Lecture – 13
Digital Textile Printing
Inkjet Technologies

So, last time we started some discussion on a new method, of printing which is inkjet, printing and so, we'll, continue with that for a few more hours. So, in summary we try to talk about

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what is the place currently, of digital printing how, do we differentiate between digital printing and analog printing? Difference between the spot colors and the process colors and Some of the very basic steps, which are used in digital printing and we realized that for various reasons, we may require, pre and post-treatment, in this, digital printing method also, because the chemistry, of the fiber and the chemistry of the dyes, have to be matched. So, we continue further and now, we say inkjet technologies. Now, digitalis one word which means that you are sending signals, pulsating manner, either there is Something or there is nothing. So, 0 and 1, that is the kind of information if you keep giving that's the digital part of it. But, inkjet is the one which we have seen, has been commercialized, the other way of printing paper for that matter is the color laser jet printer. But, color LaserJet for textile, is not there. So, we are looking only at inkjet, ink jet means there is a Solution, of a dye, it may have Some viscosity modifiers and it's called, 'Ink' because the viscosity is less and so, you put it out, of Some jet and then goes to the textiles. So, exit printers for the, paper are pretty well established and the basic principle still remains the same, the only thing that may change, is because now, you're not dealing with the material which is very smooth, that is unrelated surface is not. So, smooth the material may be very wide and expectations from the ink may be very different.

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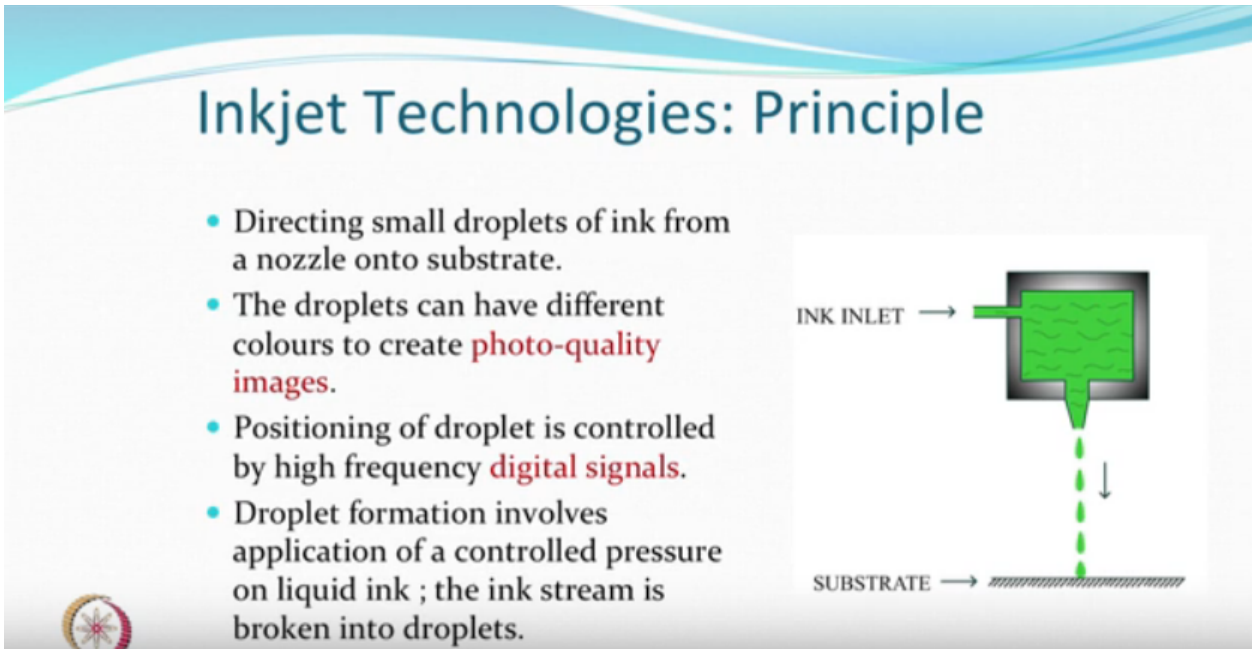

So, in principle what you're looking at you are supposed to create droplets and throw it, onto the substrate which is in our case textiles. So, droplets can have different colors to create, photo quality image. Now, the position of the droplet has to be controlled, possibly at a very, high frequency because large, number of droplets have to be produced in a very, short period of time. So, when we talk about frequency we're really talking about, high frequency. So, all that information has to be, sent through various transducers, to the jetting, area and the nozzle and then, there has to be a mechanism of continuous feeding, breaking, the jet into droplets and then we hope, that there is an affinity, to the substrate and there is a process, post printing, which can ensure, that there is a fixation or whatever drops that have come. So, one thing which is very clear is, we are looking at drops.

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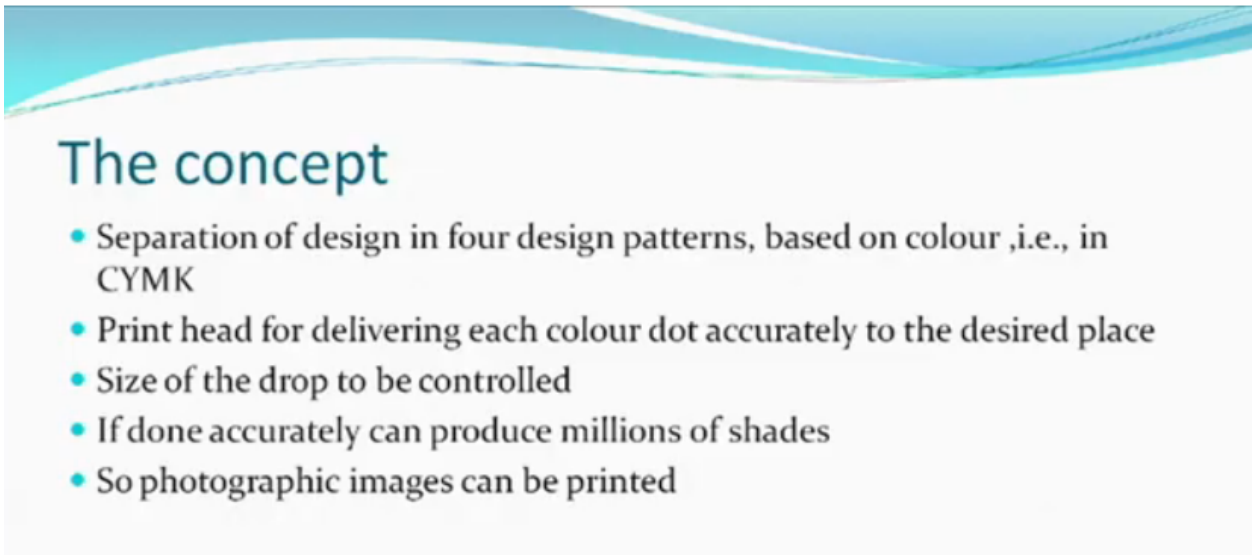

So, general concept is any design which obviously is colorful design, has to be separated, like you had a normal design an eighth color design so, you had to separate, them into eight, type of let's say tracings. So, that one tracing is for one color and so, you have so many, screams or Sony rollers and so, you push only one color, through one and then superimpose, the other that was the way; it was done in the commercial printing. In this case also, maybe through a computerized way; you will still have to separate, the design in two colors that is one design based on one type of a color and the other design based on the other type of color and all, of them when they get superimposed, then you get the final picture. So, at least there are four colors, that we are looking at and so, they must at least be divided into four different patterns. So, if a different yellow or a different green is there, that means there are different combinations of these dots, are present and so, remembering the previous one that the dots, are not put one over the other, they are put side by side and so, where the drop has to come, Some information has to be gathered and how do you, gather the information unless and until you separate. So, therefore the there's a huge, role of a Software which understands color, divides also, into that's areas, then within the area, it also finds between the four, how much percentage of each one of them, is there, then you decide as to where you're going to be throwing, the drop of which color where, so this is the first step which has to be done and which is done, only then rest of the information can come, because we are not mixing, colors before. So, every color is a separate entity and that separate entity must, be directed to a certain point, only then finally you will see. So there is Something called a, 'Print Head' which has nozzles, where the required amount of color would be present, Some signals have to come and you have to control the drop size also, if the drop size is very, large very, large then your eye can see different dots, on the fabric. So, they must be of such, small area. So, that you cannot the eye, cannot resolve them should not be able to resolve. So, you have to, have small size and that is also, understood in terms of resolution. So, when you have large, number of drops in a smaller area, than you obviously are able to produce a finer, print and you call it, 'Better Resolution'. So, when you say higher pixel, density means better resolution of every detail that is there in a picture. So, that has to be controlled. So, if done accurately, millions of shades can be produced. Now, you are not concerned, about how to mix, but because you are not concerned and if you can actually, ensure that the drop size is very small, it can be put, in a very small area, without a bear getting superimposed only the image, appears to be a superimposed image and not the drop. So, colors remain as

thing and so, photographic image can be produced, whether you want to produce a photographic image through Inkjet, it is your choice, you may like to print the normal design, with a no Inkjet printing, issues at all but, if this possibility is available, which was available in the paper printing technology. So, the same thing can be done on textiles also.

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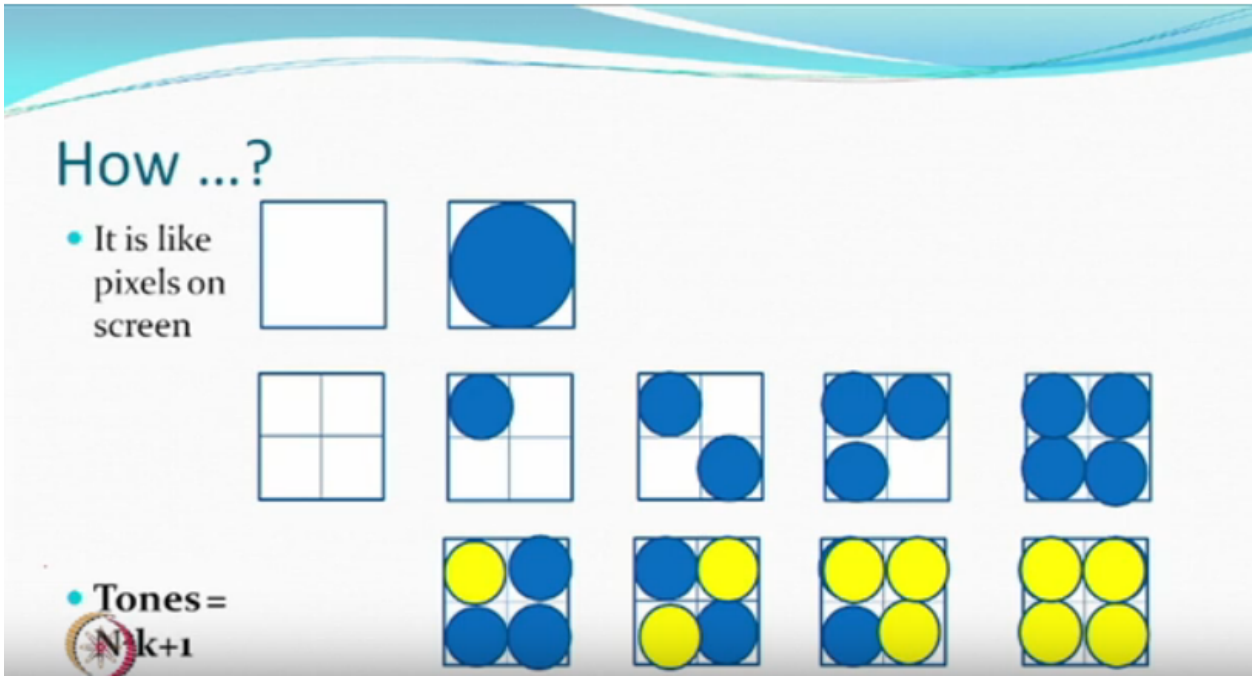

So, like you have on a computer screen or an LCD projector, the pixels the surface of a textile also, in a way, has to be divided, in the same manner and one can consider this area, the drop as a pixel, maybe on this screen you may have, fill very large number of pixels, in a textile you may not be able to create, that's kind of a resolution. But, you still have to do the use the same principle within the, if you have single color also, you can create many shades, again based on the resolution, what is the area in question and how much, smaller droplet that you can make, here this says the number of terms with single color, can be defined or can be calculated, if n is the matrix, like you have a 2 by 2 matrix, your four by four matrix, sixteen by sixteen matrix, eight by eight matrix. So, area can be divided into matrices. So, that is your N and K, is the shade or a color, the one or two or three or four and then plus 1, one means just a white, you have added nothing that's also, a shade. Right? So, let us say, we have one by one matrix and we have one shade only or a one color. So, if you look at n square it is 1 by 1, into 1plus 1 is. 2 So, that's the maximum thing they can do. But, if you divide the same area into 4 which can be considered a 2by 2, then you have 5, same area, because you have been able to reduce the size of the droplet and if you, have instead of one color at the moment white is not considered the white is giving one. But, if you have more than one, then

you can create 9, because you have two colored or two shades, a black could be, black and a gray and gray means what? Gray also, means that less amount of black, white was already there. So, if you can create different shades with the same color, because of resolution, then automatically shades keep increasing. That is what basically is the principle that is used.

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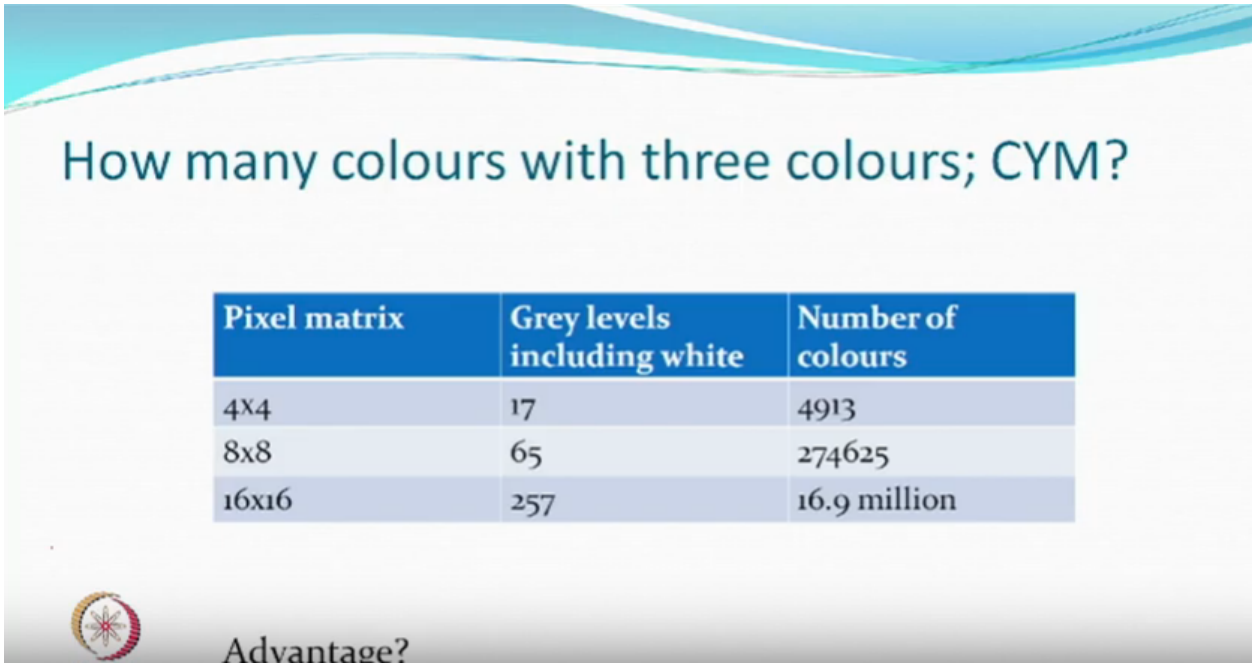

So, theoretically if you have 4x4 matrix, the gray levels in a 4x4will be 17 and if you have only three colors and not taking black also, which itself is a color you can still produce number of perceptive colors as to almost5000, you get into the 8x8 matrix, you have gray for each color it can be 65,because you can put, one dot here, there the daughter bring various kind of thing can do, because you are now, resolving the same area, higher matrix means you are going to be making the size of the droplet, smaller if you make droplet size smaller within the same area then, you can create 8x8 matrix, can create 65shades and if you use all the three colors, you will be Somewhere around 2lakh, 74,000 plus and if you have 16 by,16 you're looking at millions. So, as a principal you can create any type of shade, as long as you know? Where to place the droplet, which is not easy because, you can't see, it while it is happening and so, the controls are much more,, the Sophistication level, at the machine and electronics is much more complex and therefore the cost of the machine has been very high and that is one of the reasons, why it did not become. So, popular while knowing that this actually, is the best technology you can do anything and so, but anything also as a limitation you know? Anything also, the limitation then you will not do, a discharge printing here you will not do a resist printing here but, you will be doing direct printing. So, if you are doing a light color shade and you think everything else, on top can be visible then it's fine if you're absolutely dark colored background then as I mentioned last time you will have to create a white printing

therefore when you talk about four colors now you can actually talk about five colors minimum the white may also be a color which will also have to go and create a ground on a very dark background and then you just directly print everything should be. Okay? It was alight color you print directly with the white anyway you print directly. So, the advantage of this Lee is that you can print anything in a photographic manner these days if you go some of the dress material for example are available in the market and they are called digitally printed. So, one advantage could be you may not have a repeat at all every time you're printing the design could be different every, every portion computer way you can actually save it after every this thing you just keep changing the colors can change the design can change you may say well one whole thing is only one repeat everything is possible and So considering that the interest has not died down, in fact it has increased that people now are finding that in case there are large orders they get the cost of the infrastructure which means space machine conditioning could be compensated

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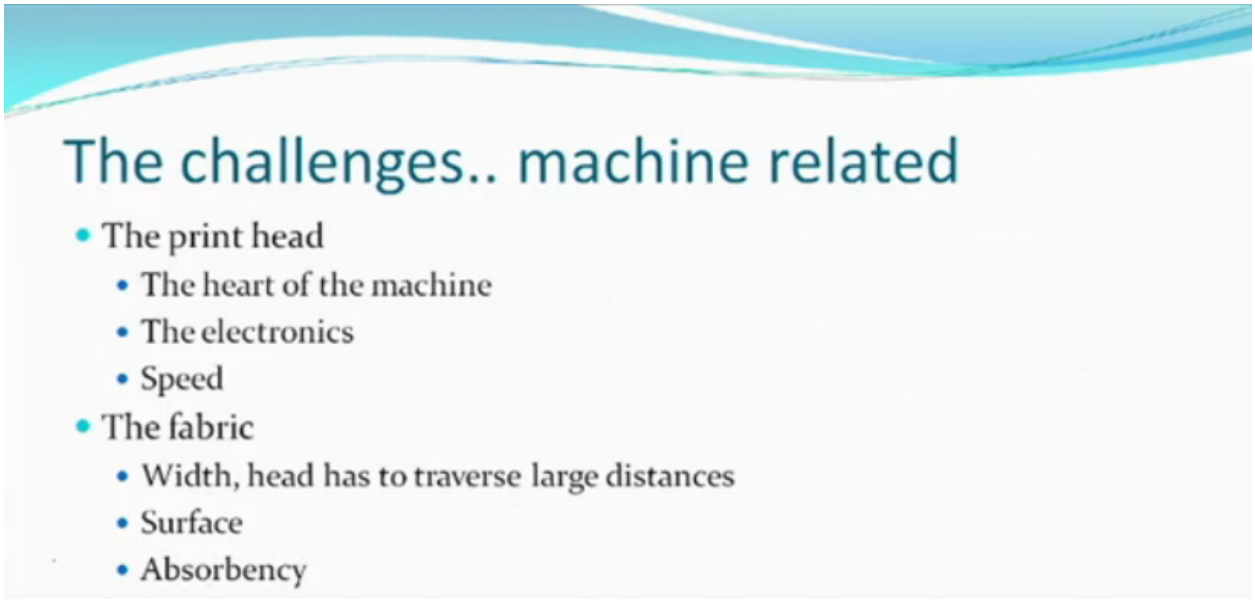

So, the challenges still remain printhead which is the heart of the machine which obviously must respond to every signal that comes and the speed of printing also, has to be seen because finally the production also depends on how, fast can you print and so, this is also still a challenge on a piece of paper people who not So much interested now even talk about thousand meter10,000 meters, being printed and people like that the speed should be high various kinds of electronic systems have to be built in, the head which may be a very, large piece theoretically has to move quite a lot from one side to the other side because, the fabric is very, wide it could be one point five meter to two meter depends on, what's happening and so, the heads must move large distances the surface of a fabric is not smooth and incase it just touches Something the life will be bad because, while you 're printing is just hoping that there will go and just stay there and you will handle it, at a different stage the heads of the printer does not, obviously touch it

but if there are hairs, protruding out things may not be good then the absorbency of course is there but, it should not be. So, much the textiles have to be absorbent by nature. So, should not be a situation where capillary action scan change the area where the impact was there in that case you will have an impression which will not be the same as you wanted. So, all these are there

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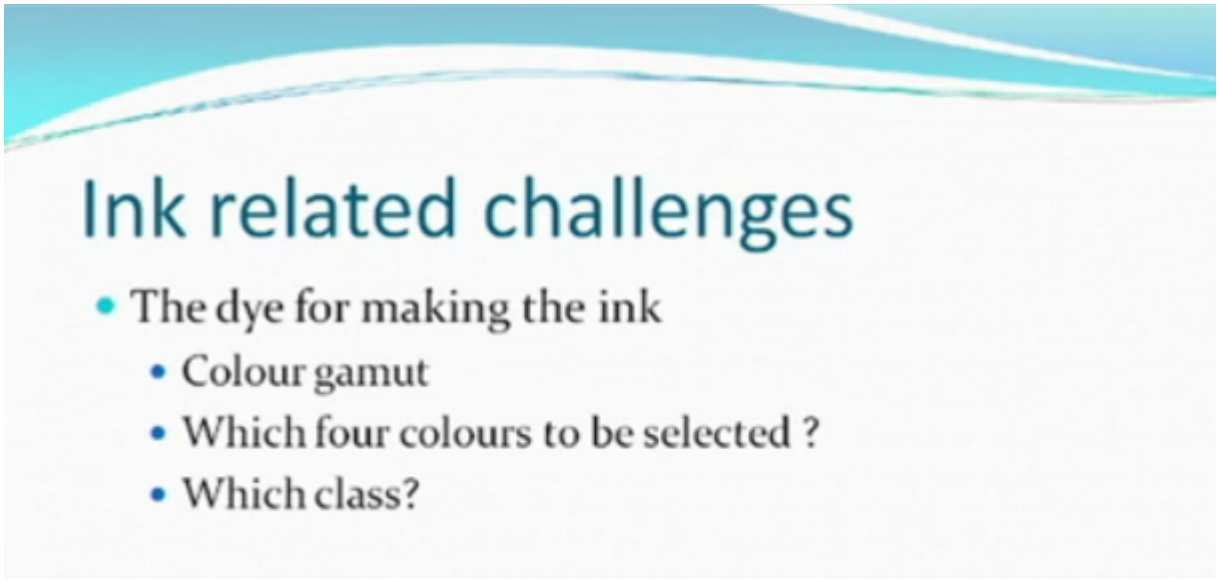

The ink or the dye which is used for making an ink has to meet all these requirements all the requirement means that you have, only four and you they must exactly, be the standard their spectral characteristics, must be exactly the same as let us say you see, something on the screen and so, finally when they go and deposit the drops are delivered and then you see the, the whole picture through your eyes, it should look the same. So, any small change of any auxochromes, in any of the dye, will be giving you a different thing which will not, be called a, 'Standard'. So, if you on a digital printing everything, therefore became a standard you cannot just take a. Okay? This also blue where you try yes you can try it, it can be but then what will come will not be, what you want and there is no correction here you know, it is printed only once. So, good technology print once final there is nothing to be done secondary but, then it has to be exactly the way one would have expected then, unlike for example, in the case of transfer printing we were struggling to get, to ionic dyes because there are. So, many fiber textiles that we use and disperse can only go to polyester or some others in limited manner but, in this case people also wanted that very of class of dye should be used. So, you have reactive you have assets you have pigments go disperse also, that means your challenging. So, this is a challenge now all of those dyes and classes must meet exactly the standard which is let us say, the some electronic measuring system must approve. So, not only it has to be pure molecule of a Right? kind but it must be approved by the try similar measurements that yes this is exactly, what we wanted if anything other than slight change means change.

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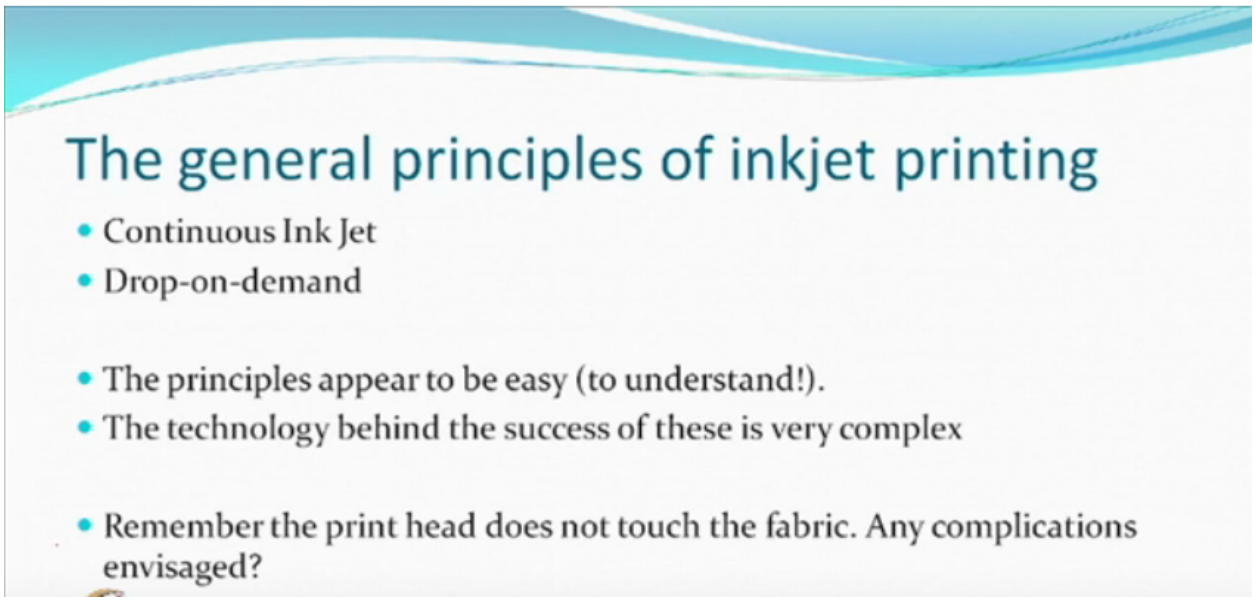

That’s the challenge. So, it's not that everyone is selling inks for digital printing there's So many manufacturers for the textile dyes but not for this. So, that has been one of the thank because it's a very, specific business. So, inkjet printing the general principles, are that one is called the continuous inkjet now this has basically been designed for textiles where the jet is continuously being generated and then you do Something. So, that wherever it has to fall it falls wherever it is not supposed to fall doesn't fall other is called a drop on demand like your video on demand. So, whenever a drop is needed a drop is generated otherwise the drop is not generated So there are two principles electronics behind the same maybe same Software maybe the one which is governing everything else So the principles appear easy to understand but getting them done is obviously more complex and so, the cost and the Sophistication still is part of this technology remember again that the printhead does not touch the fabric So every time it touches you will have problem that's the reason pretreatment not that bleaching and covering we’re talking about pretreatment. So, the surface becomes a little more smooth. So, that nothing touches because it can wrinkle it can get skewed all those things happen with tension it does not happen, in paper it's much more rigid body compared to textile, is a flexible material and therefore this is important of course was important always, in printing you had to make sure the fabric, doesn’t slip here of course that's it. So, we look at continuous exert principles we ‘relooking at principles.

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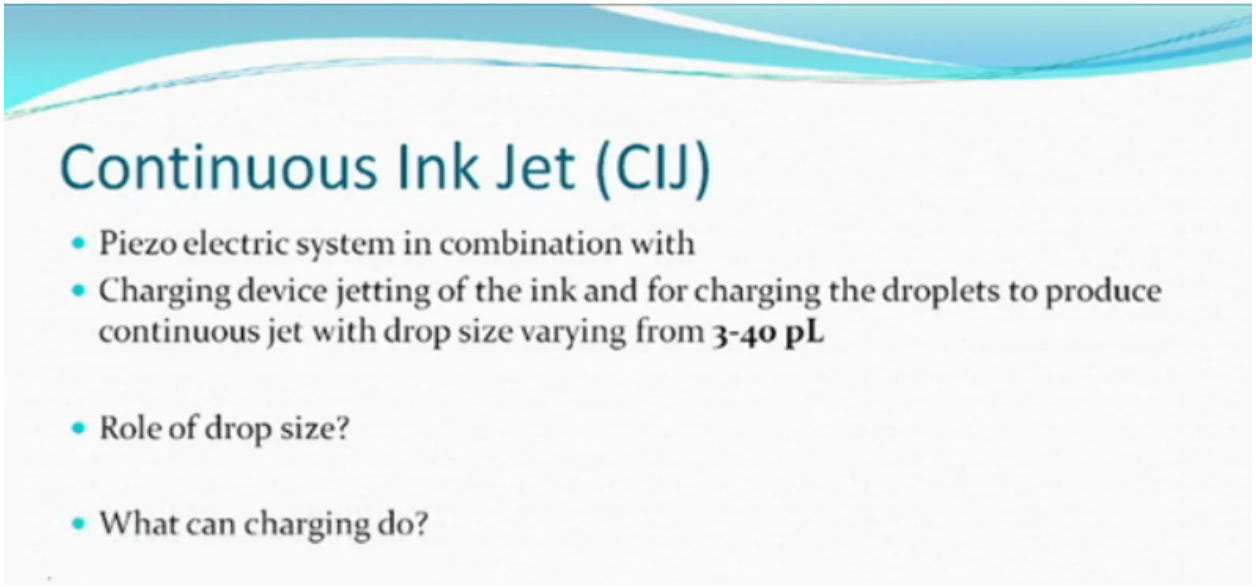

So, easy electric system piezoelectric you can appreciate is a system which or a crystal where you can get displacements by electrical input and so if you call it a pump. So, you don't have a pump of the kind that you can think in terms of pushing liquid into a trough in a padding Mangal but, So the pushing may have to be done by very small amount the small displacements and a controlled displacement can be done by systems like this. So, this could be one of the important part of the whole thing called a head So one interesting thing is that the jet is continuous it does not stop you may have a high-frequency signal coming and every time the signal comes the jet just keep serving continuously the drops are being formed and thrown when they are being thrown then we have to do Something about it So droplets are charged So you can charge them and sizes can be varied depending upon the frequency and also, the total amplitude of the change So the amplitude change is less, less amount of material will be pushed. So, you can still think what is the droplet size you're looking at three to forty Pico litters Right? it's very small you know you obviously therefore the control has to be good in paper printing they may be from 3 to15 20 in textiles in Some cases they'd wanted a larger liquid material So that it goes inside also and a paper you're only interested in surface the textile has to be washed also and So you want a bit of a diffusion and therefore creating large displacement to get larger drop also was a challenge So role of drop size we understand if it's Something to do with the resolution. So, smaller it is better its result what can charging do if you have a big drop and it is charged the charge normally like to reside on reside only on the surface but if same charge is there, there is between them at different places also is repulsion if it was Solid the charge repulsion force is not high enough to break the Solid but when it is a liquid the charge can break it also you have seen or heard about it at least that Na no fiber production So there high voltages are used to do produce a fiber and if the voltages are of different ranges you can get droplets Al right? And so they're also droplets can be formed but the charging is also used to deflect the material.

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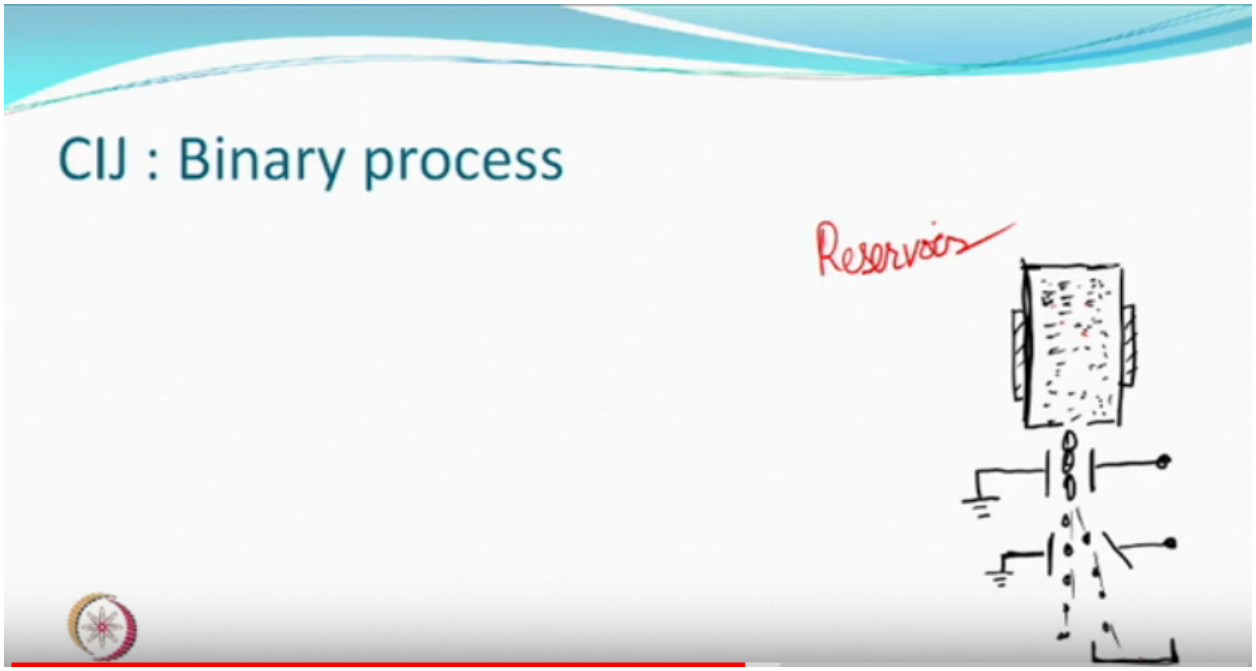

for example, if suppose there is a reservoir and there is ink here all over and through Some push pull push you may like to push the thing but as it comes out or very near then you get Some the droplets gets charged the bigger droplets can become smaller but once they are charged they can be deflected. So, the jet is coming continuously head is moving obviously with the fabric maybe moving injecting the head moves in this direction So drop falls. So, wherever the drop is not required it will be deflected to some other point which can be let's say drain.

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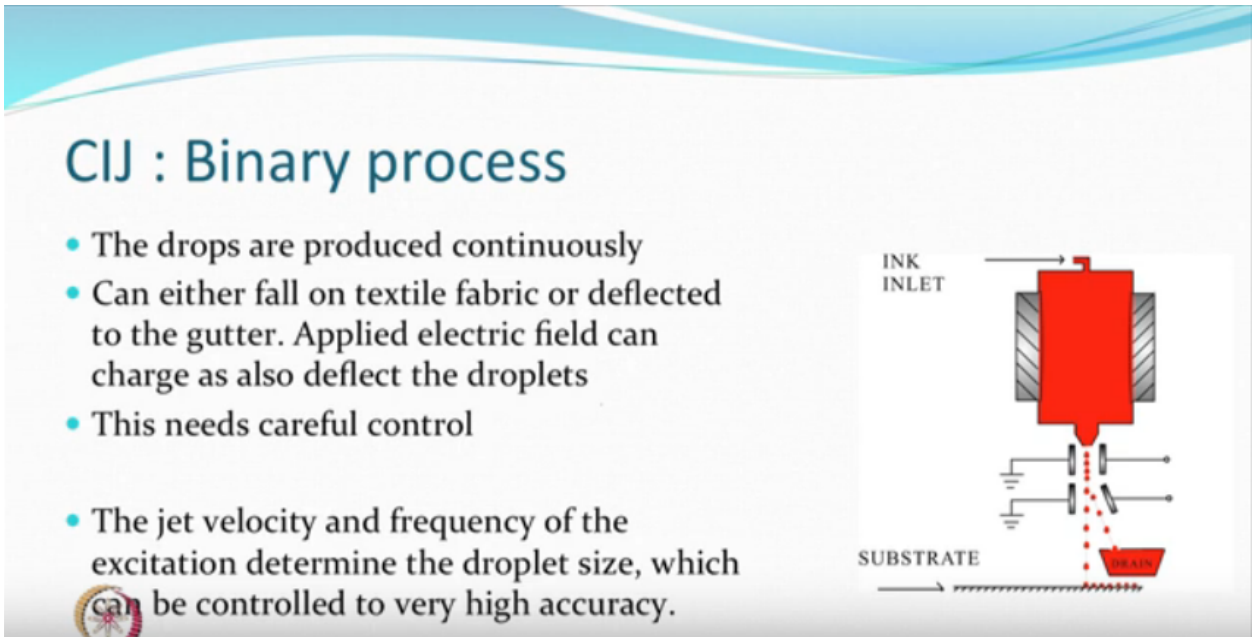

And wherever it is not deflected. So, it just keeps on falling Right? and So it reaches a point and then there is a textile substrate must be there where it gets deposited and then you keep moving it's called a binary because there are two operations are happening either the drop is going to the substrate or is going to the drain So one or the other. So, drops are produced continuously therefore it's called continuous inkjet the drops can fall either on a textile fabric or deflected to a gutter or a drain the applied electric field can charge has also deflect the droplets or Something similar as I said like electro spinning or electro spraying So one can always charge and make droplets of Solutions careful control of course the jet velocity and the frequency of excitation how what is the frequency at which the jet is being thrown out would determine the size of the droplet which should be controlled with high accuracy and this system of charging and deflection helps that process you can imagine what we are talking about a three pickle it a 10 pickle eater five people it a kind of a drop size small, small stuff. So, it can go from one to another people have even thought of the droplet size are very small you can put an air stream a droplet we don't want you just go Somewhere else and the rest will fall but then again it is pulsed but this is one of the easier one but you can say even as a principal the nose appears to be complex first Somebody is pushing then the droplet has to be managed, managed in the manner in which you want therefore all signals must keep coming at the Right? Points the. Right? Time and everything happened. So, the gap that we were talking about between the surface of a textile and the printer head if it is very large. So, the anything which goes opens out and it is very far it can spread the drop can spread if it contacts quickly the size will be small mean even if a small droplet So in any case whenever a drop is going to fall on Something it may have its own viscoelastic properties that can fall come up and then go down it's not like just goes there and deposits do you throw any liquid anywhere it bounces back. So, one has to worry about the viscosities in that manner also but that's the chemistry part of it but, electronics is going to be Something like this as a principle.

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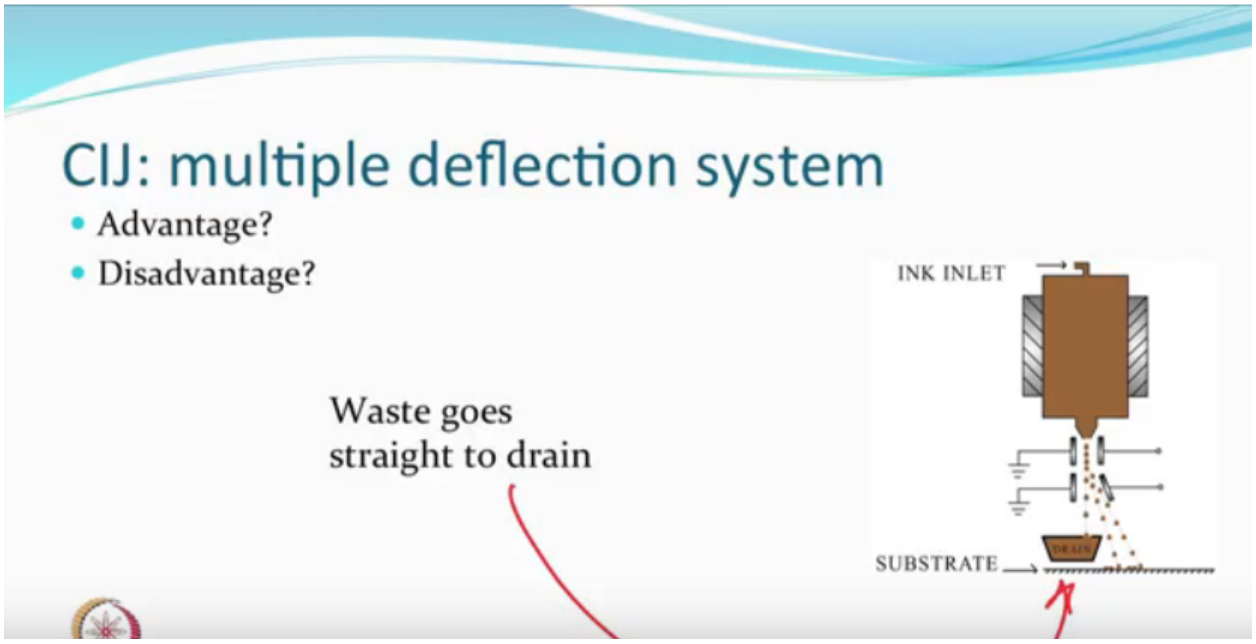

So, the other thing on the continuous inkjet system, is a multiple deflection thing, I say well, when you already have charged the material, the reverse can also be done, that drain is going straight and multiple deflections can take two different points, at the same time, one goes there, the second one has been deflected Somewhere else. So, multiple death means more frequency, more drops getting generated. So, one probably, obviously thought maybe you can do, a bit of a high production, same inkjet is going at a different points also, in the first case it was only at the same point where the jet, nozzle was. Now, the jet nozzle at one place, printing can happen at, a different places, multiple means not two, it could be three, it could be four, only it's a question of deflection that get deflected and also, take Somewhere else. So, that's the advantage in that sense, the waste in the case, is going straight to the drain now, what could be the possible disadvantage in this? Droplet said is less, small very small. So, we can produce a lot of finer sets, it means a very accurate Source. So, that's the advantage, that's an advantage, that you the drop size was controlled there also, what are we talking about, two different principles, one is taking continuously to the drain and keeping the. Right? Drops at different points, the first one was the Right? drops were coming straight, then un required, undesirable drops were going Somewhere else, size is different part of it, one of the thing which you can probably think is, the one which goes straight, would have an impression of a circle, the one which goes further, can become ellipse, of different kinds. And so, whatever resolution we are talking about, you may still be able to achieve, because I may not be able to still resolve, whether it is elliptical or circular. But, what is likely to happen is, the same droplet, Somewhere it is circular that which may occupy more area, where it is less circular, will occupy more area, is more circular than imply less area and therefore actually, what you may observe, may be slightly distorted, you may not still be able to find out.

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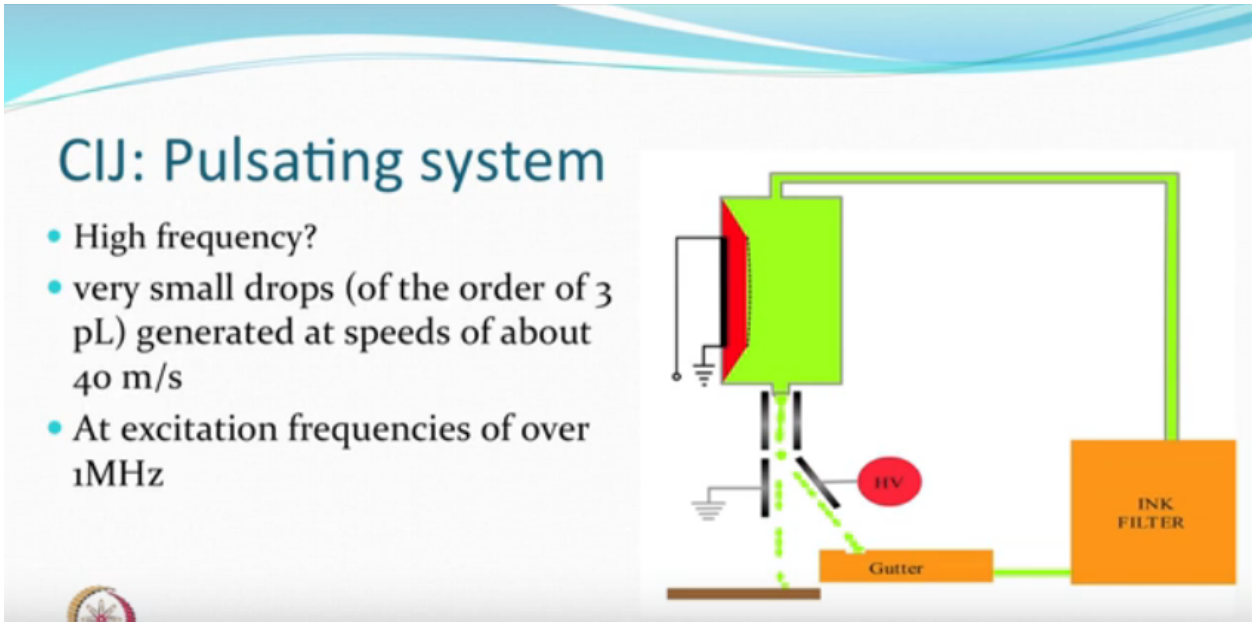

So, within the same type of continuous, it's a pulsating system continuously means that for Some time, it produces Some high frequency and large number of drops, one after the other follow and then, it's there is a gap, gap also, is very small but, there is a gap. So, that if you want to deliver more, liquid at one place that will this want to more then more drops, immediately come. But, they are still small they're, all small droplets and some are of course going to drain all so, whatever doesn't go straight. So, it's coming in bunches, sometimes was called also, 'Hertz Technology'. Because the person who proposed this world Hertz, different Hertz of course. So, the droplets are coming in batches, because you wanted more drops there. So, liquid really more if you want less, only two will be generated. So, it's coming in real pulsing systems, high frequency required, because you want lot of things happening, at very small intervals and small, small droplets to be generated. So, this is almost the limit, is there the three Peculator, is the smallest droplet will be produced and speeds are also pretty high. So, they come and strike, actually and if you have four of them coming together. So, they'll be 12 Pico liters. So, at a high speed, high frequency, small droplets, coming in bunches. So, Sometimes drops and then again starts, with that kind of thing pulsating. But, otherwise still continuous because, continuously this thing is happening, towards the textile, whatever is not requires being deflected to the drain, frequencies could be as high, as 1mega would see, the electricity that we have here is, 50 Hertz is what we get. So, we're talking about frequencies we're talking about really high. But, you still have to manage this.

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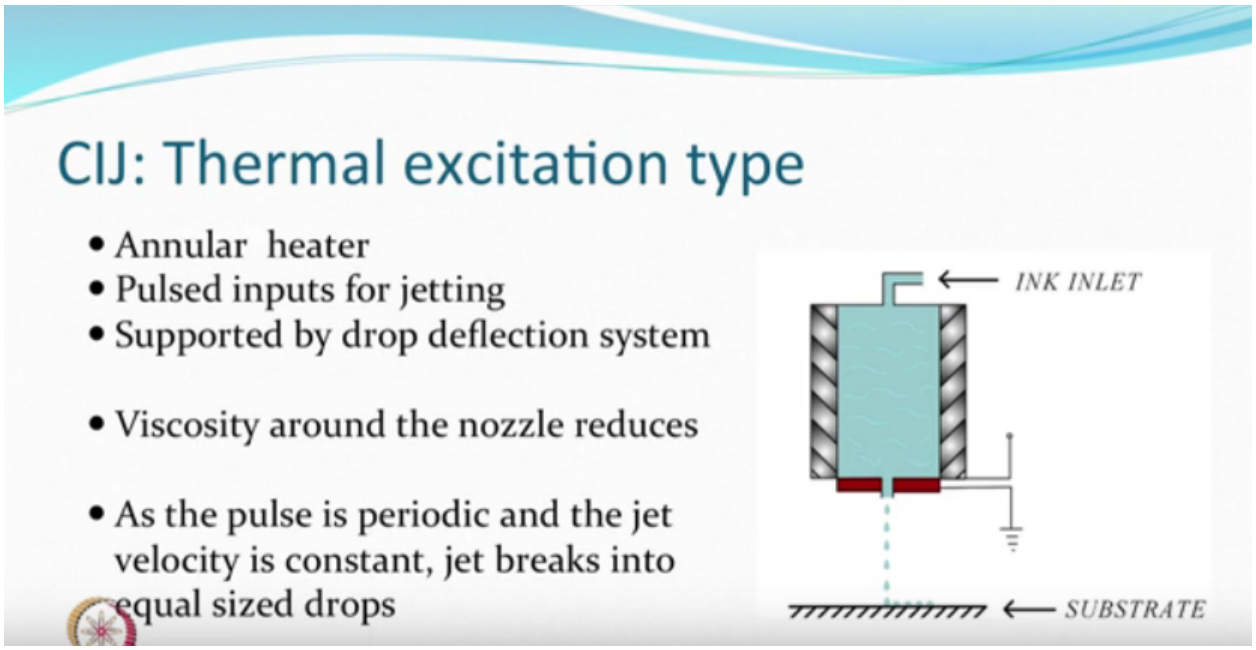

So, now the principle also people tried instead, of producing the drop by charge or another push, controlling the viscosity, of the ink near the nozzle. So, near the nozzle, you control the viscosity. So, you can appreciate the viscosity of the ink as such unless and until it is pushed, it will not come out, of the nozzle, you see on its own, you have to do something. So, once Something was being done there was pushing, pushing through, let's say a pump called a, 'Piezoelectric Pump' or Something like that and then charging and making it smaller and working out now, what it says that? This pulse will be there for jetting, there's the annular, heater you know annular; heater all around the, the nozzle and then it is heated in a pulse. So, when you heat this, the viscosity goes down and then it falls. Right? So, now you can understand what are you controlling? You're controlling a temperature, around the nozzle. So, that the viscosity becomes less. So, the viscosity of the original ink is controlled in a manner that only this much will change and default and rest the viscosity, in the whole jet does not change, it remains the same, only around the nozzle and this pulse is periodic jet, velocity can be constant and this principle also, gives equal size drops, it's a principle. So, they called thermally, externally, excited continuous, exert print heads. So, interestingly all these things, are being used, by one company or the other.

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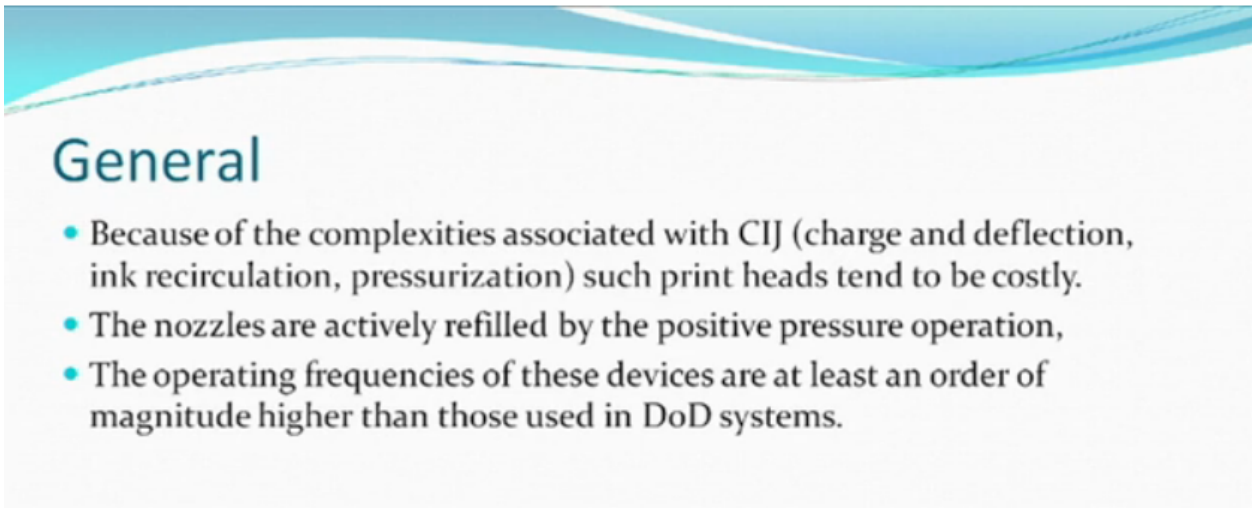

So, in general because of the complexities associated with continuous exert that you have to charge deflect and whatever, has been deflected and gone and the drain has to be recirculated, it's a costly betrayed you can be throwing Somewhere else, Some pressurization that you have to push, continuously these print heads are generally costly. So, industry which are actually, producing large amount of printed materials, may be preferring this kind of technology continue happening, nozzles are or the area around the nozzle or what we call reservoir, is appositive pressured operation and this continuous yet operating frequencies of the devices which are put in this continuous inkjet category generally use higher frequency at least an order higher then drop on demand because they're the signal and feedback has to be that this signal comes the drop comes then you wait and then, then us income it if, it is working very high frequency this feedback control system, may not respond the way and so, they use frequencies which are slightly lower than them but, the continuous inkjet printing, uses higher frequencies we pick this, up or drop on demand means drop is generated, only when it is required if it is a complete blank area let's say you see the question is that info there's a design there is some part design the rest of the portion is white. So, what are continuously draining, because that is not stopping if it, is very near it is. Okay? But, if there can do blank areas where you don't want any color at also that means continuously, you are wasting the ink or at least putting in the drain and then you will recirculate after whatever you have to do you may have to again at least make sure the viscosities remains same flow properties have not changed all that will have to be done in this case the drop will fall, only if it, is required if it is only 5%,of area being printed I mean only 5%, of time the drop will be there otherwise machine is stationary when the process is not happening, place head may be moving but, there is no drop coming out. So, from that point of view this obviously is a desirable technology. But, if suppose 90%, of the area is being printed then it doesn't matter here also, continuously the filler will have to keep working trying it out. So, one has to choose the technology which will, what kind of a technology you, want and there may be reasons why people use different technologies.

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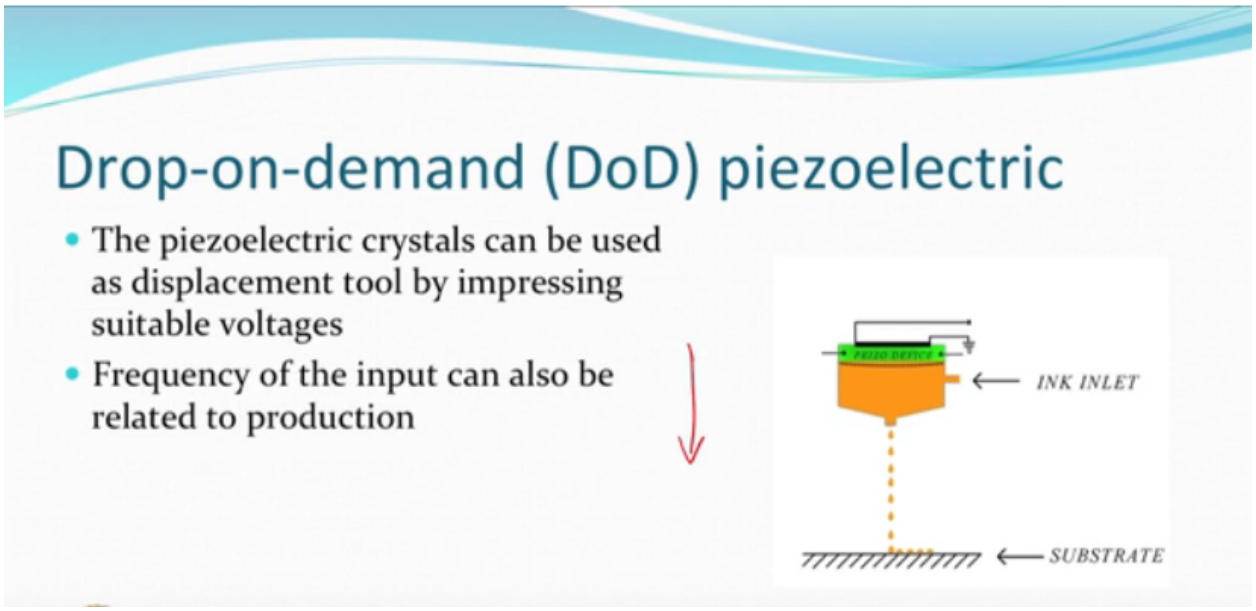

So, drop on demand, there is no deflection etcetera, etcetera here the piezo crystal, may be let's say in this case, put at the top of the reservoir and just pushes, enough it pushes enough. So, that same amount of liquid goes in goes out and the moment the liquid goes outhits, goes back and from other point which may be connected. So, that the more ink can get into the reservoir. So, piece of crystals, therefore are used as displacement tool by impressing let's say suitable voltages, if you have high frequency, these things are happening. So, in this case the frequency is. So, important that the production if the frequency is very, low drop comes in the wait for some time and drop comes, then your production is going to be slow. So, you want high production, high frequency. But, during that type frequency that means such a small time you are able to control all signals have gone, but it'll happen. So, here there is something else also there that is called paint which is a material, it is not, current can pass through very quickly, but the material which is changing a property which is Nord is going to expand. Okay? This also very quick, then it must pressure the liquid. So, that the liquid just goes out. So, you can only use certain level of frequencies, because you want a response also, you know if something happens very fast, let us say drop is not even moved out, before the drop moved out, the pulse had gone Somewhere else, then it was pushing is gone back and drop just could not move out, then just be doing this, oscillation, which must be enough. So, that it goes out and then you go back. So, some control obviously. So, it cannot be infinite, level of frequencies that you may like to use.

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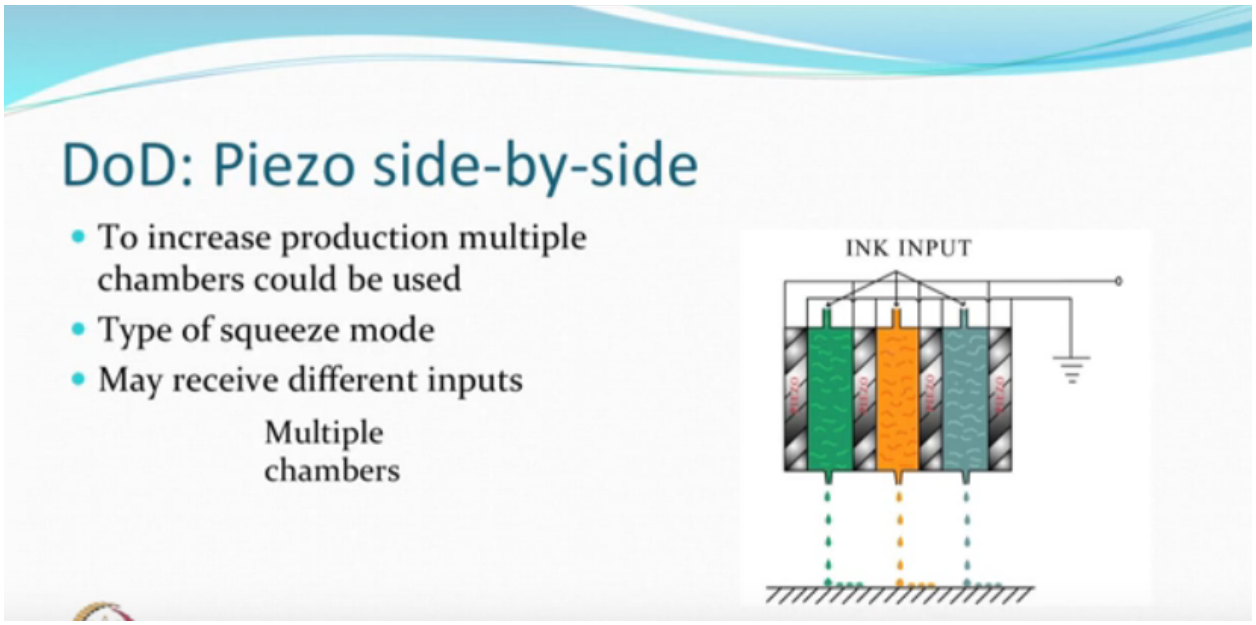

So, in this case the piezo system, can be used in different ways, one of the ways in which it can be used, is that you can put, this piezo, transducer anywhere, on the top on the side, in this case for example, there are four piezo sensors on the side, of a reservoir and they are multiple. So, it squeezes and brings out, what it means multiple means, then you can, produce more drops, the Chamber's are multiple, this transducers are multiple and depending upon the need if suppose in the same area everything is black. So, all of them just fall, in one go, if not then selected will go. So, multiple chambers are there, which have the ink and you have multiple side-by-side arrangements of various things within the same thing and you can keep taking the ink out.

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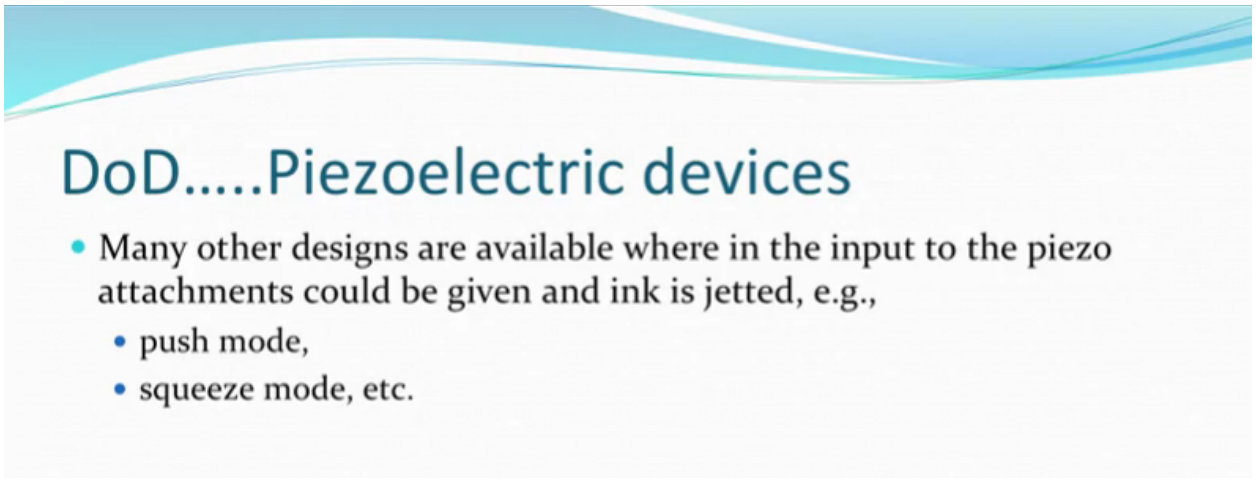

So, many other designs are also available, just like side by side, where a piezo attachment, could be fixed and jetting could be done, by pushing board by, squeezed board by single double and so on, so forth. So, principle remains the same that the piezo, electric crystal, will change is dimension, because of the voltage and therefore definitely push. Right? Piezo can do the reverse also, now if you can put the pressure, it can generate current, it can be used, as a displacement sensor, it can also be used as a pressure sensor. But, important thing is, very small amount of displacement, the displacements could be the Na no levels and very high and therefore the whole, thing called a, ‘Printhead’ is a very, small assembly doing everything. So, we can stop here and we'll continue from here next time.