Optimization of EDM characteristics of Tungsten carbide/Cobalt based Composites

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Abstract- **The Experimental Investigation of machining and mechanical characteristics ofTungsten carbide/Cobalt (WC/CO) composite,which is a vital composite material employed for manufacturing the largely universal and thriving dies, cutting tool as well as other special purpose tools. It is not possible to machine this machine this material easily through conventional techniques that is why the electro - discharge machining (EDM) is used for machining of WC/CO based material, which is produced through powder metallurgy route.It has been carried out on the influence of parameters factors such as Electrode rotation (S), Pulse on time (T) Flushing pressure (P), Current(C) and voltage (V) of EDM were chosen as input variables to optimize the process performance characteristics in terms of material removal rate (MRR) and surface roughness (Ra).The Response Surface Methodology (RSM) was used to identify the most important parameters to maximize the material removal rate and minimize the surface roughness.In this paper study to focus on optimization of EDM characteristics of tungsten carbide/cobalt based composites.**

Index Terms- Material Removal Rate (MRR), Surface Roughness (Ra), Response Surface Methodology (RSM).

I. INTRODUCTION

Electrical discharge machining (EDM) actually is a process of utilizing the removal phenomenon of electrical-discharge in dielectric. Therefore, the electrode plays an important role, which affects the material removal rate and the tool wear rate Electrical discharge machine (EDM) technology is increasingly being used in tool, die and mould making industries, for machining of heat treated tool steels and advanced materials (super alloys, ceramics, and metal matrix composites) requiring high precision, complex shapes and high surface finish

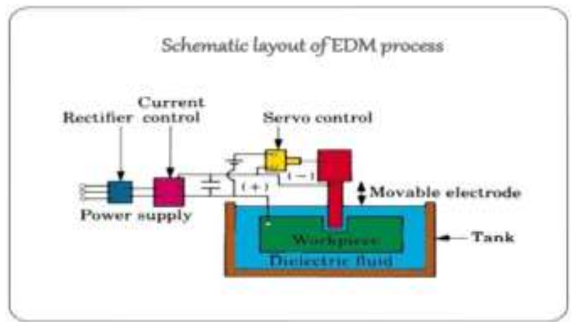

Fig 1.1 EDM Process

1.1Process Parameter- Discharge Voltage in EDM is related to the spark gap and breakdown strength of the dielectric. The present voltages determine the width of the spark gap between the leading edge of the electrode and work piece.
1.2 Peak Current-This is the amount of power used in discharge machining, measured in units of amperage and is the most important machining parameter n EDM. During each on time pulse, the current increases until it reaches the preset level,Which is expressed as the peak current.
1.3 Pulse On Time- Pulse on time is defined as the time during which the machining is performed.
The machining process becomes faster after increasing the pulse on time.
1.4 Pulse Off Time-It is the time during which re-ionization of the dielectric take place. An insufficient off time can lead to erratic cycling and retraction of the advancing servo thereby slowing down the operation cycle.

II. LITERATURE REVIEW

Experimental design is widely used in manufacturing (Ray, 2006; Sharma 2013; Luchkov, 2005).classify experimental problems in to five broad categories according their objectives: treatment comparisons, variable screening, response surface exploration, system optimization and system robustness. RSM is a critical technology in developing new processes, optimizing their performance and improving the design and/or formulation of new products.Myers (1995) also point out that most applications of RSM are sequential in nature. A screening experiment or a first order model is conducted first to identify important input factors. If the there is strong curvature exists and the first order model is not adequate, a second model or response surface model is needed., use sequential experimental design to improve the isolation of the fused biconical taper wavelength division multiplexer. In this paper, we design a full factorial experiment to find the important factors and a response surface model to optimize process parameters to improve coplanarity of the terminal of earphone.

III. METHODOLOGY

Response surface methodology (RSM) is a collection of mathematical and statistical techniques useful for analyzing problems in which several independent variables influence a dependent variable or response, and the goal is to optimize this response. In many experimental conditions, it is possible to represent independent factors in quantitative .The main idea of RSM is to use a sequence of designed experimentsto obtain an optimal response.Important RSM properties and features orthogonality: The property that allows individual effects of the k-factors to be estimated independently without (or with minimal) confounding. Also orthogonality provides minimum variance estimates of the model coefficient so that they are uncorrelated rotatability: The property of rotating points of the design about the center of the factor space. The moments of the distribution of the design points are constant.

IV. EXPERIMENTAL PROCEDURE

EDM is an unconventional machining process used for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining process. The process involves a controlled erosion of electrically conductive materials by the initiation of rapid and repetitive spark discharges between the tool and work piece separated by a small gap of about 0.01to 0.50. This study is mainly focused on aspects related to surface quality and metal removal rate which are the most important parameters from the point of view of selecting the optimum condition of processes as well as economical aspects.

4.1 Composite: A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions.The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

Ceramic matrix composites (composite ceramic and metal matrices used in this projec)

Selection of Material - Tungsten carbide -Cobalt

Tungsten carbide (chemical formula: WC) is a chemical compound (specifically, a carbide) containing equal parts of tungsten and carbon atoms. In its most basic form, tungsten carbide is a fine gray powder, but it can be pressed and formed into shapes through a process called sintering for use in industrial machinery, cutting tools, abrasives, armor-piercing rounds, other tools and instruments, and jewelry. Tungsten carbide is approximately twice as stiff as steel, with a Young's modulus of approximately 530–700 GPa (77,000 to 102,000 ksi),[4][7][8][9] and is double the density of steel—nearly midway between that of lead and gold. It is hardness can only be polished and finished with abrasives of superior hardness such as cubic boron nitride and diamond powder, wheels, and compounds.

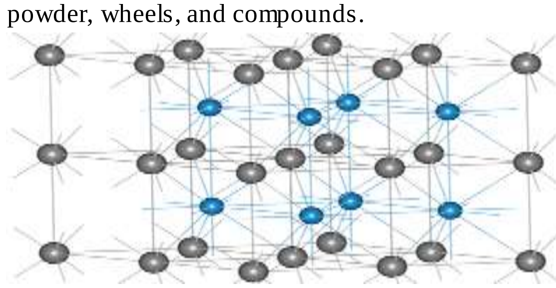

Fig 1.2 Tungsten Carbide Structure

Cobalt is a chemical element with symbol Co and atomic number 27. Like nickel, cobalt is found in the Earth's crust only in chemically combined form, save for small deposits found in alloys of natural meteoric iron. The free element, produced by reductive smelting, is a hard, lustrous, silver-gray metal.Cobalt is the active center of a group of coenzymes called cobalamins. vitamin B12, the best-known example of the type, is an essential vitamin for all animals.

Cobalt in inorganic form is also a micronutrient for bacteria, algae, and fungi. Cobalt-based blue pigments (cobalt blue) have been used since ancient times for jewelry and paints, and to impart a distinctive blue tint to glass, but the color was later thought by alchemists to be due to the known metal bismuth. Cobalt is primarily used in the manufacture of magnetic, wear-resistant and high-strength alloys. The compounds cobalt silicate and cobalt(II) aluminate ($CoAl_2O_4$, cobalt blue) give a distinctive deep blue color to glass, ceramics, inks, paints and varnishes. Cobalt occurs naturally as only one stable isotope, cobalt-59. Cobalt-60 is a commercially important radioisotope, used as a radioactive tracer and for the production of high energy gamma rays.

Fig 1.3 Cobalt structure

Composition of Tungsten carbide- cobalt (80 %WC - 20%CO) -Tungsten carbide-cobalt is an alloy of hard, ceramic tungsten carbide and the ductile cobalt, often known as cemented carbide. The material is a metal matrix composite, in which cobalt particles are ambedded in a tungsten carbide matrix,Nano-particles exhibit unexpected behavior that cannot be achieved with basic elements in their original states. These unexpected properties of nano-particles have expanded their applications to the field of cosmetics, bio-medicine, electronics, etc. This article will look into the properties and applications of tungsten carbide-cobalt nano-alloy.

Chemical properties: Tungsten carbide-cobalt nano-particles are as per the table below.

Chemical symbol	Wc-co
CAS No	-
Group	Tungsten6,carbon 14,cobalt 9
Electronic configuration	Tungsten (Xe) (4f145d46s2, carbonHe2s22p2, cobalt(Ar)3d74s2

Physical Properties : Tungsten carbide-cobalt nano-particles appear as a black powder having nearly spherical morphology. The physical properties are as below.

Properties	Metric	Imperial
Density	3.9 g/cm3	0.14 lb/in3

Thermal properties : Tungsten carbide-cobalt nano-particles are provided in the table below.

Properties	Metric	Imperial
Melting Point	2867°C	5192°F
Boiling Point	6000°C	10832°F

Some of the applications of tungsten carbide-cobalt are given below

- For press and sintering purposes
- Making of chip-less forming tools
- Mixed with coatings to enhance their hardness and strength
- Production of mining, cutting tools and other wear resistant machine parts

V. RESULT AND DISCUSSION

We are discussing about effect or influence of machining parameter, discharge current, pulse on time, voltage on material removal rate (MRR), surface roughness (Ra). Machined work piece with tungsten carbide cobalt tool and find out them.

Various input parameters:

- Rotational speed (s),rpm
- Current (c).amps
- Pulse on time (T),sec
- Voltage (v),volt

Output parameter:

- Surface Roughness,
- Metal Removal Rate

VI. DESIGN OF EXPERIMENTS:

The design of experiments is the design of any task that aims to describe or explain the variation of information under conditions that are hypothesized to reflect the variation. The term is generally associated with experiments in which the design introduces conditions that directly affect the variation, but may also refer to the design of quasi-experiments, in which natural conditions that influence the variation are selected for observation.

Std order	Speed (RPM)	Voltage (V)	Pulse on time (S)	Current (I)	MRR (mm^3/min)	Ra (µ m)
1	200	40	600	10	15.09	18.23
2	200	40	600	10	18.19	20.12
3	600	60	600	10	14.99	18.12
4	600	60	600	10	19.41	17.99
5	400	40	400	10	14.90	17.84
6	400	40	400	10	14.00	17.31
7	400	40	800	10	12.92	16.05
8	400	40	800	10	16.06	19.31
9	200	30	600	5	14.83	17.99
10	600	60	600	5	15.79	18.54
11	600	80	600	15	19.55	18.02
12	600	80	600	15	19.71	18.12
13	600	60	600	10	13.35	16.85
14	600	60	600	10	13.35	16.85
15	600	60	600	10	17.65	20.15
16	600	60	600	10	15.01	18.34

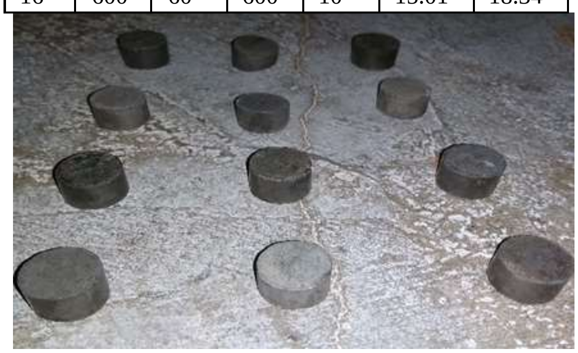

Fig6.1 Specimen view

VII. GRAPH ANALYSIS

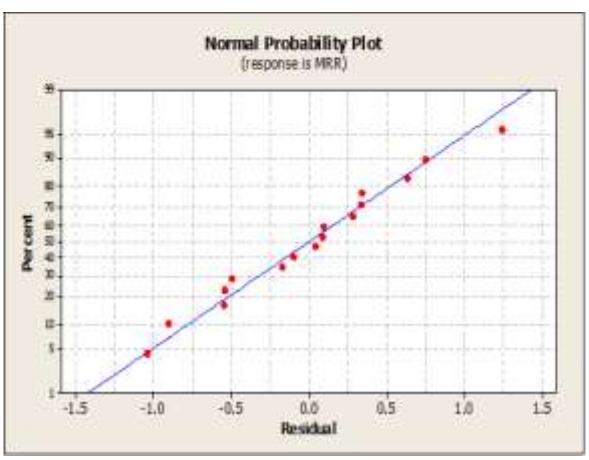

Fig 7.1Normal probability plot for MRR

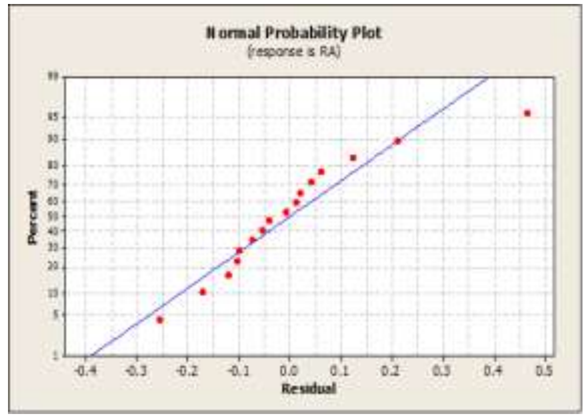

Fig 7.2 Normal probability plot for Ra

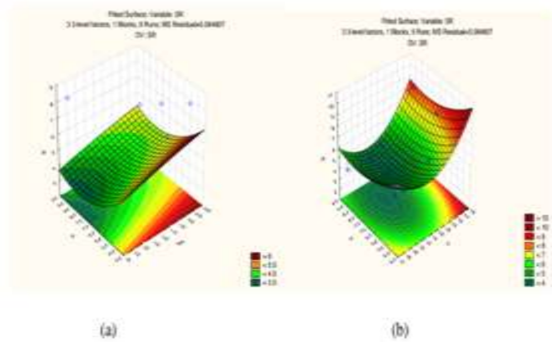

Fig 7.3Three dimensional surface plots of I, T and V

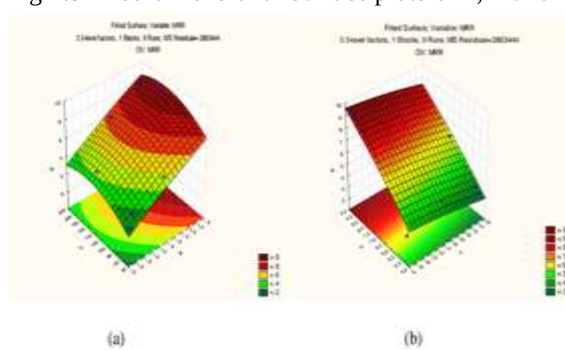

Fig 7.4 Three dimensional surface plots of I, T and V

VIII. CONCLUSION

Evaluating the effects on machining parameters on surface roughness and material removal rate presenting the optimal machining conditions as arriving the optimum values material removal rate MRR 16.85mm3/min and surface roughness SR 2.95µm. The experimental result confirms the optimization of the machining process using the RSM methodology for enhancing the machining performance.

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