Technologies for Clean and Renewable Energy Production

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Lecture-19
Heavy Crude Oil Processing

Hi friends, now we will start discussion on the topic Heavy crude oil processing. As we have discussed in the previous classes, that cleaner production of liquid fuels from petroleum crude is possible by implementing the practice to remove the impurities from it and then upgrading the vacuum residue, another was to develop technology for the treatment or for the processing of heavy crude.

Because heavy crude will be having more sulphur, metals, asphaltenes etc. So, in that case, it will be creating more pollution and it will be creating other type of difficulty for the refinery also. So, what will be the technology that can be implemented for this process that we are going to discuss in this class.

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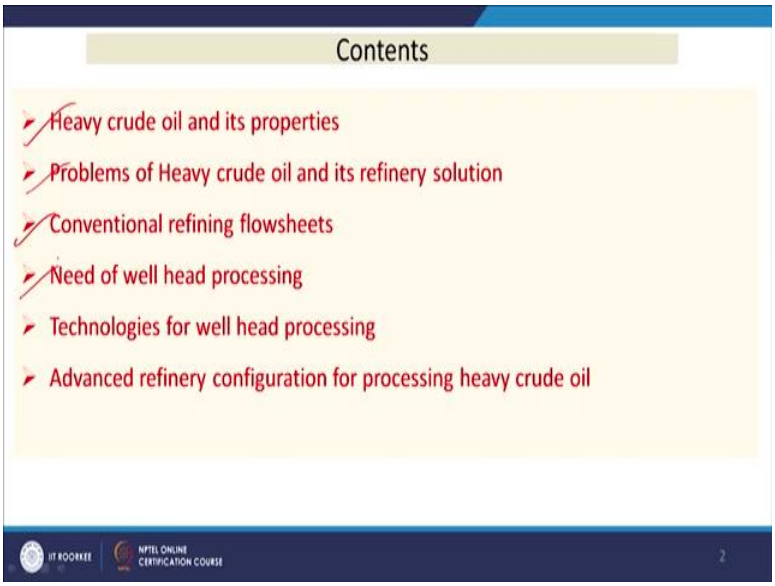

And the contents are heavy crude oil and its properties then problems of heavy crude oil and its refinery solution then conventional refining flow sheets and the need of well head processing, technologies for well head processing and advanced refinery configuration for processing heavy crude oil. Now, what is heavy crude oil? Already we have discussed in a previous class that when API gravity is lower than the crude oil becomes more heavier.

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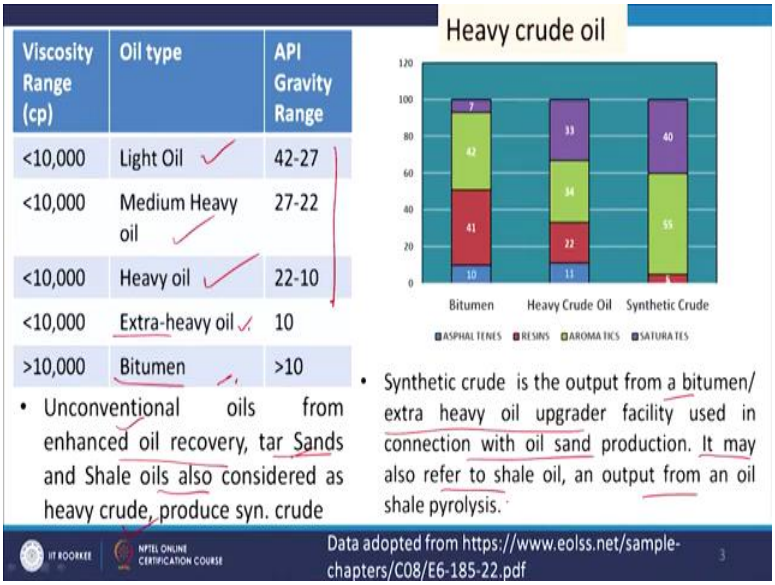

And some example were light oil, Medium Heavy oil, Heavy Oil, these we have seen in this in the previous classes and Extra heavy oil and Bitumen, these are also considered as heavy crude that is Bitumen can give us synthetic crude and extra heavy oil is also heavy crude. So, both conventional and unconventional types of crude sources are there. So we can get synthetic crude oil even from the sources like tar sand and the Bitumen and shale oil.

So, we can get crude oil from this and that can be processed. So how we can do it, we are going to discuss. So on unconventional oils from enhanced oil recovery are tar sands and shale oils also considered as crude oil, crude oil and synthetic crude are obtained from Bitumen that is tar sands and shale oil. So, synthetic crude is the output from bitumen or extra heavy oil upgraded facility used in connection with oil sand production.

And it may also refer to the shale oil and output from an oil shale pyrolysis. So, shale oil is nothing but a rock sedimentary rock which contains oil. This is the crude like material, so, that crude is produced from the shale oil through pyrolysis and that is synthetic crude. Similarly, synthetic crude can also be produced from Bitumen or say tar sand. So, that is called extra heavy oil upgrader facility, they are producing this one.

Now if you compare the composition of these bitumen, heavy crude oil and syn.crude oil. So, they are matter of concerns. We are we are going to discuss on this the how this can be converted into Clean Fuels. And then did we see the asphaltenes is here, heavy crude oil and bitumen both are having but synthetic crude is not having that asphaltene then resins are there

and then aromatics and saturates. So, saturates are increased, aromatics are increased in case of Syn.crude with respect to bitumen and heavy crude.

Then Syn.crude synthetic crude is produced that can be refined further. So how we can get the synthetic crude? So, there are a number of methods.

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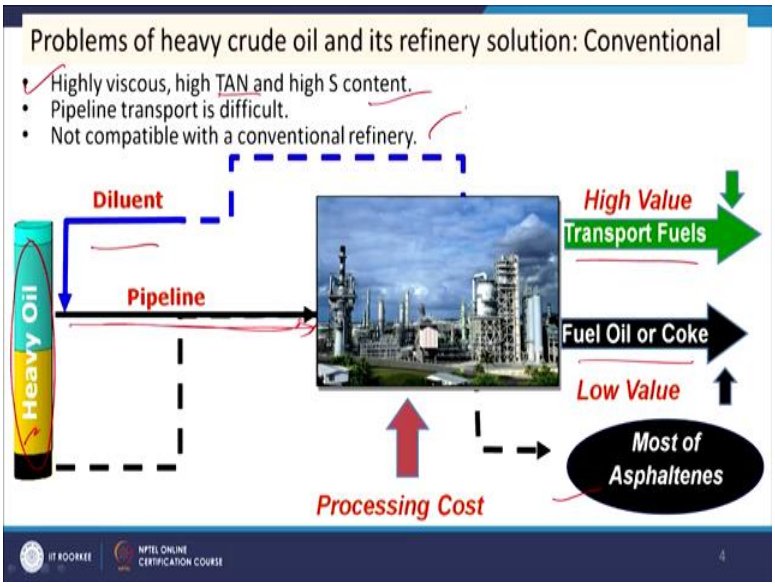

And how we will refine this heavy crude, we are talking about the heavy crude then the conventionally the heavy crude is transported to the refinery. And then heavy crude is blended the heavy crude is diluted with the addition of some diluent, so diluent addition viscosity reductions. So pumping costs reduced and it is transported to the pipeline to the refinery, then once it is coming to refinery and then refinery operation starts.

And then it gives transport fuels, high value products and then the bottom part we get your asphaltenes is here and we can get also fuel oil or coke. Already the similar conventional refinery configuration that way it is it is followed. But the difficulties that this heavy oil is highly viscous; it is high TAN and high sulphur content. And pipeline transportation is also difficult and not comparable with a conventional refinery.

So, this is not compatible with the conventional refinery. So, the important problems for this crude oil is that high crude side pressure dropped.

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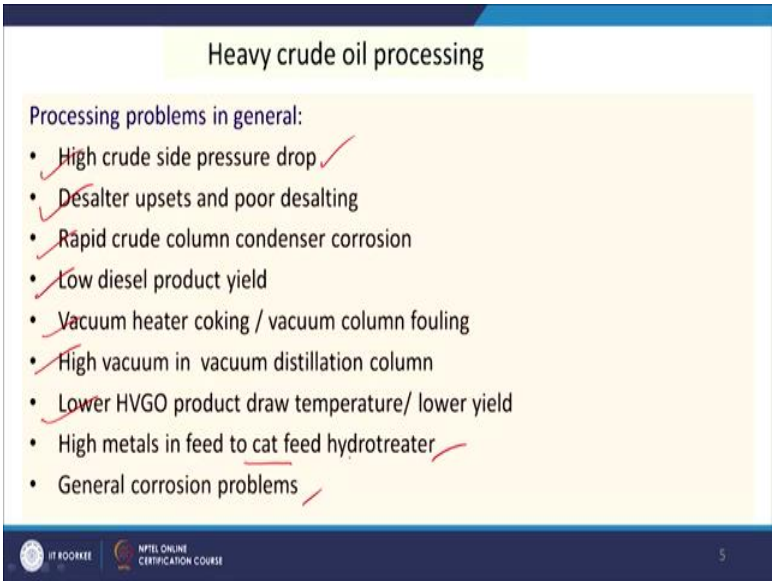

So, once we are pumping the heavy crude after dilution, diluent addition then also its viscosity is higher than the light crude and it requires high pressure. So, when it is coming to the refinery side the pressure drop takes place. So, high pressure drop is required. And then the first step in the refinery is your desalting so desalting will also be difficult here because it contains more asphaltene, more sulphur etc.

So, desalter upsets poor desalting capacity, performance we get here and then rapid crude column condenser corrosion. So, when it is going for distillation, then the crude column will be having more corrosion, the condenser part of it will also show, will experience more corrosion. So, low diesel product yield, this feedstock will give low diesel product. And Vacuum heater coking, vacuum column fouling so, it can also make more fouling of this scale formation etcetera can take place.

And high vacuum in vacuum distillation column we have to produce more vacuum so that the more relatively heavier components will also come into the liquid form. So, lower HVGO product heavy vacuum Gas oil product this low temperature and lower yield and then high metals in feed to catalyst feed hydrotreater we have high metal content. So the feed the liquid will be generated that can be sent for catalytic hydro cracking unit that will be containing more metal.

So, we have to need some demetalisation unit for possessing this and general corrosion problems are higher in this case. So, these are major drawbacks or problems with the processing of heavy crude in refinery.

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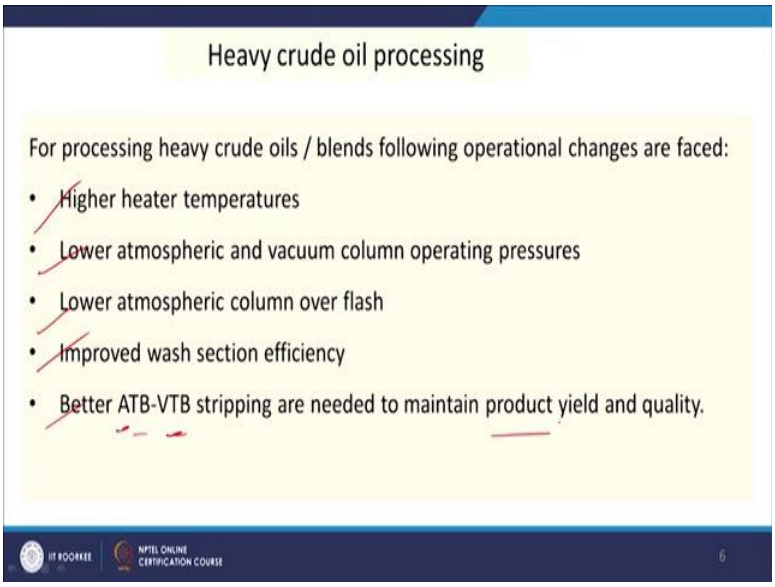

And for processing heavy crude oils or blends these are the challenges: higher heater temperature. So, we need to put higher heater temperature we got already available materials in the feedstock is a high molecular rate. So, we need more temperature for its distillation. And lower atmosphere and vacuum column operating pressure as we have already discussed, the lower the pressure, we will get more hydrocarbons, high molecular hydrocarbons in liquid phase.

And lower atmospheric column over flash obviously over flash will be less because lighters have not there, very less there. So improved wash section efficiency and then better ATB VTB stripping, atmospheric tower bottom, vacuum tower bottom stripping are needed to maintain product yield and quality. So, these are the basic features of the heavy crude oil processing.

Now, we will see the prerequisite, what are the options, or what we can do for the processing of this crude this type of crude? So, there are some prerequisites.

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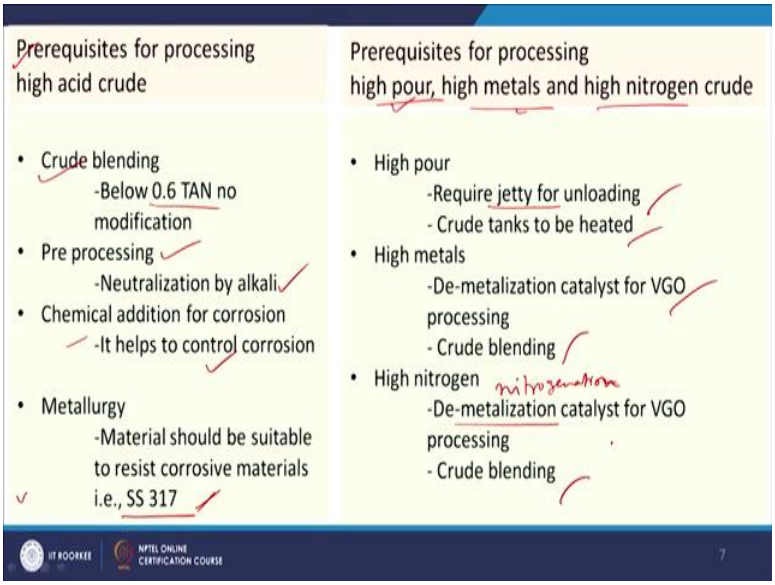

If TAN is very high acid number is very high then some prerequisites mentioned here and if it is high metals, high pour point and high nitrogen content crude then also we have some prerequisite. So, for the first case say when the TAN is very high total acid number is high in that case, we need to prove blending, but even the TAN is 0.6 or less then no modification is needed. Otherwise, there should be some blending options and that can be processed.

And then pre processing if TAN is there, so, acid is there so you have to neutralise it first, before sending to the refinery so neutralisation by alkali, if it is required. And then chemical addition, so, we may add some chemical to reduce the corrosive nature of the feedstock and we need proper metallurgy also because it means high acid. So, I have to select more corrosion resistant materials and one example is the SS 317.

So, SS 316 is considered a superior grade steel and 317 is further having more resistance to the corrosion than 316. So, that way we can use the SS 317 and for High pour, High Metal and High nitrogen content crude, we can require, we may require jetty for unloading. It is to say high pour point and crude tanks to be heated. We have to put the crude tank heated so that it can be in liquid form.

And then high metals, high metal are present then we have to demetalization catalyst for VGO processing and crude blending is another option, so the metal concentration will be reduced. And high nitrogen concentration crude if it is then you have to add some demetalization and the denitrogenation catalyst for VGO processing and crude blending is also another option. So these are the prerequisites to process the heavy crude having these high TAN, high pour, high

metals and high nitrogen. Now we will see the conventional refining flow sheet for heavy crude oil.

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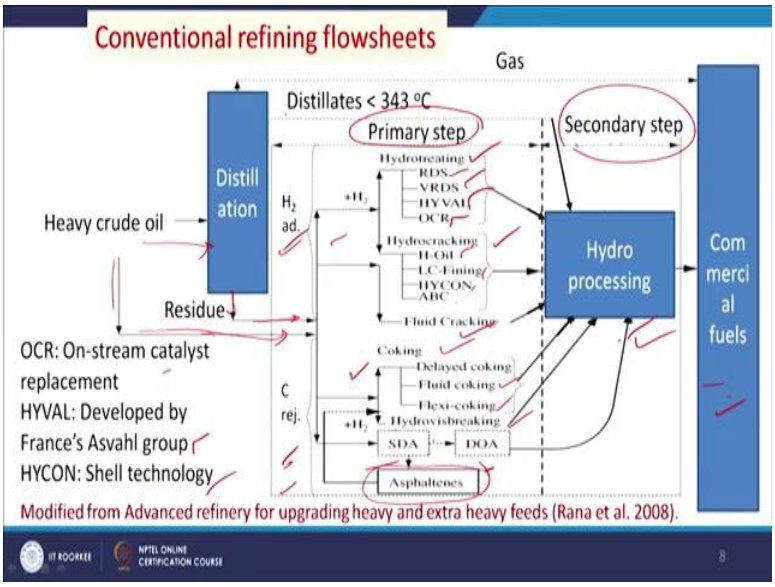

So, if we have heavy crude oil, so that can go for distillation that will give some amount of gas that will give some amount of distillates and most of it will be residue. So, this residue or direct heavy crude oil, it can go through different processes like say carbon rejection process and hydrogen addition process. So, hydrogen addition process or carbon rejection process, this process will be followed first in the first step or the primary step.

Then the product which we are getting that will go for secondary step conversion. That is nothing but Hydro processing. So, first will be primary processing then secondary processing. Though it will be the hydrogen addition or maybe carbon rejection and then the second is hydro processing, then ultimately will get the products there may be some commercial products here some steps may be required for to fine tune the quality of the products.

So, here for hydrogenation, hydrogen addition processes, number of processes have been have been reported like say hydro treating, hydro cracking, and here some fuel cracking is also there only thermal treatment and then coking. So, hydro treating maybe of different technology RDS, residual sulfurization and then vacuum residue through sulfurization, HYVAL. HYVAL is developed by Francis Oswald group, this is one hydro treating process.

And OCR is on steam catalyst replacement process in this case hydrogen addition takes place. And hydro cracking is H-oil, LC-Fining, Hycon and ABC icon is a Shell technology. ABC

technology. So, these are the technology licences for hydro cracking and fluid cracking fluid catalytic cracking can also be used for this conversion. And then the carbon rejection say delayed coking, fluid coking, Flexi coking already we have discussed about delayed coking.

So, this coking can also take place for the conversions of this heavy crude to liquid part and then to further to hydro processing to get the commercial fuel. And we can get hydro visbreaking or we can get solvent deasphating, solvent deasphalting DAO, asphatene oil, then again hydro processing and commercial fuels. And asphaltenes we can separate from this SD unit which can be used for other applications like road making, etc.

So, this is the conventional refinery closer with heavy crude oil. And from this basis, we can summarise that heavy crude oil is transported to refinery conventionally from the production field.

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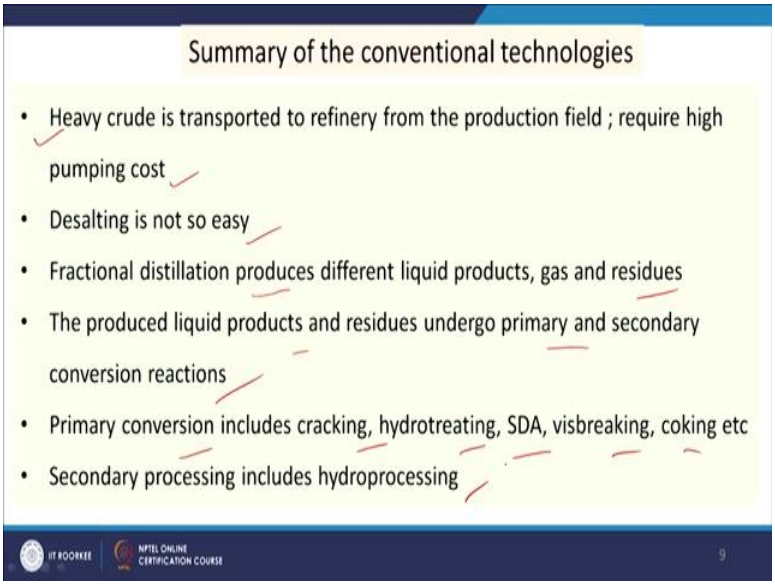

And then require high pumping cost. Desalting is not so easy at the refinery side and fractional distillation produces different liquid products gas and residues. The produce liquid products and residues undergo primary and secondary conversion reactions. And then primary conversion includes cracking, hydro treating, solvent deasphalting, visbreaking, coking etcetera and secondary processing includes hydro processing. So, this is about our conventional technology.

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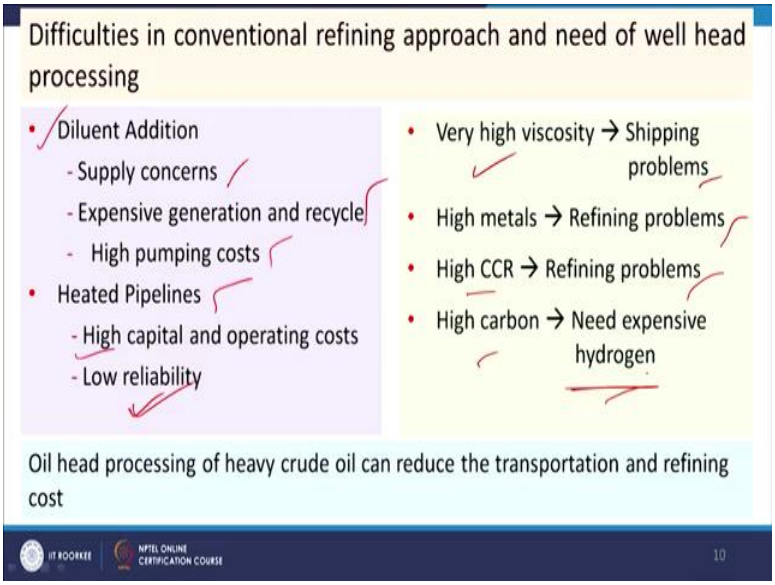

Now, what are the difficulties with the, these conventional processes? Say we need to add some diluent, we are adding some diluent then again diluents recovery operations. It, It affects the economy of the process. So supply concerns the from where we will get the diluent and whatever diluent we will add and how will recover it from it ok, then high pumping cost an expensive regeneration and the cycle of the diluent.

So, these are the difficulty with the diluent part and then heated pipelines. So we are we are using the diluent. But if the temperature ambient temperature changes to the path of the pipeline, then again that can be the flow can be seized; so we have to maintain the pipeline heated through the distance. So, high capital and operating costs is needed and low reliability. We do not know either it will work or it may be affected by some external agency factors or maybe some fault at any time.

So, it is not so, reliable solution so reliability is less. And very high viscosity It is very high viscosity so, shipping problems it will arise and high metals, I have already discussed the refining problems will be there and high CCR again refining problems and high carbon need expensive hydrogenation. And that hydrogenation unit is very, very essential for this and this hydrogenation in the refinery, this is the expensive part of a refinery.

So, that is why the difficulty with a crude heavy crude operation at the refinery side is limited by these factors, it also are restricted by these factors. So, we will try to get some preliminary removal of the impurities at the production side. So, oil head processing of heavy crude oil can reduce the transportation and refining cost. So oil head processing is implemented.

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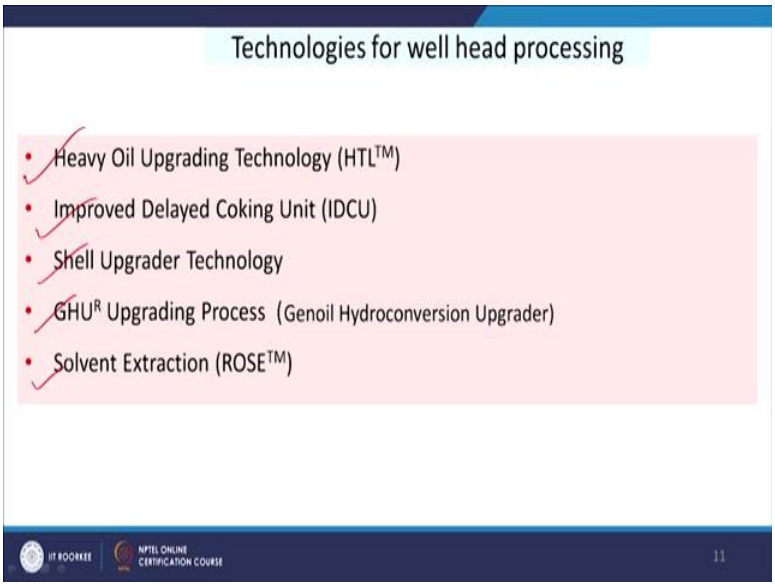

So, for that purpose for oil head processing, what are the technology available, we have discussed some of those here that is Heavy Oil Upgrading technology, HTL and then improved delayed coking unit, IDCU and then Shell upgraded technology and GHU Upgrading process that is genoil hydrocoversion upgrader and solvent extractions, ROSE TM already have discussed about the solvent deasphalting process. The same process that is ROSE team can be used for solvent recovery can be done at super critical condition.

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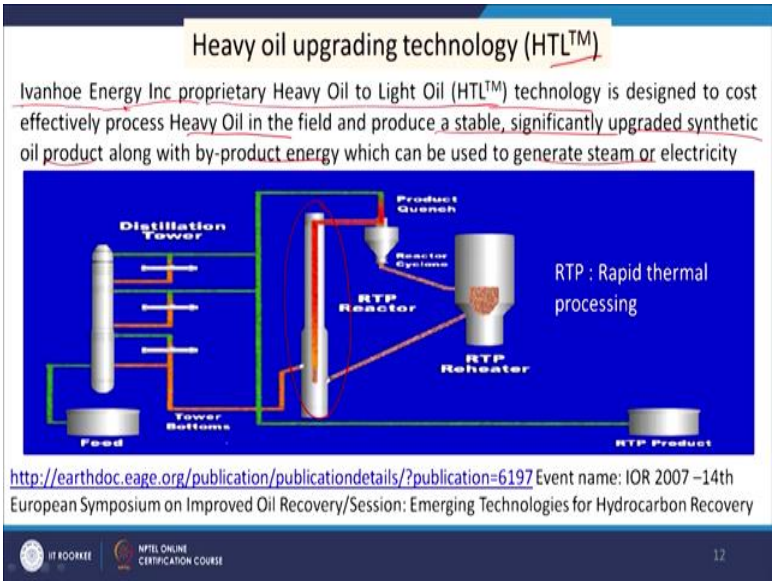

Now we see say HTL TM process. So, this HTL TM process, this is developed by the Ivanhoe Energy incorporation. This is the proprietary heavy oil to light oil technology and is designed to cost effectively process heavy oil in the field and produce a stable significantly upgraded

synthetic oil product. So, Tar sand can also be used to convert synthetic crude to this crude. And the energy is recovered.

The byproduct energy can be used to generate steam or electricity. So, this is the flow sheet. So, in this case, this is the main reactor where sand is used. So, heated sand helps comes in contact with the crude and then cracks the hydrocarbons and then lighter parts goes there. So, this is a rapid thermal processing methods so, this RTP, rapid thermal processing reactor.

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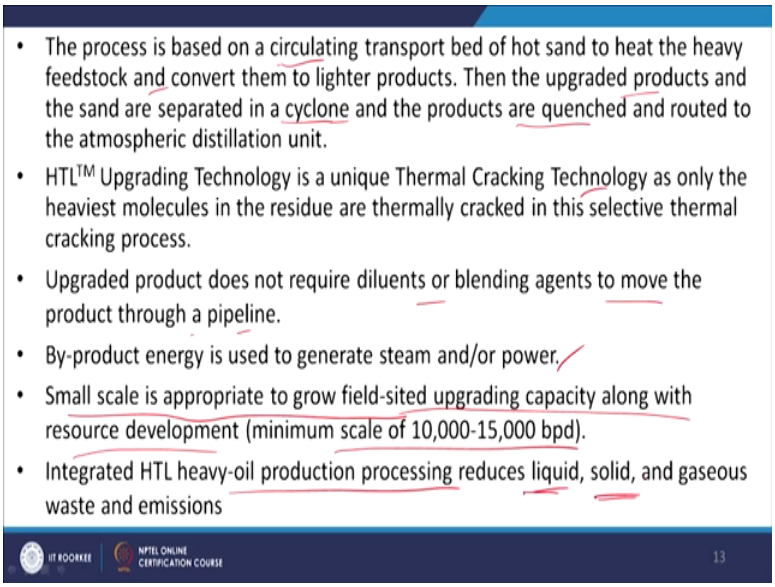

So in this case, the process is based on a circulating transport bed of hot sand to heat the heavy feedstock and convert them to lighter products. Then the upgraded products and the sand are separated in a cyclone. This is a cyclone. It is separated upgraded products and sand. Sand is separated here. Upgraded products is going there and then it is again recycled back. So, this is the process it is going on and here we are getting the synthetic crude.

Then Cyclone and the products are quenched are routed to the atmospheric distillation unit. So, here it is going to this and this atmospheric distilled distillation unit and we will get some heat. Though we can get the product this heat from the bottom you can send there and then it is going there. So, some heat recovery can take place here also. So HTL TM upgrading technology is unique thermal tracking technology.

So, in this case, what is happening the heaviest molecules which are present here, that are that those are being cracked, lighter one is not being cracked, light that is not cracked, is being there. So, heavier is basically cracked so, in the selective thermal cracking process. And then

upgraded product does not require diluents or blending agents to move to the product through a pipeline.

So, now synthetic crude we are getting which is having lower viscosity than the feedstock. And it does not need any diluent and that is one great advantage for oil site processing of the heavy crude. And the by-product energy can also be recovered. And this technology HTL TM technology that can be used in small scale is appropriate to grow field cited upgrading capacity along with resource development, so, minimum scale up these 10,000 to 15,000 barrels per day.

An integrated HTL, heavy oil production processing reduces liquid solid and gaseous waste and emissions.

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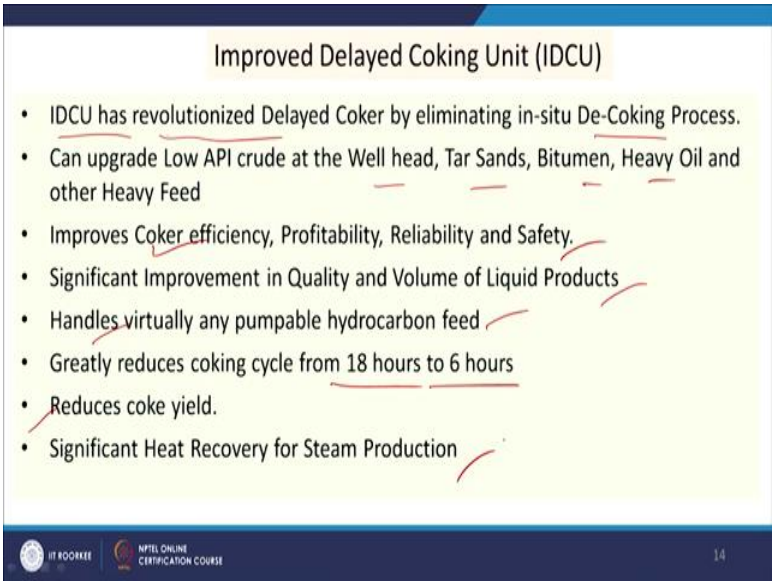

Next we will see the improved delayed coking unit. So, this improved delayed coking and we already have discussed about the delayed coking unit. So, similar delayed coking unit will be used here, but that will be having some specific nature and it is improved than the conventional delayed coking unit. In the conventional delayed coking unit, we had 16 to 18 hours of cycle time, but in this case it is reduced to 6 hours. So it is more efficient than that one.

And this ICDU has revolutionised by eliminating in-situ de-coking process, In-situ de-coking process. That is the time has been reduced means it is continuous type operations in-situ delayed coking process. So 4 hours' time for its coke removal is not necessary. So can upgrade low API crude at the well head, tar sands between heavy oil and other heavy feedstock can be processed by this process.

And it improves the coker efficiency profitability, reliability and safety and significant improvement in quality and volume of liquid products by this process. And handles virtually any pumpable hydrocarbon feed and reduce your coking yield by this. It reduces coke yield and significantly heat recovery from Steam production. Now we will see the flow sheet for IDCU process.

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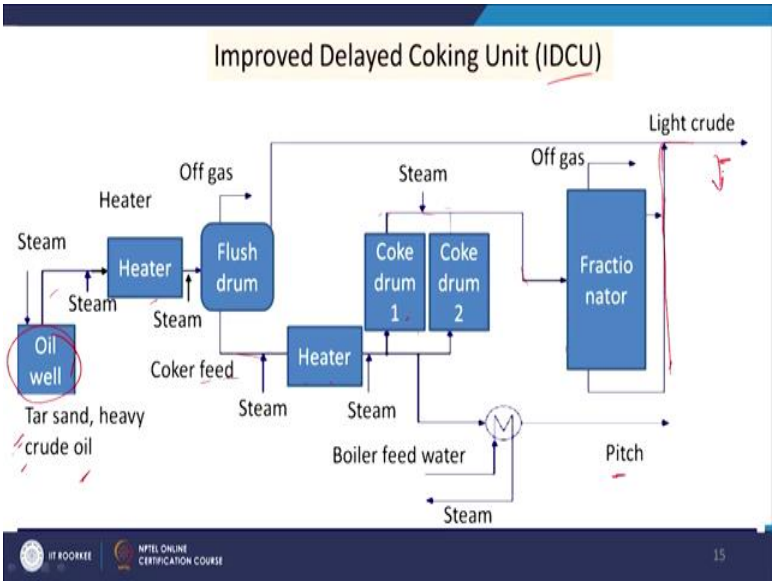

So here we are having Oil well we are getting so then we are adding steam and heating then flush drum. Flush drum will give us some light crude and then it is going to coke drum we are getting heater and then we have coke drum. Then coke drum, it is kept for some time and then we get vapours from it and get fractionated and again we are getting light crude. And then we are getting light crude, so heavy oil, heavy crude here, tar sand heavy crude here so we are we are getting light crude.

In that in case of VR vacuum residue delayed coking unit, we we had vacuum residue here and we got gas a liquid product as well as coke from this place. But here we are getting pitch we are getting pitch and we are we are getting the liquid part here which is the light crude. So, this light crude will be transported to the refinery for further processing.

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Next, Shell upgraded technology, shell upgraded technology, and this technology is developed by Shell. We will discuss this one before that you see here the IDCU this is and the previous one also this this is on carbon reaction method, application of thermal method the hydrogen is added here, but here this your shell upgraded technology, upgraded technology we see this process processes crude between from oil sands into synthetic crude oil.

It also produces synthetic crude oil from the bitumen and extra heavy crude oil. So, this is based on hydrogenation. So, hydrogenation takes place here. So, hydrogen is added to convert bitumen from Shell Muskeg River Mine in Athabasca oil sands into refinery ready sweet or light crude oil. So, this is different from that of improved delayed coking unit. This unit, this process is based on hydrogenation and the previous one is based on carbon rejection routes.

And this shell upgraded technology has a rated processing capacity up 255,000 barrels per day of 40,500 metre per day. So, it is the capacity and in this case as you are using the tar sands, so, the removal impurities removal is needed. So, your Shells Enhance treatment technology, it used to remove the sand clay, fine clay and water from oil sands froth to make clean bitumen suitable for operating by this hydrogenation method.

If we have more impurities and hydrogen if we added then more hydrogen requirement will be there and the process will be less economic. So, those are removed first, by cleaned by this shell enhance froth processing treatment technology. And it produces lower levels of sulphur dioxide emissions than the alternative programme, because already it is removed the sulphur is removed

through the shells in enhance froth treatment technology. So, these are the basic features of the shell upgraded technology.

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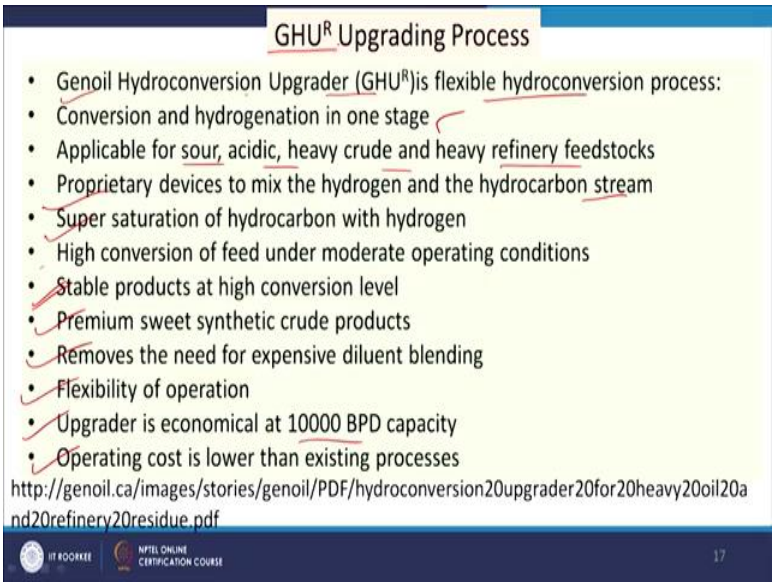

Now, GHUR Upgrading process. So, Genoil hydroconversion process, this is also based on hydro conversion and then hydrogen addition methods. So, Genoil hydrocarbon conversion upgrader is a flexible hydro conversion process its conversion and hydrogenation is in one stage and then applicable for sour, acidic, heavy crude and heavy refinery feedstocks. This can be flexible in feedstocks can be handled here.

And then, proprietary devices to mix the hydrogen and hydrocarbon stream so, hydrogen and hydrocarbons stream is mixed in a proprietary device and super saturation of hydrocarbon with hydrogen. Hydrogen super saturation takes place high amount of hydrogen in sent and high conversion of heat under moderate operating conditions and then stable products at high conversion level.

So, they have claimed that at high conversion level it can give our stable products. And premium quality sweet synthetic crude can be achieved through this route because hydrogen addition is taking place. So removes the need for expensive diluent blending. Again there is no need to diluent addition and then pumping. So reducing these and flexibility of operation and upgraded economical at 10,000 BPD capacity should be at lower capacity relatively it can be economical used.

And operating cost is lower than the existing process. These are the claims why these genoil the genoil is available in this website.

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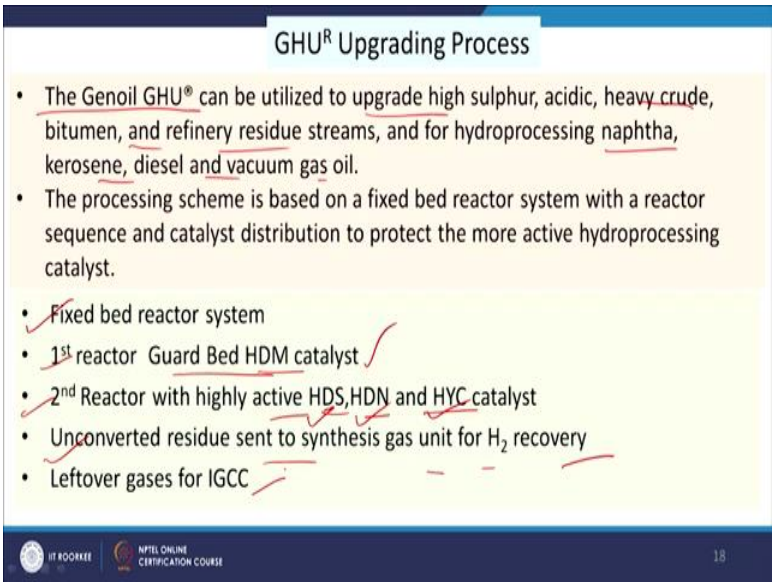

And if we see the basic features of is GHUR Upgrading process then you see that this genoil GHUR can be utilised to upgrade high sulphur, acidic, heavy crude, bitumen and refinery residue streams through the hydro processing to produce naphtha, kerosene, diesel and vacuum gas oil. This process scheme is based on fixed bed reactor and the reactors are in sequence, the sequences are in sequence.

So different, different reactions takes place in sequence. So this is a fixed bed reactor system. So the first reactor it is a Guard Bed HDM, hydro demetalization catalyst is the main in the first reactor, so, hydro demetalization, so demetalization catalyst takes place first. Then second reactor with the highly active HDS, HDN and HYC catalyst, hydro desulfurization catalyst, hydro denitrogenisation catalyst and hydro cracking catalyst. So, these catalysts are there in this reactor.

And then unconverted residue which is not being converted the residues sent to synthesis gas unit need for H2 recovery and then left over gases are used for IGCC application.

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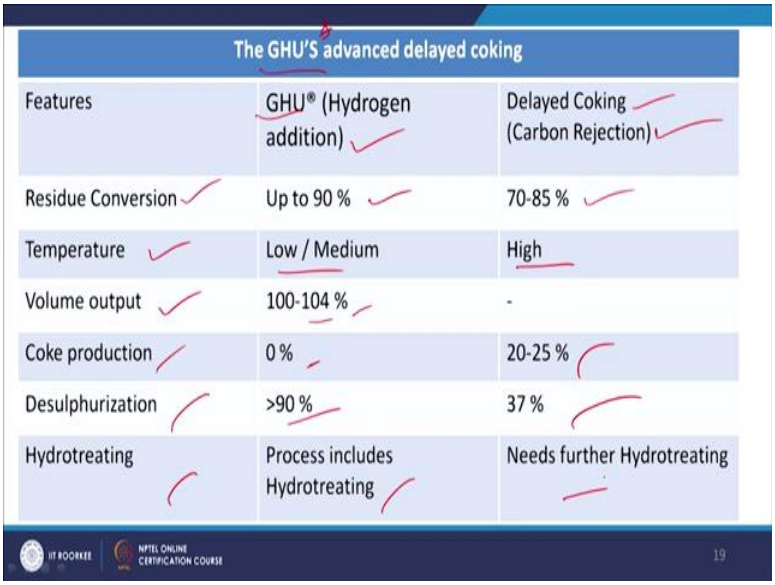

Now, we will compare this GHU advanced delayed coking, so, GHU technology and advanced delayed coking. So, this is a carbon rejection method and this is a hydrogen addition method. If we think about the type of processes, then if we see the residue conversion, you can get here up to 90% here 70 to 85%. If the temperature it is low, medium, this is high that because hydrogen addition low temperature coking is high temperature.

Volume output we get 100 to 104% hydrogen additions we are doing so, volume addition may take place. Coke production, there is no coke production for here we can get 20 to 25% coke production. Desulphurization is here in case of hydrogenation unit but here we do not get any desulphurization. Hydrotreating process includes hydro treating, it does not hydrotreating, it does not include hydro treating, request further hydro treating.

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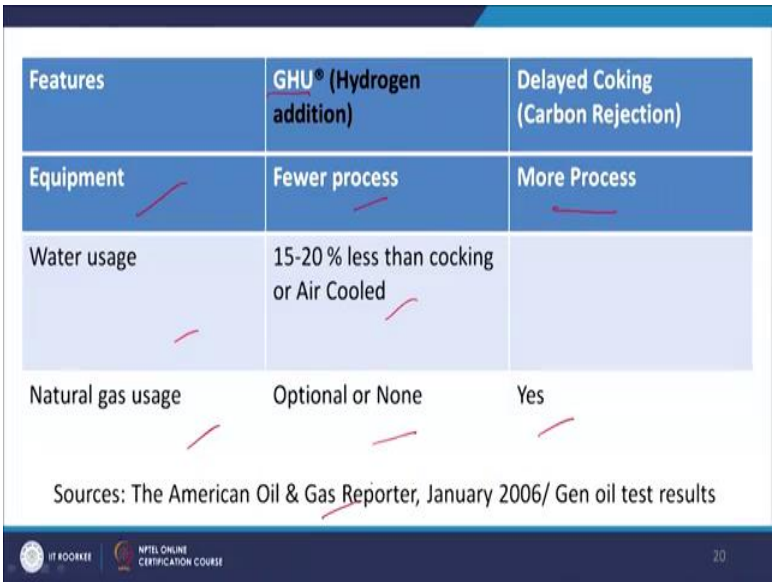

And this is equipment fewer equipments are GHU or more processing is needed in delayed coking and water usage says 10 to 15% less than coking or air cooled and the natural gas uses this optional or none here, it is available in some cases. Natural gas usage is there to heat, the preheat the feedstock. So, that way, this is taken from the difference. So, now what we are getting the conventionally which is practised that heavy crude oil then it is diluent addition and then transport to refinery and processing at refinery side.

This is this is replaced now by the introduction of oil head processing, then synthetic crude or light crude, lighter crude then it is coming to refinery for further processing.

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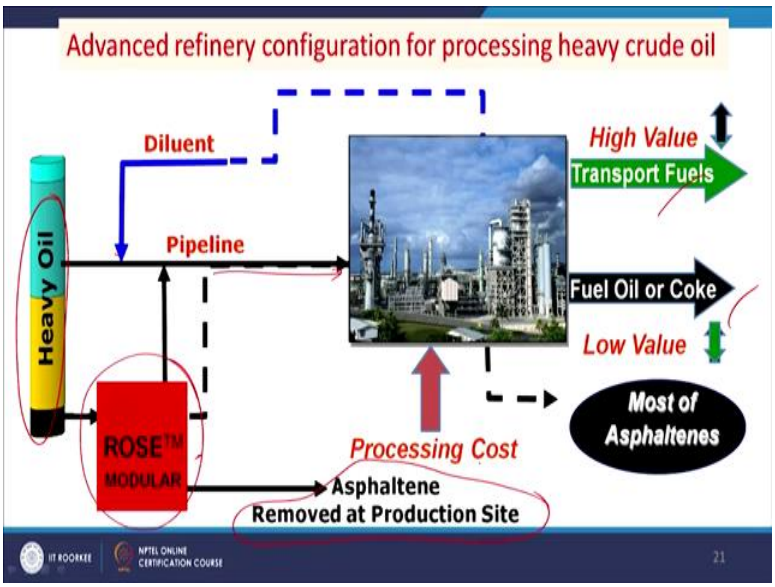

So, Heavy oil we have it is the processing is added here, added processing. Then it is maybe added with diluent or may not been added to diluent depending upon the quality produced in this state and it is sent to the refinery, and as usual the operation is there refining operation will be there, in that way, we can able to remove the asphaltenes at the product side. So, the load or the excess burden to the refinery site is reduced.

And the quality of the products is also reduced and the creation of pollution is also reduced by this process. So upto this in this class, so thank you much for your patience.