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Performance of a Low Cost Tabletop Die Sinker Electric Discharge Machining [EDM] Unit

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Abstract: New developments in the field of material science have led to new engineering metallic materials, composite materials, and high tech ceramics, having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. The recent development of new materials that are hard and difficult-to-machine such as tool steels, composites, ceramics, super alloys, hast alloy, nitralloy, waspalloy, nemonics, carbides, stainless steels, heat resistant steel, etc. being widely used in die and mould making industries, aerospace, aeronautics, and nuclear industries. Many of these materials also find applications in other industries owing to their high strength to weight ratio, hardness and heat resisting qualities. EDM has also made its presence felt in the new fields such as sports, medical and surgical instruments, optical, dental including automotive R&D areas. 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. Heat treated tool steels have proved to be extremely difficult-to-machine using traditional processes, due to rapid tool wear, low machining rates, inability to generate complex shapes and imparting better surface finish.EDM provides a easy solution. This ,present work provides an approach to make an EDM unit at reasonably low cost, and its performance.

Keywords: Sinker EDM, Die-electric media, Spark erosion**.**

THE SETUP:

The present paper deals with making a low cost setup of Sinker type EDM for general machining of hard materials like machining steels, ceramics, etc., using RC circuit with copper and graphite as tool material and kerosene as dielectric medium as shown in the Fig. 1. The performance and process capabilities of the developed setup are here under.

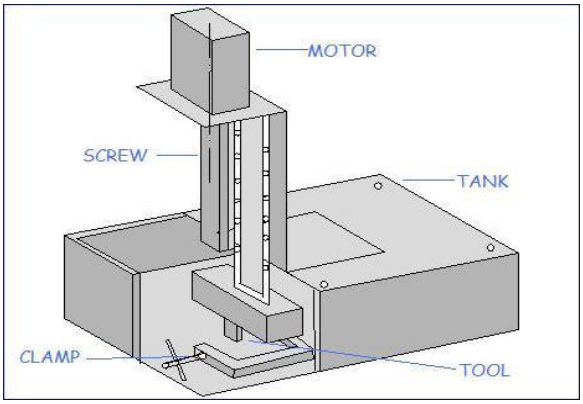

Fig. 1: Low Cost EDM Setup

Fig. 2: Low cost Sinker EDM

Part List:

Stepper Motor, Controller, Pulse Generator Circuit, Power Supply, Basic Electrical Components(Wires, Capacitors Etc), Graphite Electrode/Copper Electrode, Electrolyte-Kerosene, Plastic Tank, Fuel Filter, Etc. With Cost Of Re 7,000/-.[$300]

The power supply must provide enough spark to the sparking gap for material removal. It must also monitor the electrical conditions at the sparking gap and direct the machine servo in advancing, retracting, or maintaining the position of the electrode, in reference to the work piece. The dielectric unit must provide the dielectric fluid to the machine submersing the work piece. In addition, the dielectric unit must send fluid to the dielectric gap for cooling purposes and to remove the EDM chip. The

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dielectric unit includes a filtration system for cleaning the dielectric fluid. The machine tool is the focal point of the die-sinker.

DEVELOPMENT OF POWER SUPPLY:

A relaxation generator (R-C type) used as as power supply unit. The power supply unit used is quite simple. A VARIAC (Variable Auto Transformer) is used to adjust output voltage. In the power supply unit, rectification is normally achieved using a solid state diode. Diode has the property that will let the electron flow easily at one direction at proper biasing condition. Bridge rectifiers of 4 diodes are used to achieve full wave rectification. Two diodes will conduct during the negative cycle and the other two will conduct during the positive half cycle. Therefore bridge rectifier is used to convert AC to DC. This DC power supply is used to charge the capacitor connected in series to resistor. A filter capacitor provides smoothing of the DC voltage produced. A resistor allows the electrode to short to the work without blowing fuses, and also moderates the flow of current from the raw DC supply to the EDM capacitor and electrode.

The required circuit is connected and simulated by using the PSPICE software. The fallowing is one such circuit.

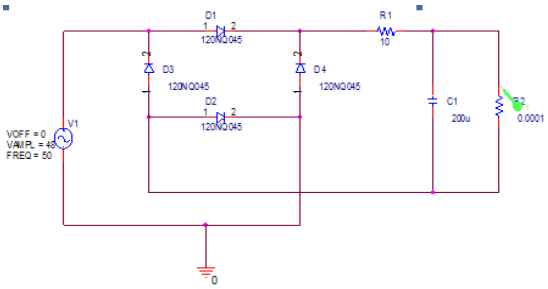

Fig.3 : Circuit of Power System

The current of 4.5amps was obtained in the simulation result. This circuit was then tested on the mild steel plate and the metal removal was observed on the work-piece surface. Thus this circuit was adopted.

SIMULATION RESULT:

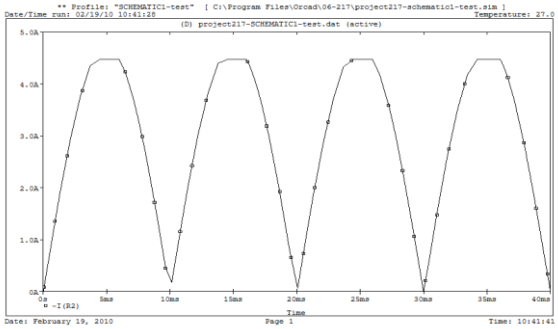

Fig.4: Charging and discharging with respect to time – for power circuit employed

RAM :

The Electrode used in the EDM machine should follow the predictable linear path free from the errors like back lash. The machine Ram designed by us consists of the following parts: 1. Drawer slide, 2. Lead Screw (1/4 -20"), 3. Coupling, 4. Stepper motor , 5. Aluminium column, 6. Electrode (Graphite and Copper)

The slide is actuated by the lead screw driven by the DC Stepper motor which is controlled by the 100:1 reduction gear box. The Lead Screw is UNC (Unified Coarse thread) 1/4 -20 in dimension. An appropriate nut of 3/8" dimension was made. This screw of longer length helps in reducing the back-lash.

The diagram shows the schematic of the RAM build. (From Bottom to Top)The insulated wooden block is used as an electrode holder. A metallic clamp is placed on the wooden block to hold the electrode firmly. The clamp can be connected to the power source. This block is mounted on the lower side of the slide. The next component is the mild steel block which carries the lead-screw nut. This block is mounted on the slide by Gas welding. Through this nut passes the lead screw, the other end of the screw is coupled to the motor shaft by a coupling made to size using mild steel cylindrical block. This coupling holds the screw and the shaft together without causing any relative motion between them.

This whole system is mounted on the aluminium "S" shaped frame as shown in the diagram and the picture. A (Dimension) plate is mounted on the Tub to carry the RAM. Two firm aluminium strips are used to support frame and stop the longitudinal motion caused by the motor vibration.

The whole system can be mounted on the milling machine table so that the machine remains flat and can be free from any other vibrations.

The followings are the different electrode materials which are used commonly in the industry: Graphite, Electrolytic oxygen free copper , Tellurium copper – 99% Cu + 0.5% tellurium, Brass.

For the present case copper and graphite electrodes are employed and their performance is observed for same workpiece.The properties of copper and graphite are presented below [6]

S.No	Property	Copper	Graphite
1	Density	8960 KG/M^3	(1.3-1.95) G/CM^3
2	Specificheat(293 K)	0.383 KJ/KG.K	(710-830) J/KG.K
3	Thermal conductivity	394 W/M.K	(25-470) W/M.K
4	Electrical conductivity	100%	(90-100)%
5	Cross Sectional Area	82.7267mm^2 (d=10.217mm)	132.1049mm^2 (d=12.911mm)

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PERFORMANCE WITH RESPECT TO POLARITY:

COPPER AS ELECTRODE: Here we conducted the experiment by connecting both the polarities to the work piece (MS) and the copper electrode of 10.217mm diameter. The picture shows the effect of the experiment on the work piece and electrode. Silver colored portion on the work piece shows the material removal. Darker portion on the electrode is carbon deposit.

S. No	Electrode	Polarity	Dielectric	Time in min	Current in A	Voltage in V	Surface Roughness
1.	Copper	-ve	Kerosene	15	4	48	0.03 mm
2.	Copper	+ve	Kerosene	15	6	48	0.07 mm

OBSERVATIONS:

By connecting the straight polarity in the circuit we got the following observations.

1. Temperature change was almost negligible.
2. Lower value of current is observed.
3. Metal removal was even.

By connecting the negative polarity to the work piece and the positive to the Tool in the circuit we got the following observations: The temperature change was around 2^0c, Observable carbon deposit was seen on crater, Color the kerosene changed drastically, Higher value of current was observed, Metal removal was uneven, Observable roughness was high.

GRAPHITE AS ELECTRODE: Here we conducted the experiment by connecting both the polarities to the work piece (MS) and the graphite electrode of 12.911mm diameter. The picture shows the effect of the experiment on the work piece and electrode. Silver colored portion on the work piece shows the material removal. Darker portion on the electrode is carbon deposit.

S. No	Electrode	Polarity	Time	Current(A)	Voltage(V)	Surface Roughness
1.	Graphite	-ve	15 min	5A	48V	0.05mm
2.	Graphite	+ve	15 min	6A	48V	0.09mm

OBSERVATIONS:

The following observations made ,by connecting the straight polarity in the circuit .

1. Temperature change was around 1^0C negligible,
2. Higher Metal removal rate was observed.

By connecting the negative polarity to the work piece and the positive to the Electrode in the circuit we got the following observations: The temperature change was around 2^0c, Observable carbon deposit was seen on crater, Color the kerosene changed drastically, Higher value of current was observed, Metal removal was lesser, higher surface roughness .

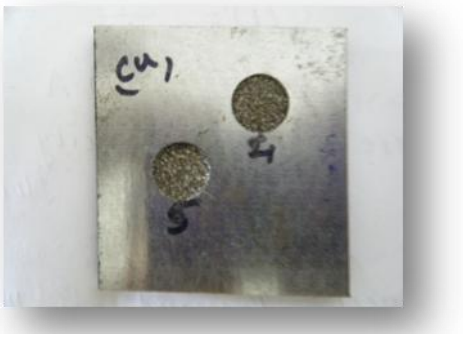
TESTS BY VARYING VOLTAGE:

This test was conducted to show that effect of the change in applied voltage on the cutting of the Electrical Discharge Voltage. The Experiment was conducted by varying the voltage applied to the EDM.

TEST WITH COPPER TOOL:

The electrolytic copper electrode was used as tool for conducting the experiment.

S. No	Voltage	Breakdown voltage	Current	Time In Min	Average Current	Surface Roughness	Depth of Cut
1.	40V	28V	4A	10	0.8 A	0.03 mm	0.31 mm
2.	45V	29V	5A	10	1A	0.07 mm	0.53 mm
3.	50V	38V	6A	10	1.6 A	0.1 mm	0.68 mm
4.	55V	40V	6.4 A	10	2A	0.13 mm	0.84 mm
5.	60V	44V	7A	10	3A	0.15 mm	1.01 mm



The table shows the increase in the Roughness with increase in breakdown voltage.

TESTING WITH GRAPHITE TOOL :

The graphite Electrode was used as tool for this experiment:

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S. No	Voltage	Breakdown voltage	Current	Time in min	Average Current	Surface Roughness	Depth Of Cut in mm
1.	40V	32V	5A	10	1.0 A	0.04 mm	0.79
2.	45V	36V	5.6 A	10	1.6 A	0.09 mm	0.94
3.	50V	40V	6A	10	1.8 A	0.13 mm	1.09
4.	55V	42V	6.4 A	10	2.3 A	0.15 mm	1.37
5.	60V	44V	7A	10	3.0 A	0.18 mm	1.89

The table shows the increase in the roughness value with increase in the breakdown voltage.

The depth of cut values increases like the trend shown with copper tool with increase in the voltage values.
The results of work-piece surface roughness for copper and graphite tools at negative and positive polarity can be seen respectively in graphs. It is observed that negative graphite tool electrodes promoted higher roughness than copper tools for all the Discharge voltage values (40, 45, 50, 55 and 60).

TESTS BY VARYING CURRENT:
This experiment is conducted to evaluate the effect of the current on the cutting of the Electrical Discharge Machine.

TEST WITH COPPER TOOL(VARYING CURRENT):

S. No	Voltage	Resistance	Breakdown voltage	Current	Time in min	Surface roughness in mm	Depth Of Cut in mm
1.	60 V	3	32V	10 A	10	0.2	1.97
2.	60 V	3.5	34V	9A	10	0.18	1.73
3.	60 V	4	40V	8A	10	0.15	1.55
4.	60 V	4.5	44V	7A	10	0.14	1.04
5.	60 V	5	47V	6A	10	0.12	0.98

It has been observed that the roughness value increases with increase in the current value. The variation in the current is brought by varying the resistance value from 3 ohms to 5 ohms.

The Depth of cut shows a gradual increase in the trend with the increase in the current values.

TEST WITH GRAPHITE TOOL (VARYING CURRENT):

S. No	Voltage	Resistance	Breakdown voltage	Current	Time in min	Surface roughness in mm	Depth of cut In mm
1.	60 V	3	32V	10 A	10	0.22	2.2
2.	60 V	3.5	34V	9A	10	0.2	1.98
3.	60 V	4	40V	8A	10	0.17	1.76
4.	60 V	4.5	44V	7A	10	0.15	1.34
5.	60 V	5	47V	6A	10	0.13	1.03

The roughness value increases gradually with increase in the current value by using graphite electrode tool.

The Depth of cut increases with increase in the current value for the graphite tool.

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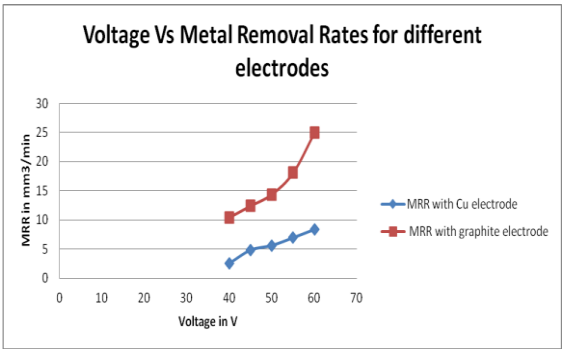
MATERIAL REMOVAL RATE:

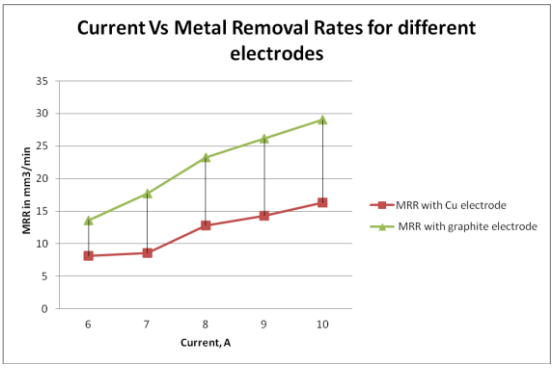
VARYING VOLTAGE:

S.No	Voltage	Copper Tool mm^3/min	Graphite Tool mm^3/min
1	40	2.5645	10.4362
2	45	4.8454	12.4178
3	50	5.6254	14.3994
4	55	6.9490	18.0983
5	60	8.3553	24.9678



VARYING CURRENT:

S.No	Current	Copper Tool mm^3/min	Graphite Tool mm^3/min
1	6	8.1072	13.6068
2	7	8.6035	17.7020
3	8	12.8226	23.2504
4	9	14.3117	26.1567
5	10	16.2971	29.0630



RESULTS & DISCUSSIONS:

ROUGHNESS:

Varying Voltage: Roughness increases with increase in the voltage for both copper and graphite tool, the possible reason for this can be increase in the power supplied per spark. Due to increase in spark power there is considerable increase in crater size which results in greater roughness.

Varying Current: Roughness values increases with increase in the current density. The increase in the current causes more sparks to generate causing increase in total roughness values. The same trend is observed in both the tool materials (Copper & Graphite).

DEPTH OF CUT:

Varying Voltage: There is significant increase in the depth of cut value with increase in voltage with both the tool materials. The increase in voltage causes more discharge through the dielectric which causes the increase in material removal rate.

The material removed by the graphite tool is more compared to the Copper tool; this is the result of good electrical and thermal conductivity of the graphite tool compared to copper tool.

Varying Current: With the increase in operating current there is increase in the depth of cut of the work-piece. This is the result of increased current density causing more material removal from work surface.

MATERIAL REMOVAL RATE:

Varying Voltage: It's been observed that the Material removal is more with increase in the operating voltage, this thing is verified by the increasing DOC.

Varying Current: The Material removal increases with the increase in the current value. The increase in the sparking is the reason for the increase in the material removal rate.

CONTROLLING OF DOC:

The Observed Values of MRR and Roughness suggests that controlling of Depth Of Cut can be effectively done by the controlling of the current, as the better surface finish is obtained in this case.

CONCLUSION:

The carried out experiments show that the time for machining and surface generated are almost equal to commercially available sinker machines. The performance of the Table Top Electric Discharge Machine using Copper and Graphite tools on the Mild Steel, HSS work-pieces has been investigated by varying important EDM variables such as Discharge Current, Discharge Voltage and Tool-Work-piece polarity. From the results of this work the following conclusions can be drawn:

- The machine was tested with change in the polarities of tool and work-piece and was concluded that the straight polarity gives better value of MRR and surface roughness.
- Copper tool with straight polarity gives better surface finish than the Graphite tool.
- The machine was tested with change in operating voltage and was found out that with the similar average current utilization; Copper tool gave better surface finish than the Graphite tool.
- Depth of cut for the Graphite tool was found to be more than Copper tool.
- The machine was tested with change in current density and was found that the roughness increases with the increase in the current density.

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- Copper was proved to be better material as tool because of the good surface finish compared to graphite tool.
- Depth of cut was more for graphite tool with increase in the current density.
- The Material removal rate for the Graphite tool is more than the Copper tool in any operating conditions.
- The Current variation is better parameter for controlling Depth of Cut.

The present unit can be further improved by having PLC control for work fixtures. , flushing systems,

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