# REGRESSION ANALYSIS APPROACH FOR PREDICTING PROCESS OUTPUT VARIABLES IN WEDM

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**Abstract:** WEDM is a complex process controlled by a number of process parameters; hence selection of proper combination of parameters to optimize the usage of tool to its designed life, producing a quality surface becomes very important. The study details the Regression Analysis technique in analyzing and predicting required process parameter values. The Study includes the Metal Removal Rate (MRR), Surface Roughness and Metallurgical Evaluation including Micrograph analysis. Machining has been done on different materials like En8, En31 and HCHC.

## 1.0 INTRODUCTION

Wire electro discharge machining (WEDM) is a special form of electrical discharge machining wherein the electrode is a continuously moving conductive wire. Metal removal is effected as a result of spark erosion as the wire electrode is fed through the work piece. Figure shows the schematic representation of WEDM process.

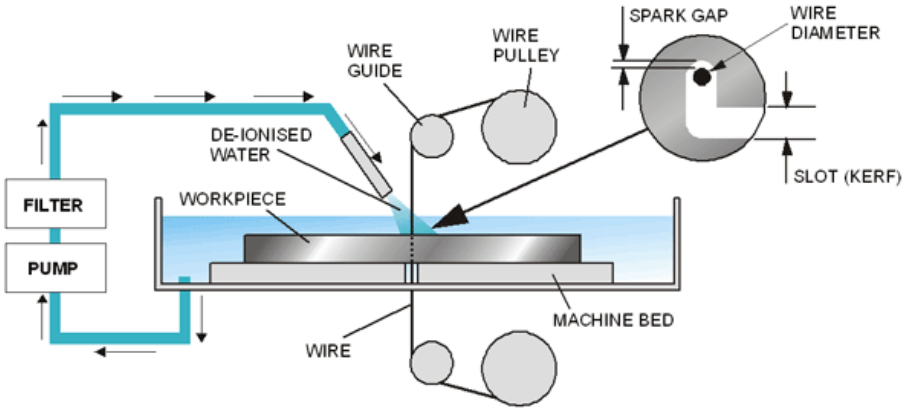



**Figure.1.Schematic arrangement of WEDM Process**

Steps in WEDM process:
Step-1: Power supply generates volts and amps.
Step-2: During on time controlled spark erodes material.
Step-3: During the off cycle the pressurized dielectric fluid cools the material and flushes the eroded particles.
Step-4: The eroded particles are removed and separated by a filter system.

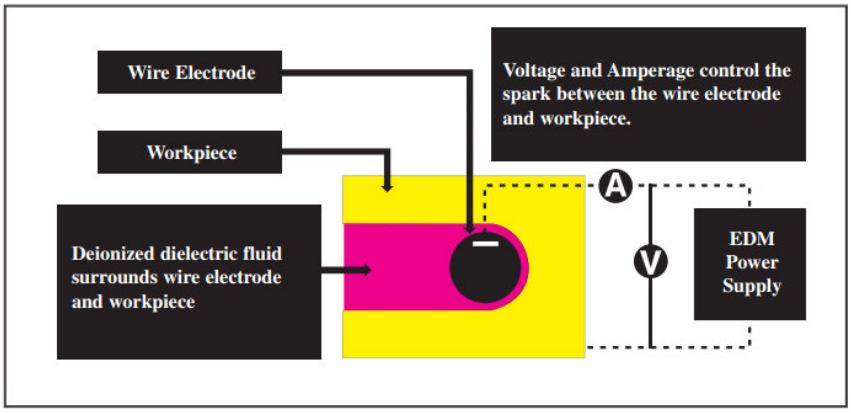



Figure 2: Step-1 of WEDM process

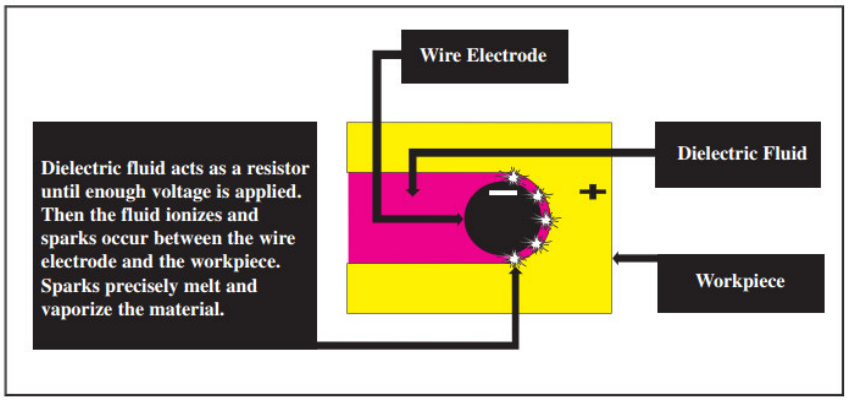



Figure 3: Step-2 of WEDM process

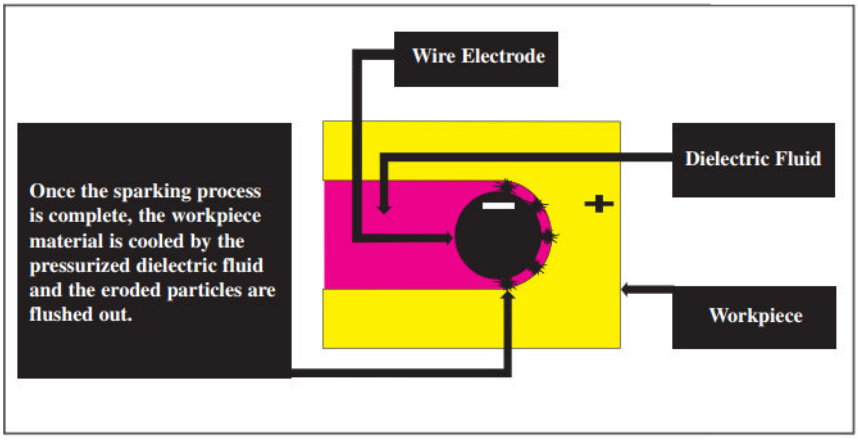



Figure 4: Ste-3 of WEDM process

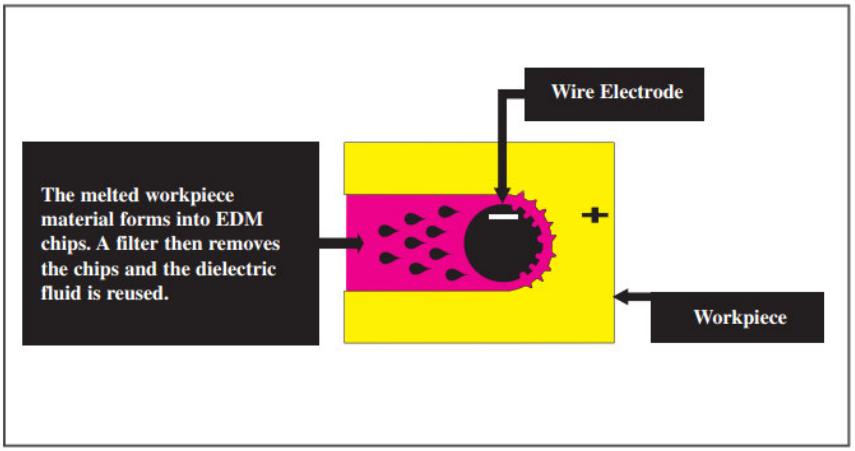



Figure 4: Ste-4 of WEDM process

WEDM is complex in nature and is controlled by large number of parameters. Choosing a proper parameter combination to get the desired surface finish is one of the most complicated processes in WEDM. As surface roughness is one of the most important parameters in machined surfaces, detailed investigations show that the surface roughness of the process is closely dependent on the machining parameters. The selection of machining parameters for various machining conditions and materials are essential to understand the desirable working condition for its effective application. Since WEDM is a potential process, it is required that the appropriate

machining parameters are selected for an economical machining operation. The machining parameters can be set for optimum machining with the knowledge of the effect of the machining parameters on the important requirements of the surface roughness produced.

This paper deals with machining different materials at different working conditions to study their effect on the surface finish produced, based on the experimental values obtained, a regression model was developed for predicting surface roughness.

## 2.0 MATERIALS AND METHODS

En8, En31, HCHC specimens were machined for different machining conditions. To get a comparative evaluation cutting voltage was maintained constant, only the machining impulse was varied for fixed increments in machining the materials considered, by keeping all the other process parameters such as cutting mode, wire tension, wire feed rate as constant. Surface damage was a vital factor in wire EDM which needs sufficient care in imposing the cutting conditions. Hence an optimal value of cutting Voltage was set to avoid frequent wire breakage. The surface roughness was the resultant effect of various parameters such as power, machining impulse time, flushing conditions, type of electrode material used, wire feed rate.

## 3.0 RESULTS AND DISCUSSION

The experimental results are given in Table.1.A regression model was developed, the values obtained from experiment was compared with that obtained by computing in Regression formula using Microsoft Excel Statistical Software.

**Table.1.Computed values of Surface Roughness for different materials**

| **Impulse, µs** | | | **8** | **10** | **12** |
|---|---|---|---|---|---|
| **Surface Roughness, µm** | **En8** | **EXP** | 2.123 | 2.162 | 2.184 |
| | | **REG** | 2.245 | 2.255 | 2.269 |
| | **En31** | **EXP** | 2.241 | 2.253 | 2.274 |
| | | **REG** | 2.105 | 2.162 | 2.199 |
| | **HCHC** | **EXP** | 2.197 | 2.238 | 2.253 |
| | | **REG** | 2.199 | 2.227 | 2.255 |

Table.1 illustrates the surface roughness, which is in increasing order for the materials considered, and the experimental values almost confirm with the calculated values. The optimum curve fitting for the above analysis is illustrated in Figure 5. The $R^2$, the Co-efficient of correlation summarizes how well the regression line fits the relation between Y and X. It indicates how much of the variation within the sample is accounted for by the fitted regression line. High values close to 1.0 indicate much variation in Y has been accounted for by the predictors - the regression is a good fit; lower values indicate much variation still not accounted for - the regression line is a poor fit .The values are observed to be nearer to unity.

A plot of the residuals for each observation can be used to verify various assumptions of the regression which will also examine how closely the computed regression line fits the variables. Residuals should be normally distributed. The histogram as in figure 6 shows the frequency of residuals, with a superimposed normal curve. The residuals are normally distributed and match well with the histogram illustrating the satisfactory machining conditions. The longer the spark is sustained more is the material removal. Consequently the resulting craters will be broader and deeper; therefore the surface finish will be rougher. Obviously, with shorter duration of sparks the surface finish will be better. This can be seen from figure 7, the surface roughness increases with raise in machining impulse. Figure 4 shows SEM photographs of HCHC. It is observed that the ductile fracture is observed during machining with the overlay. Figure.8. shows the EDXA of HCHC specimen cut with brass coated copper wire. It is observed that there is a pick up of material like Zn & Cu from wire tool. This will affect

the surface characteristics and condition of cut surface. This is a critical factor in setting the tool wire parameter in machining with wire EDM.

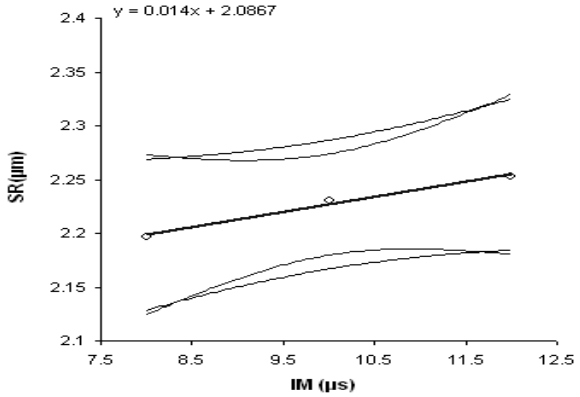



**Figure 5. Regression Curve Fitting for HCHC**

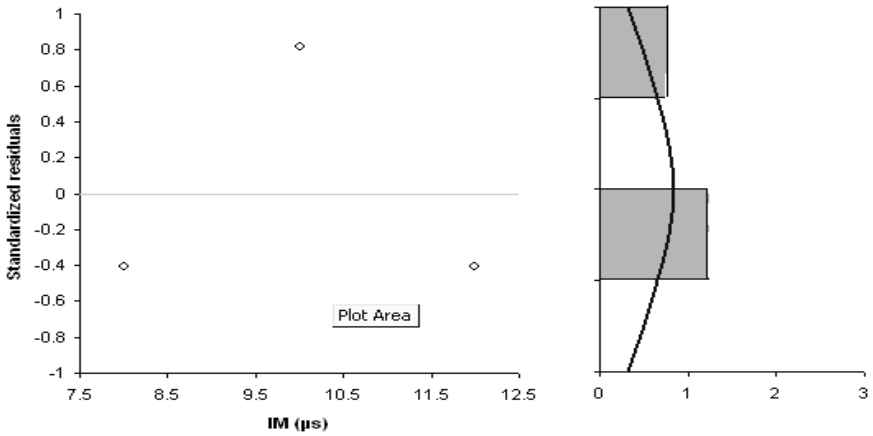



**Figure 6. Residuals Plot with Histogram showing frequency of Residuals**

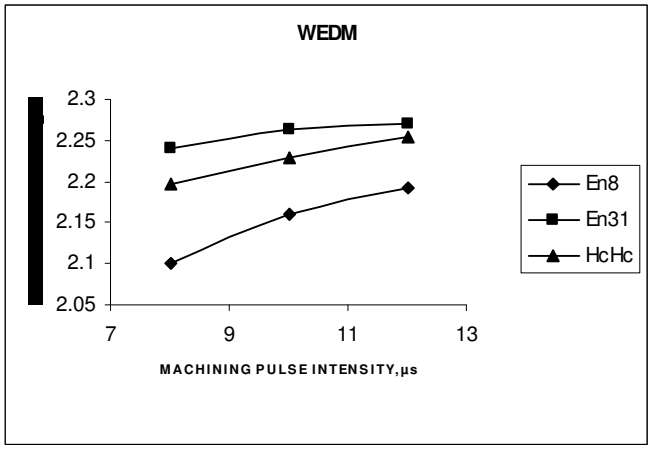
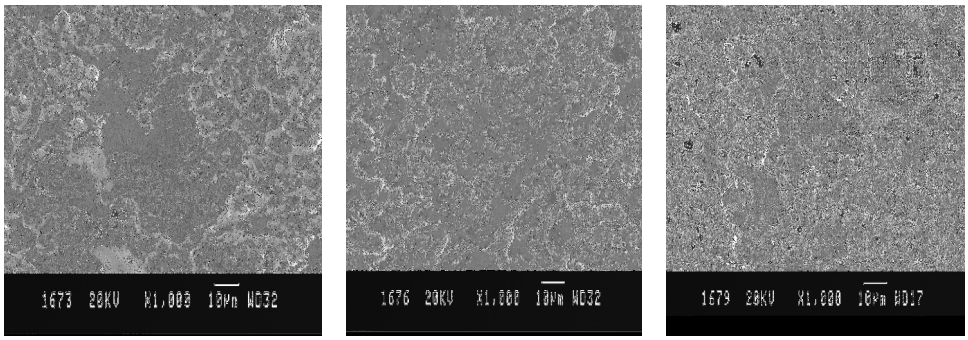



Figure 7. Effect of Pulse Rate on Surface Roughness (Wire Material: Copper wire with Brass coating, Wire Dia: 0.3 mm, Pulse Mode: 1, Water Pressure: 15 Kg/Cm$^2$, Wire Tension: 1300 G, Wire Feed: 10 m/min]




T-on 8 T-on 10 T-on 12

**Figure 8. Micrograph of HCHC Specimen**

**4.0 CONCLUSION**

- Regression models can be effectively used in predicting possible process parameters which helps in selecting the parameters for optimum production.
- The material removal rate is an important factor in any machining process as it affects the productivity and in WEDM it is not only dependent on the work material but also on the working conditions
- The effect of machining impulse is observed to be more and critical in controlling the surface finish. As the pulse rate increases, the surface roughness increases, due to greater craters generated.
- Material transfer from tool wire is observed due to interaction of tool and work material. This affects the surface condition in the machined surface.

## REFERENCES

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