ISE 2214 Manufacturing Processes Laboratory
CRN: 16793
Laboratory Report
EDM:

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Submission Date: 2/11/2025

Table of Contents:

- Introduction (pg. 3)
- Equipment (pgs. 3-4)
- Procedure (pg. 4)
- Presentation and Results (pgs. 4-6)
- Discussion of the Results (pgs. 6-7)
- Conclusions (pgs. 7-8)

Introduction:

The electrical discharge machining lab focuses on how to use brass electrode wire combined with parameters like gap voltage and working current to make a stainless-steel smoother. Each indentation has the total machining time, and the surface roughness measured, so it's possible to compute the total machining energy used for each indentation. The EDM machine produces high-frequency electrical sparks which number in the hundreds, these sparks create indentation. The brass wire runs off the spool continuously as the indentation takes place, producing new electrodes which keep the diameter consistent. This is an unconventional method, typically it is used when materials are either tiny, hard or brittle, or another situation is the workpiece is under stress. The wire offset can display changes in total energy as well as those resulting from machine time and power. To compare the wire offset, gap voltage, working current, and machining time, five separate experiments were conducted with five different surface roughness levels. The lab shows how the working current and gap voltage can alter machine time, which impacts surface roughness.

Equipment:

The equipment section for the lab has two sections: tooling and pieces, and the processing equipment/computer equipment.

Processing/Computer Equipment:

- FANUC EDM ROBOCUT: The EDM robocut works by creating sparks using electricity that's generated at a high frequency, this removes material from the piece. This machine recorded all data necessary for the lab: working current, gap voltage, and wire offset. Every experiment had the values of permitted power, energy, and total energy expenditure recorded. A water tank was used to neutralize the temperature while the EDM was operating. The water also removed the hundreds of sparks which the EDM gives off every second, the ionization of the dielectric fluid produces the sparks.
- Profilometer: The stainless-steel piece's surface roughness is measured by the profilometer which has a diamond that is used to measure. The surface roughness is measured in Ra-microinches, after all the readings were done an average surface roughness was also calculated.

Tooling and Pieces:

- Brass electrode wire: The EDM robocut machine uses a 0.010-in. thick brass wire as an electrode, the wire begins in a supply spool and travels to the stainless-steel piece, once it's finished there it is spooled in the collection spool. The wire is threaded through the machine and into the stainless-steel workpiece, after the wire is threaded through the machine a dielectric fluid cools the wire. During this EDM process the wire itself reaches an extremely high voltage, and as the wire travels from the supply spool to the take-up spool to supply a new electrode with a consistent diameter once the material is removed from the workpiece. When the wire is finished with the procedure and the surface is cut, the wire is then cut and disposed of in a trash area on the EDM machine.

- Stainless-Steel Piece: The EDM lab focused on a stainless-steel piece which showed the effects of the wire cutting through surface roughness. On the stainless-steel piece, each surface roughness was unique due to a change in variables such as wire offset. The roughness was measured by the profilometer after each experiment was finished. The stainless-steel workpiece was subject to changes in operating current, gap voltage, and wire offset.

Procedure:

After revieing safety precautions proceed with the following steps to repeat the lab.

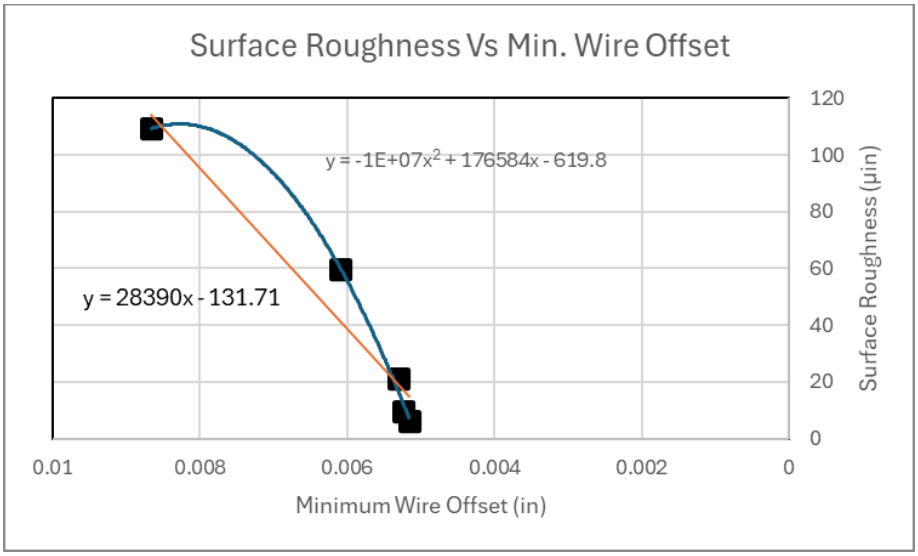
1. Start up the machine and affix your part in the proper manner
2. Load cut path for all experiments into the machine
3. Set offset for experiment 1 (if not already contained within the g-code) and start machine
4. Record Offset, Voltage, Current, and Pass-wise cut time for each pass until machine stops and prompts to begin next pass
5. Repeat steps 3 and 4 for each separate experiment while changing the minimum wire offset, Order for the wire offset is as follows in inches
    a. 0.00866
    b. 0.00610
    c. 0.00531
    d. 0.00524
    e. 0.00516
6. Follow proper machine shut down procedures and remove part
7. Take part over to profilometer and test each surface's roughness

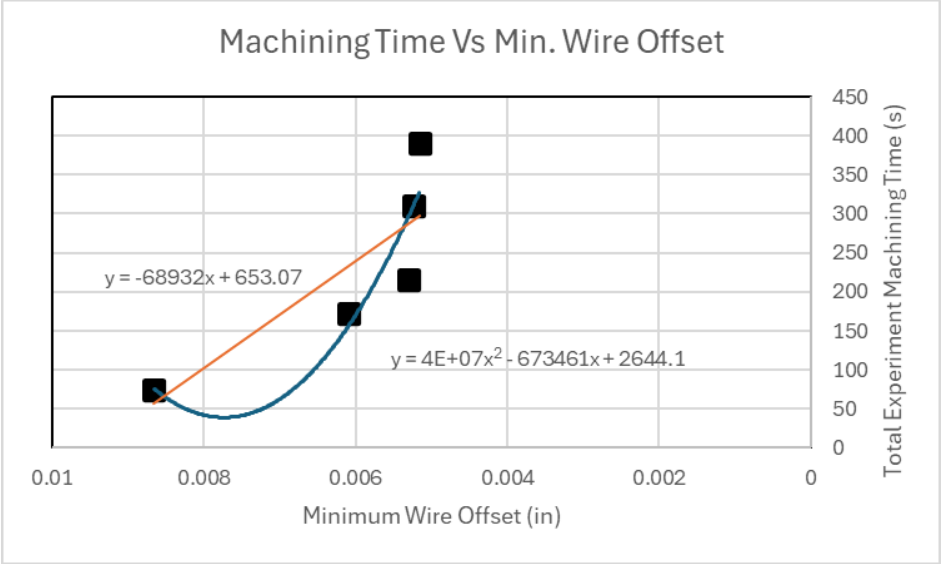
Presentation of Results:

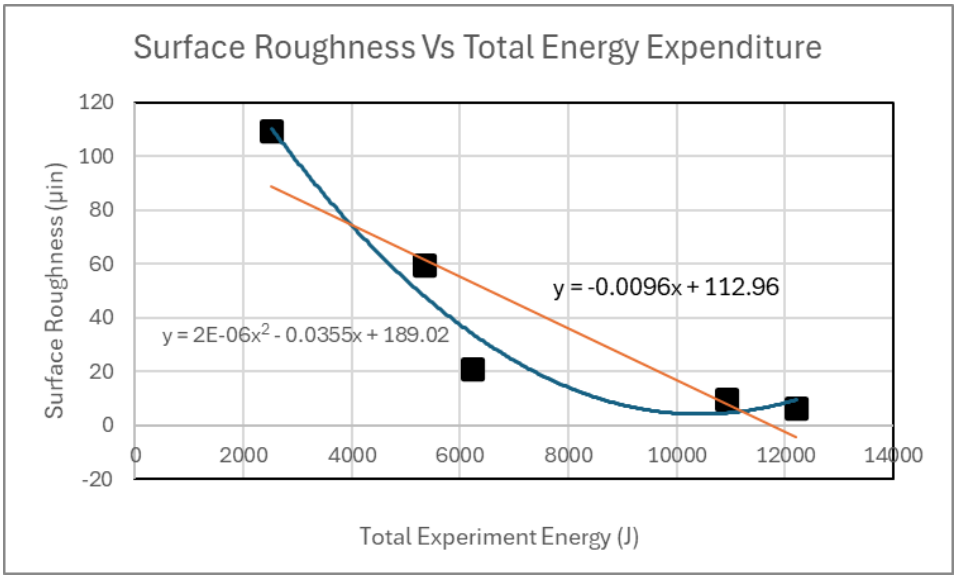
Below is as required the data collected and calculated from the experiment. Minor changes were made because of how data was collected. Since we were 1 value for each pass type (not one per pass per experiment) the pass# has been removed and single pass measurements are now taken on a single newest pass basis.

Experiment #	Minimum Wire Offset (in)	Voltage (V)	Current (A)	Power (W)	Newest Pass Energy (J)	Total Experiment Energy (J)	Newest Pass Machining Time (s)	Total Experiment Machining Time (s)	Surface Roughness (µin)
1	0.00866	42	0.8	33.6	2520	2520	75	75	109.3
2	0.00610	97	0.3	29.1	2823	5343	97	172	59.8
3	0.00531	50	0.4	20.0	880	6223	44	216	21.2
4	0.00524	38	1.3	49.4	4693	10916	95	311	9.8
5	0.00516	23	0.7	16.1	1288	12204	80	391	6.4
Note Passes were identical between experiments data originaly recorded by pass is now recorded in its respective "Newest Pass" Column									

Below are the graphs required in order. The graphs contain both a 2nd degree polynomial trendline and a linear trendline. The equations for each are placed near their respective lines on each graph.







Discussion of Results:

Surface Roughness vs Offset

The surface roughness seems to have a (inverse) second-degree exponential relationship with the position of the wire in respect to the part. As seen in the graph, the polynomial best fit line matches the data very closely and could reasonably be used to predict the smoothness of future parts. That being said, given that roughness cannot be a negative number future experimentation with very low offsets such as those belo.005 should show an asymptote somewhere between 6 and 0 where at the improvements gained from decreasing offset will slow to a point of becoming negligible. A theory on why such an experiment was not run could either

be that the risk the wire breaking was too high or more likely that the increased time needed to achieve such a low offset would make the lab run beyond the desired timeframe set out for it.

Machining Time vs Offset

The positive relationship between cut time and offset is apparent from looking at graph 2. In the case of this graph the linear trendline actually overshoots the more accurate polynomial trendline as it has an poorly placed critical point where the data seems to suggest one might not exist. Because both graphs seem to have large inaccuracies the exact relationship between the cut time and offset is harder to determine compared to surface roughness vs the same. However, my educated guess is that the relationship between the 2 is a modified version of the polynomial seen perhaps of a higher order as the last sample point seems to be outpacing the slope of the 2nd degree polynomial trendline. Regardless of the exact relationship between the 2 variables the effect of increasing machining time is significant and worth noting for when parts have less stringent requirements as said parts should be made with a greater offset to reduce machine runtime. As alluded to in the above paragraph this is a possible reason as to why our experimentation was not enough to determine the location of the Offset vs roughness asymptote.

Roughness vs Energy

The relationship between roughness and the energy required to achieve said roughness seems to be inverse. This relationship also seems to have a clear asymptote around the roughness mark of 6 as the increase in energy exponentiates without much change to the roughness (see graph 3 for proof). Experiment no3 was an outlier from the trendline in this graph with both the polynomial and linear lines being visibly pulled because of the possibly erroneous data point. The graph serves as another example that unless absolutely required the surface finish should be left as rough as possible to save as seen both energy and time (energy is related to time as energy is the product of time and power).

Does it align with intro/background

The data above and the conclusions that can be made about the data are in line with what the data was expected to represent in the lab. The data and graphs show how the Wire EDM changed during the lab as the variables it was set to changed. As a lower wire offset was set and more time was allotted to the machine the Wire EDM created a smoother piece with less tolerance which is a more quality product.

Conclusions:

There are correlations between the variable parameters (Wire Offset, Surface Roughness, Machining Time, and Energy Expended) the data gathered from the Wire EDM lab experiment which show as wire offset decreases so does roughness. In the results section there are graphs and tables which show this correlation. Insights into the machine settings were given in the lab, this allowed us to observe product quality and compare it to the other test runs. Looking at a product quality in a real sense can result in being advantageous to both the producer and the clients. More correlations with data showed that along with wire offsets that longer runtime, which results in higher energy consumption also leads to reduced surface roughness. Overall, the data backs up the conclusion that allowing the Wire EDM more time and a lower wire offset leads to better outcomes, this conclusion is consistent with the conclusions established by the equipment's performance in the lab.