Multiphase Flow
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Module No. # 21
Lecture No. # 37
Measurement Techniques for Two-Phase Flow Parameters

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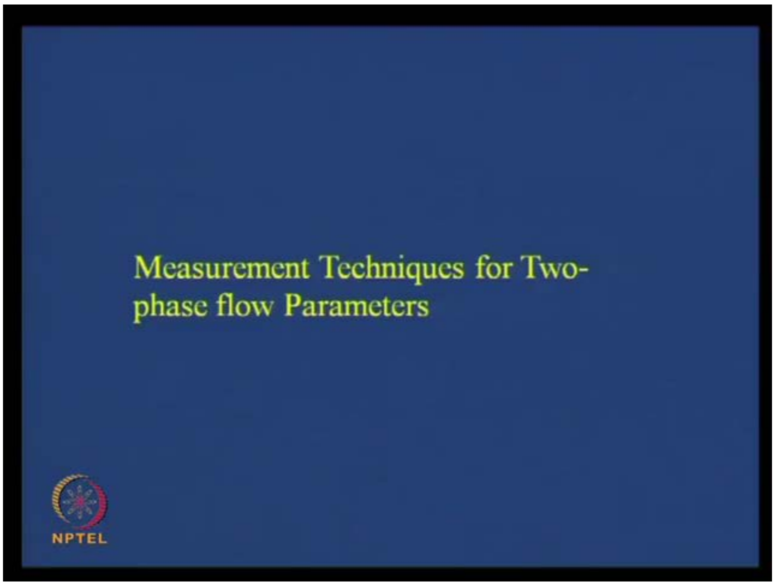

Well. So, we have come almost to the end of the multiphase flow course course course and till now you have studied the different flow patterns the different analytical models florogine based models boiling condensation. So, on and. So, far. So, I felt or rather we felt that the course will be incomplete unless we discuss some aspects of experimentation in two phase flow what are this specific challenges which have connected with the different measurement techniques in two phase flow may be the same thing we are measuring say the pressure drop we measure pressure drop for the case of water flowing through a pipe or in gas filed lines also we measure pressure drop for two phase flow also what are the special problems that we feel when we are measuring different parameters of two phase flow we will be see since a do not have much time what I have decided to do is we will first take up the most common parameter that has to be measured in fluid flow that is the pressure drop you already know pressure drop measurements how it is measured in single phase flows.

So, we will just see what are the added challenges what are the added difficulties while mesassuring measuring two phase pressure drop and naturally how to minimize we cannot eliminate the difficulties completely how to minimize the difficulties and which technique will be adopting for different flow situations next since I do not have time I will be not taking heat transfer coefficient etcectra etcectra.

Next we will take up one particular parameter which is unique to two phase flow the first important parameter which has to be measured for two phase flow is void fractions unless you know the void fraction of the insitive composition of the two phases we cannot do anything. So, I will be go for the void fraction measurement and after void fraction measurement probably I will not be having much time I will be taking up the detection of flow patterns because the once flow patterns are detected once you know how to estimate the void fraction then more or less with this particular void fraction data considering the particular flow pattern which is prevalent we can predict the pressure drop or we can at least perform analytical models to predict the pressure drop and we can also perform analytical analysis in order to predict the heat transfer mass transfer coefficients the chemical reactions kinetics etcectra for reacting systems for two phase flows. So, therefore, the it will go on in this way first will be discussing pressure drop measurements during two phase flow through a pipe.

Next we will take a void fraction measurement or the measurement of the insitive composition of the two phase mixture flowing through a pipe and after that we will be spending about two two classes on void fraction and about one or two classes on detection of flow pattern more or less the techniques adopted for void fraction measurement as well as the flow pattern detection should be the same both of them should work on some particular principal which is based on the difference in any particular physical property of the two fluids isn't it, but in one case we need a quantitative estimation in the other case we need qualitative estimation. So, will we doing void fraction in later details most of the techniques probably we can find out we can use for flow pattern detection remember one thing for void fraction usually it is a steady state sort of a thing and therefore, steady state responses sufficient for flow pattern the time variable response is needed based on the time variable response we will know what is the prevalent flow pattern and then of course, just from seeing the time varying response its not sufficient may be we have to perform some statistical analysis will be just discussing those particular things during estimation of flow patterns.

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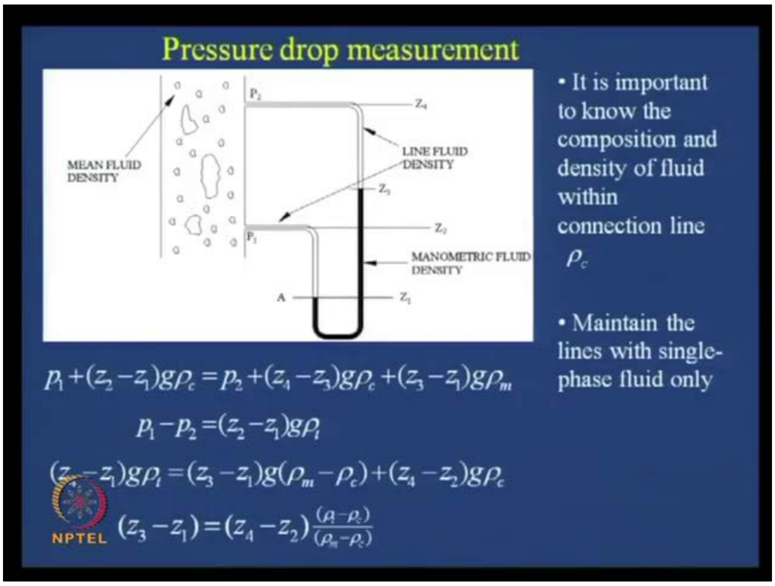

Now, let us start the measurement of pressure drop the very very simple technique you know what you do simply there is a pipe standing there are two pressure tapings you connect the two pressure tapings either to any particular pressure your measuring device it can be a manometer and if we need some better more substituted device will go for transducers you already know that you also know the principal of measuring pressure drop using manometers we just develop that or rather we will just derive that particular portion and then just. So, that you can understand why measurement of pressure drop in two phase flow present certain additional difficulties.

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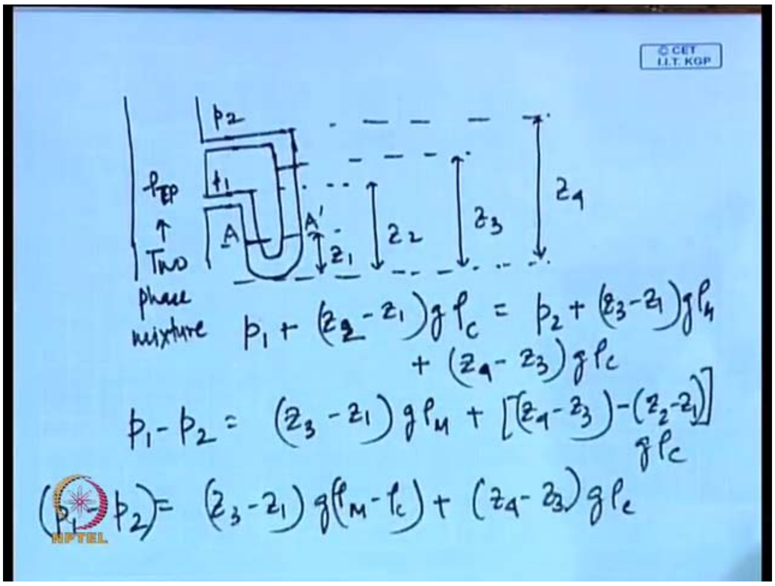

Now, I will just like to re draw the figure once it will be clear to you in that particular case. So, therefore, in this particular case a two phase mixture is flowing it is a two phase mixture which is flowing and this is connected to a manometer line. So, this is connected to a manometer line the pressure here is p 1 the pressure here is p 2 this two phase mixture is flowing it is having a density say rho t p we can put it and here the manometer level is somewhere here it is somewhere here. So, if we take this as the datum then we find that this is going to be say z one. So, z is the vertical distance of different points from the datum that we have selected this will be say z 2 this will be say z 3 and this is going to be z 4 say now in this particular case how to find out p 1 minus p 2 how do you think that we can find out p 1 minus p 2 in this particular case it is simply suppose we would make a force balance across the sections say a A prime suppose we make a pressure balance across this section a A prime. So, what do you what do we find a pressure act a what is it it is p 1 plus z 3 minus z 1 I think there are some mistakes here. So, you just follow my derivation or its all right probably I do not know.

G sorry sorry sorry sorry sorry its all right z 2 minus z 1 g rho c this is equal to p 2 plus z 3 minus z 1 g rho m plus z 4 minus ya z 3 g rho c just let me checkup this is p 1 plus z 2 minus z 1 g rho c this is equal to p 2 plus z 3 minus z 1 g rho m plus z 4 minus z 3 g rho c isn’t z 4 minus isn’t z 4 minus its going to be z 4 minus ya its all right. So, therefore,. So, from here what do we get p 1 minus p 2 if you just rearrange it further you going to get in this particular case your p 1 minus p 2 this will be equal to you have just rearranging it z 3 minus z 1 g rho m plus z 4 minus z 3 minus z 2 minus z 1 isn't it ya z 3 minus z 1 g rho m plus z 4 minus z 3 minus z 2 minus z 1 sorry here also it was z 2 minus z 1 very sorry the basic was it was sorry z it was z 3 minus z 1 g rho m z 4 minus z 3 its all right z 3 minus z 1 g rho m plus z 4 minus z 3 minus z 2 minus z 1 g rho c correct just from the typical force balance we have we we have got this particular part or in other words this can be rearranged can written as p 1 minus p 2 this is equal to z 3 minus z 1 g rho m minus rho c just rearranging this plus z 4 minus z 3 g rho c all right.

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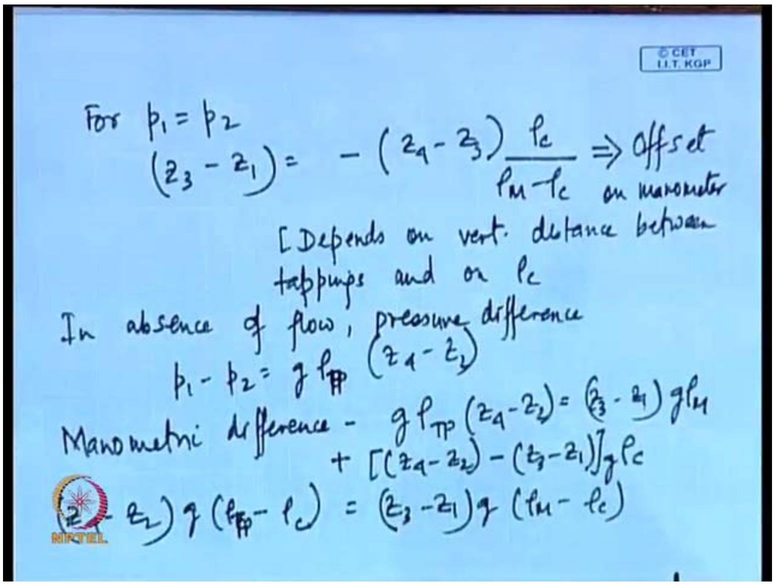

Now, you see when p 1 equals to p 2 what should happen when p 1 equals to p 2 normally what do you feel when the two pressures are the same the two manometer levels should also be the same, but from your mathematical expression do you get that for p 1 equals to p 2 what do you get in this particular case tell me just do it and tell when p 1 minus p 2 equals to zero or when p 1 equals to p 2 under that condition what do you get its going to be z 3 minus z 1 this is equal to minus of z 4 minus z 3 rho c by rho m minus rho c which one p 1 minus p 1 equal to p 2 oh (Refer Slide Time: 04:49) previously which one p 1 minus p 2 equal to this one do do you mean to say z 3 minus z 1 g rho plus z its its all right or else just check up it is simply or your mass valid its simply a force balance nothing else .

So, therefore, what do we find from here if p 1 equals to p 2 then in that case what do you find you find that normally what should have happened (Refer Slide Time: 04:49) your both the mercury levels should have been on this or rather both the manometer levels should have been the same or in other words z 3 should have been equal to z 1 that you have observed when you are measured the pressure drop for water flowing through pipes isn't it it something very common that you have seen, but from the force balance you find that well known z 3 minus z 1 does have a value and this particular value this when p 1 equals to p 2 the difference which you find this z 3 minus z 1 any idea for this is called for equal pressure the difference which you find which has to be considered when your measuring pressure drop what is this called what is this called have you heard of something like the offset in process instrumentation. So, this is the offset on manometer.

So, this offset have to be kept in mind that this offset have to be compensated at beginning to consideration when we measure the pressure drop. So, what on what does it depend on its depends on the vertical distance between the tapings and it also depends on rho c isn't it. So, this we find it depends the offset it depends on vertical distance between tapings and on rho c it depends on these two things what else to be observed from here we observed that when there is no flow under in absence of flow what to do you observe what happens. (Refer Slide Time: 04:49) So, in that particular case we find that just the hydrostatic head difference should contribute to the pressure difference yes or no isn't it in other words on when there is no flow then in that case your p 1 minus p 2 this should be equal to g rho t p the two phase fluid into z 4 minus z 3 isn't it and what is this equal to the manometer in absence of flow a pressure difference is this and what about the manometric difference is simply substitute (Refer Slide Time: 04:49) the expression of p 1 minus p 2 from here and then we can and equate this particular expression with the expression of p 1 minus p 2 here and then we can get up get the manometric difference in this particular case.

. So, we for finding out the Manometric difference what do we do it is g rho t p z 4 minus z 2 this is equal to z 3 minus z 1 the Manometric difference plus it should be z 4 minus z 2 minus just do the derivation once its going to be clear to you into g rho c or in other words from here what do we get we get the distance between the tapping lines into rho t minus sorry rho t p minus rho c this is equal to z 3 minus z 1 g rho m minus rho c or in other words when there is no flow in the pipe .

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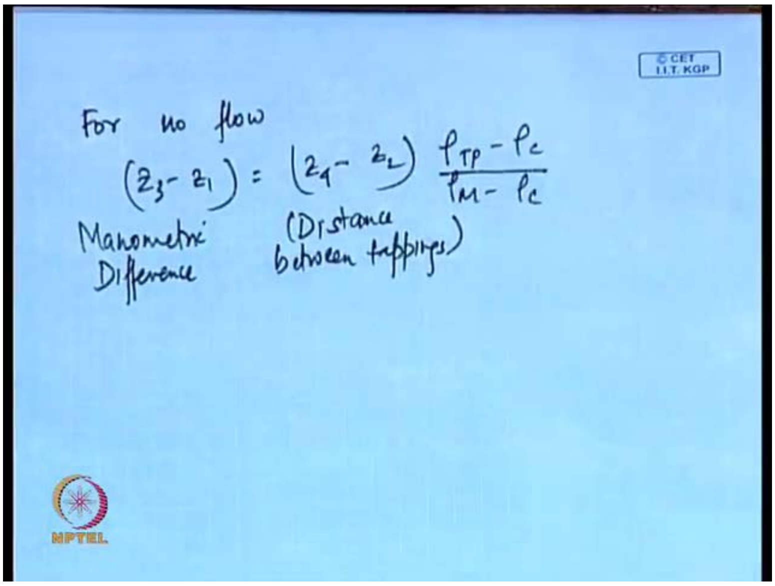

For no flow in the pipe for no flow we get z 3 minus z 1 which is nothing, but the manometric difference; that means, when there is now flow when simply the two flow mixture is standing there we should get z 3 minus z 1 equals to z 4 minus z 2 rho t p minus rho c by rho m minus rho c is it clear to you the derivation which I have done is this derivation clear to you fine.

So, therefore, from this particular thing what do you did use if you observe the final expression which I have obtained here from this particular expression what do we did use you have observed in laboratories when you have studied when in a vertical pipe simply water is standing we have connect it to your tappings and then actually that the tappings are filled with water and then probably we have mercury manometer or a carbon tetra chloride manometer. So, when no flow accurse we find that both the levels are standing at the or rather both the ah levels of the manometric liquid at the same in the manometer a very common you see this and then we start the experiment mostly the offset is. So, less that we can ignore the offset usually for your purpose it has been observed that isn't it.

But in reality we find that when there is no flow then this manometric difference it is a function of the distance between the tappings this is a distance between the tappings and it also depends depends upon some density differences what are the density differences they are the the density of the fluid which is flowing through the tube minus the density of the fluid which is filling of the tapping lines. So, if you observe this slide which I have here we find that when there is no flow just this slide (Refer Slide Time: 04:15) which I have there we felt when there is no flow when in that case a manometric difference here it will depend upon the distance between the tappings and it will depend upon the difference in density between the mixture or between the fluid which is flowing here and the fluid which is filling of the lines divided by the density of the manometric fluid minus the line fluid agreed.

Now,. So, you understand when there is only water filled up here and there is water here then in that case the density of the fluid inside the tube is equal to the density of the fluid in the manometer lines or in other words the rho here becomes equals to the rho here and that explains why z 3 minus z 1 become zero under that condition. So, we always every time I do not know whether this you have been told in your during a experiments or not it is a non to first find out that you have to first fill it up with water then see that both the levels of the mercury or the or both levels of the manometric fluid are in the same level after that you start the experiments.

But when we have two phase flow we find that in this particular case under most of this circumstances the density of the fluid inside the tube will not be equal to the density of the line fluid and therefore, they will be a difference in the manometric or rather in between the two levels of the manometer when even when there is no flow inside the pipe. So, this is the first hitch we come across why why do I call it as trembling block because we find that therefore, in order to measure the pressure difference here what do we need we need to know the density of the fluid which is filling up the manometer lines.

Now, in order to know the density the first thing is you have to know the composition of the fluid there and the other thing is we have to maintain a constant composition. So, there are two things first we have to know the composition then we have to ensure that the composition remains constant throughout the time we have made the experiments we have made the measurements that is almost impossible since suppose two phases are flowing here just to maintain a constant composition throughout the time because the composition will naturally we changing with change of operating variables this is impossible and once a two phase mixture is flowing through this special lines there is no way to find out the composition and the density of the line fluid.

So, what is the only alternative that we have if we want to measure two phase pressure drop using a manometer or wherever there is a pressures the lines connecting the manometer or the pressure measuring device with the main tube the only thing which we can do is we have to ensure that the manometer lines are filled up with a single fluid only for gas liquid measurements it can be filled up either with a gas or with a liquid and we have to ensure if it is filled up with the gas no liquid enters the tapping line if it is filled up with a liquid no gas enters the tapping line while we are doing the measurements.

So, this definitely tells you what is the hitch this trembling block we have in two phase flow measurements even when we are measuring something very simple like the pressure drop measuring pressure drop in fluid flow is is one of the most common things that we do and even for that you can very well understand where the problem arises the problem arises that in order to measure the an accurate measurement of pressure drop it needs an estimation of the densitive of the fluid which fills up the manometer the connecting lines between the manometer and the tube or the pipe through which two phase fluid occurring ok.

Now, if we have to know the density and we have to ensure that the density is constant when in that case we have to ensure that the fluid or rather rather the lines are filled up with only one particular fluid either a gas or a liquid as the situation may be and not only it has to filled up at the beginning of the experiments definitely reactive can ensure you can fill up the lines and you can start while doing the experiments can you ensure that two phase flow is flowing here and no amount of the second phase will ensure the tapping lines is it possible. So, the, but that has to be ensured ok.

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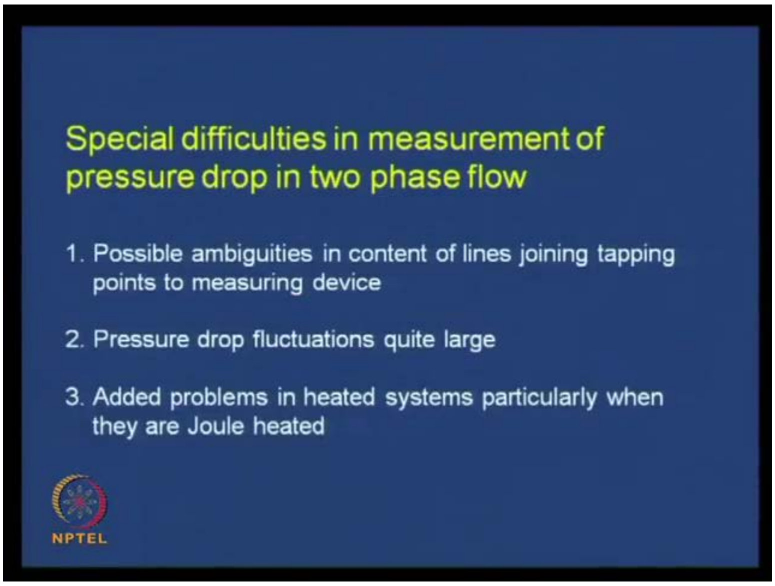

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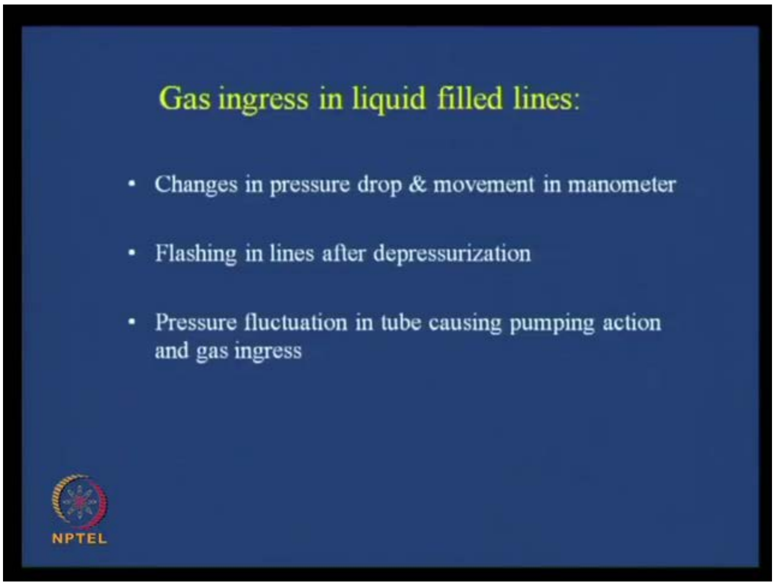

So, therefore, what are the major challengers of the special difficulties in measurement of two phase pressure drop fist thing as I have told you that movement second phase enters that are possible ambiguities in the content of the lines joining the tapping points to the measuring device this slides I think you can get isn't it the other thing is see how does the second fluid enter the first enter the your your line the reasons performed by which they can enter is say suppose the lines are filled up with liquid now what happens whenever the two phase mixture is flowing naturally they will be pressured fluctuations whenever there is some particular pressure fluctuations then actually the manometer has to recorded. So, next the manometer level will go up and down movement this level goes up and down then what happens there is some amount of pressure drop created and that cause a sort of pumping sort of action some sort of a pressure drive which goes that the ah fluid from the from inside the pipe into the tapping lines. So, this is number one that changes in pressure drop and movement in the manometer to recorded.

Then the other thing is naturally in two phase flow it is a random phenomena. So, there will be pressure fluctuations whenever there are pressure fluctuations this will cause some sort of a pumping action and the third thing is it can always happen that with for a sudden depressurization when the pressure inside the line fluid suddenly becomes very less and maybe we are working with cryogenic fluids or we are working with liquids with low boiling points under that condition following a depressurization there can be a flashing in the lines and with with that particular flashing a vapour bubble can be found see side a liquid right.

So, therefore, we find that. Firstly, suppose we have filled the tube with with liquid we have filled the manometer lines with the liquid everything we have done then we have started the two phase fluid experiments and we want you to measure pressure drop even when we have filled the everything with one particular liquid, but other the same with the liquid we are filled it up movement we start the two phase flow we find that gas can enter the liquid filled lines by either on these methods.

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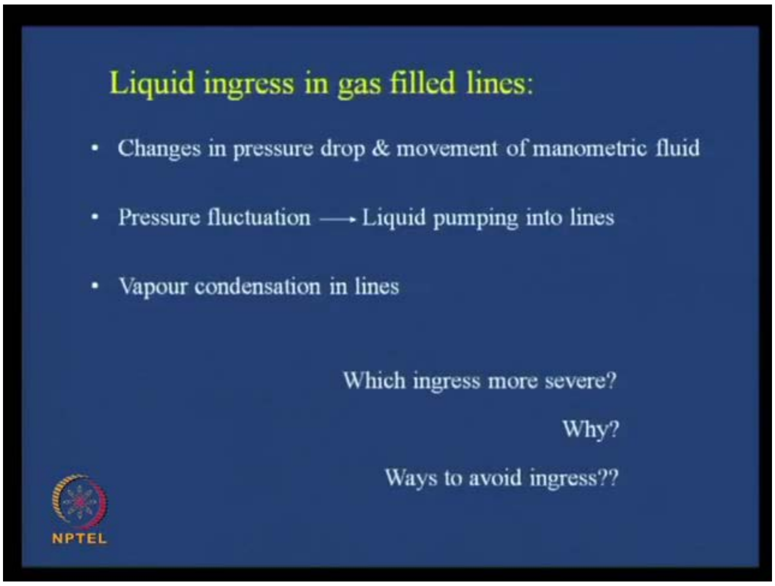

So, suppose we do the reverse we filled the lines with gases in that case also liquid can enter the gas filled lines the reasons will be the same changes in pressure drop and movement of manometric liquid pressure fluctuations due to due to with liquid is pumped inside the lines and of of course, it is low boiling where where or rather ah vapour with a low conducing temperature cryogenic fluids there will be vapour condensive.

So, either way whether we fill it up with liquid or we fill it up with gas we find that the second fluid has every chance to enter. So, we have to avoid this particular entering how can we avoid this one thing is movement you have filled it up with the liquid say suppose you filled it up the liquid then we have got to have a very efficient liquid purging system purging system we have all already studied in your chemical process calculation some subject isn't it.

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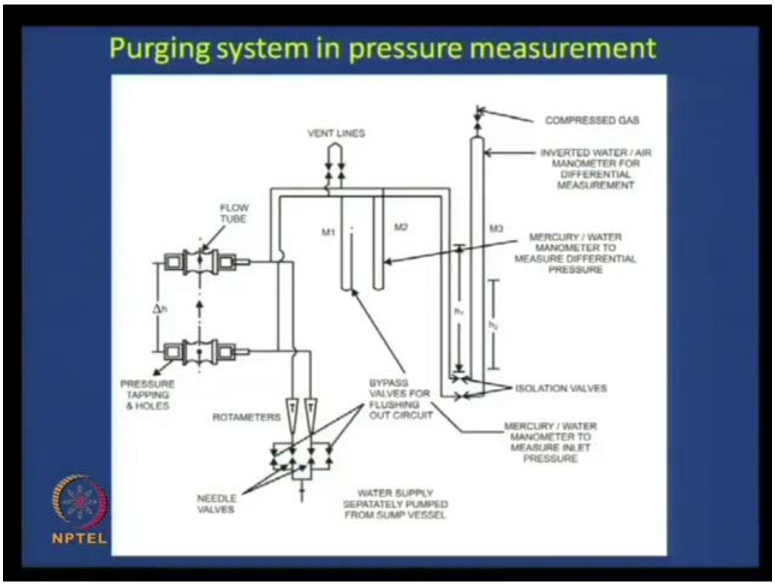

So, we need to have a very efficient liquid a one particular system I have shown here we need to have budges at different points these are the two tapping points from there they are they are being connected in this case I have shown a inverted manometer we find that we have got went lines at different places two things have to be done. Firstly, this entire line has to be transferred. So, that movement of a bubble enters we find that we can locate the bubble then there have to be vents at different positions. So, that through this vent lines we can open them we can remove the bubble we can close them again ok.

So, by a very efficient purging system this can be done if it is gas filled lines also we can make up a purging system and ensure that there is no liquid inside the line first we have to locate it now if there is a bubble. Firstly, definitely that the in that case we can we do cannot know rho c that is number one problem there is another problem also movement gases enter liquid lines or liquid enters gas lines what happens the frequency response changes naturally a movement say you can imagine when in a there is liquid filled line a gas enters naturally that particular gas it will be oscillating here and there naturally that is going to effect the performance of the manometer isn't it.

So, therefore, these are the two problems which happens first we cannot take the measurement at all. So, this has to be avoided how we can take up a purging system this is one particular thing that we can do [FL] the other thing which is very important for manometers particularly is see since there is there a rapid changes in pressure and that has to be recorded may be by the by manometric liquid rising falling etcetera there can be a chance when this particular manometric liquid it can actually enter the tube the tube through which two phase flow is occurring at sometimes this can be disasters suppose there there is a metallic system and mercury enters. So, you can very well imagine what how disasters a situation can be ok.

So, therefore, this is also another problem that there can be pressure from particular was flak flow there can be a pressure fluctuations to a large extent and movement there are pressure fluctuations there is every possibilities that the manometric liquid can enter the tubes and sometimes this can be disasters. In fact, I can tell you one thing when first I had started my phd that time just in first or the second day probably I was working with two phase flows. So, that time I was new naturally I was trying to connect everything and then I started the two phase flow mixture and then the manometer was there and more or less it was showing readings. So, I was trying to adjust everything everything was new to me. So, I was trying to adjust I was trying to measure the pressure drop etcetera suddenly the pressure drop became very high and the manometer lines to opened up the entire manometer the entire mercury it split on me and the best part was all my ornaments which was three everything became amalgamated within a fraction of a second everything my hearings hearings bangles everything became amalgamated. So, any how that is the different aspect, (Refer Slide Time: 23:40) but this is a problem in for manometric liquids ok.

(Refer Slide Time: 23:40) Now, before I proceed I would just like to ask you one thing can you just tell me we can have gas filled lines we can have liquid filled lines probably you have never seen gas filled lines as per as I know usually we have liquid filled lines, but can you tell me that which lines would you prefer and why you will prefer a liquid filled line if gas ingress is less as compare to liquid in ingress in gas filled lines. So, which particular line will you prefer considering which ingress is more severe and if you can tell me why liquid ingress into gas filled lines is more severe or gas ingress into liquid filled lines is more severe or more serious of problem which one do you think maybe you can guess something because you have already see always seen liquid filled lines most probably, but what is the reason behind it any idea regarding the reason try to understand one thing whenever there is a change on pressure the gas phase is a compressible phase isn't it.

Now, if it is a compressible phase when in that case due to the compressibility the pumping action will be much higher. (Refer Slide Time: 23:40) So, therefore, for a liquid to enter a gas filled line it is much more easier than for a gas to enter a liquid filled line liquids are incompressible. So, therefore, in this particular case the pumping action which is cause due to pressure fluctuations that is going to be a much severe number one what is the number two thing usually what we do there is a tube and we are having pressure lines which are may be glass tapilories or glass tapping lines which are connected to the tubes.

Now, in the very beginning I had told you how are flow patterns more or less restricted to a certain number of flow patterns for air water systems I had told you that always the liquid will wet the pipe valve do you remember this statement if liquid has to wet the pipe wall then in that case due to this capillarity action if it is a gas filled line then there will be a greater tendency of the liquid to enter because it is always tend to wet the pipe valve. So, therefore, wetting the pipe valve entering into the capillaries going to much more easier in this particular case . So, therefore, liquid ingress in gas filled lines are much more severe and much more serious and therefore, we usually prefer liquid filled lines, but there are certain advantages of gas filled lines as well can you tell me what can be the advantages.

If you observe the expression of pressure gradient that I have got this is the offset isn't it (Refer Slide Time: 04:15) when there is if an p 1 equals to p 2 this is the offset this offset it depends on rho t minus rho c. So, if rho c is in other words ya [FL] this is wrong I do not have that expressions sorry this is the expression very sorry for p 1 equals to just a we thing which I have written down if you see ya. (Refer Slide Time: 09:43) So, for p 1 equals to p 2 this is the offset we find the offset depends on for it depends on rho c. So, if rho c is less then actually the offset is going to be less isn't it if rho c is less rho m minus rho c is greater rho c is less. So, on the whole the offset becomes less if the offset becomes less then actually we can measure lower and lower pressure drops number one number two since in that particular case rho c will be much less. So, therefore, we find that more or less the we can get more accurate predictions of pressure drop if rho c is less.

So, therefore, pressure drop measure can be more accurate and the offset is less for gas filled lines, but the pumping action is. So, very high and tendency of liquid enter the into gas filled lines are. So, very drafted that is for most of the cases we do not prefer the gas filled lines we prefer liquid filled lines under some unless some very special circumstances to applications forces to adopt gas filled lines correct . So, therefore, this was pressure measurement with manometers now as I told you usually we do not use manometers the first problem naturally is if you have to manometers there have to very long tapping lines and then the problem of liquid ingress into gas filled lines or gas ingress into liquid filled lines common number one.

Then there is also a chance of manometric liquid entering into the you your system. So, with all this things and again again there are situations suppose we want to measure fluctuations in pressure drop just while seeing a fluctuations in manometer we cannot do it suppose we want to measure pressure response. So, for these particular situations naturally we would like to go for transducers.

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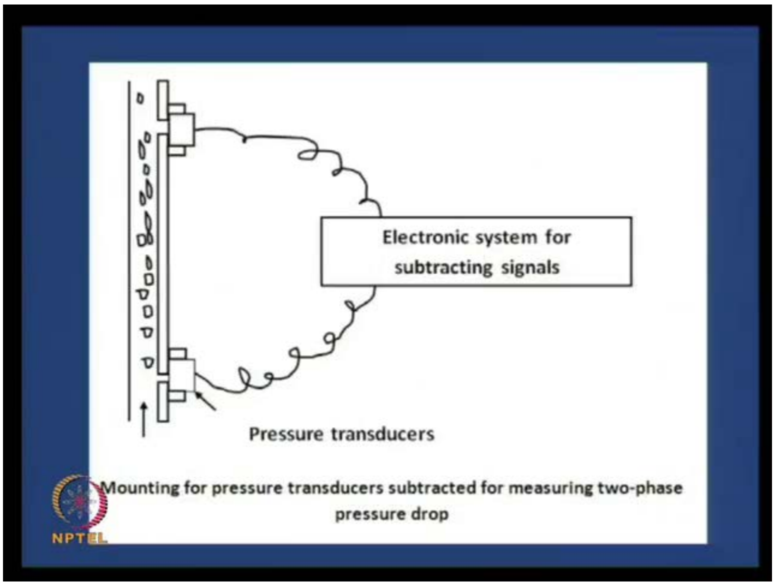

Let we do for single phase flow also. So, transducers usually what we have we have we have two particular pressure transducers they are valve mounted pressure transducers and the signals from the two pressure pressure transducers they are send to a system fake they are electronically subtracted to give us the pressure drop. So, by doing this what good have we done see the the the transducers they are valve mounted. So, therefore, the tapping line content the ambiguity in the tapping line content all those things we have done away with ok.

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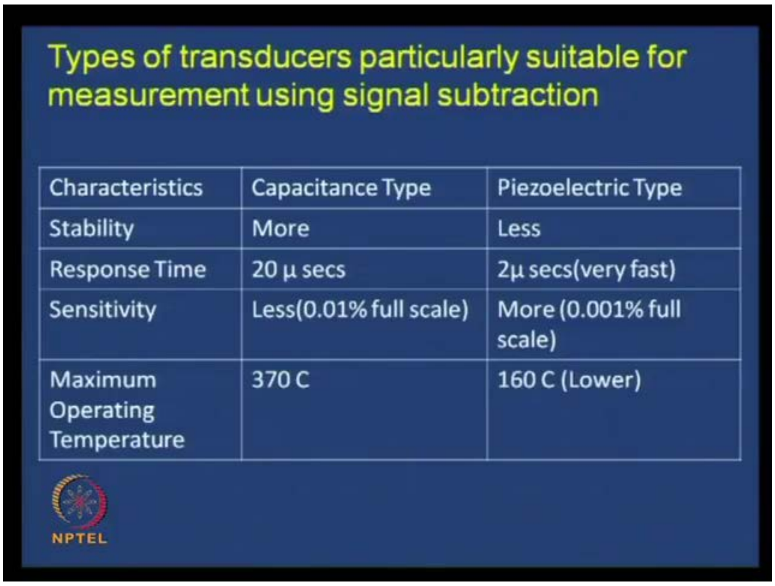

Characteristics	Capacitance Type	Piezoelectric Type
Stability	More	Less
Response Time	20 μ secs	2μ secs(very fast)
Sensitivity	Less(0.01% full scale)	More (0.001% full scale)
Maximum Operating Temperature	370 C	160 C (Lower)

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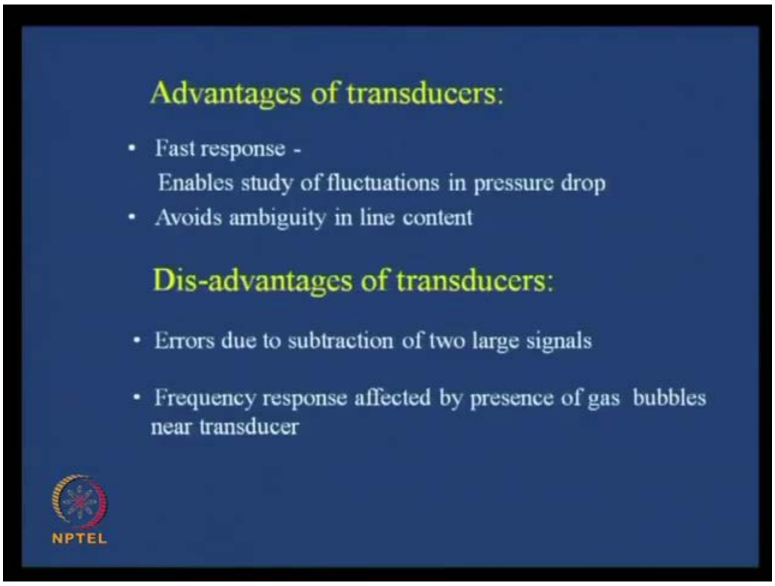

So, they are valve mounted and we have a electronic way of subtracting both of them. So, therefore, this is a good thing and usually we find that the transducers which we use they are among the different type of transducers which you will must have studied the different type of transducers isn't it potentiometric strain gauge capacitance reluctance isn't it ad type piezoelectric etcetra etcetra we find that for valve mounted signal subtraction the devices usually we have a capacitance type of transducers ah transducer we use or a piezoelectric type of transducer we have used the comparative study study I have a just just shown you that definitely we do if since we have adopted two particular type of transducers some will have some advantage over the other usually we never use other type of transducers when we have to do this signal subtraction business and as I have shown you that capacitance site it is a stability is more and its operating temperature maximum operating temperature is more at this content piezoelectric type its its much more sensitive and its response time is faster etcetera etcetera. So, these are the two types of transducers which we usually used and what are the advantages definitely fast response electrical output. So, that you can record the response and then you can come across you can come up later you can process it you can find out the pressure drop you can find out the pressure signal also the the fluctuation of pressure drop with time. So, therefore, they definitely advantages are great avoids ambiguity in line contact you know all those things the research should have ended if it would have given has all advantages and no disadvantages that never happens whatever you do you try to adopt anything new just because the previous one had some advantages disadvantages you want to eliminate or minimize them, but you you use something new it is also always associated with some disadvantages that is why again we have to go for something new and the research continues.

(Refer Slide Time: 32:57) So, for this particular case what are the main advantages disadvantages see if you see thus the system what we do we measure two signals and electronically subtracted usually both this signals are very large and such to large signals are subtracted to give you a very small difference now whenever you measure something you cannot say its hundred percent accurate there will be some errors in any measurement the you do . So, therefore, there is a error in measuring the pressure drop here or rather the pressure here there is a error in measuring the pressure here. So, when you subtract these two then actually the differences very small and coupled up with the errors may be the error introduced may be quite large it can be small other we have also may be the errors canceled out that never happens the errors they add up and therefore, by electronic electronically subtracting subtracting (Refer Slide Time: 34:38) we find that the accuracy in accuracies which we obtained in this particular case becomes much larger two very large quantities may be the error here is small error here is small small, but movingly subtract then the difference is. So, small that the error becomes larger. So, this is the first particular disadvantage.

And definitely the other disadvantage is even see there are no lines ah there there is no line or there is no connecting line tapping line between the ah tapping point and your transducer, but then also this is very much effected by the fluid present near the valve mounted transducer even if there is very small bubble present also it is. So, very sensitive it effects the response. So, therefore, this is another disadvantage frequency response is extremely effected by presence of gas bubbles near the transducer.

So, naturally in that particular case the more important problem problem is errors due to subtraction of two large signals now if this is a problem then what will we do instead of subtracting the two signals suppose we take the two particular signals in particular device say suppose the tapping lines we connect the two signals signals to one particular device which has a dire from and the two particular signals are connected to two ends of the dire from then by the dire from movement if you can measure the differential pressure that will be more accurate instead of measuring this pressure this pressure and then subtracting them this is going definitely going to be more accurate ok.

(Refer Slide Time: 33:36) So, therefore, to minimize the disadvantages of wall mounted pressure transducers what people have adopted they have adopted differential pressure transducers. So, this is nothing very important they have ya they have adopted differential pressure transducers what are these differential pressure transducers more or less there are tapping lines (Refer Slide Time: 32:57) if if I show you the here what happens there is a tapping line from here there is a tapping line from here they enter into a box there is a dire form into a the box. So, therefore, the pressure here and the pressure they are different. So, therefore, the thin dire form its starts vibrating and depending upon that that is electronical recorder and this gives us the pressure ok.

Now, generally for differential pressure we found that the transducers which was suitable here capacitance type and piezoelectric type they are completely un suitable and what is suitable in this particular case we find that usually thus the reluctance type and this strain gauge type are suitable again here I ah I have just noted down the advantages and disadvantages of the reluctance type and strain gauge type strain gauge type definitely it is more stable and it has a fast response time, but at the same time the reluctance type it it is much more sensitive it can give us much more accurate pressures for very low case .

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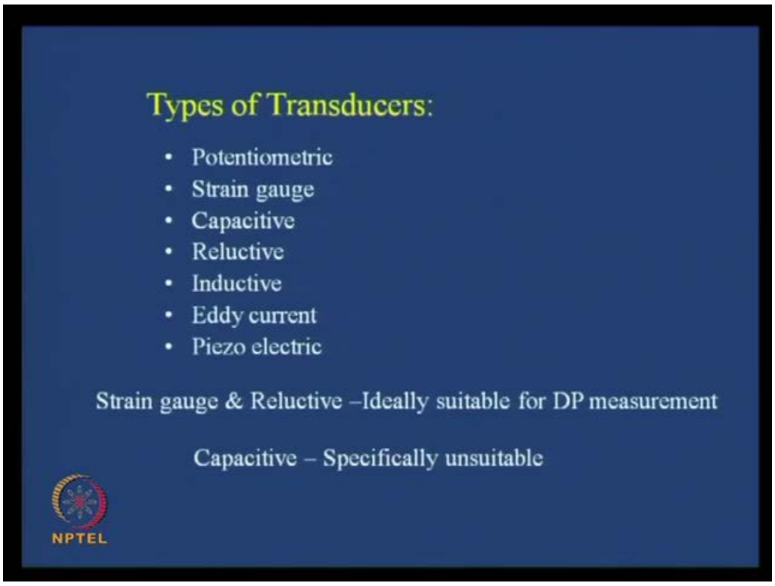

Well. So, the other thing is now you adopt the differential pressure transducer now again if it would have been very good then again we would not have bothered about the anything else there has to be some problems there what are the problems what are the problems are come to your mind in this particular case movement we take up differential pressure transducers what do we do again we are having tapping lines this tapping lines are connected to the two ends that the two sides of the dire form.

(Refer Slide Time: 23:40) So, therefore, all the problems that were associated with tapping lines the problems which I have noted down here all these problems they they should be there in the case of differential differential pressure transducer also, but the good part is see in the manometer the movement of the liquid is much more vigorous. So, therefore, this pumping action is much more there here the dire form it moves to a very small extent. So, therefore, pumping action is not. So, very high and therefore, the ingress the ingressing of the second fluid into the manometer line is not. So, very serious also, but for differential pressure we usually always use liquid filled lines. So, just in order to minimize the pressure fluctuation part and what are the other disadvantages of this number one is tapping line content. So, it has to be single phase number two is that this tapping line it it more or less if it is filled up with the liquid then usually pumping action is not. So, very severe, but there are certain other interesting problems here.

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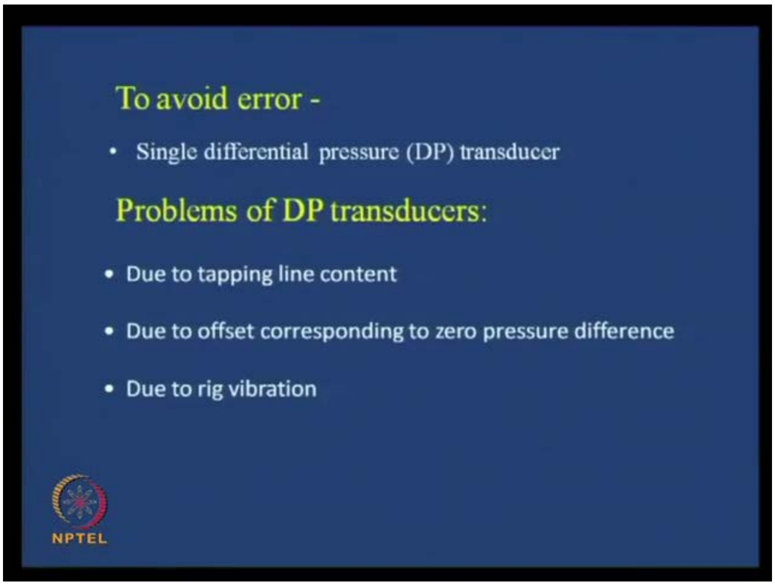

First thing is see in industries when a huge pipe is there and two phase mixture is flowing in any case two phase flow it is very random very cavities along with that there can be some amount of vibration of the test section the entire entire support for the test section has been installed there can be vibrations everywhere when really the flow is going in a under industrial circumstances at quit high fluorides differential pressure transducer it is usually designed to measure very low pressures isn't it. So, therefore, even if there is a rig vibration also that also it catches the pentic records this you have to be very careful.

And the what is the other interesting part here other interesting part here is see whenever your measuring pressure difference (Refer Slide Time: 09:43) we have I have already shown you here that there has to be an offset now if you notice that this particular offset that depends upon your vertical distance between the tapping lines it depends on rho c now if the differential pressure transducer is measuring a very small pressure suppose it is smaller than the offset then can it record that pressure because any how the offset is the minimum that offset occurs even when there is no pressure at all there is no pressure difference the offset occurs. So, suppose you have to measure pressures low than the offset can the differential pressure pressure transducer do it.

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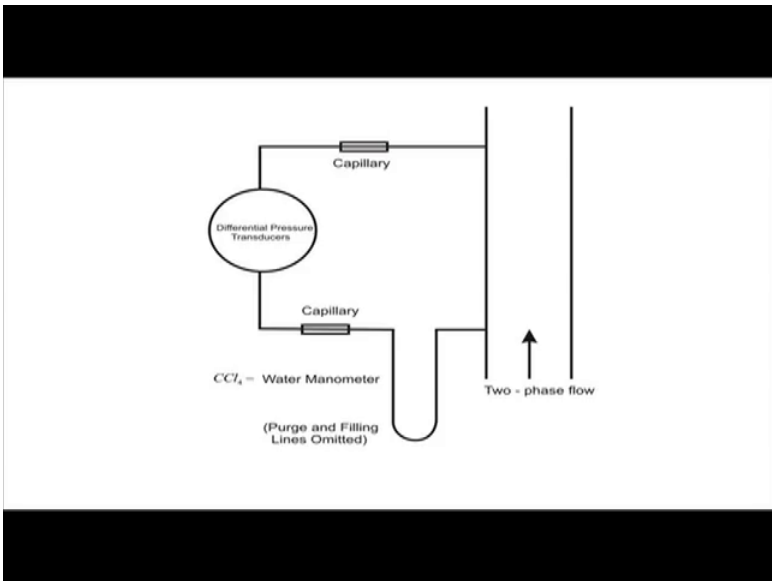

So, therefore, the other thing is that the offset corresponding to zero pressure difference the range has to be at least that particular offset and if the pressure that we want to measure if that is low than the offset then in that case we find that we can have a problem in this particular case. So, therefore, it can be it has to be selected with the range which is at least equal to the offset value if it is less than that then you get this you have a problem now again when we have problems we have to find out solutions for it also what can be the possible solutions the problem with video lecture is I cannot wait for you to answer. So, that is the problem. So, that that is sad in one way that I should admit any how. So, the thing is. So, therefore, this offset if it is compensated by some means then in that case the differential pressure transducer the dp transducer it can be used to measure pressure differences very low pressure differences if the of offset is compensated in some particular way what can we do to compensative offset a very common technique is we use a compensating manometer I do not know whether you understand see there is a ccl for water manometer here here the offset is compensative. So, therefore, after the offset only the pressure difference which is actually occurring due to flow here that goes to the dp cell and therefore, we can measure the pressure difference very very accurately because the offset has already been taken care of principal therefore, very low pressure differences can also be measured in this dp cell correct do you get me.

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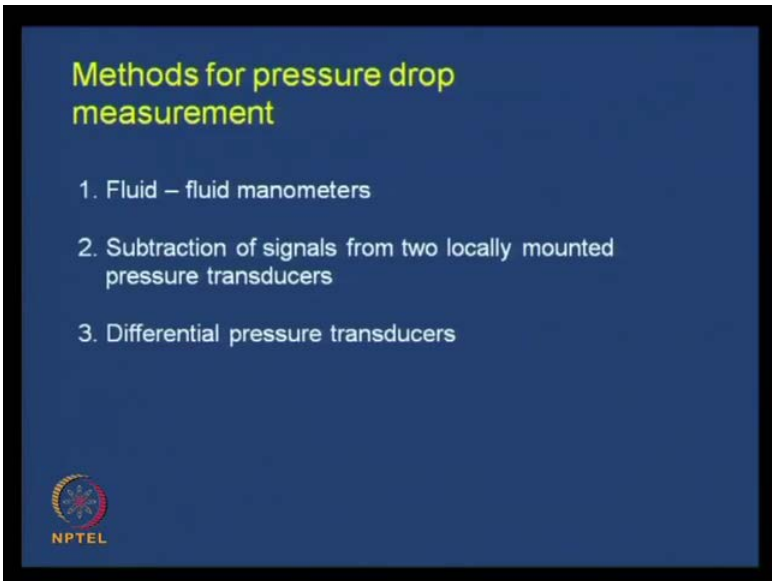

So, therefore, if we I want to conclude what are the different methods of pressure drop measurement you already know the methods one is fluid fluid manometers usually they are liquid liquid manometers when we have liquid liquid manometers they have got that own limitations regarding the range of measurements isn't it if we have to go for higher sensitivity in that case naturally for mercury manometers you go to ccl four and. So, on and. So, for we go for inclined manometers for liquid filled cases it is very frequently we see that micro manometers etcetera can also be used for better measurements then the other technique has we have already seen it is subtraction of signals from two locally mounted pressure transducers that is there and after that the differential pressure transducers it is not always that will always select that one particular method among this is the best if you consider all the factors you can never say that will dp transducers should always be used and other should never be used or in other words wall mounted transducers should always be used and the other should never be used we cannot say such things ok.

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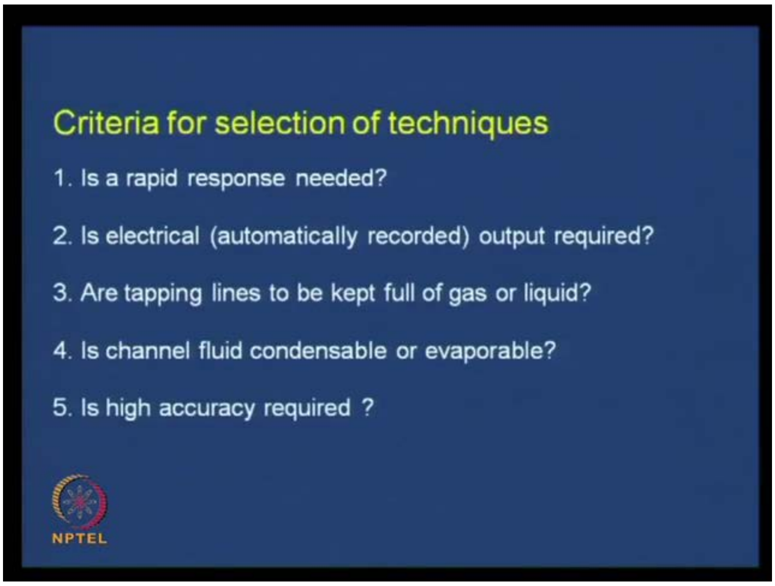

So, depending upon our conditions depending upon the application where we have to measure pressure drop we have to select a proper technique for it what are the criteria for selection that let us see what are the different ways by which this particular selection is done first thing is do you need a rapid response for example, are you interested to measure the pressure fluctuations or only the pressure drop suppose I interested to find out the pressure fluctuations then in that case naturally there is only one thing that we cannot go for manometers we cannot even go for differential pressure transducers they are also not accurate the only option we have is that locally mounted pressure transducers that is mandated and among this locally mounted pressure transducers also we have to see that depending upon the response time and the temperature what is the type of transducer that we will select.

So, and whether this transducer has to be has direct access to the fluid or not if it has direct access if we need a very fast response time and if the high temperature or something you select some type of transducers otherwise will go for something else, but remember if a rapid response is needed or rather we would like to measure record the pressure fluctuations with time there is only one thing valve mounted pressure transducers usually we try to measure when we try to measure fluctuations it is of pressure a not of pressure drop. So, therefore, its always valve mounted pressure transducers next is if you need an electrical output on other words you want to record the output from manometer you can never do it ok.

So, therefore, for the such type of cases you have to go for a dp transducer if electrical output is not needed liquid liquid manometers are find what is the next thing whether the tapping lines have to be kept full of gas or the liquid now you have already understood it is better to have tapping lines full of liquid and to also to have a liquid purging system, but at the same time remember for more accurate measurements gas filled lines are better if the line content is completely un ambiguous very important because gas filled lines with un ambiguous line condendence of something very rare if you can ensure it if you can maintain it and definitely gas filled lines are more accurate for from most of the situations we cannot do it ok.

So, therefore, this has to be remember remember and in practice usually we go for liquid filled lines what is the other thing is the channel fluid condensable or evaporated. So, in that particular case what do we do suppose we are working with cryogenic fluids what can we do in the tapping line just after the tapping point we can install and evaporated if it is gas filled a vapour filled lines or a condenser if it is liquid filled lines. So, what happens if there is a condenser or evaporator also if a vapour enters by any chance that can be condense to a liquid, but this particular technique isn't very popular one because it takes a lot of time its not worth it naturally because for condensation evaporation it takes time. So, this is not a very well favored system, but this can be one the other thing is how much accuracy do you need if suppose you you use the final points which I have given is how much is high accuracy required because if you need high accuracy then for liquid filled tapping lines we can go for inverted liquid gas manometer types of compared to liquid mercury manometers instead of liquid mercury manometers if we go for liquid gas manometers it is going to be better and if we have gas filled lines special cases we can go for inclined manometers or micro manometers remember this using manometers if we need a high accuracy then instead of liquid mercury manometers we can go to liquid gas manometers for liquid filled lines and special cases where we used gas filled pressure lines we can use inclined manometers or micrometers another thing which you already know from your single phase I would just like to remind you when we use manometers the other thing is that as I was telling you the manometric liquid can enter the fluid the pressure line how do we elevate that particular problem.

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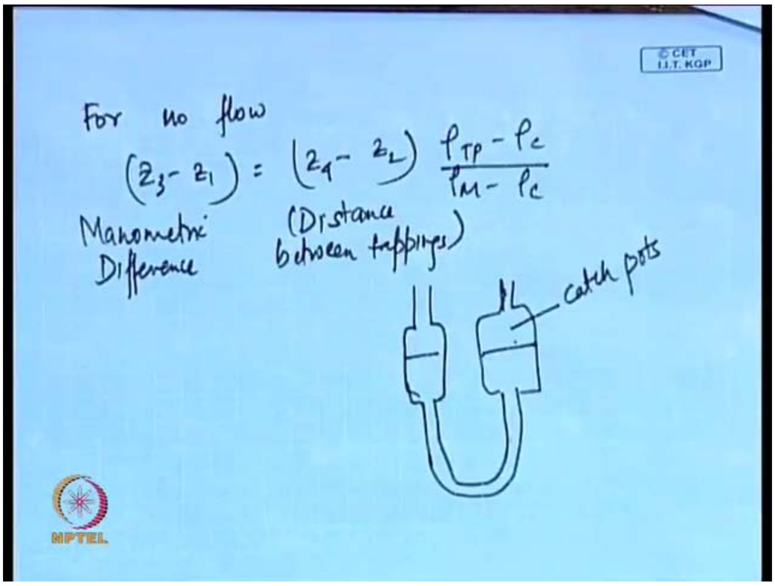

If you draw the diagram of a manometer which is usually supply to you I do not know whether you have ever noticed or whether you have ever thought why this diagram or why the manometer is made in this particular way this is usually the manometer which is made why do we do this because whenever the liquid tries to come up at least here the level rise will not be much. So, these are known as catch pots where the manometric liquid needs a tapping line liquid and therefore, these catch pots are there to prevent the or rather minimize it it cannot prevent it rather to minimize the bigger catch pots use the better it is it just minimizes the ingress of the manometric liquid into the lines. So, that the consequences of this particular ingress can be minimized. So, this completes our discussion on the challenges which we face for measuring pressure drop under two phase flow conditions tomorrow will be taking up the measurements of void fraction and then will be taking up the different ways to estimate the flow regives thank you very much .