Non-traditional abrasive machining process: Ultrasonic, Abrasive jet and abrasive water jet machining

Prof. Asimava Roy Choudhury
Department of Mechanical Engineering
Indian Institute of Technology, Kharagpur

Lecture – 20
AWJM – MCQs

Welcome to the last lecture in the course Non-traditional abrasion, meaning abrasive machining processes namely USM, EGM and AWJM. So, today we will be discussing generally MCQs on the course covered, course material covered in the last 4 lectures. So, let us start right away.

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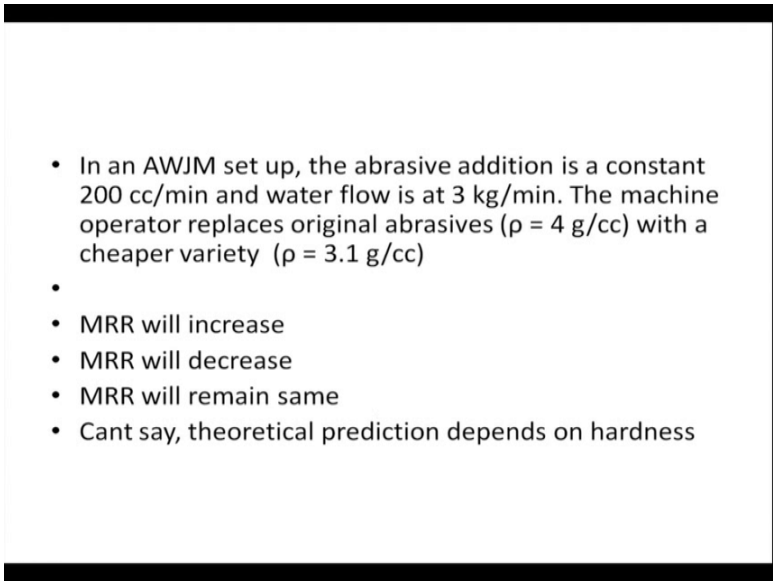

In an abrasive jet machining set up the abrasive, I think we have already discussed this problem we have already discussed this problem, so we need not go through it. Let us move on to the next one.

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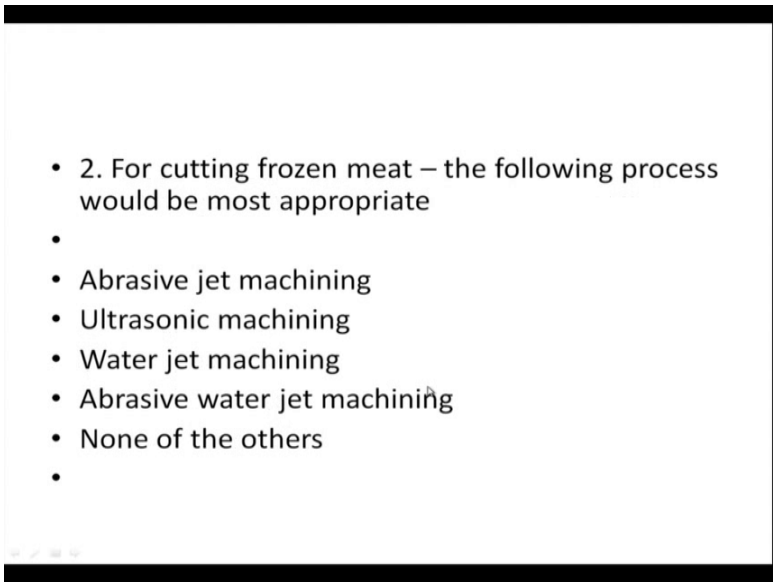

For cutting frozen meat the following process would be the most appropriate - abrasive jet machining, ultrasonic machining, water jet machining, abrasive water jet machining none of the others. So, once again let us start looking at the problems suppose you do not know anything about them you could not get the time to go through the online lectures and you find suddenly you are faced with this problem and you have to use your common sense. If you have gone through the course and listen to all the lectures this will be peanuts for you, you can definitely solve it, but otherwise let us do, let us see. Should we use abrasive jet machining for this you know frozen meat cutting I do not think. So, because you know in that case you will have plates like what you call it, chicken abrasive, chilly abrasive chicken would you like that or say chicken abrasive tandoor. So, I do not think they will be very attractive in their taste or whatever.

So, first thing is out, ultrasonic machining. Ultrasonic machining is also using lose abrasives no not at all. Water jet machining, yes water jet machining is one of the candidates which even we can definitely fit the bill. Abrasive water jet machining; obviously, for the other reason you can use your common sense and cancel out these, so, the correct answer is water jet machining. In abrasive water jet machining the task of intensifier is to increase the mixing ratio, to increase the temperature of water, to increase the pressure of water, none of the others.

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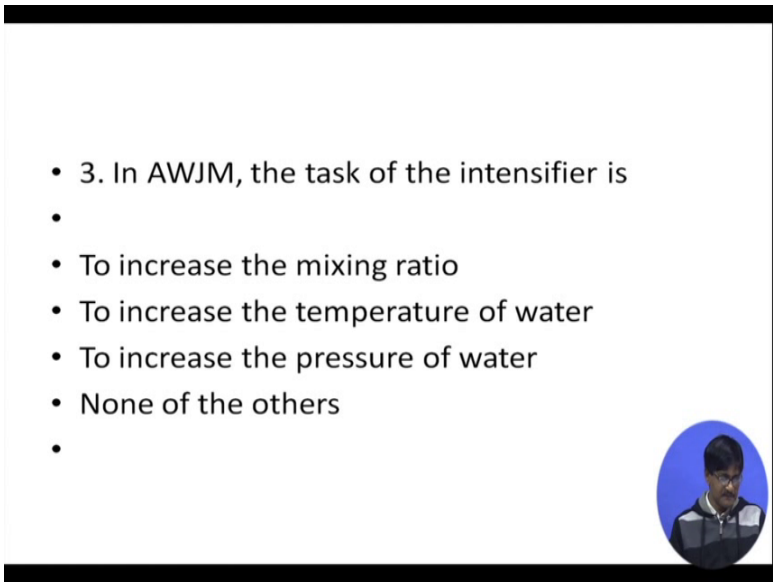

So, just to remind you if you do not seem to remember what is the intensifier all about, kindly have a look at this particular figure.

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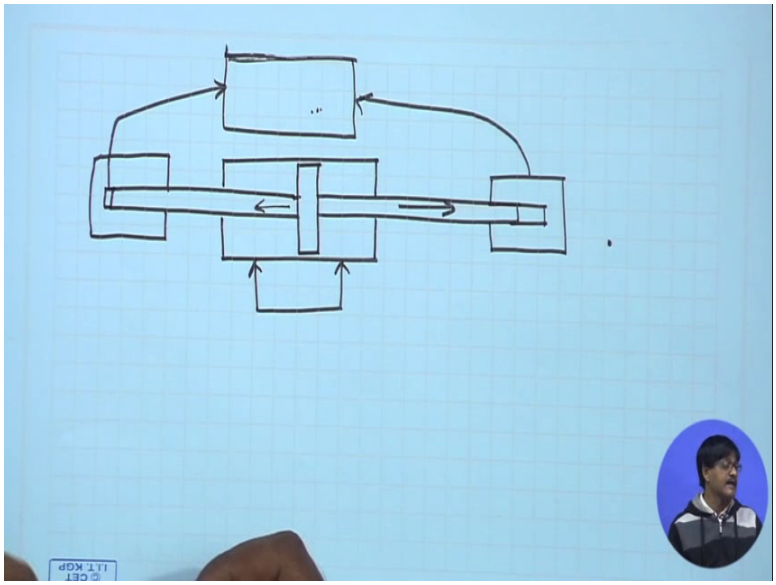

We generally what we do is we generally employ a large cross section cylinder piston cylinder and it is extended to the 2 sides very compressed water kept in a very small diameter cylinder, I mean 2 such cylinders on 2 sides.

So, this cylinder is controlled with direction control valves maybe you put in high vertically hydraulic fluid add this particular point and here you connect it to the sum and

therefore, this moves towards this side. It moves towards the side whatever water volume is here it gets compressed and it is supplied to something called accumulated. On this side it draws in more water so that when it comes this way it can again compress this water and send it to the accumulator. So, its main function is to develop high pressure of water. So, if you ask me which one is the intensifier here, this one is the intensifier, then what is this one accumulator. What is this one? This one is a signal coming from you know direction here from the hydraulic system through the direction control valve.

So, intensifiers work has nothing to do with the mixing ratio because up till now no abrasive is mixed and also it has nothing to do with the you know increase the temperature of water. If the water temperature gets increased it is not the task of interest in an intensifier, but it might be a spin of a side effect. So, the answer is to increase the pressure of water.

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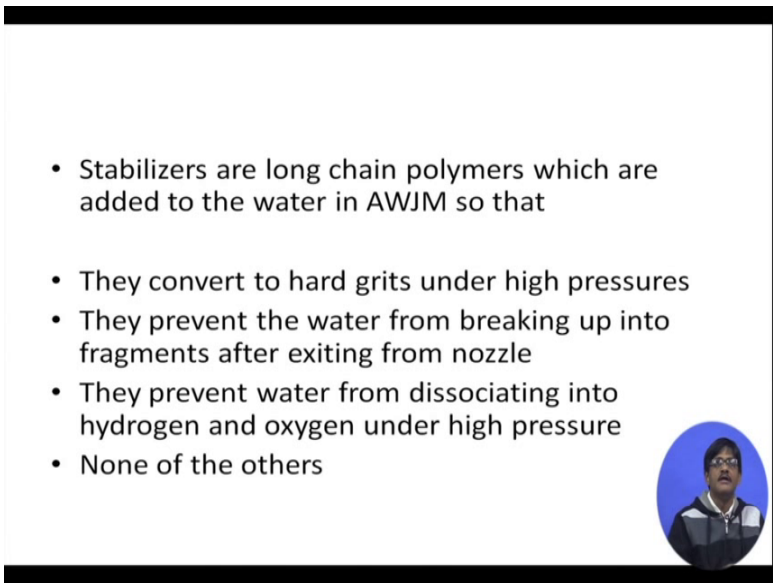

Stabilizers are long chain polymers which are added to the water in abrasive water jet machining so that they convert to hard grits under high pressures. So, definitely they are going to undergo high pressures if they are mixed with water, but this is definitely not the purpose of adding stabilizers to the water, no. Hard grits are added separately. They prevent the water from breaking up into fragments after exiting from the nozzle this is correct, if the water flares up in training air and if it you know breaks up into fragments

we should try to avoid that and these long chain polymers will see to it that it does not take place. So, we are sort of binders or stabilizers.

What about the third one? They prevent water from dissociating into hydrogen and oxygen under high pressure no not at all, we have nothing to with that. So, the answer is the prevent water from breaking up into fragments after exiting from the nozzle.

This is a problem, the change in just a moment what is this, maybe we have gone two steps ahead.

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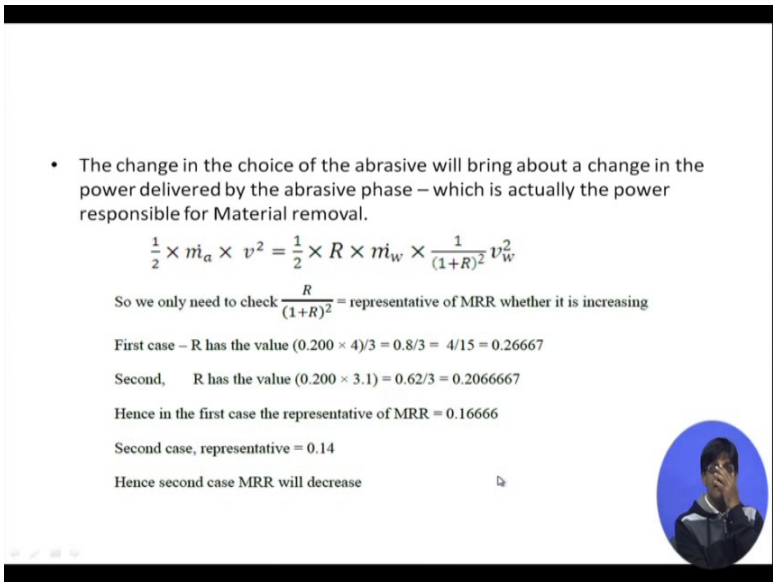

No, I think this is the solution of the problem which we have in the you know at the beginning that was already discussed and this is the answer. So, I am skipping it, we have it previously.

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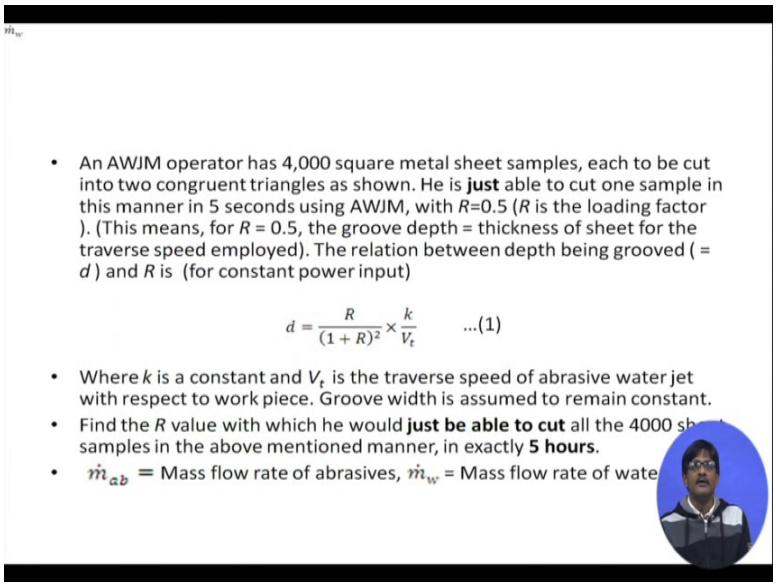

And AWJM operator has 4000 square metal sheets samples each to be cut into 2 congruent triangles as shown, oh there is nothing shown let us see, no there is nothing shown. So, have a quick look at what I am drawing.

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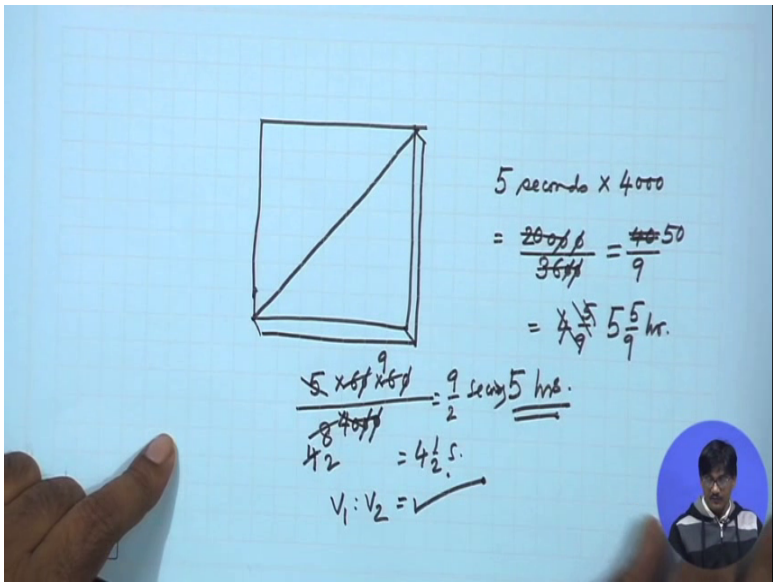

This is it is a very simple thing, he is having square metal plates d square play metal plates have to be given a cut like this all of them to place a square metal plate cut it to this way. So, coming back to the problem and AWJM operator has 4000 square metal sheet samples each to be cut into 2 congruent triangles he is just able to cut one sample

in this manner in 5 seconds using abrasive water jet machine with R equal to 0.5 I is the loading factor [FL].

Now, what are we supposed to do, this means that is we are we are explaining we are also explaining the meaning of just able to cut this means that for R equal to 0.5 the groove depth in case you have forgotten what is R, R is equal to abrasive mass flow rate by water mass flow rate abrasive mass flow rate by water mass flow rate this means for R equal to 0.5 the groove depth is equal to thickness of the sheet for the trans traverse speed employed. So, what it actually means is that you are grooving, but since your grooving depth is depth is just equal to the thickness of the material you are just able to cut it, you are giving a minimum amount of nm power required for cutting. If you are given more power then would have cut it through and some energy would have you know being unused and it would have you know passed through. So, you are giving just the minimum energy required for cutting. So, he is just able to cut one sample in this manner in 5 seconds, so this is the data provided 5 seconds.

The relation between depth being grooved and are for constant power input is we are already conversing with this all those you know extra terms like pi by 4 into d 0 square into you know 1 by what you call it that was 1 by specific energy term and then width of the cut a width of the groove and or, and pressure to the power 3 by 2 into root over 2 by rho etcetera.

All those terms are you know taken together and put inside small k, where k is a constant and V t is the traverse speed which means here basically a cutting speed and groove depth is assumed to remain groove width or cutting width is assumed to remain constant. So, depth of groove, now here as we are cutting through by just providing the air the power required for cutting depth of groove and cutting and the width and the thickness of the sheet they are the same and this expression applies in case of grooving as well as cutting.

So, what are you supposed to do? Find the R value with which he would just be able to cut all the 4000 sheets samples in the above mentioned manner in exactly 5 hours. So, the problem is now easy to understand he is cutting each of them in 5 seconds and he is having 4000 such square metal sheets, in that case what should be the R value with which you would just be able to cut all the 4000 sheet samples. Now this is obviously, if

you use 0.5, if you use 0.5 and how much time he would take let us quickly find it out let us have a look - 0.5, 5 seconds multiplied by 4000 equal to 0 0 0, 5 4 za 20 divided by 3600 is not that. Each of them 5 seconds divided by this these many hours. So, shall we find out how many hours 0 goes out, 0 goes out and we have 36 and 200, let us try by 4 so we have 40 and we have 4 9 za 36 - 9.

And therefore, this is equal to 4 5, 9 5 za 45, no just a moment, 4 9 za 46, 4; I think I made a mistake excuse me 50; 4 nine za 36 sorry, 5 9 za 45 and therefore, 5 is left. So, 5 by 9 I am sorry 5 and 5 by 9th of an hour so obviously, we have a problem. We are finishing the job in 5 hours and 5 by 9 hours while we are supposed to finish the job in exactly 5 hours this is the problem. So, naturally one way to do it is that speed up the process. So, find out the time that you can employ in this case. So, 5 hours 5 hours into 60 into 60 divided by 4000 this is the time which is available to you for each and every sample how much is that 0 0 cancels, 0 0 cancels and 5 goes into this one, 5 8 za 40, so you will have how much here you will have, 4 going out 6 6 za 36, so 9 and this one will be 4 and therefore, this will be equal to sorry this one will be 2.9 by 2 seconds this is equal to 4 and a half seconds. So, instead of 5 seconds your time is now reduced to 4 and a half seconds and the velocities will be inversely proportional to the times. So, you know the ratio of the velocities V 1 by V 2 is now known and the equation that you are going to employ is just one moment.

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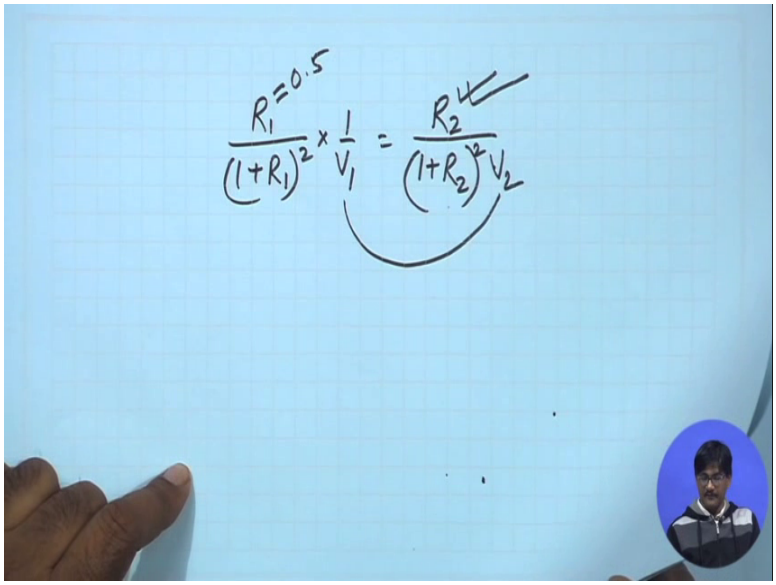

So, here V 1 and V 2 ratio is known, R 1 is given to be 0.5 and R 2 has to be found out. I suspect that you will have a quadratic coming out and there will be one of the roots coming out is imaginary and the other root will be real or one of the roots will have such a value that you cannot accept it and the other will be you know white domestic and that is the one that you have to take. So, the answer if I remember correctly when I solved it will bubbles coming out to be roughly 0.8 or something. So, solve it and find it out I am sure you can do it, it is not very difficult.

So, let us move on rapidly to the other multiple choice questions.

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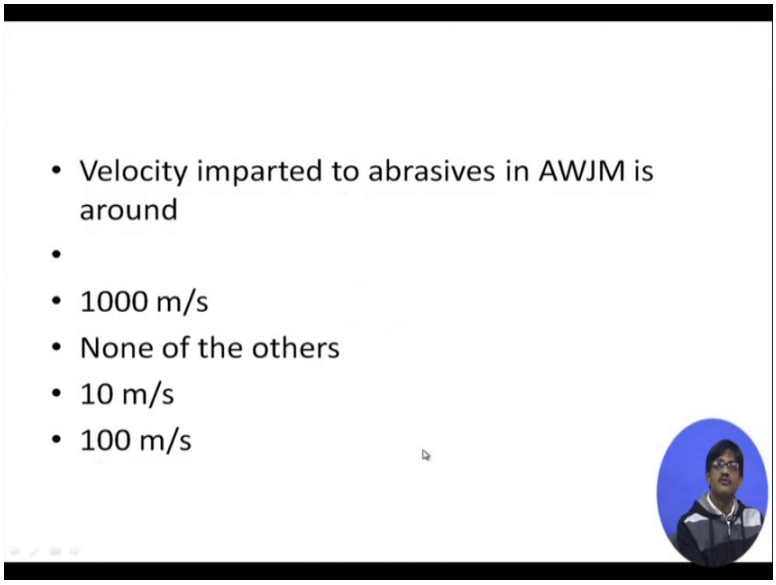

Velocity imparted to abrasives in abrasive water jet machining is around a 1000 none of the others 1000. So, that is easy in abrasive water jet machining to convert from 4000 bars to a particular velocity in water jet machining you will get around 900 meters per second and from there it will be coming down if you usually put in abrasives at you know recommended mixes in that case you will get around 700. So, the order is similar to this one it is nearest to this 1000 and therefore, this is the correct answer this one. The velocity of the abrasives will be around 700 to 800 and therefore, this will be taken as the correct answer.

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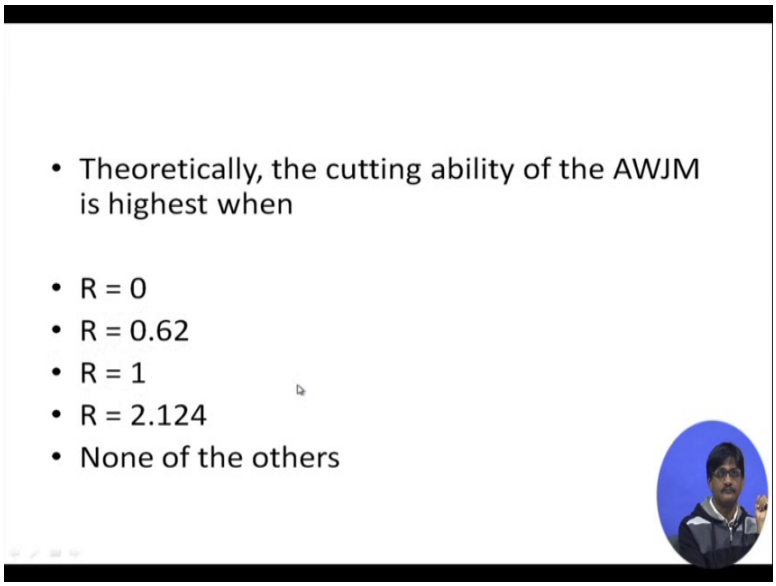

Theoretically the cutting ability of abrasive water jet machining is higher when R is equal to 0, R is equal to 0.62, R is equal to 1 and R is equal to 2.124, none of the others. Now how do we do that cutting ability is simply you know a measure of MRR.

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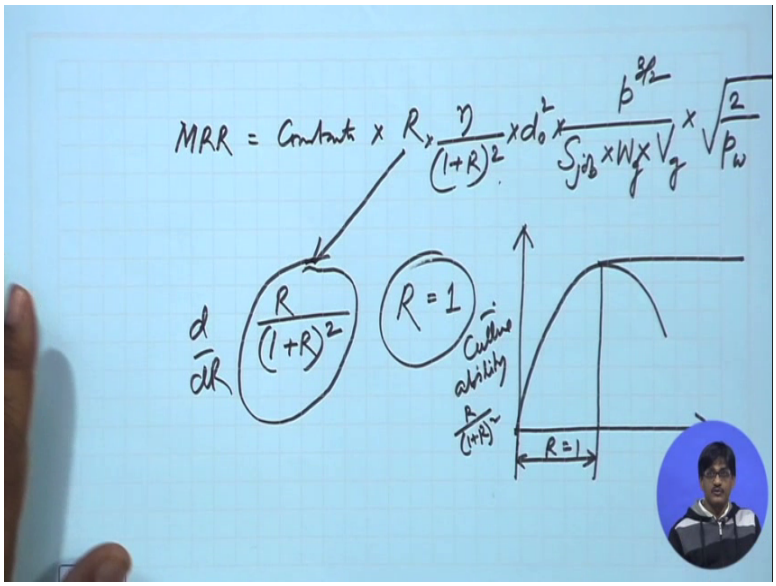

And what is MRR equal to? If you have a look here, MRR is equal to all sorts of constants multiplied by R into eta 1 plus R whole square into you know d 0 square divided by s job multiplied by width of groove, multiplied by velocity of groove, p to the power 3 by 2, 2 by. So, all these things I am sure you will be remembering better than

me. So, if it is this how do we judge cutting ability and how does it change so that it will be reaching a highest. Generally these are the terms which are changeable here, it changes with R. If it changes with R find out the change rate of change of this particular term with respect to R, find out the derivative with respect to R and see whether when it reaches a maximum. I leave it to you, I leave it to you, you will have when R equal to one it will reach a maximum cutting ability reach a maximum when R is equal to 1 cutting ability given by R, 1 plus R whole square.

So, you have to simply find out the derivative of this one and put it to 0 equated to 0. So, that you will have this maximum point this is simple and I am sure you will be able to do it, [FL] and even if you are not able to do it I will definitely post it after the disclosure of this particular lecture I will post it in the forum. So, you get a fair chance to solve it by yourselves and after that you can follow the discussion and see the notice board. So, the answer is R equal to 1.

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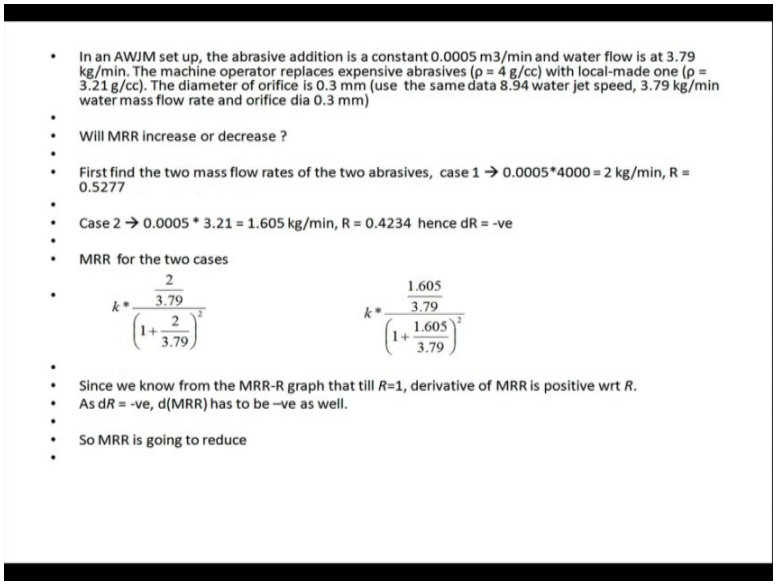

Next in an EGM set up the abrasive edition is a constant 0.0005 meter cube per minute and water flow is 3.79 kg per minute and the machine operator replaces expensive abrasives by local made abrasives etcetera this problem I am not going to solve because its exactly the same problem as the first one only, only I have slightly you know given the data in a different form that is it.

Let me just check whether the same I mean the data has been provided so that you can solve it, yeah I think. So, only there is one addition that is we are discussing it this way that 2 cases are given in one case the abrasive is being fed with rho equal to 0.4; that means, the density and in the second case the same volume of abrasive is fed, but rho is different 3.21 grams per cc. So, in that case the sorry what will be the effect on the MRR will it increase or will it decrease? So, let us have a quick look whether R can be calculated R is equal to 0.5277 in the first case and R is equal to what I call it 0.4234 in the second case. So, R is going down. So, if you have a look at this particular case.

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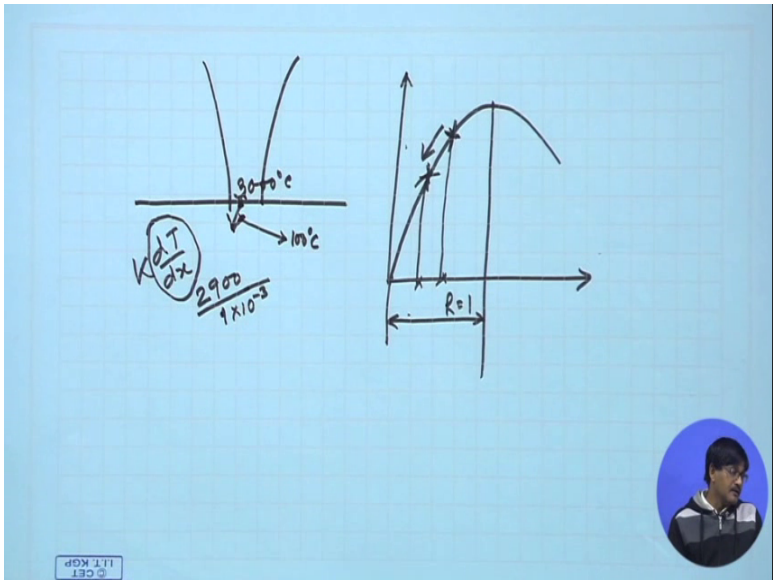

We know that R is like this and at this point R is equal to 1. So, R is equal to 0.5 etcetera it must be some point here and R is equal to 0.4234 money some point here, so the cutting ability has to decrease. As long as R is not equal to 1 before that at these respective points definitely if you are going from a higher R to a lower R definitely your cutting ability will decrease this is all logic and we can say without solving the problem numerically cutting ability will decrease. Anyway in this particular problem MRR for the 2 cases has been found out you can find them out yourselves and calculate and check whether it is really going down or not.

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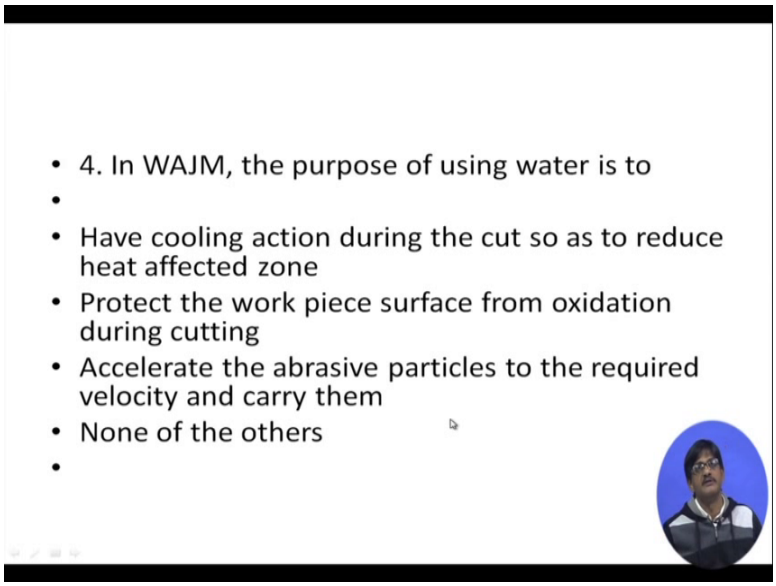

In water abrasive jet machine the purpose of using water is to have a cooling action during the cut. So, as to reduce heat affected zone protect the work surface from oxidation during cutting, accelerate the abrasive particles to the required velocity and carry them none of the others. So, have a cooling action during the cut yes though that is a side effect that is a good one. So, that is one of the purpose of using the jet protect the work piece surface from oxidation during cutting not exactly because you know a will water really protected. So, this is not one of the answers accelerate the abrasive particles to the required velocity and carry them, yes definitely this is the main task of it this is the main task. So, the answer will be both 1 and 3.

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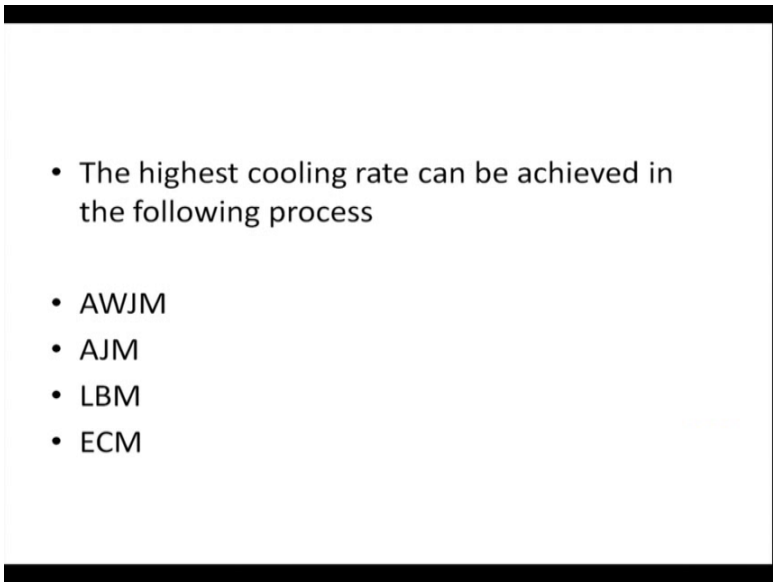

The highest cooling rate can be achieved in the following process highest cooling rate abrasive water jet machine abrasive jet machining, laser beam machining and electrochemical machining. Now you might say that it is obvious is not it that abrasive water jet machining will have the highest cooling rate because it is basically using water and initially it is hardly any you know temporary I mean rather it gives rise to the lowest temperatures, but surprisingly it is not so. Laser beam machining gives the highest cooing rates, but why so - because laser beam heats up the material locally to a very high temperature and then when this is cooling down a very high cooling rate is achieved because cooling rate is defined as dt by dx; that means, temperature gradient divided by the small distance with which the temperature gradient has been calculated let me draw it here and show you.

This is the work piece surface this is the laser and say the temperature has reached 3000 degree centigrade here, but the laser heats up so fast, so much locally that means, it drops a huge amount of energy at this place and the temperature you know shoots up just here, so much heat has been added in some little time there is not enough time for the heat to get conducted to the you know nearby places and this might well be at 100 degree centigrade sorry excuse me. And distance might be 1 millimeter. So, the difference in temperature by the difference in the positions will be you know 2900 divided by 1 millimeter 1 into 10 to the power minus 3 meters. Just imagine a huge temperature gradient and as we know heat flow is defined by k del t del x and therefore, this huge

temperature difference gives rise to an immense flow of heat giving rise to a very high cooling rate. So, the answer is laser beam machining gives the highest cooling rate among all these processes.

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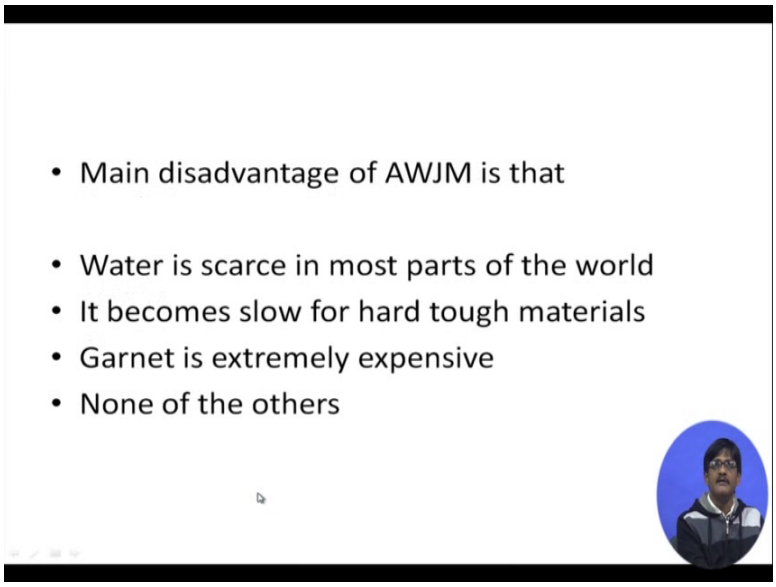

Main disadvantage of abrasive water jet machine now let us see. Water is scares in most parts of the world I do not really think the amount of water which is used up its going to be a restriction for this particular facility because if you are buying this facility and putting it in your workshop you must be pretty wealthy. So, you can definitely buy a few gallons of water to run it every day. Everything you know may be available in any part of the world if you have sufficient amount of money and if you are buying out an abrasive water jet machine you definitely have it.

So, it becomes a slope for hard tough materials this is correct yes, it is a disadvantage garnet is extremely expensive no its not, so none of the others. So, the answer is it becomes slow for hard tough materials.

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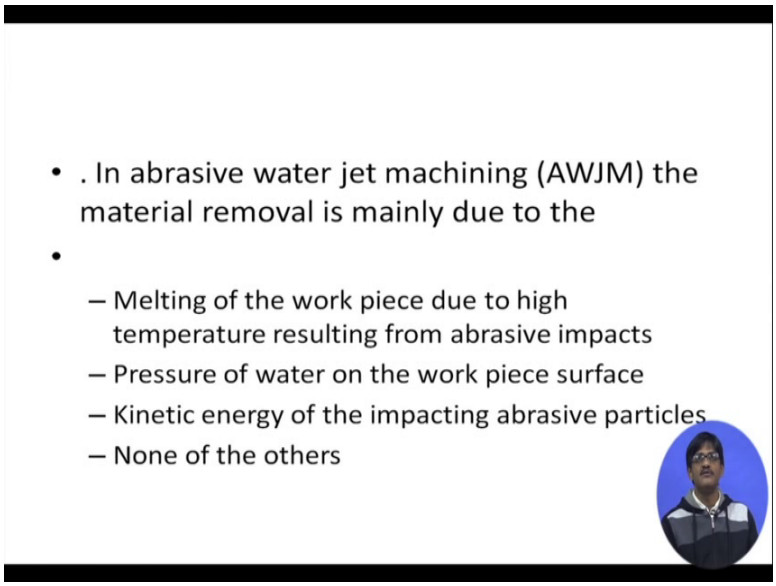

In abrasive water jet machining the material removal is mainly due to, in abrasive water jet machining the material removal is mainly due to melting of the work piece due to high temperatures resulting from abrasive impacts, pressure of water on the water work piece surface, kinetic energy of the impacting abrasive particles and none of the others. Melting is out no, definitely not because anyway we are having so much water to you know remove the heat, so it will hardly have a chance to get melted. Pressure of water on the work piece surface, pressure of water alone hardly matters because when you are removing material in abrasive water jet machining the main contribution comes from the energy of the impacting abrasive particles. So, the third one is the correct answer.

Had it been water jet machining the second point the pressure of the water on the work piece surface would have been under you know more of our consideration, but for abrasive water jet machining straightaway we can say it is a power carried by the impacting abrasive particles which really make makes a difference.

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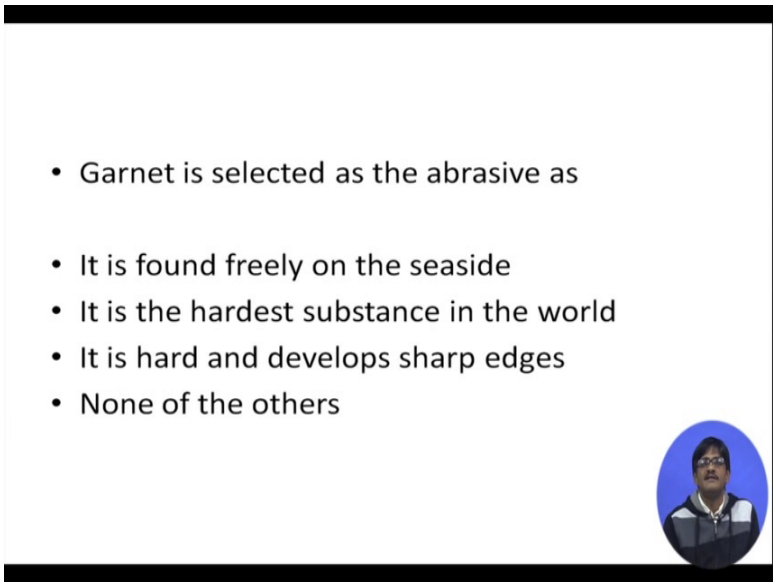

Garnet is selected as the abrasive as its found freely on the seaside not really it is generally mind and it is also found in alluvial deposits, but the ones from found in alluvial deposits they are not that sharp edges they are much more smooth and therefore, they are this particular thing we statement is not correct. It is the hardest substance in the world not really because its diamond. I mean diamond is the hardest sub substance not garnet; it is hard and developed sharp edges correct third one is correct.

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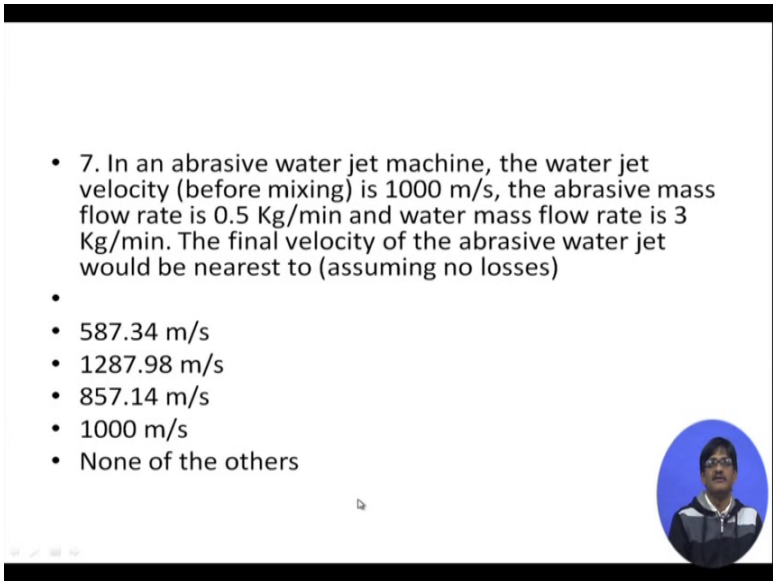

In an abrasive water jet machine the water jet velocity before mixing is 1000 meters per second and the abrasive mass flow rate is 0.5 kg per minute and water mass flow rate is 3 kgs per minute. The final velocity of the abrasive water jet would be nearest to hear you have to do a you know momentum balance and by that momentum balance you will be achieving the answer you know very easily.

Let us see 0.5 and 3 my guess is most probably the answer will be 857.14 meters per second. Momentum balance has been done in the previous lectures we have solved numerical problems. So, I definitely I am definitely sure that you will be able to do it and anyway we will be discussing and disclosing the answers in the forum.

The intensifier in an abrasive is a setup increase the temperature I think we have done this before, the answer is increases the pressure. Suspended type abrasive water jet machine the advantages is there is no abrasive entrainment there is no water there is no air entrainment, the third one is correct there is no air entrainment.

So, now we come to the end of the series of lectures. Thank you very much it was a great time for me sharing my ideas, you are welcome to share your ideas also about this lecture like you can you can give me some constructive criticism how it can be improved, what other subjects can be incorporated, what parts of the lecture can be dropped you know because from your side also you would be able to give me some feedback which parts might be dropped and be replaced by something more informative or something more you know scientific or something more mathematical etcetera. So, you are welcome with your ideas.

Thank you very much and all the best ahead.