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Effect of EDM Process Parameters on Tool Wear

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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. At the present time, Electrical discharge machine (EDM) is a widespread technique used in industry for high-precision machining of all types of conductive materials such as: metals, metallic alloys, graphite, or even some ceramic materials. The aim of the present study is to investigate the variation of Tool wear, Relative wear with the varying machining parameters ($T_{on,}$ discharge current and gap voltage) in die sinking EDM .Variation of responses with respect to each input machining parameter is presented and analyzed.

1. INTRODUCTION

Electric discharge machining (EDM) is a non- conventional machining method which possesses the potential to machining hard, tough and strong material which otherwise cannot be machined using conventional machining method. Electrical Discharge Machine (EDM) is now become the most important accepted technology in manufacturing industries since many complex 3D shapes can be machined using a simple shaped tool electrode. Electrical discharge machine (EDM) is an important 'non-traditional manufacturing method', developed in the late 1940s and has been accepted worldwide as a standard processing manufacture of forming tools to produce plastics moldings, die castings, forging dies etc.[1] The supplied energy in EDM depends on the discharge voltage, the peak current and the pulse duration[2]. Lin etal. showed that shortening the pulse. On-time is more efficient than reducing the peak current in achieving a high quality machined surface [3]. The copper is used as a tool material because of its higher MRR (metal removal rate) and less TWR (tool wear rate) and yields a better surface finish [4].

Lin and Lee investigate the TWR reduced upon increasing the pulse duration, even though the EWR became negative at 350 µs pulse duration with both 15 and 20 A peak currents. The discharge column would expand to reduce the energy density of discharge spot at upon increasing the pulse duration. In general, the effects of material removal mechanisms caused by melting, vaporization, as well as impulsive force of exploding dielectric fluid were decreased. Therefore, the TWR decreased at a longer pulse duration. In addition, the TWR became negative under 15–20 peak currents and 350 µs pulse duration. This can be attributed to the fact that increased pulse duration at larger peak current would result in the generation of massive amount of pyrolytic carbon from kerosene dielectric. The pyrolytic carbon could deposit on the electrode surface to form a protective layer, resulting in a negative TWR [5]. Long Ton provides a large time to deposite carbon on the tool surface [6]. TWR increases with increases with discharge current for all levels of T_{on}. With the increase of current density, the discharge zone temperature increase due to which the temperature of dielectric fluid increases. Discharge current is the most dominant factor, followed by T_{on} and voltage for the response MRR whereas the same for the tool wear is T_{on}, I and V [7].

2. EXPERIMENTAL DETAIL

In the present experimental work rectangular mild steel specimen were used to study the effect of T_{on}, I_p and V_g on TWR and RWR. All the experiments have been conducted on a Z numerically controlled (ZNC) oil die-sinking EDM machine, (R50#ZNC). The EDM machine is of Elektra, Electronica Machine Tools (India) make. In this machine, the Z-axis is servo controlled and can be programmed to follow an NC code which is fed through the control panel. The servo control feedback is based on the gap voltage between the tool and the workpiece electrodes. The power supply system produced a DC pulsed power in the frequency range of 0.07-300 kHz. The pulse has been idealized by considering the pulse delay time as negligible small. The pulse can be defined in terms of gap voltage (V_g), peak current (I_p), pulse-on time (T_{on}) and pulse-off time (T_{off}). The control panel allows independent control of the gap voltage, discharge current, pulse-on time and the duty factor. Corresponding to each T_{on} value, duty factor can be set to values between 8% and 96%. In step of 8%, subject to the maximum and minimum frequency limitations of the power supply.

3. EDM PARAMETERS

Table1 shows the experimental detail used during the present study

S. No.	Parameters	Detail
1	T_{on} (µs)	10, 50, 100, 200
2	Voltage (V_g)	25, 30, 35,40
3	Discharge current(I_g)	4, 5, 6, 7
4	EDM Oil	Servo Oil
5	Machining Time(minutes)	10

4. EVALUATION OF PERFORMANCE MEASURES OF EDM

The performance measures of EDM like TWR and Relative Wear Ratio (RWR) were found in this experiment and evaluated as follows-

4.1 Evaluation of Tool Wear Rate (TWR):

Tool wear is an important factor because it affects dimensional accuracy and the shape produced. Tool wear is related to the melting point of the materials. Tool wear is affected by the precipitation of carbon from the hydrocarbon dielectric on the electrode surface during sparking .TWR is expressed as the ratio of the difference of weight of the tool before & after machining to the machining time and density of the material. That can be explain this equation.

$$\text{TWR (mm}^3\text{/min)} = \frac{W_{tb} - W_{ta}}{\rho . t} * 1000$$

Where
W_{tb}= Weight of the tool before machining (gm)
W_{ta}= Weight of the tool after machining (gm)
t = Machining time (minute)
ρ = Density of copper (8.96 gm/cm^3)

Electronic balance was used for weighting the workpiece and tool, before and after machining. It had a weighting capacity of 210 grams and can accurately measure the weight of 0.001 gram.

4.2 Evaluation of Relative Wear Ratio (RWR):

It is a new ratio to identify the material removal rate with respect of tool wear rate. It is defined as the ratio of the MRR to the TWR from the workpiece and is usually expressed as a percent. Following equation is used for calculating the RWR.

$$\text{RWR} = \frac{MRR}{TWR} * 100$$

In the present experiment work, three process parameters, namely T_{on}, I_p and V_g have been used at four different levels to study the effect in variation of parameters on tool wear. Table 2 represent the loss in weight of copper tool while machining mild steel workpiece at various parameters.

Table2. Loss in weight of copper tool at various parameters

Parameters		Initial wt.(gm)	Final wt.(gm)
T_{on} (μs)	10	15.2077	15.1638
	50	15.1638	15.1500
	100	15.1500	15.1472
	200	15.1472	15.1467
Current (Amp.)	4	14.9592	14.9390
	5	14.9390	14.9137
	6	14.9137	14.8815
	7	14.8815	14.8418
Voltage (V)	25	14.7671	14.7484
	30	14.7484	14.7321
	35	14.7321	14.7209
	40	14.6269	14.6176

4.3 Pulse on-time (T_{on}):

T_{on} is an important EDM machining parameter. T_{on} is the most dominant factor followed by discharge current (I_p) and voltage. Figure1 & 2 shows the tool wear and Relative wear at different T_{on} time respectively.

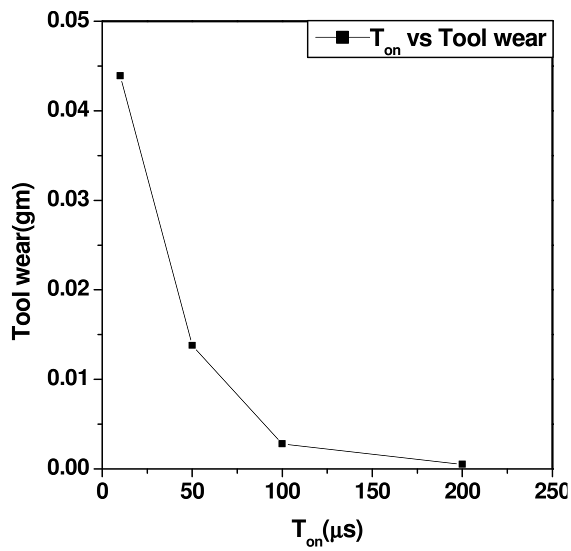

Fig. 1. Variation of Tool wear with T_{on}.

Figure1 represents the variation of Tool wear with respect to pulse on time. Tool wear decreases with T_{on} time continuously in a non- linear manner. Initially increase in T_{on} time from 10-50 μs provided in sharp decrease in Tool wear from 0.045 to 0.015 gram. But increase in T_{on} time 100-200 μs is provided moderate decrease in Tool wear. Reduction in Tool wear with respect to time may be attributed to spark energy is directly proportional to T_{on}. Therefore spark energy increases with increase in T_{on} but higher T_{on} leads to spreading of the spark (plasma channel), due to which heat transfer to the tool reduces and to the work piece and dielectric increases which results in less tool wear and high material removal rate.

Figure2 shows the variation of relative wear with respect to pulse on time. There is sharp increase in Relative wear with increase in pulse on time from (100-200 μs) as tool wear rate decrease and material removal rate increases.

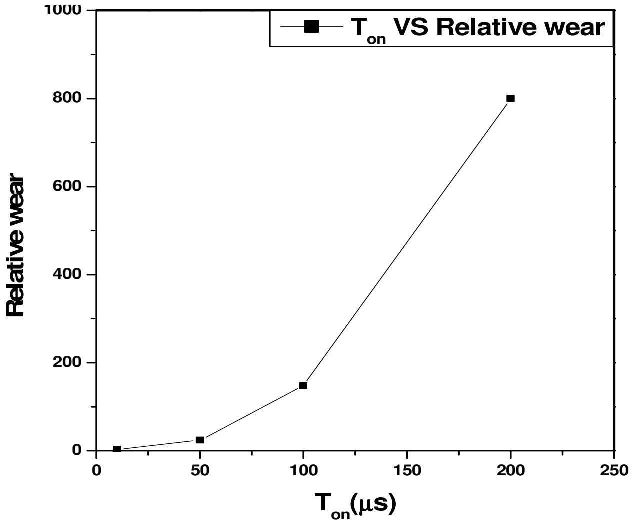

Fig. 2. Variation of Relative wear with T_{on}.

4.4. Discharge Current (I_p):

Spark energy is directly proportional to discharge current as the current increases spark energy increases but at constant T_{on} more spark energy is utilized in melting and evaporating the material from the tool which results in increase in tool wear and decrease in relative wear. Figure3& 4 shows the tool wear and Relative at different discharge current.

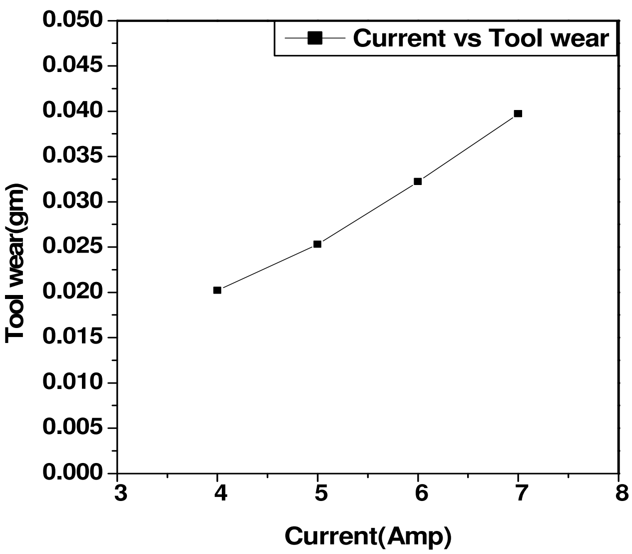

Fig. 3. Variation of Tool wear with current.

Figure3 represents the variation of Tool wear with respect to current. Tool wear increases from (0.02-0.04 gm) with increase in current from (4- 7 Amp) in an approximately linear manner. Spark energy is directly proportional to discharge current as the current increases spark energy increases but at constant T_{on} more spark energy is utilized in removing the material from the tool which results in increase in tool wear and decrease in relative wear.

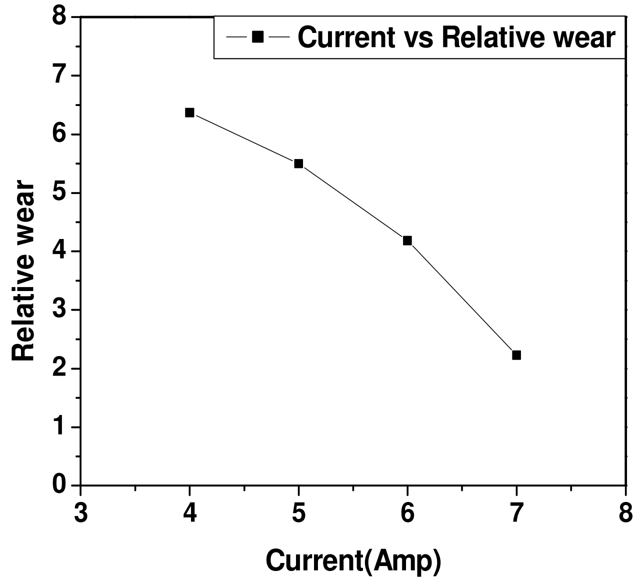

Fig. 4. Variation of Relative wear with current.

Figure4 represents the variation of Relative wear with respect to current. Relative wear decreases from (6.4-2.2) with increase in current from (4-7 Amp) in an approximately linear manner. The decrease in Relative wear is due to the fact that it is inversely proportional to tool wear which increases with current.

4.5 Gap voltage (V_g):

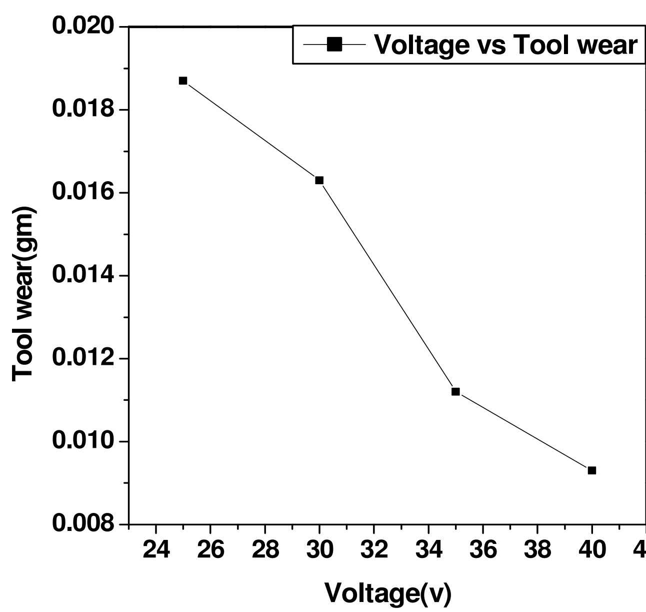

Fig. 5. Variation of tool wear with voltage.

Figure5 represents the variation of tool wear with respect to Voltage. Tool wear decreases slowly from (.019-0.016 gm) with increase in Voltage from (25-30 Volt) and after that tool wear decreases sharply from (0.016-0.011gm) with increase in Voltage from (30-35 Volt) again there is slow decrease in tool wear from (0.011-0.009gm) with increase in voltage from (35-40Volt). Spark energy is directly proportional to gap voltage means if gap voltage increases, spark energy also increases. Due to increase in spark energy, machining zone temperature increases which decomposes the dielectric into carbon atoms that carbon atoms attached to the tool surface. Carbon layer on tool surface reduces the conductivity of tool due to which tool wear reduces.

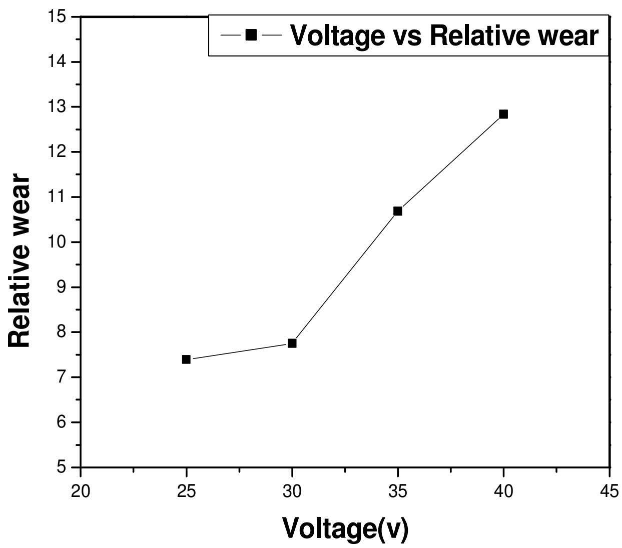

Fig. 6. Variation of Relative wear with voltage.

Figure6 represents the variation of Relative wear with respect to Voltage. Relative wear decreases slowly from (7.4-7.7) with increase in voltage from (30-35 Volt) after there is sharp increase in relative wear from (7.7-10.68) with increase in Voltage from (30-35 Volt) and there is moderate increase in Relative wear from(10.68-12.83)with increase in Voltage from (35-40Volt). The increase in Relative wear is due to the fact that it is inversely proportional to tool wear which decreases with Voltage.

5. CONCLUSION

Tool wear shows the inverse whereas Relative wear shows the direct relationship with T_{on} i:e Tool wear decreases with increase in T_{on}. Similarly Relative wear increases with increase in T_{on} time.

From the above result the effect of current on tool wear and relative wear is that Tool wear increases with increase in current while Relative wear decrease with increase in current.

Further, the effect of voltage on tool wear and relative wear is that Tool wear reduces with increase in voltage while Relative wear increase with voltage.

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