Farm Machinery
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Lecture - 43
Problems based on the Design and Selection of Spraying Equipment – II

Lectures and farm machinery. Well, the previous lecture was also on problems. We have selected certain problems particularly to let you know about all the gametes of design and selection of a spray equipment, what are the different details which are required if you want to design a equipment or to create a select a equipment from galaxy of equipments and so on and so forth.

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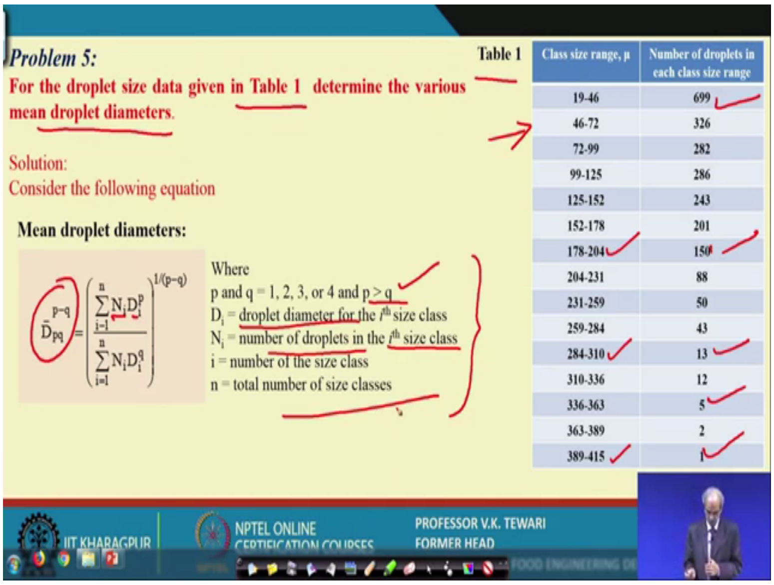

Let us see a problem first problem, in fact, this is a problem which was which is continuation of the previous lecture where we had we had done 4 problems and that is why this number has been given problem number 5. Well, for this it is very interesting see we discussed about the particle size, we discussed the droplets size, we discussed about the distribution of that. And then what are the different classes in which the particle size is situate when we spray the chemicals at wearing sprayer pressures as well as rate, flow rate.

Now, here droplet side data given table 1, this is table 1 here. So, in this table we had given data. Determine the various mean droplet diameters. Now, what is given in the table here class size I mean microns; that means, 19 to 46, 46 to 72, 72 to 79, 99 to 125, 125 to 152 like this, 284 to 310, then 389 to 415, this is the micron size.

The number of droplets in these each class size that has been this is in fact a case where the droplets have been measured in a study and that details are given over here for you to understand and try to classify. And understand what sort what is the level of deposition, what is the size of the droplets which are deposit deposited on the canopy or on the target.

So, these are the number of droplets in each class. Say in this 19 to 46 there are 69; similarly say 178 to 204 there are 150; all these details are given. So, it 284 to 310 13, 336 to 63 5, and two eighty ni[ne]- 389 to 415 1. Now, as you can see that as the class size or the range of microns of the droplets increases, the number of droplets in that is decreasing. So, it will happen so.

Now, how do you find out the various diameters of these droplets? Well, you may recall the equation which I give you the earlier expression where in we have D pq mean D p q p minus q this parameter which will give us various diameters which we had discussed. We will discuss them again here. Now, it is given as summation of N i D i which is nothing but N i is the number of droplets in the i, i size class and D i is droplet diameter for the that class.

So, this D i is the diameter and diameter here and the number of the droplets. So, the number of droplets are given over here; and the class range is given over here. Similarly, N i D i to the power q here where q p and q are 1, 2, 3, 4 or p greater than q this is very important to note in this particular expression 1 by p minus q here.

So, using this particular equation, you will be in a position to find out that the mean the droplet diameters of various types which we have discussed earlier. Now, let us see what how do you take up this.

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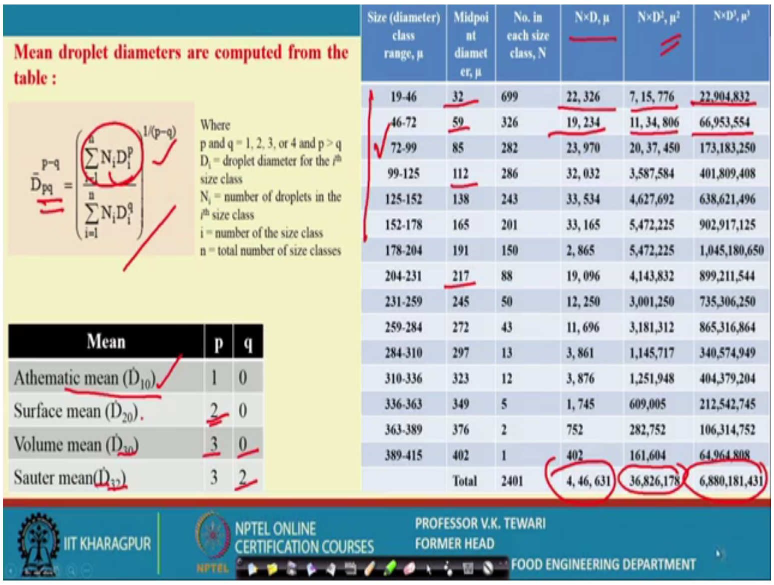

Now, what are the mean diameters from the table, what are the different ones? Well you know it that the arithmetic mean where p is 1, q is 0 that is D 1 0. Similarly, surface mean it is where p is 2, q is 0 that is p D 2 0 this talks of this here. Then volume mean D 3 0, where p is 3 q is 0. Similarly Sauter mean D where 3 is the p and 2 is your q.

Now, how do we get this? We need to make, we need to have the summations of this. So, what is done is this size diameter class range which is already given to you. Now, midpoint of this diameter, so the midpoint of this has to be found out and then approximate value mid time mid value is 32 for this, 59 for this, similarly 112 for this, similarly 217 for this and so on this has been found out.

Then the number in each size class with this number which is which was given in the table already. So, we have to simply take that value which is already given here, then what we get and n i d i; that means, individual this is N i, this D i. So, N i D i will be this value in microns. Similarly, for this it will be this.

Now, summation is this value. This is the summation that we are talking with respect to this. Similarly, when we are talking of p 2 when the value will be p 2 because when we will talk of surface mean. So, p 2 that means p 2 will be that means, we will talk of diameter square here. So, then N D, N remaining same here the D 2 will be simply we can get these values because you can see here. So, we will get these values. And this is the summation here when we are talking of D 2 where p is equal 2.

Therefore, when p is equal to 3 in this case here then here we will talk volume mean, you will get this value because n remaining same N i D i then p will be 3 here. So, we get these values just multiplication of this. So, it if you get, then the total is given over here. Therefore, once these are known it is very easy to put in this expression and get the values.

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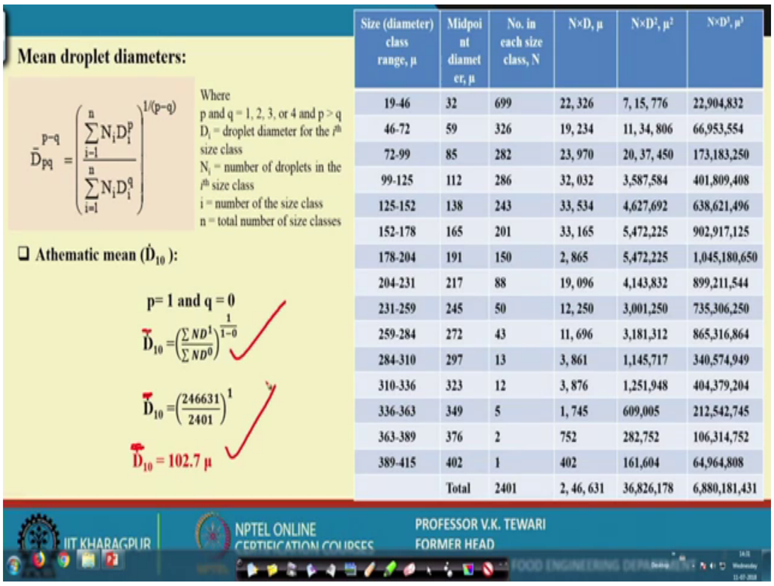

Size (diameter) class range, μ	Midpoint diameter, μ	No. in each size class, N	N×D, μ	N×D², μ²	N×D³, μ³
19-46	32	699	22, 326	7, 15, 776	22,904,832
46-72	59	326	19, 234	11, 34, 806	66,953,554
72-99	85	282	23, 970	20, 37, 450	173,183,250
99-125	112	286	32, 032	3,587,584	401,809,408
125-152	138	243	33, 534	4,627,692	638,621,496
152-178	165	201	33, 165	5,472,225	902,917,125
178-204	191	150	2, 865	5,472,225	1,045,180,650
204-231	217	88	19, 096	4,143,832	899,211,544
231-259	245	50	12, 250	3,001,250	735,306,250
259-284	272	43	11, 696	3,181,312	865,316,864
284-310	297	13	3, 861	1,145,717	340,574,949
310-336	323	12	3, 876	1,251,948	404,379,204
336-363	349	5	1, 745	609,005	212,542,745
363-389	376	2	752	282,752	106,314,752
389-415	402	1	402	161,604	64,964,808
	Total	2401	2, 46, 631	36,826,178	6,880,181,431

So, if you take those values here, you can get the arithmetic mean. Now, how do get the arithmetic mean you know that p is equal to 1, q is equal to 0. So, the values were already given to you here N D N i D i where p is equal to 1. So, these values there, use this value and you get here. This is the value which you get for D 1 0 mean. Similarly, here in fact this will be mean we are not dot because we have already talked of this. So, this will be mean. So, this is the value which you get for the arithmetic mean. So, arithmetic mean you can measure we can calculate like this.

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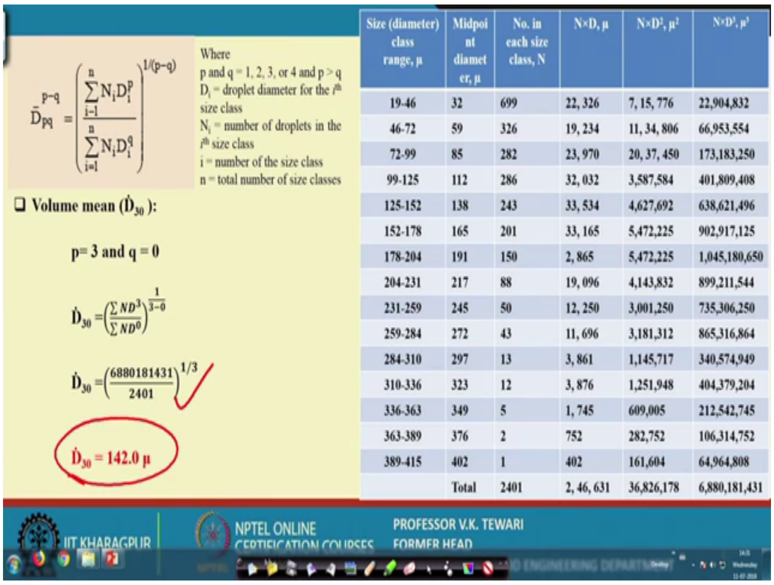

Next surface mean where D t 2 0 that means, p is 2 and q is 0. So, using that p and 2 the equation which is here this is the value which we have got and N D 0 is here so that means, this is equal to 1. So, automatically you get this value, this is the value which you get, and these value which you get. And this is the actual value of D 3 0. So similarly when you want to get the other one.

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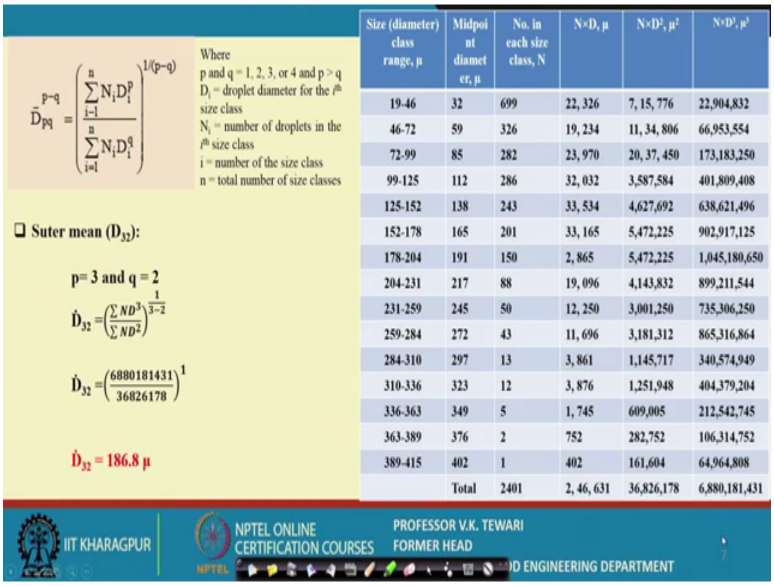

Sauter mean, now Sauter mean we know that p is equal to 3, q is equal to do 2. Therefore, there immediately you can get this value here and this is this. So, these two are already given to you can put this value is here and p minus q is 1 here. So, just divide by this which is the value which you get here as equal to this. So, this is how you can get this all the different diameters.

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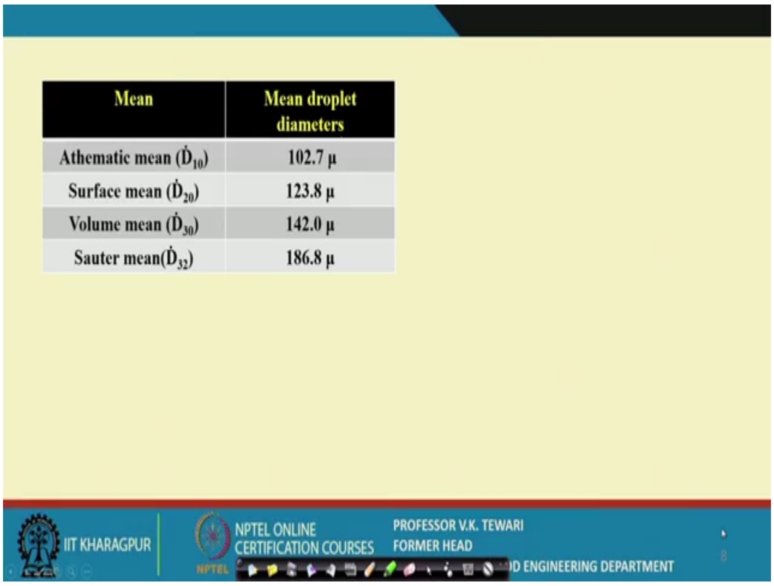

So, if we talk of then all the diameters which we are talking of the droplets in that particular data which was given to us we have got arithmetic mean, surface mean arithmetic means D 1 0, surface mean is D 2 0, then volume mean is D 3 0 and Sauter mean is D 3 2 and these values are known. So, this gives you a methodology by which you can classify you can know what are the different diameters of the droplets which have been deposited at various locations in that canopy or at the target where ever the case may be.

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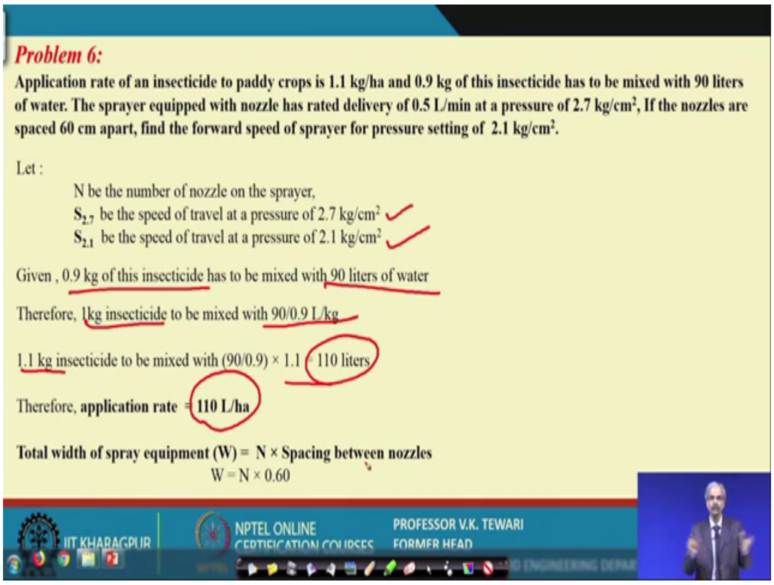

Let us take another problem. Now, you must take a recall that as I said that was the problem number 5. So, this is problem 6 in series of what we have done, because the last lecture we have talked of four problems. And this is the 6th problem in that series.

So, this problem indicates that application rate of an insecticide to paddy crop is 1.1 kg per hectare this is what do we have call as active ingredients. And 0.9 k g of this insecticide has to be mixed with 90 liters of water this is the requirement of the crop for the insecticide, because insects have infected the crop. The sprayer equipped with nozzle has rated delivery of 0.5 liter per minute that means, the nozzles deliver 0.5 per minute and a pressure of 2.7 k g per centimeter. If the nozzles are 60 centimeter apart find the forward speed of sprayer for pressure setting of 2.1 k g per centimeter square.

So, what we get here is and with the number of nozzles on this sprayer S 2, 7 with the speed of travel at a pressure of this, then S 2, 1 talks of the speed of travel at a pressure of this. So, 0.9 k g of the insecticide has to be mixed with 90 liters. So, how do you get 1 k g of insecticides to be mixed with this much kl litre per k g? So, 1.1 will give you this much litres. And then therefore, the application rate required is 110 litre per hectare. Now, if this is the one which is required total width of a spray is given as n into a spacing between the nozzles. So, the total spray your W is given as n into the spacing between the nozzle. So, we will know the total width.

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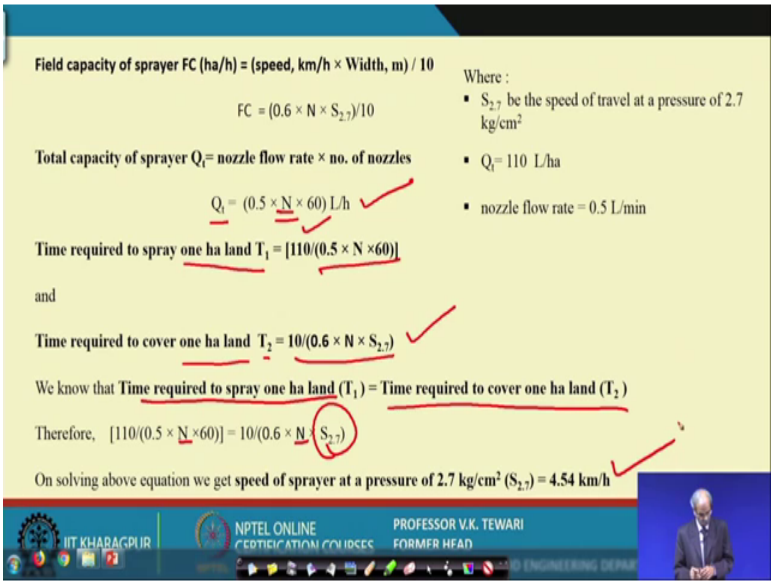

So, field capacity of the sprayer then what will the field capacity, width we know and then speed. So, that means width and speed by 10; this is the standard formula which you must have come to know W S by 10. So, we are talking of the kilometer per hour at the speed and width in meter by 10. It gives you the field capacity in hectare per hour.

So, this is the same formula which has been used here. So, S talks of the speed at 2.7 k g per centimeter square pressure and yes. So, the total capacity of the sprayer Q will be total nozzle flow rate into number of nozzles, yes number of nozzles we do not know the number of nozzles. So, you have put the n number of nozzles. So, what we get from here is Q t is will 0.5 into this here.

And the time required for 1 hectare land see what will the time required for 1 hectare of a land if you know a particular speed. So, if you know this that this is the one which is to be sprayed and this is the rate at which it has to be sprayed we will know how much is the time taken. Similarly, time required to cover 1 hectare T 2 when you are talking with respect to another the next time the time required to cover 1 hectare land time required to spray and time required to cover 1 hectare of land is 10 by 0.6 into N this value.

Now, when we are talking with respect to this that means we are talking that the time required for spray of 1 hectare and the time required to cover 1 hectare of land the this two must be same these two must be same. So, if you way equate them, what you get is you will be in a position to get because there are N here, N here. So, you get S 2, 7 that means you will get the speed at 2.7 k g per centimeter square which you have got over here. This is how you can get the operation the speed of operation of this sprayer.

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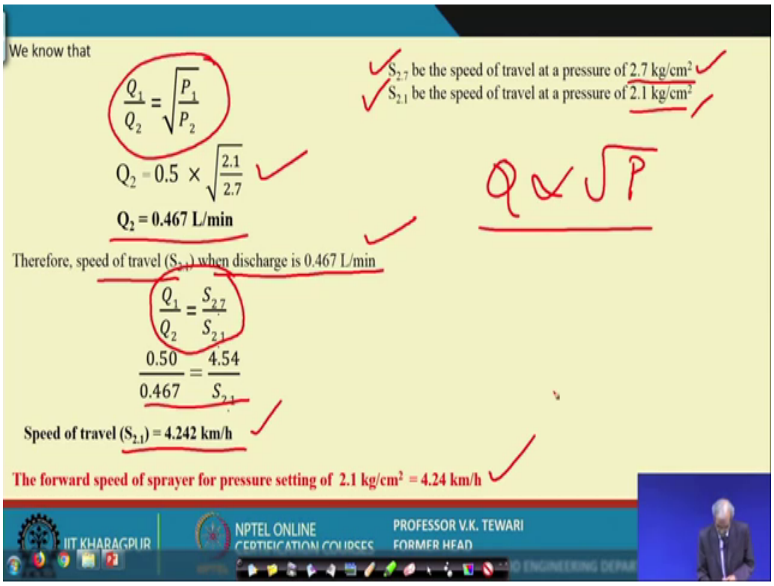

We know that now Q, we you have seen in the previous problem which we discussed and this theory as well that that this Q is proportional to under root P, P, where P is the pressure. So, we use this equation straight away and what has been given is S 2 2.7, S 2.1 is at this pressure and this pressure these are the two speeds. So, we can directly use this and get Q 2 from here.

So, if you have got Q 2 the travels speed to S 1 mean discharge when discharge rate is this much can we just calculated from this equation here, because they are directly proportional in this case, no inversely proportional in this case here. So, you can get these values and you can get S 2.1 at 4.2 kilo meter per hour.

So, you have got the both the values one, we have got earlier at the at 2 k g, 2.7 k g per centimeter square and at 2.1 k g per centimeter square is this value. So, this is what was asked in a few while we wanted to know with the details which were given to that to you through the problem.

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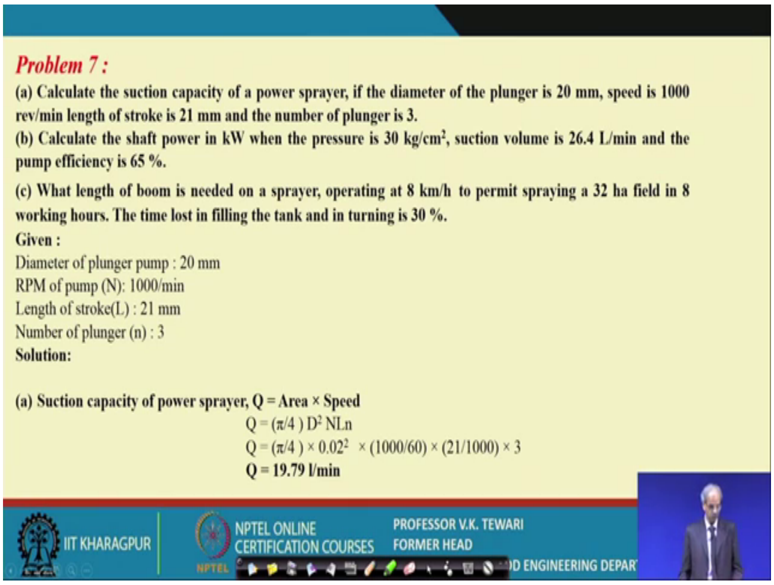

Another problem, now this problem is slightly different from where we have done with the other two problems. In one case we discussed about the diameters of the various sizes of the particles when they are there in different class ranges. Then we discussed about if the speed variation is there at where is a pressure how knowing the other details how will you find out the speeds at which they should be operated, so that you get certain amount of volume per liter which is required for the system.

Now, problem 7. So, calculate the suction capacity of a power sprayer what is this section capacity for if the diameter of the plunger is 20 millimeter and speed is 1000 revolutions per meter length of stroke is 21 millimeter and the number of plungers is 3, there about 3 number plungers. Calculate the shaft power in kilowatt when the pressure is 30 k g per centimeter square suction volume is this much liter per minute, and a pump efficiency 65 percent. C, what length of boom is needed on a sprayer operating at 8 kilometer per hour to permit spraying a 32 hectare field in 8 working hours. The time lost in filing the tank and in turning is 30 percent.

Now, this is there are three different things which are asked you. So, you need to think and then try to attempt these questions, because this requires a complete knowledge of what you have been taught so far.

So, what is given here is the diameter of the plunger pump is 20 milli given, rpm of the pump is given, length of stroke is also given, number of plungers are also given. So, the suction capacity of the sprayer is what area into the speed. So, area into this speed will give you the volume that is the suction capacity, how much it will suck how much your volume of liquid it will suck is straight away you have to pi d square before is the area and speed is you can get from here.

Because you will know the rpm here, the rpm is given to you, the stroke length is given to you and the number of plungers are given. So, from each of the plungers and at that rpm what is the amount which is coming. So, you can directly multiply and you get this suction capacity.

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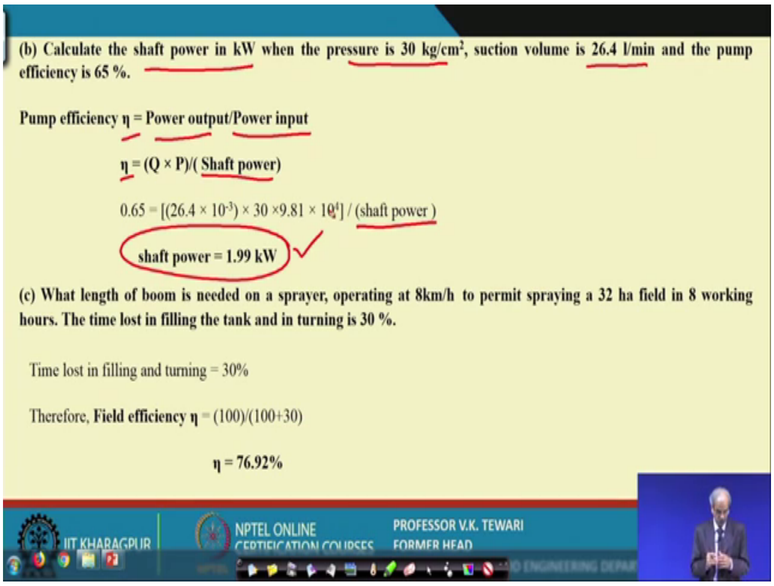

Second one; calculate the shaft power in kilowatt when the pressure is 30 k g per centimeter. Suction volume is this and the pump efficiency is this much. Now, you see pump efficiency, what is pump efficiency pump output by pump input fine. So, if you think of this pump efficiency power output by power input. Now, this is efficiency Q into P by shaft power here. So, using this because shaft power is already in kilowatt, we need to get what is the shaft power shaft power. And the pressure is this.

So, this pressure is given to you, this is the volume which is given to you. So, use this and we know the efficiency which is already given. So, the shaft power you will be immediately calculated it simply putting this, but then you have to understand what exactly they are trying to ask in.

Third what length of boom total boom because that talks of the total area to be covered. So, how much what will be the rate at which to be cover what is the speed at which it should operate on all that. So, with that regard they are asking length of boom is need for a sprayer. Operating at 8 kilometers per hour and permit spraying at a 32 hectare field in 8 working hours. So, 8 hours we have to work and 32 hectare has to be covered. So, you have to find out what is the boom length and then turning losses is could be taken as maximum of 30 percent. So, it is very simple.

Now, you see the time in filling and turning etcetera that is time lost is 30 percent. Field efficiency, how do you get field efficiency, we are talking a field efficiencies that the when we talk of field efficiency you say what is the field actual field capacity by theoretical field capacity.

So, using this what you get here that means, the 100 by 130, because this assuming that 100 was the total power and 30 is loss. So, you can get this is a field efficiency, once you get the field efficiency then you go back to because this area to be covered this is the time which is given to you.

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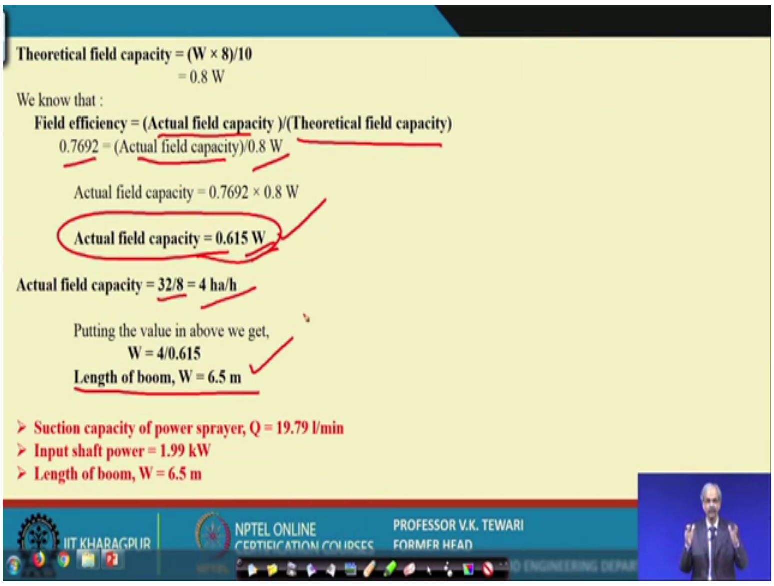

So, the theoretical field capacity will be we do not know, what is the widths of width W into 8 by 10 that is the field capacity, this is how we do W s by 10, so s is the width, which we have talking. Width we have to find out at 8 kilometers per hour. So, then what we get is 0.8 here.

So, field efficiency is the actual field capacity by theoretical field capacity, you have got this already here. So, actual field capacity you can get, if you know this theoretical field capacity, so then from there you are in a position to get what is the actual field capacity. So, once you have got the actual field capacity is this, so with a width of W.

Now, this has the width here. And what you have to do, we have to do 32 hectares in 8 hours, so that means, 4 hectare per hour you have to do. So, this 4 hectare per hour is a actual field capacity, which you will be there and from your equation you got that point 0.615 W is the one, which is actual field capacity. So, just equate these two. And then you get length of the boom by 6.5 meters.

Now, when you gets 6.5 meter, this is the value which is given actually out of the you can say a computations, but then you have to think, when you are settling those number of nozzles and all the details, you need to do some sort of fine tuning and adjustment as a designer to see that you really complete this area, in the particular time which is given to you.

So, although theoretical this 6.5 is a value, but then practically if you come across a case, that you might have to adjust some little bit here maybe 6.8 or 7 meters or something like that, but then this has to be the minimum value, which you should take.

So, if we talk of all the three items which were given to you, a suction capacity of power of the power sprayer was 19.79 liter per minute, the inputs have power is 1.99 kilowatt, and length of the boom W is 6.5. So, this is this was which was asked to you and this how you have got. So, what we have talked of let us say.

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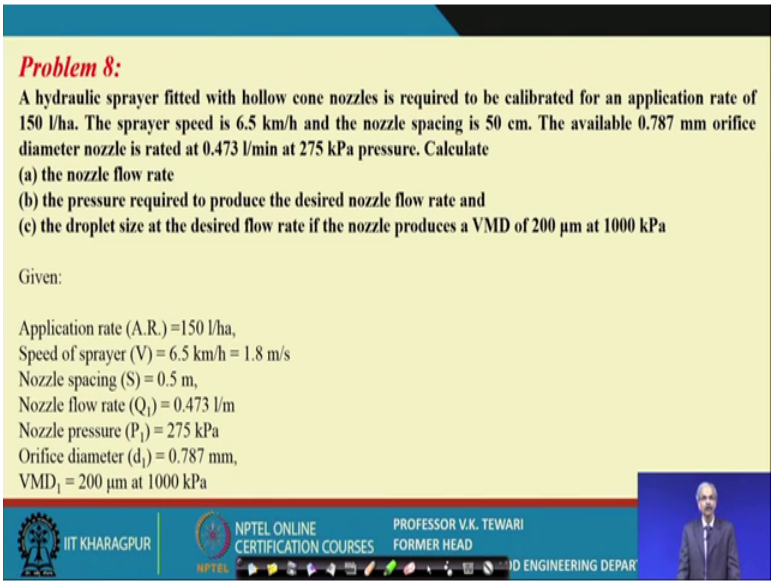

So far we have talked of these details. Now, another problem which also takes makes you to think regarding the type of the nozzle, which have been you say. A hydraulic sprayer fitted with hollow cone nozzle, you know what is a hollow cone nozzle is required to be calibrated for an application rate of 150 liters per hectare. Now, this calibration we have talked the calibration of nozzles etcetera. So, this from there a problem has been picked up.

The sprayer is speed is 6.5 kilometer per hour and the nozzle spacing is 50 centimeter. The available orifice size is 0.787 millimeter, so available orifice size is this. So, the diameter nozzle and at a rated volume of the available 0.787 millimeter orifice diameter nozzle is rated at 0.73 liter per minute that means, the nozzle is giving this much of liter per minute at 275 kilo Pascal per pressure, so at this pressure.

Now, what you need to calculate the nozzle flow rates? So, what will be the nozzle flow rate, the pressure required to produce the desired nozzle flow rate, then the droplets side at the desired flow rate if the nozzle produces VMD of 200 micrometers at 1000 kPa, it is a very good problem.

Now, you see whole aspects of your knowledge is being tested here you have a particular type of nozzle, you have a certain pressure at certain pressure that the nozzle is giving certain discharge. And then we want you to find out, what should be the flow rate etcetera, at the required pressure and they required size of the particle.

So, if you use this what is given to you is the application rate is given say 150 liter per hectare, speed of the sprayer is given, the nozzle is spacing is also given, nozzle flow rate is given, nozzle pressure is given, orifice diameter d 1 is given, and VMD 1 is given.

Now, these are the things, which are given. Always when you attempt a problem, please remember out of the statement of the problem, you must write what is given. And then think of what are the aspects of problem equations and formulae that you have been taught. And try to recall them and put them together, then only you can you will be able to follow a proper sequence for solving this problems.

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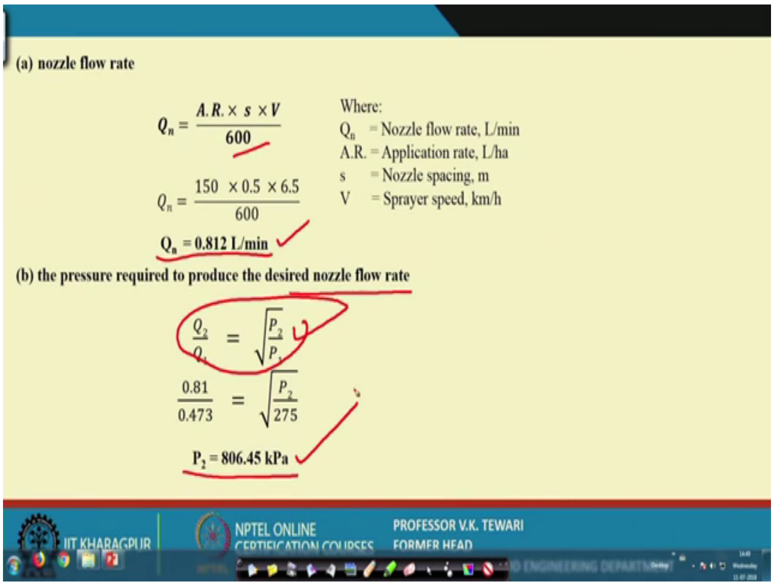

So, nozzle flow rate. Now, nozzle flow rate very simple you with application it read is known to you, and then the nozzle spacing is known to you, and sprayer speed is known with these speed we are. So, directly if you know the speed, if you know the spacing of the nozzle, you can get this simply multiplication of thus.

And this 600 talks of the this 600 talks of the unit conversion so, the value of Q n nozzle flow rate is this, you have got it. Now, the pressure required to produce the desired nozzle flow rate, what is the pressure. We had talked of similar thing in the previous problem.

So, here Q 2 by Q 1 is under root P 2 by P 1. So, Q 2 and Q 1 is given to you, P 2 is given, P 1 is required. So, there just use this here and you will be in a position to get the pressure required, produce the desired nozzle flow rate. So, using this you are in a position to get this pressure at the desired nozzle flow rate.

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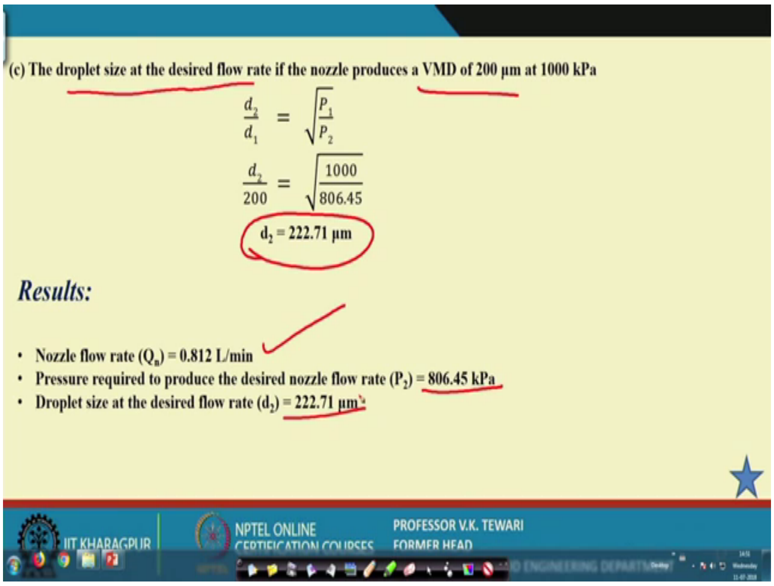

The droplet side at the desired flow rate if the nozzle produces so much VMD of 200 micrometer at 100 kPa well, you again same expression which was shown to you earlier with respect to the diameters the sizes of those particles.

So, d 2 by d 1 is under root P 1 by P 2 inverse. And so if you know d 2 and d 1 is if you want to know d 2, d 1 is given to you here, and you have got the value of P 1, P 2 from there. So, once you put this, you will be in a position to get the value of d 2 here that this is the droplet size at desired flow rate when the VMD of this is there, because this is one which you is talking of one size of the particle.

So, the three things which were asked you have been properly all put here that means, nozzle flow rate is 0.812 liter, pressure required to produce this much, and then droplet size is 222.71 micrometer.

Now, through these four problems, what we wanted to explain to you is that how will you design, how will you select a particular sprayer, a particular nozzle or when you have to select a fleet of sprayers for a large area, suppose you have 10,000 acre area. And you need to do spraying, whether it is orchard or it is a cereal crop or any other crop or tall trees, how will you decide this.

So, through the problems which we talk, through the through the theory which we have discussed, I think we have made you well equipped with these answers. And I am sure you should be in a position to follow the process, which we have brought to you, and see the problems which we have given you. They are very illustrator problems.

These are very much problems, which will make you to understand even there if there in problems in understanding your theory, you can get back your theory back. And then try to understand that yes this is the value and this is how a particular aspect is explained, we have talked of the class size in the particles, we have talked of the flow rate, we have talked of the capacity. Various types of the mean diameters what are the mean diameters where they are applicable on things like that.

So, with these and then we are also talked of the different classes and from those classes what else can be can we get all those details. So, if I say that in the classes that we have covered for spraying we have talked of the different types of sprayers and dusters, then we have talked of their performance evaluation. Then we have talked of how to test and certify, then we have talked of the various problems so that you can understand the whole gamut of this spraying equipment system.

I hope that we have tried to deliver a do justice to see that you follow. If you have any questions, we will take up at as and when they time requires, and so we close here at this point of time.

Thank you very much.