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EVALUATION OF TOOL CHARACTERISTICS OF COATED AND UNCOATED WIRE TOOL USED IN WIRE-EDM PROCESS FOR CUTTING STEEL

Dr. Srikantappa. A. S
Principal, Cauvery Institute of Technology Mandya India

Abstract

Wire-EDM is a non-traditional machining process used to cut difficult to machine materials. This paper deals with evaluation of tool characteristics of bare brass and zinc coated brass wire used to machine work materials such as Mild steel, OHN Steel and HCHCr Steel to determine the optimum spark discharge current and discharge time conditions. The tool characteristics like wire wear rate and material removal rate are analysed. The temperature distribution in the wire-EDM setup is analysed.

Key words: Wire-EDM, Tool characteristics, bare wire, coated wire

1. Introduction

Wire-EDM is widely used to cut intricate and complicated shapes in difficult to machine materials. In the EDM process electrical energy in the form of short duration impulses called spark are supplied to the machining gap to heat and evaporate the work material. The spark characteristics such as discharge current and discharge duration affect on the process parameters of EDM Process [1]

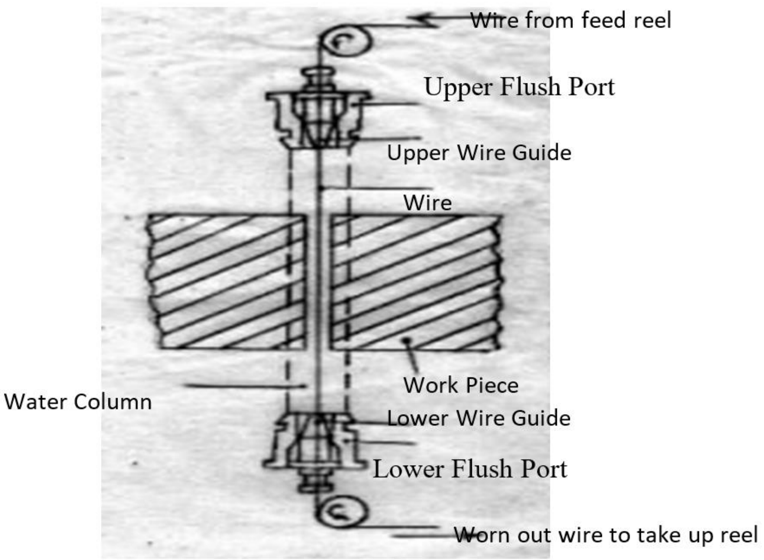

Figure 1: Wire-EDM process

Figure1 illustrates the Wire-EDM process. Wire fed from the wire feed reel is passed through upper wire guide and worn out wire after machining passed through lower wire guide is wounded on take up reel the dielectric fluid is supplied through upper and lower flush ports at certain flushing pressure which form a column of fluid around the moving wire. Spark is struck between tool and moving wire. As the unwanted material is removed from the work piece to cut it, appreciable amount of material from the tool i.e., the wire is also removed leading to the wire wear.

2. Experimental Study

Machining tests have been conducted on computer numerically controlled wire-Electro Discharge Machine 'Electraelcut 334'. Machining of work materials such as Mild steel, OHN Steel and HCHCr Steel has been carried out using bare brass and zinc coated brass wire for different spark discharge current and time conditions. The following are the machining specifications.

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Machining specifications

Specimen height	:	25 mm
Discharge voltage	:	80 Volts
Pulse Interval time	:	4 micro seconds
Dielectric	:	Distilled water
Flushing pressure		
Upper	:	0.75 kg / cm2
Lower	:	1.00 kg / cm2
Wire tension	:	800 gmf / cm2
Wire speed	:	3 Metres / min.
Capacitance	:	4 micro farads
Wire diameter	:	0.25 mm
Current contact distance	:	62.3 mm

3. Evaluation of Results

Figures 2 and 3 show the variation of material removal rate with increased discharge current and discharge time with both bare brass wire and zinc coated brass wire. With increased current, material removal rate increases up to a certain point and then decreases for bare brass wire whereas material removal rate increases for zinc coated brass wire revealing the necessity for the optimum imposed condition for maximum material removal rate condition.

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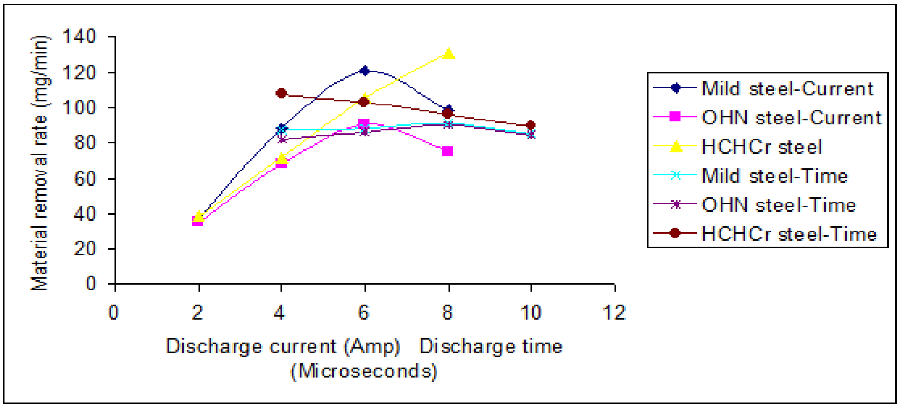

Figure 2: Variation of material removal rate with discharge current and discharge time when machined with bare brass wire

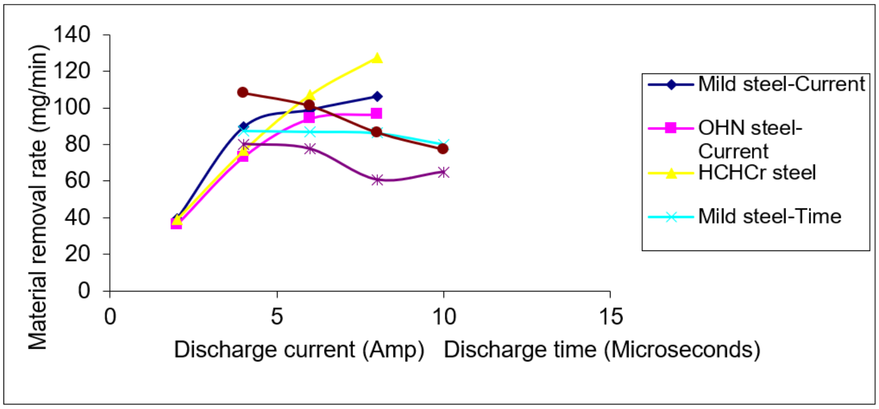

Figure 3: Variation of material removal rate with discharge current and discharge time when machined with zinc coated brass wire

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When a pulse is applied, part of the pulse energy is used to heat up the wire locally. Part of the wire residual heat will be used to overheat the wire coating which consequently evaporates. This creates a heat sink effect of the wire and hence a cooling of the core material resulting with a stable condition in increasing material removal rate for zinc coated brass wire. It is seen that the variation of material removal rate with discharge time is more or less same for both bare brass wire and zinc coated brass wire and change in material removal rate is not appreciable.

It is also observed that the material removal rate decreases initially and then increases considerably with increased hardness for both bare brass and zinc coated brass wires. Bare brass wire performs better at higher values of discharge time and zinc coated brass wire performs better at higher values of discharge current.

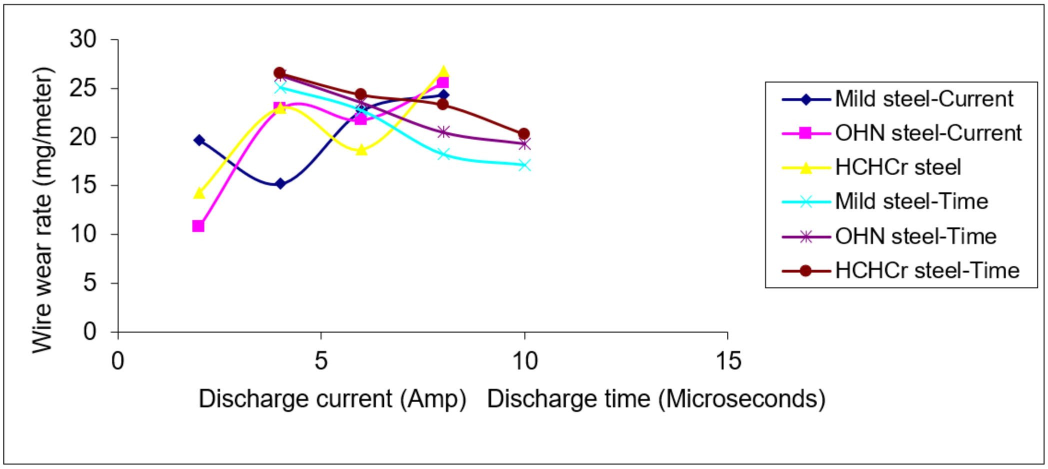

Figure 4: Variation of wire wear rate with discharge current and discharge time when machined with bare brass wire

Figures 4 and 5 show the variation of wire wear rate with increased discharge current and discharge time in machining using bare brass wire and zinc coated brass wire. Both bare brass

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wire and zinc coated brass wire indicate the same behaviour with increased current but zinc coated brass wire shows a better performance well with lower wear rate than bare brass wire.

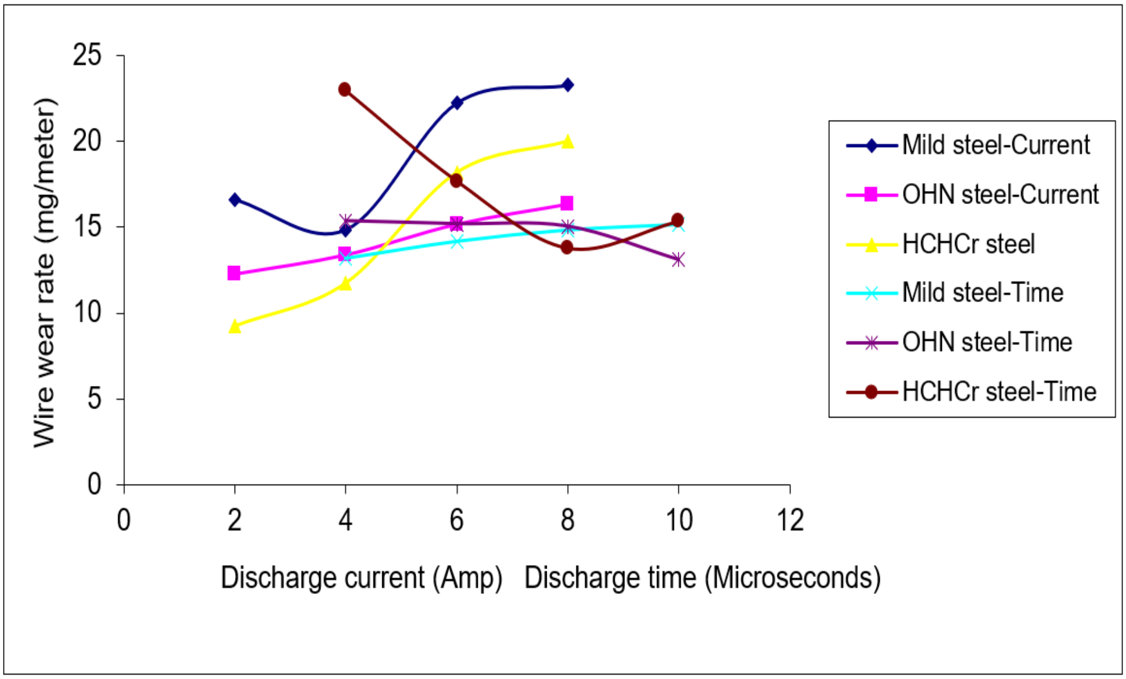

Figure 5: Variation of wire wear rate with discharge current and discharge time when machined with zinc coated brass wire

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Wire wear rate slightly increases for zinc coated brass wire where as it decreases for bare brass wire with increased discharge time. But comparatively wire wear rate values are for below for zinc coated brass wire compared to bare brass wire though bare brass wire shows a decreasing trend. Hence zinc coated brass wire exhibits better resistance for wear. It is also observed that the wire wear rate increases with increased hardness of work material and also it is seen that zinc coated brass wire performs better than bare brass wire giving lower wire wear rate.

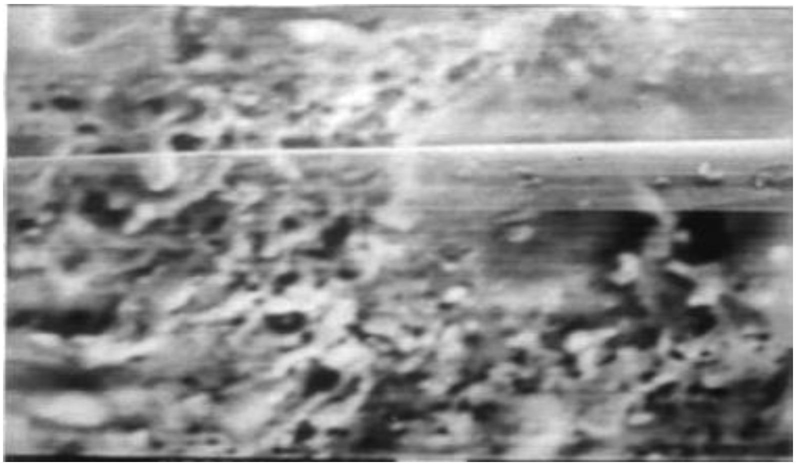

Figure6: SEM Photograph showing the used brass wire. Local erosion due to fusion can be observed

Figure 6 and 7 illustrate the SEM photographs of bare brass wire and zinc coated brass wire respectively used in machining HCHCr steel at 4 microseconds of discharge time. Local erosion due to fusion can be observed on bare brass wire. The surface of zinc coated brass wire has deteriorated due to flow of coating material. This can be observed from SEM photograph illustrated in figure 7. The spark discharge between the wire and the work material leads to the generation of extremely high temperature of about 80000c to 120000c causing fusion and partial vaporization of the work material and the dielectric fluid at the point of discharge and the same heat energy heats up the wire electrode also. In case of zinc coated brass wire part of this energy is used to heat up the wire locally part of the residual heat will be used to over heat the wire coating which consequently evaporates. This creates heat sink effect of the wire and hence a cooling of the core wire material. It is observed that during the erosion process the surface coating still intact.

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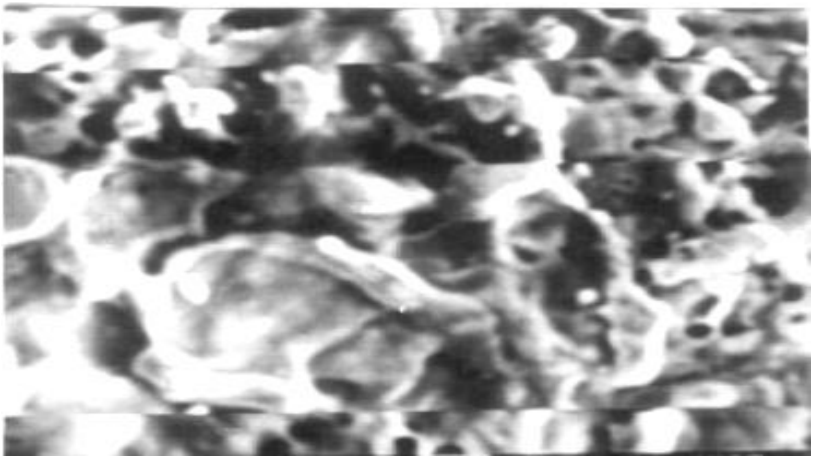

Figure7: SEM Photograph of used zinc coated brass wire. Surface has deteriorated due to the flow of the coating material

4. Finite Element Analysis Results:

In wire-EDM process the temperature at the spark region is very high and it shows the gradual decrement in temperature as the distance from spark is increased. Figure 9 shows the distribution of temperature along width of the work in the machining zone. Different colours illustrate the range of temperatures at different regions. Maximum temperature is observe near the spark area. Different sectional views shown in figure8 illustrates the temperature distribution in the wire-EDM setup.

To cut the given specimen by wire-EDM under discharge current 8Amperes Pulse discharge time 6 Microseconds Pulse off time 4Microseconds

Power consumed = 0.50 KWH

Time taken = 21Min = 0.35Hours

$$\text{Heat Input used for machining} = \frac{0.50}{} = 1.428KW$$

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0.35

When 1.428KW heat is applied in the spark gap of 0.25mm flooded with water between work and the tool. Temperature developed due to convection in the gap is determined using the relationship

$$Q = h * A * T$$

Where h = Convection Heat transfer co-efficient

A = Surface area

1428Watt = (200Watts/M2 0C) * 25 * 25 * 10-6 * T

T = 114240C

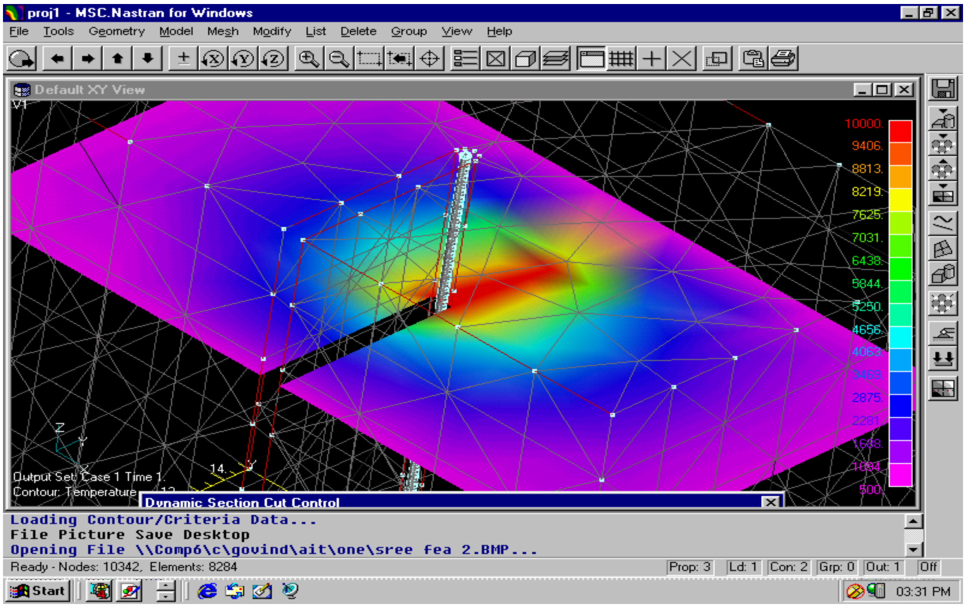

Figure 8: Temperature distribution at the work piece in machining zone along horizontal section plane

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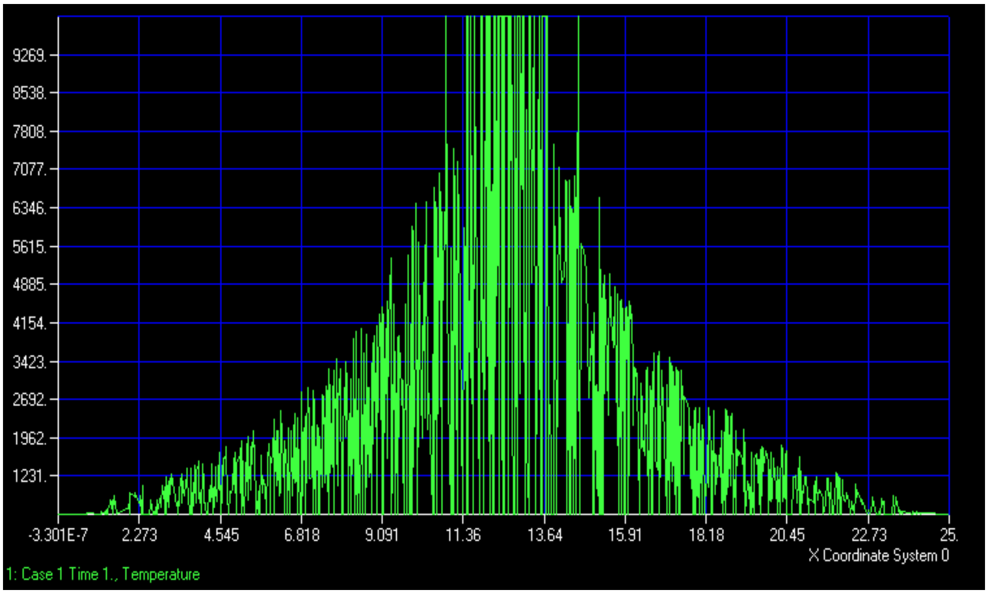

Figure9: Temperature distribution along width of the work piece in the machining zone.

The heat dissipated on to the tool and the work can be determined using the relationship

$$Q = \left\{ \frac{\text{Thermal conductivity * Area * Temperature difference}}{\text{Length}} \right\} \text{KW}$$

Total Drag force on the work piece is given by the equation

FD = τ * Area of the work

Where τ = shearing force due to friction

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5. CONCLUSIONS

- Wire failure is an important phenomenon in wire-EDM process. In continuous machining for the same material removal rate zinc coated brass wire are prone for less failure compared to bare brass wire because of its low wear rate and cratering leading to reduced chances of premature failure.
- The surface deterioration of the work surface is more in machining with bare brass wire compared to zinc coated brass wire. The failure is due to flow of material assisted by failure of tensile behavior. The transportation of material from work material to wire is also an important factor
- Finite Element Analysis helps in the study of temperature and stress distribution in wire-EDM process. This is helpful in selecting the optimum working parameters in the working of the process.
- A detail study of temperature and stress distribution is essential in understanding the working of EDM process and selecting the optimum working conditions to be imposed during the machining process with little disturbance due to tool failure due to breakage and maintaining the quality of the machined surface

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