# Upstream LNG Technology
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## Lecture – 80
## Hydrocarbon recovery in natural gas system – II

Welcome. Today we shall be looking further into the Hydrocarbon recovery in the natural gas systems. So, in this one we shall be looking into the dew point control and fuel conditioning and low temperature separator.

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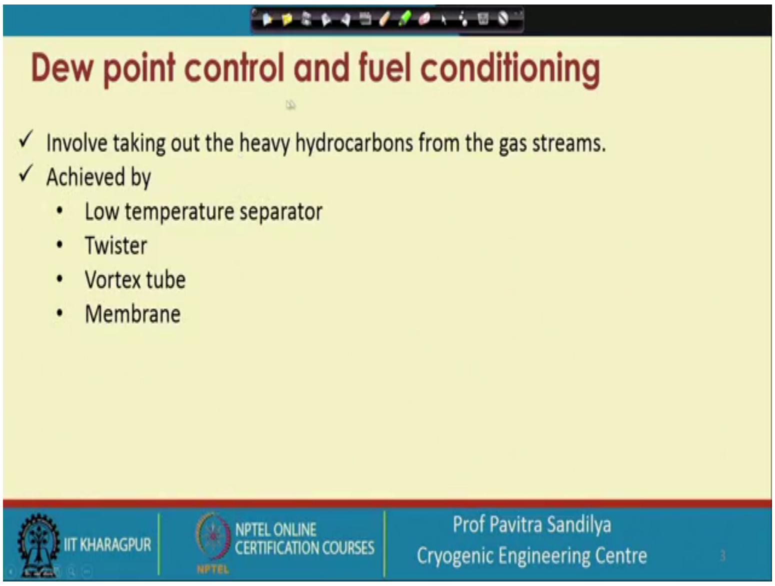


So, first let us come to this dew point control and fuel conditioning. Here the purpose is to take out the heavy hydrocarbons from the natural gas streams and these are achieved by these all these methods, low temperature separator, twister, vortex tube and membrane.

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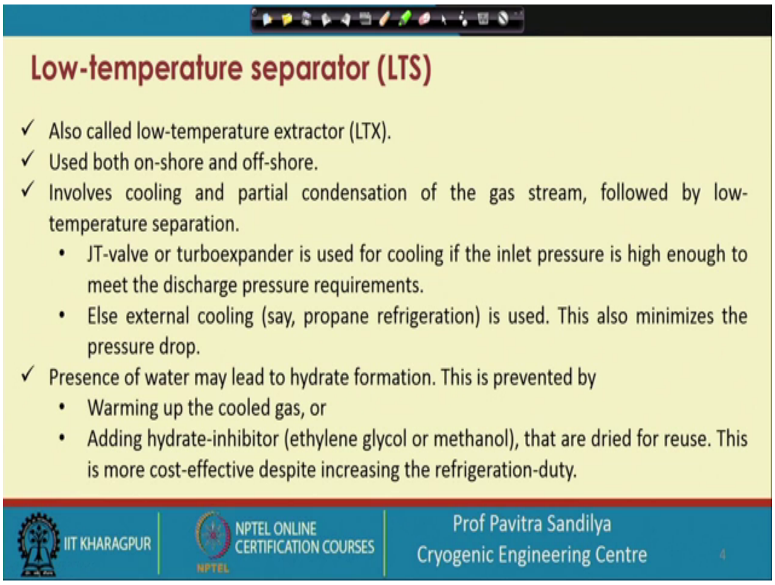


So, first let us come to the low temperature separator, these separators are also called low temperature extractor and this is the way this LTX stand for the low temperature extractor and LTS stands for the Low Temperature Separator, but they mean the same thing. And these are used for both onshore and offshore that is they can be offshore means that this is in the ship and this onshore means this is on the land. So, both ways this process may be used for the recovery of the heavier hydrocarbons. And it involves cooling and partial condensation of the gas stream and it is this is followed by a low temperature separation.

Now, to achieve this low temperature either a JT-valve or a turbo expander may be used, if the inlet pressure is high enough to meet the discharge pressure requirements. That means, whenever we are using any JT or the turbo expander we know that there will be a pressure drop. Now if the pressure drop is too high or we do not have at the inlet very high pressure, and at the outlet maybe the pressure a pressure is also quite high then if we have and in a n pipeline, if you do not have enough delta p pressure difference, then we will find that addition of a turbo expander or a JT-valve may not be recommended because then we will need to boost up the inlet gas. This is recommended only when the inlet gas has high enough pressure so, that it can overcome the pressure drop across the lines plus the pressure drop due to this JT or the turbo expander.

And in case, we do not have enough pressure at the inlet, then we have to use some kind of external cooling. Suppose we are say we propane refrigeration about which we talked about in our last lecture. And if you are using this propane refrigeration this minimizes the pressure drop.

Now, there will be a possibility of hydrate formation due to presence of the water, and this is prevented by warming of the cooled gas or adding some hydrate inhibitor. For example, ethylene glycol or methanol that are dried for reuse and this is more cost effective, despite increasing the refrigeration duty. So, there are various types of precautions taken to avoid the gas hydrate formation.

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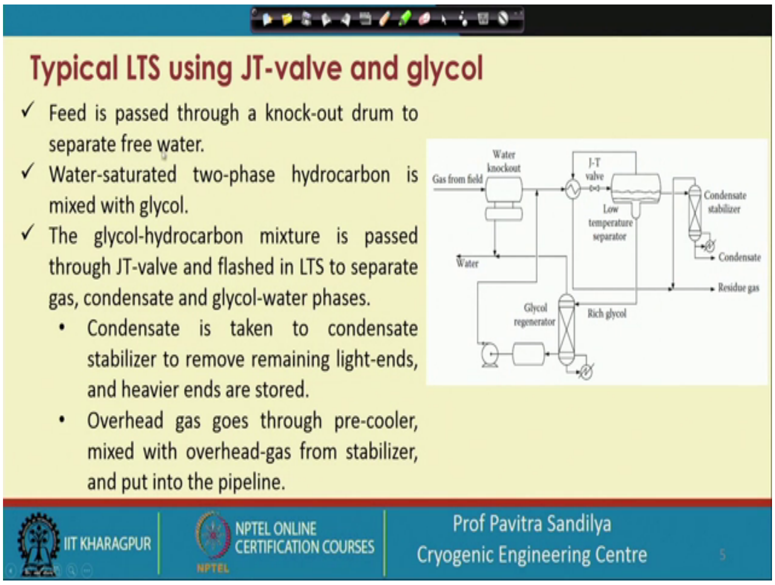


Now, let us see a typical LTS using the JT-valve and glycol. So, here in this figure we see this particular a typical system with of LTS and feed is passed through a knockout drum to separate the free water. So, here we have the gas from the field and here we have the water knockout system. So, here we are simply trying to remove the water ok. So, we are dehydrating it so, that we can reduce the chances of hydrate formation.

And the water saturated two phase hydrocarbon is mixed with the glycol. Now this is here this water which is coming out this enough saturated because most of the water have been removed. So, what we do? Here we are taking the glycol and we are mixing up with this water saturated hydrocarbon. Now this glycol hydrocarbon mixture is passed through JT-valve and flashed in LTS to separate the gas condensate and glycol water phases. So, here we have that here we are taking out taking to here, and we are getting this one is we are getting the rich glycol system here and this we are getting that hydrocarbon rich will saturated with water and here we are getting the lighter one.

So, this is the one which we you see saw it earlier also in the gas liquid separator system, and this is we are using the three phase gas liquid separator system. So, one phase is the lighter gas here this is the one which is going to be our product and this is the one is the water rich phase, which is come from here and this is the glycol rich phase which is come from here.

So, this glycol rich phase is taken over here into a regenerator system and it is you know taking out this water which is coming out from the glycol rich phase, it is again taken out from the system and this glycol which is coming here which is taken through this pump and this is fed back to the system. So, this is how we are able to recycle the glycol whereas, this gas is coming out from here and it is taken the residue gas, and this one this is which is coming from this condensate here, it is going to a condenser stabilizer. What it basically means that we are trying to again take out the lighter fractions from this.

So, in this stabilizer we are till lighter fractions. So, it is coming from here and this lighter fraction is mixed with the lighter fraction, which is coming from the low temperature separator and these are mixed and taken out a residual gas, and this particular fraction is liquid this condensate is the heavier hydrocarbons.

So, this is how this system is working.

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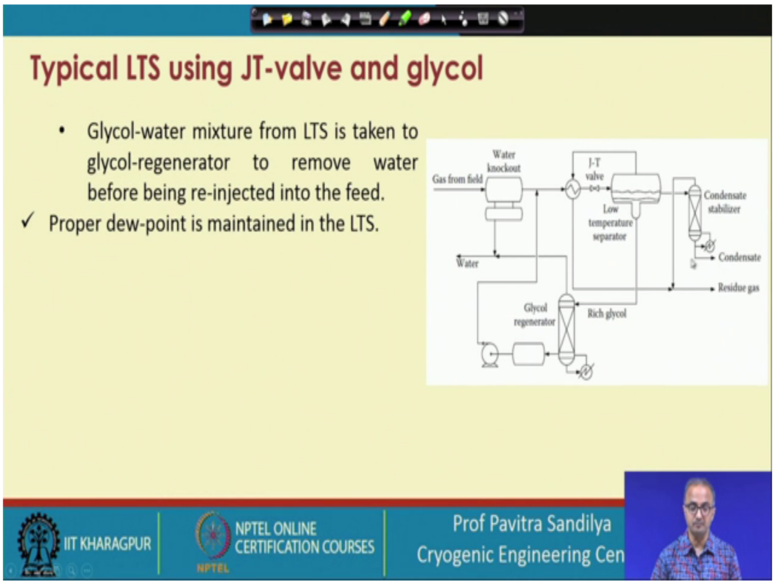


And we have to keep the proper dew point in the LTS system to maintain the amount of the heavier gas component, in because we know that the dew point dictates that at the temperature at which the condensation will start taking place. So, if we are maintaining the dew point properly; that means, we are ensuring the right quality of this residual gas and to from the system. So, if we change this dew point then we find these residues this composition residue gas will also change.

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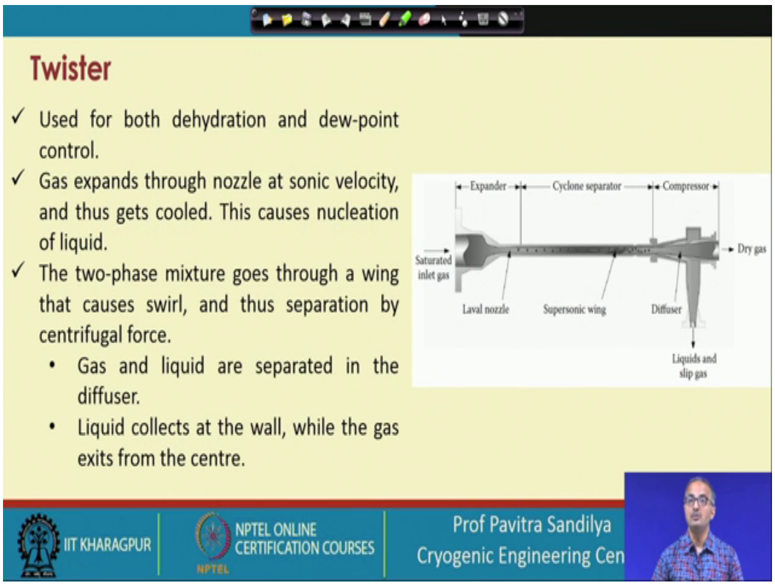

Now, this supersonic twister or simply twister, we saw this one also in the case of earlier in case of the gas liquid separators, here we find the same thing is used for the recovery of the hydrocarbons. So, I shall not be going into detail of the functioning, here just to recapitulate we found that we have three sections; one is the expander, then we have the cyclone separator and lastly we have the compressor and the liquid is obtained at this particular end and here we have an laval nozzle and here we have a supersonic ring. So, here we find again it is used for both dehydration and dew point control

So, first we find that the gas expands through a nozzle at sonic velocity and then gets cooled this causes nucleation of liquid. So, here we find that through this through this the gas is coming (Refer Time: 07:48) it expanded to about sonic velocity and this is Laval nozzle. It is something like a hourglass you can you know the hourglass that which we used to see the time. So, this something the shape is like an hourglass.

So, it comes like this and its expanded to about sonic velocity and then what happens the cyclone separator; in sonic velocity the temperature also decreases and temperature decreases and due to which liquid is formed and here we have the cyclone separator this liquid and gas are separated liquid goes towards the wall and gas moves towards the axis of the separator. And so, ultimately in this again we are compressing it and when the diffuser type here, we are recovering the pressure energy and we find that here we are getting a liquid.

So, two phase mixture goes through this wing that causes swirl and the separation occurs due to the centrifugal force as I just mentioned. The liquid collect at the wall was a gas exists from the center.

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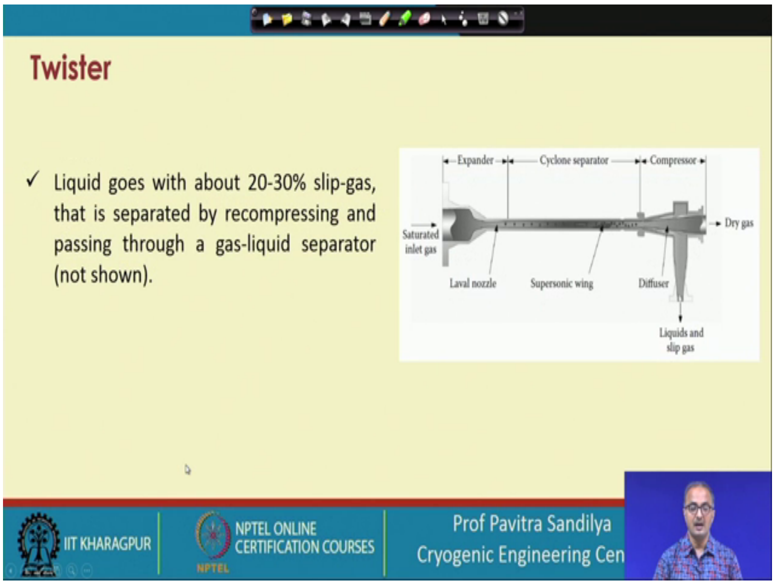


And we find that liquid goes with about 20 to 30 percent slip gas and that means, here the liquid does not come out alone it also entrance some gas along with it. This gas is called the slip gas I mean that is which is slipping out of the system is not able to go here.

So, this because it has slip gas; so, what we do? We have to recompress it is separated by recompressing and passing through a gas liquid separator. So, we a use a separate gas liquid separator to take separate the liquid and gas we recompress it and when we take it to gas liquid separator, which is at a lower pressure ok. So, because of this low pressure we find that a flash happens and due to this flash we find the gas and liquid portions again separate out. So, this thing has not been shown in this particular figure.

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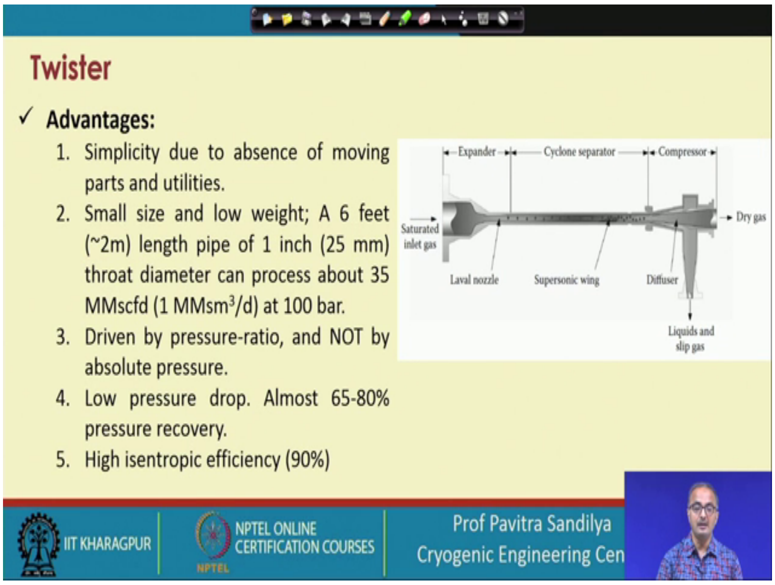


And the advantages of this twister are that they were quite simple in construction as you can see, and they do not have many moving parts and it is also not using any other utility. It is the process fluid itself is been processed in a way that it can lower its temperature and undergo this separation.

So, we are not using any external agent or utility to make this possible. And this is quite sizes and size is small and weight is low, it is about an example is a 6 feet that is about, 2 meter length pipe of about 1 inch diameter, then can process about 35 million standard cubic feet per day about 1 million standard cubic meter per day at about 100 bar. So, this is a typical figure that it shows that even in a many small tube, twisted tube. We can process a high among of the gas and it is driven by the pressure ratio and not by the absolute pressure.

So; that means, we have to maintain a pressure difference. So, whatever in the absolute pressure if we can maintain the pressure difference, then this can work and it has a low pressure drop about 65 to 80 percent pressure is recovered in the diffuser section. So, the quite; that means, it is quite energy was also it is quite efficient and it is a high isentropic efficiency.

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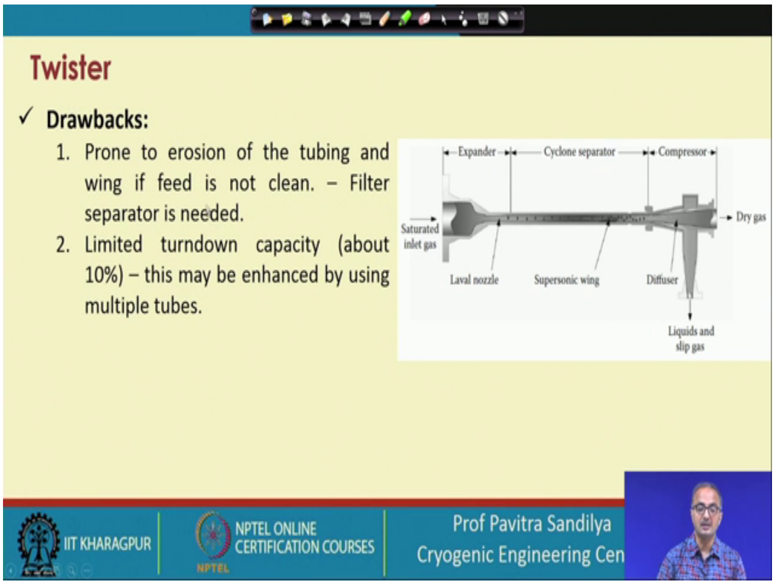


Now, the only drawbacks are that they are prone to erosion of the tubing and the wing if the feed is not clean. That means, if the feed contains particulate matters and if they are not taken off before it is passed through the system, then they may erode the system. So, they may erode the tubes and they may erode the wings in the cyclone separator zone.

And they have limited turndown capacity, and that is about 10 percent. A turndown capacity as we know it is the ratio of the minimum to maximum flow rate. That mean it gives us a an idea about the flexibility of the process that what is the range within which the one particular system can be used, and in this case it is about 10 percent and this may be enhanced by using multiple number of twisted tubes. So, these are the advantages and the limitations of the twisted tubes.

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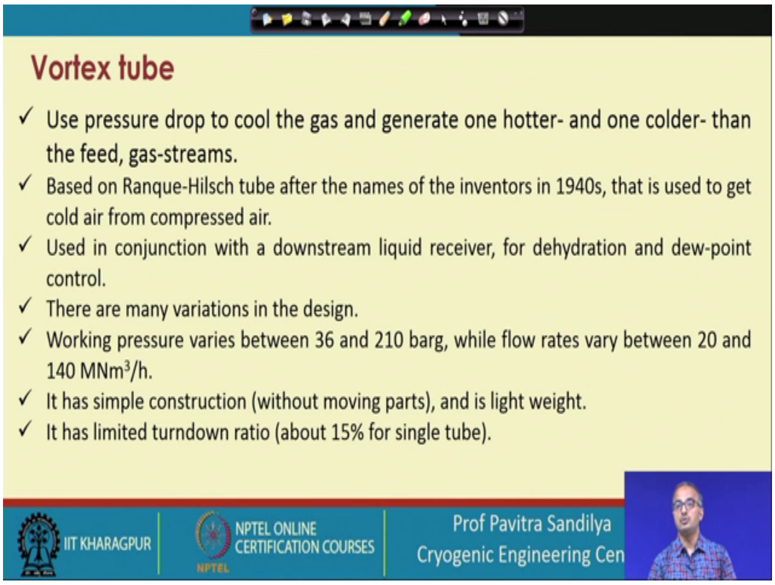


Next we come to another kind of tube that is called the vortex tube. It also works on the basis of the centrifugal force we shall see it later and first let us see that this is used for pressure drop to cool gas and generate one hotter and one colder than the feed gas streams. So, this vortex tube can generate from two streams; one will be hotter than the feed stream another will be the colder than the feed stream. And this was invented by two scientists Ranque-Hilsch and in the 1940s and then they were using to get cold air from the compressed air.

So, there are these vortex tubes are also sometimes called Ranque Hilsch tubes. So, these are using conjunction with a downstream liquid receiver for dehydration and dew point controller so; that means, they are not always used in standalone mode they are using with a liquid receiver; and there are many variations in the design. So, we will not be going into the details of this vortex tubes because there are lot many variations and lot many different types of configurations and purposes for which they are being used sometimes they are used for cooling purpose sometimes they are also used for separation of the gas and vapor and sometimes to affect mass transfer. So, the various applications are there. So, we will not be going into all those details, we shall be just looked looking into the basic purpose and basic principle of this vortex tubes.

The working pressure in this in case of the hydrocarbon recovery typically varies between 36 to 210 barg, this is this range will vary from the application to application.

And flow rates vary between these two figures 20 and 140 million normal cubic meter per hour.

So, this is the typical variations of the pressure and the flow rate in case of the hydrocarbon recovery, and it has quite simple construction and it does not also have any moving part and is lightweight. So, this is similar to the twisted tube. It has also very limited turn down ratio about 50 percent for a single tube and this turn down ratio may be increased by inclusion of multiple vortex tubes.

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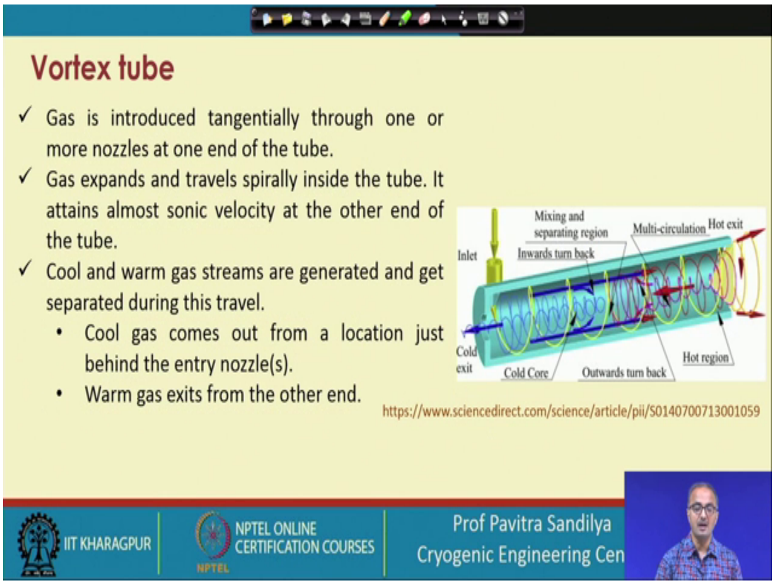


So, here we have a typical figure of a vortex tube, and this is a tube now this tube may be conical or it may be cylindrical. So, depending on the shape of the tube, we can have we will have different performances of the vortex tubes for performance in terms of the energy separation or the mass separation. Energy separation means that how much temperature difference we are getting in the product streams and the mass separation means that how much separation of the masses in terms of the lightener and high heavier hydrocarbons we are getting.

So, here we have shown a typical vortex tube configuration here we find the gases introduce tangentially through here we have someone nozzle, but it may be through multiple nozzles they may come out and then what happens? Once it goes tangentially, it now goes like a cyclone separator what happens this gas undergoes a swirling motion. And because of swirling motion what happens that the heavier ones the heavier fractions tends to move towards the wall, what is lighter fractions tends to move towards the axis of the tube.

Now, in this case what happens that, the gas may reach a sonic velocity and also there will be an expansion in this valid swirling. So, all this expansion if it creates a energy difference and also there is the wall friction which also affects the energy generation. So, all these factors when they come together, what will find that the in the inner one from the inner one this colder stream that goes here and it comes back and comes back and it comes out from this side, where is the hot stream which is near the wall it goes out. And during this process also we find that the cold stream may get so, cold that it may lead to some condensation of the hydrocarbons, and when there is a condenser hydrocarbons what happens, that they also tend to move towards the other end of the vortex tube.

So, this way we find that there could be a mass separation or what we call the recovery of the heavier hydrocarbons from the vortex tubes. So, as I told you that depending on the design variations design variations may be that we may have the only one exit we may not have two separate exits the same from same end, we may have the both the warm and the colder stream coming out. So, these are the variations are possible and also depending on the aspect ratio, that is the length to diameter ratio of the vortex tube the amount of the energy separation and the mass separation will also differ.

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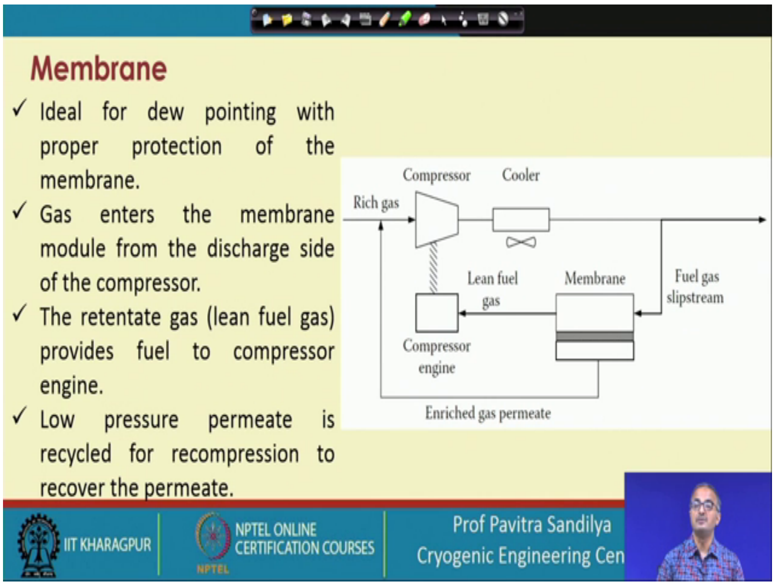

Next we have the membrane separation, we learnt earlier in detail about the membrane separation and here we find that how this membrane is used for the hydrocarbon recovery. So, here we have shown a very typical membrane setup, here we find that we have the rich gas and which has been compressed; compressed because as we know that in case of membrane the separation is due to a difference between the partial pressures of the each of the components across the membrane.

So, to have a higher difference of the partial pressure of the components, we need to compress the gas on the permeate side. So, this is the permeate side retender side; that means, on the permeate side we have the feed. So, we are compressing it and cooling it and then we are putting it into the membrane.

So, this gas enters the membrane module from the discharge side of the compressor and then what happens that on this side we get the lean gas and on this side we get the enriched gas permeate this enriched gas contains the heavier hydrocarbons.

Now, we find that this low temperature this lean gas which is the lighter hydrocarbons, they are taken out from here and then they are combusted, and so, that the energy that energy from the combustion will be used to drive the compressor through the compressor engine. So, and this heavier component is taken and it is sent and with mixed with the rich gas, and to further recover the hydrocarbons.

So, this is how it goes; now, what we find that, generally we expect that the membrane should be allowing the lower hydrocarbons; that means, the smaller hydrocarbons to pass through them and not the higher ones, but in this case it is a bit different. We find that the higher hydrocarbons are passed through the membrane whereas, the lower ones are being retained this seems to be a bit unusual. But this is happening why that particular choice of the membrane material.

So, the as we know that in case of gas separation, we used non porous membranes we learnt it earlier that and these non porous membranes works on the solution diffusion mechanism and in this case what happens? It depends on that how the particular hydrocarbon is getting adsorbed on the membrane surface. So, if we choose the membrane metal in such a manner, that it will be having more affinity towards the heavier hydrocarbons, than the lighter ones then it is obvious that lighter ones will not be able to pass through the membrane whereas, the heavier one because of their higher affinity to the membrane will be going through the membrane.

So, that is how we find that the solution diffusion mechanism works out to take out the higher hydrocarbons through the membranes well whereas, the lower hydrocarbons are retained or rejected by the membrane.

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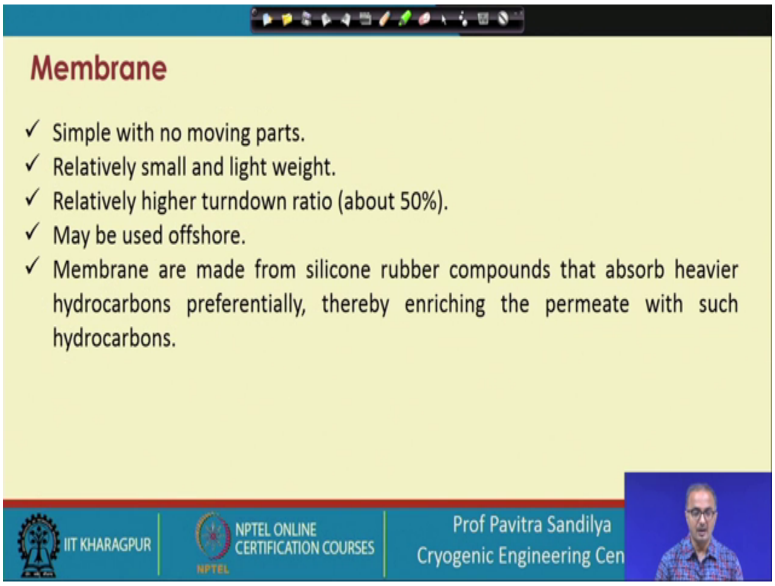


And these membranes have simple construction and they do not have any moving part, and they are quite relatively small and lightweight because they generally come in modules in modular fashion so, that is why we can maintain a small and size small, and the weight light.

They also give much higher turn down ratio than the vortex tube and the twisted tube. So, it is about 50 percent may be used for offshore applications and as I was telling you, the membranes are made from the silicon rubber compounds, which result in the separation of the heavier hydrocarbons from the lighter ones.

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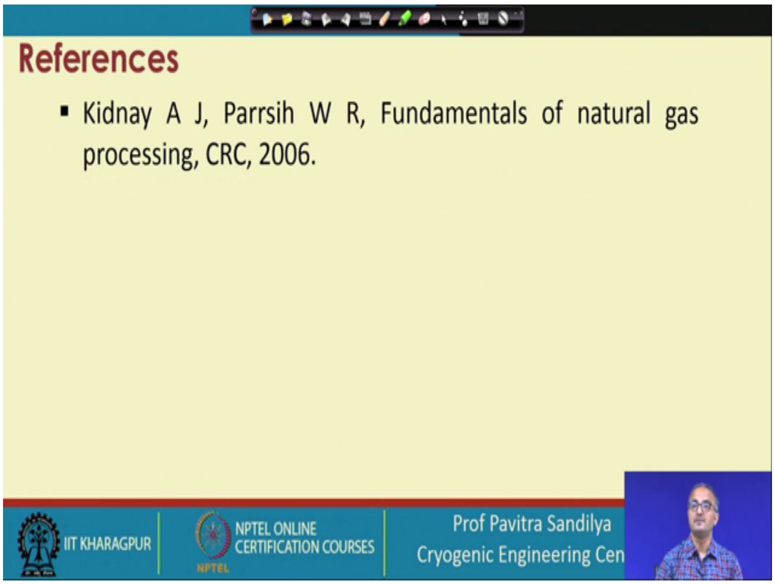


And this is the reference, which you can see for details about these processes.

Thank you.