Upstream LNG Technology
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Lecture - 81
Hydrocarbon recovery in natural gas systems - III

Welcome, today we shall be looking into a few more techniques for the recovery of the natural gas liquids. So, in this particular lecture what we shall be learning about is two things; one is the low ethane recovery and the high ethane recovery.

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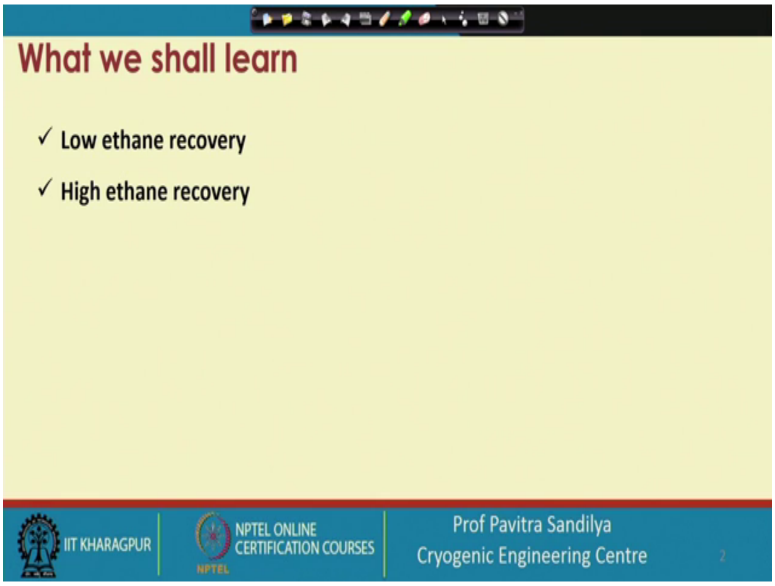

These two pertain to the different processes by which we can recover the ethane depending on the how much ethane we want to recover whether we want to recover the low amount of ethane or high amount of ethane depending on that we again have a different types of recovery processes.

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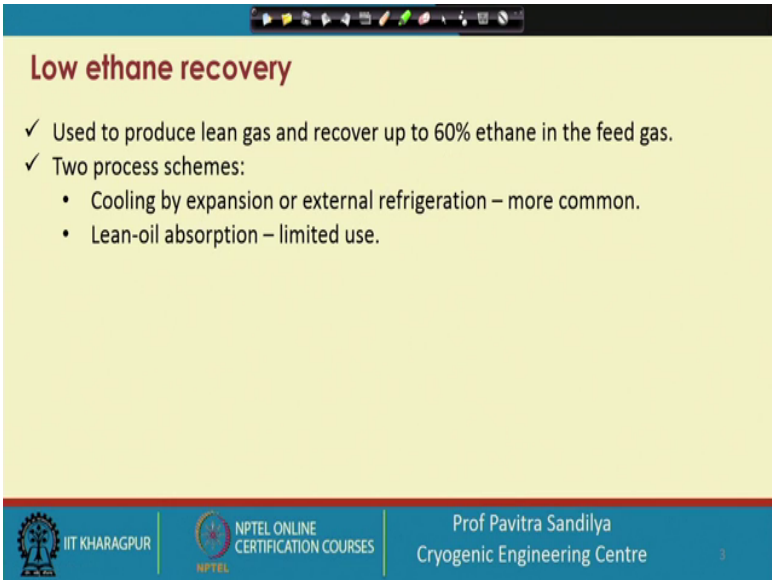

Now, when we talk of the low ethane recovery what we mean that we want to recover about 60 percent of the ethane that is present in the original feed gas. And this way we can produce a lean gas, lean gas means which that is having less amount of ethane that you know original one. So, that is how we are producing the lean gas and recovering up to about 60 percent of the ethane. And in this we generally use two types of processes one is that refrigeration and it can be by external refrigeration or some expansion which is more common and less common, but it which was historically used more is the use of the lean oil absorption. So, first let us start with the one which is more common and this is the cooling by the expansion or external refrigeration.

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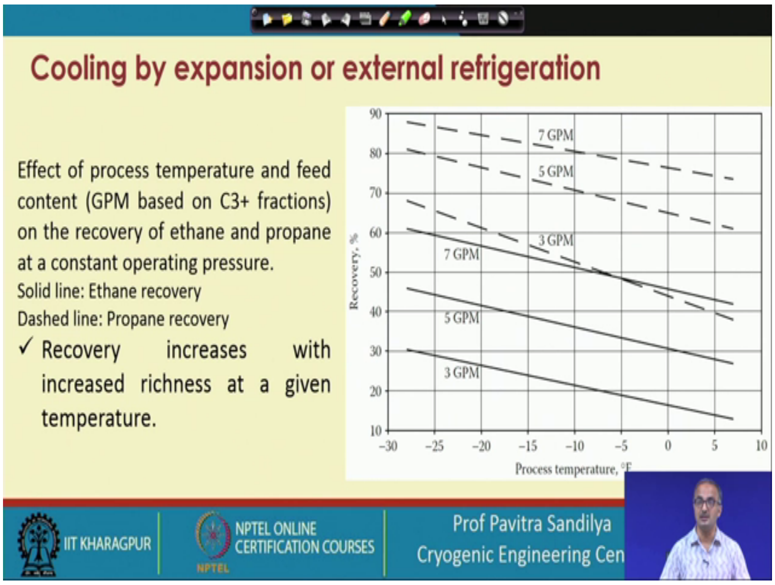

Now, we have learned in our earlier lectures about how cooling can be brought about by using expansion that is the one we have studied that we could use turbo expander or we can use joule Thomson effect.

So, all these principles which we learnt earlier it will be now used here for the recovery of the natural gas liquids and in this case it is the ethane recovery we are concerned about.

So, here in this particular figure what we see that the how the temperature affects the recovery. Now here we see that we have drawn some lines have been drawn over here and each of these lines represent in term different amounts of the feed content and these feed content is given in terms of GPM that is the gallons per minute. And this has been calculated based under C 3 plus fractions that is the propane and higher hydrocarbons.

So, and depending on that these two types of lines you can see have been found and this dashed line is for the propane recovery and this solid line is for the ethane recovery. And we see that for this recovery is decreasing as we increase the process temperature, it is expected because what happens that as we are increasing the temperature more and more of the components are going towards the vapour side and less they are remaining in the liquid.

So, that is how we are finding that the recovery. Please note that when is a recovery means that we are trying to recover the components in the liquid. So, and the gas we are producing that gas is supposed to have more of the methane.

So, as we see from in this graphs that as we increase the temperature process temperature for a given feed content or feed content of the higher hydrocarbons we find that the these components are going more in the vapour so, that we are getting less and less recovery in the liquid.

And the same thing we find that both whether we talk of propane or ethane we are finding that recovery is decreasing with the temperature for a given feed content. And also what we find that for a given feed content, for example, we compare this 3 GPM over here and 3 GPM over here. We find that propane is showing more recovery than ethane.

It is also expected because the heavier the component the more will be the tendency of the component to go the liquid phase. So, here that is why we find that because propane has a higher molecular weight than the ethane.

So, we will find that it will tend to go more towards the liquid that is why the higher hydrocarbons we will have more recovery for the same operating conditions. And here we see that recovery increases with increased richness at a given temperature. So, that is what we find that if you go from for a given component, so, if you are going from 3 GPM to 5 GPM to 7 GPM we find for the same temperature we are getting more and more recovery.

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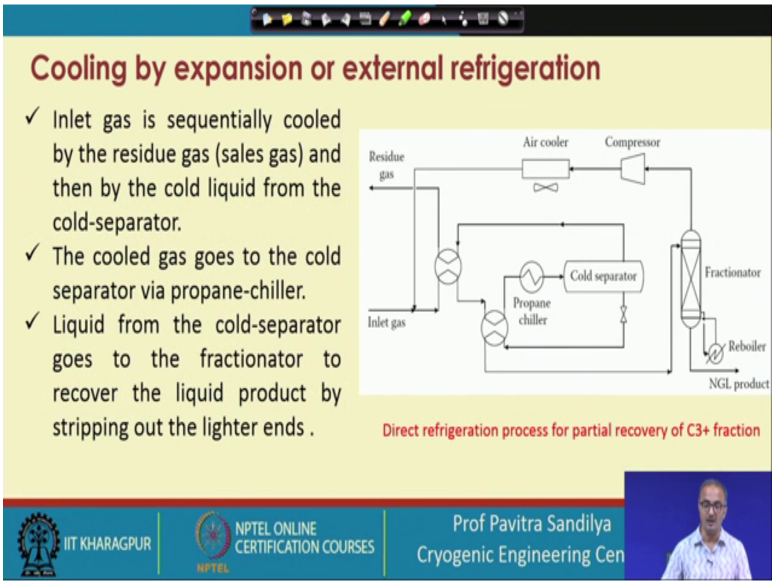

Now, here we have a typical flow chart for the expansion or external refrigeration. Here we find the inlet gas is sequentially cooled by the residue gas or the sales gas and then by the cold liquid from the cold separator. So, what we find? Here we have the inlet stream. So, here the inlet stream is first been cooled by these residue gas which is obtained from the cold separator.

So, first this is; that means, we are trying to recover the cold from the residue gas. So, here first it is done there and then we take it to this another heat exchanger.

So, here we find this is again this inlet gas is getting further cooled and this is getting cooled by the liquid which is coming out from the cold separator. And then it is going to a propane chiller.

Now about the propane chiller we have learnt in our previous lecture. Now please understand this even though we are showing here with single symbol, but this is not a single unit, but it is a kind of a cycle which is a refrigerant cycle in itself.

So, this is a propane chiller propane refrigeration cycle and from there we are making it cold enough so, that we are we will be getting a liquid and a vapour phase.

Now, what happens? This vapour is taken back from here and it is now getting as I said that it is going to cool the inlet gas and the liquid is also coming here and is also cooling the inlet gas. Now what happens that after that the cooled gas goes to the cold separator where the propane chiller as I was told you the propane chiller is goes to the cold separator and liquid from the cold separator goes to the fractionators to recover the liquid product by stripping out the lighter ends.

So, this liquid which is on a cold separator it is going from here and it is going to this fractionators and in this fractionators we are stripping of the lighter components from whatever it is coming in this liquid lighter components. And those lighter components are going from here and the heavier components are coming from the downwards.

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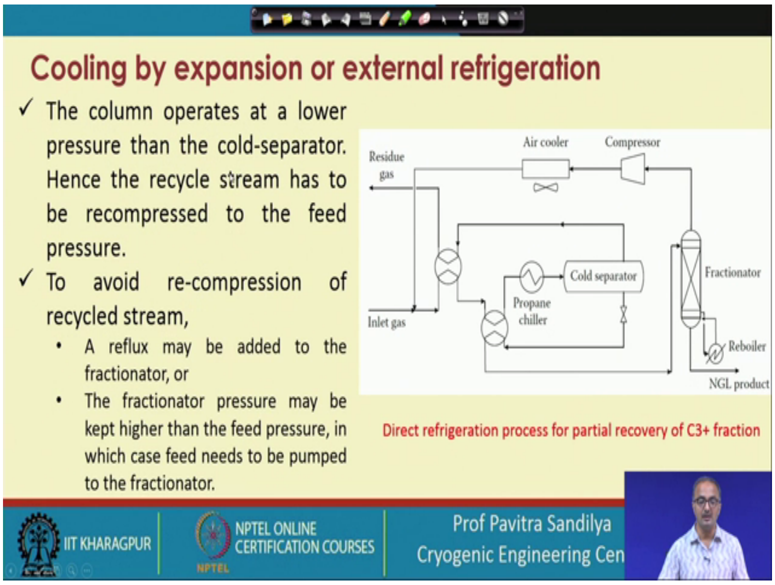

The column operates at a lower pressure than the cold separator. Hence recycle stream has to be recompressed to feed the feed pressure. What it means that because this particular thing fractionators has a lower pressure than the feed pressure is the cold separator.

So, when we are passing it through back to the inlet gas. What we are finding that we are recompressing it and by recompression we are able to bring the pressure back to the inlet gas temperature with which we are mixing it ok. So, that is why we need the recompression of the vapour from the fractionators.

And to avoid recompression of this recycle stream a reflux may be added to the fractionators or the fractionators pressure may be kept higher than the feed pressure in which case feed needs to be pumped to the fractionators.

Now in this case what we see that suppose because each of this extra equipment or the extra operation we are doing it will incur cost. So, if you decide that we do not want to have any compression because it will involve some work to be done on the system.

So, we want to reduce that then one may decide that let us keep the fractionators at a higher pressure. So, that this return stream may be sent back to the feed side without any recompression, but in that case what will happen because it is at a higher pressure than the feed then we need to a pump this feed gas from this side. So, in either case we are finding that whether we are going to recompress the gas or whether we are going to compress the inlet gas that will depend on the particular situation at hand that at what pressure the inlet feed is available according that we have to decide that whether we shall be going for compression over here or compression over here.

So, it is a typical situation we have shown here that where we are recompressing the vapour from the fractionators. And if here you can see that here we are not doing any kind of reflux as we learnt earlier that reflux helps in increasing the separation of the heavier components from the vapour.

So, that thing we are not doing here. So, that is why we would have to recompress it. And this may be avoided if we are putting some reflux over this fractionators.

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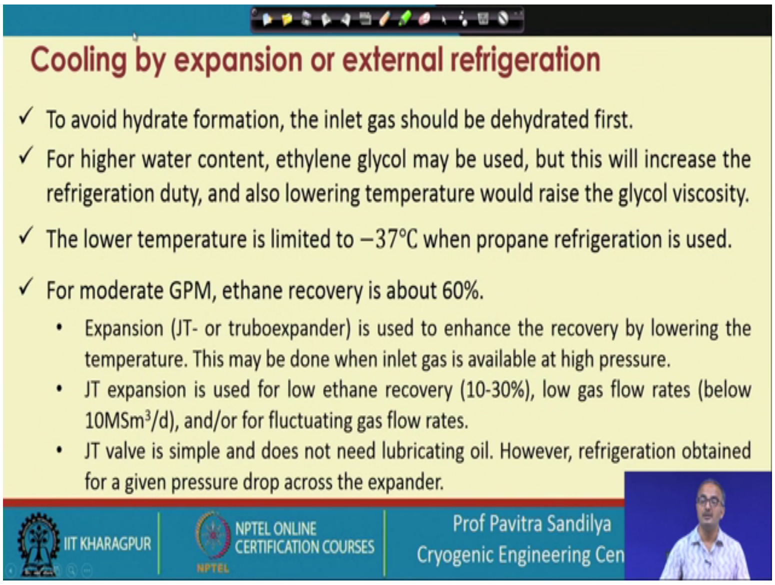

And there may be possibility of hydrate formation that because if there is a substantial amount of water in the inlet gas then this water made form hydrate and it may form hydrate with the hydrocarbons themselves like methane from hydrate ethane from hydrate. So, all these gases may inform hydrate with water and. So, that is why we to reduce the chances of the hydrate formation it is seen to it that we dehydrate the gas before we go for the NGL. And that is now we can understand the importance of dehydration in the natural gas processing and why we need to maintain the particular sequence that we have to first dehydrate the natural gas before we take it for any further processing.

So, this is why that any kind of hydrate formation will be avoided if we are taking out the water initially. Now if there is too much of water then ethylene glycol may be used and ethylene glycol as we learnt that we may use ethylene glycol or other glycols, they may be used to do what you call that they are act as hydrate inhibitor.

So, this kind of glycols may be used, but if you are putting these external glycols. First thing is that they also make our stream impure and not only that they will increase the refrigeration duty that means, now we will find that the work or the amount of refrigeration we need that will also increase because of this addition of the glycols. And one more thing will be there that if we now lower the temperature.

What will happen? It will increase the glycol viscosity. And if the viscosity increase it what it means is this it will put more resistance to at the flow of the gas streams and in that way what we will find that our pumping power will also increase, but we have to understand this again in many of these things if have to be done they have need to be done and we cannot avoid it. And we have to have some kind of penalty in putting all these kind of evolving or exploring these various options.

So, these are the various options which are followed in the natural gas processing in the recovery of the natural gas. Now the temperature is limited to minus 37 degree centigrade when propane refrigeration is used. Now for moderate GPM that is the feed content the in ethane recovery is about 60 percent and expansion may be done by either joule Thomson valve or turbo expander is used to enhance the recovery by lowering the temperature.

Now as we learnt earlier also that expansion also cause the pressure drop. Now pressure drop means we are losing the energy for the flow. So, then we need to compress the gas at higher pressure.

Now if we have the inlet gas initially at a high enough pressure then expansion is recommended. Now joule Thomson expansion is used for low ethane recovery it is about 10 to 30 percent why because joule Thomson gives lower cooling than the turbo expander and it can it is also used for low gas flow rates below about million the 10 million standard cubic meter per day and for fluctuating gas flow rates. Now for fluctuation gas flow rates these trubo expanders are not recommended because they cannot work with too much fluctuations of the gas flow rates. And one more advantage is this JT valve is simple and does not need any lubricating oil that is needed by the any kind of moving machinery rotating machinery. And however, refrigeration obtained.

For a given pressure drop across the expander is less. So, we get less amount of refrigeration for a given pressure drop when we are using the JT valve.

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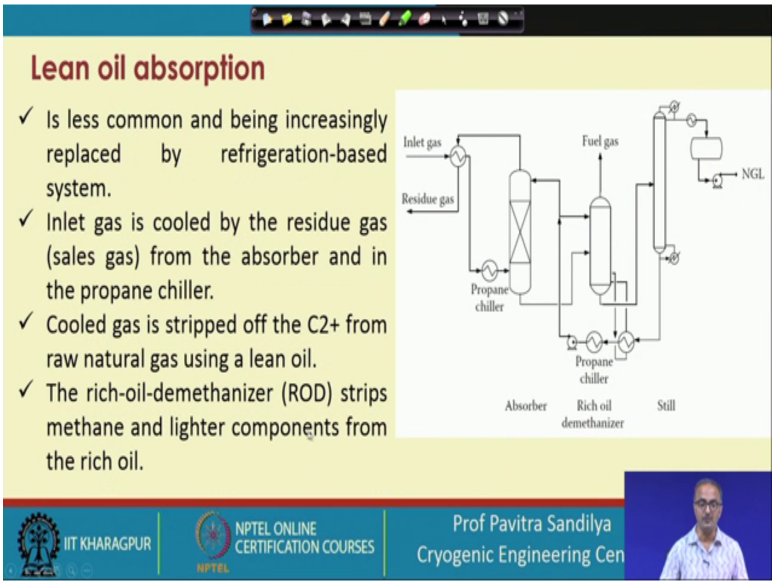

Next process which is there as we said that this has an historical importance and now at present this has become quite low in this application, but still it is there at some plants. This is the lean oil absorption and this absorption as we learnt earlier we studied about the absorption and how to design a column for absorption.

So, in this case we have what we are doing that we are going to use a solvent to take out the some components from the natural gas. So, in this case we are the lean oil is used.

So, it is less common and being increasingly replaced by the refrigeration based system. Now here we find that inlet gas is cooled by the residue gas that a sales gas from the absorber and in the propane chiller. Now, here you see that here the inlet gas is coming and it is to be cooled and this is cooling is done from this particular inlet gas this the vapour which is coming from the absorber

This is a absorber you can see this is the absorber the gas is coming which is quite cold and it is cooling the inert gas initially and then what is happening that this inlet gas is going and it is going to the propane chiller. As we understand again that this propane chiller in itself is a cycle.

So, it is going to the propane chiller and then it is entering the absorber now cooled gas is stripped of the C 2 plus component from the raw natural gas using a lean oil.

So, when it is going over here we are taking at the bottom of this thing and what will happen that here we are putting the propane this lean this lean gas. Now what is happening that what we are putting in the bottom because gas has a tendency to move up the column. So, we are putting it at the bottom of the column and from the top we are putting the lean oil. And then what is happening during this contact this is this particular thing is signifying a packed bed.

So, you know this thing what is happening that the gas is moving up and as it moves up this oil is taking up the higher hydrocarbons C2 plus that is ethane and higher hydrocarbons and the gas we are getting here will be richer in the methane.

So, here from here we are getting the higher hydrocarbons to the rich oil demethanizer that is in short it is ROD, Rich O-il Demethanizer strips methane and other lighter components from the rich oil. The rich oil means this is the oil which we are getting from the bottom is rich in the higher hydrocarbons.

So, which is going in this reach or the demethanizer. So, from here what we are doing that we are able to strip of the higher this right advance and which are taken as the fuel gas now.

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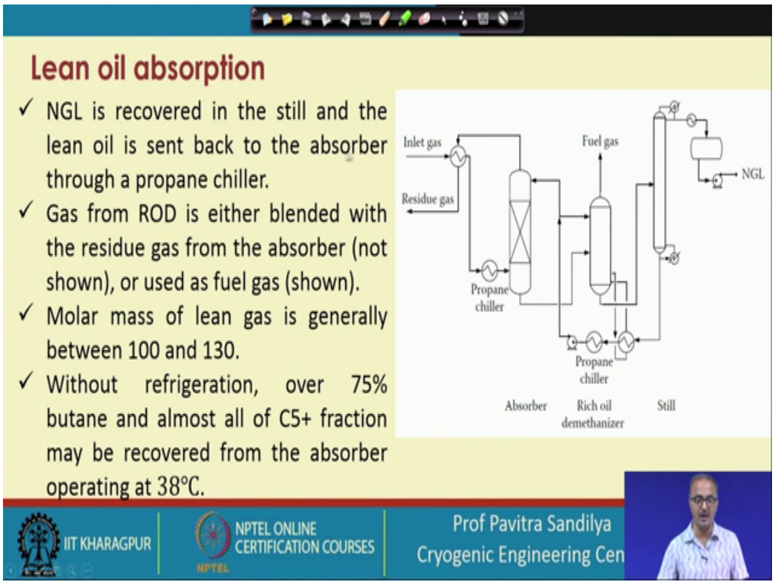

NGL is recovered in the still and the lean oil is sent back to the absorber through a propane chiller. Now here in this is the still. So, here we see that in the still what we are doing that we are getting this rich oil from the bottom of the still and it is being sent back to the absorber through this propane chiller over here.

So, this is how and what we are doing that during this we are also exchanging the heat with this stream and this is how it is getting this reboiled and this particular stream is getting riboiled is this has the higher temperature and it is going back to this column.

And here we are to the propane chiller we are taking it back to the particular absorber. And gas from the rod is either blended with the residue gas from the absorber and or used as fuel gas as. So, as I was telling that from this rich oil demethanizer this here we are showing this used as fuel gas.

But this may also be blended with the residue gas this from residue gas it may blend with residue gas it can be connected with this particular stream and taken out. So, this because ultimately residue gas is also used as fuel.

So, this gas may also be you were taken along with the residue gas. Now molar mass of lean gas is generally between 100 and 130. So, this is the kind of because there can be many valves can be there. So, this is the molar mass is about 100 to 130. And without refrigeration over 75 percent butane and almost all of C 5 plus fraction may be recovered from the absorber operating at 38 degree centigrade.

So, it is a typical figure which has been shown here that the heavier hydrocarbons that is the butane and C 5 plus that means, pentane hexane etcetera they may be completely recovered from the natural gas at 38 degree centigrade and butane is about 75 percent of butane may be recovered.

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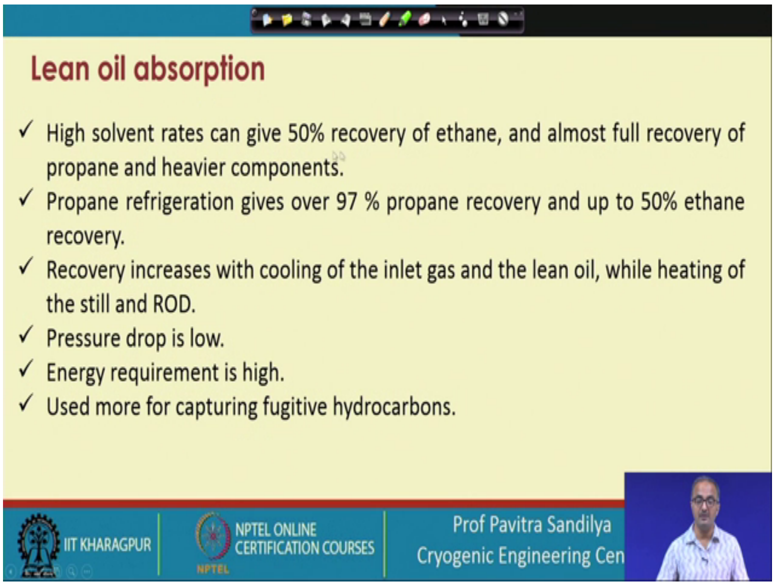

Now, the high solvent rates can give 50 percent recovery of ethane. So, we can see that the ethane recovery still goes up if you are using high solvent rates and almost full recovery of propane and heavier components that means, high flow rate of this solvent is preferable, but at the same time you have to understand that if you are increasing the solvent flow rate it is also going to increase our pumping costs.

So, propane refrigeration gives over 97 percent propane recovery and up to 50 percent ethane recovery. So, this is a comparison at this if you are using the propane refrigeration then we are able to get quite high amount of the propane in the natural gas liquid and about 50 percent we are getting in the natural gas liquid and rest of them is going with the overhead gas. Recovery increases with cooling of the inlet gas and a lean oil while heating of the still and ROD. Because we have seen that that is why we are finding that the inlet gas is being cooled and lean gas is also being cooled as we have seen from here that here the inlet gas is cooled and also this lean gas is also getting cooled through these liquids here.

So, that is why this both these things are getting cooled. So, that we can increase the recovery, pressure drop is generally low and the energy requirement is quite high because of the compression and chillers we are from the chillers we are using for this.

The energy quantity is quite high and it is used for capturing fugitive hydrocarbons. Those hydrocarbons reach can escape easily. So, those kind of hydrocarbons are recovered by the lean oil absorption.

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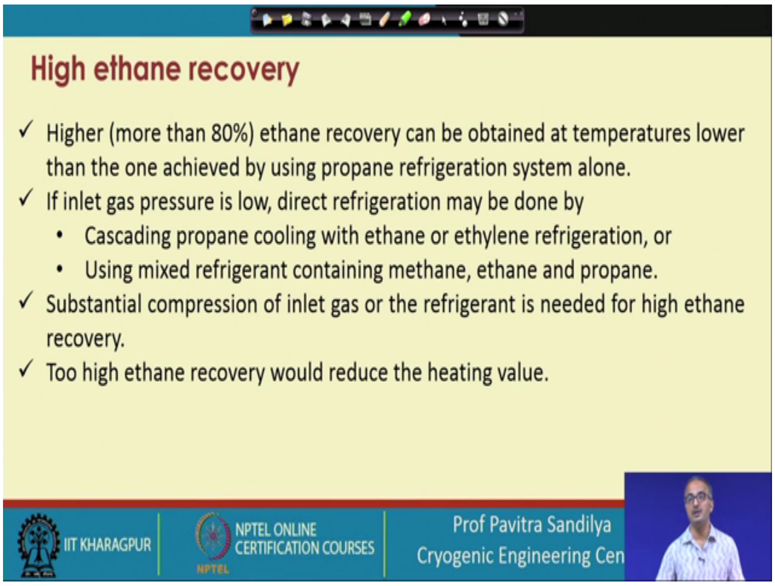

Now, after learning about the low ethane recovery we come to the processes which are used for the high ethane recovery in this fame it is a high it means we want to recover more than 80 percent of the ethane which is present in the feed gas. And this can be obtained at a temperature lower than the one achieved by the propane refrigeration system. In the low ethane recovery we were using the propane refrigeration, but that and that are temperature reached by the propane refrigeration was limiting the recovery of the ethane.

So, if we can make the temperature go still less than the propane recovery that is about minus 37 degree centigrade minus 40 degree centigrade. If you can go below that temperature we can go for higher amount of ethane recovery.

Now if inlet gas pressure is low then direct refrigeration may be done either by cascading the propane cooling with ethane or ethylene refrigeration or using mixed refrigerant containing methane ethane and propane.

So, this is the case that if we do not have enough pressure on the feed side then expansion should not be done because expansion is going to create still more pressure drop. So, in that case we are completely dependent on the.

Refrigeration either by the cascade refrigeration and or by the mixed refrigerant. Both these things we have done earlier in separate lectures. So, I am not going to go in detail about these two types of refrigeration. The substantial compression of the inlet gas or the refrigerant is needed for high ethane recovery.

So, it is the requirement that we need to have compress it quite well compress to quite high pressure.

So, that we can increase the ethane recovery. And to high ethane recovery would reduce the heating value that means, if we are taking out the ethane too much in the liquid that means, less of ethane is going with the overhead gas then what will happen the heating value of the overhead gas will also come down. And we learnt that why we were doing this whole in a NGL recovery was there to keep the heating value under control because if all the hydrocarbons go together they will increase the heating value, but at the same time if we are taking out all the high hydrocarbons that will also reduce the heating value which is below the permissible level. So, that is why we also need to C 2 it that we are not recovering all the hydrocarbons high hydrocarbons other than the methane in the NGL process.

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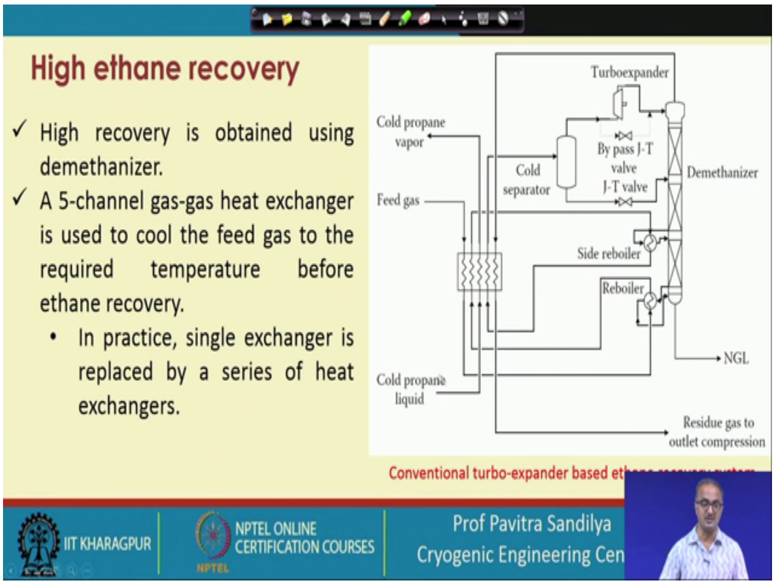

Now high recovery is obtained using demethanizer as we have seen again this is the conventional turbo expander based ethane recovery system. So, here we are has in demethanizer this is from where we are getting this high ethane recovery.

And here we have a five channel gas heat exchanger is used to cool the feed gas to the required temperature before in a recovery. Now even though it is showing shown as a gas heat exchanger one, but in practice signals heat exchanger is replaced by a series of heat exchanger that means, we generally use a heat exchanger network over here which is being compressed and shown in a very to show that we are using a simply five channel heat exchanger. It should not be taken as the actual one, but should be taken as a representative of the heat exchangers which are used for the cooling of the feed gas.

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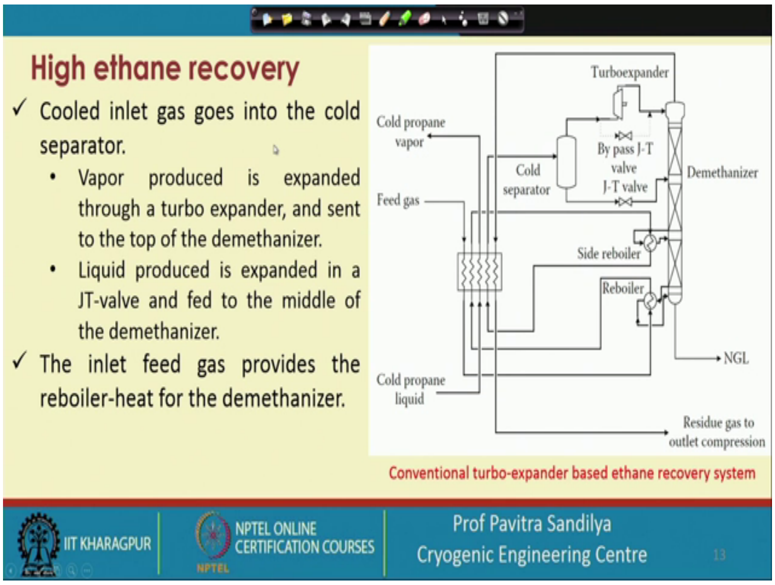

Now you can see here that the cold inlet gas goes to the cold separator. Now you see that how the cooling is getting done that the feed gas is coming through some heat exchanger. And here this heat of the feed gas is also used in the reboiler to boil up the liquid in the demethanizer. So, this is this that means, this heat is used as boiler. So, that is why this feed is get is getting cooled and it is colder than the initial feed gas.

So, it is also used to cool the incoming feed gas and then it is taken to another reboiler over here and again this colder feed gas is again taken back and it is sort of again coming back to this heat exchanger and ultimately it is going into the cold separator. And in this code separator what is happening we are getting the vapour and the liquid the vapour is passed through a turboexpander and it is taken into demethanizer whereas, the liquid is expanded through a JT valve and is put somewhere in the middle of the demethanizer ok. And now what we find that a curve in this case we find the methane will be moving out with this particular gas stream and then vapour stream at the top and it will be again taken back to before it is taken out as residue gas it is again used to cool down the feed gas further through the heat exchanger network and it is taken as residue gas.

Well in this case we find this that from the bottom we are getting the natural gas liquid. So, this is how and also we are also using this cold propane liquid in this particular heat exchanger to cool the feed gas.

So, except the feed gas all the other streams here we have shown here are cooling the feed gas.

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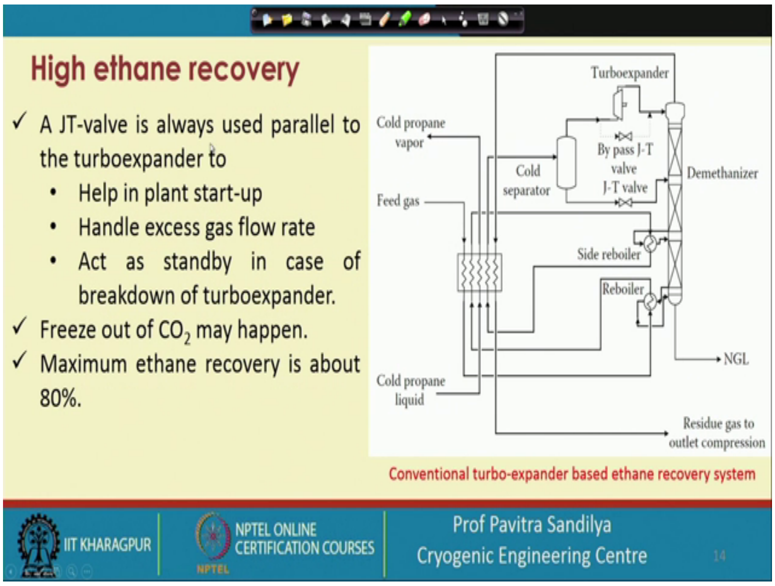

Now, a JT valve is always used parallel to the turbo expander here we are using parallely to turbo expander JT valve why to help in plant start up handle excess gas flow rate and act, act as standby in case of turbo expander.

So, for these reasons we are using a JT valve in parallel to the turbo expander and there may be a problem of freeze out of carbon dioxide and the maximum ethane recovery is about 80 percent.

So, in this particular conventional turbo expander based ethane recovery is ten we are getting about 80 percent recovery.

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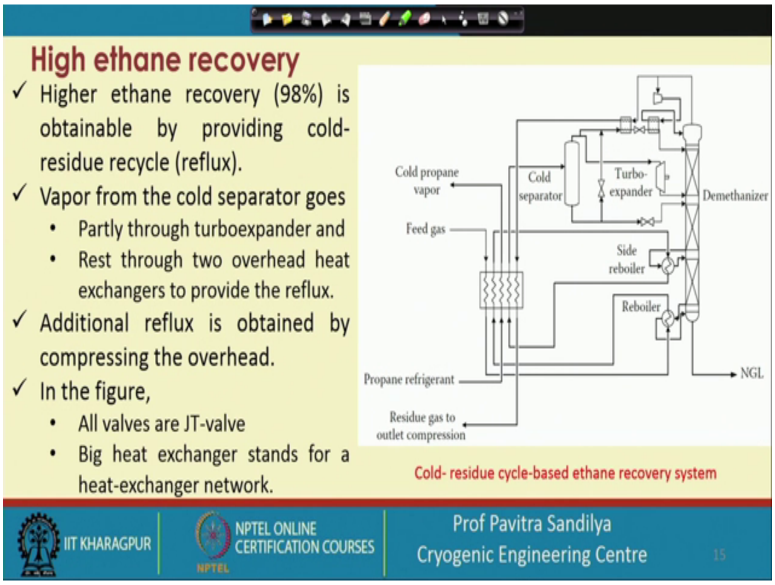

Now, if you still further want to increase the recovery to about say 98 percent. So, what we are doing it is almost same as the conventional among except that we are now using a reflux. So, here we find that I was not explain the this things here because these same remains same as the conventional one only thing is we are here shown that here this there is a extra thing.

So, what we find this particular pole separator what is happening the vapour which is coming out it is again bifurcated a part is going to the turbo expander and put into the demethanizer and the rest of the part is taken to these two heat exchangers to the J T valve and it is taken as one reflux.

And as the reflux is the vapour which is coming from the top which is again it is part to the it is taken out through it is we have to cool the incoming feed gas and a part is again taken through this expander and through this heat exchanger it goes and it goes a reflux that means, this there are two reflux streams in this particular in particular system. And rest of the things are remaining the same as earlier in the conventional turbo expander based in a system.

So, with this modification one can get a still higher ethane recovery when which is near about 98 percent. And this as I told you that here also this particular big heat exchanger denotes a series of heat exchanger or heat exchanger network.

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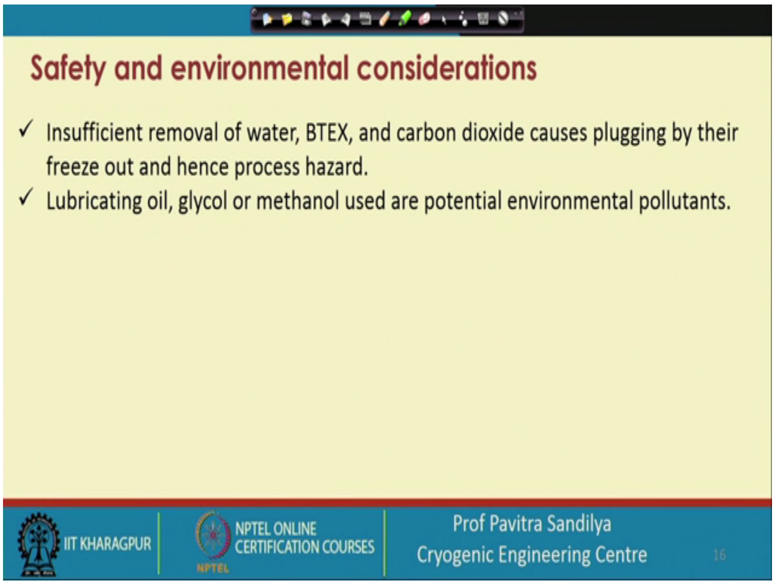

And there are some safety and environmental considerations though even though this is process is not that hazardous.

There may be that insufficient removal of water BTEX that is the benzene ethyl xylene and toluene and all these things ethyl benzene they and their carbon dioxide. They may cause plugging by their freeze out and hence process hazards and either will be some environmental pollution may be created if you are using any kind of lubricating oil glycol or methanol.

So, the environmental pollution effect or the safety hazards are not very high. But still some of them may be there in these types of angel recovery process, further details can be found from this particular book.

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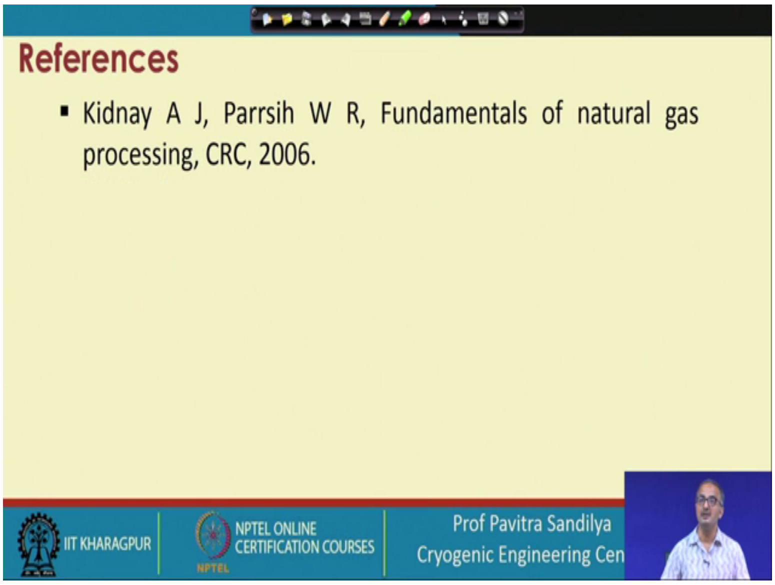

Thank you.