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Experimental Investigation to Optimize Process Parameters Using Copper Electrodes in Die Sinking EDM Process Machining P20 Steel

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ABSTRACT:

The sinker EDM machining (Electrical Discharge Machining) process uses an electrically charged electrode that is configured to a specific geometry to burn the geometry of the electrode into a metal component. The sinker EDM process is commonly used in the production of dies and molds. Two metal parts submerged in an insulating liquid are connected to a source of current which is switched on and off automatically depending on the parameters set on the controller. When the current is switched on, an electric tension is created between the two metal parts.

The main aim of this thesis is to investigate the performance characteristics during sinker electrical discharge machining by taking P20 steel as work piece materials. The electrode material is copper. The parameters pulse on time and off time, spark gap and current are considered as input parameters to determine effect of parameters on material removal rate (MRR), tool wear rate and surface roughness. Different electrode shapes round, hexagonal are taken for experimentation. Different experiments are conducted to optimize the input parameters by considering their effect on material removal rate and surface finish.

I. INTRODUCTION:

INTRODUCTION TO EDM:

A machining method typically used for hard metals, Electrical Discharge Machining (commonly known as "EDM Machining") makes it possible to work with metals for which traditional machining techniques are ineffective.

An important point to remember with EDM Machining is that it will only work with materials that are electrically conductive. With good EDM Machining equipment it is possible to cut small odd-shaped angles, detailed contours or cavities in hardened steel as well as exotic metals like titanium, hastelloy, kovar, inconel, and carbide. The EDM Process is commonly used in the Tool and Die industry for mold-making, however in recent years EDM has become a integral part for making prototype and production parts. This is seen in the aerospace and electronics industries where production quantities remain low.

When the distance between the two electrodes is reduced, the intensity of the electric field in the volume between the electrodes becomes greater than the strength of the dielectric (at least in some point(s)), which breaks, allowing current to flow between the two electrodes. This phenomenon is the same as the breakdown of a capacitor (condenser) (see also breakdown voltage). As a result, material is removed from both the electrodes.

Once the current flow stops (or it is stopped – depending on the type of generator), new liquid dielectric is usually conveyed into the inter-electrode volume enabling the solid particles (debris) to be carried away and the insulating properties of the dielectric to be restored. Adding new liquid dielectric in the inter-electrode volume is commonly referred to as flushing. Also, after a current flow, a difference of potential between the two electrodes is restored to what it was before the breakdown, so that a new liquid dielectric breakdown can occur.

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Die-sink EDM:

Two Russian scientists, B. R. Lazarenko and N. I. Lazarenko, were tasked in 1943 to investigate ways of preventing the erosion of tungsten electrical contacts due to sparking. They failed in this task but found that the erosion was more precisely controlled if the electrodes were immersed in a dielectric fluid. This led them to invent an EDM machine used for working difficult to machine materials such as tungsten. The Lazarenkos' machine is known as an R-C-type machine after the RC circuit used to charge the electrodes. Simultaneously, but independently, an American team, Harold Stark, Victor Harding, and Jack Beaver, developed an EDM machine for removing broken drills and taps from aluminium castings.

Initially constructing their machines from feeble electric-etching tools, they were not very successful. But more powerful sparking units, combined with automatic spark repetition and fluid replacement with an electromagnetic interrupter arrangement produced practical machines. Stark, Harding, and Beaver's machines were able to produce 60 sparks per second. Later machines based on the Stark-Harding-Beaver design used vacuum tube circuits that were able to produce thousands of sparks per second, significantly increasing the speed of cutting.

AIM OF THE THESIS:

The main aim of this thesis is to investigate the performance characteristics during sinker electrical discharge machining by taking P20 as work piece material. The electrode material is copper. The parameters spark gap, pulse on time and off time, and current are considered as input parameters to determine effect of parameters on material removal rate (MRR), tool wear and surface roughness. Different electrode shapes round, and hexagonal are taken for experimentation. Different experiments are conducted to optimize the input parameters by considering their effect on material removal rate, surface roughness and tool wear.

Fig – Die Sink EDM Machine

TECHNICAL SPECIFICATION:

Model	Max. Normal Output current LV/HV (AMP)	Max.machining Speed(mm³/MIN)	Min. Electrode Wear ratio (Under)	Best surface Finish (Ra µm)	Power Consumption (KVA)
30A	30/5	200	0.2%	0.2	4
45A	45/5	300	0.2%	0.2	5.5
60A	60/5	400	0.2%	0.2	7
90A	90/5	600	0.2%	0.2	10
120A	120/5	800	0.2%	0.2	13

Machine Specification

Model	M430 CNC	M750 CNC	M860 CNC	M1060 CNC	M1270 CNC	M1310 CNC	M1470 CNC
Table size	840×520	840×520	1250×750	1250×750	1350×820	1430×1100	1850×1000
Worktank(L)	1200	1380	1570	1670	1870	2010	2010
(W)	660	790	1100	1100	1250	1700	1350
(H)	410	460	625	625	625	800	625
X axis travel	400	700	800	1000	1200	1300	1400
Y axis travel	300	500	600	600	700	1000	700
Z Axis travel	300	450	500	500	500	600	500
Table-Quill Distance	650	700	420-920	420-920	510-1010	750-1350	550-1050
Maximum Electrode Weight	150Kg	180Kg	400Kg	400Kg	400Kg	500Kg	450Kg
Maximum Table Load	4200Kg	5200Kg	6000Kg	7000Kg	8000Kg	11000Kg	8500Kg
Dielectric tank capacity(L)	100	400 or 600	1400	1600	1800	2800	2000
Filters	3	3	6	6	8	8	8
Machine Weight	2700+650Kg	3200+650Kg	5200Kg	5600Kg	6600Kg	13100Kg	8100Kg

Fig – Technical Specification of EDM machine

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PROCESS PARAMETERS AND DESIGN:

	ROUND ELECTRODE				
	PULSE ON TIME (µs)	PULSE OFF TIME (µs)	SPARK GAP (mm)	ELECTRODE DIA (mm)	CURRENT (Amps)
CASE 1	10.55	11.45	12.6	12.35	7
CASE 2	11.5	12.2	12.7	12.35	10
	HEXAGONA ELECTRODE				
	PULSE ON TIME (µs)	PULSE OFF TIME (µs)	SPARK GAP (mm)	ELECTRODE DIA (mm)	CURRENT (Amps)
CASE 1	10.55	11.45	12.6	12.35	7
CASE 2	11.5	12.2	12.7	12.35	10

Fig – Die EDM machine

Fig – Initial workpiece material

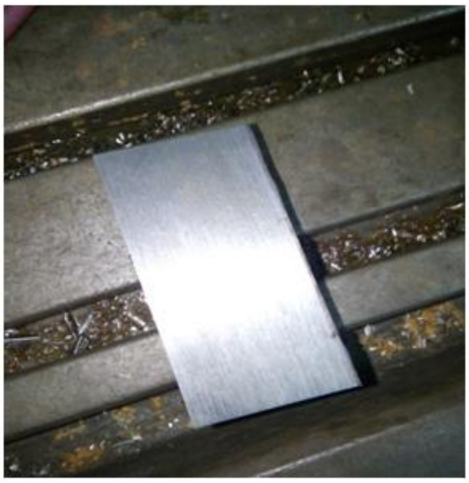

Fig – Workpiece after initial machining

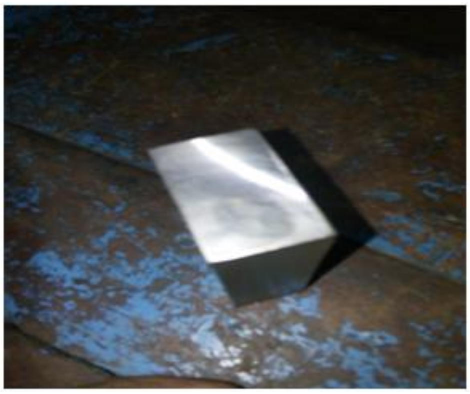

Fig – Workpiece after initial machining

Fig – Machine Setup

Fig – Workpiece setup in machine

Fig – Round Electrode Setup

Fig – Round Electrode Setup with fixtures

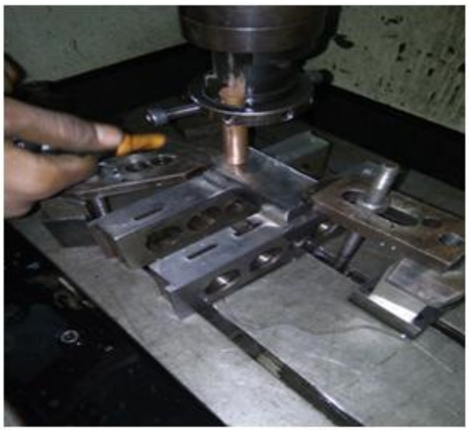

Fig – Arrangement for Lubricant Oil Flow

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Fig – Machine with electrode and work piece

Fig – Machining of work piece using round electrode

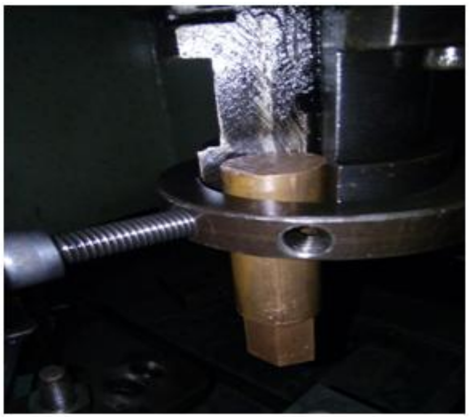

Fig – Setting of Hexagonal shaped electrode on the machine

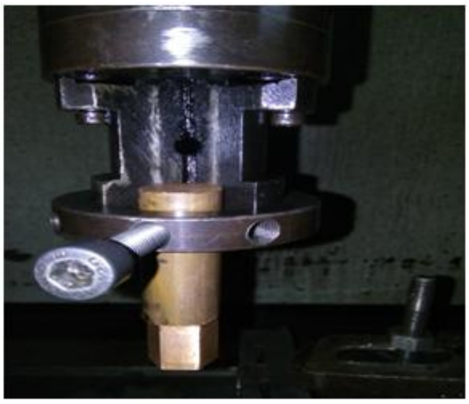

Fig – Hexagonal Electrode

Fig – Machining of work piece using Hexagonal electrode

Fig – Final work piece after machining

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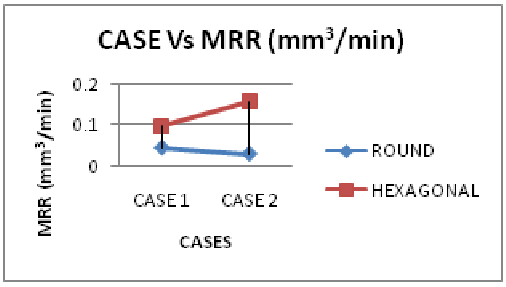
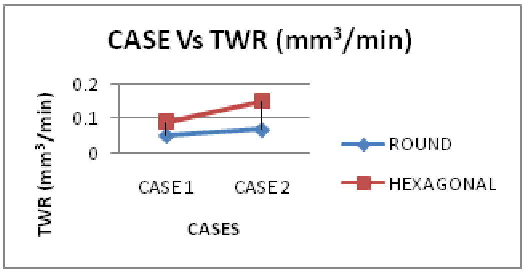
EXPERIMENTAL RESULTS:

MATERIAL REMOVAL RATE:



By observing the above results, material removal rate is more for hexagonal electrode.

TOOL WEAR RATE:



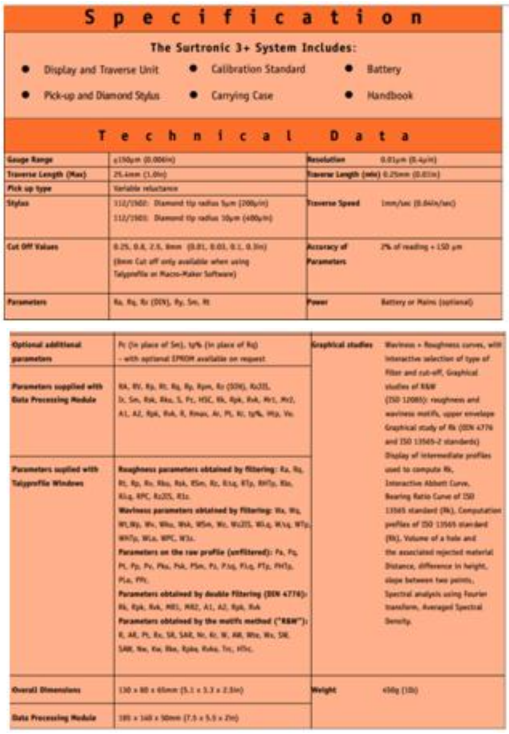
By observing the above results, tool wear rate is less for round electrode.

SURFACE FINISH RESULTS:

In this project most important output performances in Die Sink EDM such as Surface Roughness (Ra) is considered for optimizing machining parameters. The surface finish value (in μm) was obtained by measuring the mean absolute deviation, Ra (surface roughness) from the average surface level using a Computer controlled surface roughness tester.

Surface Finish Tester – Model Surtronic 3+, Rank Taylor Hobson Ltd., Made in England which is periodically calibrated using Reference Specimen Type 112/1534. Lab Temperature 20 ±20^{0}C.

Fig – Surface finish Tester



Specification

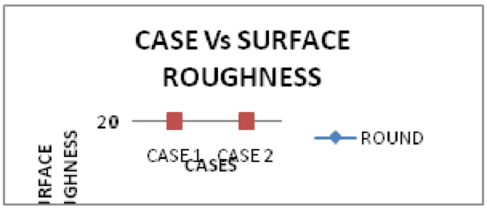
The Surtronic 3+ System Includes:

- Display and Traverse Unit
- Calibration Standard
- Battery
- Pick-up and Diamond Stylus
- Carrying Case
- Handbook

Technical Data

Gauge Range	±150μm (0.006in)	Resolution	0.01μm (0.4μin)
Traverse Length (Max)	25.4mm (1.0in)	Traverse Length (min)	0.25mm (0.01in)
Pick up type	Variable reluctance	Traverse Speed	1mm/sec (0.04in/sec)
Stylus	112/1502: Diamond tip radius 5μm (200μin) 112/1503: Diamond tip radius 10μm (400μin)		
Cut Off Values	0.25, 0.8, 2.5, 8mm (0.01, 0.03, 0.1, 0.3in) (8mm Cut off only available when using Talyprofile or Macro-Maker Software)	Accuracy of Parameters	2% of reading + 150 μm
Parameters	Ra, Rq, Rz (DIN), Ry, Sm, Rt	Power	Battery or Mains (optional)
Optional additional parameters	Pc (in place of Sm), tp% (in place of Rq) - with optional EPROM available on request	Graphical studies	Waviness + Roughness curves, with interactive selection of type of filter and cut-off. Graphical studies of R&W (ISO 12085): roughness and waviness motifs, upper envelope Graphical study of Rk (DIN 4776 and ISO 13565-2 standards) Display of intermediate profiles used to compute Rk, Interactive Abbott Curve, Bearing Ratio Curve of ISO 13565 standard (Rk), Computation profiles of ISO 13565 standard (Rk), Volume of a hole and the associated rejected material Distance, difference in height, slope between two points, Spectral analysis using Fourier transform, Averaged Spectral Density.
Parameters supplied with Data Processing Module	RA, RV, Rp, Rt, Rq, Ry, Rpm, Rz (DIN), Rz(JIS), Dr, Sm, Rsk, Rku, S, Pc, HSC, Rk, Rpk, Rvk, Mr1, Mr2, A1, A2, Rpk, Rvk, R, Rmax, Ar, Pt, W, tp%, Htp, Vo		
Parameters supplied with Talyprofile Windows	**Roughness parameters obtained by filtering:** Ra, Rq, Rt, Rp, Rv, Rku, Rsk, RSm, Rz, R∆q, RTp, RHTp, Rlo, R λq, RPC, Rz(JIS), R3z. **Waviness parameters obtained by filtering:** Wa, Wq, Wt, Wp, Wv, Wku, Wsk, WSm, Wz, Wz(JIS), W∆q, Wλq, WTp, WHTp, Wlo, WPC, W3z. **Parameters on the raw profile (unfiltered):** Pa, Pq, Pt, Pp, Pv, Pku, Psk, PSm, Pz, P∆q, Pλq, PTp, PHTp, Plo, PPc. **Parameters obtained by double filtering (DIN 4776):** Rk, Rpk, Rvk, MR1, MR2, A1, A2, Rpk, Rvk **Parameters obtained by the motifs method ("R&W"):** R, AR, Pt, Rx, SR, SAR, Nr, Kr, W, AW, Wte, Wx, SW, SAW, Nw, Kw, Rke, Rpke, Rvke, Trc, HTrc.		
Overall Dimensions	130 x 80 x 65mm (5.1 x 3.3 x 2.5in)	Weight	450g (1lb)
Data Processing Module	195 x 140 x 50mm (7.5 x 5.5 x 2in)		

Fig – Technical Specifications of surface finish tester



By observing the above results, surface roughness is less for round electrode.

CONCLUSION:

In this thesis, the performance characteristics during sinker electrical discharge machining by taking P20 Tool Steel as work piece materials are investigated. The electrode material is copper. The parameters spark gap, pulse on time and off time, and current are considered as input parameters to determine effect of parameters on material removal rate (MRR), tool wear and surface roughness values. Different electrode shapes round and hexagonal are taken for experimentation.

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By observing the experimental results, the following conclusions can be made:

- Material removal rate is more for hexagonal electrode and increases with increase of pulse on time, pulse off time and current.
- Tool wear rate is less for round electrode and increases with increase of pulse on time, pulse off time and current.
- Surface roughness is less for round electrode and increases with increase of pulse on time, pulse off time and current.

REFERENCES:

1. M.A. Ali, M. Samsul, N.I.S. Hussein, M. Rizal, R. Izamshah, M. Hadzley, M.S. Kasim, M.A. Sulaiman and S. Sivarao, The Effect of EDM Die-sinking Parameters on Material Removal Rate of Beryllium Copper Using Full Factorial Method, Middle-East Journal of Scientific Research 16 (1): 44-50, 2013, ISSN 1990-9233.
2. Nikhil Kumar, Lalit Kumar, Harichand Tewatia, Rakesh Yadav, Comparative study for MRR on die-sinking EDM using electrode of copper & graphite, International Journal of Advanced Technology &Engineering Research (IJATER) , VOLUME 2, ISSUE 2, MAY 2012.
3. J Jeevamalar and S Ramabalan, Die sinking EDM process parameters: A Review, Int. J. Mech. Eng. & Rob. Res. 2015, ISSN 2278 – 0149, Vol. 4, No. 1, January 2015.
4. Bhavesh A. Patel, D. S. Patel, Haresh A. Patel, Influence of Electrode Material and Process Parameters on Surface Quality and MRR in EDM of AISI H13 using ANN, International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169, Volume: 1 Issue: 12 858 – 869.
5. KuldeepOjha, R. K. Garg, K. K. Singh, MRR Improvement in Sinking Electrical Discharge Machining: A Review, Journal of Minerals & Materials Characterization & Engineering, Vol. 9, No.8, pp.709-739, 2010.
6. S V Subrahmanyam, M. M. M. Sarcar, Evaluation of Optimal Parameters for machining with Wire cut EDM Using Grey-Taguchi Method, International Journal of Scientific and Research Publications, Volume 3, Issue 3, March 2013, ISSN 2250-3153.
7. Atul Kumar, DR.D.K.Singh, Performance Analysis of Wire Electric Discharge Machining (W-EDM), International Journal of Engineering Research & Technology, Vol.1 - Issue 4 (June- 2012), e-ISSN: 2278-0181
8. M. Durairaja, D. Sudharsunb, N. Swamynathan, Analysis of Process Parameters in Wire EDM with Stainless Steel Using Single Objective Taguchi Method and Multi Objective Grey Relational Grade, Volume 4, Issue 1 (2016) 69-73 ISSN 2347 – 3258, International Journal of Advance Research and Innovation.
9. Ricky Agarwal, Optimization of process parameters of micro wire EDM, Research Gate
10. J.T. Huang, Y.S. Liao and Y.H. Chen, A Study to Achieve a Fine Surface Finish in Wire-EDM.

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