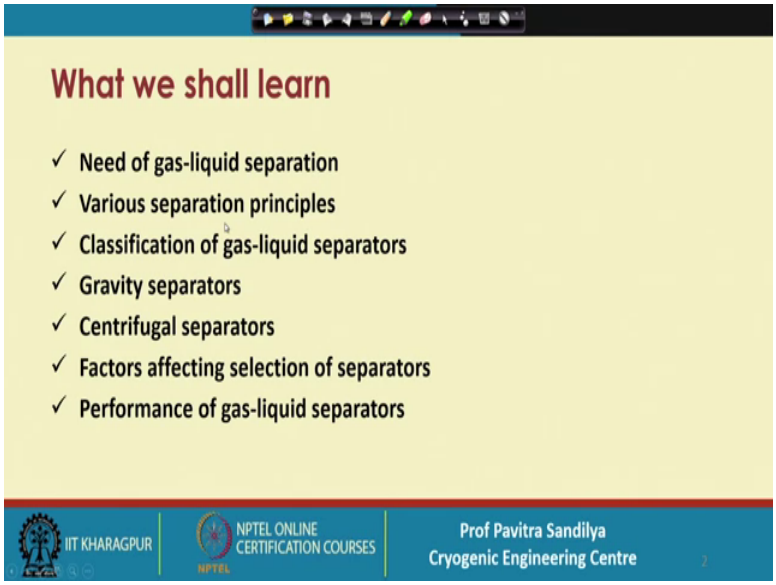
Upstream LNG Technology
Prof. Pavitra Sandilya
Department of Cryogenic Engineering Centre
Indian Institute of Technology, Kharagpur

Lecture - 59
Gas liquid separation in natural gas systems – I

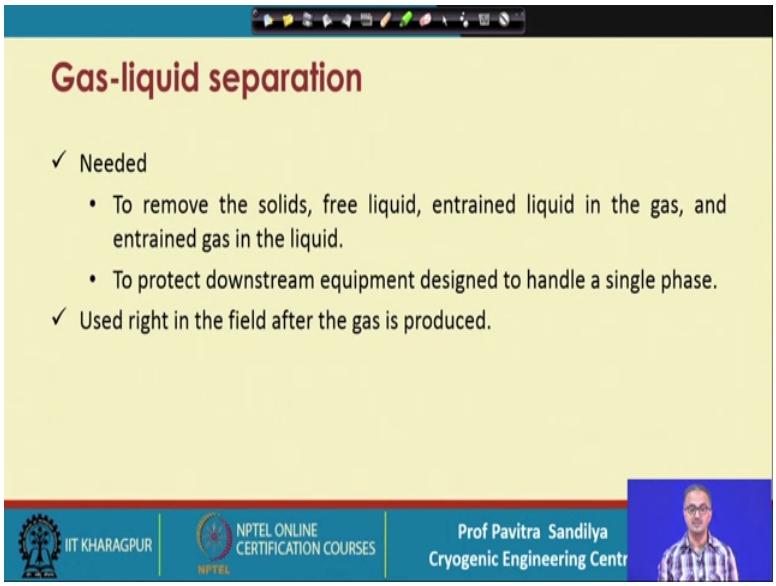
Welcome, in this lecture we shall be looking into the Gas liquid separation in the natural gas system and this is the part 1 because there are several ways of separating the gas and liquid.

(Refer Slide Time: 00:29)



So, first in this lectures what we shall see the need of the gas liquid separation, the various types of separation principles then classification of the gas liquid separators the gravity separators, centrifugal separators which will covered in this particular lecture and then factors affecting the selection of the separator and performance of the gas liquid separators.

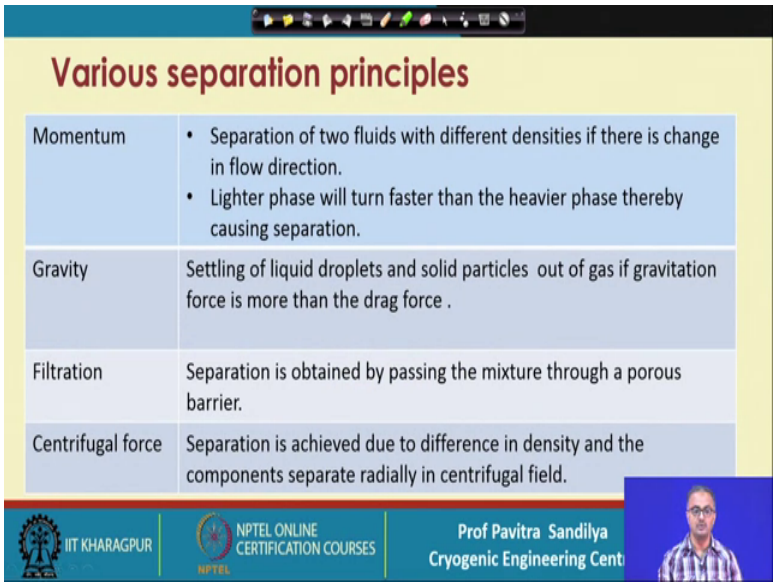
(Refer Slide Time: 00:53)



So, first let us see the need of the gas liquid separation why they are needed? To remove the solids free liquid, entrained liquid in the gas and the entrained gas in the liquid.

To protect the downstream equipment designed to handle a single phase that means, if some equipment have been designed to handle single phase when we cannot allow multiphase system streams to go into those equipment. So, we need to separate the gas or liquid and because of natural gas when its coming out from the earth it is also maybe trapping many liquids many hydrocarbons with it in different phases liquid phases and some solids also there. So, we need to only take out the gaseous stream and not the other phases like solids or liquids. And this is used right after the gas is produced from the gas field.

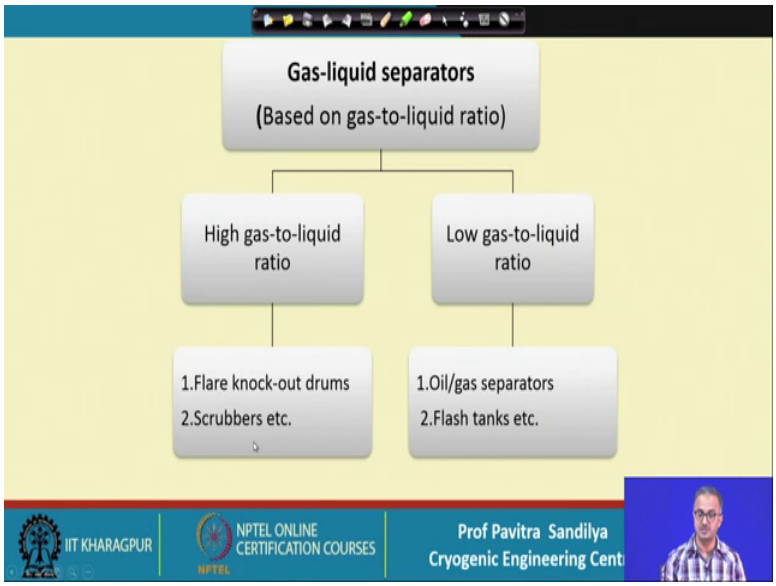
(Refer Slide Time: 01:51)



So, here are some of the principles based on which this separators work it be momentum, gravity, filtration and centrifugal force. The momentum is the separation of two fluids with different densities if there is change in the flow direction, the lighter phase will turn faster than the heavier phase thereby causing separation. So, we effect some kind of a change in the direction of the flow. In the gravity what happens? It is by their own way the setting of the liquid droplets and the solid particles out of the gas just due to the gravitational pull. And it works only if the downward gravitational pull is more than the drag by the particular fluid.

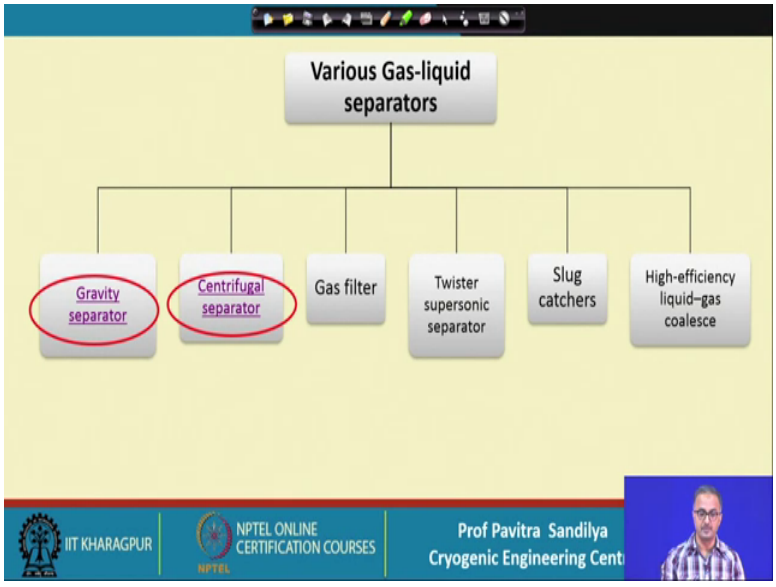
The filtration is that we are using some kind of a porous barrier which will be having pore sizes that will allow some of the components which are smaller than the pore size to pass through it and bigger once will be retained by the barrier. And then we have centrifugal force in this case what we do is the rotational action and by the rotational action what happens? The heavier particles and the denser particles will be moving away from the axis whereas, the lighter particles or the smaller particles will be moving towards the axis and thereby we shall be able to separate the two phases.

(Refer Slide Time: 03:21)



Here in this, we have this based on the gas to liquid ratio we have different types of separators one is high gas to liquid ratio and there is low to liquid ratio under this we have the flare knockout drum scrubber system, and the for low gas to liquid ratio we have the oil gas separators and the flash tanks etcetera.

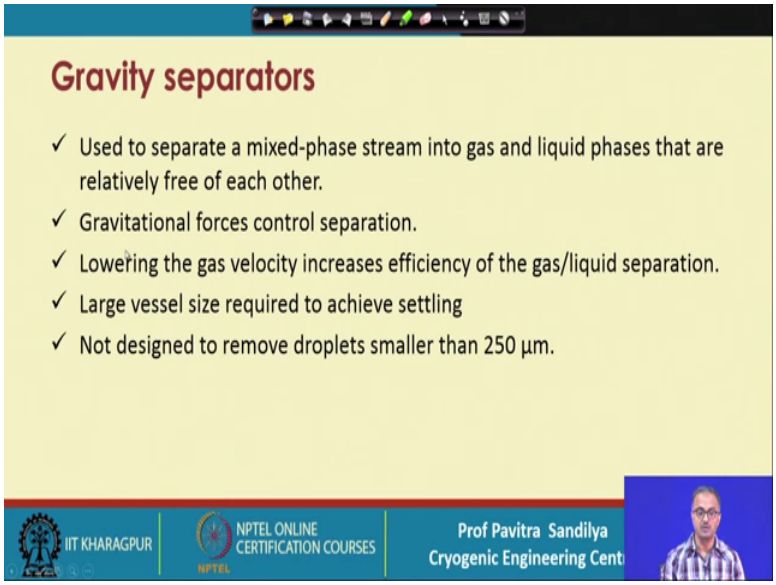
(Refer Slide Time: 03:41)



So, there various ways of separating them and here we find that these are some of the various gas liquid separators.

So, today in our lecture we shall be looking into gravity separator and the centrifugal separator. So, first let us go to the gravity separator.

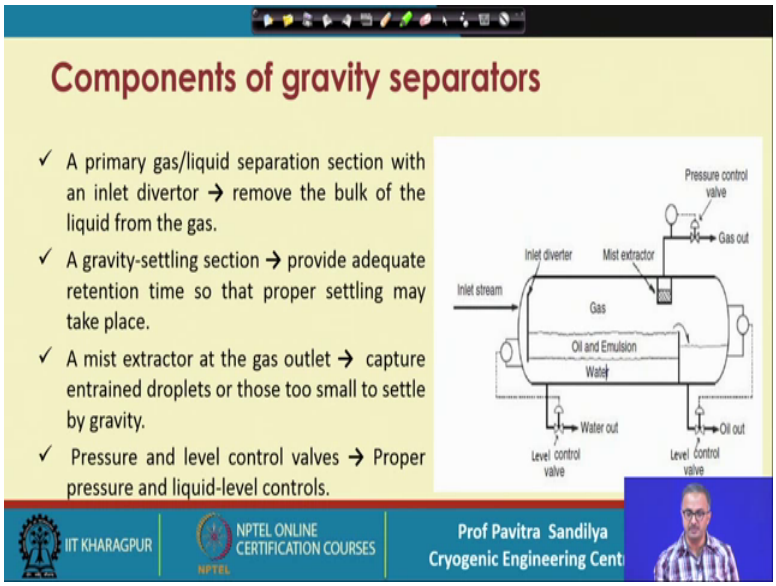
(Refer Slide Time: 04:03)



Now here we find that these are used to separate mixed phase streams into gas and liquid phases that are relatively free of each other.

That means they are will not be much of entrainment of each of the phases into the other. And here we are using the gravitational force. Then we find that if you lower the gas velocity it increases the efficiency of the gas liquid, separator because it gets more time for the particles to settle out of the gas, but it needs large vessels and these are not generally designed to remove droplets smaller than 250 microns. So, for higher particles size particles these gravity separators are used.

(Refer Slide Time: 04:53)



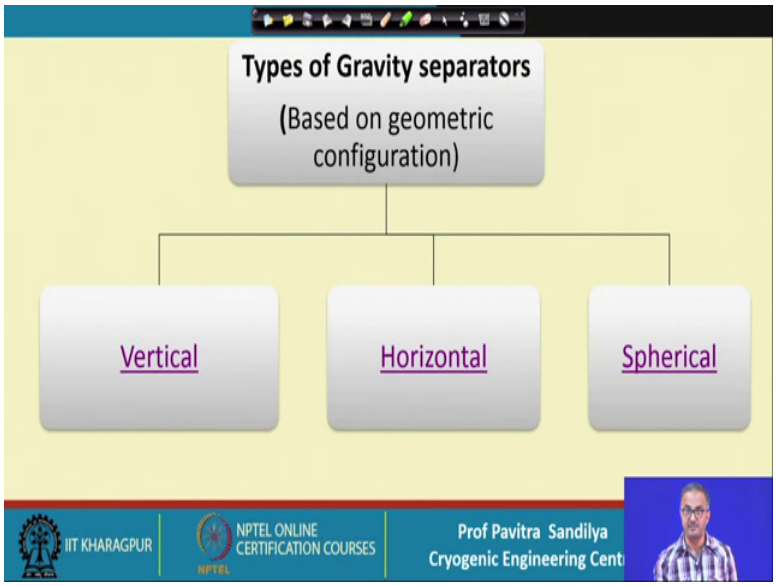
So, here we find the typical components of the separator here first we have the primary gas liquid separations section here what we do? They remove the bulk of the liquid from the gas.

So, inlet gas comes, inlet diverter from this diverter what happens? The gas will tend to go move up and the liquid will tend to move down. So, this is the primary bulk separator then gravity settling of the section. Here we find that there will be in this zone because depending on their density differences we will finding different types of zones are being formed gas is lightest.

So, it will be staying at the top if water at the heaviest then it will be staying at the bottom. And then we have mist extractor at the gas outlet here, the mist extractor this what is it doing? It is trying to reduce the entrained liquid to go out with the gas.

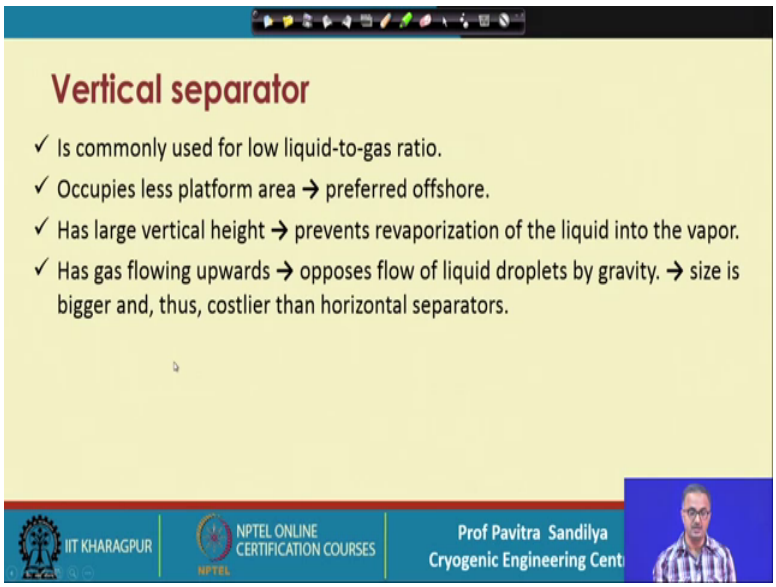
So, if any kind of oil is there with the gas they will be retained by the mist extractor. And then we have pressure level control valves to maintain the proper pressure and level inside the control, inside the tank. This a pressure and this is the level control valve for the various liquids. So, these all these things constitute a typical gravity separator.

(Refer Slide Time: 06:17)



Under gravity separator also we have again more classifications it could be vertical, it could be horizontal or it could be spherical.

(Refer Slide Time: 06:25)

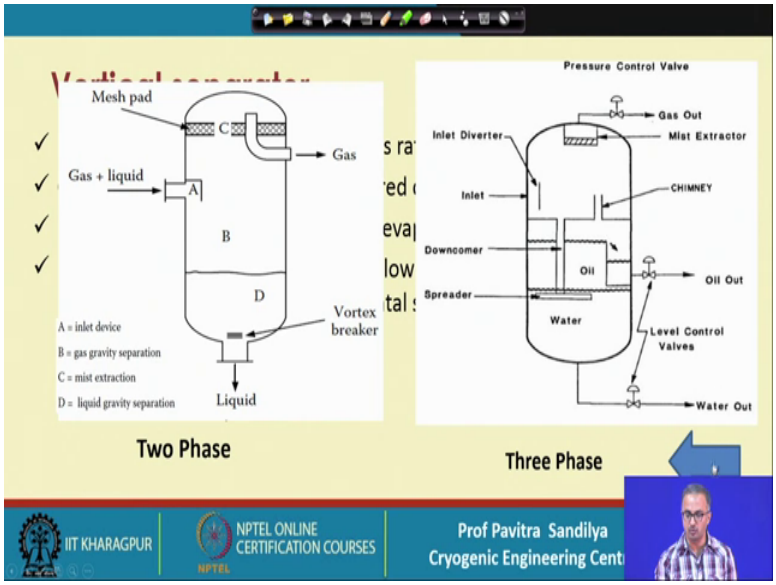


So, let us see the vertical separators, they are commonly used for low liquid to gas ratio. And they occupy less platform area and that is why they are preferred in the offshore applications.

And they have large vertical height and when they large vertical heights they prevent the re vaporization of the liquid into the vapour. And has gas flowing upward and that is the

oppose the flow of the liquid droplets by gravity and size is bigger thus, costlier than the horizontal separator. So, these are the typical features of the vertical separator.

(Refer Slide Time: 07:06)

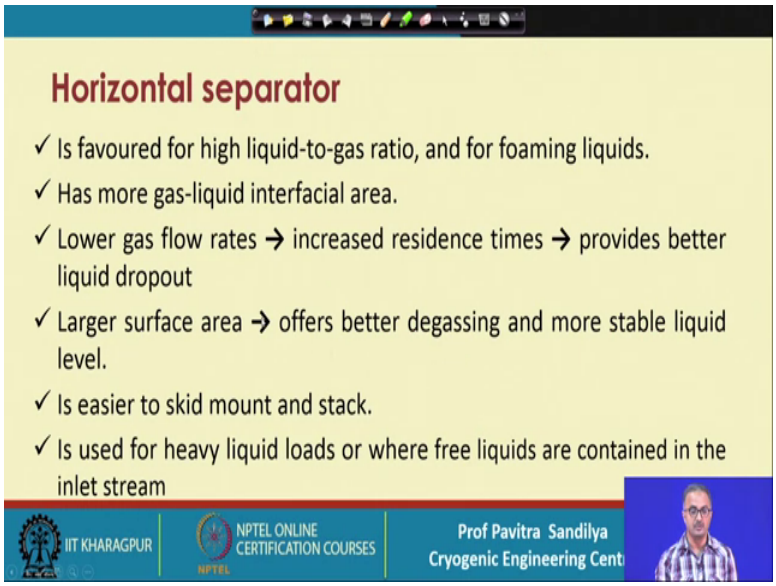


So, here we show a two phase vertical separator. Here we have the gas liquid mixture here with the liquid is there for you define the gas is going and will moving out of from the top and the liquid is coming out of the bottom and in this we have the mist extraction. And in this zone, in the D we have the liquid is separating by gravity. And this here we have the gas is getting separated from the liquid.

So, we have to give enough space for the gas and liquid to get detached from each other. And then we have the three phase separator, the things are similar only thing is this in this three phase separator we are able to separately take out the oil phase and the water phase in the two different vertical heights of the separator. Gas is still coming out from the top and again we have the mist extractor, we have the chimney to take out any of the gas which may be going with the liquid and we have the down comer through which the liquid goes into this section.

And then after going to a section then what happens, it forms two layers and this lighter layer will come out from this. So, there is (Refer Time: 8:27) short waves duffel over here it will be coming through this the upper section of the column. And here we have the two valves to control the level of the water and the oil and here also we have the pressure control valve. After this what we do we go to the horizontal separator.

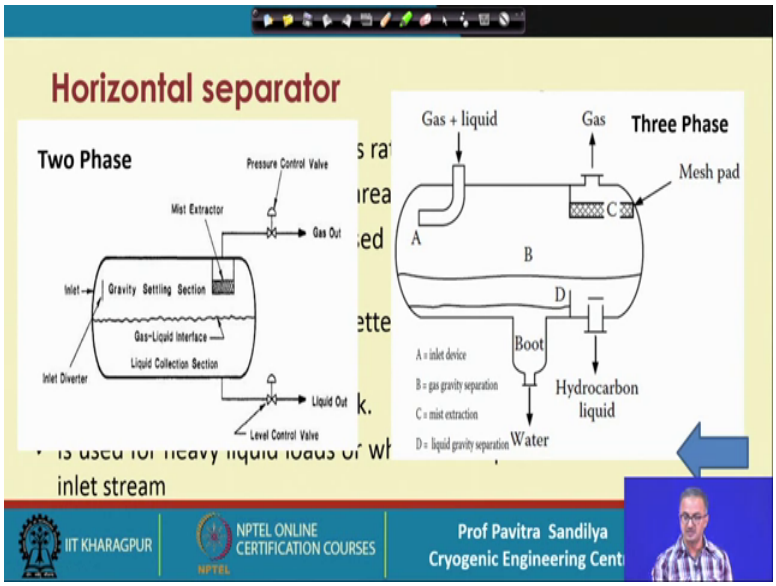
(Refer Slide Time: 08:52)



These are favoured for high liquid to gas ratio unlike the vertical separators and for the foaming liquids a have they have more gas liquid interfacial area. Because they are horizontal they are providing more gas liquid interfacial area. And they have they can accumulate lower gas flow rates and that means, they have higher residence time and if their residence time is increasing; that means, if you provide better liquid drop out.

Then they provide large surface area it means it is better for degassing and for more stable liquid level they are easier to skid mount and stack and that used for heavy liquid loads where all that liquid loads are contained in the inlet stream. So, for those cases and generally because they are horizontal they are favoured more for the onshore applications unlike offshore applications of all the vertical separator.

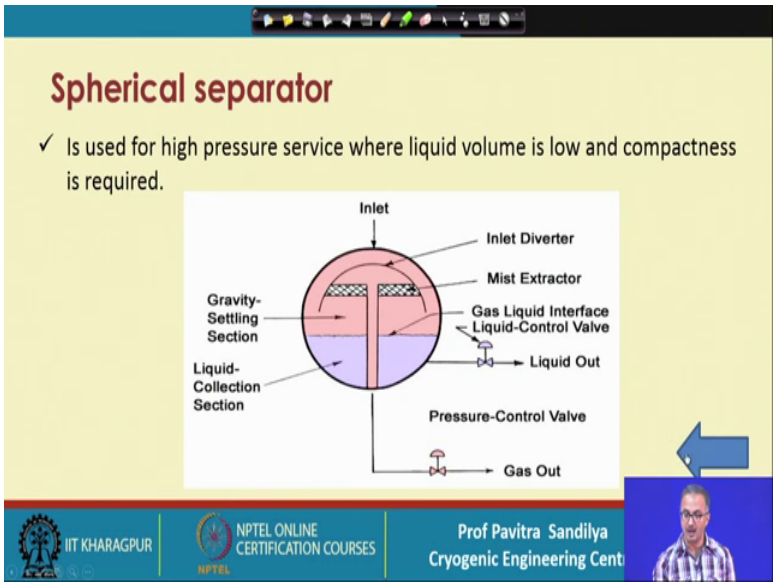
(Refer Slide Time: 09:53)



So, here we have the two phase horizontal separator again we find the inlet is coming near here it is the very large surface area and when this gas is going out through a mist extractor here we have the pressure control valve and the liquid is coming out from the bottom and we have the level control valve. And here we have a three phase separator, in this again we find the gas goes out from here and the it is inlet is from this side, this a inlet device and this is the gravity separation zone and this is the mist extractor through which the gas flows out and here we find that again we have a barrier and this barrier is this is the oil rich layer.

This a water rich layer, the water rich layer will come through this and the oil rich layer will come from this side. So, that is how we are able to separate the three phases in a horizontal separator.

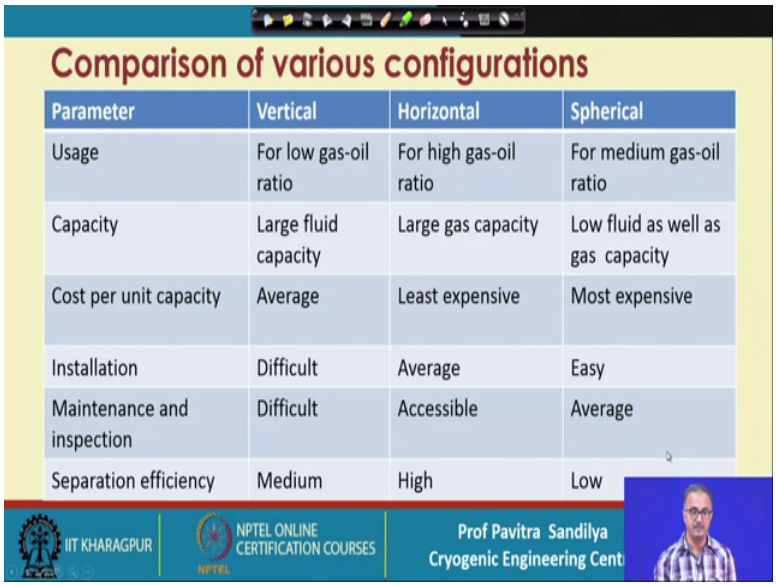
(Refer Slide Time: 10:53)



Next we come the spherical separator and these are used for high pressure services where liquid volume is low and compactness is required as we know for a given volume a sphere has the lowest surface area.

So, in this again we have a similar thing that here we have the inlet and it is again gravity settling over here we have the mist extractor over here and what we find the liquid is taken out from here and the gas moves up from the liquid and it comes through this particular down comer and is coming out from the this spherical separator. And here we have the flow control device and the pressure control device.

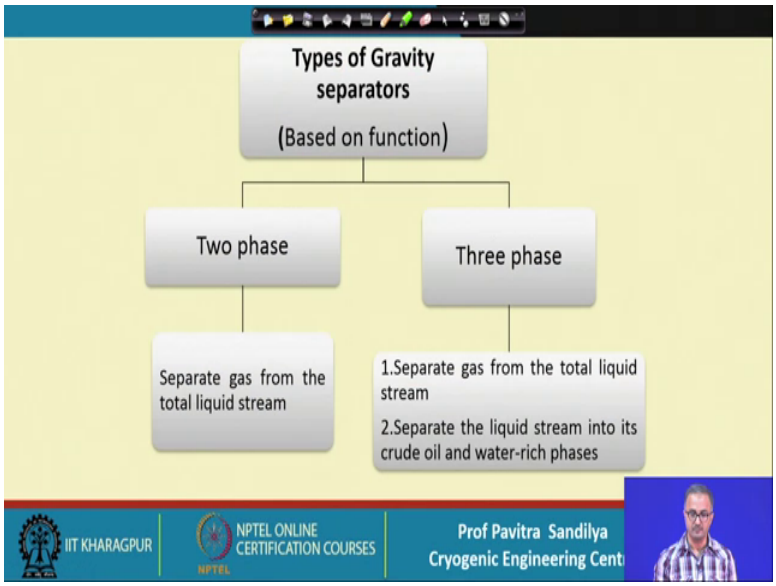
(Refer Slide Time: 11:40)



After learning about this gravity separators we made comparison in terms of the usage, capacity, cost, installation, maintenance inspection and the separation efficiency. We find that the usage wise that this is for the low gas oil ratio horizontal for high gas oil ratio spherical for medium gas oil ratio. Capacity wise it can handle large fluid capacity this can use large gas capacity and it has least of all, the capacity is least among the other separators the cost wise this is the most expensive is the spherical and least expensive is the horizontal.

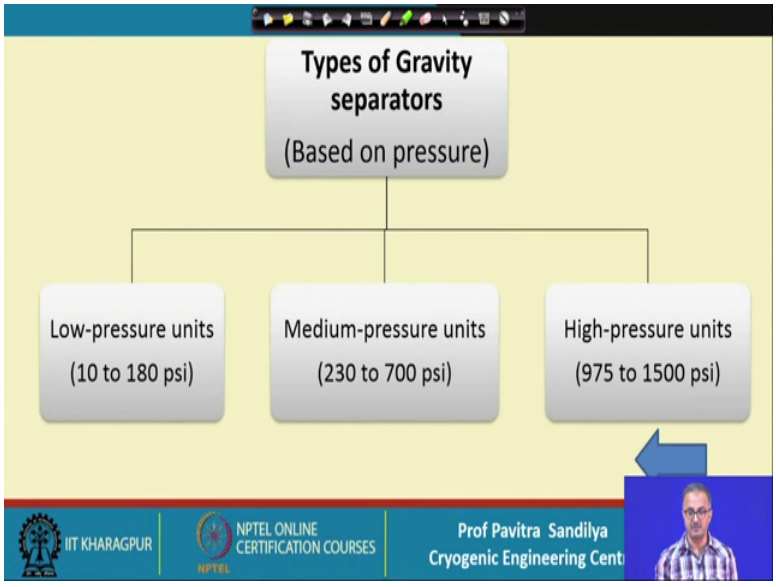
Installation wise we find spherical is easiest and the most difficult is the vertical maintenance inspection wise, again vertical is the most difficult and separation efficiency wise we find the horizontal give the best efficiency then comes vertical and lastly comes a spherical.

(Refer Slide Time: 12:35)



Now we come to this two phase and three phase gravity separators. And in this case we find this two phase separate the gas from the liquid stream whether in the three phase we are separating gas from the total liquid and again the total liquid is getting separated into the oil and the water rich phases.

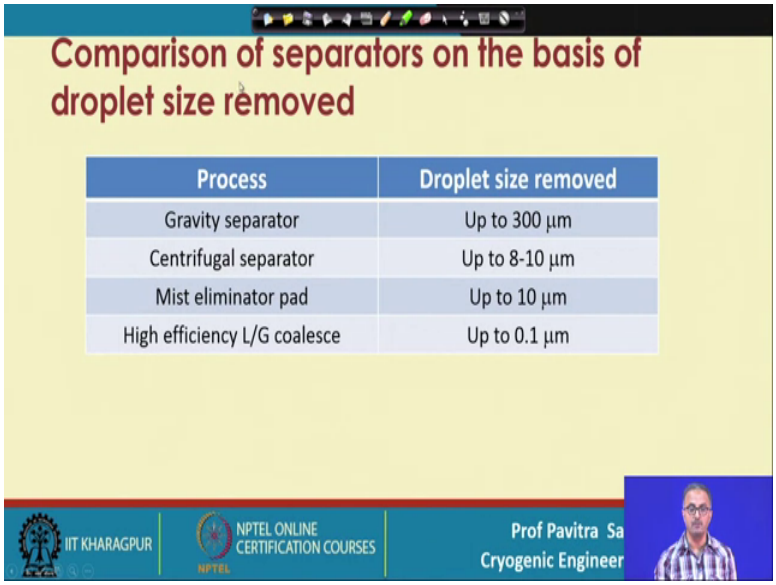
(Refer Slide Time: 12:55)



And here we have we may have again classification based on the pressure, we may have low pressure units medium pressure units and high pressure units depending on the

pressure level it is 10 to 180 p s i this is 230 to 700 p s i and it is 975 to 1500 p s i. So, we may have different ranges of pressure for this kind of gravity separators.

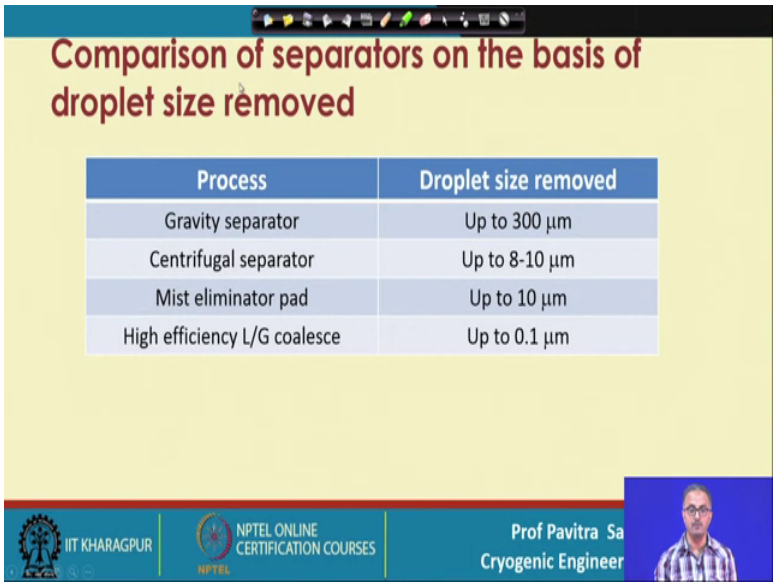
(Refer Slide Time: 13:25)



Next we come to the comparison of the separators on the basis of droplet size. So, we find that all the separators we are having gravity separator, centrifugal separator, mist eliminator and this L by G this the liquid gas coalesce.

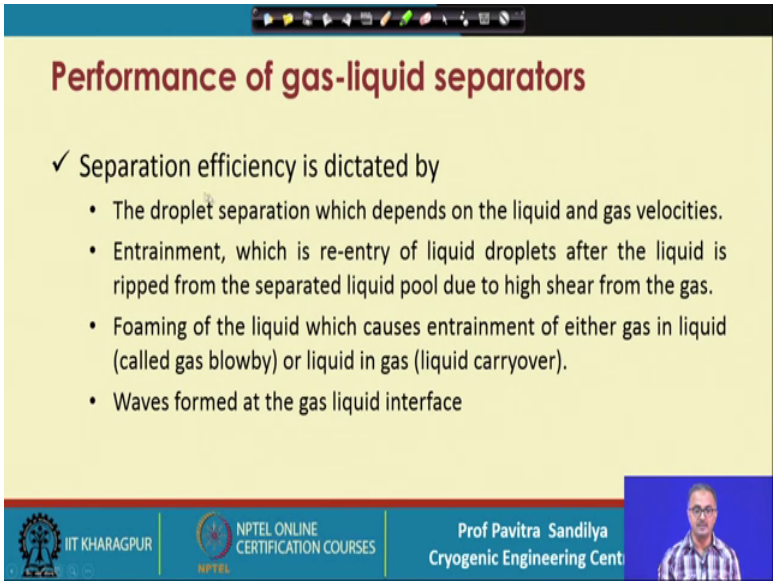
So, we find the as we move down this particular table we find the, it becomes final and final droplets may be separated from by using different types of separators. So, coarsest of them is gravity separator.

(Refer Slide Time: 13:57)



Then these are the some of factors which our affect plus selection of the separators by gas and liquid flow rates, the type of the natural gas indicated by the specific gravity the specified quality of oil and water, then operating conditions the presence of solid and available floor space.

(Refer Slide Time: 14:23)

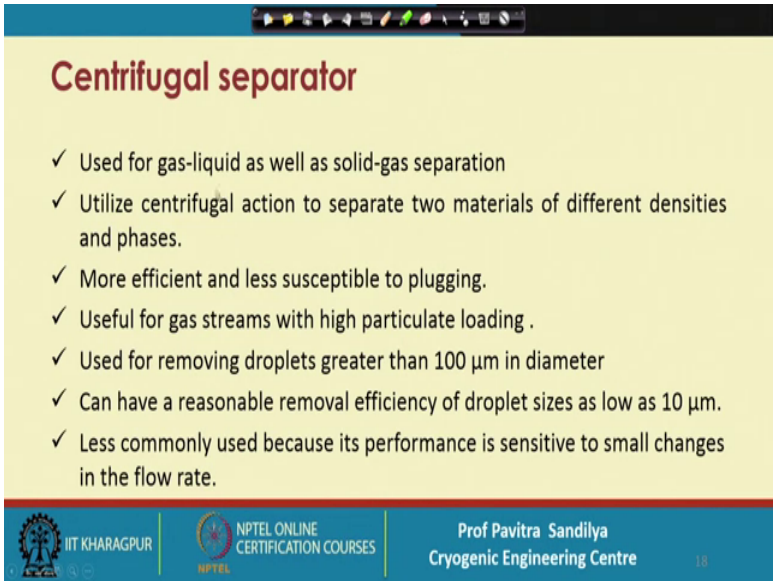


And these are the performance for the gas fluid separators; we find the separation efficiency is dictated by the droplet separation which depends on the liquid and gas velocities. The entrainment; entrainment means that any kind of liquid that is being

tracked by the gas. So, if there is too much of liquid entrainment by the gas then it we shall be losing the oil with the gas then that is not desirable; then foaming means if the liquid is foaming what will happen that it will trap quite a lot of gas.

So, gas will going into the liquid that we call the gas blow by or the liquid may be going into the gas we can call it the liquid carry over due to the foaming. And there could be waves generated at the gas liquid interface. Now we shall be looking into the centrifugal separator.

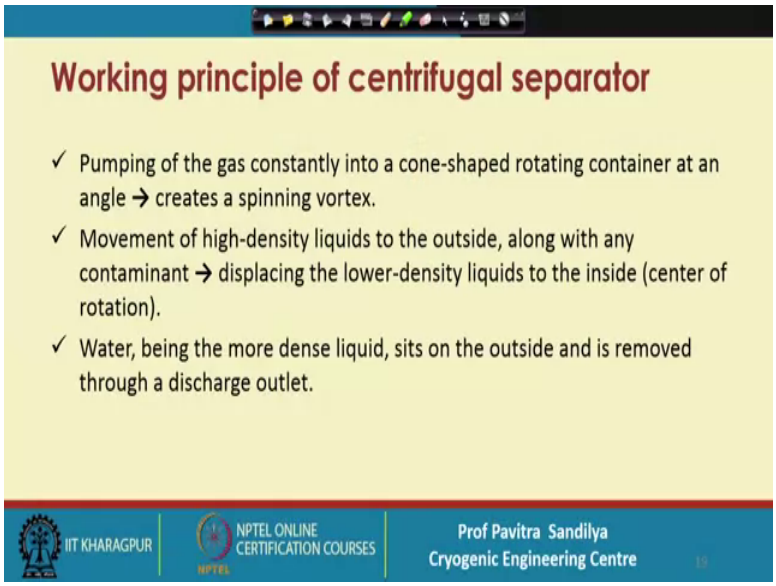
(Refer Slide Time: 15:23)



So, these kind of separators are used for gas liquid as well as for solid gas separation. And perhaps we are aware of such kind of separators which are commonly used for de dusting the air in our day to day life. So, these use the centrifugal action to separate the two materials at different densities and phases. They are more efficient and quite less susceptible to plugging; they are useful for gas streams with high amount of the solid particles.

They can remove particles which are greater than about 100 microns in diameter. And can have quite high efficiency for separation for droplet sizes as low as 10 micron and are less commonly used because its performance is sensitive to small changes in the flow rate. So, if there is not much change in the flow rate they are quite effective.

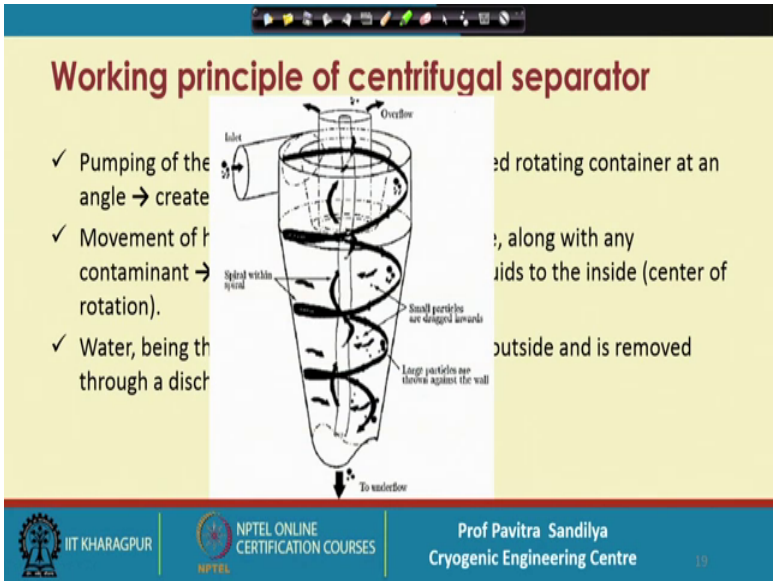
(Refer Slide Time: 16:20)



And these are the working principles that we first pump the gas constantly into a cone shaped rotating container at an angle. And this creates a spinning vertex and this what happens, then this is spinning of this thing the high density liquids are pushed towards the valve of the cone whereas, the low density liquids are pushed towards the axis of the separator.

And water is generally the denser component. So, it will be going towards the valve and will be drained out in the, from the bottom.

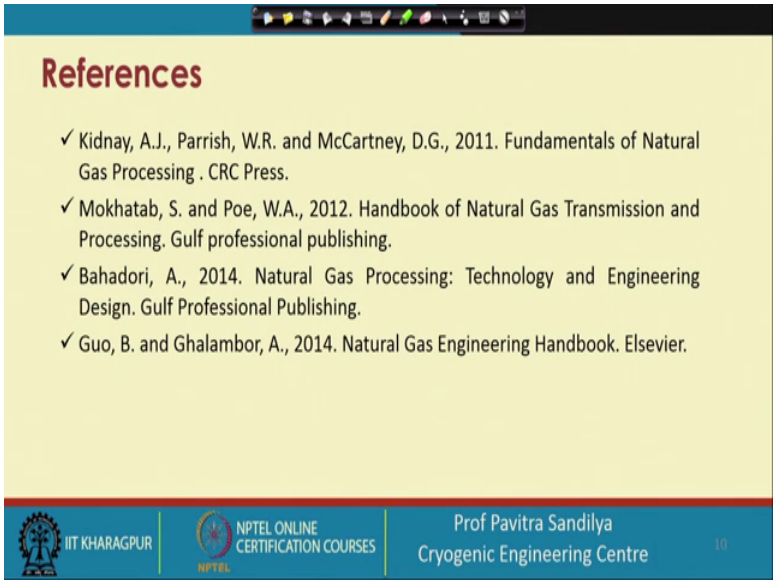
(Refer Slide Time: 16:59)



And here we have a typical cyclone separator, here we find these the inlet and the way it is introduced it causes a vortex inside the particular separators and due to this conical shape what will happen? That this gets accelerated and the larger particles or denser particles are pushed towards the valve of the separator and they are coming out from the bottom.

Whereas the lower density particles or the smaller particles are driven towards the axis and then they also move out and they come out from the centre of the axis from the top. So, this is the overall system on which this centrifugal separators are based.

(Refer Slide Time: 17:45)



And these are the references which will give us some more details about these various types of separators.

Thank you.