrid machining process is performed by connecting the ultrasonic machine tool with its +ve & -ne poles that are linked to the tool electrode as well as the work piece, respectively. Due to the comparative movement between the tool electrode and the work piece a pulse discharge is generated. In this the two-hybrid process, the EDM & ultrasonic machining are complementary techniques. Experimentation on Titanium Alloy coated to ceramic results showed that the MRR is a bit higher than just the combination of USM as well as the EDM. The surface roughness obtained look similar to that of finishing obtained in the USM.

Keywords: *ultrasonic machining, EDM, Titanium, Ceramic*

Introduction

In the engineering applications the advanced ceramics are rapidly emerging for their wide range of remarkable properties in terms of strength, hardness at elevated temperatures and also their chemical stability, electric properties and extreme wear resistance that are making them appropriate as components in the aeronautics, tools & dies[4]. Apart from their applications the difficulties in the fabrication process and the high cost helped them to gain a partial acceptance in the industrial applications. The process of machining the ceramics with the traditional methods need high labours work and takes more time to attain the finished dimensions. To recognize the possibilities of the materials there is need of development of a new technique for machine comple component with high precision and good surface integrity[3].

Ultrasonic machining, where abrasive fragments in a slury by water will be presented to the working surface in the company of an ultrasonic oscillating tool shaping it to the suitability in machining of ceramics because of its low MRR. EDM is a thermal process, in which the process of succession due to the electrical discharge, the material is removed. In this experimental study, USM associated with EDM method is conducted by means of dc power to characterize the spark erosion with an ultrasonic frequency[7].

Methodology

The virtue of combination of USM & EDM use the fundamental spark erosion principle by ultrasonic frequency. In a fluid form there is no change in resistance generally[8]. The relation $U_{kp} = E_{kp} * L$

helps to find the distance of micro meters. The ultrasonic frequency electrical signals have being transformed into the mechanical vibrations and this vibration happens to be amplified by a concentrator (see Fig 1). At the tip of the tool the amplitude of vibration enlarges to $10\ to\ 50\mu m$ which makes the tool to vibrate ultrasonically at specific amplitude. The equation to express the vibration is $u(t) = A.\sin(2\pi ft + \varphi)$. ------(1)

$u(t) = tool\ face\ displacement$

$A = tool\ face\ amplitude$

$f = frequency\ of\ vibration$

The equation for the tool velocity is $v(t) = 2\pi fA.\cos(2\pi ft + \varphi)$ -------(2)

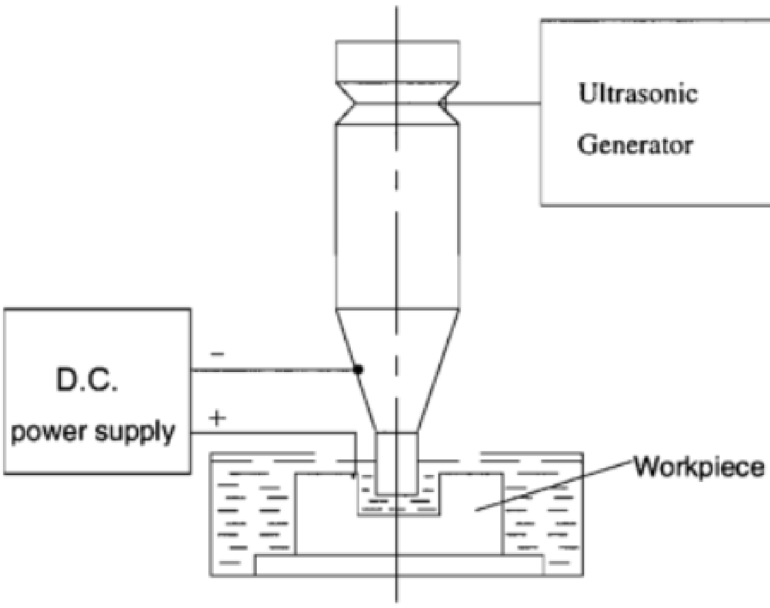

Fig 1: Spark erosion Principle

Once the tool goes towards the work sample, the gap reduces gradually and reaches a specific value the electrical potential amongst the conductors ends around dielectric liquid and the discharge proceeds[1]. On the closer approach of the tool towards the work piece, a discharge channel is created where the discharge energy is concentrated. This creates an detonation effect and increase in the melting effect at that point. The gap of the tool is directly proportional to the pressure developed at the zone, here the movement of the tool from workpiece makes the melted material to flow away and the new dielectric fluid come into the gap[3]. As the gap increases between the tool and workpiece the electric discharge medium cut off. The tool face typically vibrates at a frequency of $appox\ 25\ KHz$. The phase time for one discharge is $T = 1/f$. And the time interval $t_o = T - t_e$. And the peak current is $I_p = \frac{U-U_e}{R}$.

Materials

For the experimentation the Sic ceramic and Titanium $Ti - 6Al - 2Sn - 4Zr - 6Mo$ alloy are chose and their compositions & properties are tabulated Table 1 & 2.

Table 1: The Mechanical properties of SiC ceramic

Silicon Carbide Properties			
Mechanical	**SI/Metric (Imperial)**	**SI/Metric**	**(Imperial)**
Density	gm/cc (lb/ft^3)	3.1	(193.5)
Porosity	% (%)	0	(0)
Color	—	black	—
Flexural Strength	MPa (lb/in^{2}x10^3)	550	(80)
Elastic Modulus	GPa (lb/in^{2}x10^6)	410	(59.5)
Shear Modulus	GPa (lb/in^{2}x10^6)	—	—
Bulk Modulus	GPa (lb/in^{2}x10^6)	—	—
Poisson's Ratio	—	0.14	(0.14)
Compressive Strength	MPa (lb/in^{2}x10^3)	3900	(566)
Hardness	Kg/mm^2	2800	—
Fracture Toughness K_{IC}	MPa•m$^{1/2}$	4.6	—
Maximum Use Temperature (no load)	°C (°F)	1650	(3000)

Table 2: Chemical composition of Titanium Alloy

Element	Al	Mo	Zr	Sn
Weight %	6	6	4	2

Owing the high temperature and elevated energy density throughout the province of a plasma channel, eletro discharge to be processed of thermal shock sensitivity substances like the TiB_2 remove material by thermal spalling[2]. Material has been removed by melting, vaporization & ejection. The lack of corelation between the MRR or surface integrity an entirely new machining technique that blends the both process of USM & EDM including ultrasonic frequency can be carried out.

Results & Discussions

A hot hard-pressed Sic centered ceramic was chosen as work-piece material. Table 3 presents a summary of its MRR & SR of Ultrasonic machining of SiC ceramic**.**

Table 3: MRR & SR of maching

Test Conditions	Material Removal Rate (MRR) (mm^3 min^{-1})	Surface Roughness (Ra) (µm)
2A = 15 µm, W =1.35 kg, 240 grit $NaHCO_3$	0.504	0.5037
2A = 15 µm, W =1.35 kg, 150 grit $NaHCO_3$	0.9408	0.6717
2A = 15 µm, W =1.35 kg, 80 grit $NaHCO_3$	1.288	0.7613
2A = 15 µm, W =2.25 kg, 80 grit $NaHCO_3$	1.1424	0.7277
2A = 15 µm, W =0.45 kg, 80 grit $NaHCO_3$	0.784	0.6493

The tool 6*18 mm^2 sized top surface, the volumetric material removal rate has been noticed to be an average of $0.504\ to\ 1.3\ mm^3\ min^{-1}$ dependent upon the progression parameters. As the grit size increases there is direct increase in the values of MRR for the static load on the tool. Likewise, a surface texture has been found to be enhance and distinctively lies between the 0.5037 to 0.7277 mm contributed to the improvement in the end conditions.

Spark erosion along by ultrasonic frequency was conducted along through an ultrasonic generator with an amplitude range 100 to 70%, with an ultrasonic power of 3KW, frequency 20KHZ. The tool surface size is of 6*18 mm^2 and the distilled water has been used as insulating fluid. The test results indicate that the MRR and SR both rise with increase in voltage as it is mentioned in equation (1). Unless the voltage remains so elevated that discharge to the channel gap cannot be disrupted once the gap makes its biggest size, the process could not function properly[6]. Experimental results show that MRR of in combination technology is slightly larger than simply the sum of ultrasonic and EDM at the same time the surface texture remains not beyond the one in which of EDM.

Conclusion

The integrated technique of making ultrasonic vibration equipment for EDM know how to be done utilizing an ultrasonic machine instrument with a power supply of direct current, its $+ve\ and\ -ve\ poles$ are attached to the work piece besides the electrode of the instrument, correspondingly [5]. Throughout the process of assembling the equipment, the ultrasonic & EDM equipment assists with one another. Test findings demonstrate that the removal rate is just higher than the total amount of ultrasonic and EDM equipment, and the area size is beneath that of EDM. Test results indicate that the rate of removal of goods & the size of the environment increase with increasing dc strength. power supply, tool tip size, and current discharge.

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