# "Investigation of Material Removal Rate, Surface Roughness and Surface Morphology in Wire-Electro Discharge Machining of Die Steel D3"

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**Abstract -** *Wire-EDM is a non-ordinary cutting procedure used machine materials with high hardness, affect obstruction and durability. It defeats the challenges looked by ordinary EDM as it machines with the assistance of a moving wire terminal. This examination is led on Wire-EDM for machining of Die Steel D3 with bass wire cathode in order to set up the connection between WEDM process parameters with material expulsion rate and surface unpleasantness. The examination uncovered that material expulsion rate and surface harshness were significantly impacted by the pinnacle current. Heartbeat on time was observed to be the second most overwhelming parameters for both execution measures while wire strain was the slightest commanding parameter for both execution measures.*

## 1. INTRODUCTION

Wire cut Electrical-Discharge Machining (Wire-EDM) is a variation of EDM which utilizes a thin wire (around 0.18mm) which fills in as the terminal. For the most part metal wires are normally utilized, which is nourished gradually through a wire reel into the material and the power releases through the wire cuts the work piece in type of sparkles. In Electrical-Discharge Machining (EDM) Wire Cut is typically performed in a shower of dielectric (ordinarily utilized is water). On the off chance that we watch the procedure under a magnifying instrument, the wire itself does not really interacts with the metal to be machined; the electrical releases in type of sparkles expel little measure of material and afterward enables the wire to movement through the workpiece. A release happen between the two nearest purposes of the anode and cathode, the extraordinary warmth is produced close to the zone liquefies and dissipates the materials in the starting zone.

Wire-EDM is a broadly acknowledged as a non-contact and non-traditional machining process utilized for creation of segments having unpredictable profiles. In wire EDM, the conductive materials are machined with a progression of electrical releases (known as sparkles) that are delivered between a precisely situated moving wire (the anode) and the work piece. High recurrence beat of AC or DC supply is released from the wire onto the work piece with a little start hole through the protected dielectric medium. WEDM process by and large includes the disintegration impact of discrete start releases between the device cathode in type of wire and work piece submerged in a liquid dielectric medium. WEDM is utilized for generation in aviation ventures while machining small scale gas turbine sharp edges and other electronic segments.

Wire electrical release machining (WEDM) is a warm material evacuation process that is prepared to do exactly machining parts with much hardness and complex structures, having sharp edges which are extremely hard to cut by the regular machining forms. WEDM is likewise a generally spread strategy utilized in enterprises for exactness machining for a wide range of conductive materials of any hardness. Wire-EDM machines have likewise embraced the beat creating circuit that utilizations bring down capacity to touch off and higher power for cutting. Since fine surface isn't accomplished as the vitality produced by the high-voltage sub-circuit is too high subsequently it isn't used for some activities.

As more current and more extraordinary materials are created, and more intricate shapes are introduced, customary machining tasks will keep on reaching their confinements and the expanded utilization of wire EDM in assembling will keep on growing at a quickened rate.

WEDM machining technique is usually used to cut hard metals that are unthinkable by other customary machining forms. It has been broadly utilized, particularly to cut confused shapes or fragile depressions that are hard to deliver with regular machining techniques. In any case, one basic confinement is that Wire-EDM just works with electrically conductive materials.

### 3.1 TAGUCHI METHOD

Taguchi has generated a methodology for the application of designing of experiments, which includes a practitioner's handbook. This methodology has taken the experiment design from the world of statistician and is applied fully into the world of manufacturing. This contribution have made the work much simpler by making the use of only fewer experimental designs, and providing a better understanding of the variations and the economic consequences of better quality engineering in the world of production. He introduced his approach using the experimental design for:

Designing the products and processes which are robust to environmental conditions;

Designing and developing products and processes which are robust to component variation;

To minimizing variation about a target value, this philosophy of Taguchi is applicable. He proposed that optimizing engineering process or product should be carried out in three step procedure, they are the design of system, parameter design and tolerance design. In system design the engineer applies scientific engineering knowledge to produce a basic functional prototype design. During the stage of product design stage, the selection of the work materials, components, parameter values etc. are involved. Since system design is an initial step, functional design may be far from optimum in terms of quality and cost.

The objective of parameter design is to optimize the setting of process parameter value for improving performance characteristics and to identify the product parameter values under the optimal process parameter values. Also it is expected that the optimum level of process parameters obtained by the parameter design are insensitive to the varying environmental conditions and other noise factors. Hence the parameter design plays a key role in Taguchi approach for achieving high quality without increasing cost. To solve the problem, Taguchi approach utilizes a special design of orthogonal arrays for studying the entire parameter space using small number of experiments. Loss function is afterwards defined so as to find the deviation between the desired values and experimental values. The value of this loss function is then transformed into a signal-to-noise ratio. Basically there are three category of performance characteristic during the analysis of the signal to noise ratio, they are the lower-the-better, the nominal-the-better, and the higher-the–better. The S/N ratio for each level of process parameter is computer based on the S/N analysis. Larger S/N ratio basically are corresponding to the better performance characteristic and hence the optimal level of the process parameter is the level having the highest S/N and ANOVA analysis, the optimum process parameters can be predicted. Finally, a confirmation test experiment is conducted to verify the experimental optimal set of process parameters obtained from the parameter design. The Taguchi method is adopted to obtain optimal machining performance in the die sinking.

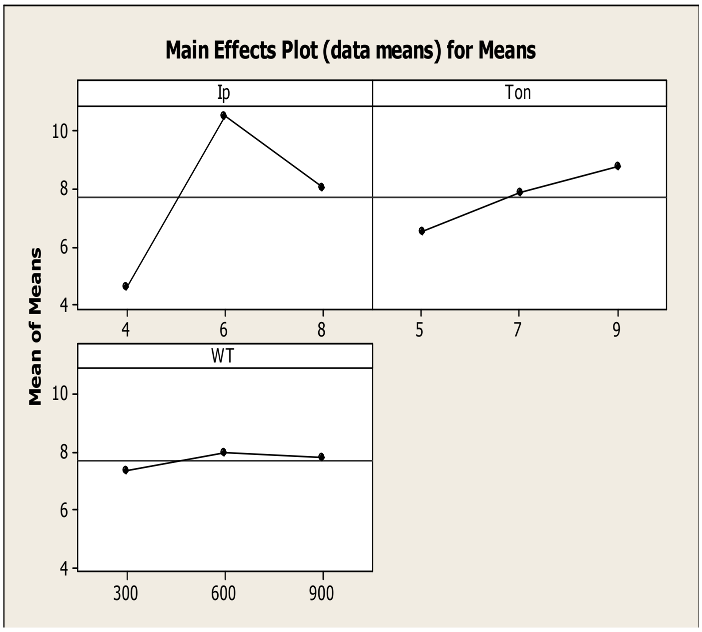
| S.No. | Parameters | Units | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 1 | Current (Ip) | A | 4 | 6 | 8 |
| 2 | Pulse-on-time (Ton) | Msec | 5 | 7 | 9 |
| 3 | Wire Tension | | 300 | 600 | 900 |

**: L9 Orthogonal Array**

| Exp. No | Ip | Ton | WT |
|---|---|---|---|
| 1 | 4 | 5 | 300 |
| 2 | 4 | 7 | 600 |
| 3 | 4 | 9 | 900 |
| 4 | 6 | 5 | 600 |
| 5 | 6 | 7 | 900 |
| 6 | 6 | 9 | 300 |
| 7 | 8 | 5 | 900 |
| 8 | 8 | 7 | 300 |
| 9 | 8 | 9 | 600 |

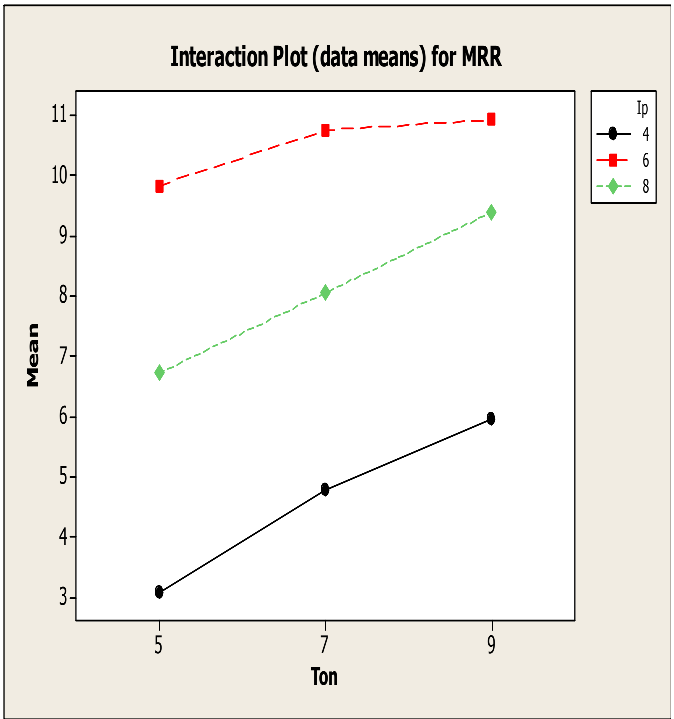
**Calculation of Material Removal Rate**

| Exp. No | Current | Pulse on Time | Wire Tension | Material Removal Rate ($mm^3$/min) |
|---|---|---|---|---|
| 1 | 4 | 5 | 300 | 3.079 |
| 2 | 4 | 7 | 600 | 4.775 |
| 3 | 4 | 9 | 900 | 5.940 |
| 4 | 6 | 5 | 600 | 9.830 |
| 5 | 6 | 7 | 900 | 10.748 |
| 6 | 6 | 9 | 300 | 10.928 |
| 7 | 8 | 5 | 900 | 6.715 |
| 8 | 8 | 7 | 300 | 8.050 |
| 9 | 8 | 9 | 600 | 9.390 |



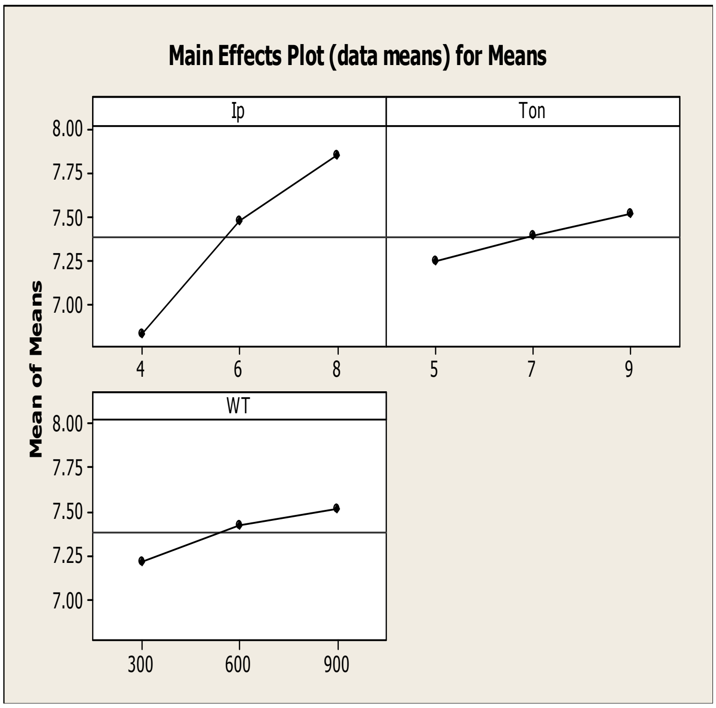
| Source | DOF | SS | Adj MS | F Value | Contribution |
|---|---|---|---|---|---|
| **Current** | 2 | 52.789 | 26.395 | 160.10 | 86.25 |
| **Pulse on Time** | 2 | 7.424 | 3.712 | 22.51 | 12.13 |
| **Wire Tension** | 2 | 0.658 | 0.329 | 1.99 | 1.07 |
| **Error** | 2 | 0.330 | 0.165 | | 0.53 |
| **Total** | 8 | 61.200 | | | 100% |

**Interaction plot between WEDM parameters and MRR**



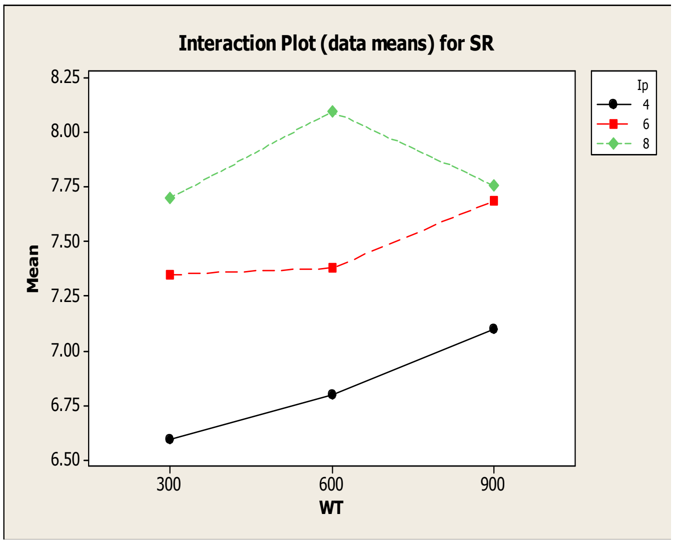

**Calculation for Surface Roughness**

| Exp. No | Current | Pulse on Time | Wire Tension | Surface Roughness Ra(µm) |
|---|---|---|---|---|
| **1** | 4 | 5 | 300 | 6.59 |
| **2** | 4 | 7 | 600 | 6.80 |
| **3** | 4 | 9 | 900 | 7.10 |
| **4** | 6 | 5 | 600 | 7.38 |
| **5** | 6 | 7 | 900 | 7.69 |
| **6** | 6 | 9 | 300 | 7.35 |
| **7** | 8 | 5 | 900 | 7.76 |
| **8** | 8 | 7 | 300 | 7.70 |
| **9** | 8 | 9 | 600 | 8.10 |




**ANOVA of Surface Roughness**

| Source | DOF | SS | Adj MS | F Value | Contribution |
|---|---|---|---|---|---|
| **Current** | 2 | 1.60549 | 0.80272 | 43.29 | 84.46 |
| **Pulse on Time** | 2 | 0.11262 | 0.05631 | 3.04 | 5.92 |
| **Wire Tension** | 2 | 0.14562 | 0.07281 | 3.93 | 7.66 |
| **Error** | 2 | 0.03709 | 0.01854 | | 1.95 |
| **Total** | 8 | 1.90082 | | | 100% |



## CONCLUSION

- This test think about depicted the advancement of info machining parameters in Wire-Electrical Discharge Machining of Die Steel D-3 with metal wire as terminal utilizing L9 symmetrical cluster of Taguchi technique. Components like Current, Pulse on time (Ton) and Wire Tension and their collaborations have been found to assume huge part in WEDM activity for expansion of MRR and minimization of Surface Roughness.

- In light of above work following conclusions are made:

- With increment in the current, the MRR tends to increment at a high rate than beat on time and voltage. Pinnacle current is the most noteworthy factor for MRR.

- MRR at first increments with crest current however with additionally increment in its esteem MRR has a tendency to lessen. The explanation behind such conduct is that the garbage introduce between the terminal wire and the workpiece does not permit adequate spaks to strike the surface of work.

- MRR increments with increment in heartbeat on time yet at a slower pace when contrasted with that of current. The release vitality is higher at larger amounts of heartbeat on time accordingly we get higher material expulsion rate. For bring down heartbeat on time, the release vitality is lacking hence the material expulsion rate is low.

- With Wire Tension, at first the MRR tends to increment, however additionally increment in its esteem has a tendency to debase the MRR. Wire strain has relatively unimportant impact on MRR and is the minimum affecting parameters with a commitment of just 1.99%.

- All the three parameters demonstrate an expanding pattern with surface harshness i.e. with increment in the levels of WEDM parameter, the surface unpleasantness of the machined surface increments.

- By expanding the current the surface unpleasantness increments and the surface complete corrupts. Rough surface is produced as we increment the current. Pinnacle current is the most critical factor having a commitment of 84.46%. As present expands, the start force increments and subsequently the surface debases more. The base surface harshness is seen at 4A.

- With increment in beat on time and wire pressure the surface harshness increments however at an ease back pace when contrasted with current. The base surface unpleasantness was seen at 5 µsec beat on time and 300 wire pressure. The commitments of heartbeat on time and wire strain are 5.92% and 7.66% separately.

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