Multiphase Flow
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Lecture No # 38
Measurement Techniques for Two-Phase Flow Parameters - Void Fraction Measurement

Well. So, today we will be continuing our discussions on the measurement of two phase flow parameters. In the last class, I had discussed the measurement of the most basic flow parameter; I should say the pressure drop measurement, which you have been doing very frequently. I think in even, in your under graduate fluid flow laboratories and thinks like that, is not it? So, there also we found that definitely it is not impossible, but special care has to be taken when one goes for the measurement of two phase pressure drop or pressure drop when two phase flow occurs through any particular conduit. And today we are going to start our discussions on the measurement one of the most vital parameters of two phase flow that is, how to measure it is (()) composition?

Since we are mostly dealing with gas liquid flows, because maximum number of literature available. So, we will be mentioning it in terms of measurement of void fraction, but even if it is a liquid liquid systems are any other two phase systems or three phase systems, it just the measurement of the (()) composition of the two phases, why it is, so very important? It is so very important, because the first thing is the (()) composition is not related to the inlet composition in a straight forward manner. It depends upon a large number of factors which are a function of the distribution of the two phases, the flow rates of the two phases, the physical properties the contuse dimension, contuse orientation and so on and so forth.

Now, if there is no direct relationship between the inlet and the (()) compositions then we can measure the inlet composition, but we cannot determine the (()) composition in a straight forward manner. And this particular (()) composition that is very very important for prediction of any hydrodynamic parameters of two phase flow. Or for that matter, for any particular further studies on two phase flow, unless we know the distribution of the voids, unless we know the void fraction we cannot proceed for further for any further analysis. So, therefore, I thought that we it is prudent to spend good amount of time on void fraction. We will be probably doing one and half or two classes on this and then finally, I will be ending of this course with the estimation of flow patterns.

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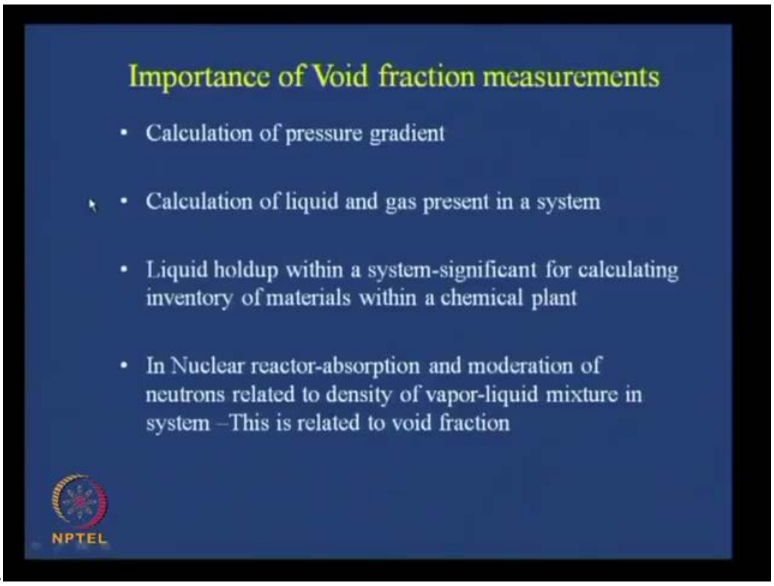

Now, what are the importance of void fraction measurements, more or less as I have said that the void fraction is gives us a measure of the (()) composition of the two phases. So, therefore, unless we can measure the void fraction, we do not know the composition, unless we do not know composition, we do not know the mixture density the (()) velocity etcetera etcetera. So, therefore, the first thing in industrial situations is to calculate the pressure gradient or the pressure drop. If you have to calculate the pressure gradient or the pressure drop? As you already know that for the gravitational pressure drop is the most important pressure drop component for vertical systems that cannot be evaluated without knowledge of alpha or liquid hold up heating.

The next thing is it calculates the liquid and gas inventory which is present in the system. And so, therefore, suppose you have to calculate, what amount of material is needed within a chemical plant? So, now therefore, for such particular applications liquid holdup an estimation of liquid holdup or an estimation of void fraction is very very essential. Then, of course, some special applications there is no pointing in discussing applications of void fraction measurements you already know it, but it is a just some of the salient applications in nuclear reactor absorption and moderation of neutrons related to density of vapor liquid mixtures this also it is related to void fraction. So, therefore, as the last application is just to show as we progress more and more and come across more applications of two phase flow, the importance of void fraction is further augmented.

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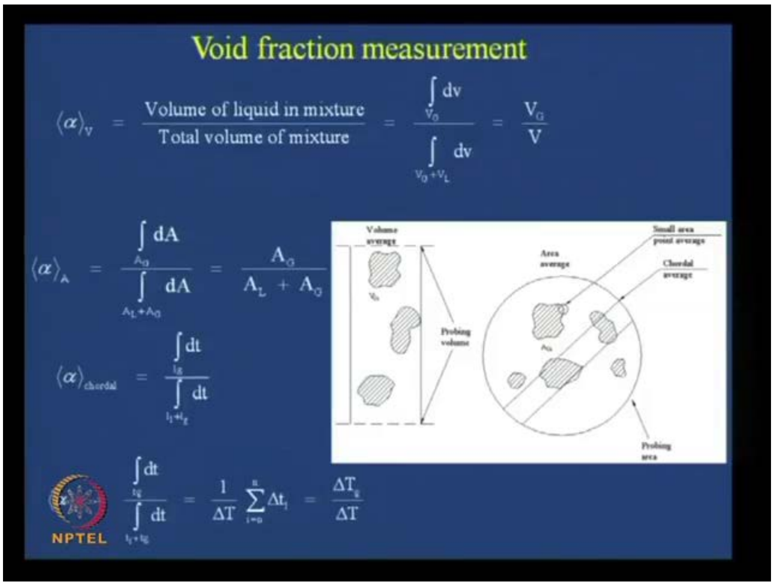

Now, so what are the different techniques of measurement of void fraction? We have already discussed that void fraction or the (()) composition is nothing, but more or less the fraction of the total channels which is occupied by a particular phase. Fraction of the total channel; obviously, means the fraction of its total volume or it; obviously, means the volume fraction, void fraction of the volume fraction liquid holdup. But as we had already discuss in order to see, suppose you have to measure the volume fraction. So, the entire volume has to come into your control, several times it happens that it is not always possible to measure the volume fraction void fraction. So, therefore, then we go for an area average value as I have shown here.

And under study state conditions, we for fully develop flow we can assume that area average gives a reasonable estimate of the volume average void fraction as well. There can be circumstances, where neither the volume average nor the area average is possible. Under that circumstances, what we do? We go for the cordial average void fraction, which gives us the void fraction across the; see the diameter of the channel cross section or across any particular cord. I shown it here, you can see it this gives you the volume average if you concentrate on a particular cross section then this entire thing gives us the area average have already discuss these things may here.

For example, suppose we concentrate on a very thin section very thin segment, it gives us the cordial average. Now, there are certain times, where we would like to have a idea of the point average, if you say at the void fraction at a point as I have already mentioned long long back, did our introduct, the lecture that the point average void fraction as got no meaning, because the void fraction at a point will either be one or zero. So, in this particular key what is relevant the variation of void fraction at that particular point or if we take if we measure the void fraction at the point over a good length of time. Then, in that case ford fraction or during ford fraction of the time that particular point was occupied by the gas phase, ford fraction of the time that point was occupied by the liquid phase.

Or in other wards it gives you the time average void fraction there is nothing like the point average void fraction. This is particularly important why because from all these above quantities we had obtained the average void fraction over some particular section of the channel. It can be over a volume element and area element across are called, but it gives over that particular element it gives the average void fraction. But this thing it actually gives us the distribution, it is sometimes very important to know the distribution also rather than the average values, because once you know the distribution say for example, you want to perform a chemical reaction a gas liquid or liquid liquid whatever a reaction.

Naturally, the rate of reaction will depend upon the distribution, how they are distributed in some places? If they are fusty distributed the reaction will take place at a lower rate, where there is a larger concentration of reactance reaction will take place, because at a faster rate. So, we would always like to ensure that they are more or less uniformly distributed or else we would like to predict the rate of reaction by knowing the distribution. Unless, we know it, just if we assume some average value then we might not get correct results. So, it is very often very important to know the profile rather than the average value, in order to find out the profile the time average void fraction is very very important.

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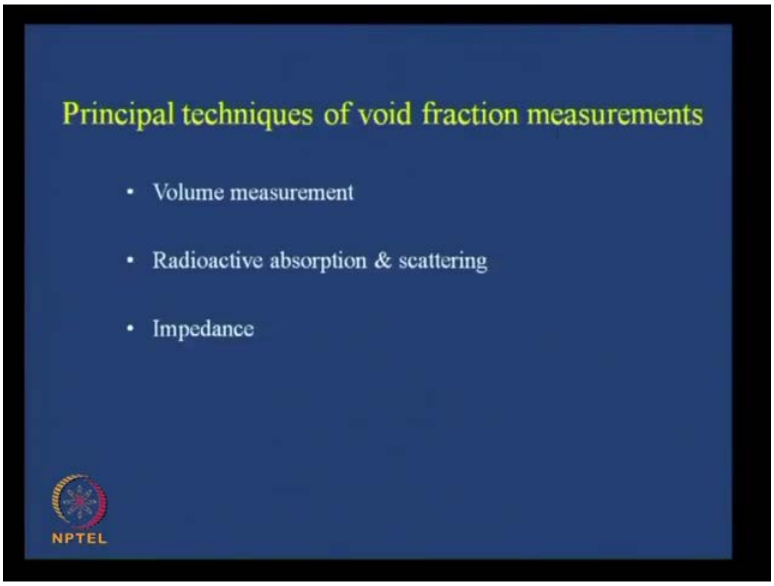

So, there are different techniques of measuring the volume average, rather the void fraction measurements. They can broadly we categorized into volume measurement, simply by some process you very directly you measure the volume which is occupied by phase one volume which it is occupied by phase two. Naturally, this is the most direct method and this is the most standard method definitely this; there are some problems in using it in industries due to which other measurements of come up. But remember one thing; everything has to be calibrated with this volume measurement value before they can be used for further applications right.

So, therefore, the one thing is direct volume measurement. Now, remember one thing whenever we are trying to measure void fraction, we have to keep in mind certain things. See, we have to explode some particular physical property, which is different for the two phases, do you agree with me? Only that particular physical property will have a particular value inside the gas phase a different value in the liquid phase something intermediate, when it is a two phase mixture?

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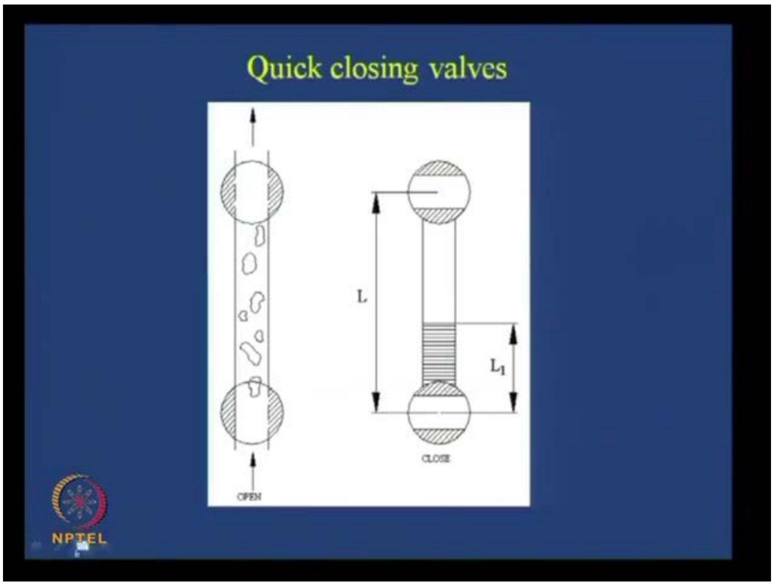

If we have or rather if we can identify such a type of physical property and it is not very difficult to estimate or measure that particular physical property. And more or less its response is quite fast, it is not very expensive, we can adopted for void fraction measurement? Correct some property has to be there, which is widely different for the two phases of; what can it? Be first thing is density; it is definitely going to different for the two phases. So, based on density the two phases can separate out and we can measure the measure the fraction. The other thing suppose it is not so very easy the volume measurement I will tell you, the most direct way of doing its very evident to you a two phase mixture is going there are two valves attached at the two ends or across a particular section of the entire test tricks.

They are close simultaneously this it is very common technique they are close simultaneously to arrest the two phase mixture within them. Now, once they are arrested naturally so, the difference in density they will separate out it is very easy to measure the void fraction or the liquid holdup from this particular measurement very easy, very accurate. And in fact, all methods are based on this particular technique, but if it was so very easy. So, very friendly everything then there was no need of devising any other method. It must be having some advantage, disadvantages despite so many advantages when we are not adopting it as a sole method definitely there are some problems with it.

What are the problems of this particular technique? Which is known as the quick closing valves techniques. Remember certain things they are has to be valves at the top and bottom, important thing is they have more or less they should not be obstructing the flow when they are fully open. If the obstruct the flow there fully open? Then definitely they are going to influence the flow distribution here the void fraction here and we in that case we will not get an accurate measurement. First thing there inside both should be equal to the diameter of the tube, so that they do not obstruct the flow.

What is the second thing? Both of them have to be closed very fast and simultaneously, instantaneously and simultaneously. So, that at one particular instant both of them are closed and the mixture gets arrested. If we take of finite time to close then during that time the flow distribution will be changing, because in that particular finite time naturally this it is going to obstruct the flow passage and the flow distribution is going to change. So, definitely we cannot use a gate valve for this particular purpose the normally the thing which is done is we can use to valves or may be electrically operated solve in ad valves which is the best, because in that case many one or two particular switching of is going to stop the flow there.

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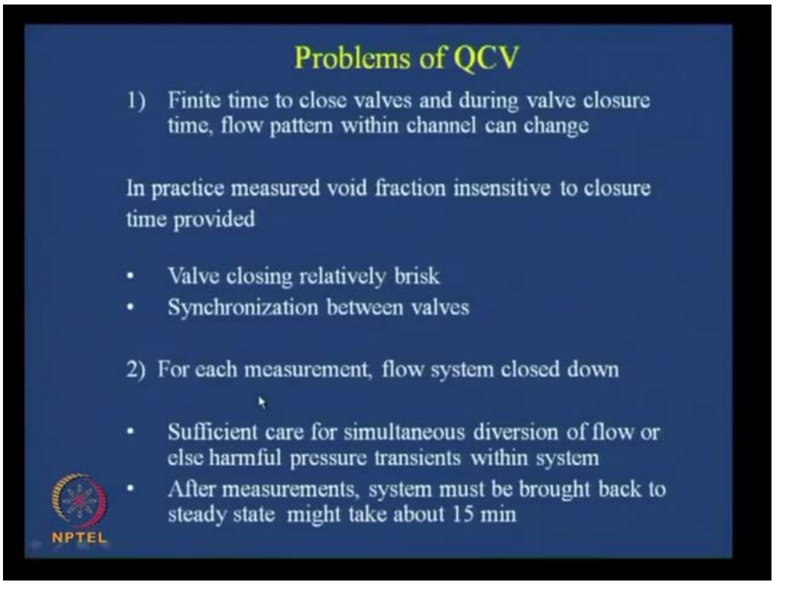

The other thing is; suppose you use mechanical valves then in that case they have to be linked up by some particular mechanical linkages, so that they can be closed simultaneously. So, these things have to be kept in mind. So, in short what are the problems of quick closing valves techniques, first thing is it takes a finite time to close the valves and during valves closure time flow pattern might change within the channel. So, in practice it has been observed that void fraction is more or less (()) to the closure time. If the valves closing is relatively brisk and there is proper synchronization between the valves are both of them can be closed simultaneously. But the most important disadvantage I did not tell you, see when you are practicing then (Refer Slide Time: 10:16) what you are doing? You are actually stopping the flow, you are closing the valves you are actually stopping the flow.

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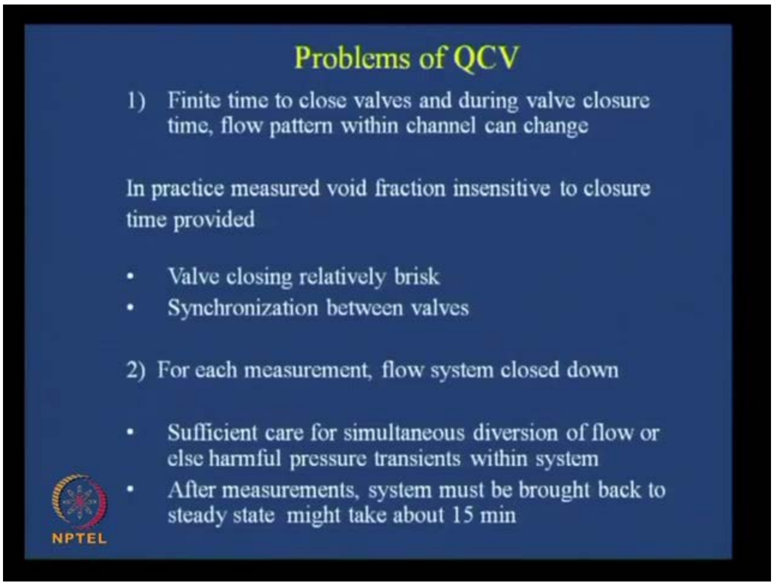

Now, thing is you have to keep two things in mind this flow then as to be diverted through some other portion or other otherwise it will accumulate and it will create a large amount of transient pressure may be the blow down of the (( )) of the test section. So, this firstly, has to be kept in mind. The other thing is or else you can simply stop the flow you can just close the valves, close pumps everything even stop the flows. Again you have to start every after every reading of holdup. So, therefore, what you have to do? Every time, first you have to stop the flow and may be you have to divert it to some other area or you have to stop it completely.

Then, once after the measurement is done again you have to start the flow; for flow in this particular direction, again you have to wait for the entire system to attain steady state and again you have to take measurement. So, therefore, it is means that it is a very time taking process and in industries you very well know that we cannot start and stop the flow in this particular manner, so very frequently. So, therefore, it is not used in on a large scale, but definitely it is used for calibration of the other techniques. This is definitely the best and the most accurate technique and this is usually used for calibration and they may be the technique which has been calibrated is further used.

That technique definitely it has to be an online technique, so that the flow need not be stopped at every at after each measurement like it is done for the quick closing valves technique. So, this was one definitely this is based on a difference intensity of the two fluids, this is one. Apart from this, what other physical properties do you anticipate is going to be different for the two phases, some particular physical property which we can exploit. May be some particular fluid will absorb a greater amount of say a radiation, may be gamma rays or x rays beta rays or something, some other fluid will absorbable lesser quantity.

Naturally, suppose it is water, water will absorb a greater of gamma radiation, gas will absorber a lower amount of gamma radiation or any particular radiation. So, therefore, if we know that; well with a tube full of water, this is the amount which has we which is absorbed. If we know with a tube full of air or empty tube this is the amount absorbed under two phase flow condition, you will get some particular amount of radiation absorb. So, that if you can link it up in a straight forward manner with the composition then probably this can be a technique. What is the other thing? Usually we find that the electrical conductivity or the electrical capacitance at different for the two fluids. So, the impedance technique can also be taken.

Lot of methods can be used, we find that the velocity of sound is different in the two medium. If we can measure the velocity of sound in only air only water two phase flow and then if you can co relate to void fraction, this can be used, large number of radiations can be used. It can be gamma radiation x rays, beta radiation neutron by emission micro wave radiation, infra red radiation lot of things can be used. But it is always not very easy to co relate your difference in physical property with void fraction in a straight forward manner, that we have to keep in mind before you can adopt any technique.

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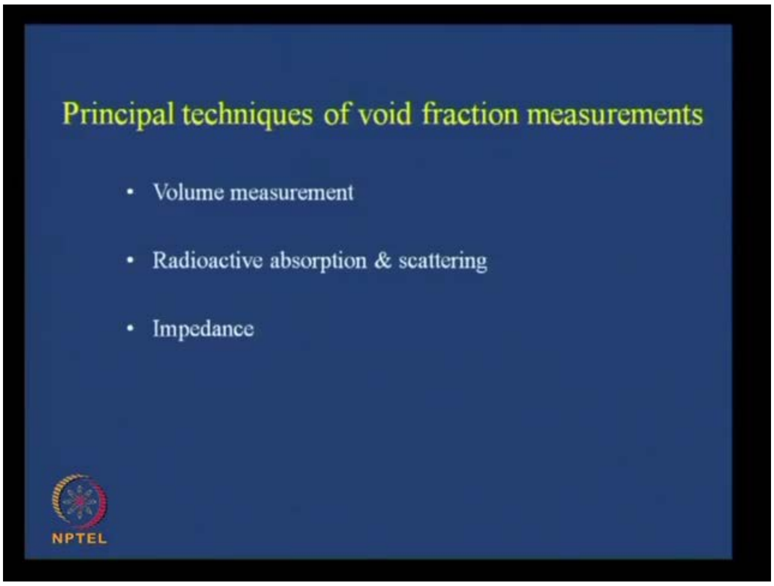

Now, the most widely used techniques which are used is one is definite volume measurement, the direct method I have already discuss the quick closing valve method. There other indirect methods also which are device in order to see that the system can need not be close term every time after the measurements. But they are also not very successful, in other some indirect volume measurement techniques as well. The next thing is radioactive absorption and scattering. We can measure the amount of radiations which is absorbed or may be the disperse phase it is scatters radiation the amount which its scatters.

We can combine the two also in order to know the void fraction as well as the void distribution, that also we can do. Third technique is the impedance technique which is based on the difference in the impedance of the two phases, it can be either the conductance conductivity of the two phases or the capacitance of the two phases. So, theses are usually the techniques, which are used the most widely used technique is the radioactive absorption and scattering. And then the impedance certain other techniques are coming up now. (Refer Slide Time: 10:16) And they are being used will be discussing them in short at the end of the this class.

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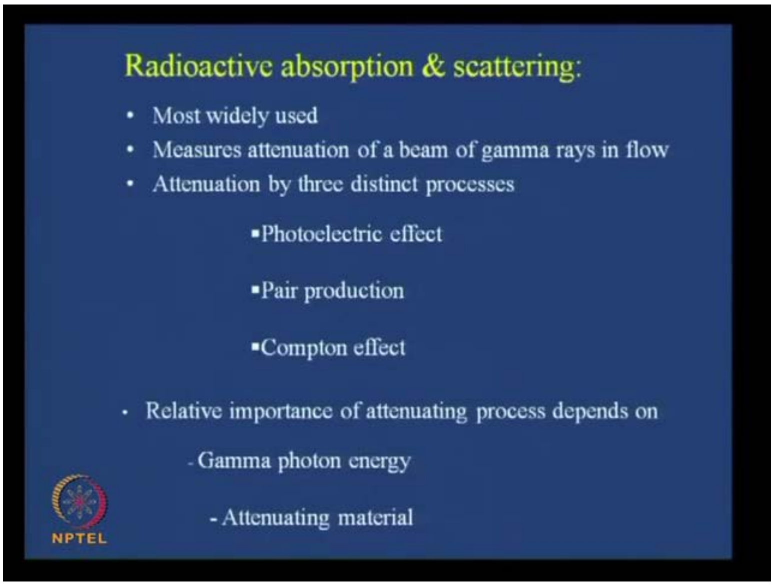

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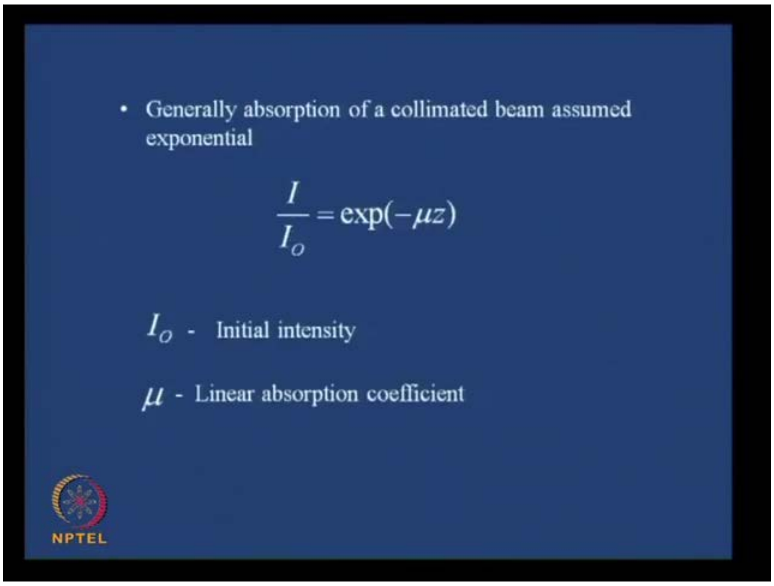

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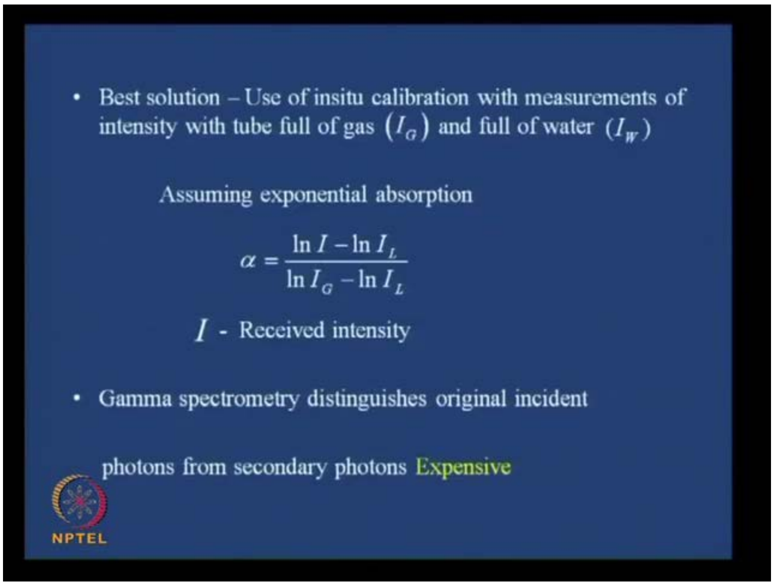

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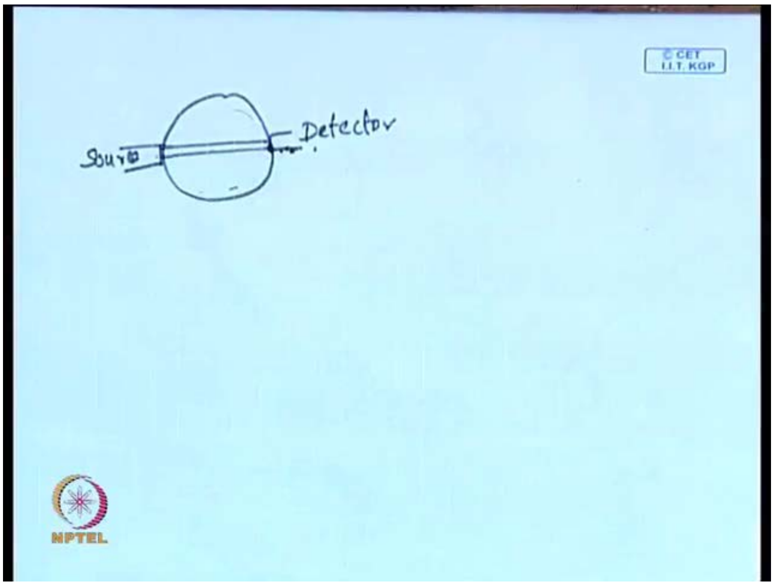

Now, what is this radioactive absorption and scattering techniques? Usually the technique, which is used is it measures the attenuation of a beam of gamma rays during flow, what happens? We have a source, I do not know further I have a photograph no I do not have a photograph. So, what do; what we have? We have a; say suppose we have the channel cross section. Here we have a source of gamma radiation here this emits gamma rays, the gamma rays it penetrate through the valve flow through the flow passage and then on the diametrically opposite point, there is a detector.

So, this particular detector, what happens, while it is flowing? It is penetrating the valve the two phase mixture and the other valve and reaching the detector in the process, a good amount of it is getting absorbed. So, therefore, the amount which is absorbed the rest amount will be; some amount may be scattered also rest will be transmitted the amount, which is transmitted that falls on the detector. And we actually measure the amount, which is transmitted and from that we try to get a measure of the void fraction. Now, usually we find that this particular amount which is attenuated that is a better word compared to absorb, that takes place by usually the three methods which I have written down here.

If you see this transparency the three methods or the three distinct processes by which they take place they are the photoelectric effect. Now, in the photoelectric effect, what happens? The gamma photon it first strikes a particular or rather, while it is going through any particular two phase mixture, it gives all its energy to any particular atom causes electron ejection from the inner orbit, this is the photoelectric effect. The other thing, what can happen? It pair production, what is that? It; in this case the photon it creates a positron electron pair and in the process it gets absorbed. Then, this particular positron; this again produces too much lower energy photons. So, this is the pair production and this occurs usually at high gamma energy, where the secondary photons are much readily absorbed as compared to the incident beam.

So, in the first case what happen it simply strikes an atom, it librates an electron gets absorbed in the process pair production it produces a pair of positron, electron. This particular positron, this again produces too very low energy photons, which is of much lower energy as compared to the actual stores intensity and in the process after they are produced they are also completely absorbed. So, therefore, we can assume that more or less by this pair production also the gamma radiation is more or less completely absorbed by the mixture. And this is usually applicable when we have a very high intensity gamma source or a strong gamma source.

The other is; other technique or rather other process by which attenuation takes place is the Compton Effect. Now, in this Compton Effect for what happens? This gamma photon it interacts with in atomic electron and it gives some energy to this atomic electron and after it gives some energy it has a reduced energy now. So, it now proceeds at a reduced energy in an altered course. So, since it is as a reduced energy and traversed altered course, it is expected that it does not reach the transmitter in the diametrically opposite point, do you get my point? So, therefore, by this particular process also the energy which is scattered that is more or less related to the initial intensity and that particularly we can calculate the amount which is absorbed.

Now, which process is going to be important out of the three the photoelectric effect, the pair production, the Compton Effect? Out of these, we find their relative importance of the attenuating process that depends on two things what is the gamma photon energy. For example, if the energy is high pair production is more important and remember one thing for Compton Effect also more or less there as to be a good amount of difference between the incident radiation and the scattered radiation, if more or less both of them are a similar energy then in that case both will go and strike the transmitter.

The transmitter will not be able to differentiate between the scattered radiation and the incident radiation. So, therefore, these things have to be kept in mind. So, therefore, the attenuating process it depends upon the gamma photon energy and also on the attenuating material. If it is metal it is something, if it is liquid it is something, if it is gas it something else. So, therefore, for our two phase flow we can say if it is only what are it is something if it is gas, it is something else. If it is a two phase mixture then it will be something in between gas and liquid. Now, what it will be; what value it will have? That will not only depend upon the proposition of gas and liquid it will also depend upon the distribution of the gas and liquid to some extent.

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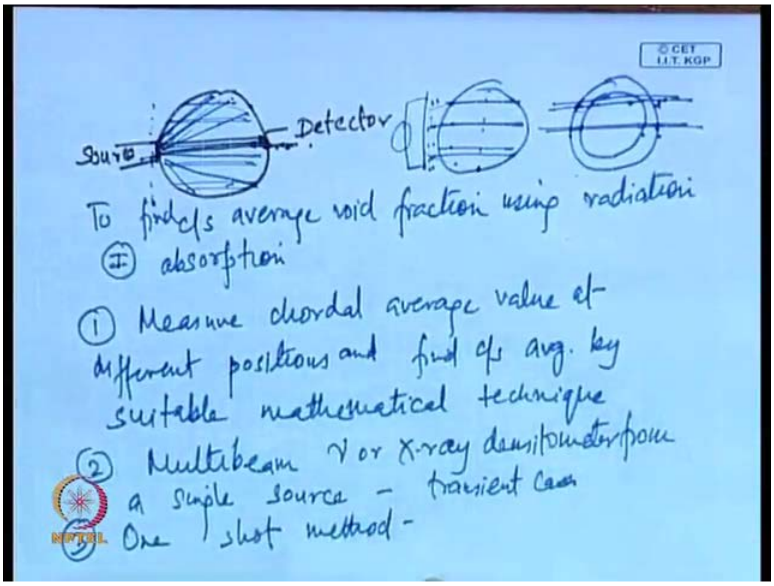

But, usually we find that whatever be the attenuating process we find that (Refer Slide Time: 19:02) the absorption of a beam it is assume to be exponential. Usually the absorption of a collimated word I do not know, whether you have heard it previously. It is just to ensure that the rays of the beam are more or less parallel to one another. Usually when you have a slots what do have this particular; suppose here I have drawn this particular source from this particular source the (( )) the rays will come out in all particular direction. So, therefore, depending upon the path which is travelled, naturally the amount absorb is going to change. So, therefore, if we have to ensure that more or less equal paths have been traverse then we have to ensure that the rays are parallel to each other.

In order to ensure that (( )) some collimators are used and therefore, you will find mostly when you are working with radiation people say a collimated beam and remember the other thing also, it is also very important that we have a very small source. So, that this beam can be as narrow as possible, such that it can give us an idea recording Chordal average void fraction. This also has to be remembered; otherwise we are not going to get the Chordal average void fraction in this particular way. Now, once we get Chordal average void fraction, naturally or a ultimate saying is to get the volume average or the area average. Now, how to transform, how to convert this particular Chordal average into cross section average? There are two things that we can do.

We can place the source at different particular positions along the test section and that each particular point we can measure the Chordal average void fraction. Once we get the Chordal average void fraction as a function of position then we can find out the cross sectional average value by suitable mathematical manipulations. So, the first technique of finding out the cross sectional average void fraction using radiation absorption techniques. The first one is measure Chordal average value at different positions and find cross sectional average by suitable mathematical manipulations. So, this can be one technique, what else suitable mathematical technique.

Now, remember one thing if we use this technique then we cannot measure transient values this will give you a time average this, suppose this particular void fraction, it is varying with time is transient response we cannot get by the technique which I have measured. For transient cases, what you need? You need the a large number of beams at the same time which is illuminating this particular cross section, is not it? This particular cross section at the same time if you have a large number of very narrow beams then we can get a transient value.

So, therefore, this can also be one, in this particular case what we do you can use a multi beam gamma or X ray densitometer from a single source. So, from a single source we can use a multi beam gamma ray densitometer or a multi beam X ray densitometer from a single source at this is useful for transient cases. And this is definitely now a days it is very widely used in nuclear reactors safety work for blow down studies, very widely it is used in nuclear reactors safety work for blow down studies. What is the other technique that we can used? The other technique, it is usually known as a one shot method you must be coming across this in your textbooks.

This is nothing, this is we have a very instead of a large number of radiation from one particular source we have a very broad radiation, which is almost the size of the channel. A very broad source we have which is almost the size of the channel and then we have special collimator arrangements here which adjust for the different path links and valve absorption, is this part clear to all of you? So, what we do in this radiation absorption? We measure the amount which is attenuated. The amount attenuated that depends or rather that takes place by three techniques as I have written down it is the photoelectric (( )) effect the pair production the Compton Effect.

Now, we find that from all this techniques whatever, be the technique more or less the absorption of a collimated beam this can be assume to be exponential, where I is the initial (( )) sorry I zero is the initial intensity I is the intensity after absorption mu is the linear absorption coefficient z is the axial distance which has been covered. Definitely this mu will depend upon the attenuating material and the source and therefore, for two phase flow this mu is going to vary with the composition of the two phase mixture. And we find from here we can get Chordal average void fraction from the Chordal average we can get the area average by either of the three techniques.

The first technique is we can measure it at different particular positions and then we can obtain the area average by suitable mathematical manipulation. The other thing is we can use multi beam densitometer where the multi beams are generated from one particular single source and we; this is particularly useful for transient cases. The other thing is known as the one shot technique, where we have a very broad source which is a same as which is almost of the same dimension as the channel from that particular source using special collimators, because whenever we use a one particular source there is a tendency of diverging.

So, therefore, we have to use special collimators such that each ray is parallel and we have to also keep in mind that sees suppose; this is the channel. Now, any particular beam which is coming from here and a beam which is coming from here it has to cross a lower proportion of the channel valve, here it has to go through higher proportion of the channel valve a lesser proportion of the flow passage. So, these things they have to be adjusted. So, therefore, we; the special collimators they must be a; we design such that they adjust for the different path links that are being traverse here in any case the path length is small here the path length is larger.

So, therefore, therefore, it has to adjust for different path lengths which are traverse and also the valve absorption the different amount for valve absorption which takes place. But this one shot technique this is because this densitometer which is quite expensive. So, it is one shot technique is quite popular in that particular way, but whatever, be the technique that you are using see. Firstly, the initial measurement has to be accurate unless the basic Chordal average void fraction measurement is not accurate it is very difficult to get an accurate area average value so. Firstly, the initial measurement has to be accurate and then the subsequent mathematical operations of whatever you are doing that has to be accurate. Now, for accurate measurements we know that usually the absorption it follows the exponential relationship.

So, the best way in to get an accurate measurement is (()) calibration. Under the condition of the experiments, you actually fill the tube full of water you actually and you perform the radiation absorption experiment. Then, you empty the tube completely when it is full of air, there is no water in that case you see the amount which is absorbed and after that you start the experiments. And to find out that, what is the amount absorbed under the actual two phase flow conditions? Now, we know that their relationship is exponential as I have shown you in the previous slide the relationship is exponential. In the transparency that I have shown you this particular relationship this is exponential.

(Refer Slide Time: 19:03)So, therefore, if this exponential relation has to hold then definitely your void fraction should; we should get void fraction from something of this shot, is not it? From this particular; this sort of a relationship we should be able to get a value of the void fraction. But remember one thing, the relationship it will definitely depend upon the distribution of the voids, because the mu it is a function is linear absorption co efficient it is a it will be function of the distribution the amount of voids and so on and so for.

(Refer Slide Time: 19:03) So, therefore, by this particular technique we can find it out now. Remember one thing, suppose we have a hot source, hot source means, the source where the amount which is absorbed is less even in case of water filled tubes, they strong source means high intensity hot source means a source in which the amount absorbed even when the tube is full of water is also very small. Under that condition, what happens? The amounts absorbed they are very less, is not it? When the amounts see whenever work with some very small quantities, we can assume linear relationship this you all of you know. Whatever, be the actual relationship if you are working with small quantities we can assume the relationship to be linear.

Now, whenever the relationship can be assumed to be linear the mathematical computations become much more simpler. So, there can be cases where you refer to work with hot sources, just in order to obtain linearized output. So, that getting void fraction from the measured intensity becomes much more; straight forward and simple to calculate this is one particular thing.

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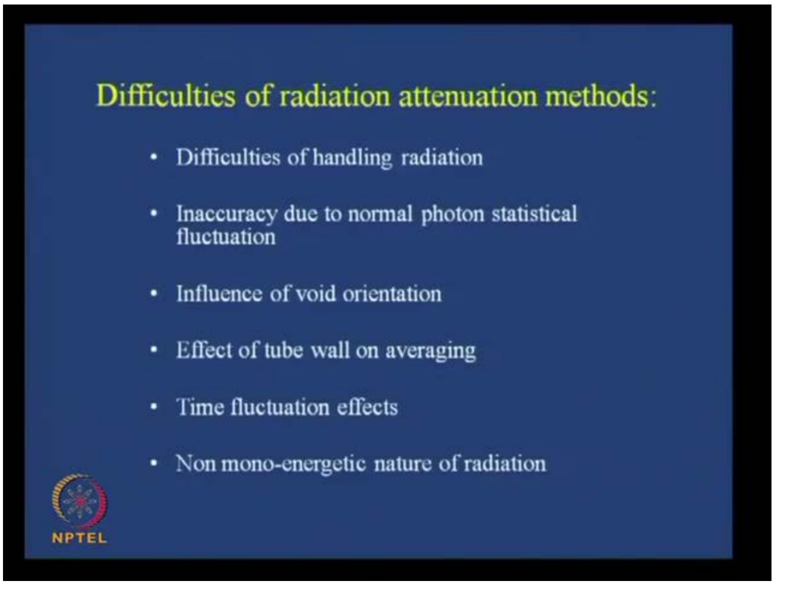

Now, what are the difficulties in of these particular radiation attenuation techniques, that definitely has to be some difficulties otherwise this would have been the standard technique. First difficulty there is no point in discussing it all of us know it is just a difficulty of handling radiations, is not it? So, handling radiation itself is as address number one difficulty, number two is that there are some in accuracies due to normal photons statistical fluctuation. Some errors come up due to, because see this photons are absorbed and the photons are then emitted etcetera etcetera.

So, good amount of in accuracy comes out due to normal photons statistical fluctuation. The only way to minimize this particular error is to have long counting times. So, if you have a very long counting time, because this particular error it is inversely proportional to the number of counts that you take. So, if you have a very long counting time the number of counts are lot automatically this error gets reduced.

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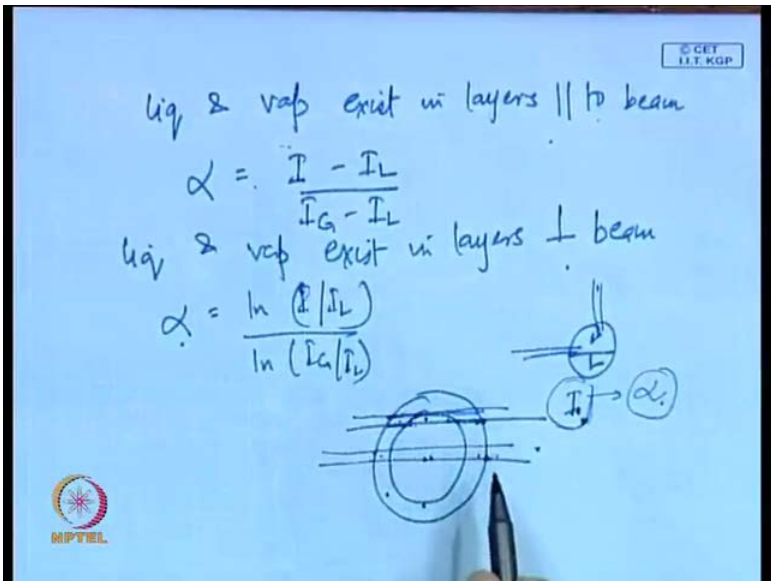

The other thing which I was telling this is influence of void orientation; because we find may I do not have it. The influence we find that the relationships are completely different. If we have say the voids are oriented parallel to the radiation and if the voids are oriented perpendicular to the radiation. Usually people have found the out that when the liquid and vapor exist in layers parallel to beam, under that condition alpha becomes equal to I minus I l by I g minus I l. And when liquid and vapor exists in layers perpendicular to the beam; that means, this liquid and vapor they are oriented in this; this is vapor, this is liquid and may be the radiation is falling this way or may be the radiation is falling perpendicular.

When it falls perpendicular? Under that condition alpha equals to l n I by I l by l n I g by I l. So, we find that even for the void orientation if the orientated perpendicular to the beam or parallel to the beam the expressions are completely different. So, therefore, and also we will find that if it is separated flow and this is dispersed flow, we have different expressions to find out alpha. So, therefore, we have to find void fraction void orientation also becomes important. Now, in for this particular purpose, what can we do? The only thing that we can do is we can take up a very; sorry a very hot source.

Such that as I was telling the amount which is absorbed even for the tube full of water is also very less, if that that is the case then more or less all the outputs can be assume to be linear and we need not have to bother with the orientation after voids are the flow distribution or the distribution of the voids. What is the other thing? Other thing as I was mentioning that the tube valve effect comes averaging and this has to be kept in mind in this particular case if it is flowing it has to travel through a large number of tube valve. Or else in this particular case a very small proportion of the tube valve has to is covered.

So, therefore, this has to be kept in mind when we are see the problem is; if we just see the amount absorb no problem when we want to use it to find out something quantitative, you want to find out alpha then in that case we have to keep in mind. That is, see suppose in this particular case we get a very low value of I the measured intensity, it does not naturally mean that a large amount of liquid is here, it may mean that the large amount of valve had to be traverse and thats why the amount attenuated was high the amount transmitted was low, do you get the point? So, therefore, we have to keep these in mind when we are actually using this particular I to find out alpha, because we are trying find out something quantitative here.

So, therefore, this particular measurement and this interpretation has to be very very accumulated. This particular case the I which we get, here the I which we get both this I is cannot be related by the same equation for alpha. Here we have to make a lines what the fact that the radiation is travelling over a larger distance where as in this particular case it is travelling with the smaller distance. So, this effect of tube valve on averaging, because the; from this what will get? Will get a series of I s or a series of alphas then we will average it and will get the area average value. So, while we are doing it we have to keep in mind I we have got from here the I we have got for from here both of them cannot be subjected to the same averaging loss.

What are the other problems? Time fluctuating effects this is something very normal for two phase, it is random, it is cavity always there are fluctuations. Particularly if you take of the flux slow pattern, in the flux slow pattern what you have at some point only gas is going may be you have I g, which you will you will get I almost equal to I g at some other point you will get I almost equal to I l. So, if you just perform on arrangementing average it is just always you will get the void fraction as 0.5. So, in this particular case then average value does not give you the accurate void fraction, the weighted average has to be taken please keep in mind this particular thing.

The next point which had written down the time fluctuating effects keep this in mind at this is very very important, particularly if considering the time fluctuating characteristics of certain, you are the certain flow parameters particular the flux flow. Now, in order to reduce this, what we do? We use two different sources, which have widely different your strength or intensity of the incident radiation, one may be a very hot source one may be a very strong source one emits a radiation of high intensity the other emits a radiation of much lower intensity. Then, we make measurements with both of them and then we try to find out the average in this particular case we find that the average is much more accurate as compared to using a single source.

And what is the other one the last one which is very important, remember one thing whenever we are trying to find out you are alpha it is very important that we get in accurate value of I I l I g etcetera. Now, for getting these the first thing is the incident radiation, all these relations if you remember all these relations come from the basic expression where I have shown. So, therefore, in order to get an accurate value of I we have to maintain or rather we have to maintain a constant value of I zero number one. So, the radiation must be of constant in density, the other thing is; see we can never work with a ray. We have a beam, the beam can be very narrow, but it has to be a beam. Whenever, it is a beam, it comprises of a large number of rays each ray will have a different intensity.

(Refer Slide Time: 19:02) So, therefore, this I 0 of gatt incident beam this might vary and if this varies it becomes a problem. So, we have to see which particular source gives us a more or less mono energetic beam of radiation, this is very very important. The other part is as I had already mentioned see the attenuation takes place by three methods if you remember in the Compton Effect, what I said? That it gives some amount of its energy to the atomic electron and then it proceeds with lower energy, do you understand? Now, suppose this; the basic radiation it has got a range of intensities and Compton Effect is also taking place.

So, from that the scatter radiation that will have a lower intensity as compared to the incident radiation now, if this lower intensity falls within the range of the incident beam then we cannot differentiate between the scatter beam and the incident beam. So, therefore, this is also very very important, the mono energetic nature of radiation has to be ensured and this is always not possible. In order to ensure this usually, what we do?

Usually two sources are used mostly for radiation absorption techniques, one is the thulium source the other is the cesium one. These two source are usually used iridium and such other sources are not generally used, because they give us more or less a mono energetic nature of radiation and cesium is of course, a harder source as compared to your thulium source.

And remember one thing see an optimum has to be struck, because for several things for example, in order to minimize the normal photons statistical fluctuation error we need a long counting time or we need a very hot source. (Refer Slide Time: 36:08) But again for minimizing the influence of void orientation, for minimizing effect of tube wall on averaging we need a very hot source, hot source means? When the intensity absorb is less even if when the tube is full of water. So, therefore, what we have to keep in mind? We have to keep in mind that we have to strike a balance between a hot source and to strong source, for some cases a hotter source is useful for some cases a stronger source is useful. Usually a hot source is preferred in order to get linearized outputs. If we have to use a strong source then we have to ensure that the output is linearized and then by suitable techniques and then we can use it.

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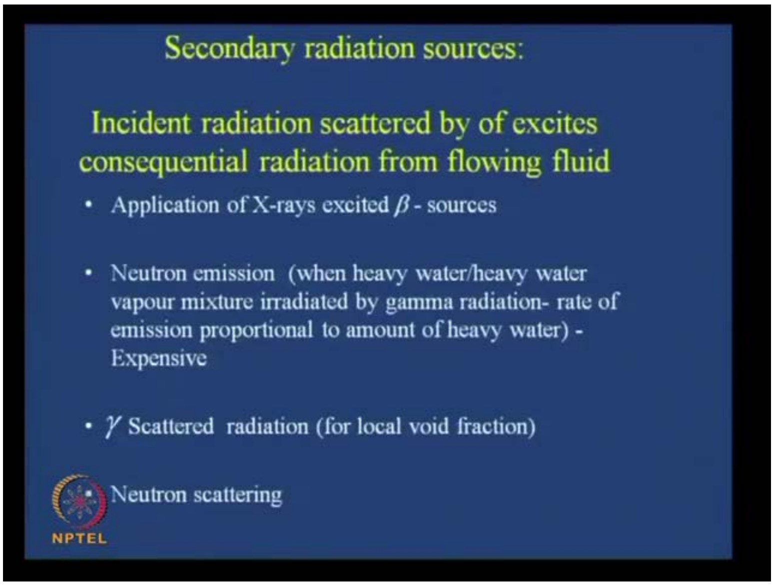

Now, apart from radiation attenuation, there are certain other techniques also which are usually used. It can be; that may be the radiations which is incident on a particular two phase medium that is scattered instant of measuring the amount which is transmitted we can measure the amounts, which is scattered this can be one technique. The other technique can be; this particular radiations which is incident on a particular two phase medium, this; it emits or it forces a secondary radiation to come out from the medium that can also happen. So, we measure the intensity of the secondary radiation which is come out.

So, these radiation techniques they can be radiation attenuation technique, they can be radiations scattering technique and they can also emit a secondary radiation from the flow passage whose intensity can also be measured. So, this secondary techniques are as I have said that is what happens we can have instead of a gamma source you can have a beta source, what the; it does? This normally, this beta rays they are not very useful, why because they are very easily absorbed by the tube wall. So, therefore, very less amount passes through the two phase mixture. But sometimes what happens this beta sources they when fall on the two phase medium they emit X rays from the two phase medium, is it clear?

And the amount of X rays, which has been emitted that is measured this is; this can be one thing the other thing is say suppose we have heavy water heavy water vapor mixture. So, this particular heavy water heavy water vapor mixture this can be irradiated by gamma radiation. Now, when it is irradiated by gamma radiation then, what it does? It emits a large number of neutrons, from that particular source. From this particular heavy water heavy water vapor mixture it emits a good number of neutrons and what we can do? We can actually measure the rate of emission of the neutrons in this particular case this is much more accurate, why because we are directly measuring the amounts (Refer Slide Time: 37:42) which has been emitted instead of measuring the amounts which is absorbed and then subtracting two large quantities, is not it?

We have to subtract I minus I l by I g minus I l, so we are subtracting two large quantities again number of errors can come up due to that, do you understand? So, in this particular case what happens? This gamma rays they are incident on the heavy water heavy water vapor mixture and then from there they emit neutrons amount of neutrons emitted will give us a measure of the proportion of heavy water in the flow passage. But this is usually done in nuclear reactors it is usually expensive. So, the normal circumstances we cannot use this.

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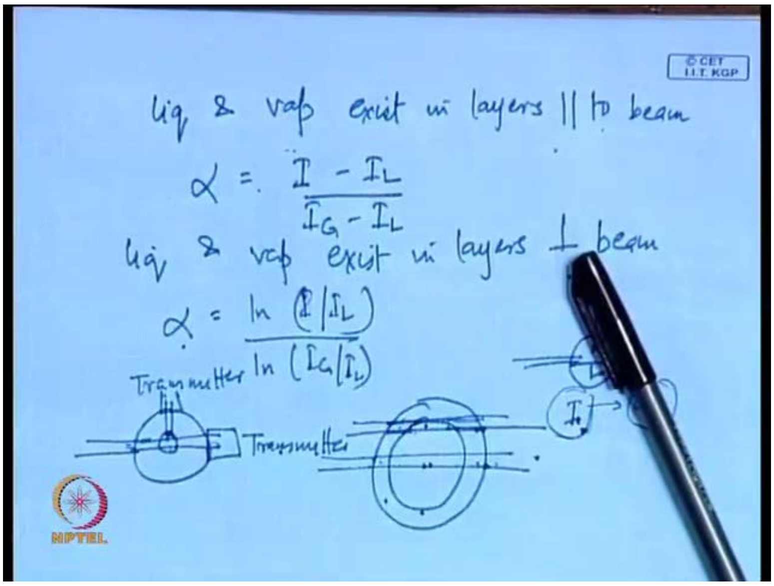

The third method as I have said instead of measuring the amount of gamma rays which is attenuated we can measure the amount of gamma rays which is scattered. If the predominant scattering process or rather the if the predominant attenuating process is by Compton Effect. Good amount of it will be scattered the best thing is if you can measure I think I have got a photograph also, may I do not have that particular photograph. The best thing is suppose from here, we have a gamma source and then good amount of it is absorbed we have a transmitter here and we also have the transmitter here. We can adjust this source such that the scattered radiation it is detected by this particular transmitter the emitted radiation is detected by this particular transmitter and then from these two measurements we can get a very good idea about the local void fraction here.

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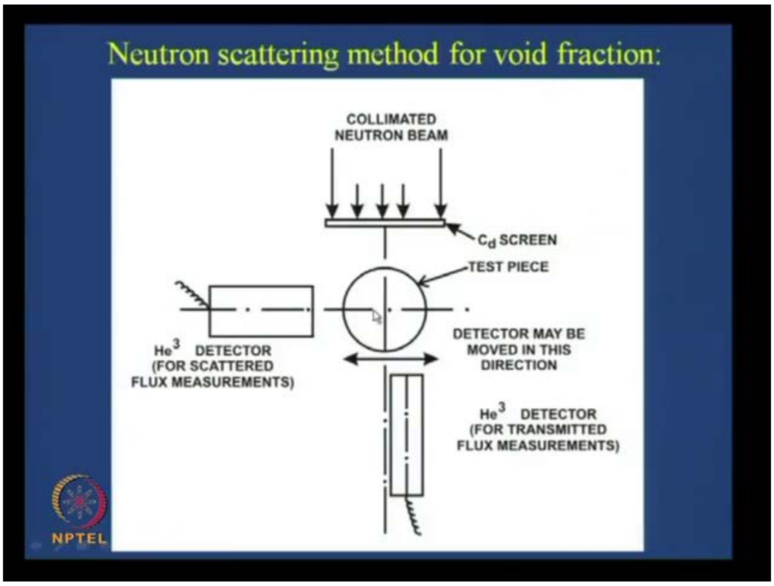

So, this is one more thing instead of measuring the amounts which is attenuated, we measure the amounts which is scattered. And this is very good method for finding out the local void fraction in this particular case. And what is the final technique? The neutron scattering method, for this; what we have to do? We have to place the medium in a neutron beam just as I have shown you and then from here good amount of it is a scattered good amount of it is transmitted. So, the transmitted from here the neutron beams come and then the amounts which is transmitted, it is noted by this detector the amount which is scattered is noted by this detector and we can use this. The only requirement of this method is to have a good neutron source here.

So, these were some of the techniques for radiation absorption, which is the most widely used technique for void fraction measurement in the under the present circumstances. So, remember one thing, radiation absorption techniques they usually they operate on the basis that the amount which is absorbed is a function of the two phase composition. So, the (()) calibration is the best we where; we would like to find out the amounts which has been attenuated, when the test passage is full of one phase, when the test passage is full of the other phase. The naturally fen there are mixture of two phases the intensity will lie in between the two relationship between void fraction and measured intensity has to be noted.

And only after that we can use it the only problem is if the relationship between alpha and the measured intensity is linear, naturally it is easier for us find out void fraction if we have to ensure linear relationship. Naturally, we have to use a hot source where the amount which is attenuated even for the maximum conditions when the tube is full of water is also very low, but if we do that? Certain errors might also come up. So, we have to keep into mind those particular errors other than attenuation, there are certain other radiation techniques also which can be used for void fraction measurement they are scattering techniques and techniques where this particular radiation it librates a consequential radiation from the two phase mixture

So, whose emission can be measured, why this is a better technique? Because in this case the amount of emission is proportional to the void fraction and therefore, finding out void fraction from the amount emitted is usually easier or usually much more accurate. But we do not cannot always use it may be either the source is expensive or the arrangements are expensive or maybe there are some asserts in doing this. But overall these techniques are very accurate they are based on the fact, that the amount which any particular substance it attenuates the amount which it emits, it is a function of the composition of the two phase mixture. So, this particular technique is based on the different amounts of radiation attenuated by the two phases comprising of the two phase mixture. It can be gamma radiation, it can be neutron beam, it can be beta rays, it can be optical rays, it can be any other radiation as we shall be discussing in our miscellaneous methods. So, thank you very much will continue with this discussion in the next class as well.