Farm Machinery
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Lecture – 42
Problems Based on the Design and Selection of Spraying Equipment – I

Well students, in this session, I have brought certain Problems Based on Design and Selection of Spraying Equipment. Well you if you have gone through my earlier lectures, you will see that we have discussed various aspects of spraying equipment, and parameters there are testing, evaluation etcetera. Now, I thought it what is discussing certain numerical problems on that. And through that also you can clarify many doubts, which you have in your mind.

And I have come up with about four problems here. And we will see what are the requirements, how they have been answered. And later if you find that there is a problem in that you can always approach, and we will try to give answer to that. So, let us go through each of the problems, what is the stated, what is given, and what formulae we have how to use these formulae and how to get the answers.

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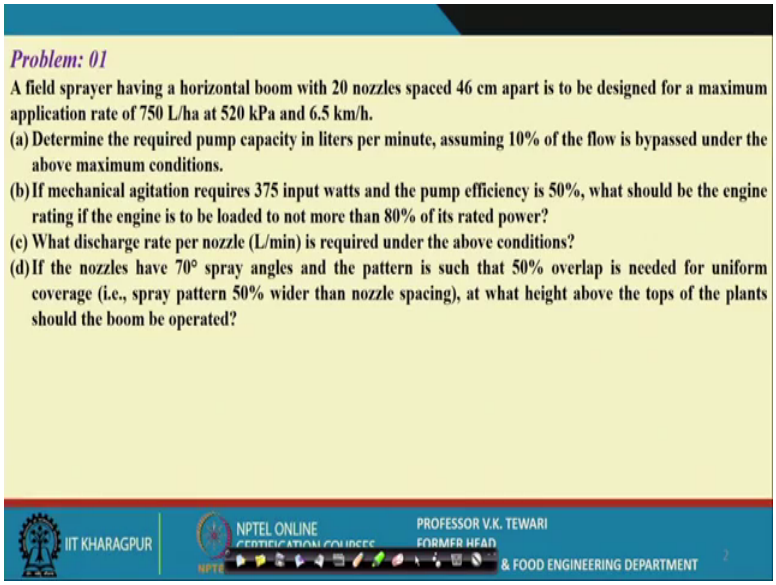

Problem number 1, see if this problem here, a field is sprayer having a horizontal boom of 20 nozzles 20 nozzles are used at a spacing of 46 centimeter apart is to be designed for

a maximum application rate for 750 liters per hectare at 520 kilopascals and 6.5 kilometers per hour it is a good design problem.

In fact, you need to design a sprayer, where there will be 20 nozzles at certain spacing. And then this is the 750 liter per hectare we require. And this is the pressure at which, and the speed at which it must work. So, determine the required so for this, what you will require, what is to be done. Determine the required pump capacity in liters per minute, then assuming 10 percent of the flow is bypassed under the above maximum conditions.

So, with the (Refer Time: 02:08) data, what you need to find out, determine the required pump capacity in liters per minute. Then mechanical agitation, because this is will be a long one, and agitation is required. So, you need to know what is the mechanical agitation requires 375 input Watt, and the pump efficiency is 50 percent. What would should be the engine rating, if the engine is to be loaded, to not more than 80 percent of its rated power.

So, well, in this particular design problem these are details which are given. And you need to use your knowledge what you have learned so far to find out how they behave or how they actually perform. Then what discharge rate per nozzle, what is the discharge rate per nozzle is required under the above conditions. See we have 20 nozzles at 46 centimeter apart; and with the given data how much will be the discharge per nozzle discharge rate per nozzle.

If the nozzle have 70 degree spray angle, we have seen that spray angle, which we have discussed. If the spray angle is 70 degree, and the pattern is such that 50 percent overlap is needed for uniform coverage. As we have talked at distribution of uniform coverage is very very important.

So, at what height above the top of the plant should the boom be operated. Very excellent problem so far as understanding a design of a good sprayer is. You have this sprayer, you have the conditions you have given nozzles, you have been given spacing of those nozzles, but certain aspects are given to see whether how do you check for the performance of this.

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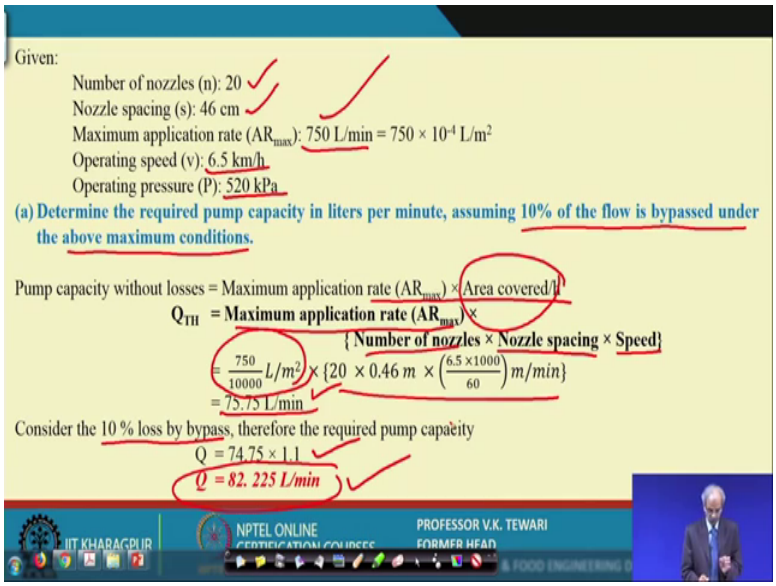

Let us see how do we approach the first is determine the required pump capacity. So, what is given here in that see the nozzles as I said we have been given to you the nozzle spacing is also given to you. Then maximum application rate is 750 liter per minute is given here. Now, this you can, because you want to change it to hectare or per square meter you want to check this you can see this. Then operating speed is 6.5 kilo meter per hour. Operating pressure, which is also given 520 kilopascal.

Now, determine the required pump capacity in liters per minute. How will you get this, assuming 10 percent of the flow is bypassed under the above maximum conditions 10 percent of the flow is bypassed. So, what will be the required pump capacity? Now, we need to know; what is the pump capacity without losses straightaway maximum application rate into area covered will give you. So, you have the maximum application rate AR and number of nozzles and number of spacing and speed. So, when you get these things definitely number of nozzles the spacing and the speed will give you how much you have got area covered.

So, area covered will give you from the number of nozzles the spacing and speed at which is moving. So, area covered per unit time you will get from here. And the maximum application rate which is already given to you the maximum application rate which is given to you. Then this information is multiplied by this which you get about 75

liter per minute (Refer Time: 05:54). So, the pump capacity without losses is 75.75 liter per minute.

Now, consider 10 percent loss by bypass that means this is bypassed. Then what will happen, the pump must give more than this, because there will be a lose. So, just increased by that much that means say 1.1 times that value so, this is the value which you are going to get. So, you understand that given everything how do you approach two aspects pump capacity is needed, so maximum application rate and the area covered. When you want to find out the area covered you must know; what is the number of nozzles, spacing of the nozzles and the speed at which there moving.

So, you will be able to know what is the area covered per unit time and the application rate. So, then you will be able to know, how much is the requirement. When there is no loss from the pump, from the pump which you required, but when it is said that 10 percent is getting bypassed well you have to increase that amount actually we get this.

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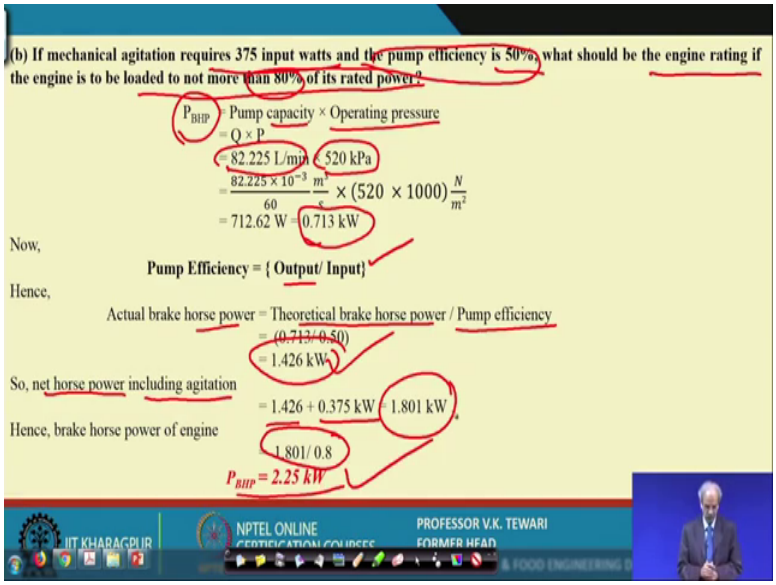

Second aspect mechanical agitation requires 375 input Watts and the pump is 50 percent pump efficiency is 50 percent. What should be the engine rating, if the engine is to be loaded not more than 80 percent of its rated power. Very nicely avoided problems see you are taking of the power BHP of that. Now, the pump capacity and the operating pressure this gives of the power. So, the pump capacity is you have already found out

from the other side, and then what is the operating pressure, which is mentioned 520 kilopascal already mentioned.

So, taking care of the units what you get is this kilowatt this is the power. Now, pump efficiency how do you say pump efficiency the output by input is giving you the efficiency. So, the actual brake horse power is theoretical brake horse power by pump efficiency, this is what you get, because what is given here is 50 percent is the pump efficiency is only 50 percent. So, with respect to that what do you get the actual brake horse power is this. Then the net power including agitation, how much will be the net power including agitation, because for agitation you are requiring certain amount of the power, which is this input.

So, if you put this 375 watts, so 0.375 kilowatt. So, this kilowatt plus this that means the two net power including agitation is 1.180. Now, brake horse power of the engine will be, because this engine as such the engine rating, if the engine is loaded 80 percent of its rated power, it is working at 80 percent of its rated power. So, this has to be so and 1.801divided by 0.8, so this is the power so that means, at this 2.25 kilowatt should be the power. What should be the engine rating engine rating should be this, because it has 80 percent rated power is being used this is the value which comes. You only need to understand the aspects, which are asked and then follow.

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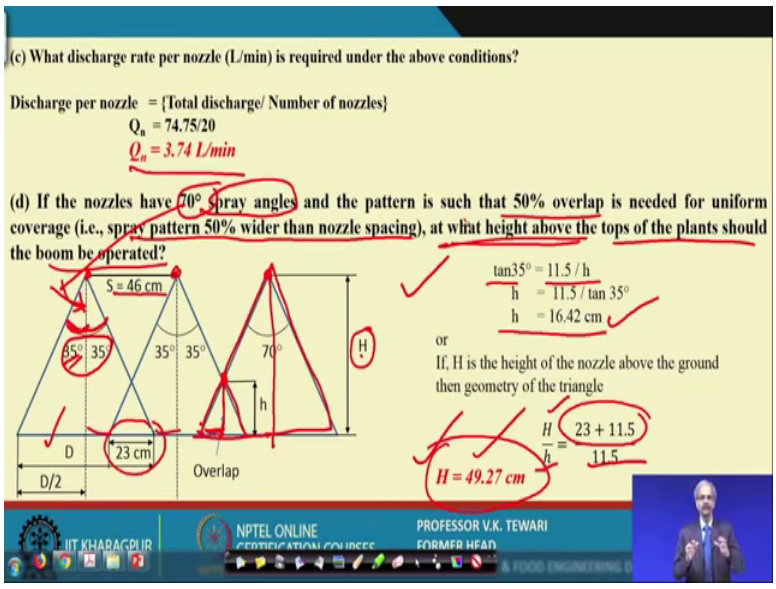

What discharge rate per nozzle? Well is required under the above condition. It is very important what will be the discharge rate, discharge per nozzle, how do you get total discharge by number of nozzles definitely, so this is what you have got discharge per nozzle. Then if the nozzles have 70 percent spray angle, now the spray angle we just this is called the spray angle. You can see this is the angle which is known as the spray angle this spray angle is this spray angle this is what it is this is about 70 degrees this is spray angle.

And the pattern is such that 50 percent overlap, so it says that 50 percent overlap is needed for uniform coverage, what is this spray pattern 50 percent wider than the nozzle spacing. This is the meaning of the overlap that we are talking with respect to this. So, where you have this at what height above the top of the plant should the boom be operated. Now, it is once this is known to you can see that. As if there are three nozzles, one nozzle is here, the other nozzle is here, the other nozzle is here.

So, the spacing of this, now you can see that one nozzle has a coverage area like this other has a coverage area from this to this. And now what how do we approach this you see yes, if you drop this here, you get tan you get this angle, which is 35 degrees. So, with this, and if this is the D is the total diameter or the width, which has been covered. So, D 2 will be up to this.

So, now we have said that the 50 percent wider than the nozzle spacing nozzle is spacing is 46. So, what do you get here the coverage which is in the overlap comes this is equal to this. Now, if you have this, so this and this can be found out. Now, if this is known this D 2 is known to you. So, tan 35 will be nothing but if you if you are talking with respect to this, what do you get tan 35 over is 11.5 by h, if this is the h, which we are talking with respect to this.

So, this is 70 percent, here 70 degrees this is 35 degree. So, this is the one which we have talking is half of this. Now, you get h this h as this. So, once you get this h, now you cover these ones, because this is the h which is capital H here. So, this if you take the triangle if you talking of this triangle here, and this triangle, which you are talking with respect to this triangle this one here.

So, what do you get is H by h. Now, this is this the height here this is the height here h this by this if you are talking of this that means what you get is twenty three point 23

plus 11.5 here in this case this will be here. And then h this is H here corresponding to this h you will correspond to this is 11.5.

So, the H value you can get, because is small h you have got from here. So, bigger H you will get from here. So, that means the height should be 49.27 centimeters above the boom should be operated, so this is how we get. Now, this these I have explained these if you have further questions, you can always ask us and we like to clarify, but this is worth understanding how to design a new system.

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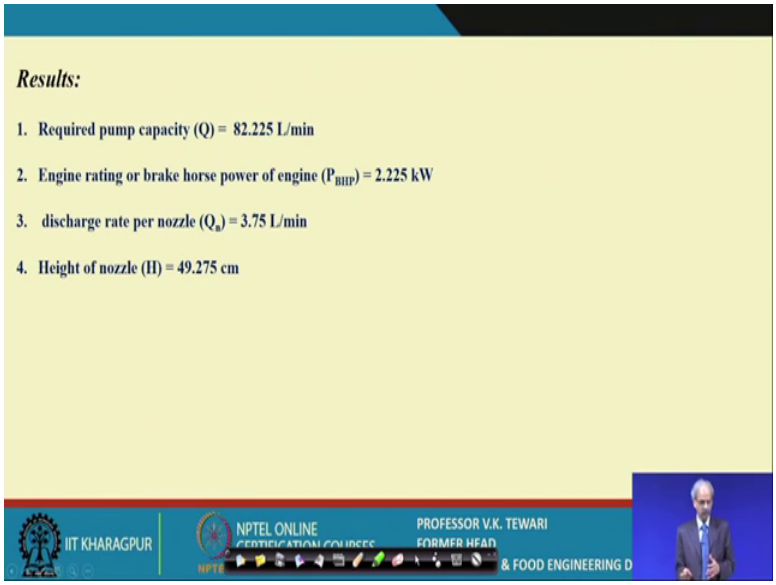

So, the results I have already said these the results if you put them together at one location, the required pump capacity is 82.225 liter per minute, engine rating or the brake horse power should be about to 2.225 kilowatt then the discharge rate per nozzle is 3.75 milliliter per minute and that the height at which 49.275 centimeters. This is the result which we got from the previous one previous. It was a good design problem. Let us see another problem considering some other aspects of the design.

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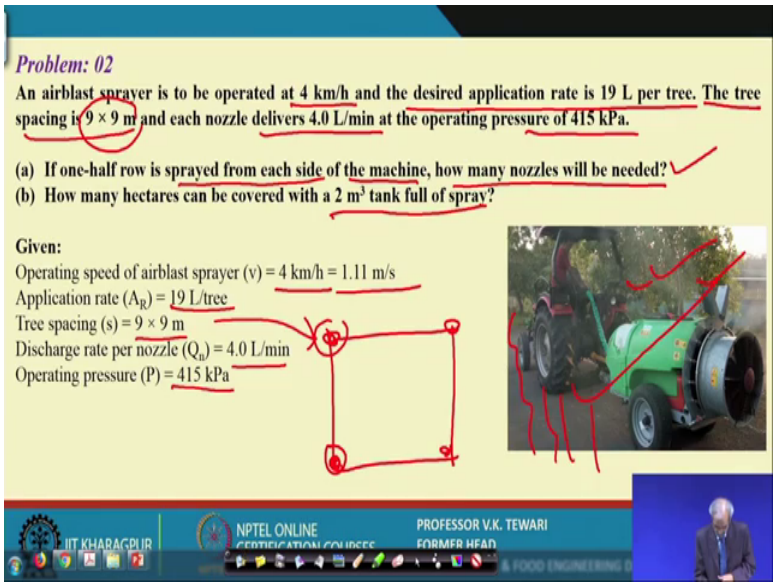

An airblast well we have talked of sprayers, and where no pressure and here carrier it sprayers where airblast is there, and I which we are optimizing particles. So, it is good that a problem like this has been taken. And I am sure you are aware of this particular device, which we had seen shown you earlier. This equipment has been shown to you earlier the lectures, if you have seen those lectures.

So, and airblast sprayer is to be operated 4 kilometer per hour, and the desired application rate is 19 liter per tree. So, the tree spacing is nine point 9 into 9 meter that means these spacing on this way I mean when you talking of this, so maybe one is here, the other is here, here and here. This is what I talks of this 9.9 and each nozzle delivers 4 liter per minute. And the operating pressure is 415 kilopascals.

So, if what is asked. If one half row is spread from each side of the machine, how many nozzles will be needed. Now, you can see here that. In fact, this is exactly done here. You can see that there is no plants here, but this is on plants are only on this side. So, if only this side is to be spread, so how many nozzles should be required. And definitely when it goes into an orchard, then on both sides there will be the canopy. So, it will have to have a spray on both sides, and hence once you know on one side, you can just double for the other side.

So, how many hectares can be covered if there is a 2 meter cube tank full of a spray. This is another aspect which is asked. Now, let us say how will you approved, what is given to

us the spacing that means distance between one tree and another tree is given. So, operating is what is given here already 4 kilometer per hour speed is given, which is which can be changed to 1.11 meter per second. Application rate is 19 liter per tree so much of apply you have to apply. So, you must know how much time the nozzle must be spread so that you get that much. Then the tree spacing as I showed here. Then the discharge per nozzle is given here, the operating pressure is here.

So, once you have this the details you use this given details into the problems that you know, in the formulae that you know, the expressions you that we know for finding out the details of finding out the total number of nozzles or the nozzles required the specifications spacing of nozzles, and pressure etcetera.

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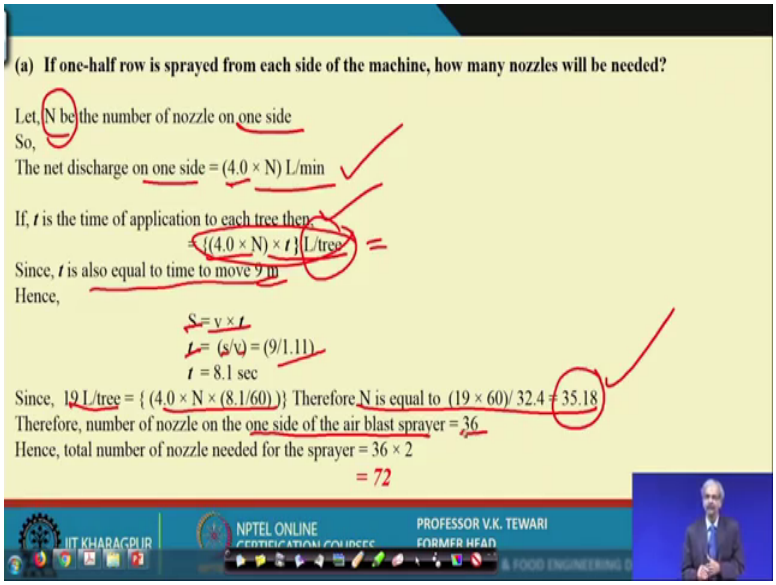

So if one row is spread from each side of the machine, how many nozzles should be required? Let us say that only N is the number of nozzle on one side that is say. So, if net discharge on one side will be because 4 is coming out from one nozzle, so N into 4 will give you total this much. Now, if t is a time for application to each tree, you know that 19 liter is required. So, 4 into N into t this is the amount which is per tree, and you know that this is equal to the time of application is given.

So, then t is the time of application to each tree. Then what do you get 4 into N, which is the net discharge, and N this much time. What will, so much liter per tree is the one which you get. Since t is also equal to equal time to move 9 meter sure. So, in this time it

has moved from one to another one that it. So, during this period see what how much time it has taken see S is equal to v into t where t is nothing but S by v the distance by the velocity at which it is moving. So, what do you get here the 19 liter is equal to this. Therefore, N is equal to 35.18 is very simple.

Now, it says that about 35.18 nozzles will be required. Now, you should not take less than 35. So, definitely 35 cannot be size at 36, but then you will have to go for 36, because the minimum is this, so you will have to go. And therefore the answer is that one side at least 36 should be there. And then when you talk of the other side, so the system will have, therefore on both sides it we will not like to have only nozzles on one side, you will like to have nozzles on the other side as well.

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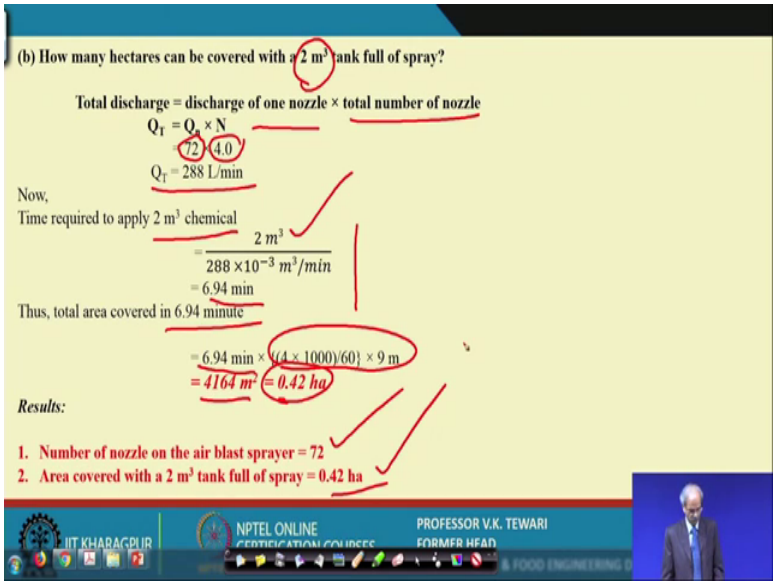

So, 72, so this what is the answer for that. How many hectares can be very simple, if you if you know that 2 meter cube tank is full of spray, the total discharge how may you get discharge one nozzle total number of nozzles are known to you. So, 72 nozzles and this is the discharge of total this is the value. Now, time required for this now, chemical to be utilizes 64, because you know that how much is the discharge what you require, and how much is already in the tank. So, on that basis you required that is to take about 6.94 minutes just by ratio will give you.

So, the total area covered during this period, what is the area covered, because you know the speed at which it moves. So, you should be in a position to find out, because this is

one and this is what you get the distance covered, and this is the rate at which it is moving. So, you can get this and hence this much area. So, the answer is 72 nozzles and this much hectare. So, if you have 2 meter tank full of spray here, it will cover about 0.42 hectares this is what it says.

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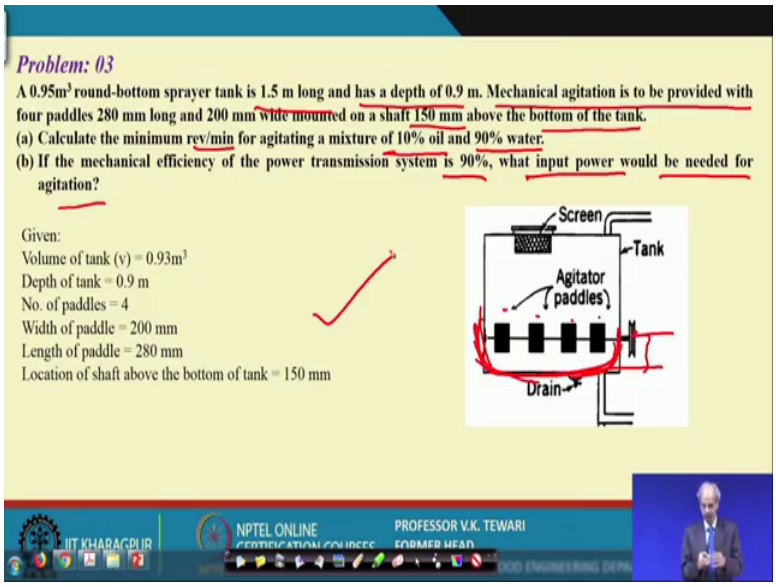

Another problem a very simple problem, but then it requires you be to remember some of these formulae which we had talked of particularly with respect to agitation mechanical agitation. So, this talks of mechanical agitation a round-bottom sprayer. Well this you need to take this to be a round-bottom one a round-bottom 1.5 meter long and has a depth of 0.9. So, (Refer Time: 20:43) the details for remaining already. Mechanical agitation is to be provided with 4 paddles, yes 1, 2, 3, 4 paddles, 280 millimeter long, and 200 millimeter wide mounted on a shaft 150 millimeter above the bottom of the tank.

So, this distance is known from here to get is this distance is known to you, then calculate the minimum revaluations per minute for agitating a mixture of 10 percent oil and 90 percent water. And mechanical efficiency of the power transmission is 90 percent, what input power would be needed for this particular agitation?

Well these are already given to you. So, let us see you how do you proceed. In fact, here hardly anything is required what you what is required, you need to remember those empirical equation, which the researchers have found out regarding the details of the paddles, the spacing location of the paddles, and the width etcetera.

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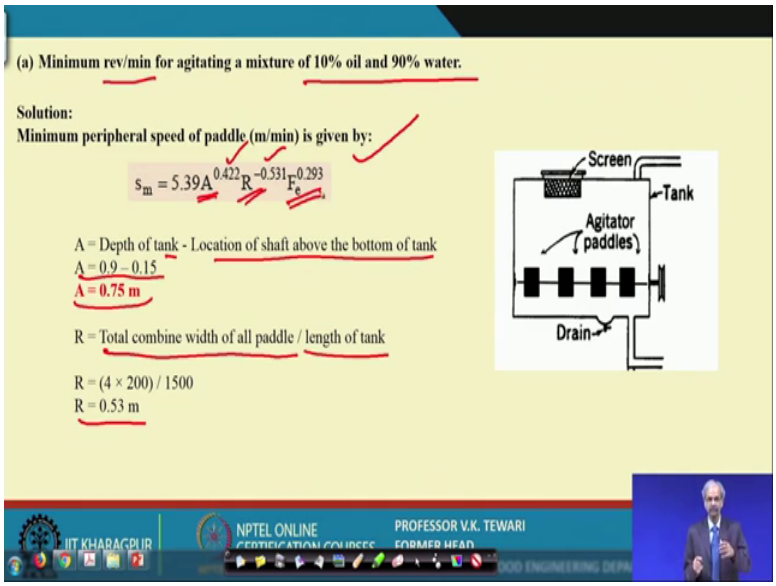

See, so the minimum revolution per minute for agitating a mixture of 10 percent oil, 90 percent water. This is given to you already this formula is given to you. So, A is the depth of the tank-Location of shaft above the bottom of the tank, then minus location of the shaft. So, what you get is 0.9 minus 0.15 your location of the shaft above the bottom was given already. Then A is actually 0.75.

This A is here A is raised to 0.422 this will need to remember. R here, this r is the total combine width of all paddle by length of the tank very important, this is raise to minus 0.531 this you need to remember. This is what you need to remember, because these are replica equations and they have been found out with large experimentation. So, you need to understand this and have may be you need to remember that length of the tank. So, this is R, which you get. So, you got R, you got A now, F e you need to get F e, where it is this is a value which will be available.

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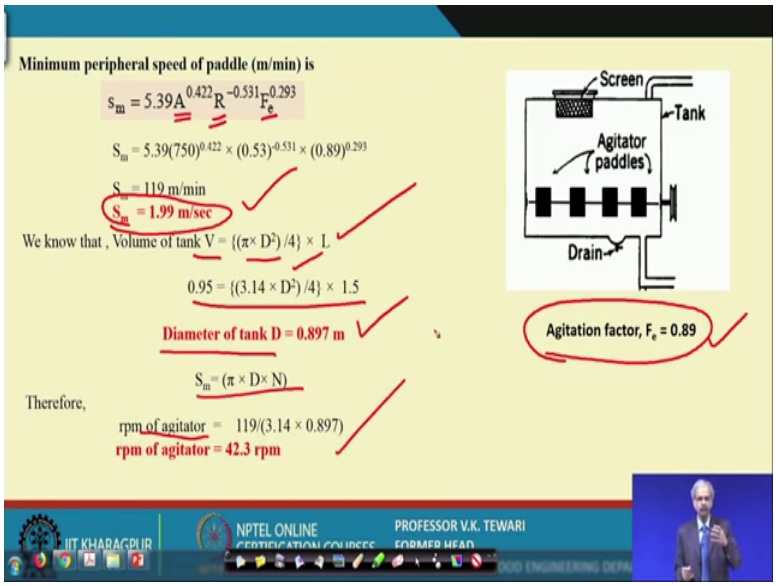

Now, let us so F e, now F e agitation factor. So, the agitation factor here F e agitation factor is taken from the table is 0.89. If it is not given in the formula or in the problem, you need to take from the table here. And these are maybe we had given you earlier, what is the emulsions are there, so this had been given. So, from there you need to take them.

And put these values as you can you got for A or an F e and using this, then you get S m is so much meter per second. So, the volume of the tank V is pi D square of 4 in into L simple. So, this is known to you, you can get what will be the diameter of the tank this is the diameter of the tank. And S m then is pi D n, so you know the pi D n, S m is already given to you here.

So, you should be in a position to know how much (Refer Time: 24:04) rpm, what should be the revaluations per minute. So, simple you get this revaluations per minute here. So, by this you are you can you see, this is also you can we want to clarify better with what you have we have thought you or shared the knowledge particular with respect to sprayers and dusters and they are details.

So, with this numerical problems we are trying to clarify more details. If you have further information, which you need to know, you will be happy to answer those at some point of time, when it is required.

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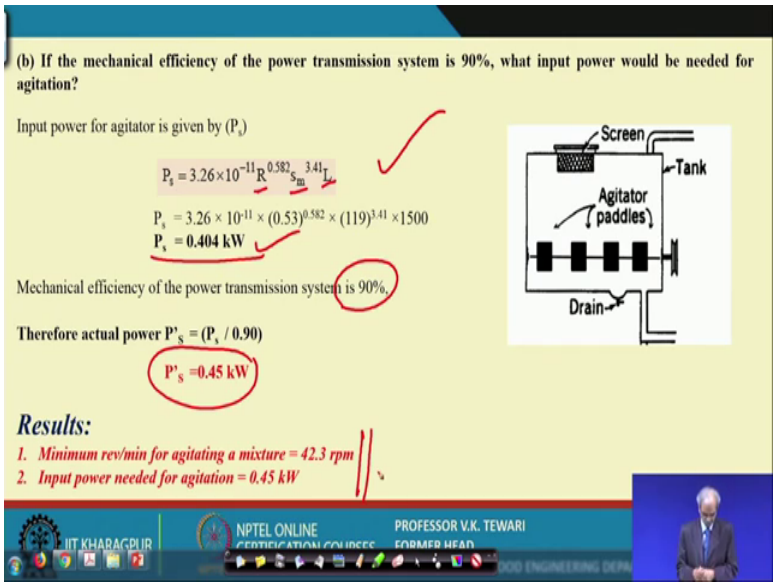

If the mechanical efficiency of the power transmission 90 percent, what input power? Well for input power of an agitator, this also is given to you. So, you can use that R, S m, and L. S m is you have and you got it already, R you have got already, and the L is given to you.

So, using this is the one which you get from here, but mechanical efficiency is only 90 percent. So, this has to be enhanced to 90 percent. So, it comes to about 45. So, the ultimately these are the things, which we are asked of you and you have to using these you are in a position to find out the details of the problem, which was presented to you.

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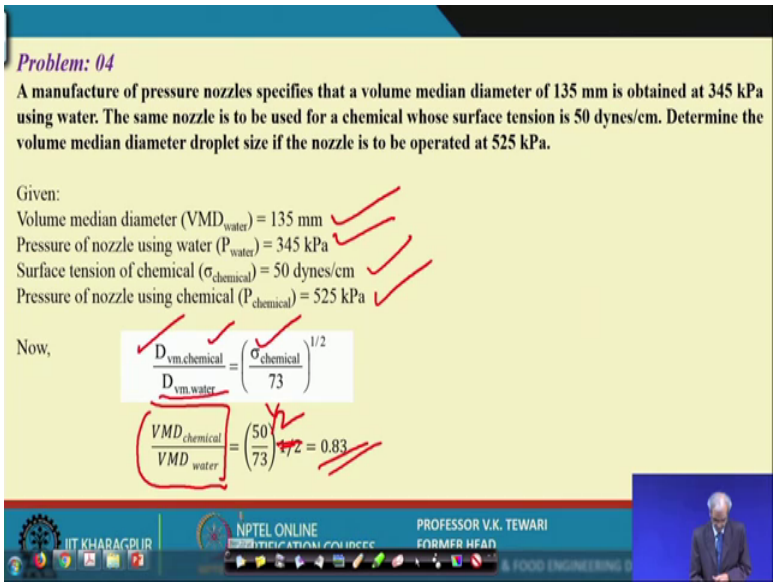

Let us check another problem. Well it is worth showing you this, because this is a problem which has been talked of with respect to one aspect of the volume median diameter. And it is very straight forward problem. Although to you once you see once you have not seen the solution to you it will appear that, it is very difficult.

What is asked here is a manufacturer of pressure nozzles is specified that a volume median diameter is 135 millimeter is obtained at 345 kilopascal using water. The same nozzle is to be used for a chemical whose surface tension is a certain value. So, determine the volume median diameter droplet size, if the nozzle is to be operated at this.

Now, tension remaining same remaining same here what do you get, volume median diameter is this volume median diameter is this, which is given. Pressure of nozzle using water is given here, and surface tension is given here, and pressure nozzle using chemical is also given here.

So, the relationship which is known to us, you should go for the relationship. If you if you gone through the details of this sessions which I had earlier, then you will be able to get this. See here how it is connected, the surface tension of the chemical is given here. And then this is the D vm and D vm water and D vm chemical.

So, they are in this relations are nothing but this with respect to these here. Now, this in fact this is wrong this should be 1 by 2 here so, the value is 0.83. So, you get the value

determine the volume median diameter 0.83. So, let us see what else; how do you get the details.

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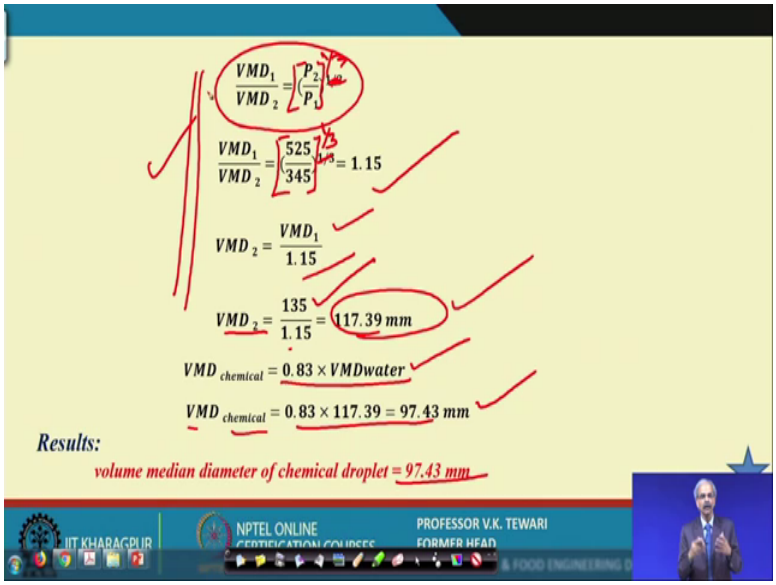

So, we had got this volume median diameter D 1 by D 2 this was given to you, you might have checked. This is this is of whole actually one-three here. So, so this is what you get, So, VMD 2 is VMD1 by this. So, VMD1 was given to you, so VMD2 is just this is the value. So, VMD2 of the chemical will be this times of water VMD of the chemical is this time of (Refer Time: 28:25) this. So, the volume median diameter of chemical droplet is 97.83 millimeter. This is how very simple only thing you must have your concepts clear so far as the volume median diameters are concerned.

And I think through these four problems, what we have discussed is, we have enhanced your knowledge related to this sprayers and the details of sprayers, what is the pressure maintained, what is the overlap, what is the nozzles spacing, how do you test them, and how do you find out the different parameters. You need to of course as we seen one of the problems, you need to remember some of these empirical equations, which have been developed by the researchers.

So, with these four problems, we have tried to enhance your knowledge related to this. May be you will pay of few more problems in this regard, and see that you are a very well equipped with the knowledge rate to the spraying equipment and application part of

it. And if you have any questions, we will definitely like to answer them as and when they come. And we close this at this point of time.

Thank you very much.