Micro Irrigation Engineering
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Lecture - 34
Demonstration of Drip Irrigation Components and Evaluation of Drip Emitter

Hello, participants. Welcome to Lecture 34 of Micro Irrigation Engineering subject. Lecture 34 is on demonstration of irrigation components and evaluation of drip emitters. In the previous lecture, we discussed about different components. We discussed about the performance, how they work theoretically, and then we discussed about the fertigation unit. We discussed about different types of filters.

How to install all these units in the field and then, how to maintain them? Now, having installed it in the field, we need to know whether my drip system is working satisfactorily. So, evaluation is a very important component of the micro irrigation system whether they are functioning in the field or second part when the set of drippers after the manufacturing, they should be collected and tested in the laboratory condition before they are installed in the field.

This way also we can understand that whether they are really effective. So, random samples of 25 from the lot should be collected, and then their performance should be evaluated in the laboratory condition. So, here in this particular lecture, we are discussing the demonstration of these components. And then what are the different parameters through which the performance evaluation of drip emitters can be done.

So, when we talk of the drip irrigation components, we already have discussed but I am just refreshing you that the drip irrigation system consists of a control head unit and distribution network. So, the control head unit involves a pump, or overhead tank if it is a small area of a few 100 square meter, then the overhead tank is sufficient and because the number of drippers and the size of the irrigation plot will be small. So, accordingly, the overhead tank can be used. Overhead tank or pump is used to provide adequate pressure head in the pipeline so that the water can easily flow through the drip emission devices. Then, the bypass system is also one of the components when the water in excess is being pumped by the pump. Then the part of this water can be diverted so that an adequate quantity of water can go to the system.

Then, fertilizer or chemical injection unit, as the name it says that it is the applicator. So, this device is used to apply fertilizer or chemicals, or nutrients along with the irrigation water. A pressure gauge is used to monitor the pressure in the pipeline. And then sand filter, screen filter, and then gate valve, these are the other devices which are put up under the control head unit.

Then, under the distribution network, as the name says that distribution means water distribution. So, by using the pipe sizes, these pipe sizes are of different sizes. And when we say the large pipe diameter that is the main pipeline and then this is the characteristic. Normally, these are of you know when the area is very large then the large-diameter pipeline will is used or if it is a smaller area 50 millimeter is the size. And then depending on the size of the pipeline and also the amount of water it is handling then it should withstand the pressure range. That is from 4 to 6 kg per square centimeter. Sub-main pipeline receives water from the main pipeline and this size ranges from 1 and a half-inch to 3 inch in size. And then it should withstand the pressure range of 2 to 5 kg per square centimeter.

Then ball valve, flush valve, and other devices which are used to regulate the flow or remove the dirt deposited in the pipeline by using the flush valve. And lateral pipeline, it is you know these are also of different sizes. In fact, this could be 10 millimeter, 12 millimeter, 16 millimeter, 20 millimeter, these are in those different sizes. These pipelines are made up of low-density polyethylene or linear low-density polyethylene. This is the plastic material that is used for manufacturing the lateral pipeline. Emission devices are attached with the lateral pipeline and depending upon the requirement a particular type of emission device such as a dripper, micro-sprinkler, micro jet, these are of different discharges are used as per the requirement.

The control head unit of drip irrigation is being shown over here. Water is taken from a deep tube well. In this tube deep tube well, a submersible pump is attached over there. So, in this submersible pump, this is the delivery end of the pump. Then water is being taken into the system. Now, the water will come. So, this particular unit, where the water is being raised by using an elbow. So, this is the supply end. And at the supply end, you see this place is the pressure gauge. This is the inlet end of the gravel filter where at the inlet end we have to attach one pressure gauge. And in this particular sand filter, sand is of different grades have been filled in. So, water passes from this filter it goes to the layer, and then at the downstream end, you can see this is the outlet end of the sand filter.

So, water passes through this particular material. And then filtered water enters the system. Then it comes to this end. So, these 2 ends, one is the inlet end pressure gauge are attached. At this end, a pressure gauge is attached. The difference in the pressure head gives that how much is the pressure difference it has caused whether sand is blocked by the impurities available in the water. Then it comes to this is the gate valve where we can regulate the flow. And then this part is having a Venturi injector. This Venturi injector is for injecting the chemical nutrient or fertilizer which is soluble in water is supplied to the system. Then we come to this is a screen filter. So, water will pass through the screen filter. Then it goes to the pipeline and then here there is an arrangement where one can measure what is the volume of water it is passing through this particular pipeline.

So, in a given time, the volume of water that passes is measured. So, here there is a counter one can see. See, in this counter, there are different graduation which has been made, where it can be monitored. And then the water goes to the main pipeline. From this place onwards, the water is supplied to the field where the network of the sub-main pipeline and lateral pipelines are attached. I am going to present here a performance evaluation of drip emitters. When the drips emitters are being manufactured, so, from the lot as I just told you that the randomly from the lot the samples are collected. And these samples could be the order of 10 to 25 in numbers. And then by using a test bench, their performance is evaluated.

So, here in our laboratory condition, we have made our own hydraulic test bench. It is of course very small in size 3 meter long. And in this test bench, a 3 meter long lateral pipeline is attached. And then there is a provision in this test bench that one can change the slope. So, a slope can be made up the hill or down the hill. So, here provision is there that we can change slope up to, this is 3 meter long. So, there is a 30 centimeter drop. So, 10 percent slope means we can vary the slope 2.5 percent or 2 percent, 4 percent, 6 like this you know 6 percent, 8 percent, and 10 percent. And then see whether how much discharge variation takes place through the drip emitters for the different places. So, water is supplied from the inlet by using the pump. And then the water is supplied in the lateral pipeline from the upstream end or inlet end.

And then adequate pressure, required pressure because we want to establish some certain relationship. So, pressure is created. So, this pressure could be in the order of 0.2, 0.4, 0.5, 0.6, 0.8 means how these drippers they are performing at different pressure. Of course, the ideal pressure to operate these is 1 kg per square centimeter. But there could be different situations where that much pressure may not be available or pressure is available at a higher rate.

Then one can use these pressures and know that how much the discharge variation takes place by changing the pressure, due to a change in the pressure head. And normally, pressure compensating drippers, these types of drippers they are rarely used means majority of the drippers are non-pressure compensating type, they are attached with the lateral pipeline. And then for different pressures or changed pressure means for a given slope the observation is taken. Then we will change the slope and then take the discharge values. So, the discharge value is calculated by taking the volume of water for a given time. So, discharge is calculated.

So, this is a hydraulic test bench that you see here. The pipeline in which, the lateral pipe is attached. And in the lateral pipe, these are the drippers that have been shown in the figure. Then the water is being collected by measuring cylinder and then the volume of water which is collected in a given time. So, discharge is estimated. So, here there is a provision that you can change the position. We can change the position of the lateral line. And when we are changing the position say we are bringing here and this is the position. So, this will be when the water is being supplied from one end. So, water will go from this end to the other end. So, it will be up the slope. Or, you are keeping it here. And then bringing this particular downstream end of the pipeline to this position. So, that it was the up the slope and this is the down the slope. And then discharge values are estimated.

So, there when we want to evaluate drip emitters. So, this evaluation is done by using certain parameters. So, one of the parameters is manufacturing characteristics. This means, when the drippers are manufactured, there can be a heating process. And then the polymer means material. So, there could be because of the heat or difference in the temperature there could be malfunctioning of some certain component. And you may find that some of the drippers are not falling in the same correct category. So, here it is based on the discharge estimated. And from the given discharge, we find out the coefficient of discharge. So, the coefficient of discharge is known as the manufacturing coefficient of variation. This means the coefficient of variation is estimated as the standard deviation divided by the average flow rate.

Now, having got the value of Cv, so, American Society of Agricultural Engineers in 1989, they have recommended that if it is a point source type of dripper and then the coefficient of variation is falling less than 0.05, it is considered as excellent. In the case of line source dripper, if it is less than 0.1, it is good. Like this you know excellent, average, marginal or poor, or unacceptable. So, if the Cvm value, is too low or it is a very high value that let us say greater than 0.15. It means these drippers will have too much variation. And the basic purpose of using the drip system will be defeated. So, one should reject the lot, that particular lot of the drippers which have been manufactured. This should be rejected. And it should not be used for the system. That is the way. That is the reason for estimating the manufacturing coefficient of variations.

Then there are other parameters are operational characteristics. Operational characteristics mean, basically it is giving that how uniform water is being delivered by the set of drippers. So, the drippers which were connected in the lateral pipeline in the hydraulic test bench, the data are being collected. And from that data, emission uniformity is one of the parameters, it is estimated. So, the emission uniformity, EU is given by

$$= q_n / q_a \times 100$$

Where q_n is the average of the lowest one-fourth of the emitter flow rate and then q_a is the average flow rate. So, let us say that suppose we have got 24 number of drippers so, one-fourth means all 24 data will be arranged either in descending or ascending order of the magnitude.

So, if suppose, it is a descending order of the magnitude so, the last 6 dripper discharges will be used for calculating the emission uniformity. So, the last 6 means one-fourth will be 6 drippers. So, the last 6 mean that is the lower order. So, an average of these last 6 dripper that is q_n. And q_a is the average of 24 number of drippers. That will be the average flow rate. And then this value will be used to calculate the emission uniformity. Absolute uniformity is another parameter. Here it is given as

$$= \frac{1}{2} [(q_n / q_a) + (q_a / q_x)]$$

Where q_x is the average of the highest one-eighth of the emitter flow rate. So, I was telling you about 24 number of drippers. So, in the case of one eighth become 3 drippers, so, from the top 24 drippers, discharges will be used to find out the average of the highest one-eighth of the flow rate.

And then that is the q_x. And remaining values will be the same as that is q_n by q_a. And then already we know qa that is the average of 24 number of drippers. And then we will find out the absolute emission uniformity. This absolute uniform as the name it is given that it is the value which will be giving us that how the variation is taken. Then percentage difference, that someone wants to know that how much variation is the discharge takes place. So,

$$= \{(Q_r – Q_a) / Q_r\} \times 100$$

Where Qr is the nominal flow rate. So, the nominal flow rate is the discharge of the design as specified by the manufacturers. Say, it is 8 liter per hour dripper. So, this Qr is say 8 liter per hour, and then the average value of 24 number of dripper divided by the nominal flow rate. That is 8 liter per hour multiplied by 100. So, if we are taking 8 liter per hour drippers from there, you are finding out, how much is the percentage variation it is there? That way it will be obtained by using.

Then another parameter of evaluation is hydraulic characteristics. So, the hydraulic characteristic is evaluated by using the flow rate. That is Q equal to the coefficient of discharge multiplied by the operating pressure to the power exponent x. Now, exponent x value which we will get by using because you are monitoring the discharges for the different operating pressures. So, Q is known to us.

Means, suppose there are, as I told, there is 24 number of drippers. So, there will be 24 Qs from the 24 operating pressures. So, from those values, you will be getting the value of the coefficient of discharge. And then means you will plot the data. And then you will get the value of x. So, x is obtained by plotting these data either in the log-log sheet or you are using a set of equations to find out the value of Cd and x and then x defines what type of emitter it is? What is the type of emitter and under which flow regime it is there? So, these are the parameters. Suppose, when we say the x equal to 0, x equal to 0 means Q equal to Cd. It is simply Q equal to Cd means irrespective of any change in the pressure, discharge remains the same. So, such drippers are categorized as pressure compensating drippers.

Such drippers are means characterized as pressure compensating drippers. Now, if x is equal to 1, this is another extreme case. When x is equal to 1, such drippers are known as the fully laminar flow. And then this is a capillary. Means, the water is coming from the capillary tube or diameter means the flow there is not much resistance to flow which takes place. And then if it is a 0.9, so, this is mostly laminar and then microtube is the case that water is flowing there. So, there are different you know cases. Normally, you will find that the majority of the drip emitters fall under the orifice or tortuous path type of dripper or long or a spiral path of drippers.

So, you will be getting the set of data. And from those data, you are getting the value say here data that we are collecting discharges from the given pressure. Say this is the one particular slope. Then this is the second means for this slope, for the different operating pressures, what are the values of the discharges? Then the second slope, when we have changed the slope, then you are again collecting and then like this, from this, for a given slope, you are establishing the relationship between flow rate and the operating pressure. And then you plot these data on the log-log paper, it should follow a straight line.

Then we will evaluate from those data, the results. So, result, we will get a coefficient of variation, which we called as a manufacturing coefficient of variation. We will establish the relationship between flow and discharge. So, this equation will be established. We will find out emission uniformity, absolute emission uniformity in percentage. And then you will interpret the results from the table which already I have given you. So, this particular thing means, we are showing you how the data are being collected from the hydraulic test bench. And then these data will be analyzed for these parameters from the given set of theoretical formulae which I have explained to you.

This is a hydraulic test bench for the evaluation of drip emitters. This hydraulic test bench is meant for finding out the emission uniformity of drip emitters. So, a pump is used to collect water from the source. Then the water comes through a set of drip irrigation filters. Then it goes to the main pipeline. From the main pipeline, it goes to the sub-main and lateral pipeline.

In this particular laboratory experiment, we have kept in the lab where you can see the water is taken from this source. So, this is a collection tank which is a sump. And in this sump, water is stored. And then the water is pumped. So, this is the suction end of the pump. This side is the delivery end of the pump. And this pump is coupled with a small motor. Then the water is being pumped. It comes to this delivery end of the pump. And then it goes to the lateral pipeline. So, in this lateral pipeline, this is a lateral pipeline. We have attached drip emitters. There are 10 number of drip emitters that are spaced at 30 centimeter spacing. We will evaluate the performance of these drip emitters. Now performance, means that we want to see how the water is getting distributed. Or, it is passing when some amount of water is getting distributed in all these drippers.

So, how uniform this water is being distributed, we will take the observations in a given time of water dispensing out of these emitters. So, water will be collected with the help of these graduated flasks where you can see here each graduated flask is of 250 milliliter. So, for a given time, the amount of water which is collected in the collecting flask and then we will find out how much discharge it is coming out of the drippers. So, one part is to find out the uniformity. So, in the theory class, we have explained to you different types of emission uniformity. What happened when these drippers are being manufactured, there could be some manufacturing defect. So, there we can also find out the manufacturing coefficient of variation. So, we will evaluate the data collected from this. Then this is a very important aspect that to classify the dripper under which category it passes through.

So, we will be evaluating the pressure discharge relationship. So, this test bench has a provision where we are using a pressure gauge that how much pressure is available at the supply end of the lateral. That is at the inlet end of the lateral. Now, in this test bench, one can change the slope. This means, when the laterals are to be laid up the hill or laterals are coming down the hill. So, in this case, up to 10 percent means this if you see here this slot is made so that we can change the slope. So, when we will bring it down, it means the lateral will go up the hill. So, up to 10 percent, this particular, you know it is of 30 centimeter. This fall is there, fall in the slope. And then the other end also if you see here, this end also, there is a provision. So, if I put it on the top and then bring the lateral position at this place that is 30 centimeter down.

So, we can have the gradual variation in the slope which normally exists in the field that lateral is placed up the slope or down the slope. So, the effect of the slope on the discharge and pressure relationship also varies. And how much is the head available at the drip emitter, accordingly the discharge will be coming out of this. So, we are now going to start the test of the data which will be collected from these drippers.

The operating pressure to supply water in the drip lateral is 1 kg per square centimeter which is equivalent to 10 meter of the water column. We start. 9 ml of water has been collected from the dripper. When we will collect a set of these data, from these data, we will find out the coefficient of discharge and exponent x.

Now, data which were collected say for 1 kg per square centimeter, the time of observation was 1 minute and then we have got data say there were 10 drippers. And then for these 10 drippers, the observations were taken. And these observations were again repeated in order to get this. So, we repeated it 3 times. So, the volume of water collected from the 10 number of drip emitters was collected for 1 minute at the pressure of 1 kg per square centimeter.

Then the pressure was reduced. And then again, 3 sets of observations means 3 time it was repeated for these drippers. So, this is for another pressure. The data were obtained. Then again you know, when the discharge, this means your pressure was reduced to 0.5 kg per square centimeter. Then the volume of water collected from 10 drippers, were collected. And then, what we will do? We will find out the different parameters which are needed. So, say just I am, for example, we calculated because it was for 1 minute so, we calculated the value of discharge. So, discharge says what it is shown as 7.5 liter per hour. So, the average value from the 3 sets of observations, no for one particular observation it is being shown. So, this was 125 ml in 1 minute. So, we converted to the liter per hour. So, liter per hour, it is coming 7.5 liter per hour.

Like this, you know for all the 10 observations, data we collect, we estimated. And then similarly for the second set of observations. This is for the third set of observations. Then average values of the discharges from this 10 number of drippers at 1 kg per square centimeter were obtained. So, this average qa was estimated. And this particular value is what you are seeing here that is 7.994 liter per hour is the average value.

Similarly, the manufacturing coefficient, the formula if you remember it is given by standard deviation by the mean. So, we calculated the standard deviation. It is a simple formula xi minus x bar. That is x bar is nothing but q average and then divided by n minus 1. And then whole this summation of this value and then taking the square root of this that gives the value of standard deviation.

So, the standard deviation we obtained was 0.2438 liter per hour and then the average was 7.994. So, we got Cvm equal to 0.031. We will characterize these, this particular emitter under which category it falls at later part. Now, coming to operational characteristics when we were finding out so, first we are required to know what is the average lowest one fourth. So, here only 10 numbers of drippers were there.

So, we are taking 3 numbers of observations and then from there, 3 observations which are the lower lowest one-third. So, we are getting the value as the average of lowest one-fourth is 7.72 liter per hour. And then if you remember for getting the absolute uniformity, we are getting one eighth. So, here one-eighth of the dripper, we have got only one dripper which is of the highest in the order that is 8.3 liter per hour.

So, emission uniformity is given by the ratio of the lowest one-fourth to the average value. So, lowest one-fourth, we estimated as 7.72 divided by 7.994. This gives the value of 96.57 emission uniformity is a very high value. It is a very good acceptable range. Absolute emission uniformity, so, this already we got the qn. We know that this is the value same value. This is qn by qa.

So, 7.72 the then this part that is 7.994 is the average value. And then this is the average divided by the highest one eighth. So, this is your only one observation that is 8.3. So, we got 0.9644 or 96.44 percent is the absolute emission uniformity. And then the percentage difference or deviations, percent deviation when it is being calculated. So, the percentage deviation is estimated that is the Qr minus Qa. So, we take here the absolute value. This is the nominal flow rate of the dripper is 8 liter per hour. And this is the average flow rate divided by the nominal flow rate. So, this is coming percentage value is 0.075 percent so, very low value.

Similarly, for other discharges, you know for your 0.7 kg per square centimeter we have calculated. Similarly, for 0.5 kg per square centimeter, these values have been estimated. And then we are getting the hydraulic characteristics. So, hydraulic characteristics, if you remember the discharge Q is related with the operating pressure H to the power x. So, we have been given the pressure head means discharge versus the operating head. So, this particular graph in fact discharge is dependent on the operating pressure head. What we will do? We will plot the graph.

And then we will find out that what kind of relationship it is there. Or, simply taking the observation between the H versus x and from there the when we plot it on the log-log paper this value x is coming at 0.8063. And the coefficient of discharge is 1.25. So, the equation Q, as I told you, that it is a function of operating pressure. So,

$$Q = C_d H^x = \mathbf{1.25(\mathit{H})^{0.806}}$$

This is the equation. Now, by looking at this equation as well as from these data, one can interpret. That the coefficient, this is the result, that manufacturing coefficient of variation Cvm is 0.031. So, if you look at the American Society of Agricultural Engineers that table they have given. That table which, already I have shown you that this particular type of dripper is a point source dripper. And the value is 0.031. It is less than 0.05. So, this falls under the category of excellent.

Then the flow rate versus this part, when we are seeing that flow rate Q and this establishes the relationship. This one we got. And this is by looking at the value of Cd as well as the value of x. So, that means the flow regime is mostly turbulent. And the dripper is falling under the long path drip emitter so that this is another category based on the value of x, which we are getting.

Then the emission uniformity is because the emitter is performing under the excellent category. So, emission uniformity is of very high order that is 96.57 percent. And then the absolute emission uniformity is 96.44 percent. So, if we look at the American Society of Agricultural Engineers 1989 recommendations, they say the emission uniformity of point source emitter and this particular emitter which we used in our case.

This is 30 centimeter spacing. They are giving for less than 2 meter category spacing and then uniform slope. So, here this was under the uniform slope. That is a zero slope category. We got this value. So, these types of drippers can be recommended for use in the field.

So, these are the references. And then we can summarize that we demonstrated to you the different irrigation system components. We evaluated the performance of drip emitters. And then in the forthcoming lecture, we will discuss about soil water movement under drip emitter. Thank you very much.