Chemical Technology
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Module - 6
Petroleum Refinery
Lecture - 3
Crude Oil Distillation

We have discussing the module 6 of the organic chemical technology course and we already discussed lecture one. In lecture 1 and lecture 2 about the different aspect of the introduction to the petroleum refinery the various type of the crude oil which we are processing. What are the things that is, needed for the evolution of the crude oil? What are the changing scenario in case of the petroleum refinery and how the quality of the feed that is affecting or the crude oil that is affecting the further process? So, we discuss in the lecture 1 and lecture lecture 1 and lecture 2. Now, we will discussing about the crude oil distillation that is one of the major or the prime you can say, the primary operation that we are doing in case of the refinery that is the crude oil distillation.

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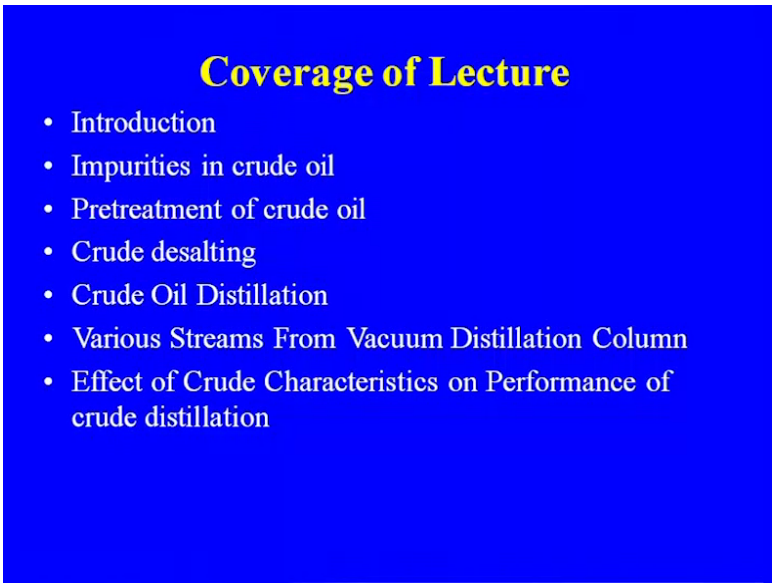

So, for the coverage of the lecture is concerned we will have the introduction of the crude oil distillation. Impurities present in the crude oil because, they play very important role in the further processing of the product, which we are getting from the crude oil distillation. Because, whatever the product we are getting from the crude oil

distillation as such they cannot be used for various purposes and the some improvement in the quality that has been so, further the impurities which are there which may cause corrosion, which may cause the you are catalyst poisoning. So, impurities and their pre treatment removal that is very important and some of the steps in case of the pre treatment.

Whether it is at the site or at the refinery that will be discussing here and the crude oil desalting process because, there has been lot of the development in the crude oil desalting, but normally because just to requirement of the process we are the two stage crude oil desalting. Then the crude oil distillation various stream from the atmospheric and the vacuum distillation column effect of the crude characteristic on the performance of the distil. These are the some of the things that will be covering in this lecture.

Let us start with the crude oil distillation, why the crude oil distillation is there? The petroleum refining process is the separation of the different hydro carbon as I told you the during the discussion of the crude oil evaluation. The different basis of the crude oil it may be paraffinic naphthenic intermediate base and it is around it is ported as the 1000 time of the hydro carbons that may be there. Although, it is only c and h, but the various type of the your hydro carbons are present and so, we are separating some of the major hydro carbon, which are been used in the as a fuel which are used as the feed stock.

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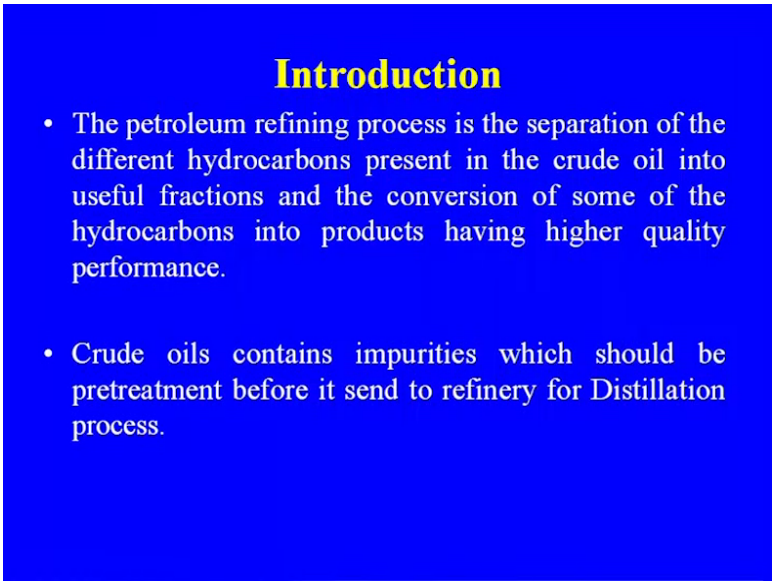

So, this petroleum refining process is the separation of the different hydrocarbon present in the crude oil into useful fraction and the conversion of some of the hydrocarbons into products having higher quality performance. So, this is not part of the crude oil distillation, but the product which you are getting from the crude oil separation that is being for the further process. Crude oil contains impurities, which should be pretreated before it is being send to the refinery for distillation process.

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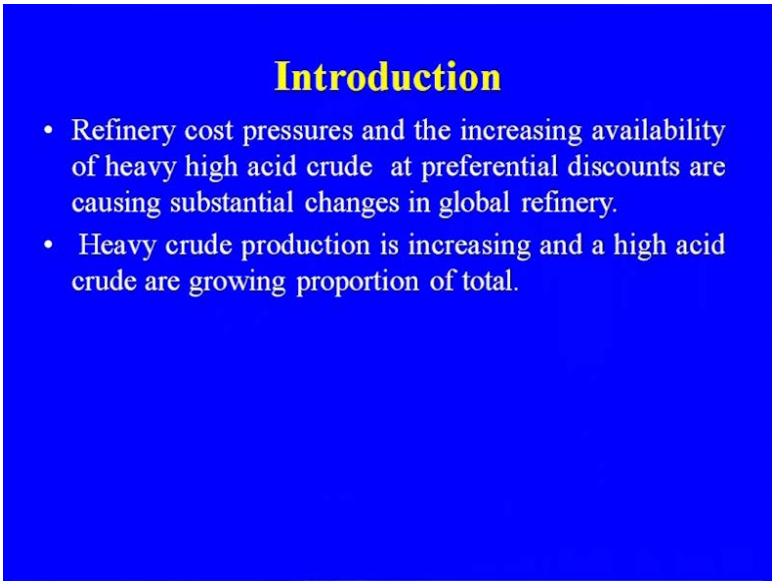

Refinery cause pressures and the increasing availability of the heavy high acid crude means, the high tenure crude at a preferential discounts are causing substantial changes in the global refinery. Heavy crude production is increasing and a high crude, high acidic crude are growing proportion of the total crude plane, which is going to the refinery and so the pretreatment that has become very important in case of this crude.

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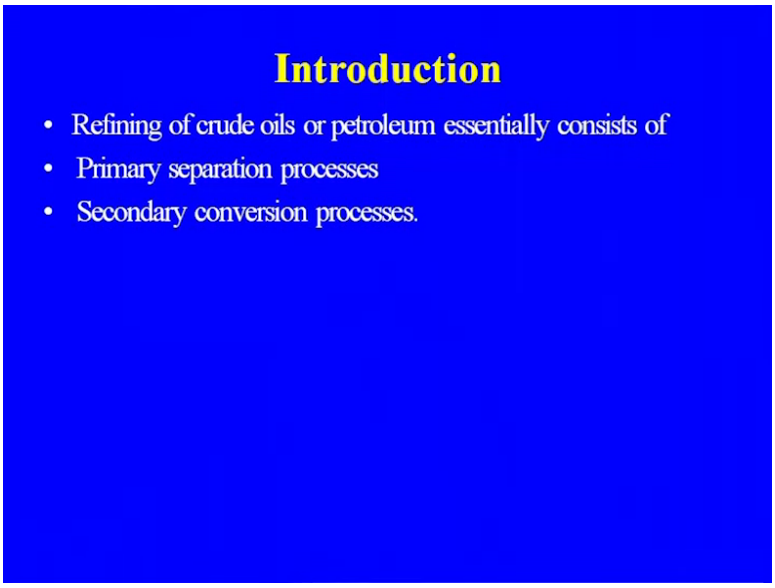

Refining of the crude oils or the petroleum essentially consists of the primary separation, which is we are doing in case of the crude oil distillation, secondary conversation process and the we will be discussing in the subsequent lecture in detail of the various secondary conversation process. Already I have given the summary of the some of the secondary conversation process, which we are using in the refinery.

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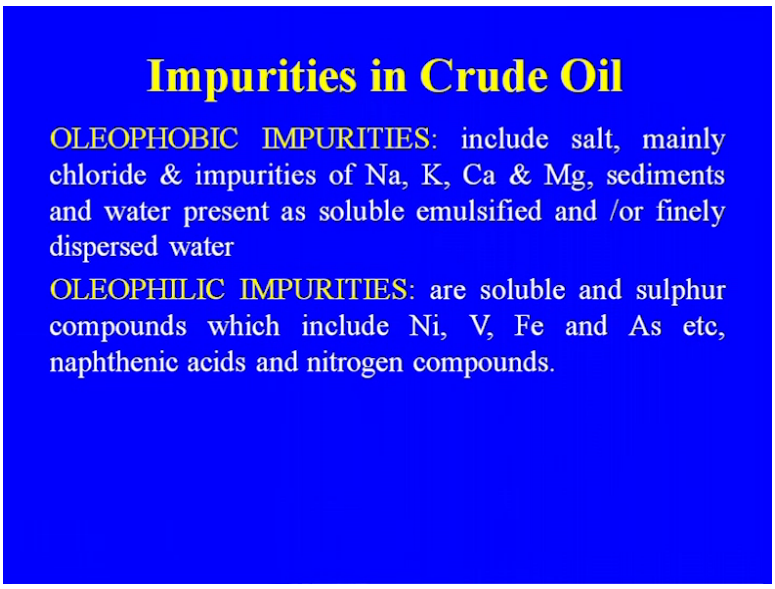

Let us discuss about the impurities, which are present in the crude oil and why the importance of the removal of these impurities are there. So, we are having the oleo

phobic impurities, which include the salt mainly chloride and impurities of the sodium, potassium, calcium, magnesium, sediments and water all are present in the crude oil, which is getting problem in the further part. Oleophilic impurities are soluble in sulfur compound, which include nickel, vanadium, iron and arsenic naphthenic acid and the nitrogen compound because these are the impurities, which has to be removed to avoid the you are poisoning of the catalyst.

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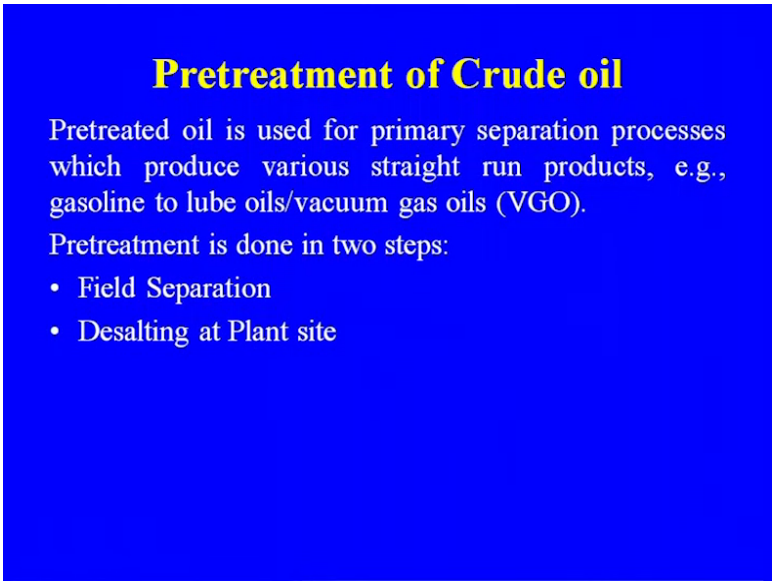

So, pretreated oil is used for primary separation process, which produced various straight run products example gasoline to lube oils vacuum gas oils from gasoline to diesel or it may be the kerosene. So, various products we are getting, so pretreatment is done in two steps; that is one step is the field separation, which is taking place when the crude we are getting after the dealing and the processing of the crude oil for the separation of the sediments water and the sour gases that is taking place at the slight itself. Just like the hazera, we are having the pretreatment facility GONGC plant like that there are some other ONGC plants they are having the pretreatment facility. So, the field separation and desalting at the plant site because, the requirement is very stringent in case of the presence of the salt in the crude oil and so, the diesel all the refineries they are having the desalting process they are performing at the site views in the refinery.

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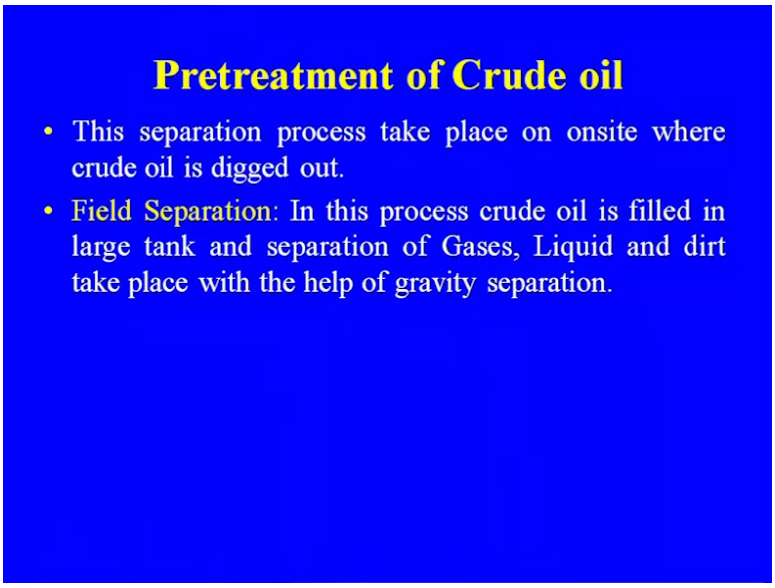

The separation takes place onsite where crude oil is digged out as tiding at this field separation. In this process crude oil is filled in large tank and separation of the gas liquids and dirt takes place with the help of the gravity separation. So, the some of the impurities that we are removing even the pretreatment for the removal of the eminent treatment also we are doing for the removal of the sulfur compounds.

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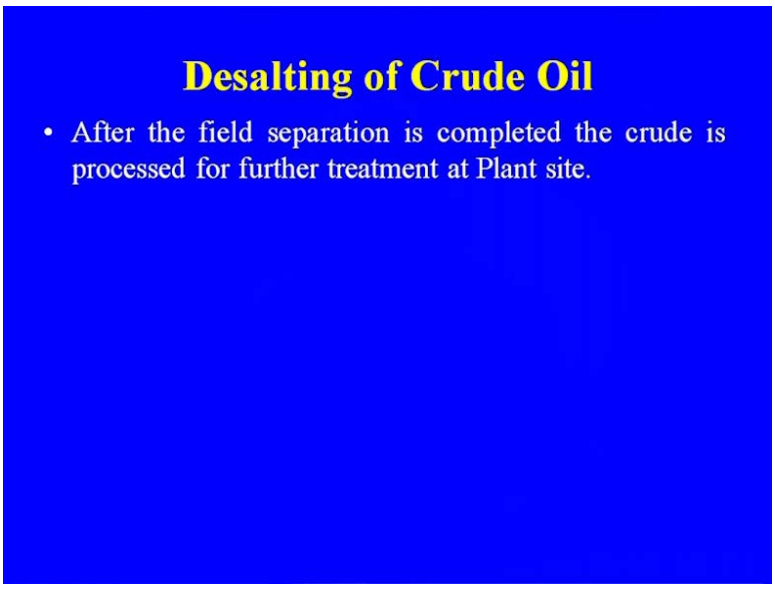

After the field separation is completed the crude is processed for the further treatment at the plant site.

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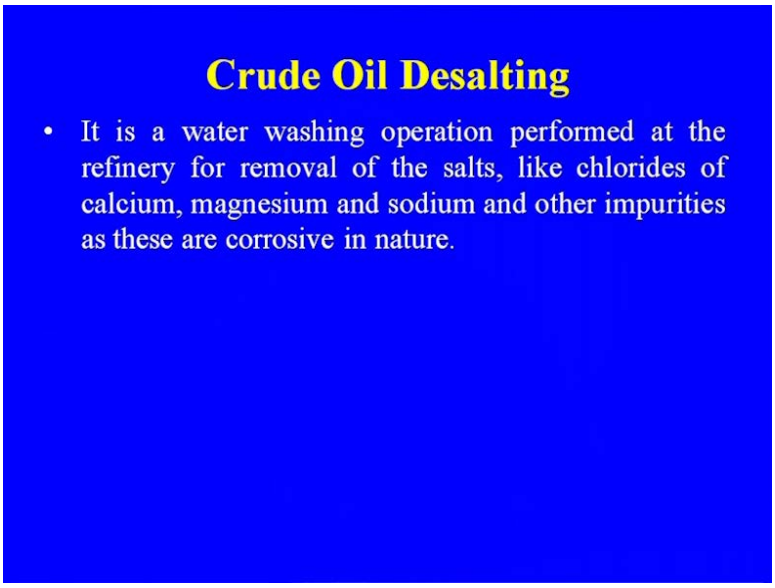

It is a water washing operation performed at the refinery for removal of the salts, like chlorides calcium, magnesium and sodium and other impurities as these are corrosive in the nature.

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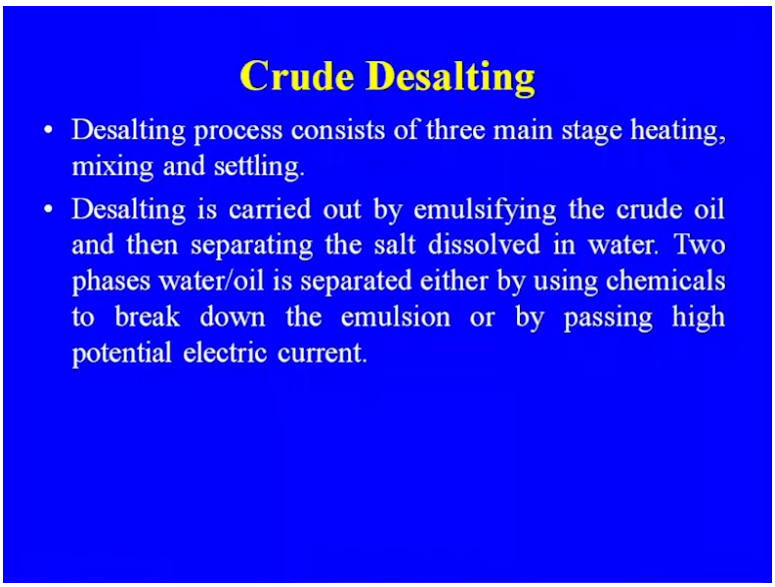

So, what are these this is involved in case of the desalting? Desalting process consists of three main stages; heating because a particular temperature low or high temperature that is affecting the if you sea of the desalting process. So, heating of the crude oil mixing and settling because the separation of the impurities, which has there after the, because

what we are doing were emulsifying and de emulsifying and separating. So, mixing and proper mixing and settling that is very important in case of the desalting.

So, desalting is carried out by emulsifying, as I told you the crude oil. Then separating the salt dissolved in the water two phases water oil is separated either by using chemicals to break down the emulsion or by passing high potential electric current, so normally we are using the electrostatic and de emulsification. That the, what we call as the electric and desalting process for the all the refinery they are having and that is the two stage desalting process is there.

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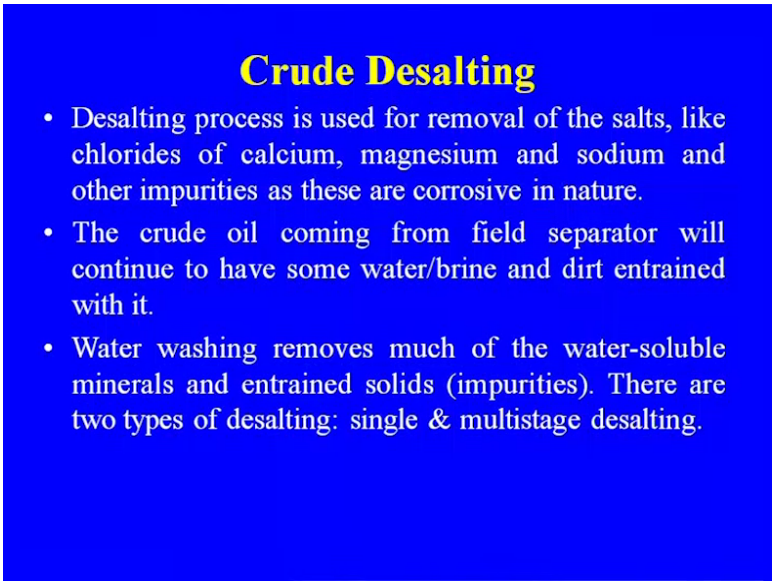

So, as I told you the why the importance of the desalting is there because, the removal of this impurity that has to be done and the crude oil coming up the field separator will continue to have some water brine and other dirt entrained in it, in spite of the pretreatment at the site. So, that has to be removed at the refinery to meet the requirement of the process. So, water washing removes much of the water soluble mineral and entrained solid there are two types of the desalting, which I told you the single or the multistage desalting.

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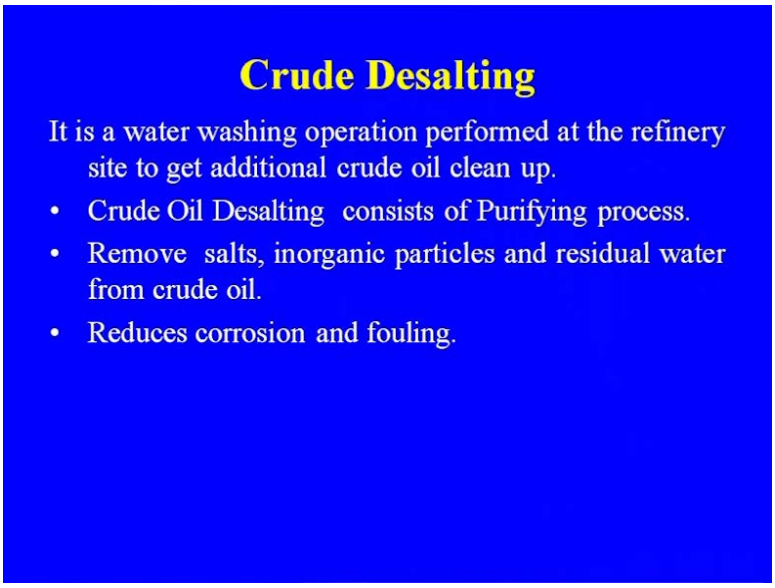

And already I discussed this is a water washing performed at the refinery site to get the additional crude oil clean up, crude oil desalting consist the purifying process, removable salts reduces the corrosion in the folding. This is the why we are going for the de salting.

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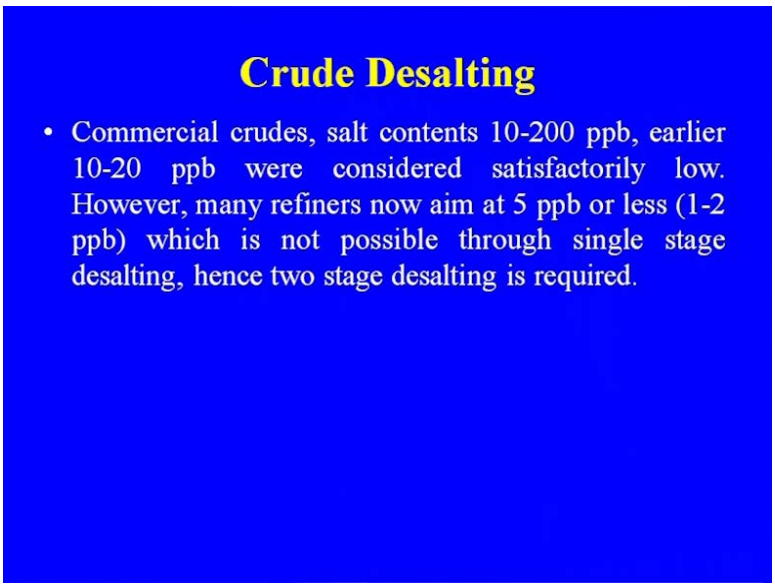

Commercial crude salts contain 10 to 200 parts per billion earlier, it was the 10 to 20 were consider satisfactory low. However, many refinery now aim at the 5 parts per billion that should be the content and so the to and are even 1 to 2 parts per billion, which is not possible through the single stage desalting. Hence, the two stage desalting

that we are doing just to meet the requirement of the impurities in the crude, this is being further process.

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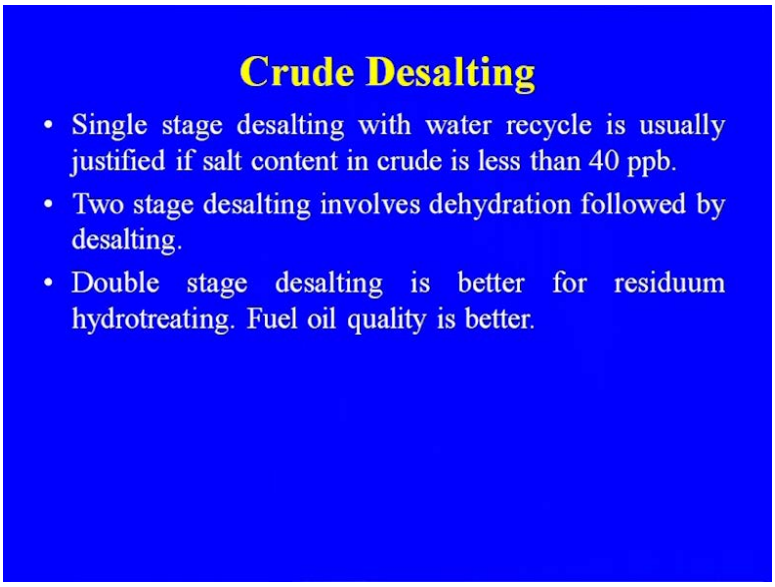

So, this is about the single stage desalting with the water recycle usually justified if the salt content in the crude is less than 40 ppb. If the low salt content is there two stage desalting involve dehydration followed by desalting. Double stage desalting is better for residuum hydro treating fuel oil quality is better, so this is the reason why the we are having the two stage desalting process.

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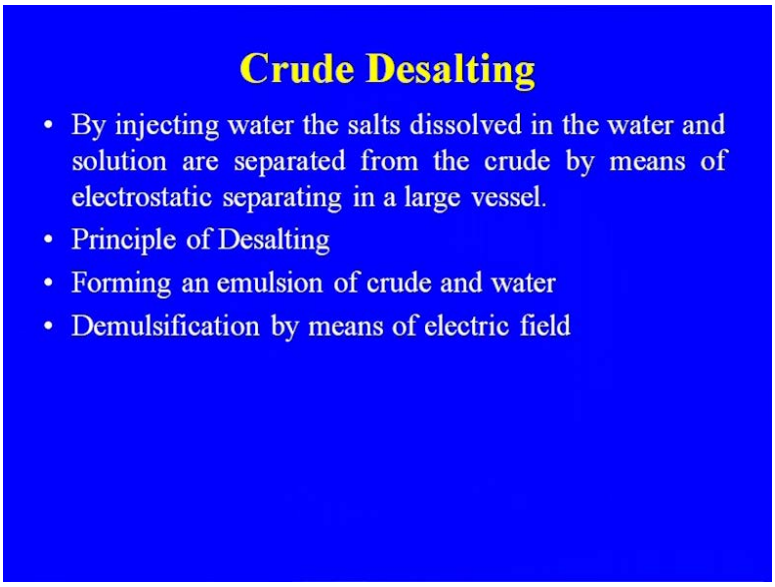

So, let us discuss the process the by injecting water was the salt dissolved in the water and solutions are separated from the crude oil by means, of the electrostatic separation in a large vessel, which I told at the why we are the electric field high? What is the electric field you are getting? So, the principle of desalting forming an emulsion when water we are adding forming an emulsion of the crude and water and then de emulsification by means, of the electric field this is the procedure, this is the method that which we are using in the case of the desalting of the crude.

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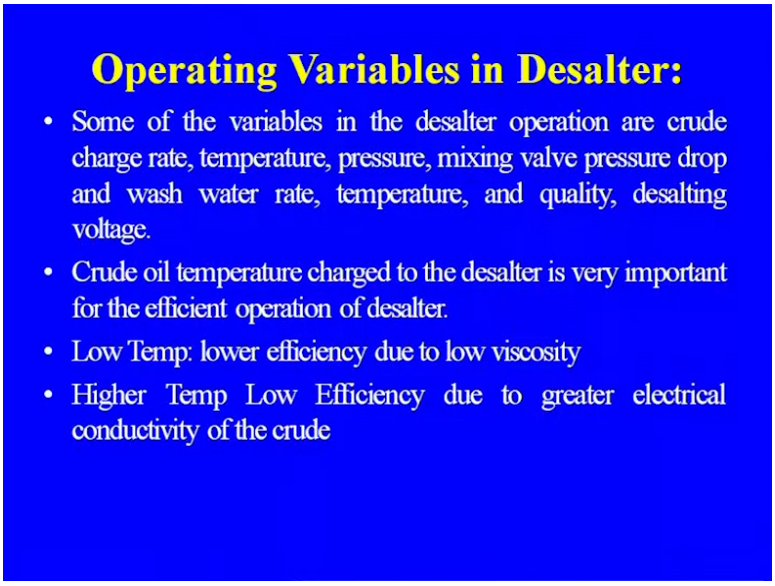

What are the operating variables in the desalter? Some of the variables in the desalter operation are the crude charge rate, temperature, pressure, mixing valve pressure drop and the wash water rate, temperature, and quality and the desalting voltage. So, these are the some of the major variable, which affect the performance of the desalting process and at the same time if you seen, see of the you are desalting process, crude oil temperature charged to the desalter is very important for the efficient operation of the desalter.

At low temperature lower efficiency due to low viscosity because, low viscosity then weak signal be affected all those parameter, because of the lower temperature. That will be there and even the settling removal because, highly viscous settling then the higher temperature low efficiency due to greater electrical conductivity of the crude. So, this is the reason why optimum temperature that has to be maintained during the desalting process.

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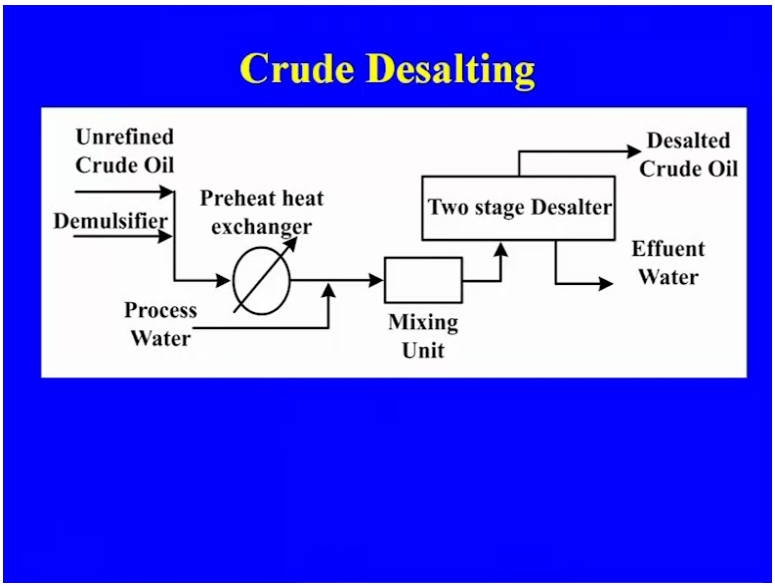

This is the process, which we are using for the crude desalting that is unrefined crude oil de emulsifier you are adding. Then it is going to the, for preheating after the preheating the process water that is going to the mixing water, then it is going to two stage desalter and the desalted crude. Finally, it is going to refinery. One of the major problem in case of the refinery is the generation of the effluent, which is carrying these impurities and so this is one of the major problem or the proper treatment of the effluent that has to be there. So, that that can we can meet the environmental standard.

Now, let us come to the crude oil distillation. Crude oil distillation consist of the, because there are two units because, what we are doing we are separating the crude oil into different fraction and the temperature that is very important factor. Because normally whenever you are going for higher temperature there is always chances of the cracking that will affect the product quality at the same time higher temperature, also have the influence on the formation.

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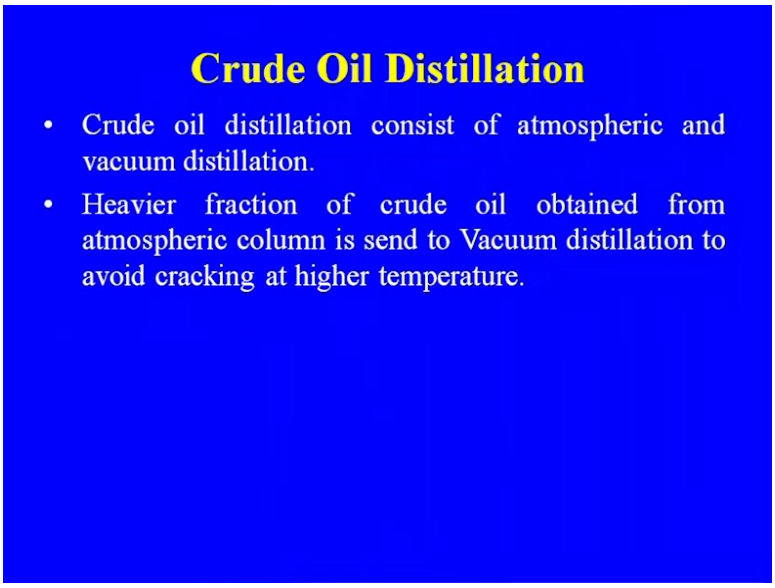

So, crude oil distillation consists of the atmospheric and the vacuum column vacuum distillation, why we are going for the vacuum? We know that under vacuum the lower temperature that will be required otherwise the higher temperature. Then the cracking reaction that may take place so, that is why the atmospheric in vacuum distillation both we are using and that is the integral part of any refinery.

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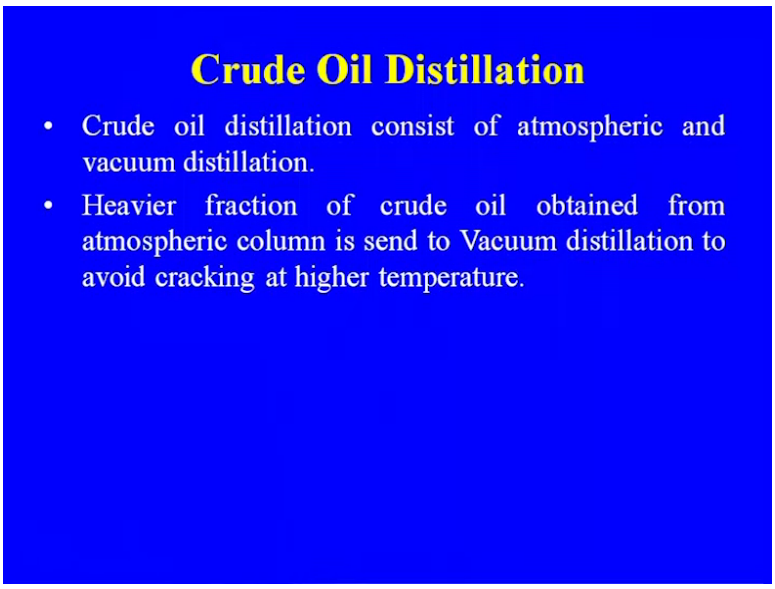

Heavier fraction of the crude oil obtained from the atmospheric column is send to the vacuum distillation column to avoid the cracking at higher temperature. Let the

temperature is around 500 to 550 centigrade, we are maintaining in the vacuum otherwise, the temperature would have been much are if the vacuum is not maintained so, that will result in the cracking which is un desirable part.

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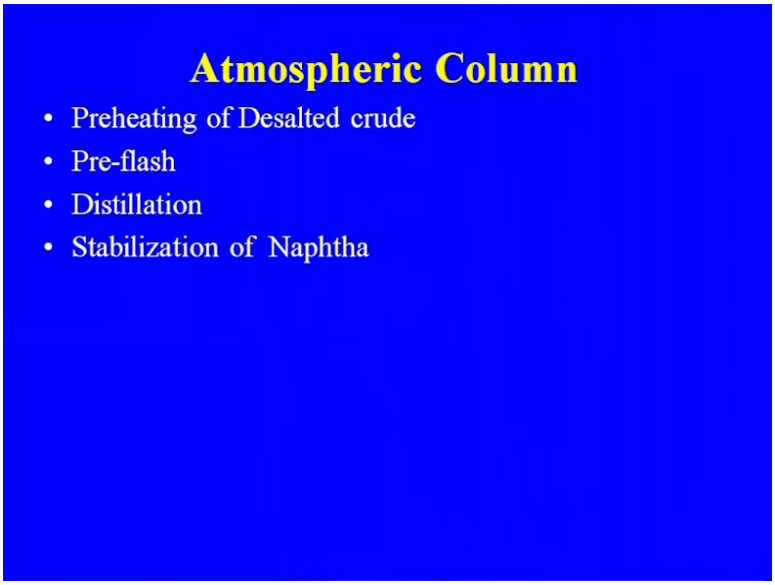

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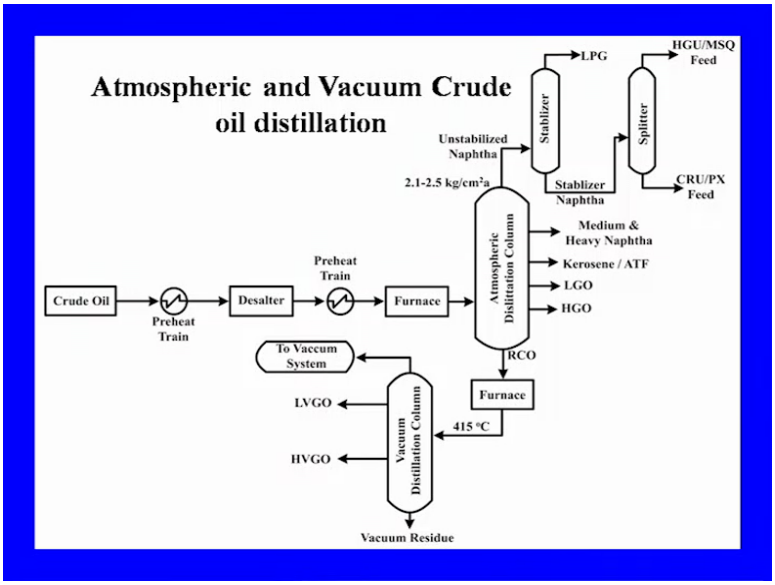

So, the atmospheric column, what is happening? The preheated desalted crude that will go to the pre flash section distillation column and the stabilization of the naphtha because the naphtha, which we are getting especially the lighter component of the naphtha, the gases has to be removed from the light gases LPG. That has to be removed from the light

naphtha and the light naphtha again it will go through as we what we call it the styrene gasoline, which will go to the gasoline form.

This is the actually the flow diagram of the how the crude oil that is going to preheated train desalter, again pre heating in the then it is going to the furnace after furnace it is going to the atmospheric distillation column from the atmospheric distillation column. We are getting this is not exactly from this point will be getting the unstable naphtha then stabilizer and from the stabilizer, again the gases that will be separated and the light naphtha that will be getting.

Similarly, medium and heavy naphtha kerosene gasoline not sorry light gas oil, heavy gas oil and there is due that from the atmospheric column reduce crude oil, that will again it will be as I told you it will be heated and around 500 degree centigrade that you are maintaining in the vacuum column. The high temperature is avoided just to avoid the cracking so, from the vacuum column we are having the large number of the products, but what about the product is there they are not suitable there no value added product.

So, to improve the to utilize this just like to take the case of the light vacuumer it will go to the FCC, it will go to the hydro carbon, so that the further improvement that can be done. Then the high vacuum gas oil and the residues will go to the further processing in the, you are (( )) breaker or the delayed coking plant. So, this is the overall although all the some of the units are not shown here, but this in the general block diagram for a atmospheric and the vacuum distillation unit.

So, operating what are the various operating variables? Because the operation of the atmospheric or vacuum distillation column that is very important and so this is the refinery also in the separation process. While discussing the you are lecture 1 of the introduction part of this course, we discuss lot of the improvement changes that has been done in the separation process also same thing. In case of the atmospheric and the distillation column regarding the packing regarding the trays, bowel cap to the seep, seep to the other type of the trays, trays then the packing all those things changes that has taking place in case of the distillation column, but this is the actually the some of the parameter operating parameter, which are going to affect the separation process.

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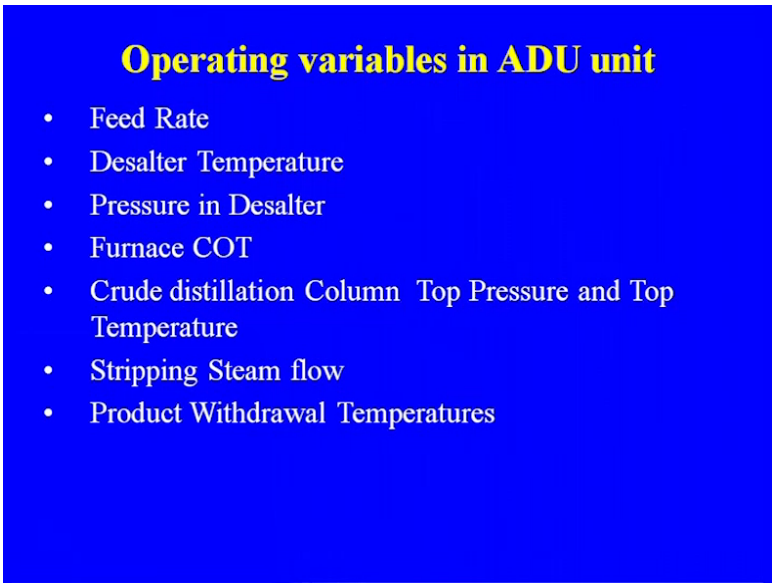

In case of the atmospheric distillation column that the feed rate, desalter temperature, pressure in the desalter, furnace coil, outlet temperature, crude distillation column because, the temperature if you… What about the temperature you are going from the desalter for this? It has to be heated and form after pre heating that will go to the your atmospheric. Crude distillation column top pressure and the top temperature, stripping steam flow, product withdrawal temperature, so these are the some of the parameters, which will affect the operation of the atmospheric distillation column.

Now, let us discuss what are the products, which we are getting from the atmospheric column. As I told you we are having the light end light end containing the unstabilized naphtha and from the unstabilized naphtha naphtha. We are separating the gasses the light gases and the LPG and so this is the temperature that we are having, but you see the gases are below 20 degree centigrade around 20 to 80 that is the gasoline part of the naphtha, which are directly straight on gasoline, which is having the electron that you have (( )).

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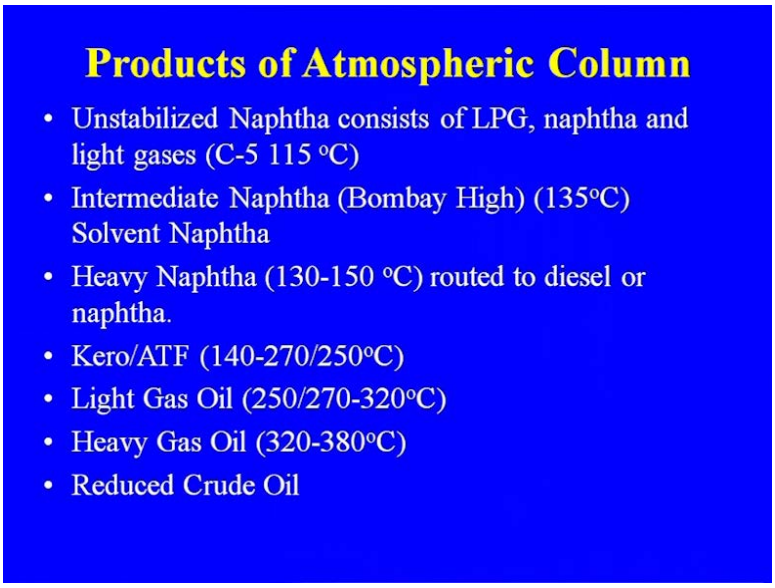

So, intermediate naphtha or the solvent naphtha depending on because, this is the different refinery they are giving different heavy naphtha routed to the diesel or the naphtha, kerosene, ATF aviation turbine fuel the temperature actually the cut, which we are different cut that the temperature is because, some component of the kerosene some component of diesel although thing that may be there. So, light gas oil of the diesel fraction reduced crude oil, which will go further processing further separation to the distillation column.

So, this is the how the various product, which we are getting having the hydrocarbon different carbon atoms will be there and so that will utilize for the just like in case of the naphtha. We are having the lighter naphtha, which called as the gasoline below 80 degree centigrade that if the higher octane number is there, so directly that will go to the gasoline (( )). But if the lower octane number naphtha, normally it is going for the further processing in the catalytic deforming to improve the octane number or it is made available to the fertilizer plant for the steam reforming for making the synthesis gas. The fertilizer are for the naphtha cracker, where we are using the naphtha as a feed stock for the production of the olefins.

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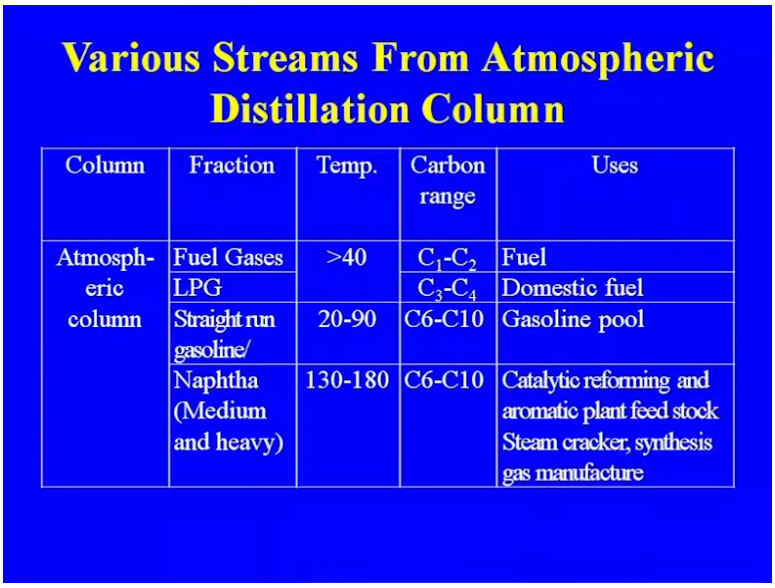

These are the, I was telling already we had discuss about the products. This is the actually then you are carbon different carbon atoms, which we are getting from the atmospheric distillation column.

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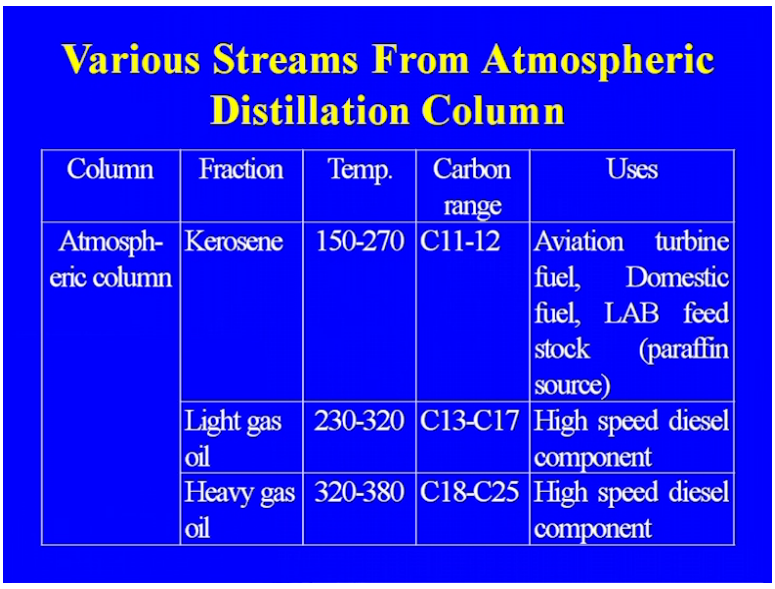

Kerosene fraction, light gas oil, heavy gas oil different fraction this is the temperature range, which I was telling that may vary slightly some part of the naphtha that may be the part of the kerosene or some part that may be because, suppose if you are going naphtha you are going to be use naphtha cracker for the production of the benzene or

production of the (( )). So, different cut of the naphtha that will be taken because, the type of the temperature of the actually the composition of the naphtha or the boiling point, that will have the impact on the production of the benzene, ethylene or the ethylene, which fraction will be more.

Now, let us come to the vacuum distillation column, which we are using again as I told you that the why we are going for the vacuum, you must be named as the whenever the vacuum when with they are the boiling point will be reduced. So, then if you are fractionating at atmospheric phase you also then the fractionation of the residue more had temperature that will require and that will result in the cracking though, so to avoid that we are fractionating the residue from the atmospheric column in the vacuum column.

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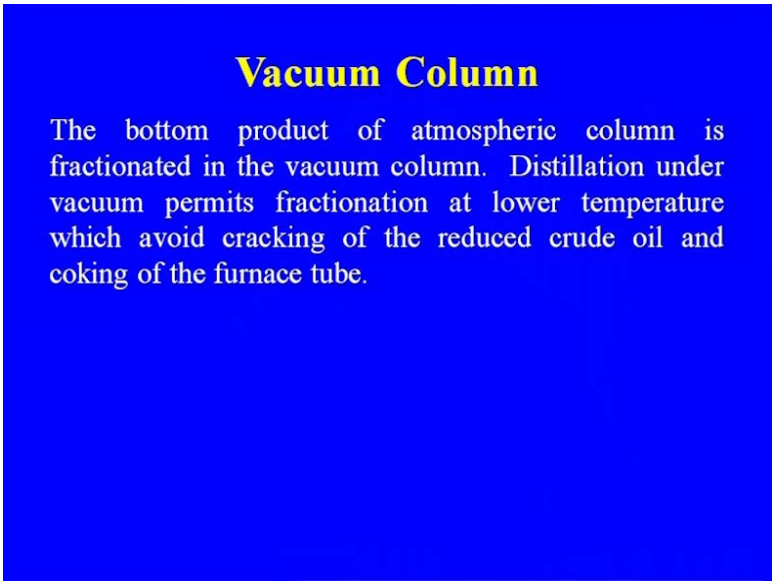

Distillation under vacuum permits the fractionation as I told you at a lower temperature which avoid cracking of the reduced crude oil and coking of the furnaces also.

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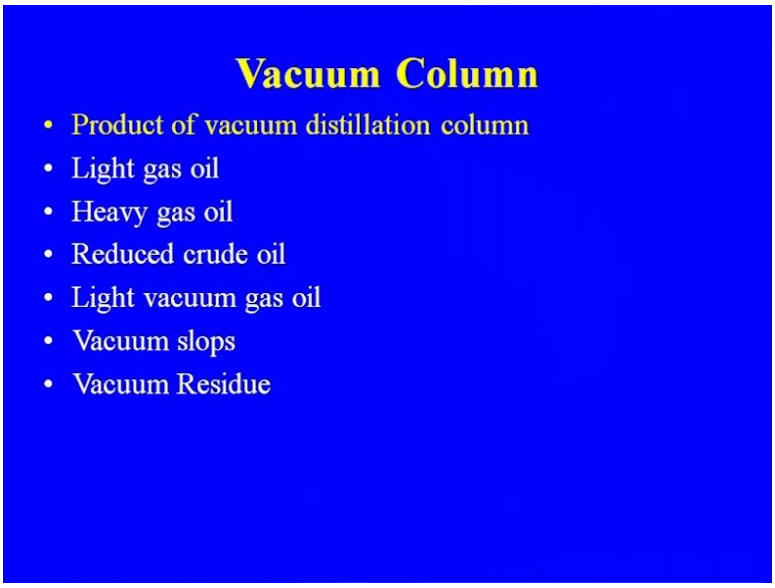

These are the products, which we are getting from the vacuum column light gas oil, heavy gas oil, reduced crude oil, light vacuum gas oil, vacuum slops, vacuum residue. Light gas oil that is the feed for the FC and now the with the coming of the hydro cracker we are also able to part process the heavy gas oil, fraction or it may light or the heavy that may go to the RFC or it may go to the hydro cracker units.

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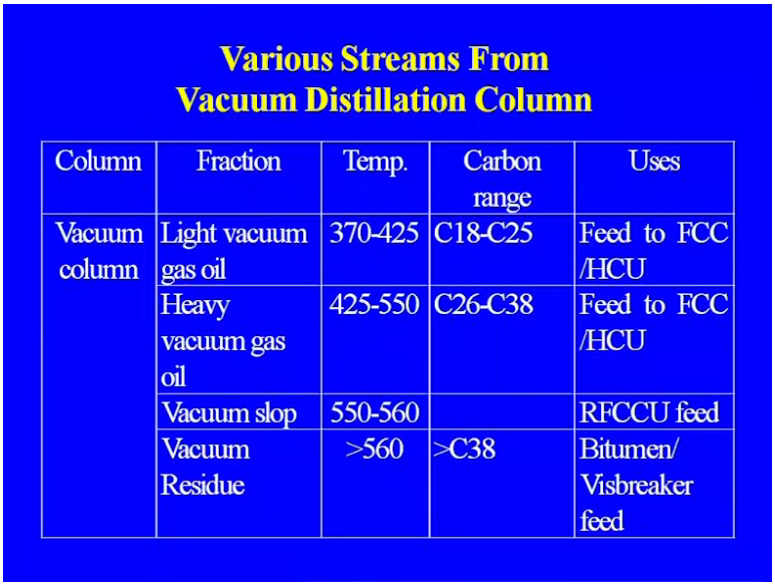

These are the products, which we are getting from the vacuum distillation column, the light vacuum gas oil, heavy vacuum gas oil, vacuum slop, vacuum residue, which will

have the bitumen or it will go to the (( )) breaker unit feed to FCC catalytic cracking or the hydro cracking units. So, these two are the very important, because, you cannot effort otherwise earlier what was happening the residue that was being used as the fuel some of the fertilizer plant was set up to use the fuel oil and that was the some of the NFL plant they started there making ammonia from the fuel oil.

Although, now they have shifted from fuel oil to natural gas or the naphtha so, that was the actually low value added product and so to improve the economics the FCC or the hydro cracker that has become the integral part of the refining. This is operating pressure on the vacuum column products from the video already we have discussed and the temperature the different cut we are saying, if they are we are getting at a high temperature definitely and the feed to the FCU from the light gas already it is going.

Now, let us discuss because the, whatever the crude oil we are getting, they will have the impact on the fractionation requirement of the temperature. Then the formation of the coke in the furnaces because, in the atmospheric vacuum we are doing the pre heating of the you are crude oil in the furnaces, because in refinery see the in refinery we are using large number of the furnaces for pre heating either it may be FCC or it may be the catalytic reforming. So, the crude oil heaviness that is one of the measurement that where to do the heavier crude or the lighter crude depending up on the API that will affect the separation process also.

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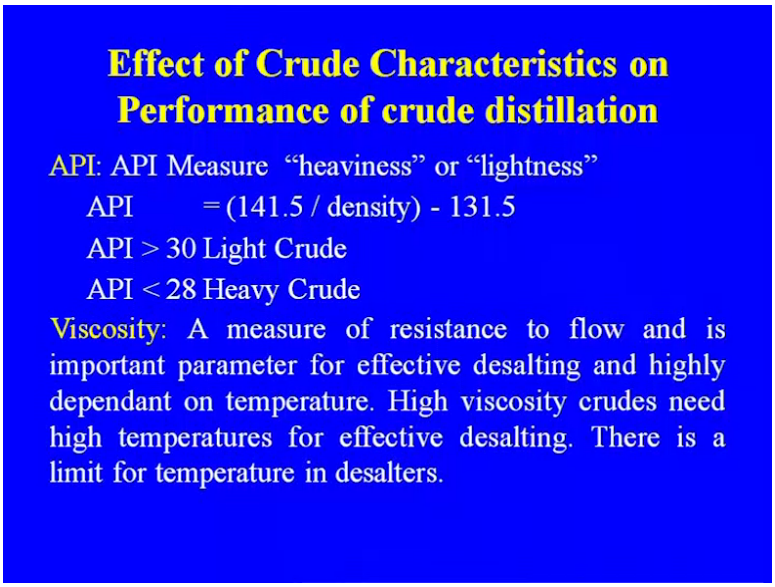

Similarly, the viscosity a measure of the resistance to flow and is important parameter for effective desalting as I told viscosity low or higher viscosity they will have the important role in the desalting or the separation of the salts, high viscosity crudes need high temperature for effective desalting. There is a limit for the temperature in desalter because you see the, if you are in going beyond a temperature this separation again the separation if you see, in the desalter that will go down so, this is the why the viscosity or the PI that is the important in case of the desalting project. Because the desalting you cannot look separately from the atmosphere that is part of the you are distillation being.

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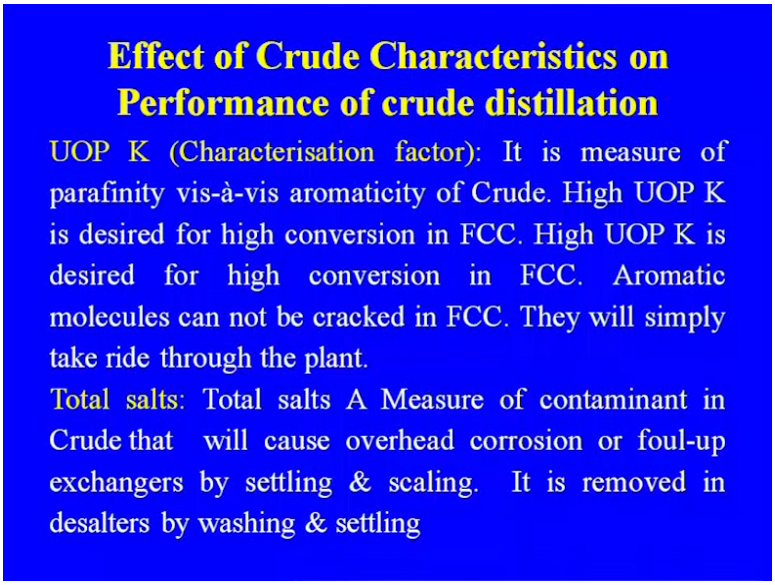

Characterization factors already we discuss it is a measure of the parafinity. Parafinity of the crude high UOP K is desired for high conversion in the FCC high UOP K is desired and the aromatic molecules cannot be cracked in FCC. So, depending up on the characterization factor you can have the idea of the product, which we are getting from the separation. Total salts that will cause the overhead corrosion foul up of the exchanger so, these are the some of the by settling or the scaling that may be there.

So, it is removed in the desalter by washing and settling, so the knowledge of the what is the amount of the total salt higher if the salt content is more, then more severe actually the operation of the desalter data is to severe means it is not the temperature, which is the more effective removal of the imported data has to be there. Total acid number acid total resign number means heavier crude will contain the more higher.

If the acid number means high then what was happen, that will result more corrosion in the substitute process, even we are doing some chemical treatment or chemical dosing we are doing in FCC to avoid the corrosion in the FCC because the corrosion in FCC there has been reported corrosion in the atmospheric and vacuum column that has been reported so, to avoid that corrosion that will because the with the help of the tan number you can or the totalized number you can have a idea of the nature of the crude. And the requirement because the as we are doing the chemical treatment on the product have the crude during before it is going to atmospheric so, the chemical dosing will be also you can adjust if you are knowing the impurities present.

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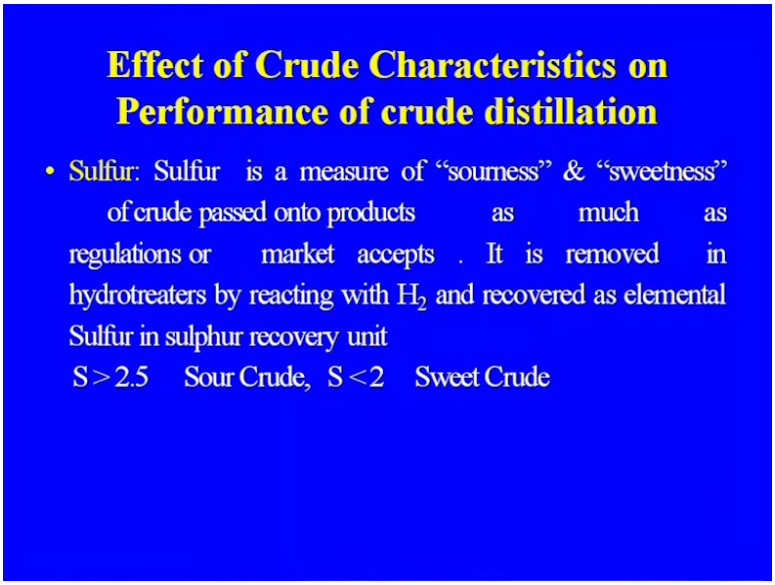

Sulfur is the measure of the sourness and the sweetness of the crude passed onto the products because, this is the one of the actually they compound which is causing corrosion problem in the process. So, it is removed in the hydro treaters by reacting with the hydrogen and recovered as an elemental sulfur, but the some of the removal if the more that will create the corrosion problem.

And the substance is there that may be that has to be before it is going to either catalytic de forming or the FCC the feed if you are getting from atmospheric or the vacuum distillation column. The sediments bottom sediment in the water is a measure of the water dissolve impurities, which are there and so the removal you can have an idea what

is the inlet and what is the outlet content of the dissolved crude oil? Depending up on that you can adjust the condition.

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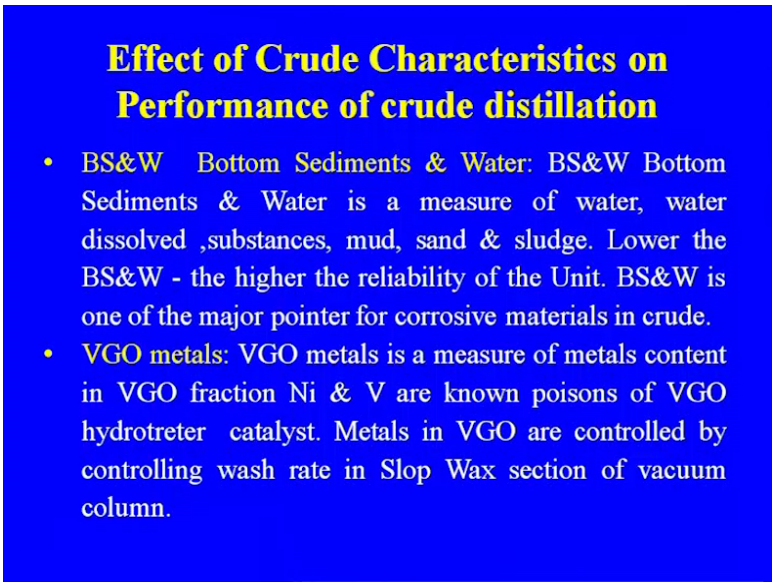

So, VGO metals is a measure of the metals content the VGO fraction nickel and vanadium are known poisons of VGO hydro treater catalyst. Now, let us come to the, because as I told you in case of the atmospheric and vacuum column distillation column. We are now the crude, which we are using that is becoming more and more so means, the more sulfur content is there high naphthenic acid crude we are high tan number crude that we are processing.

So, they always the corrosion data has been reported and so what is happening if you are what about the product and that is deflected in the product, which we are getting after the crude oil distillation. That is affecting the operation in the substantial stage just like you take as the FCC, where the corrosion data has been deported or naphtha, which is going to the your catalytic reforming, where the catalytic poison if the impurities the various metal which present there they will have the they will poison the catalytic. So, the this is the reason why the pretreatment needed and the further chemical injection some chemicals that we are using for the removal of impurity.

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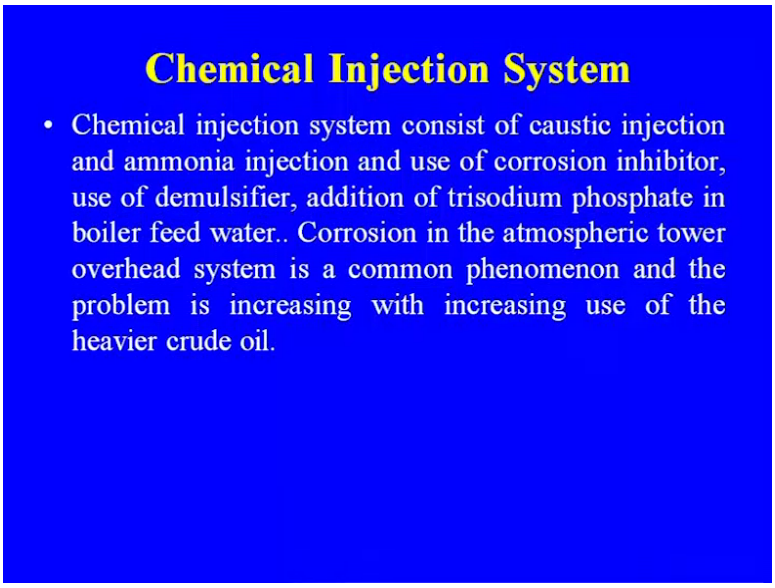

So, the chemical injection system consist of the caustic injection and the ammonia injection and use of the corrosion inhibitor, also we are doing using their use of demulsifier, addition of the trisodium phosphate. Especially in the case of the boiler feed water corrosion in the atmospheric tower overhead system is a common phenomenon as i told you because of the crude oil, which is becoming more and more sour and the problem is increasing with the increasing use of the heavier crude.

So, this was about the crude oil distillation atmospheric and the vacuum distillation column that we are using for the separation of the crude oil and the product, which we are getting. Some of the product directly it is going for the use and some of the products just like low naphtha. Low naphtha, low octane number naphtha that will the further process for improving the octane number in the refinery itself or it may be used for the production of the petro chemical through the naphtha cracking or it may be earlier because, the number of the fertilizer quantities came in the early stage they are best on the naphtha reforming process.

Because, the naphtha at that time it was sulfur, even if you the history of the cracker plant where we are assume the naphtha, that is first cracker plant that was started by official around nozzle, it was the first nozzle and then forward by you are (( )). So, at that time because when the refinery was started there was no use of the naphtha from the you are crude oil distillation, because of the low octane number and many of the refinery at

this during the early stage the catalytic reforming unit was there how to improve? So, these this naphtha that was available to you are fertilizer part.

So, the this was the actually the and then the kerosene and the diesel other some of the and the where though one another thing that we are using in case of the crude oil that is we are using a term straight run, straight run gasoline is it is in naphtha straight run kerosene means the product, which we are getting directly from the distillation of the crude oil from the atmospheric distillation column or in some of the cases if the cracked naphtha, cracked gasoline, cracked diesel.

All those product that we are getting by the further processing of the product, which we are getting from the crude oil and the atmospheric. You see the in case of the crude oil distillation, there has been continuous development in case of the configuration of the atmospheric in the distillation column and distillation column. You can say, this is the heart of the refinery, whole efficiency of the separation the energy consumption everything that will depend up on the affective operation of the crude oil distillation unit and at the same time desalting which is the integral part of the your crude oil distillation.