Fundamentals of Food Process Engineering
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Lecture - 58
Non Thermal Processing (Contd.)

Hello everyone, welcome to the NPTEL online certification course on Fundamentals of Food Process Engineering. Since, the last two classes we were discussing about the Non Thermal Processing which are the processing methods by which without heat treatment we will try to inactivate the microorganism.

And so far we have discussed about high pressure processing and pulse electric field. So, we have seen then how in this two method we can inactivate the microorganism and what are the process parameters that actually can be varied during different inactivation of microorganism. Because not all microorganism need the same intensity of application of any particular process because it varies from types of microorganism so, all this we have discussed. And today we will see some more techniques non thermal techniques by which the inactivation of microorganism can be done.

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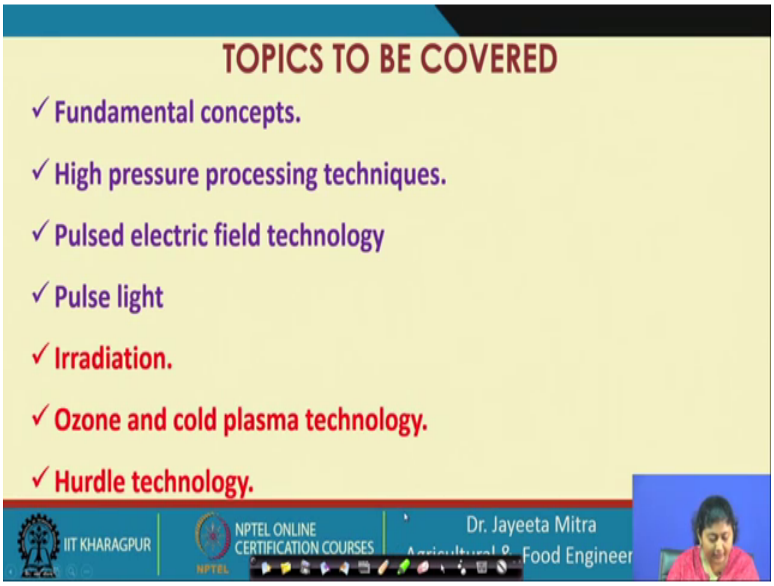

So, this technique high pressure high pressure processing and pulsed electric field technology this we have discussed. Pulse light will discuss today, followed by irradiation, ozone and cold plasma technology and at the end we will discuss what is hurdle technology?

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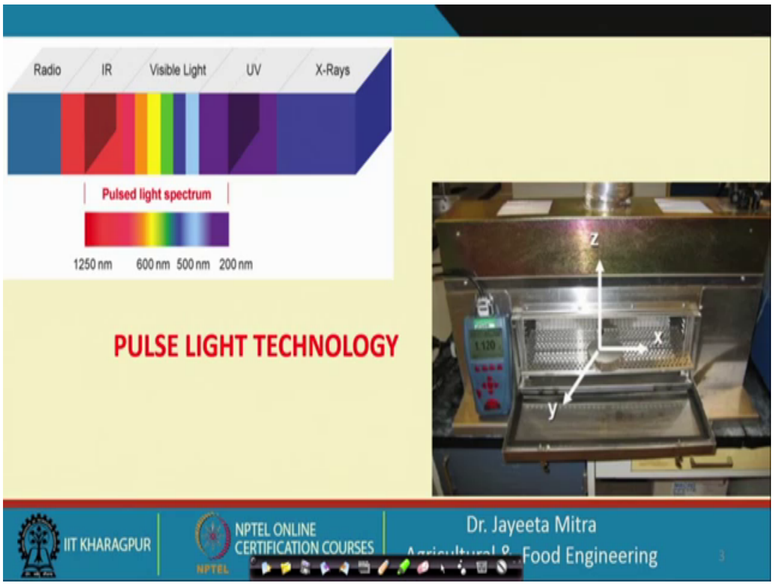

So, first we will discuss the pulse light technology, what is pulse light? Pulse light actually a broad spectrum white light and this has capability of sterilizing the material. Basically, this works on the surface the surface of packaging material or the food contact surfaces; that means, the equipments or utensils that we use for processing the food or for example the you know the conveyor where the food or fresh vegetables are after processing we want to convey that from one section to the other section.

So, for sterilizing all those equipment and posturizing the packaging material; we use the pulse light technology. Traditionally in the industry this sterilization of packaging material is being done by hydrogen peroxide, but we know that hydrogen peroxide leaves the residue both in the packaging material or in the food itself and that is harmful; that is why pulse light technology is becoming important nowadays and it is very effective.

Also we can see that pulse light is considered can be considered from 200 nanometer to almost 1200 or 1250 nanometer this is the range. And it can include the UV from 200 to 400, then 400 to 700 the visible light spectrum and the infrared spectrum. Although the inactivation of microorganism by pulse light technology fully not understood. The technology or how they actually you know have the detrimental effect on the microorganism is not fully understood by now, but whatever may be the case, UV definitely playing a significant role right.

So, that is understood that UV is definitely playing a significant role in decreasing the microbial contamination on the surface using the pulse light treatment. So, we will see now what are the parameters associated with it.

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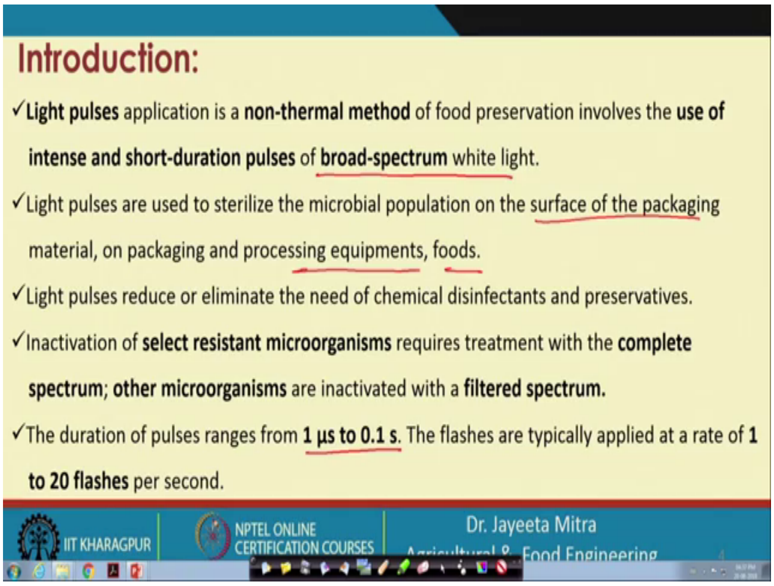

So, light pulses application is a non thermal method of food preservation involve the use of intense and short duration pulses. These are very intense pulse and short duration pulses of broad spectrum white light; we have seen the range it starts from 200 nanometer to almost 1250 nanometer. Light pulses are used to sterilize the microbial population on the surface of the packaging material and also on the surface of the processing equipment and food.

Light pulses reduces or eliminate the need of chemical disinfectants and preservative because, this is the conventional method we use that disinfectants and preservative and those obviously, have some chemical residue so, that we can eliminate by this use as I mention about H2 O2. And inactivation of selected resistant microorganism requires treatment with the complete spectrum; that means, the range that we are having 200 to 1250 and other microorganism are inactivated with filtered spectrum.

That means, from this broad range that is 200 to 1250 not all the spectrum is needed for kill all the microbes it is specific to some microbes. So, some selected or filtered spectrum is needed in some cases the whole complete spectrum is required. And the duration of pulses ranges from 1 microsecond to 0.1 micro second.

So, the duration of applying pulses is also very less. The flashes are typically applied at a rate of 1 to 20 flashes per second and at times 1 pulse is enough to inactivate the microorganism on the surface. So, we can say that this is an effective method and cost involvement is also very less and there is no residue. So, you know removal of the residue or chemical preservative cost that is also can be nullified so, that way this is very helpful method in the industry.

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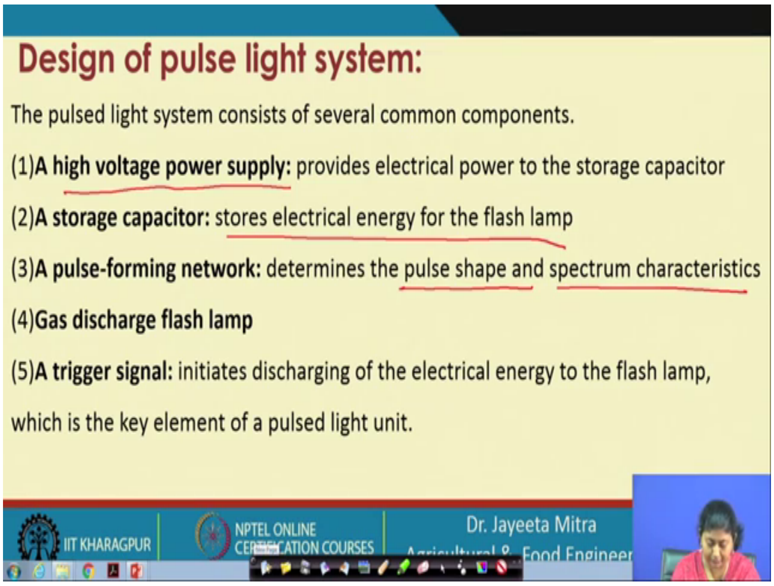

Now, the pulse light system consist of several components. So, what are those components? One is the high voltage power supply that provide the electrical power to the storage capacitor. There is a storage capacitor to store the electrical energy for the flash lamp; we generally use an inert gas lamp to have that intense light pulses. And that lamp is actually gradually you know glow from the low intensity to the high intensity and the pulse forming network is there. This pulse forming network determines the pulse shape that of which type or which pattern of the shape is generated and the spectrum characteristics.

That means the spectrum of what length we are using ok, where it is the total pulse we are using, total spectrum we are using or a filtered spectrum we are using and the pulse shape. There is a gas discharge flash lamp is there that is the inert gas lamp and a trigger signal is there.

So, this initiate the discharging of the electrical energy to the flash lamp which is the key element of the pulse light unit. Now, when we have a lamp of the inert gas and we initiate the discharge of the electrical energy; then that electrons will interact with the atoms of the gas and they produce the high intensity white broad spectrum light that helps in the inactivation of microorganism. And that generate for a very small duration as we mentioned about the millisecond to the microsecond range.

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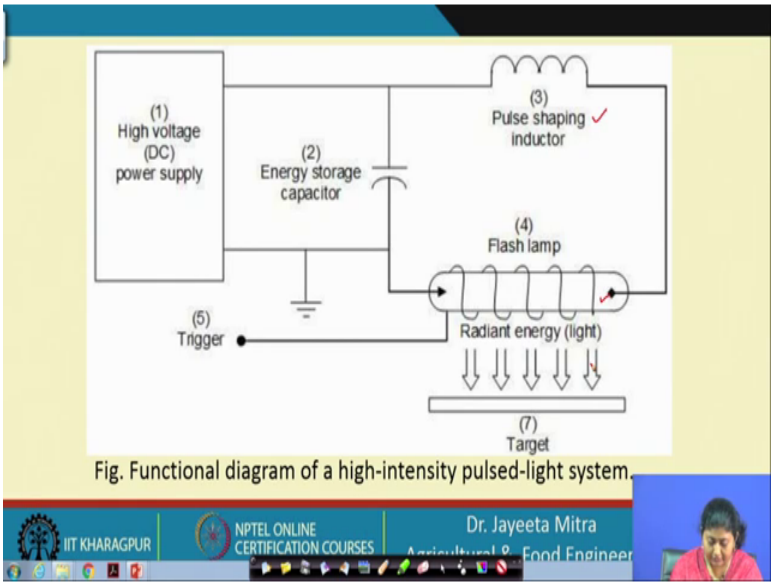

So, this is the system here we have the high voltage DC power supply; we have a capacitor energy storage capacitor that stores the in energy and when we apply the switch? So, the flash lamp here it starts generating the intense intensity of the light from the low to high and a flash will be generated.

So, that radiant energy coming to the target of the food contact material any surface or the packaging material etcetera and there is a pulse shaping inductor which indicate or which determines that what kind of pulse shape will be generated? So, the this is the functional diagram of pulse light treatment.

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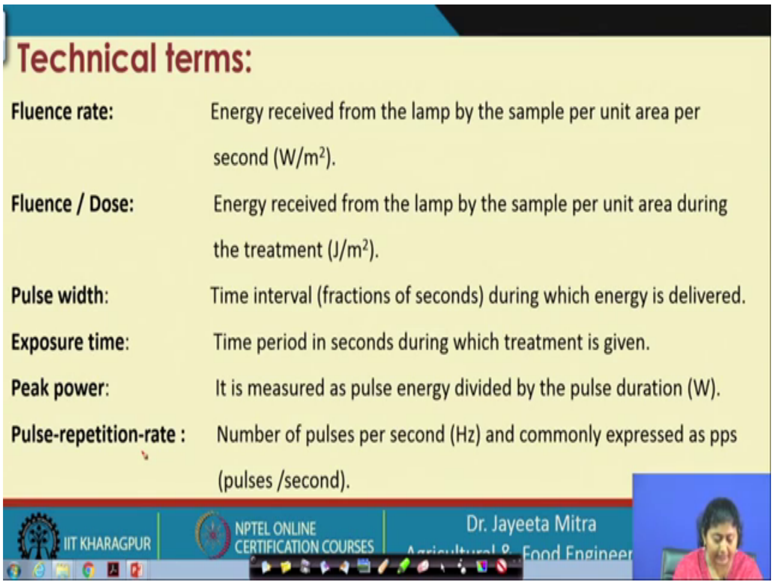

So, there are certain terms that we need to know before applying this pulse light treatment to any contacts food contact surfaces or packaging material because, on this parameter it depends the intensity of the action of the pulse light will depends. So, one is the fluence rate; fluence rate means the energy received from the lamp by the sample per unit area per second ok. So; that means, per unit area, per unit time that is energy receive from the lamp that is called the fluence rate.

Now, fluence per dose signifies energy received from the lamp by the sample per unit area during the treatment. So, this is considering the whole treatment what is coming not per unit time, then there is pulse width. Pulse width is time interval that is fraction of second during which the energy is delivered that is the pulse width. Exposure time; that is time period in second during which the treatment is given ok so, time interval there is a fraction of second during which the energy is delivered.

And the time period in second during which the treatment is given this is the exposure time. What is peak power? It is measured at the pulse energy divided by the pulse duration because it generates a peak and then it gradually diminishes. So, we have to determine the peak power by the pulse energy divided by the pulse duration. Then pulse repetition rate; so, number of pulses per second that is the frequency of the pulses in hertz and commonly expressed as pulse per second. So, this is the pulse repetition rate that is in per second how many pulses are generated. So, these are the technical terms that we need to look for while designing the pulse light system.

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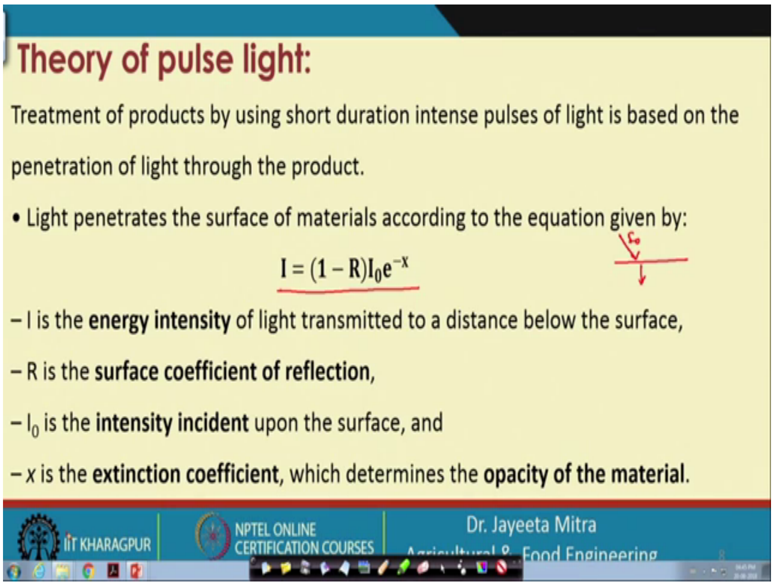

Now, the treatment of products by using short duration intense pulse light is based on the penetration of the light through the product ok. So, as we are mentioning that basically it acts on the surfaces. So, it can if it can penetrate a little, so what will be that depth and how it can work there so, light penetrates the surface of material according to this law ok.

So, it says that I equal to 1 minus R into I 0 e to the power minus x. I is the energy intensity of the light transmitted to a distance below the surface ok. So, if this is the surface and we are applying this intense radiation. So, what will be the in this direction what is coming in? So, the energy intensity of the light transmitted to a distance below the surface. R is the surface coefficient of reflection; so, because what is coming in some will be reflected, some will be transmitted. So, the R is the surface coefficient of reflection, I 0 is the intensity of incident upon the surface.

So, I 0 which is coming intensity of the incident radiation; here it is light intensity of the light which is coming and x is the extinction coefficient which determines the opacity of the material. So, opacity of the material defined by x; that means, that define that how much the light can penetrate? So, if we see that we have that diagram ok.

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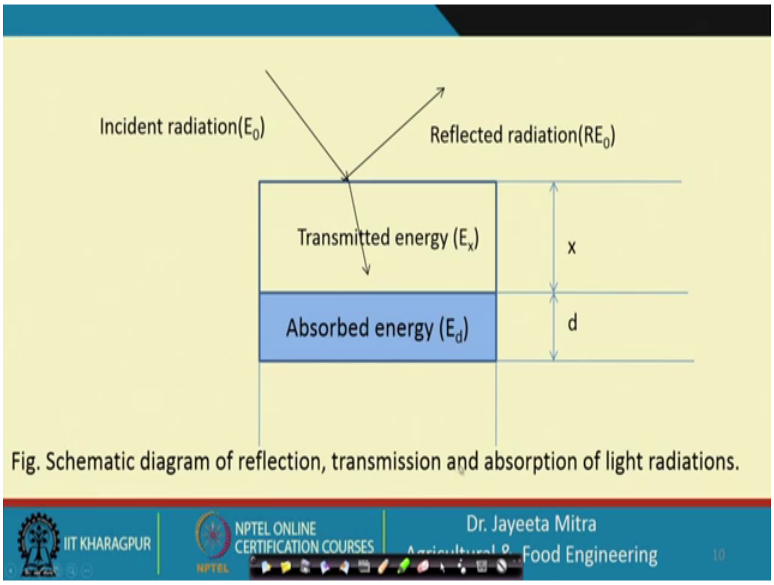

So, first we will see that and then will go back to those equation. So, incident radiation when it is coming then it is reflected some part and some part is transmitted. So, it transmitted at a distance is x that we have defined there extinction coefficient and there is d. So, here it is the absorbed energy and this is the transmitted energy E x. So, this is how when the pulse light comes in on the surface of a material so, the reflection transmission and absorption of the light radiation takes place.

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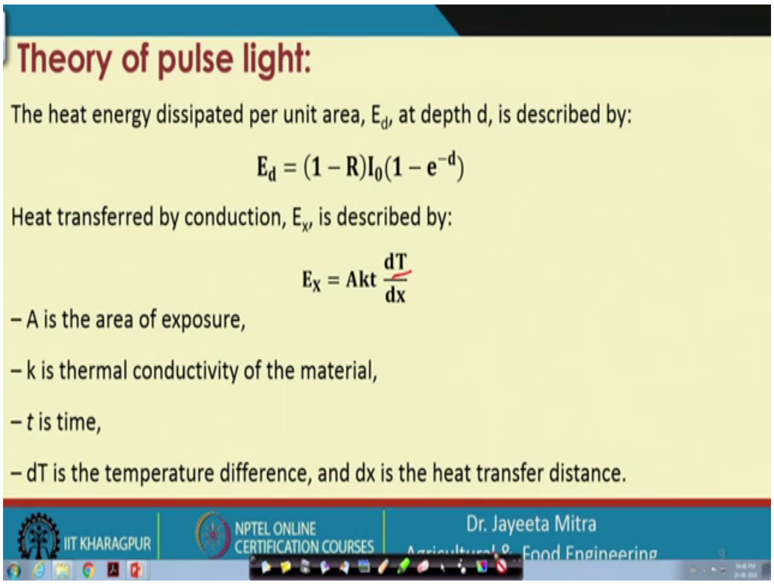

Now, we will go back to so, this expression we have discuss. So, the next is the heat energy dissipated per unit area E d, the heat energy dissipated per unit area will be E d that is equal to 1 minus R into I 0 the intensity of incident light into 1 minus e to the power minus d.

So, energy dissipated per unit area E d or that energy absorbed at a depth d is described by E d equal to this 1 minus R; I 0 1 minus e to the power minus d. And heat transferred by conduction E x is described by E x equal to A; that is the area of the exposure into k; that is thermal conductivity of the material and t which is time into d T by dx. So, dT this dT is the temperature difference between these the in and out of that layer so, that the distance it crosses and dx is the heat transferred distance.

So, across the distance dx if there is dT temperature gradient so, the heat transferred by conduction will be this much; k A t dT by dx. Now, we have described already that what will be the energy incident energy, then reflected energy, transmitted energy or conducted and then absorbed or dissipated at the distance d ok.

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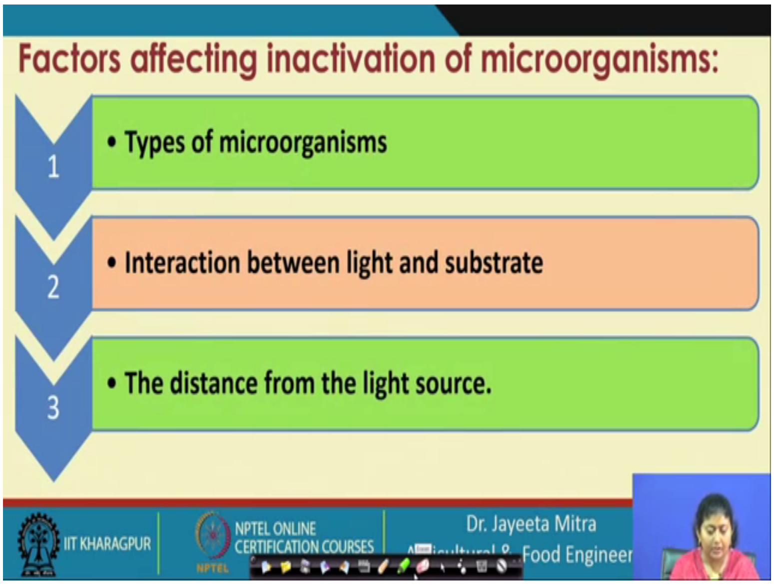

So, then there is factors affecting the inactivation of microorganism. Now, this depends on three things first is type of microorganism then the interaction between light and substrate and the distance from the light source.

So, type of microorganism because you know every microorganism or if we consider their characteristics is different; some have suppose cell wall membrane is strong some does not have cell wall. So, there are many kind of microbes and what is actually defined that what type of the microbes is sensitive to particular spectrum of the light.

So, that is why we have mentioned initially that some for to inactivate some microorganism; we need a whole spectrum of the light and for some we need the filtered spectrum. So, that specifically depends on what kind of microorganism is present then interaction between a light and substrate. It actually based on whether the material is transparent, whether the material is opaque, whether their surface is rough or it is having any kind of interaction with the light, it is you know penetrating at the surface or not.

So, many parameter; it depends on the on the substrate that is what we are taking. And finally, the distance from the light source; so the distance from the light source is again important so, that it can have it is energy and it is effect on the surface to a higher extent or a lower extent.

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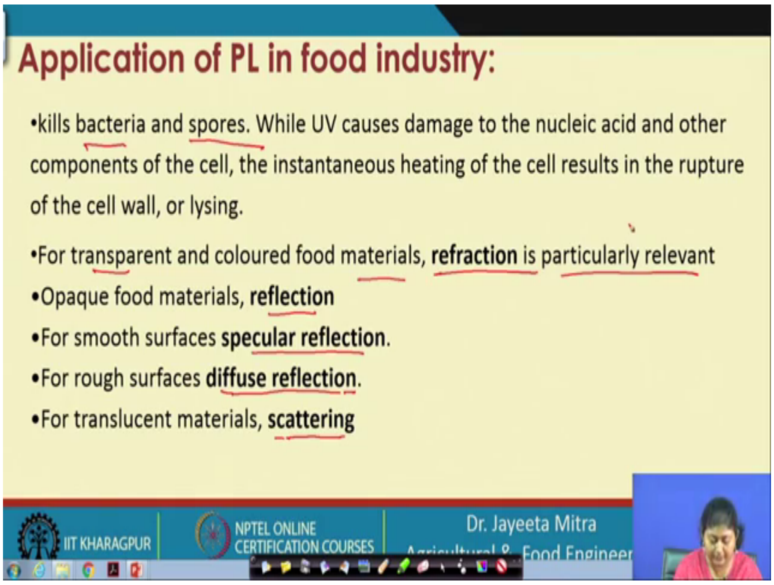

So, we have some application related to pulse slide in the food industry. So, it kills the bacteria and spore as we have mentioned initially that the type of microorganism is very important. So, now, we will see that what type of microorganism on which the pulse slide is very effective.

So, it kills the bacteria and spores while UV causes damage to the nucleic acid and other components of the cell; the instantaneous heating of the cell results in the rupture of the cell wall or lysine. So, we have mentioned initially that whether the effect of you know the microbial destruction is because of UV only or any other mechanism that is not very clearly understood. But, this has been you know assume that the initial effect that causes damage to the nucleic acid and you know in the cell wall destruction that causes because of the UV spectrum and this causes damage to the nucleic acid, but because of this energy absorption there will be high amount of heat generation as well.

So, that heat causes the results in the rupture of the cell wall and eventually UV attack the nucleic acid and the destruction happens. So, this is a combined effect of the UV and the heat and maybe some other parameter which is not very clearly known as of now because, there are effect of other spectrum as well. Now, for material is concerned we can see that transparent and coloured food material if it is transparent material and coloured food material so, refraction is particularly relevant because we have the you know incident and then transmittance and then reflection.

So, if for the transparent and coloured material refraction is relevant; opaque food material reflection will be the concern, so we need to see that how much will be actually transmitted. For smooth surface specular reflection will be there, for rough surfaces diffuse reflectance, diffuse reflection will be there, when the surface is rough and for translucent material scattering will be there ok.

So, therefore, from this we can see that all such cases transmittance will be varied and based on transmittance and absorption, the destruction of the cell will be there. So, we need to analyze properly that what is the interaction of the light, pulse light and the surface.

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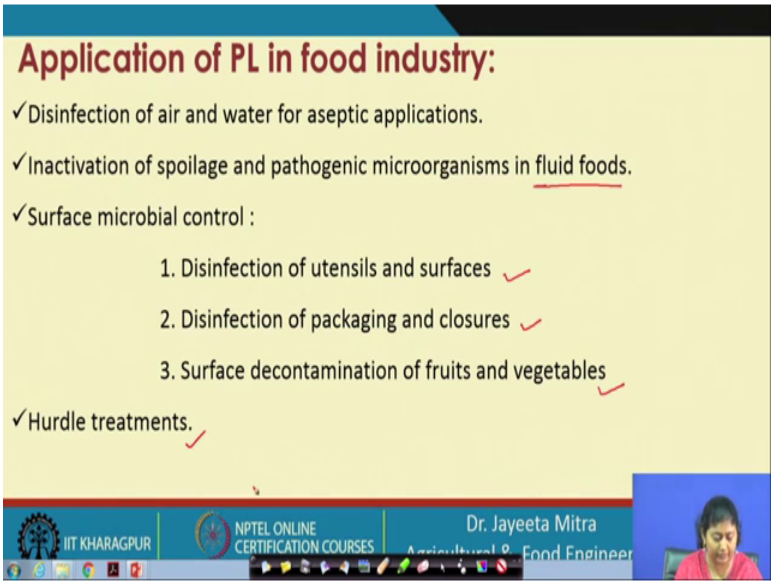

So, therefore, this pulse light can be used in disinfection of air and water for aseptic application. The thing we previously used, previously done by some chemical disinfectants so, that is now used by pulse light treatment. Inactivation of spoilage and pathogenic microorganisms in fluid food this is being done fluid food because, in that case we can destroy the surface microorganism.

For a solid we have to penetrate deep and that may not be done by the pulse light treatment that is why we consider on the microorganism pathogenic microorganism of the fluid food, then surface microbial control; so, disinfection of the utensils and surface as we mentioned. Disinfection of packaging and closure surface decontamination of the fruits and vegetable so, suppose we want to convey this from one location to the other and while conveying the; it is exposed to the pulse light treatment.

So, that the surface decontamination can be takes place those thing can be done and also pulse light is used in the hurdle treatment. So, hurdle treatment at the end of this non thermal we will discuss in a small way. So, there we will elaborate what is hurdle treatment is? So, this is the use of the pulse light in food industry. So, we will stop here and we will move on in the next lecture with one more topic of non thermal preservation.

Thank you.