Farm Machinery
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Lecture – 40
Performance Evaluation of Sprayer

Dear students welcome to your another lecture that I would I have presented to you in the form of Performance Evaluation of a Sprayer. Well, I discussed in my previous lectures if you have gone through you will find that we have talked of the various types of sprayers and what are the special features of those sprayers how they are designed.

And now the time has come we must know how to find out the air performance. I mean what are the parameters which need to be evaluated with respect to a particular sprayer. And we can say that; yes this is a sprayer which is worth being used in a particular field or in a particular situation of crop field either it is a cereal crop or it is a orchard crop or plantation trees etcetera. So, with respect to this we will discuss in this particular section the performance of a sprayer.

Now, let us go through the slides what I have brought to you one by one in which we will see the parameters and what are their details required for those parameters.

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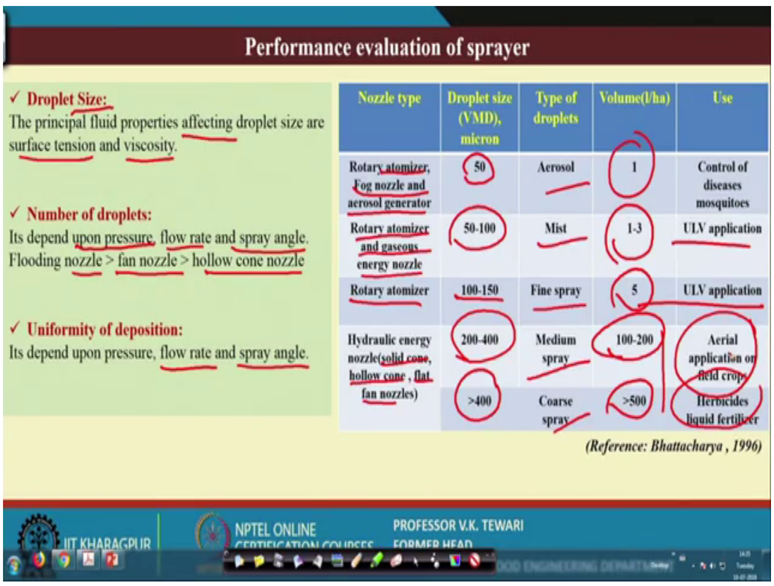

See when we talk of a performance evaluation of a sprayer you know that the items which are there in a sprayer or the pump which develops the pressure. And then after that you will have the boom, after that you will have the lance and then the cut off device. I mean start and stop device and then the nozzle. The nozzle gives you different types of the pattern which you require as per the requirement of the crop or as per the requirement of the infestation which has taken place in the field.

So, here we will talk of the different parameters. Now let us talk of the droplet size. Yes, as I told you that droplet size droplets are important because those droplets if they are bigger definitely they are going to not cover the whole area at the same time they amount of spray required or the volume of solution required will be quite high.

So, we must talk about what is the droplet size. See, the droplet sides size is affected because of the surface tension and viscosity. So, these are the fluid properties of surface tension and viscosity, so the droplet side will be affected because of this. Now here when you talk of the number of droplets we must know we have idea about the droplet size which is the principle fluid properties or surface tension and viscosity.

Now when you talk of the number of droplets what sort of droplets are required, whether large volume of droplets are required of a particular type or not. And what will be the sizes of that depending upon the type of nozzle that you have used. So, you can see that; here we can say the depending upon the pressure that you have the flow rate and the spray angle.

We it has been found that the flooding nozzles which are simply throwing or spraying in a jet form flooding nozzles are greater than the fan nozzles then greater there the hollow cone nozzles. That means, the droplets; the droplets if you go through flooding nozzles the droplets are higher than this and this is how it moves.

So, uniformity of deposition now how do you go about the uniformity of deposition which is very important, whether the droplets are uniformly placed at the right location or not, or they are concentrated one side more and the other side less and so on and so forth this could be situation. So, the uniformity is very important as the size is important and the properties of the liquid which are important the uniformity is another important item which depends on the flow rate and the spray angle which has been take.

In fact, these parameters are very much interrelated when you talk of the liquid you have to talk of the surface tension, you have talk of the level of viscosity of that, you have talk of the density of that you will have to talk of the orifice through which they are coming out then you have talk of the flow rate what is the flow rate and then you talk what is the spray angle.

So, if you go through this now I have presented one table here which will give you some idea about how to think how to learn about the droplet size, the types of droplets and the volume and what is their corresponding use. So, let us have a look at this see nozzle type. If you have the rotary atomizers, fog nozzles, or aerosol generators; so were there the droplet size which is represented in VMD volume in median diameter in microns is given as 50. If you talk of rotary atomizers and gaseous energy nozzles then it is increasing 50 to 100 droplet the 100 microns 50 to 100 microns of VMD which will have.

The same they are similarly when we talk of only rotary atomizers that it is 100 to 100 50 microns then hydraulic energy used once, then where you can have the solid cone where you can have hollow cone you can had flattened fan nozzles. So, for them the droplet size varying 200 to 400 micron and sometimes greater than 400 microns for some of these.

So, depending upon the requirement of which one you have chosen it will vary from 200 to 400 even it can go beyond that. And the types of droplets what will be the types of droplets if you have the corresponding ones the aerosol this is the mist type you can see that these ones then fine spray you will get in these. Then medium spray because the size has increased here and then coarse spray it has more than 400 micron.

Volume per liter particularly corresponding that you will have a volume per liter see when you have aerosol it is 1 liter per hectare when you have mist type you can have 1 to 3 liters per hectare. And fan spray five about 5 liters per hectare, then when you have see sizes which are about 200 to 400 you can go about to 100 to 200 liter per hectare. Now these will be required, because as per the crop you will have and depending upon the infestation which is already there in the crop you will have to choose this and accordingly then you will have the nozzles.

So, these are given as a guideline which will help you when you are talking of and when you are trying to design or select a particular nozzle. And if it is very coarse spray then you can it can go more than 500 liters per hectare. The uses of course, they are given when it is between 1 and 3 you can see the ultra low volumes applications even up to 5 liter per hectare is a ultra low volume. If you are sometimes people say about9 liters or so, but then quite often you will find that 5 to 7 we will say is within this.

Now, 100 200 and below and above 500 liters per hectare those will be going the aerial application of field crops and herbicide liquid a fertilizers. Now these are some of the things when you are talking of high volume then you need to have different the type of equipment as well as the process by which these are to be given.

So, with this what I wanted to show you is what is the droplet size what are the different what are their numbers and how do you get uniformity, how do achieve uniformity with regard to the their application. When they are taking; when you have taken a particular nozzle you have taken a particular equipment in which the nozzle is fitted. So this will give you an idea about the nozzle type and nozzle details.

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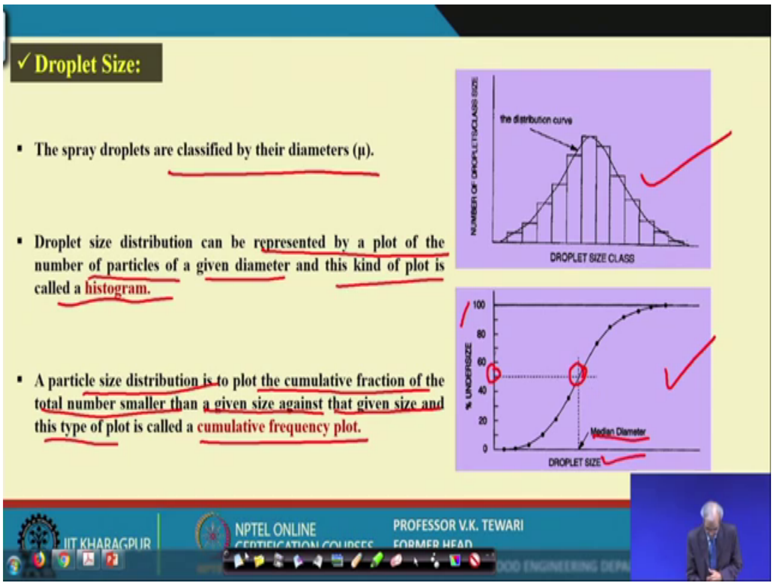

Droplet size now how do you I just said droplet size there, but now when you want to say about this droplet size, how do we class classify these sizes, and what are the different parameters which we talk of as I said about BMD we had given in the previous table.

So now, you see what these are see here the spray droplets are classified by their diameters it is in micron meter. Now a droplet size distribution can be represented by plot of the number of particles of a given diameter and this kind of plot is called histogram yes this is the one here. So, you can see the droplet size class on the basis of this will number of droplet or the class of this on this side.

So, depending on this the droplet size is here and then the class is given on this side. So, what we can show you that this talks, this particular way we represent the class and with the droplet size. Now when we talk of the droplet size with respect to the; I mean percentage of undersize I mean when you were trying to find out what is the particle size distribution?

So, droplet size distribution is one where we can put this class and the droplet size. Now when you are talking a particle size distribution could be a cumulative fraction of the total number of smaller than a given size against that given size. And this type of plot is called cumulative frequency plot this is important, because then you would like to know, what is the exact name that we have given volume medium or mass median diameter and all that.

So, here if you see this plot the second one here the droplet size is given on the abscissa and percent undersize. So, depending on the percent underside is presented on the ordinate and we see here that at somewhere around 50 or so if this is the value here you call median diameter. So, the median diameter of that droplet is here it if you take this value to be 50 then median diameter here is the median diameter. Now, whether it will be volume or mass we will talk of this later.

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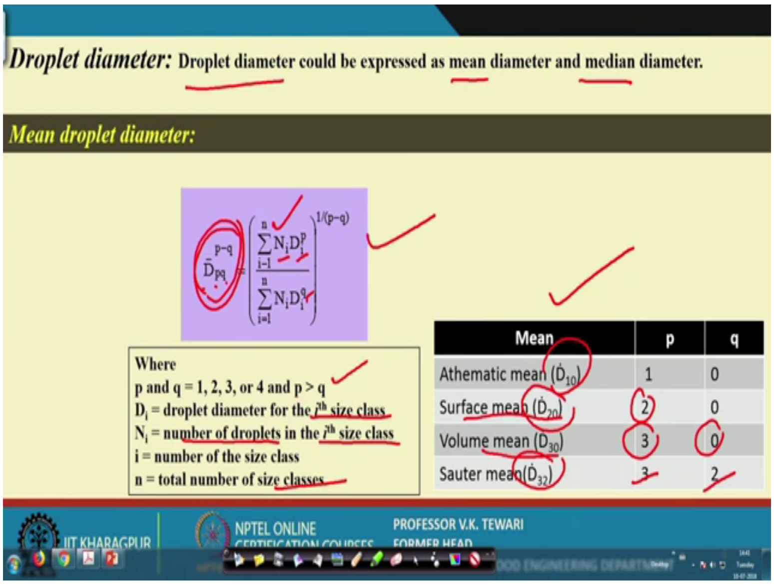

Well, droplet diameter we have talked of this droplet diameter could be expressed in mean diameter and median diameter well, there are various ways which we can do. So, this can be droplet diameter could be as mean diameter or median diameter well I have; we have shown you as to where this median means what does it mean and all that.

So, mean droplet diameter is given by this particular expression this of course, this expression we have taken, because these are the ones which have already been in the literature. And it is worth telling you about what is already available in the literature and you should make use of it when you are looking of representing a particular droplet size.

So, if you talk of this particular see here p and q talk of 1, 2, 3, 4, or p greater than q. Now this talks of the when we are talking of a particular when you have large number of droplets and how do you represent a particular in the diameter of a section or a class of droplets. So, D i talks of droplet of the i h size class so D i talks of droplet size class. Similarly N i talks of number of droplets in the i i-th size class this is what is explained here then i is the number of size classes how many number.

And is the total number of size classes if there N is total number and i talks of the number of the size class. So, if you put this thing together what you get here is N capital N is the number of droplets here multiplied by the diameter which is the diameter droplet of i-th size. So, i-th size class i-th size class diameter and then it has to be taken i minus 1 that 1 to N a which is the class.

Similarly, these talks of i the number of size class here it is number of size class with respect to q where q is more than p. Now these p and q talks of this talk of the well these talk of the numbers I think, we have these talk of the various numbers when we take the droplet size distribution ok. Now here, just have a look at this table the arithmetic mean when you talk of arithmetic mean is represented by D 10 dot D 10 where p is 1 q is 0 and you were talking about metric mean p is 1 q is 0, Similarly surface mean diameter D 20 this is p is 2 q is 0.

Now, how many talk of volume mean diameter D 30 then this is 3 here p is 3 this is 0 when you talk of Sauter mean diameter now this the Sauter mean diameter. So that means, Sauter mean is D 32, where 3 is the p and 2 is q here, because you can see that here we have talked of D pq. So, depending upon what whether we are talking about arithmetic mean surface mean the volume mean or Sauter mean this p this representation is indicated. This is one way of how we talk about the droplet diameter or droplet size or droplet class in which these fall.

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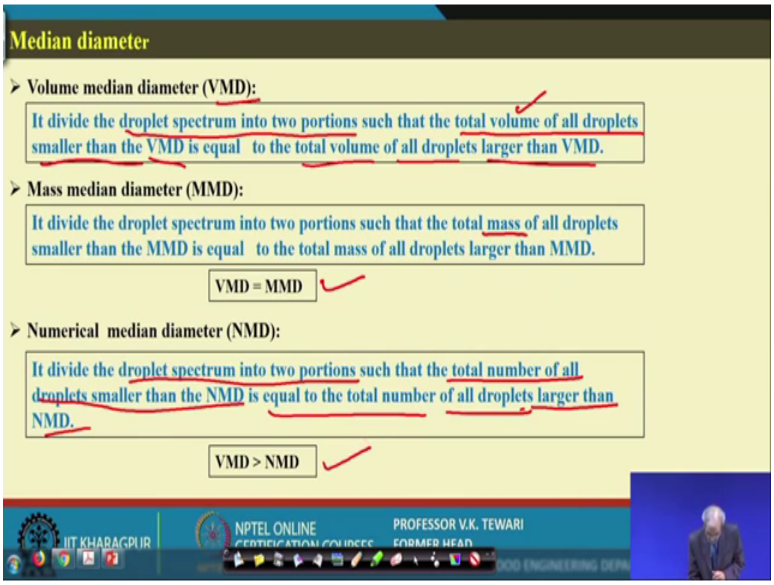

Median diameter: now as I said earlier that in the table it was there a volume median diameter. So, what is this some; these definitions I think you must have clear idea about these definitions that is why I have given you here for your information and you must take cognizance of these, while you are talking with respect to the various representations in your experimentation and your reports when you write about are the report of performance evaluation of a sprayer see.

The volume median diameter volume median diameter VMD what is this; it divide the droplet spectrum into two portions. If you have the droplet deformations in two portion such that the total volume of all the droplets smaller than VMD is equal to the total volume of all droplets larger than VMD that value. So, if VMD has a certain value so if you divide into two parts so the equal number will be on this side on smaller than and the equal number will be on the larger side.

Similarly, mass mean when you talk of this the only difference is that you will be mass of all droplets here it has the total volume of droplets here it is total mass of the droplets, and then at similar definition that us why VMD is equal to MMD. That means: numerically equal you would we can see that they are numerically equal VMD is not that volume is equal to mass no not like that, but numerically VMD is equal to MMD. But one will talk of the total mass value and below that of the smaller ones the number must be equal to that beyond that value.

So, VMD and MMD are virtually numerically equal now numerical median diameter NMD numerical median diameter what is this stocks of when if you divide the droplet spectrum to into two portions. If you again, supposing you have got a large volume of droplets of various classes or whatever when you have applied in the sprayer or the droplets or a chemical onto a certain location or to a certain canopy.

Then, if you divide these droplets two portion such that the total number of all droplets smaller than NMD smaller than NMD is equal to the total number of all droplets larger than NMD. So, numerical median diameter this is what is the value of this where or if you see the definitions all talk that put in two parts and of the value.

If in case of a volume it will talk the number will be equal on both sides. Similarly for mass it will be equal on both sides where it talks of numerical median diameter also it seems similarly. But then the VMD will be greater than NMD here it was VMD was equal to MMD there, but VMD will be greater than NMD here when you consider the numerical mean diameter when we are talking with respect to the classification of the various sizes of the particles which are there.

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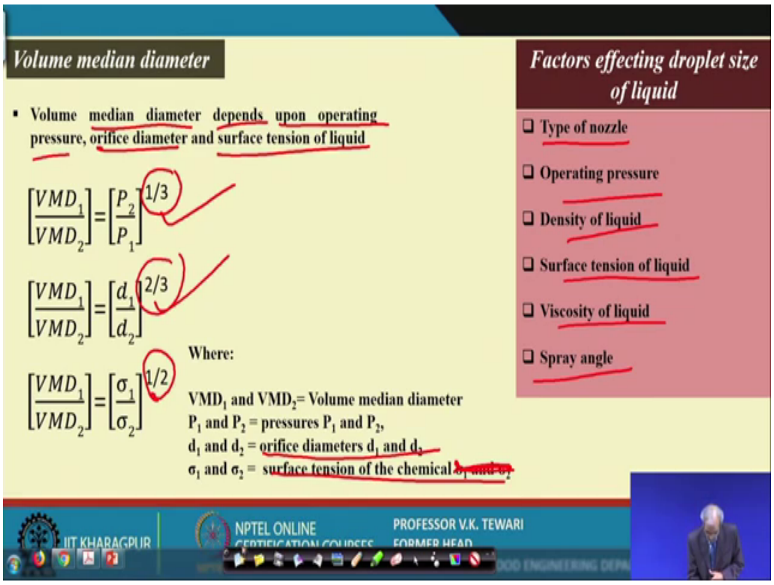

Now, what relationship exists between all these factors? So, let us have a look at these see the factors affecting droplet size of a particular liquid what are the factors affecting. You can have type of the nozzle yes this will definitely talk of the droplet size it will affect the droplet size, operating pressure what pressure has been maintained: yes it will, if the pressure is low then there will be the droplet size will be something a value.

And then when which pressure is very high lot of atomization will take place density of the liquid surface tension of the liquid viscosity of the liquid and the spray angle: yes, when from the nozzle what is the spray angle maintained. So, the droplet size will depend on these factors which are very important factors whenever you want to design a nozzle, when you want to design a spraying system you would have to consider these parameters.

And we have already discussed about what are the various ways by which we can talk about the diameter of the particles diameter of those droplets sizes. Now a relationship is given here, which is worth knowing this the volume median diameter depends upon operating pressure orifice diameter and surface tension of the liquid mark here, that this orifice diameter pressure and the surface tension of the liquid these are very important.

So, the volume median diameter this is given by this straightaway we are talking of value medium volume median diameter 1 by volume medium diameter 2 if you have two then the pressure is this is a rate. That means this VMD is proportional to p. And so if you are talking of two sets of this value then VMD 1 by VMD 2 is nothing but this similarly, VMD 1 by VMD 2 is this where D 1 and D 2 you can are orifice diameters and the orifice diameters of this here we talked of the pressure, here we talk of the orifice diameters.

Now, when we talk of the (Refer Time: 19:52) diameter you see here what is the change which has taken place. It is the power which has change it was one third here now it is two third of that with respect to when you are talking of the orifice size. When you are talking of the surface tension of the chemical sigma 1 and sigma 2 and the surface tension surface tension of the chemical this did not be there.

So, with this the VMD and is related like this under root of this you can say just half so of the power is half. So, with these parameters when you are talking of volume median diameter how this related with the pressure with everything nozzle orifice size and the surface tension of the liquid which is being handled here this is the weight percent.

This will help you when you want to solve the problem when you want to understand better the effect of these parameters surface tension. And the size orifice size etcetera on the total particle size and the total diameter of this. And the pressure etcetera when the when you are encountering with a design of a particular sprayer.

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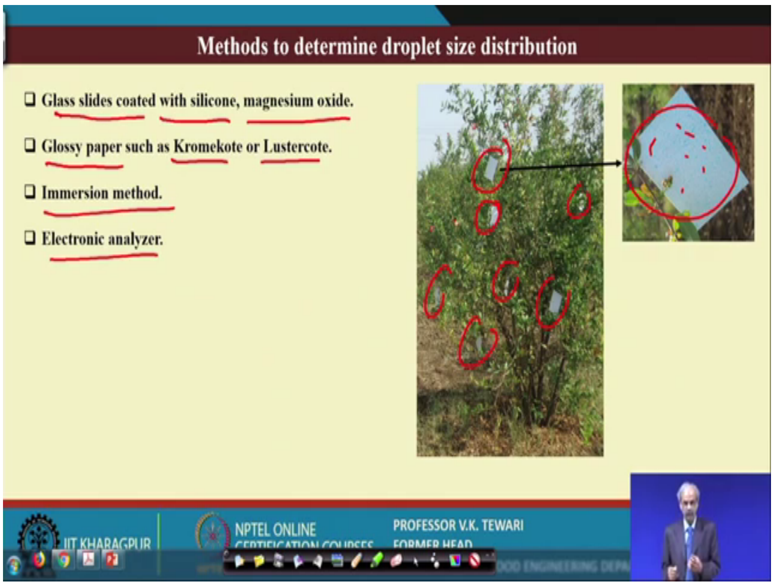

Methods to determine droplet size distribution there are various methods actually how do you determine that we just talked of the droplets their sizes and their representation etcetera. Now when we talk of the methods by which we find out this droplet size distribution suppose spray has taken place on a canopy and how do you find out.

So, there are various methods I just listed those methods you also you can see in literature. And then maybe that some of the materials are very simple way. See if you want to find out how many droplets have fallen on a particular location what you can do is put a paper on that and if the liquid if it is colored you will get these spots and from there you can get.

Now, what are the different measuring well glass slides coated with the silicon magnesium oxide the glossy paper such as this or this paper which is a glossy paper actually. This is the glass slides which are coated with these materials on which are if you put those locations and this free it takes place then you can take those values and you can determine the droplet size.

Then immersion method emerges what is the; a immersion method that is utilize electronic analyzer these another way of finding out droplet size. Actually by seeing as to what are the different sizes and electronically you can find the value of the droplet size. Various methods, various sophisticated equipment are available to find out this droplet size this is one practical which you can put on the; as you can see that we have put here you can see that the droplets are here.

All the droplets are seen here you can see this and these are at different locations have been kept. In fact, a field demonstration in which we wanted to measure this. And that is why we have shown you here for practical understanding of this aspect of droplet size distribution.

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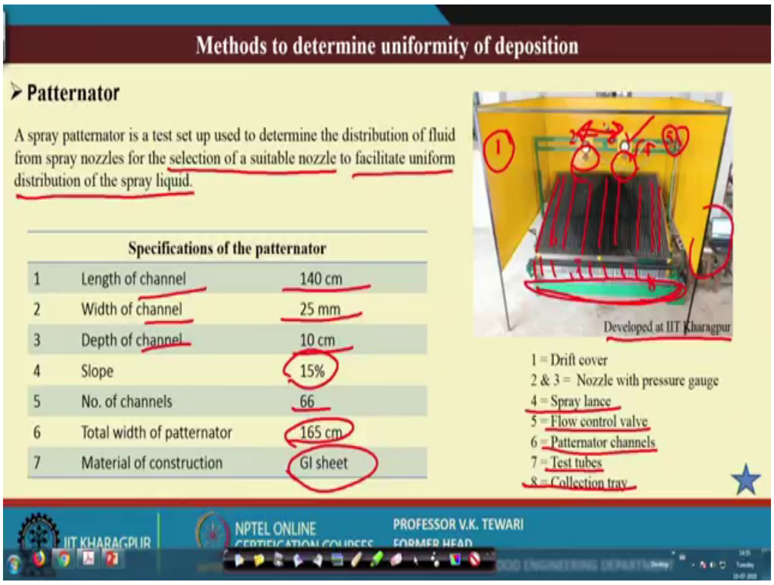

Methods to determine uniformity of deposition this is important actually once you have talked of all this must know what is the method by which we see that distribution is uniform or not. The one which is very widely used is using a particular equipment which is known as patternator.

So, this patternator we have made at IIT Kharagpur and I can show you what are details of this is the one which is very widely used with other its other adding gadgets etcetera which are kept on that and attached to this and you can very easily determined this uniformity of deposition. For example here the drift there is a cover here, so there is no drift which takes place we have the nozzles you can see there is one nozzle here another nozzle here.

These are the nozzles and then that with pressure gauges where you can find out what is the pressure. Then the spray lance four is the spray lance you can see here this is the spray lance this is the one which is connected. So, this is the one flow control valve fifth is a flow control valve here this is the flow control valve you have to have flow control valve patternator channels.

Now, these are the channels which would see these are the channels here where the when the liquid falls this will come here. And then that liquid test tubes are you can see here their several number of test tubes are put here, and then the on just at the base of the channels. So, this will all get collected inside this, you can take it and then see whether what is the level of uniformity when you are considering this total length of this is the collection tray. So, you have this collection tray to full measure the total volume which has come. So, we using this which is developed at IIT Kharagpur. In fact, this facility is there with us and then we are in a position to use the sprayers you having other details of how much we can give the power etcetera from the pump.

And then do this exercise under the laboratory conditions and we can measure you can see here the specific dimensions of these are worth knowing, because suppose you want to make a petternator at your location to do this a study to understand that. So, you we have here length of the channel about 140 centimeters width of the channel, about 25 millimeter depth of the channel, 10 centimeter slope about 15 percent slope because the liquid has to fall here.

The liquid has to fall here then the number of channels what is the number of channel that you have kept actually when you are talking of distribution you have to have a large number of channels then only you can know what is the spread in which the whole chemical is falling and how much you are getting. So, all this will fold flow down and get collected into the tubes, and ultimately it will fall into this total width of the patternator maybe 1 65 centimeters. So, this is the total width this will talk of that what is the swath that you will have if you have nozzles here.

Now, what are the changes material of construction where GI sheet has been this is one material of construction which is given here. But this can be used for selection of a suitable nozzle to facilitate uniform distribution of the spray liquid from the type you want. See what are the things what changes you can make in this for example, if you want that we would like to see how about the spray angle. So, when you change this you can change this and say what is the spray angle when you want to see the spacing of the nozzles.

So, you can increase this spacing which is given over here you can increase the spacing and see how much is the distribution you can that means, you can change the height you can change the angle and you can change the spray angle, you can also change the types of nozzles. Suppose you have different nozzles you can put those different nozzles and then you can see the distribution and can compare the distribution.

So, you by this particular device you could be in a position to actually understand. What will be the pattern, what will be the size of the droplets, what is the pressure which should be there which type of nozzle is better what spacing I should maintain what the spray angle I should maintain. And all details and how much will be the total swath if I maintain this or what should the optimum value of number of nozzles in a particular swath area when you are designing with this.

So, this particular patternator had been in use for long time and this is a very standard and very easy tool to measure this is the uniformity of deposition what is the uniformity. And we have all talked of the other parameters when we talked of the how to categorize the diameter of the droplets what should be the pressure, how the various diameter (Refer Time: 28:21) various diameters are related to the other parameters in which connection and all that we have discussed.

So, that way I think we have discussed about the performance of a sprayer we have not talked about the pump as such. Particularly I have not I have particularly avoided that because if you talk of the pump we have discussed much detail earlier. And that is why identify and better just to talk with respect to pump when we are talking of the performance of a sprayer.

When you talk of the sprayer does require a pump, but since we have product of the details of the pump etcetera. So, I avoided that and the other thing is that the nozzles which are the most important, the spacing of the nozzles, type of the nozzles, their distribution pattern, their other diameters their distribution and all sorts of things which are required you I have discussed in this.

And I think then I have conveyed what I wanted to say by performance evaluation of a sprayer. Well, we will welcome your questions as in when they require. And, I think this is we will try to close here.

Thank you very much.