Farm Machinery
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Lecture - 38
Selection and Design of Plant Protection Equipment/ Machinery

Well, students we have already discussed in the my previous lecture about these sprayers and dusters. Now, we will go into some more details of how to design and how to select plant protection equipment, keeping in view the requirement of the crop, requirement of the situation and the other parameters which are there at the hand of the designer.

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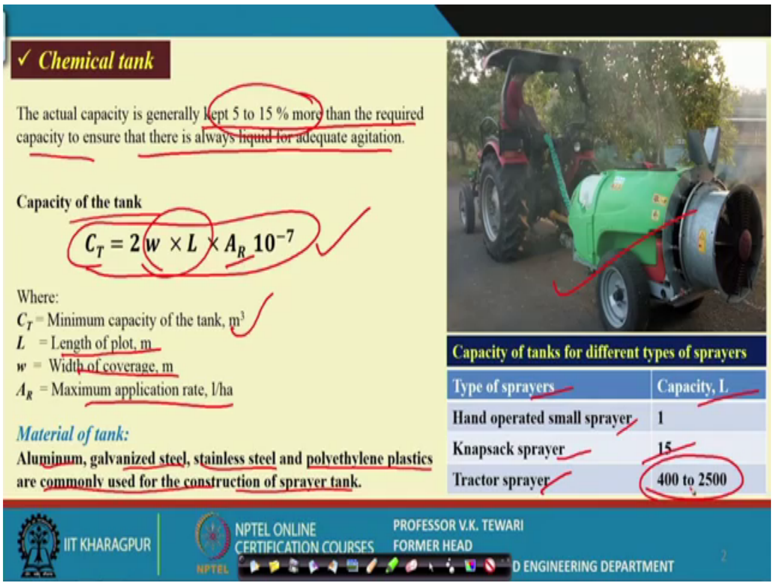

So, see the chemical tank, as I said this is the first item which is to be there, now how what should be the capacity of this? How do you get the capacity of this? Will be it will depend on certain aspects whether you are talking of the power source? What is the power source? If the power source is a is manual then what will happen? If the power source is mechanical then what will happen and what should be size? This is what is important.

Now, how do you get this capacity? See the actual capacity generally 5 to 15 percent more than the required capacity to ensure there is always liquid for agitation. Now, you see sometimes when the agitator is there it will keep that the liquid which we have created is in the right composition. It should not be that the particles settle down and then water is there on the top, no. So, there should be the agitation should be sufficient. so, in order that this happens actual capacity should be 10 to 15, 5 to 15 percent more now we need to know what is the capacity of the tank?

So, for knowing the capacity tank it is very simple it you do not require such big mechanics for that, you should know what is the length of the plot that you have at your disposal and what is the width of coverage which you want to do. So, if you know these two things the application rate is known to you because depending upon the inter station or depending upon the earlier data that you have you will utilize this.

And once this is there you can get this formula. This is very simple you can just multiply this should be in the area this is the application rate in liquid I mean liters per hectare. So, with this area I got you are getting actually liters or, you can get into meter cube, here it will be in meter cube because we have given the units accordingly and that is why is state 10 to the power minus 7 so, the capacity of the tank can we know.

Now, what is the material of the tank? See, you know that these materials could be corrosive. So, it will finish, virtually the tank will not last long so, we have to away careful about the material of construction on the tank which is thought off.

Generally, the aluminium is one which is fair enough then galvanized steel which is used, stainless steel and polyethylene plastics are commonly used for construction of sprayer tanks. Yes, these are these are ones which are used and we find that these plastics are coming up in a big way particularly with regard to the weight as well as non-corrosive.

So, these are ones which are coming up you do require a technology for creating those big tanks of plastic and all that, but that that is now very much in use and various types all in fact, all the sprayers which might have seen or all use of plastics. Hardly anybody uses aluminium or galvanized all, but these are the materials one can use depending upon the situation depending upon what you wants so, these are the materials.

And you can see that we have shown you the is one which is there with us at IIT, Kharagpur which is of course, procured one, but then this is the one which we have for the for orchards we are trying this testing is for orchards.

So, and upon the capacity generally or the types of for sprayers the capacity generally for hand operated small sprayers could be 1 liter, could be 14 liter, knapsack sprayers are 15 liters, 14 liters, 16 liters sometime depending on the size and the tractor operated once a 400 to 2500 liter capacity.

Now, because once it is in the power source which is very high in that case then you can use this big ones and ultimately it will you will be in a position to minimize the time for completing this particular operations so, that is very important.

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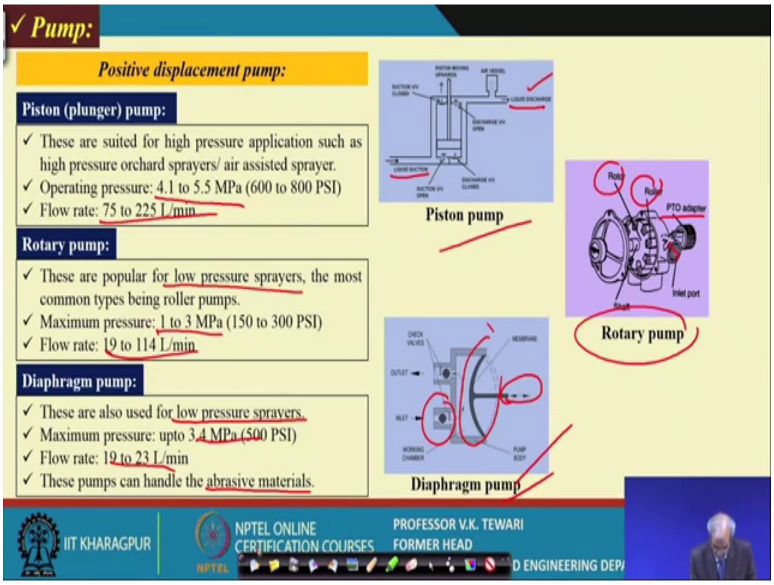

Well, the heart of this particular this sprayer is the pump here because, these the one which is in fact, delivering the energy for creating the droplet us. Now, let us have a look at these what are the different types of the pumps which are used and how they are constructed what is the pressure which is required and all these things. So, if generally you know that when you are talking of high pressure pumps, generally these high pressure pumps are piston pumps or plunger pumps or diaphragm pumps or rotary pumps.

Now, this the pressure you can see we have talked of this pressure, but then it is worth mentioning here also the operating pressure is varying from 4.1 to 5.5 MegaPascal or 600 to 800 PSI, then the flow rate is about 75 to 225 liter per minute. So, this much is the flow rate.

Now, plunger pumps high pressure applications as I said earlier then rotary pumps when slightly low pressure once maximum pressure goes between 1 to 3 MegaPascal, and the flow rate is 19 to 114 liter per minute. Well, these are the informations which we are from the literature available and from the experience that we have observed in testing of various types of sprayers.

The diaphragm once also lowest sprayers ones and these have about 3 point Mega Pascal up to this and up to 90 to 23 liter per minute, of the these are sometimes these diaphragm ones are better for particularly for abrasive materials you can use them. Now, each has it is own requirement and each has it is own uniqueness particularly with regards to use.

So, we can see that what are these piston pumps? You the piston pumps are very simple once, you have seen all the pumps which we are used for our water lifting and all that there are all piston pumps or plunger pumps. You can see here that this is the plunger here and inside this pump this is the one which when it goes here, you can see that suction will take place from this location here, and that the liquid will be discharged from here.

So, these are the walls which are closed once you pull it the suction is created, vacuum is created then the liquid will be sucked in and after the moment it is pressed when the valves will open. And the vent is created the valves will open and the liquid will go through this here.

Now, the diaphragm type, the types of membrane is there so, this is this is the membrane which is there, and then the inlet and outlet very simple you can see the inlet covers from here and because of the movement of this you will see here. The movement of this diaphragm is to and fro so, as it is moving out so, inside then it sucks in aniod moves the reverse direction and it is pushes out.

So, during that pressure see this in check valves. This check valves are direction, check valves are only talking of unidirection because, here check valve is inlet one when it is only putting inside there, the other one which is only for outside. So, these two check valves are they are very simple type of diaphragm and as I said these are good for abrasive materials. Then rotary pumps are also low pumps low pressure pumps but then they are also positive displacement.

Now, what is this positive displacement? Remember that it is not affected because of the pressure as such the discharge, ok. But there are other pumps which are affected because of the pressure which we call the non-positive displacement pumps.

So, the rotary pumps you can see here that these rotary pumps where there is a rollers are there, then the rotor is there, and PTO driven, here is the inlet. Now, the moment you have been see this rollers they move to and fro so, when they move to and fro while moving inside they suck in and while pushing that and this particular rotor keeps on rotating.

So, when keeps on rotating they will go to the location where the outlet is there, they will and deliver it. From the inlet point they will be sucked inso, these rollers are moving to and fro and then they do the job of suction and forcing it out this is what is in the rotary pumps is a very concept is very simple if you are open you would be able to understand what are this.

But, it as a designer you must know what is happening inside the pump then only you will be able to change the pump, you will be able to design a new pump and see that the losses in the pump are lesser. And then you are in a position to choose a particular pump for a particular application part.

So, these are the positive displacement pumps that we have talked off (Refer Time: 09:34) the piston pumps, the rotary pumps, in the diaphragm pumps and the pressures and volumes which are there I have talked of these. Then let us know which are the non positive and what are their behavior?

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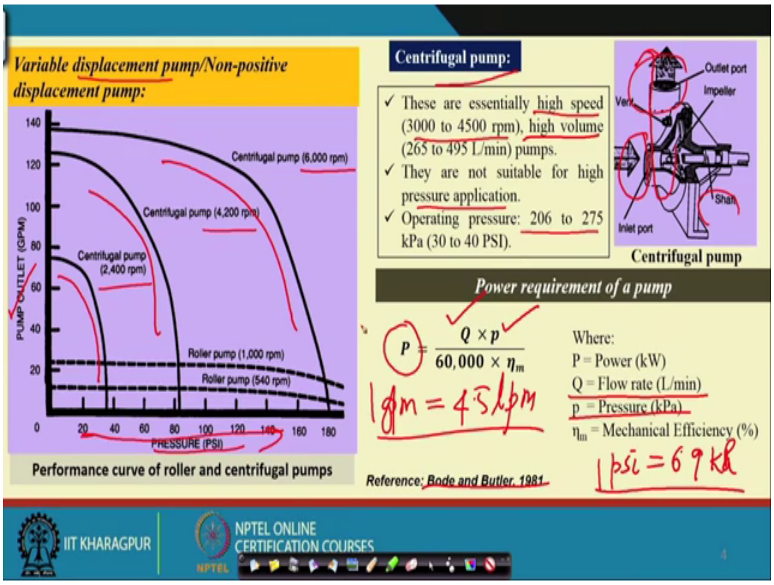

See here, the non-positive, variable displacement pumps simple as that. The very displacement will vary as the pressure you can, you in see here you see here that this centrifugal pump here. So, see these pumps generally for high volume and the essentially high speed once 3000 to 4000 rpm, and the these are for low in a operating pressures you can see that low operating pressures, but they are high volume. And they are not suitable for high pressure applications of course, as I said these are meant for but high volume low pressure.

Now, here you can see that the inlet is here, this is the air location of the inlet here when it is sucked in and this is the outlet here and the impeller is the here. So, these sucked from here as the shaft is connected to the impeller. So, at the shaft rotates the impeller is in a position to suck in and then it is thrown from the periphery you can see that this is this is how it is taken here and then this is thrown out from this side. So, this is this is the way it will be thrown out outlet.

Now, these are why they are called a non positive? Because of the variable displacement, what is so variable? You here you see that centre when the pump is speed is 6000 rpm, 4500 rpm, 2400 each case see what is there. See when you plotting here pressure and this says pump outlet, you see here as the pressure see 20 PSI, if I say PSI well; please excuse me because we have not changed the nomenclature of this which was given because we have taken from the literature and it is worth telling about exactly what they have given.

So, you know that 1 PSI is over 6.9 kPa, so, 1 PSI is equal to 6.9 kilo Pascal so, you can just know this. So, using this is of course, gallon per minute here, this also one gallon generally beauties gallon about 4.5 meter. So, 1 gpm this is gallon per this is nothing but about 4.5 liter per minute this can be taken.

So, irrespective of the units that you are talking of you can see it for each of the speeds of these centrifugal pumps. See as the pressure changes increases here there is a drop on all these things so and although the volume handled by this is very high. So, the importance is that the volume handle is the high but they are they are affected because of the change in pressure. So, these are not used for constant at high pressure locations, where it is required where your are using the other pumps as I discuss about piston pumps or plunger pumps, diaphragm pumps, rotary pumps etcetera.

Now, what is the power requirement in a pump? It is important you should have the how do you get the power source for running the pump because pump is the heart. So, for that itself you need some energy and that energy can be provided by the PTO of the tractor or if you have an engine or whatever is the power source that you can think off. So, how do you get the power? Which is very simple you can see the Q into p, where, p is the Q is the flow rate and p is the pressure.

So, once you know this you are in position to find out what is the power requirement of a particular pump. So, this is important so far as the different type of the non-positive displacement pumps are there, we had talked first individual pumps we have talked non-positive different pump what else is there? Now, we will go we are going ahead with the different components you had seen we are talked of the tank. Now, we are talking about the pump and then we are talking we will talk about the droplet us to be created and so on and so forth let us go ahead.

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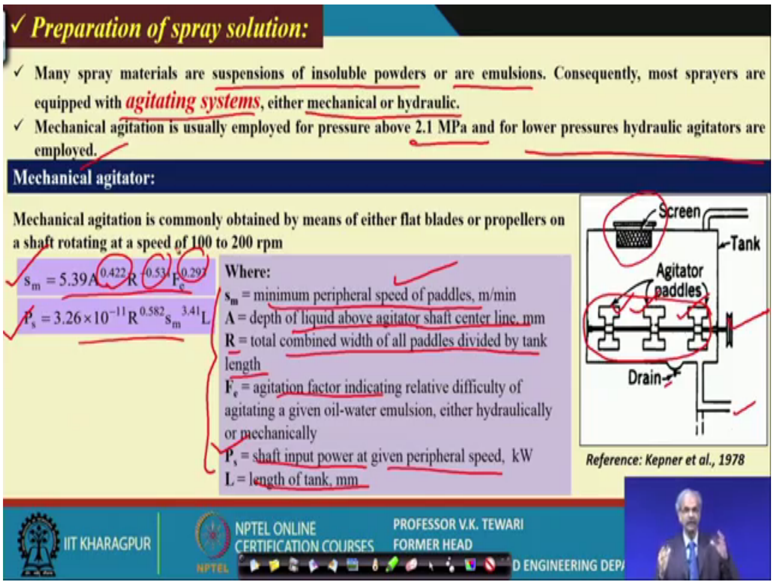

Preparation of spray solution, how do you prepare this spray solution? This is important, sometimes you have the emulsion which are oil emulsion liquids which are which need a constant stirring, otherwise the solution will not remain colloidal throughout on the process, and otherwise when you want to apply you will find that the chemical is not actually in the same concentration which it should be there.

So, you see here that many spray materials are suspensions in soluble powders or emulsions. So, we need to have agitating system in that spray whether mechanical or hydraulic whatever we need to have the agitation how do we do it? If it is a very large one and handling large amount of chemical, then in the tank there has to be mechanism created. You can create that mechanism as it is a mechanical or hydraulic system.

So, mechanical agitation employed for pressures above of 2.5 MegaPascal, these are some of the informations which are given and the lower pressure hydraulic agitators are employed. Well, these are some of the literature informations which are worth knowing because then once as a designer when you want to choose a particular type of agitation system you should know what is the requirement and what is the device or what is the method which will be suitable for you that you can take.

So, when you are talking of mechanical agitators well in the mechanical agitators what will be there in mechanical agitator we definitely, this is the one, see this particular these are the pedals as shown here, these are the pedals. So, when this shaft rotates and you can give power to this pulley here. So, when you will give power to this pulley you will be rotation and then these baffles will move inside so, the size of the baffles their diameter etcetera has to be very carefully chosen and then for this you will require power for operation of these.

Now, in the tank, now you can see that there should be a entry of here and then there will be a screen for putting the chemical here. So, this where you will get the agitation from? Now, some of the information which is available in literature is worth mentioning to you empirical equations people have developed using these pedals.

For example, they have used the minimum peripheral velocity of the pedals which are to be there, then the depth of liquid which is essential above the soft centerline which is important, then the total R is the total combined width of pedals divided by tank length. See these are some of the empirical equations so, all these parameters have been taken into consideration.

Then F e is agitation factor, then P s the shaft input power and L is the length of the tank. So, using these then these are the two expressions which are available for you. So, minimum peripheral speed how will you get the minimum peripheral speed, then how will you get the shaft input power at a particular given peripheral speed and kilowatt.

So, these you have to use these in fact, what is important it you have to be careful about the units of this. So, these are you the proper units are to be definitely followed then only these powers which are given here will be effective, otherwise they will not be effective and they will give a wrong value.

So, you when you are talking of the spray volume solution to be created it has to be particularly for larger units it has to be stirred or agitated over throughout the course of the application part. And it could be depending upon the it has been given a pressure is very high never press it is then we are will go for mechanical and lower pressures slightly lower than that maybe you can go for hydraulic one.

Now, what we do in these? In the mechanical one we have seen like this, in hydraulic system what we do so, we will have what is there in this.

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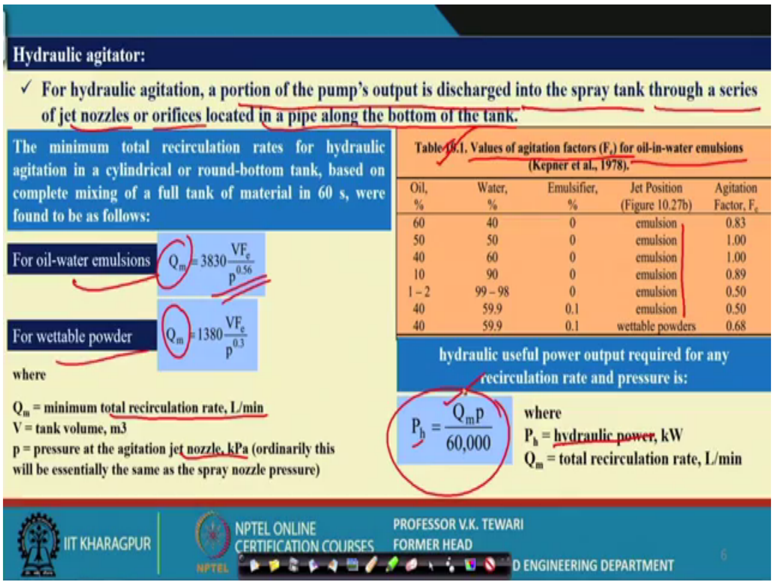

See, in the hydraulic agitation as it is said that is for a low slightly lower pressure as say 2.1 MegaPascal in case of that and lower pressure should be here. A portion of what is done, a portion of the pumps output is discharged into the spray tank. This is beauty of this that when the tanks output a portion of that may be about say 10 percent, 15 percent of that is diverted back into the tank. And where it is diverted? Through a series of jet nozzles or orifices located in a pipe along the bottom of the tank.

So, at the bottom of the tank if you have small nozzles are or orifices created, so bring back the output certain portion of the output back into it. So, it will keep on delivering through this nozzles or the orifices at the bottom. So, each time there will be a rotation I mean there will be a stirring of the whole chemical and that is why, then you will be able to achieve that.

Beauty of this is particularly this is good for the sea oil emulsions, sea oil emulsions where if the mechanical ones who will have the metal part and all that the pedals. So, they may get deposited onto that. So, but this system is beautiful particularly for this emulsions. A some we have given some information this table you can see a table 1, this since we have picked up from there table 1 say. So, value of agitating factor now I said you that what is this agitation factor now that agitation factor has been has to be taken this is the empirical information available from literature.

So, it is worth mentioning who here and you should take up these depending upon the type of emulsion which is going to be used you should take this thing. And then only you will be in a position to find out the emulsion and the wettable powder for those what is the amount of minimum total circulation rate that you will have to rap this in these are given. So, you can use this and find out the find out the rates minimum total circulation rates and here is the hydraulic power.

So, once in the hydraulic power in order to find the hydraulic power you will have to have Q m which is nothing, but the minimum total circulation rate and the pressure that you are talking of pressure at the agitation nozzles. So, with these you will be in a position to find out what is the pressure power; hydraulic power which will be required.

So, if you are talking of the different selection and design of this we have slowly you are coming from the tank, we are talking for of the pump, well anyway talking of the agitators in that system and then we will talk of small you can say that droplet us how to create an droplet us and definitely they will require some nozzles so, what are all these.

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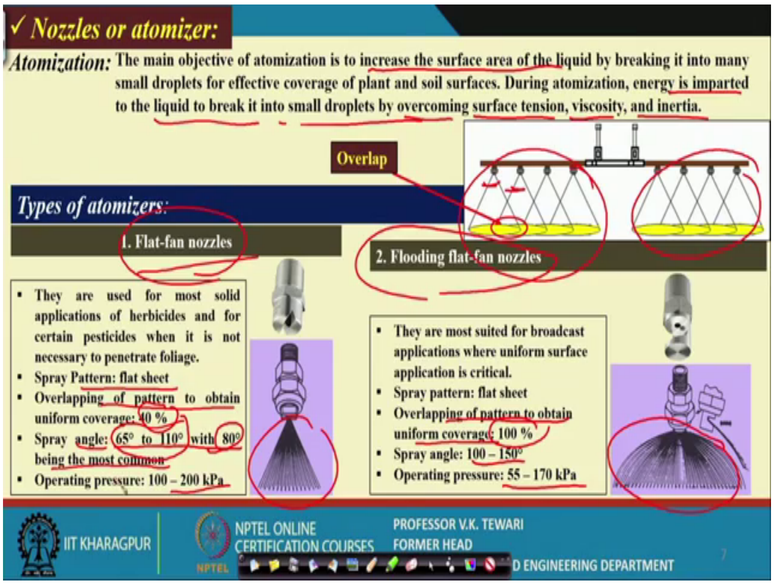

These nozzles are atomizer; yes, these nozzles are the ones which will create the atomization which will create the smaller particles of the size which you want. So, these the basic purpose of it is I have already explained here if you go through that you will know. The basic purpose of atomization is to create small as small spurts you will this the particles which will then be in virtually it will increase the surface area and then when it gets deposited on through the whole canopy it will get spread here.

So, with the lesser amount with if you have better atomization or a good amount of increase in surface area that is what it is in fact, increase the surface area of the liquid, but I breaking into many small droplet us to cover the whole plant. So, this is the basic thing.

Now, the during atomization energy is imparted at to liquid to break into small particles and by overcoming surface tension viscosity and inertia, of course, these are the mechanics of it this in the system which happens inside is given here. So, the atomization is important how do you do it? You got to create pressure you got to create circulation, you got to have the particular type of the nozzle which will give you that.

So, but where should we keep the nozzles? We have also given this I will come to this slightly later, you talk of the different types of nozzles, what is there in the nozzle? See the nozzle could be flat fan nozzles that means, when the deposition takes place it will be like this you can see that the fan just like a fan if you have you have seen that flat fan nozzles, where the overlap now well is spray pattern is flat sheet type.

Now, the moment you have these what is the level of overlap? Say when you are talking about supposing the oil I mean the solution comes to this and then we have this arrangement or we have this arrangement here. So, there should be a overlap in order to that the uniformity is there. If you do not have then there is a possibility that the spread which you get for coverage of all may not be sufficient enough, and that is why we need certain level of overlap. These overlap varies from as low as 15 percent, 20, 25 percent to as high about 50 percent or so, depending upon the requirement depending for the type of nozzle you have used.

So, here for spray angles 60 to 110 with 80 degree with the most common one, so, what is the spray angle? This angle in fact, we are talking of this angle so, when this angle depending upon this angle which is over here say 65 to 110 and with 80 being the most prominent which you use, you will get a overlap above 40 percent you obtain uniform coverage in case of a flat fan nozzle.

In case of a flooding or this type of nozzle you see that for overlapping of patterns to obtain uniform coverage 100 percent overlapping, this is different because, you are virtually you can see this is what happens. Spray angle is 100 to 150 degrees and the operating pressure, where 55 to 170 kPa or so, here also 100 to 200 kPa.

So, what happens in the atomization? We are talking of having small particles and then these particles were actually once they are of a particular size then we need to know where this would be the overlap, and what should be the angle of these spray which should be maintained of these nozzles. So, the angle has to be, the spray angle has to be designed or selected then the pressure has to be selected and then only you can know what is the required overlap for getting uniform coverage, these are important when you are talking of the different types of nozzles.

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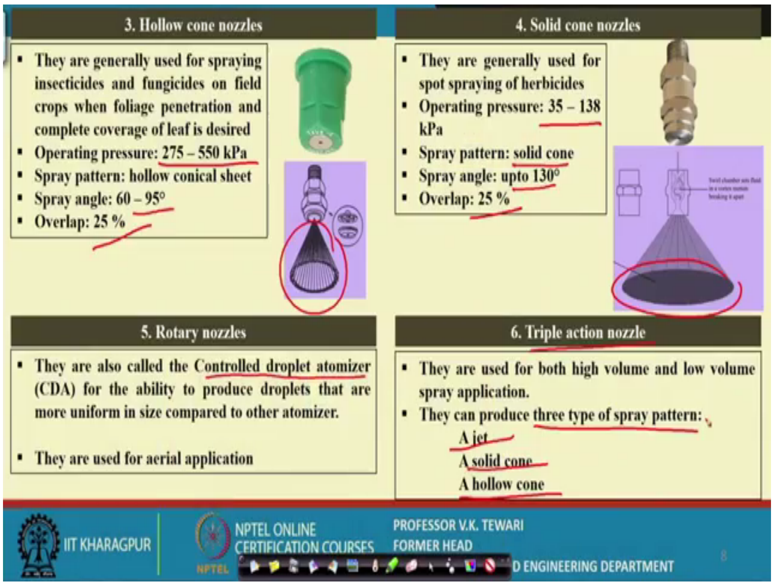

Well, hollow cone nozzles, sometimes we require that we do not want this to be there so we require hollow cone nozzles. So, you can see that this is the cone a cone which is hollow inside, so, this is the type of pattern which you will find in case of a hollow cone nozzle. And the other details are very simple, the spray angle is varying from 60 to 95 degrees the overlap is as since a low 25 percent overlap it is able to cover. And the operating pressure is 270 to 550 kPa or so hollow conical sheet as I said this will look like this.

Solid cone, well it is hollow and that is solid, you can see here that this is a solid cone. This will be required because then you want you want that this should happen and this will be virtually covering the over area. So, then you will have this, so this will be overlap is your 25 percent overlap, spray angle is about 130 degrees spray pattern and solid contact and the application pressure is this.

The rotary nozzles, we are also talked of fruitiness control droplet atomizers they are chorus CDA. Then there are triple action nozzles which are jet type solid cone hollow cone they can produce three types of patterns. So, these are different types of nozzles which are used and depending upon the requirement, these are very much used and depending upon your requirement you should select these nozzles.

See each and everything when we talk of design the selection proper selection is also designed, it is not necessary that you will start fabricating you will design each and every aspect and then you will fabricate and then casting etcetera and then you will use no. We are talking of what are the things which are minimum requirements and correspondingly what is available in the market which we have to choose for our system.

So, that is why I have listed that this particular topic what we are discussing selection and design, we will select the pumps, we will select the nozzles which are available depending upon our requirement, depending upon what sort of overlap I want, what is the crop which is there with me for to be spread and things like that.

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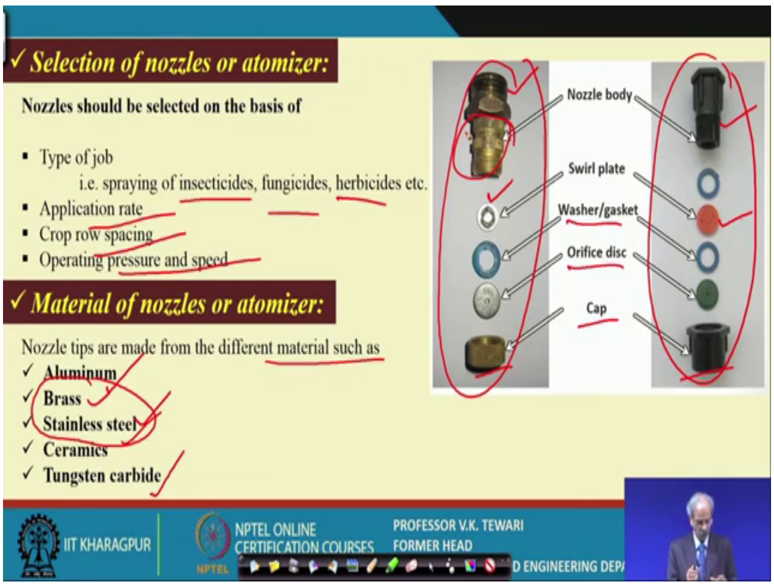

So, like these nozzles what are there in the nozzles; we thought that these are some of things which we have and you wanted to show you many locations you may not find. So, it is worth showing you here that see the nozzle body these are the nozzle body here, then swirl type the swirling action takes place through these, then the washer or gasket is required for order. So, that there is not losses do not take place, then orifice disc, there is a orifice disc which will help you to deliver that and there is a cap for closing it.

So, this is this is the details of the two type two nozzles which we have shown you these are the smaller components which are there inside. Selection of these, now how do you select? Well, I have discussed a lot about this it will depend on these insecticides, fungicides or the herbicides.

What is the chemical or what is the type, nature of the liquid or the powder whatever it is to beat them? So, if it is powder we do not need these more nozzles, but definitely when the powder has to made into a liquid and to use so, you have to think of depending on the application rate, crop row spacing and operating pressure and speeds you will have to select these nozzles. Because, these nozzles a specifications are given that these are fit for what is the pressure ranges on which it this should be work so, you should select that. What sometimes is furious design nozzles and sometimes, these are nozzles which are defective and not good quality ones of course, particularly with regard to material and it is life.

Otherwise, you should be able to pick up these nozzles from the market and from good manufacturer who does this, reputed manufactures who will have all these specifications, and you will also see what is the type of pump, and what pressure you will definitely get and all that and mention and the size of the particles which you will get.

Nozzles materials well these different materials you start from aluminium, brass, stainless, ceramic, tungsten, carbide you will find in brass and stainless steels are very commonly chassed the of these you can see here. So, you will find that these materials are used for the atomizers.

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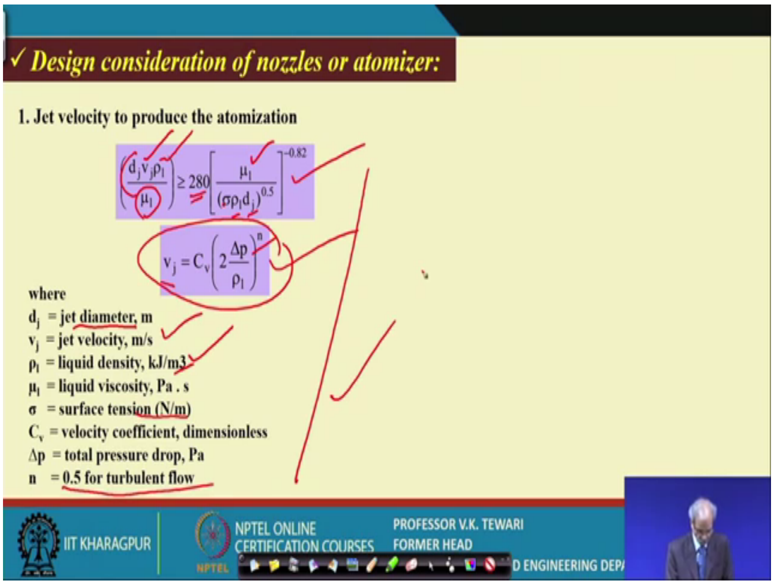

Design considered, for nozzles are atomizers, what are the design considerations? What you are talking? So, you need to know how much is the velocity which will come out so that you get the proper atomized particles of that size. So, with this out of literature the people which have research and found out the empirical relationships between the various properties of the liquid for example, the density of this with the viscosity and the material the surface tension of that liquid and what is the pressure at which and what sort of flow we want.

So, depending upon all these parameters then the empirical equations have been developed and it is worth choosing these equations. It is not that one has to again start and do it for that, until unless there is a special requirement. You must use this and check how far is the is it from the reality so, it is worth utilizing these.

For example, you can see here that, see here the jet diameter, this the jet diameter d j that v j is the velocity of the jet and rho is the density in kg per meter cube is this one. Then this is the viscosity this should be greater than equal 280 times this where again you have rho here which is the surface tension, and this is the density, this is the diameter and this viscosity so, there is a relationship here.

Then v j talks of the jet velocity so, this v j is given by something like this, where delta p is the pressure and n is the turbulent flow for a 0.5 for turbulent, that is talks of what type of flow will take place in the nozzle system when it is working. So, this is one available information about jet velocity for atomizers and nozzles, which we which can be used, which can be selected for our use.

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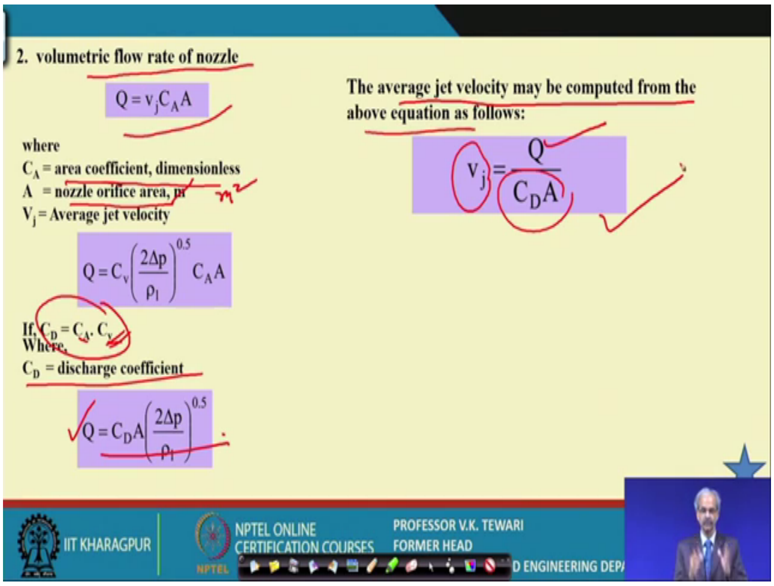

So, what are the different things that we have learned with regard to particular with regard to the flow rates, with regard to the nozzles, and with regard to the discharge of these nozzles, etcetera. See, we have the volume flow rate this nozzles is given by this, where v j is we have seen it, our jet velocity, then A is a nozzle area and C is the area coefficient here.

Then we are talking of what is this relationship between C and C D that is C D is the discharge coefficient and C A is area coefficient. So, discharge coefficient area coefficient are related like this, where C v is the one which we are talking of the volume, ok. So, using this what we get here is Q is given by this formula and then ultimately using these you get v j to be given as Q by C D into A, where A is the nozzle orifice area where nozzle orifice area. So, this has to be in meter square because this is an area.

So, you can see that every jet velocity may be computed from this particular equation. So, if you know these, these details it is possible that you will be in a position to design a sprayer, and for a particular applications the pump you can select with the pressure and the fluid rate that you want the low volume, ultra volume, over in higher volume etcetera and the type of application with is for orchards or where ever.

So, with these information I think it is worth knowing and selecting etcetera particularly with regard to sprayers. So, I think if you have further questions we will definitely try to answer at the point of time when it is required. But I think this is sufficed for the time being.

Thank you.