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INVESTIGATION FOR OPTIMIZATION OF PARAMETERS OF WIRE-EDM OF EN-31

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ABSTRACT

In recent decades, many attempts were done on Wire EDM technology in order to satisfy various manufacturing requirements, especially in the precision mould and die industry. Wire EDM efficiency and productivity have been improved through progress in different aspects of WEDM such as quality, accuracy, and precision. The current research focuses on elucidating the influence of major WEDM parameters on MRR and Surface Roughness while machining EN-31 using brass wire. The result shows that the MRR is mainly influenced by peak current while the surface roughness is influenced majorly by pulse on time.

Keywords: *Wire-EDM, EN-31, MRR, Surface Roughness*

I. INTRODUCTION

Several researches were performed on WEDM to modify and improve its overall capabilities. In recent time, major attempts were done on Wire EDM so as to satisfy various manufacturing requirements, especially in the precision mold and die industry. The efficiency and productivity is improved through progress in different aspects of WEDM such as quality, accuracy, and precision.

Sharma and Rizvi [1] through their investigation concluded that material removal rate is majorly influenced by Ip and Toff while Ton has least effect on it. They also concluded that Ip is the major dominating parameter for surface roughness. Asghar Rizvi et al [2] from their research on EN-40 found current to be the major influencing factor for surface roughness while pulse on duration was least affecting factor.

K. Kumar et al [3] carried out experiments and found that factors like speed, feed, Time on and Time off play a significant role for MRR and surface roughness. H. Singh et al [4] by their study concluded that wire feed and wire tension has negligible influence on MRR, while Ton has direct effect on the MRR. With increase in Toff, the material removal rate decreases. With peak current, the material removal rate increases.

Manoj Malik et al [5] concluded that peak current is the most dominating parameter for MRR and TWR while pulse duty factor is the least influencing factor. They also concluded that the Ton has major influence on surface roughness. Liao et al [6] performed an investigation using SKD11 alloy steel and established mathematical models relating the machine performance like MRR, SR and gap width with various machining parameters.

Scott et al [7] developed mathematical models for predicting MRR and surface finish during machining of D-2 tool steel at different machining conditions. No single combination of levels of the different factors that can be optimal under all circumstances. Lin and Lin [8] reported a new approach for the optimization of the electrical discharge machining (EDM) process with multiple performance characteristics based on the orthogonal array with the grey relational analysis.

Miller et al [9] investigated the effect of Ton and spark on-time ratio on MRR and surface integrity of porous metal foams, metal bond diamond grinding wheels, sintered Nd-Fe-B magnets and carbon–carbon bipolar plates. Ramakrishnan et al [10] described the multi objective optimization of the WEDM process using parametric design of Taguchi methodology. It was identified that the pulse on time and ignition current intensity has influence more than the other parameters.

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II. EXPERIMENTAL DETAILS

The work material chosen for the present study is EN-31 while the electrode is brass wire of 0.18 mm diameter. The material is machined on Electronica Wirecut EDM.

Figure 1: Wire-EDM machine setup

The Taguchi approach is used, which is very effective in dealing with responses influenced by multi-variables.

The current study considers peak current, pulse on time and pulse off time as Wire-EDM parameters whose influence is observed on material removal rate and surface roughness of the material.

Table 1: The levels of Wire-EDM parameters

S.No.	Parameters	Units	Level 1	Level 2	Level 3
1	Current (Ip)	A	4	8	12
2	Pulse on time(Ton)	Msec	20	30	40
3	Pulse off Time(Toff)	Msec	15	30	45

ANOVA is performed to identify statistically significant process parameters. Based on the results of ANOVA, optimal combinations of the process parameters are predicted.

III. RESULTS AND DISCUSSION

3.1 Material Removal Rate

Table 2 : ANOVA for MRR

Source	DOF	SS	Contribution
Ip	2	153.974	61.32
Ton	2	74.706	29.75
Toff	2	11.701	4.66
Error	2	10.718	4.27
Total	8	251.099	100%

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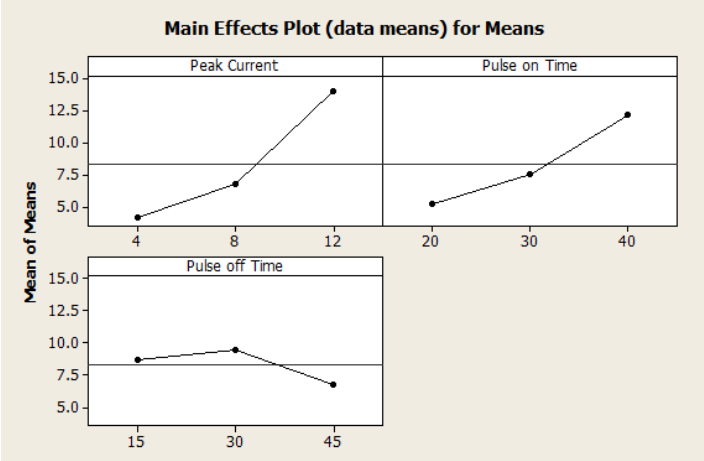

Figure 2. Relation between MRR and WEDM parameters

From the above graph it is clear that as we increase the current, the MRR tends to increase at a high rate than pulse on time and voltage. Intensity of spark increases with current and thus metal removal rate increases. The graph elucidates that peak current is the most significant factor for MRR and ANOVA shows that it has a contribution of 61.32%. MRR increases with increase in pulse on time but at a slower pace as compared to that of current. The discharge energy is higher at higher levels of pulse on time thus we get higher material removal rate. For lower pulse on time, the discharge energy is insufficient thus the material removal rate is low. Pulse on time has a contribution of 29.75% towards MRR. In the case of voltage, initially the MRR tends to increase, but further increase in its value tends to degrade the MRR. The MRR increases with increase in gap voltage and then it starts to decrease. This is due to increase in gap voltage result in higher discharge energy per spark because of large ionization of dielectric between working gap. Consequently, the MRR increases. However, a too high voltage result in high discharge energy per spark which causes unfavorable break down of dielectric and large amount of debris between the working gap which unable the material removal rate increases.

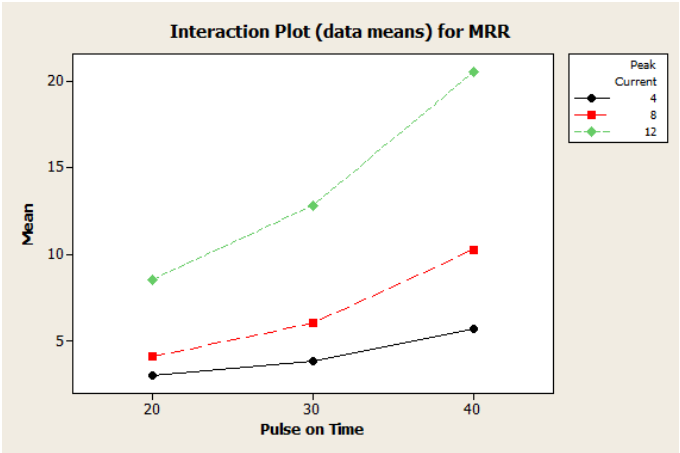

Figure 3. Interaction plot for MRR and WEDM parameters

The above interaction plot reveals that at all levels of peak current, the MRR shows an increasing trend with pulse on time.

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3.2 Surface Roughness

Table 3 : ANOVA for Surface Roughness

Source	DOF	SS	Contribution
Ip	2	4.161	9.20
Ton	2	32.784	72.54
Toff	2	5.287	11.70
Error	2	2.964	6.56
Total	8	45.196	100%

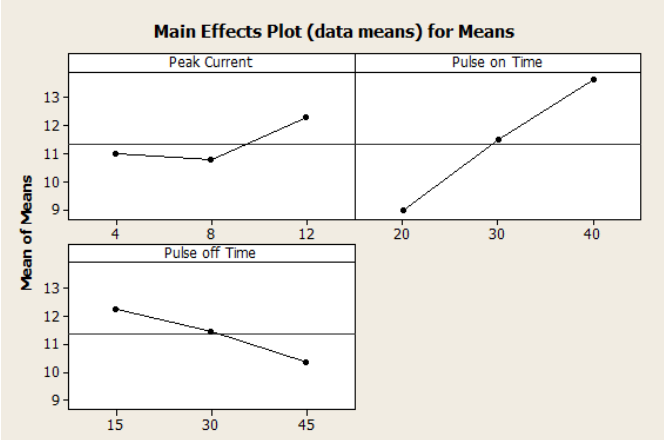

Figure 4. Relation between SR and WEDM parameters

The above graph predicts the effect of input parameters on surface roughness. It shows that by increasing the current, the surface roughness increases. Peak current is the least significant factor for surface roughness. As current increases, the spark intensity increases and hence the surface degrades more. The minimum surface roughness is seen at 8A. Pulse on time is found to be the most dominating parameter for surface roughness with a contribution of 72.54%. With increase in pulse on time the surface roughness increases at a higher pace as compared to current. The minimum surface roughness was seen at 20 µsec. As compared to pulse on time, peak current and voltage have insignificant influence on surface roughness.

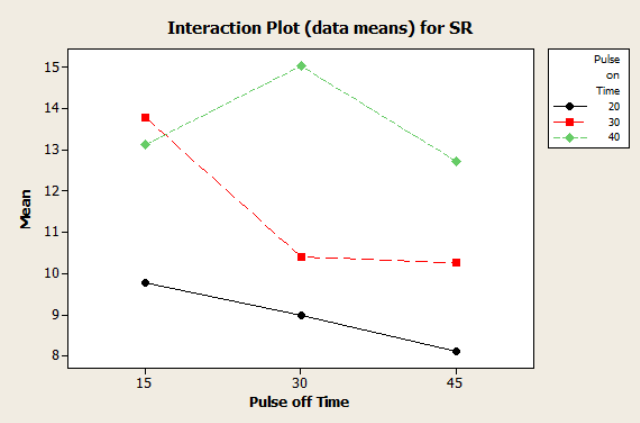

Figure 5. Interaction plot for SR and WEDM parameters

Figure 5 i.e. interaction plot shows that at low level of pulse on time, the surface roughness decreases linearly with pulse off time. At higher level of pulse on time, initially surface roughness increases with pulse off time but later it get reduced.

3.3 Surface Integrity

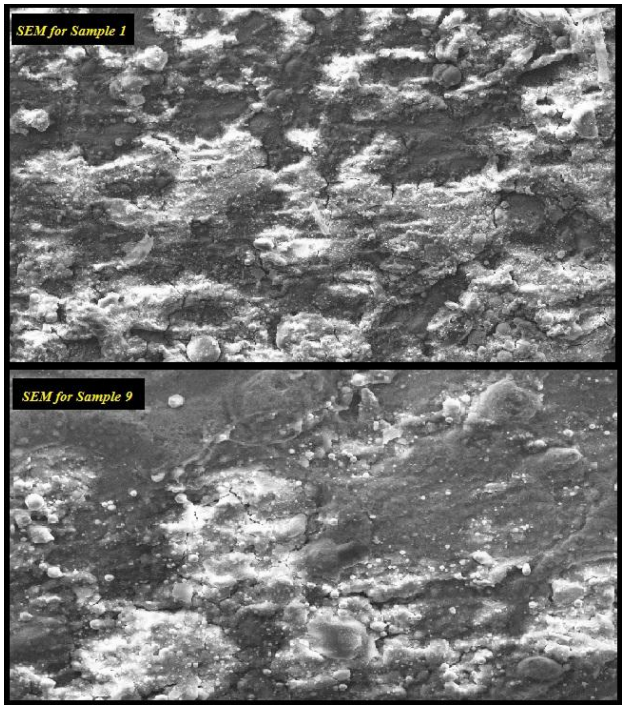

Figure 6: SEM images of Wire-EDM samples

The above figure shows SEM images of samples. The SEM reveals that surface get degraded at higher level of Wire-EDM parameters. Cracks are also observed on the surface due to heat generated by high intensity sparks.

IV. CONCLUSION

The current analysis performed on EN-31 using Brass wire for determining the influence parameters of Wire-EDM on MRR and surface roughness have following conclusions:

- Peak current is the major influencing parameter for MRR followed by Pulse on time while pulse of time has least effect on it.
- Discharge energy plays a vital role in effecting the rate of material removal from the work-piece.
- Pulse on time is observed to majorly influence surface roughness of EN-31 while peak current and voltage have negligible influence as compared to it.
- Surface degrades as the levels of parameter are increased.
- Cracks seem to develop on the surface due to intense heat developed during machining.

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