Metal Cutting and Machine Tools
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Lecture – 20
Numerical problems

Welcome viewers to the last lecture of our course metal cutting and machine tools. So, let us move right away. So, today we are going to have some discussion on the numerical problems which can be you know in these areas to.

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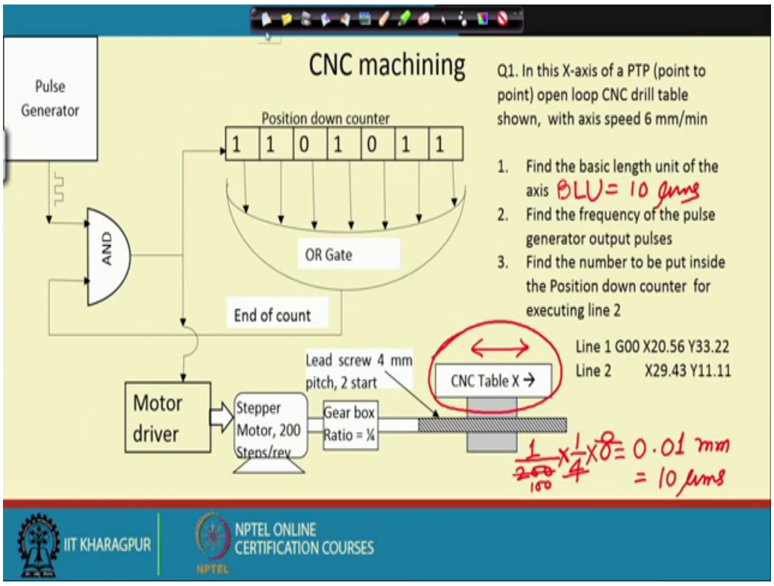

So, let us start right away with our figure that we have come across and the question reads in this X axis of a point to point open loop CNC drill table shown with axis speed of 6 millimeters per minute find the basic length unit of the axis, find the frequency of the pulse generator output pulses and find the number to be put inside the position down counter to for executing line number 2 of this particular couple of lines.

So, first of all which is the table; the table is this one this is the CNC table X axis. So, it is capable of moving this way and that way; who is moving it the lead; screw is moving it the lead screw is connected to the motor through a gearbox the motor is run by the pulse generator. So, the pulses which are emitted here, they are moving through and for the timing, let us assume that nobody is stopping these pulses from reaching the motor basic length unit means the smallest distance that we can control or measure for movement here we are, sorry, not measuring anything because this is working in open loop, but we are controlling the movement by you know our smallest controlling element is one pulse.

So, let us see how much movement we are acquiring by one pulse and that is basically our basic length unit or BLU, sorry. So, first of all, let us see, whether we can have some calculation here, yes, first one pulse must be moving the motor shaft by one by 2 hundredth of a rotation. So, let us write 1 by 200, this is the movement correspond to 1 pulse rotation gearbox further reduces, it gearbox multiplies it by a factor of one fourth ok, one rotation here is converted to one fourth of a rotation here.

And therefore, this also is proportionately reduced lead crew; however, will be undergoing h millimeters per rotation of the per rotation of it is you know of the lead screw. So, this one for these many rotations of the lead screw, it will be rotating, it will be moving the table by h millimeters into this. So, how much is this equal to 4 cancels out with 8 and this 2 cancels out and we have left 100 and therefore, this is equal to 0.01 millimeters, 10 microns, this is equal to 10 microns.

So, we have this answer basic length unit is 10 microns find the frequency of the pulse generator output pulses. Now we are given this information that axis speed is 6 millimeters per minute. So, let us consider a pulse generator frequency to be f.

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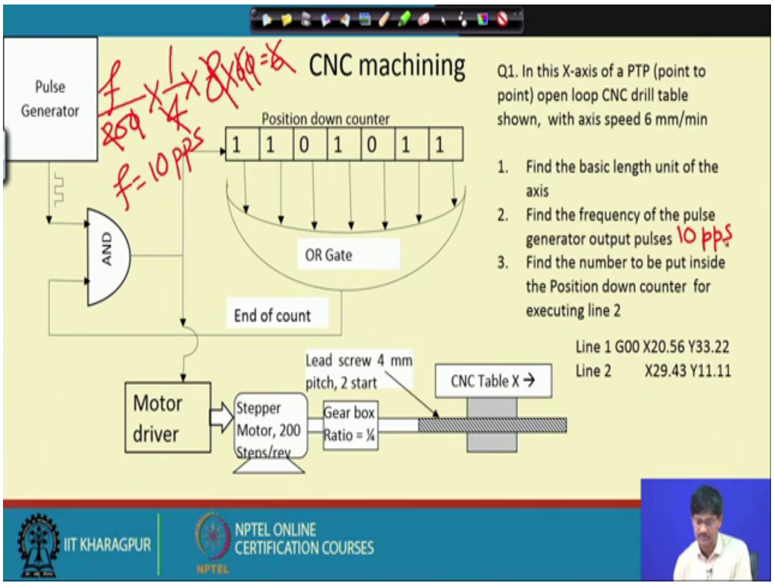

So, f ; how many of these pulses will give us one rotation 200 pulses. So, these many rotations of the stepper motor will be obtained per second. Now, these rotations will be reduced by the gearbox by a factor of one fourth and the amount of motion obtained will be multiplied by the lead of the lead screw and therefore, this should be equal to when multiplied by 60, this should be equal to 6 millimeters. Now, here what will cancel out 6 with this 6 and this 0 with this 0, this 4 with this 8 and this 2 with rest of 8 and therefore, we will have f is equal to 10 pulses per second ok.

So, this one is 10 pulses per second, find the number to be put inside the position counter for executing line number 2 line number 2 says that I want a movement of 29.43 millimeters.

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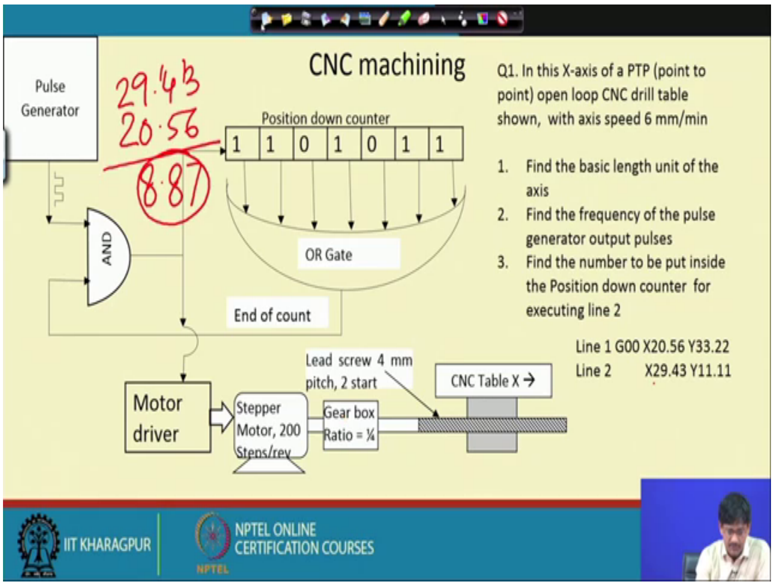

So, let us subtract it, 29.43 and it was already a 20.56; 20.56. So, this means 13, 7, 1, 14 and this is 6. So, this is 8 and 1 goes here 8; 8.87 millimeters of movement are required. So, I have to put some number. So, that this will get decremented and it will exactly become 0 when the required motion has taken place per pulse, I am having 10 microns of movement.

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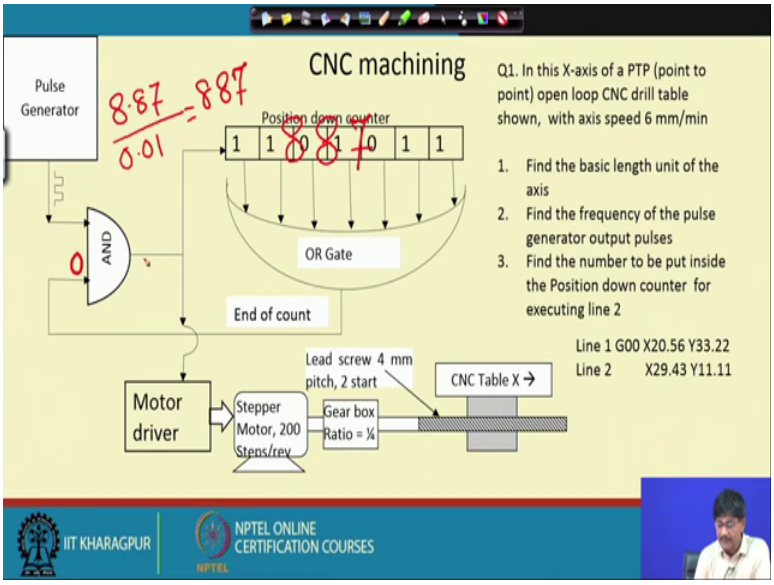

So, this means that if I want to have 8.87 millimeters of movement, how many pulses would be required? 887 pulses will be required in order to get the stepper motor move the table through 8.87 millimeters.

So, if we put 887 in binary inside this position down counter, our job will be done because while 887 pulses are coming here, 887 pulses will be coming there; going there and it will be down counting the contents to 0 and or gate will put out a 0 here for the pulses will be stopped. So, the number to be put inside is rate 887.

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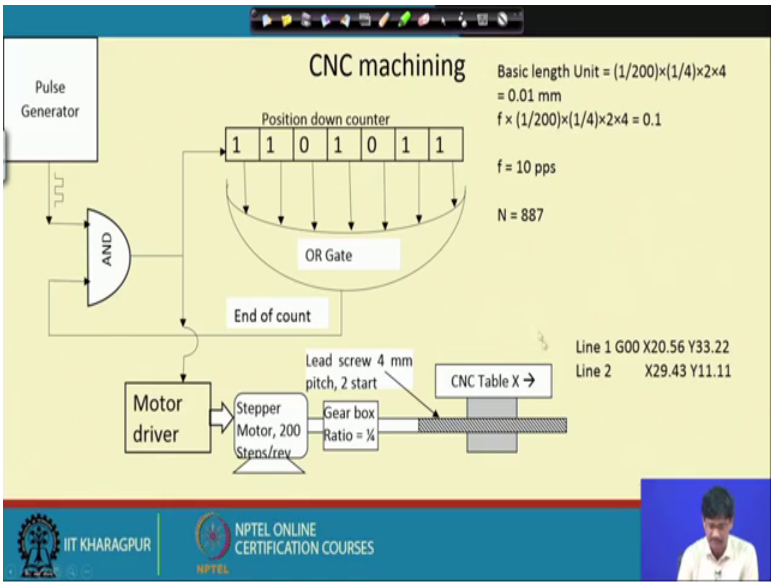

Let us see, yes, these are the answers provided here ok, this was 0.1 and from here you can easily calculate f. So, having understood this one, let us move on to the next problem.

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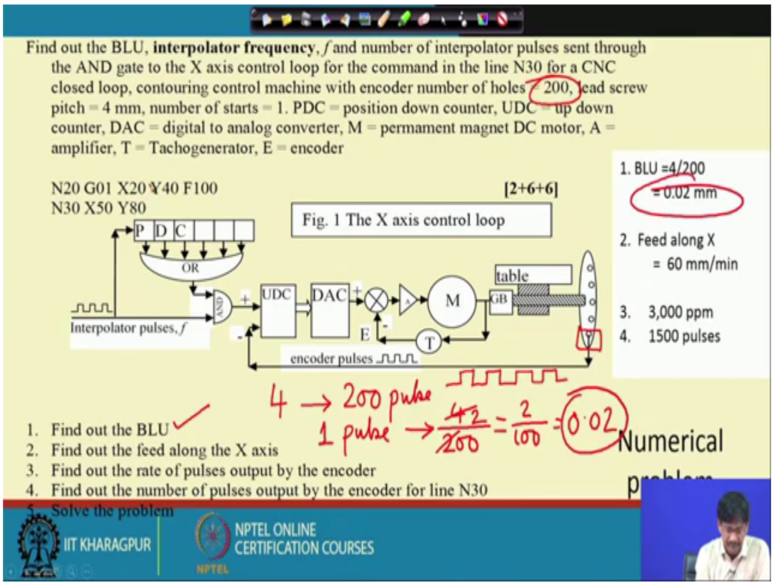

Find out the basic length unit interpolated frequency f and the number of interpolator pulse is sent through the end gate to the X axis control loop for the command line 30 for a CNC closed loop contouring controller continuous control whatever with encoder number of holes 200 lead screw pitch for millimeters number of starts equal to 1 and PDC stands for position down counter ok.

So, this is the thing position down router, next UDC up down counter, here just as we have discussed this thing. So, let us not lets go into the problem directly find out the basic length unit, how is the basic length unit decided, this is a closed loop system in which we are keeping track of the movement which is taking place and the encoder sends back pulses each pulse is therefore, our smallest unit of the actual movement carried out what is this smallest unit. So, how many holes does the encoder have 2 hundred holes that is fine.

So, each rotation of the lead screw also causes 200 holes to pass through, you know some there is a control circuit placed here which sends out pulses here corresponding to each such hole each hole when it passes through the control circuit sends out pulses like these and these encoder pulses are a counting you know unit. So, let us find out, how what movement of the table corresponds to the passage of one encoder pulse to create I mean one encoder pulse across the control circuit.

So, we understand the table moves by 4 millimeters; 4 millimeters of table movement is obtained for 200 encoder pulses ok, therefore, one pulse one pulse of the encoder will be counting this much amount of movement and how much is this 4 cancels with 2. So, that a 2 remains upstairs 2 by 100 and therefore, this must be equal to 0.02 and this must be the amount of distance kept, I mean read or kept track by the encoder one encoder pulse, therefore, this is the answer next is what is the feed along X axis. Now this seems to be difficult feed is mentioned here, but that is a long sorry, but that is along a ah path which is not along X axis you are at 20 you are at 20 and 40. So, you are at this point.

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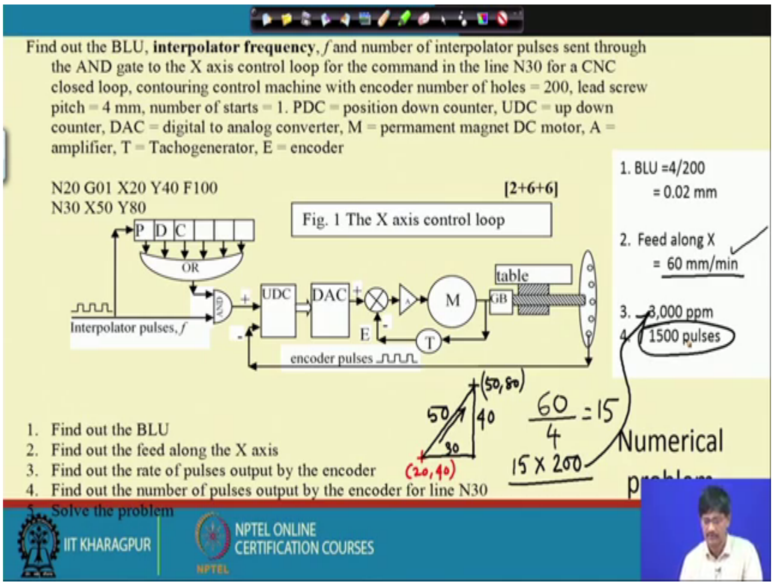

This is 20, 40; now this red is little difficults to ok, let us have this you are at point 20, 40 and from there you are going to another point 50, 80.

Now what is happening; 50, 80. So, we can easily compute these distances 20 to 50, 30, 40 to 80, 40. So, this must be 40 and therefore, this must be 50 so; that means, the feed of 100 millimeters is along this path 100. So, if 50 is here by, you know Pythagoras theorem, we can say, this is 30, this is 40. So, if 100 is here, since feed triangle and displacement triangle, they are similar for linear movements. So, if 100 millimeters movement is there, he must be having 60 millimeters per minute movement along X axis ok. So, that is why feed along X axis 60, next find the rate of pulses output by the encoder this must be easy, we have done something like this very I mean in the last slide itself. So, let us find out how much movement rate of pulses output by the encoder, now this is X axis. So, we are having 60 millimeters per minute ok, if we are having 60 millimeters per minute movement, this corresponds to how many rotations of the lead screw per minute 60 divided by 4 15; 15 rotations of the of this shaft.

So, 15 multiplied by 200 must be the pulses coming out from the encoder. So, that is equal to 3000 ok. So, 3000 pulses are coming out. So, this way I leave the last one to you they are absolutely easy, find out the number of pulses output by the encoder for the lime N 30. So, for the line N 30 find out, what is the total number of pulses corresponding to this movement, just like we have done previously and find out whether it is equal to 1500 or not and leave that one to you.

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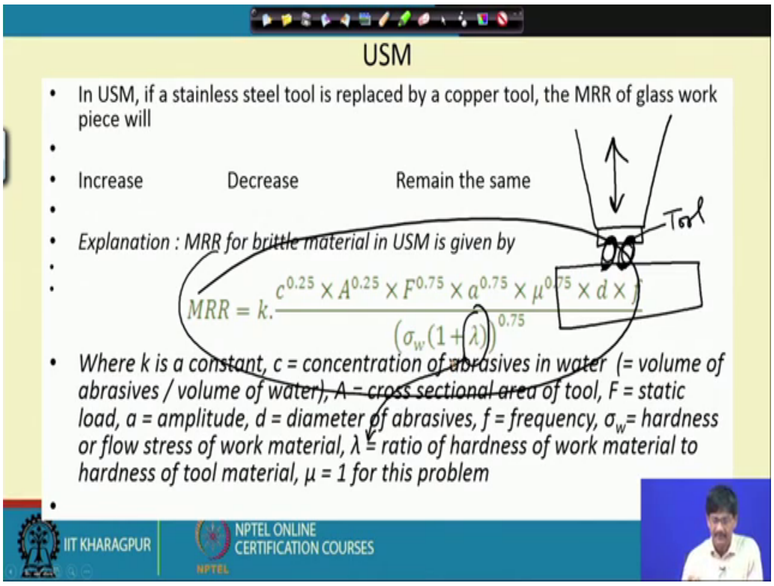

Next ultrasonic machining in ultrasonic machining if a stainless steel tool is replaced by a copper tool the MRR of glass workpiece will increase decrease remain the same. So, a tool is replaced remember the tool which was vibrating against the workpiece. Now, if steel tool is replaced by copper, tool are the tool is softer, I have worked it out through this formula, but I will give you a physical idea also this is the last part of the horn and this is the tool. So, this being the tool there are abrasive particles in between and this is the workpiece. So, if the workpiece if this is going on hammering from the top and if these abrasives are very hard they will cause indentations on the workpiece side as well as the tool side.

Now, if the tool becomes softer these indentations will be higher on the tool side and workpiece will be you know getting a relief on their side the indentations will not be much because most of the hammering action will be absorbed by larger indentations of the tool, if it is softer copper tool and therefore, material removal rate will definitely decrease and we have given here an explanation based on this formula please study this yourself I will give you a hint it is lambda which is affected and work it out yourself.

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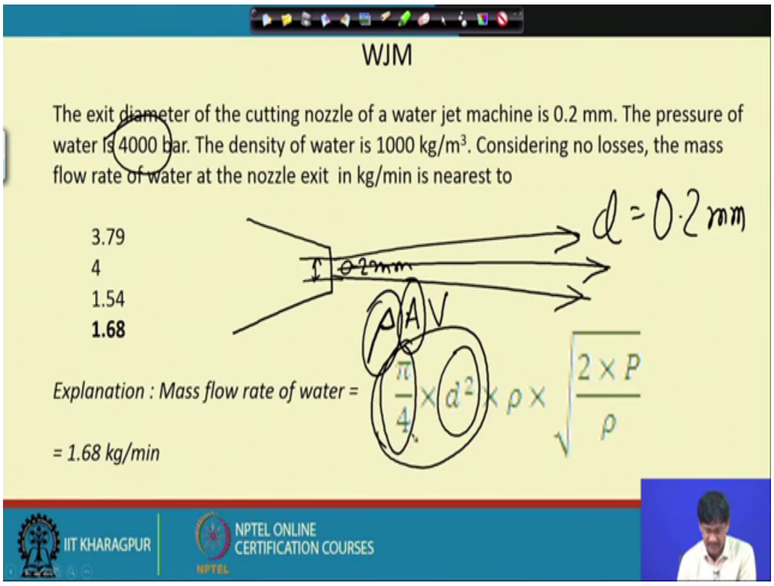

Next the exit diameter of the cutting nozzle of a water jet machine is 0.2 millimeters, the pressure of water is 4000 bars, the density of water is 1000 kg per meter cube, considering no losses, the mass flow rate of water at the nozzle exit in kg per minute is nearest to these are options and I am providing the answer 1.68 kgs per minute.

So, let us first see; what is the problem about the problem says that there is a nozzle from which water is emanating in water jet machining water is coming out at high speed ok, therefore, it is able to cut most of the nonmetal like leather paper meat frozen meat etc these things it can cut efficiently for from 4000 bars and the nozzle diameter outlet here is only 0.2 millimeters just imagine 0.2 millimeters; so small. So, how can we find out the mass flow rate of water at the nozzle exit in kgs per minute ok?

So, I will just give you the basic idea and from there you can find out first of all we know that mass flow rate will be equal to rho into a into v where rho is the density in this case thousand e is the cross sectional area which is pi by 4 into d square where d is equal to you know d is oh d is given 0.2 millimeters and rho comes here. So, rho av.

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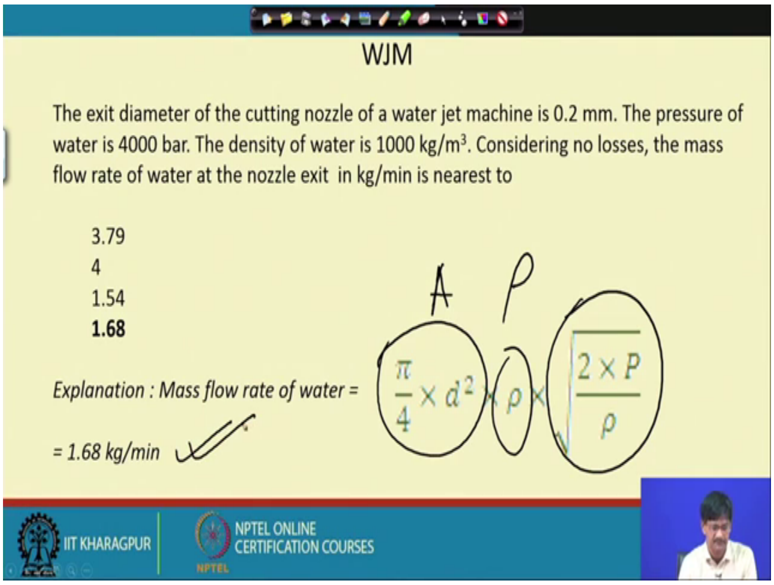

This is a sorry, this is a, this is rho and this is v how is we found out v is found out by converting the pressure energy completely to velocity energy ok.

If you remember we have Bernoulli's equation where p by gamma is equal to v square by 2 g is equal to z. So, the same thing has been done here I leave this calculation to you I am sure you can solve it and this way the mass flow rate can be is calculated to be 1.68 kgs per minute next.

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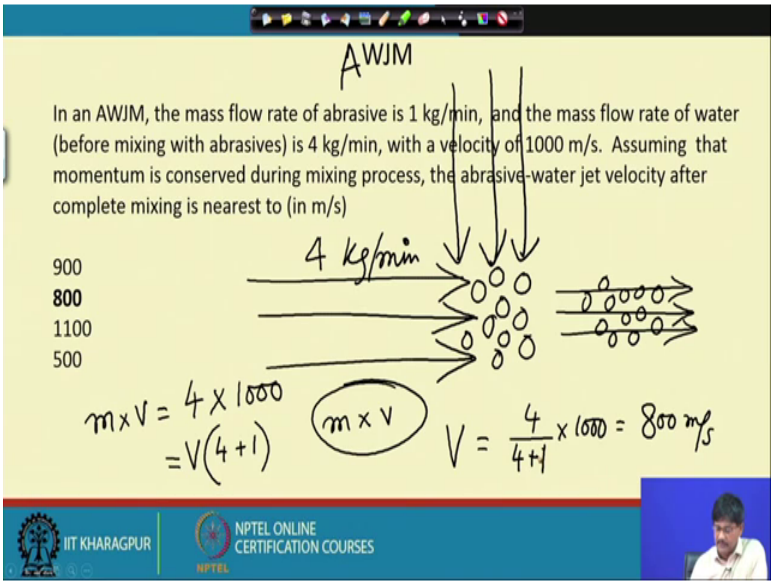

So, what a jet machining in case of abrasive water jet machining just a moment what are we working with ok. So, this will be sorry this will be abrasive water jet machining in abrasive water jet machining the mass flow rate of abrasive is one kg per minute and the mass flow rate of water before mixing with abrasives is 4 kgs per minute with a velocity of 100 meters per second assuming that momentum is conserved during mixing process the abrasive water jet velocity after complete mixing is nearest to in meters per second. So, what is this dealing with in abrasive water jet machining what happens is water is coming at high speed at high speed and its having a definite mass flow rate the mass flow rate is given to be 4 kgs per minute and its speed is very high with a velocity of 1000 meters per second.

So, we can immediately find out what is its momentum how do we find it out mass into velocity ok. So, here mass into velocity whatever momentum is carried by the water jet abrasives are put inside this particular stream what is the abrasive velocity practically 0 the abrasives have no velocity to contribute. So, ultimately if we if we are following this momentum is conserved, we have to assume that whatever momentum is carried by the water into the mixing chamber that is the only momentum available. So, m into v here means 4 multiplied by thousand now this one is ultimately giving us after the mixing chamber an abrasive water jet where both of them are sharing the same velocity; that means, the abrasives have got completely mixed inside and they are coming out.

So, we are assuming that in this case momentum is conserved no other losses, but energy is not conserved due to mixing some energy is lost. So, we can only apply the momentum conservation relation and say that ultimately if the velocity is v its minus that is being carried in this stream, it has become higher because abrasives have been added. So, it is 5; 4 plus 1 and therefore, the velocity comes out to be 4 by 4 plus 1 in to 1000 which is 800, 4 by 5; 800 meter per second this one is sometimes referred to as the loading factor loading factor which one this can be actually let me just remove this, this can be referred to as m dot.

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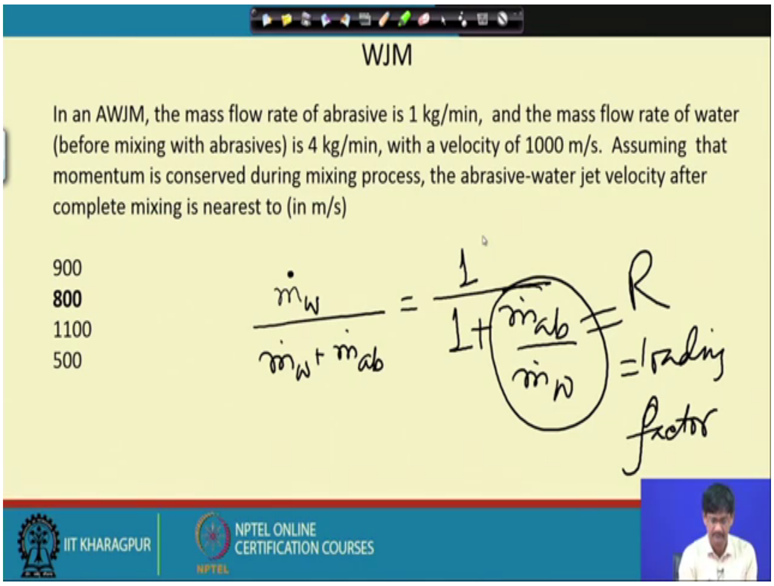

Water by m dot water plus m dot abrasive equal to if you divide this by m dot water, it becomes 1 by 1 plus m dot abrasive by m dot water and this one is called loading factor or r loading factor.

It is one of the most important parameters in abrasive water jet machining ok, I intend to include ah some solve problems and upload it for your use where you will come across the use of such parameters in abrasive water jet machining.

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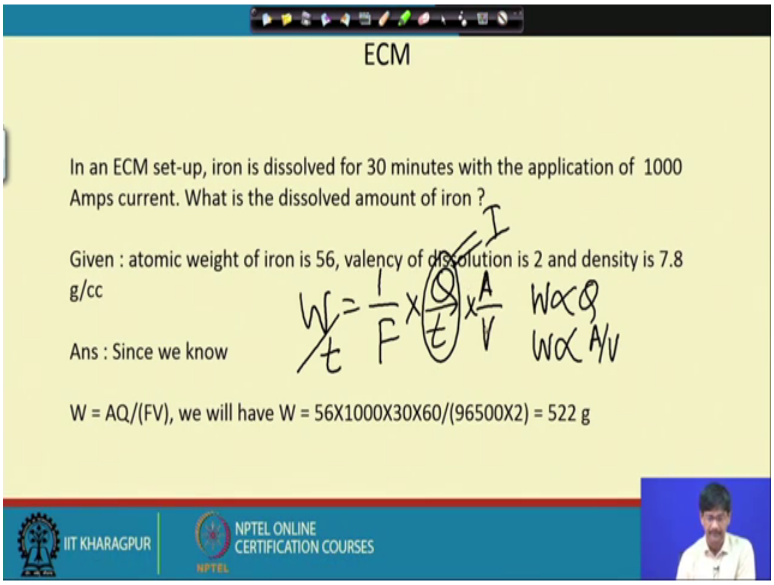

ECM is an ECM setup iron is dissolved for 30 minutes with the application of hundred amperes current what is the dissolved amount of iron. So, in this case what we have given is atomic weight of iron is given to be 65; that means, gram atomic weight is 56 grams valency of dissolution is 2, you know, I do not have 2 valencies, one is 2 and one is 3 and the density is 7.8 grams per cc [FL], what do we know from previous calculations? From previous calculations as we did, if you remember, we had weight is proportional to Q weight is proportional to A by V and therefore, weight is equal to 1 by F into Q into A by V and if we take material removal rate it we divided by t and we divided by t here.

So, that this becomes current MRR is equal to 1 by F into I into A by V it is not. So, complex here it is even simpler than that let us see what we have been given. So, W have we have we being oh this is what we have to find out; what is the dissolved amount of iron.

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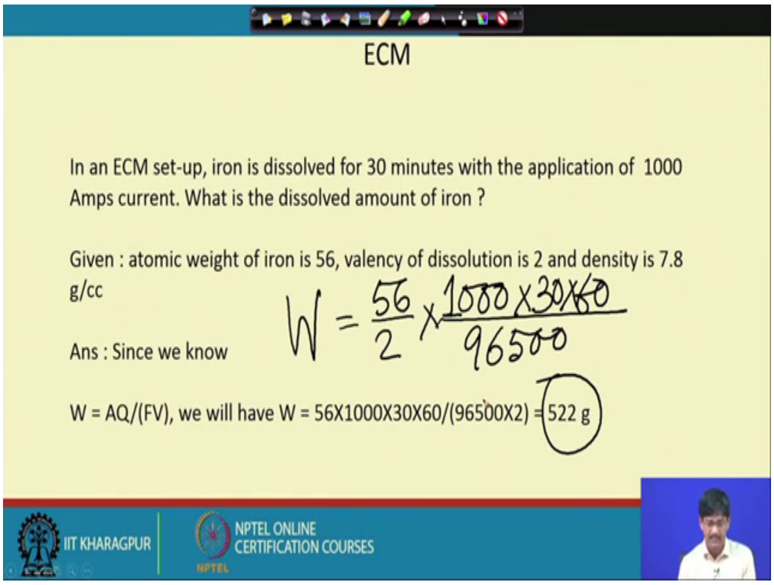

So, let us write W, it is already written here this must be equal to atomic weight by valency. So, let us put 56 just a moment 56 by 2 multiplied by charge wait a minute I think I made a mistake this should be actually I am cutting this should be actually equal to no wait a minute it is all right it is all right, right.

So, we have multiplied by charge which is amperes ampere is thousand amperes into time 30 minutes into 60 that gives the seconds. So, this is the total amount of charge in coulombs once we have this. So, 56 by 2 into this thing divided by 96500 faradays constant; so, this one after calculations will give you 522 grams of iron, just imagine you are able to dissolve about half a kilo of half a kg of iron by applying this current for 30 minutes.

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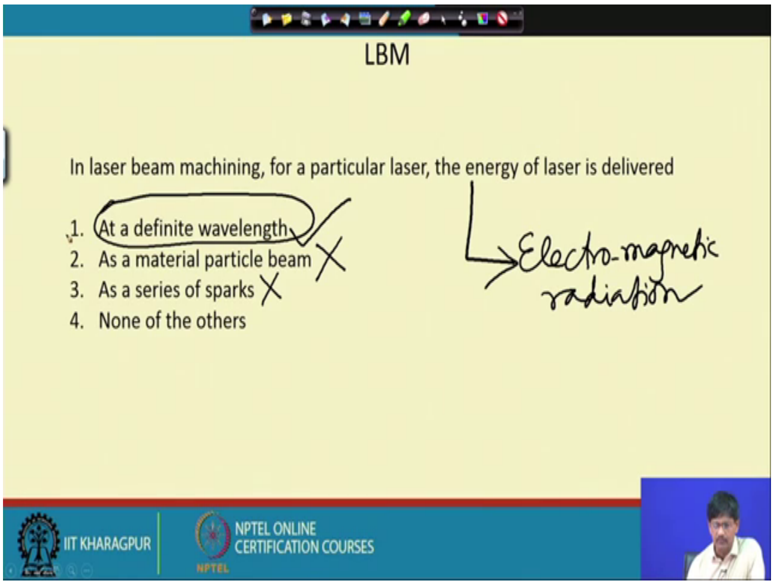

Next laser beam machining a laser beam machining for a particular laser the energy of laser is delivered at a definite wavelength as a material particle beam as a series of sparks none of the others.

So, first of all at a definite wavelength lasers always correspond to a definite wavelength or maybe a mixture of 2 wavelengths like that, but in general the concept is at a definite wavelength. So, this first one is correct we will term this as correct as a material particle beam no this is wrong lasers are basically they are light or they might be light at frequencies which we cannot see ok. So, they are basically electromagnetic radiation as a material particle beam no as a series of sparks no sparks are pertaining to you know electrical discharge machining. So, that you know people confused with that we will take this one, this is not correct and therefore, we have this as the correct answer this as the correct answer.

So, this gives us an opportunity to discuss a little more about some other methods which I have left behind, but they are equally important they are equally important that is first I would like to just mention just order yeah.

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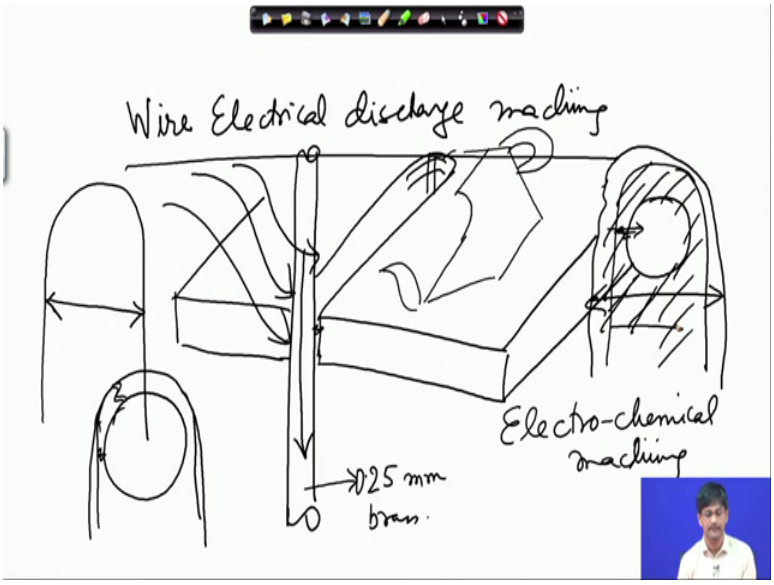

There is another method called wire EDM, wire wire electrical discharge machining which works on the same principle as you know EDM, only difference is that there is a wire which is moving and it is used as the cutting element; that means, if there is a material here say a sheet of metal and I want to cut this along this line this way I want to cut it.

If I want to cut such a piece of material then; obviously, you know if I make the wire move. So, what is the diameter of the wire maybe say 0.25 millimeters as a very thin wire what material say brass it, it can carry current, but that is all, it does not have a such any cutting ability, but suppose I give electrical connection to this and I am produced providing voltage pulses and I am flooding the whole place with some dielectric fluid say deionized water or kerosene like that.

So, if I am giving an electrical connection in between them the moment the wire comes close sparks will fly and if I make the wire move along a definite path accordingly material will be cut and 2 dimensional CNC control cuts can be taken very conveniently. So, you can move and along any path that you want and have practically anything which you require.

So, this Aladdin's lamp show signifies whatever you want in 2 dimensional 2 dimensions its available from wire cut EDM, it has become very popular and surprisingly, the other method electrochemical machining has not been able to produce a corresponding method electrochemical machining why. So, there is no wire electrochemical machining process no why is this. So, this is because wire electrical discharge machining is a method where sparks are deciding the material removal if you have a definite distance existing between if you see the wire from the top if you have a definite distance existing between the wire sorry between the wire and the other electrode if the distance crosses certain limit sparks will not fly.

So, laterally the size of the cut is extremely well defined beyond the certain distance further pulses will not occur and you have well defined cuts taking place of definite dimensions this dimension becomes extremely well defined in electrochemical machining the problem is that electrochemical dissolution can take place over any distance practically and it is not by sparks by, but by electrochemical dissolution. So, if this place is filled up with dielectric fluid you really do not have a choice, but they are going to be totally uncontrolled cuts and you might be ending up with large over cuts and therefore, it is not very well controlled and that is why wire electrical discharge machining has been widely accepted while this is not ok.

So, with this we come to the end of our lecture series. So, whenever you have any difficulty you can use our forum to get in touch with me and I will be ready to explain all your doubts wish you all the best.

Thank you very much.