

Basics of Mechanical Engineering-2

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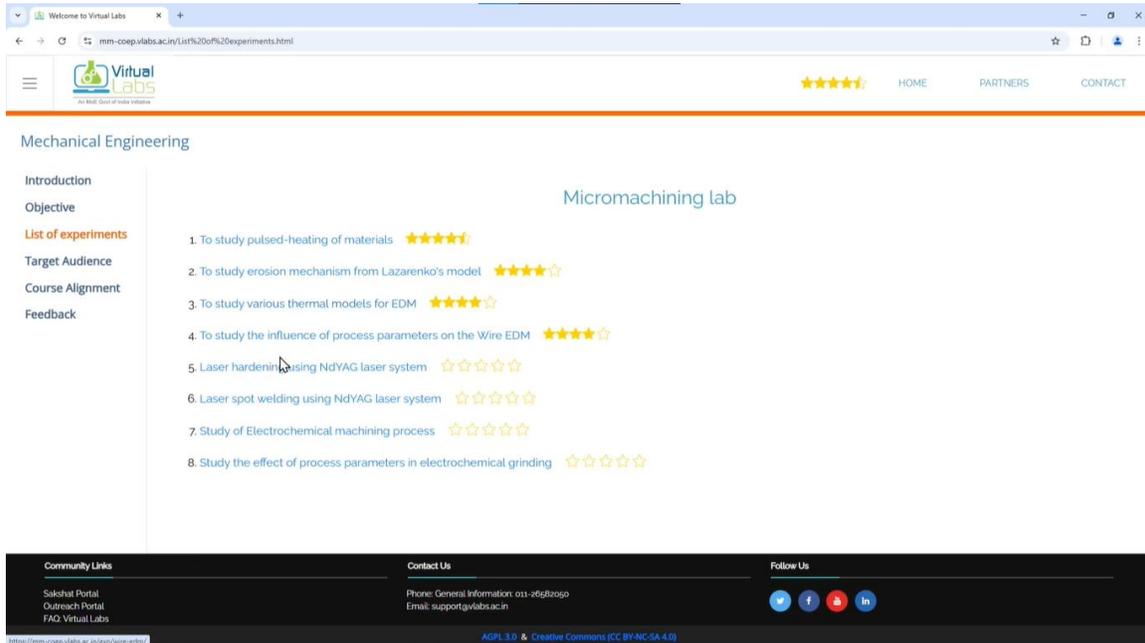
Indian Institute of Technology, Kanpur

Week 11

Lecture 47

Virtual Lab. Demonstration (Non-Conventional Machining)

Welcome to the virtual laboratory demonstration on non-conventional machining or micro-machining. We have seen the micro-machining processes in the theory part this week. I have taken some problem statements. Let me come to the VLAB. I will say VLAB micro-machining here. If you put this in Google, you will see the second page here: micro-machining lab.



The screenshot shows a web browser window displaying the Virtual Labs website. The page title is "Mechanical Engineering" and the main content is titled "Micromachining lab". The page features a list of 8 experiments with star ratings:

- 1. To study pulsed-heating of materials ★★★★★
- 2. To study erosion mechanism from Lazarenko's model ★★★★★
- 3. To study various thermal models for EDM ★★★★★
- 4. To study the influence of process parameters on the Wire EDM ★★★★★
- 5. Laser hardening using NdYAG laser system ★★★★★
- 6. Laser spot welding using NdYAG laser system ★★★★★
- 7. Study of Electrochemical machining process ★★★★★
- 8. Study the effect of process parameters in electrochemical grinding ★★★★★

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Mechanical Engineering > Micromachining lab > Experiments

Aim
Theory
Pretest
Procedure
Simulation
Posttest
References
Feedback

To study influence of process parameters on the Wire EDM

To study the significance of process parameters viz., voltage, current and pulse on, off time; on Wire EDM process.

Objective

1. To study the Wire Electrical Discharge Machining process
2. To understand the effect of variation of pulse time, leading towards variation in desired output.
3. To acquire knowledge regarding effect of voltage and current on the Material removal rate in WEDM

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Here is the list of experiments to study pulse sheet materials and to study the erosion mechanism of the Lazerkos model. Then we have experiments on EDM. Experiments number 3 and 4. Two experiments on laser.

Experiments number 5 and 6. And two experiments on ECM. That is the study of the electrochemical machining process. And effective process parameters in electrochemical machining grinding. Let us first try to visit an experiment on EDM.

The experiment which I pick here. Is to study the influence of process parameters on the wire EDM. I am clicking on the experiment. Here is the objective to study the significance of process parameters. That is voltage, current, pulse on, off time on wire EDM process.

Objective is to study the wire EDM process to understand the effect of variation of pulse time. To acquire knowledge regarding the effect of voltage, current and other parameters here. Majorly voltage and current is being studied here. The theory part shows the EDM process, the details, how the machining result comes, wire electrode, material dielectric. Other functions, adjustable parameters are discharged, current gap.

All these things are given here that we have studied. Though it will be more detailed than we have studied because it is specifically about micromachining. Let me come to the pre-test questions. Some trivial knowledge about the EGM. Let us see what do we have here.

Wire EDM is used. Viridium is used for die sinking, pocketing, majorly for cutting. So here we have a wire which is also an electrode and the material is just passed through it. It cuts the material into two parts. So cutting operation is majorly there.

Tool is of the form of wire in viridium. Cutting very hard electrically conductive material in EDM can be performed using. This could be performed using wire, metallic ribbon, thin metallic softened disc. Yes, all of these could be used. The dielectric fluid used in EDM is generally, the dielectric fluid generally is water that is deionized.

CNC wire EDM. Generally, these are 2-axis, 3-axis, 4-axis, all kinds of the machines are there. Depending upon the kind of the work which we wish to machine. So, I submit. So, these are all correct.

The procedure is given that how we conduct the simulation. Let us come to the simulation directly here. So, here we have been given the EDM process here and let us see the trials which it is given here. First trial. In the trial 1, voltage is 48 to 50, machining time is 4.36, T on is 0.25, T off is 1.28.

Let me add this trial here. So this is MRR 2.417 millimeters cube per minute and RA is obtained as 1.02 micrometers. So, the parameters which I put here are voltage, machining time, T on, T off is already there. What I get responses, two responses, one is MRR, second one is RA. So, this is trial 1.

Let me see the trial 2. If I add here trial 2, you see how the pulse is being generated. You can see here on the right hand side of the dashboard. So this is the second parameter in which machining time is now 3.64, T on is 0.377. And voltage is being varied between 48 to 50.

The third trial lets me see. So here, the machining time is now 3.08 millimeters cubed per minute. The Ton is 0.505. Let me pick a slightly further value, trial number 7. Here, Ton is 1.016 microseconds.

And the machine time is 2.71. So here, the MRR is quite higher in comparison to the previous values. Let me try to see another value, maybe value 9. Here also, the MRR is 4.313, and Ton is 1.27. The last trial, the 10th, I will also add.

Here also, the MRR is higher. Let me try to see the graph. The two graphs are Ton versus MRR, Ton versus RA. Let me pick Ton versus NMRR. So here, you can see the experimental value and theoretical value, both are there.

Experimental value is blue, theoretical value is red. So, this one experiments that we conducted based upon that these two plots are obtained. And this is in a increasing trend continuously. Let me try to see Ton versus RA. This is also an increasing trend.

The experimental versus theoretical value these are very close here. So, this is the study of the parameters that is t on is one of the parameters. That is studied and the output or response is taken are MRR and RA. It is response and the volume removal. So, let me come back to the post test questions.

Wire EDM is generally used where fixed frequency, pulse time, pulse of time. Variable frequency, pulse time and pulse off time, second is the right option, option B. Material removal rate depends upon pulse time, current, pulse off time, everything determines the material removal rate. Selection of process parameters are done on the basis of job, job specification, job roughness, job productivity, matrix is major parameter here. Wire EDM is generally used for ferrous materials with reverse polarity.

That wire is positive and work is negative. Does porosity in job material affect the machining process? Yes, porosity does affect it. That is why we have put the matrix as the process parameter that is important here. The accuracy of the job depends upon wire tension and feed rate. And got this.

Let me come to another experiment. The list of experiments I open again. Let me come to the laser hardening. That laser system equipment is the user phenomenon of laser hardening. Differing from conventional heating.

So laser hardening the theory part is there. So this is what it is giving, that through laser how hardening is happening. In pre-test questions, laser is a dash manufacturing process. It is a flexible manufacturing process. Irradiation by itself is a monochromatic light.

Laser material processing is a thermal process. Laser material processing is associated with the absorption of total energy, absorption, transmission, and reflection. Absorption, I would say. The efficiency of laser systems for machining is generally between 0.5 to 1 percent only. Let me try to see the procedure.

It says, let us go to the simulation and see how the simulation helps. So, here we have the type of state, pulsed or continuous, and the power in wattages. And the spot size, this is pulse heating of materials with high-energy-density pulses. Let me try to add this parameter here. The maximum that, that is a plane, is 69.3 micrometers.

The maximum width is 1328.73 micrometers. Now, in the pulse itself, let me try to change the parameters. I will keep the voltage the same and try to change the spot size in the next spot size level. Then I will pick another spot size. Then I will pick another spot size of 1.66.

Let me try to add. Let me now try to change the power and add an experiment. It could also show us the graphs here. Spot size versus depth. Spot size versus width.

Let me try to see the graph. Spot size versus depth. See, the spot size versus depth. The case depth first decreases, then increases. That is, when we increase the spot size, the case depth is minimized at a specific point.

For example, at around 1.1, then it increases. Let me try to see the spot size versus width. It also shows a similar trend. At around 1.01, it is the minimum. Less than that and more than that, it is greater.

So, we can vary the power, we can vary the spot size. We can vary between the two categories that is pulse and continuous. You can try to review or view the different plots here. And try to see how pulse and continuous both the categories are being plotted here and how do you have a sensitivity analysis. For example, if you fix specific spot size and keep on varying the power here or you speak the average or the middle power.

For example, the middle power here is be around. You fix the power at 905, vary the spot size or you fix the spot size at specific value, vary the power. Try to see different plots so that you understand how does the laser parameters behave. Now, let me come to the post test questions. Performance of laser spot hardening process is affected by welding speed.

Focal length of the beam, focusing length, workpiece position, all of these is the right answer. Which of the following conditions need to be satisfied for laser hardening? High accurate positioning of the components, accurate positioning of the components in the focus of the laser. To prevent large variations in the irradiance. All of these are the correct answers.

Laser hardening can be performed using pulse and react system, continuous wave and react system, pulse fiber laser system or all of the above. All of the above can be performed here. laser cannot effectively machine it cannot machine copper or aluminium because these are very reflective Surface texturing can be carried out using EDM, laser machining, electroforming. B and C can help us in surface texturing because EDM we cannot understand or we cannot very closely find the texture.

Though there are experiments or there are studies which say surface texture is now somewhat possible through EDM. But majorly it is done using laser or electroforming. I am submitting. These are the correct answers. Now, next I have picked spot welding using NDAG laser system.

So, I will directly come to the simulation here. What I need to verify, I have to first select between beam power and spot size. I say beam power. Beam power I fix at 486 and try to take one reading. You see the laser through the mirror.

It is being reflected here. And the machining is happening here. Machining or spot welding, you could say. So, beam power is 46. So, let me now say a beam power of 553 in this experiment.

The output parameters here are the spot size: 553 millimeters, weld strength was 152.2 Newtons. The next experiment, where beam power is 553, we have a spot size of 486 millimeters and weld strength of 372.6 Newtons. Another parameter I will pick and add. Another parameter that is beam power I will pick and add. So, the plot is generally made here when we at least add 5 of the readings.

So, 5 readings are obtained. You can now plot it. Let me also see once I refresh and try to see the spot size now. 0.68 spot size. Then a spot size of 0.73.

I will add another spot size I will be 0.77 add, another spot size of 0.83. I will add and 0.93 also I will add if we try to see the graph. So, here depending upon the beam spot size you see experimental and the theoretical experimental are the blue. It increases first then it decreases. However, the theoretical calculation said it will keep on increasing as the spot size increase.

The weld strength keeps on increasing. But here you see the maximum strength is obtained at a specific spot size that is 0.73. So, sometimes the machine behavior is different than one theoretical part. So, this is also one of the outcomes in realistic situations. The laser is behaving in this way that for a specific soft spot size the strength is higher, then it decreases further.

So, this is for specific setup that we have here. So, these are all the parameter of the value which are put as input in the GUI of this design. The virtual avoided design virtual laboratory setup of laser. Let me try to see again the post test questions only the performance of laser spot. Welding process is affected by welding speed focal length of the beam.

And focusing length, workpiece position—all of these affect the laser spot welding process. Which of the following conditions need to be satisfied in laser spot welding? High-accuracy positioning of the components. Accurate positioning of the components in the focus of the laser prevents large variations in the irradiance. All of these. Which welding technique includes spot welding modes?

That is conduction and penetration resistance welding, laser welding, MIG welding. TIG laser includes both conduction and penetration. A laser cannot effectively machine copper and aluminium. That we have also seen in the previous post-test questions. Because copper and aluminium are both very shiny.

So, the laser reflection is present. So, can we consider the laser anchor thermal model for laser beam or electron beam heating? Here, yes—that is the first experiment given here. Because that was not part of our study, I did not go through these experiments to study the erosion mechanism of laser-encrusted models. You can also walk through this experiment if you wish to.

Let me now come to the electrochemical machining process. This experiment is just a study of electrochemical machining. So, where the theory gives the complete electrochemical machining system. How does it work, the certain parameters that we have studied as V is equal to I into R , R is equal to H rho by A . These things we have studied already.

Let me come to the pre-test questions. Which electrode is eaten away in electroplating? In electroplating, electrochemical machining uses the electroplating phenomenon. In which a node is being heated. In ECM process, the tool act as the tool in ECM is cathode.

The ECM is normally used for machining of the materials which are very hard. That is extremely hard materials submitting. Let me come to the simulation. So, here we can select the metal. Depending upon the different metal, they will give us the metal removal rate here.

So, aluminum, beryllium, chromium, cobalt, copper, iron—so many metals are there. For example, if I fix aluminum here. Now, we are in ECM. Aluminum could also be machined. Atomic weight and valency are given.

We have to select the valency. For example, some metals have two valencies. Iron has valency 2 and 3. That is ferrous and ferric. Let me pick ferric here.

Valency 3. Select the removal rate. We need to get the removal rate in grams per second or 10^6 raised to the power minus 6 meters cubed per second. So, you can see a pop-up window here. The pop-up window shows the metal removal rate as 0.5.

So, if I need to see this in $\times 10^6$ meter cube per second, it is 0.193. If I need to see this in grams per second, it is also showing the same value. So, if I try to run this experiment, I've just switched on this button. I clicked on this button that was red before.

You see the pump is pumping here. The system is working. So it is being filled here. Now the reservoir is being filled with the electrolyte. So electrolyte is being filled and the electrolyte is now getting restored into the container.

That will now turn this back into the original electrolyte reservoir through the filtration process. So this is how the process is now in a continuous running position. You see electrolyte starts from here. It goes, it is getting filled here and it is now a continuous process. A continuous rotation of electrolyte is here and electrochemical machining is happening.

Let me try to refresh it and try to rerun it for any other metal. For example, I pick titanium. It is very hard. Valencia I pick 3. I try to run it.

Now the color is only little different. You see the electrolyte is being run here. The filter cleans it. It is being passed through this tube and here is the reservoir that is being filled here. This is the shape of the workpiece through this workpiece also.

You will see the complete container would be filled here. And electrolyte now is getting through filtration. After the cleaning it is getting back to the electrolyte reservoir here. This is a study of the ECM process. I can click on the removal rate.

Here, it says the removal rate is 1000 amperes. Nautic efficiency is 100%. That is the assumption they have taken. Now, if I click the removal rate, I get a pop-up here. It says the removal rate is 0.165 grams per second.

Let me now come to the post-test questions here. Does the material removal rate in ECM depend on the hardness of the workpiece? Now, what do you think? We have been talking about this time and again. Hardness is not a parameter that affects the material removal rate in ECM.

The commonly used electrolyte in ECM for steel is NaCl. There are kinds of electrolytes that we use: sodium chloride, HCl, sodium carbonate, and sulfuric acid. There are electrolytes which are for soft machining. There are electrolytes which are for aggressive machining, that is, more machining or higher MRR is required. Other electrolytes are there where a rougher surface is required.

So, depending upon these, these are there. Let me come to another experiment that studies the effect of process parameters in electrochemical grinding. This is electrochemical grinding, like electrochemical turning; the electrochemical grinding in which a wheel is used. So, here is the theory part of electrochemical grinding. Let me try to see if the figure is given here; it will be there in the simulation. We test a question: let us see which is the very commonly used metal in grinding wheel in the

It is copper. For grinding steel workpieces, which is the commonly used abrasive metal? Aluminium oxide. The seizure—yes, here we have this grinding wheel. This is insulated grit.

An electrode wheel is there, which is generally copper here. And electrolyte is being flushed through this nozzle. We have tool and workpiece connection here. And this mechanism you have seen in the theory part. So, this is ECG, electrochemical grinding. Let me come to the simulation. You see here the electrolyte flow is present. It is coming through this. And here it is being filled. And this is a rotating electrode wheel.

And the grinding is being conducted here. The effect of voltage on the depth of cuts. You can select different voltages and try to see how the depth of cut varies. It shows the current density is 18 microns. Then at a voltage of, let me say, 10, the depth of cut, I will say again with 5, it is 30 microns.

With the depth of cut 10, it is 22 microns. The current density is shown here. So I can also see the effect of voltage for different electrolytes. So, this is the effect of parameters on current density. The effect of different depths of cut, the effect of different electrolytes.

Then effect of voltage for different electric concentrations. Also, effect of current density of MRR, this is also here. So, current density if I keep on varying and for higher valency, for lower valency. I can see it is showing that predictive metal removal rate is 2 millimeters cube per second. This is the model that is there which is doing calculation and this is showing the values here.

So for another let me say for the current density of 18 amperes per millimeter square. And for lower valency it is showing 12.5 millimeters cube per second as the MRR. Now experimental also we can see here experimental is 3 millimeters cube per second. So, this is as a study you can keep on clicking different parameters keep on studying. The things as the requirement that you have you wish to study you can read certain publications.

Which are there you can study different books which are given in the references to study about the non-conventional machining systems. This is just a virtual laboratory setup that I have shown. So, let me now come to the post test questions and try to close this lecture. If the voltage is increased then the current density will increase or decrease. If the voltage is increased, the current density will also increase.

If the current density is increased, then the material removal rate will increase or decrease. If the current density is increased, the material removal rate also increases. That is the trend we have observed. So, this was the micro-machining lab, where different experiments are conducted. With this, I am concluding this week's topic on non-conventional machining.

We have studied the types of non-conventional machining. The theoretical part covers very basic information about them. Because this is a course on the basics of mechanical engineering. Generally, the basics of non-conventional systems are not taught. But to give you a brief introduction, nowadays non-conventional systems are also helping us in micro-machining. With this, I am concluding this lecture, and we will meet next week.