Surface Facilities for Oil and Gas Handling

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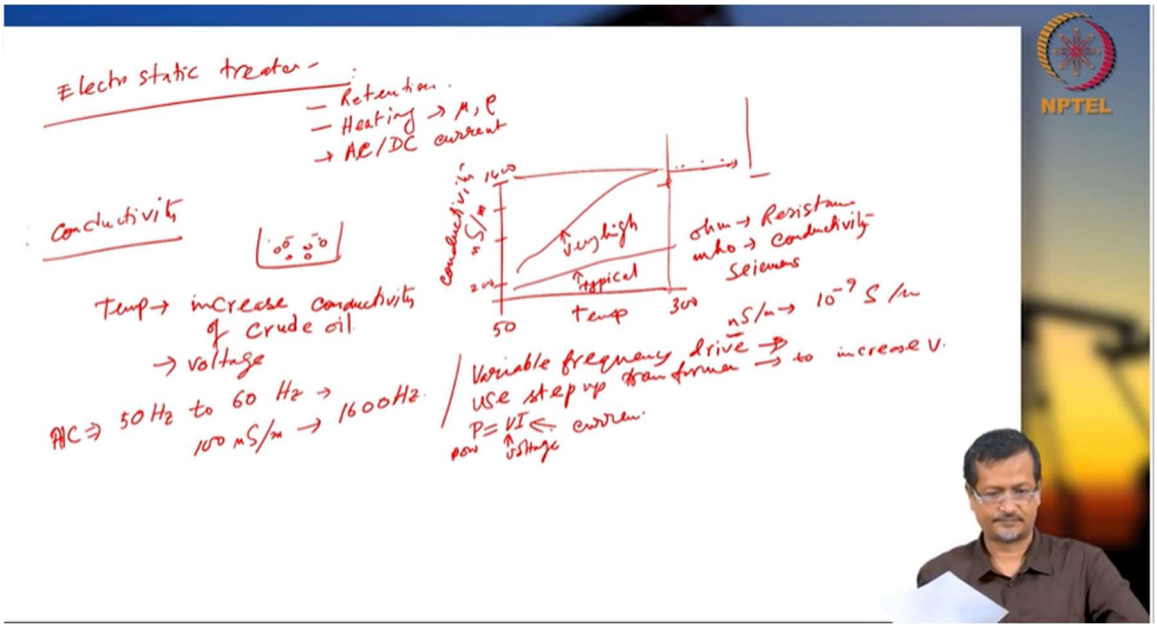
Introduction to Electrostatic Treater-01

Good morning, today I will be starting the electrostatic treater. Previously we have discussed about gun barrel, we have discussed about heater treater, then today's discussion is about electrostatics treater. We have given basic idea about electrostatics in previous lecture, but in this lecture we will go into details further. So, how it is getting oil and water is getting separated because of electric field, AC field or DC field, we can apply DC current or AC current. And what is the criteria to apply DC or AC and how much distance should be there, particle distance, particle size, all this relationship we will try to discuss in this lecture. And we will try to discuss relation between heater treater and electrostatic treater also, because whenever you are using electrostatic treater, heater treater temperature maximum temperature ah can be reduced actually.

So, you will get same separation, but you can reduce temperature. When you are reducing temperature actually your economics a fuel economics lower amount of fuel you are giving. So, actually you will be it will be beneficial. So, how the whole system works I will try to discuss in this lecture ok.

So, first go to the heavy oil differences. So, 20 degree API, API or low it will be called as heavy oil, approximate thumb rule heavy oil and if it is 14 degree then we will say very heavy. And if it is coming let us say 11 degree or less then we can say this is extra heavy extra heavy. So, whenever any oil is there 20 degree or less just you are saying heavier, but if you know that viscosity I mean if a gravity is further lower less than 11 or something then you can say this is extra heavier. So, whenever you are moving towards light oil to heavy very heavy extra heavy.



So, actually your separation difficulty will be there because water and oil the viscosity density difference although will be negligible and the difference is negligible particularly not try to move ok, but it will be almost static. So, in this case you have to give very long separation time or you have to use this sort of mechanism maybe gun barrel sort of mechanism or heater heater mechanism electrostatic mechanism you may have to use emulsion also at the same time ok. Whenever you are separating emulsion so, and emulsion breaker emulsion breaker some chemical is there already we discussed in previous lectures. So, that emulsion breaker the chemical you have to add a demulsifier we say along with all these things ok like heater heater electrostatic, gravity settlement all these things all together you have to apply ok. And why you are not using only heater heater only electrostatic heater only one system may not give your desired BSW with economical way ok.

BSW normal range will be like 0.222 ok B S and W basic sedimentation and water that range will be approximately within this range ok. But normally we say thumb rule 0.5 percent ok and if some company specifying certain amount of like buyer then you have to maintain that one and if nothing is given for your calculation purpose for your separator operation system then 0.5 is ok the standard thumb rule ok.

But it should be within this range should not be too low not possible because 100 percent removal water and sedimentation is very difficult job then you have to keep retention time maybe 1 year to years. So, that is also not feasible or practical. So, within your feasible limit of retention time temperature limit economics of fuel and maintenance of whole system BSW 0.2 to 2 percent will be your normal range ok. Difficulty in dehydration low oil water density difference very low

difference is there possible heavy oil extra heavy oil density will be very low difference will be very low ok.

So, in that case particle not oil particle water particle not try to move ok. High crude oil viscosity crude oil viscosity very high again it will not allow water particle to move ok. One thing is the density difference density difference high means oil try to move down very high difference, but if viscosity high of oil then oil will say I am not allowing to go ok. So, smaller water droplet size also will be a problem ok. You can remember the formula terminal velocity ok.

Sg difference dm by mu right. So, viscosity high is VT low inversely proportional specific gravity high VT will be high dm high again VT high ok. So, this information you have to remember actually ok and there will be some if you make like VT equal sign then in that case I think some constant parameter will come then you can use this parameter dm mu and Sg ok. Normally upper limit of electrostatic heater will be around 300 degree Fahrenheit upper limit ok for heater heater not electrostatic heater heater ok. It will be around 300 degree Fahrenheit.

If you are increasing temperature further what will happen ah, lots of low molecular weight hydrocarbon that will also go with your gas ok. So, it will be shrinkage of oil volume and you will be losing your money because oil gun to your pipeline or gas pipeline ok. So, you should give that limitation of temperature and for other safety and other aspects also will be controlling this maximum temperature. So, normally in oil field crude oil will be producing certain amount of water every time ok. Without water getting oil from wellbore is very difficult job ok.

Some amount of water some amount of debris sand and all particle will be there ok. That is why you need actually all these mechanism like heater heater electrostatic heater all these mechanisms very good ah. And this lecture actually I am taking from 2 ah papers you can download a theory of economics of electrostatic heater and field implementation of electrostatic heating technology along with this book also ok. So, if you go through this book so, you will get lots of theories ah how ah electrostatic heater working for the different formulation ok. ah So, electrostatic heater technology when you are using electrostatic heater when you are using actually controlling factor will be retention time ok.

So, it will be reducing retention time you have to give certain retention time. So, that particle will be moving slowly or it will be colliding each other for certain time you have to allow ok. And you can add heat also heater heater already you are using heat and changing viscosity density of crude oil or water viscosity density will not change much, but crude oil viscosity will change much ok. So, heating you are applying and you are changing viscosity and density ah ok. Then you are

changing you are giving AC or DC current you apply very high voltage because of voltage the particle will be polarized polarized particle will be colliding each other they will be creating bigger particle and bigger particle is there and already change viscosity of crude oil.

So, water particle will be trying to trying to settling down ok. Crude oil conductivity. So, normally oil will not have any conductivity, but oil will have some ah ionic material inside oil ok contaminant you can say. So, those will be conducting. So, when crude oil is there ionic material is there ionic material will be moving each other or it will allow electric ion to flow ok.

If very high amount of ion is there it will create short circuit I have 2 electrode ok and lots of ionic liquid is there. So, actually electric will try to flow from one electrode to another electrode right and if you do not have ionic liquid then oil actually non conductive ok. Now, if you increase temperature because heater heater you are using anyway. So, you are increasing temperatures what will happen it will allow the ionic fluid or ionic particle to move faster. So, it will increase conductivity actually ok.

So, one graph they have presented like this temperature and conductivity. So, conductivity unit they have written n as Siemens per meter n n is nano siemens ok that is actually ah M h o move right O h M unit of resistance ok. So, M h o is this conductivity right. So, oil industry they have accepted this Siemens also one siemens ok. So, Siemens also unit of conductivity.

So, nano siemens means divided by ah 10 to the power 9 ok. So, if you are using temperature that ok I will give 50 to 300 they have taken limited temperature within 50 to 300 and conductivity they have written 200 and 1400. So, 700 are other division you can do and it is becoming like this ok this is typical curve ok. Contactivity how temperature increasing conductivity increasing, but in some cases very high amount of ionic ah salts or ionic ah material is there in oil. So, in that case your conductivity can go very high also ok.

So, this is will be very high condition typically it will be like 200 300 n s per meter, but in certain cases it can go further 1000 or more also. So, very high conductivity is there actually it will be creating detrimental for your separation ok. You want to ionize water oil in water you are separating water oil water in oil ok you are taking lots of what oil is there and water particle will be separated like this ok. So, when you are putting electrodes your purpose is to remove water. So, you have to ionize water not oil your main purpose.

So, if you are ionizing oil because of this extra material ionic material what will happen electric field you are applying. So, ion will be transferred your voltage will be dropped. So, that voltage will not be useful actually. So, it will not give you proper efficiency of system electricity used, but water is not getting separated because actually short circuiting ok because of ionic ion conduction ok.

So, that will not help ok. So, if you have low conductivity oil that is very good, but again you are increasing temperature some cases ion will be creating it is the crude oil more conductive. So, that will create your low efficiency ok low performance ok. So, you can remember this typical curve ok with temperature in some cases ion it can be very high conductive oil ok. So, what will be doing temperature? Temperature can increases conductivity of crude ok. We are concerned about crude oil conductivity water is already polarized right.

So, it will be giving voltage drop because of conductivity creation ok you create a high conductivity so voltage will be dropped, but water they need ion and they want to polarize they want to move they want to collide. But instead of doing that you are giving ion to what oil actually ok. So, that is detrimental. So, mobility of conductive particle increases. So, conduct so voltage drops ok because of temperature increase ok.

One nano n this unit also you should remember n s per meter they have written and this is acceptor also they have written article this is called Siemens ok nano Siemens per meter ok. And unit will be like 10 to the power minus 9 Siemens per meter because nano term is there ok. And this is conductivity so if it is opposite of resistance ok M H O MO is your conductivity unit resistance is opposite of it. So, this is also actually opposite of resistance. So, it is not giving resistance rather it is assisting to flow ion will be flowing from one electrode to another electrode so separation performance will be dropping ok.

So, normally 50 to 60 hertz electric current if you are giving to 60 hertz electric current if you are giving then it will be ok. But in case of increasing conductivity especially AC ok AC current AC current will have frequency DC is not having frequency right it is plus and minus AC is changing polarity continuously. So, that is why it will have positive negate it will have frequency but DC will not have frequency actually ok. So, 56 hertz frequency normally you are giving this is fine. But your this nano Siemens per meter if it is increasing let us say 100 ok n s per meter.

So, in that case your frequency may have to increase 1600 hertz ok. And how to increase the electrical frequency these days variable frequency drives are there you may have heard variable

frequency drive variable frequency drive this is one electrical instrument. If you give 50 60 hertz it will convert any frequency you want you want 2 frequency 2 hertz frequency 100 hertz frequency 200 hertz. So, it will convert ok. So, using variable frequency drive you can change electrical frequency ok.

Variable frequency variable some more terms are there just you can google and you can find some more terms of variable frequency drive variable VFD VSD variable speed drive. So, some other terms also there ok. And step up let us say if you give 220 volt it will not work I will we already have calculated right. So, in that case you have to use transformer and you have to use step up transformer ok. Use step up transformer transformer to increase voltage to increase voltage ok.

When you are increasing voltage power is fixed your current will be going down right. So, V how can I say that V equals V into I power voltage current ok. So, if you are changing voltage and power fixed that means, current is dropping ok. Whenever we are using terms step up step down we are not using for current we are using for voltage only ok. So, they need voltage if you are changing current actually amount of flows separation will be changing ok.

Voltage means you are creating field gradient 2 electrodes are there plus minus you are creating gradient using voltage. Current means how much ion is moving ok. Current how much how many ions are moving the voltage will be giving how much pressure difference you are creating ok. So, voltage will be pushing your ions ok. So, 10 ions 20 ions 30 ions whatever number of ions are going.

So, voltage will be pushing ok. So, current is related to ion the voltage means it is gradient of pressure like you can assume the water pressure. So, very high pressure high flow rate you can create ok and velocity and current will be like flow rate current will be flow rate ok. So, sometimes they create electrical analogy electrical analogy means like voltage will be like pressure difference current will be flow rate that way ok. And resistance means friction or pressure drop in piping flow you have that is resistance ok.

So, conductivity increase 100 nanoseconds ok. Conductivity increases with temperature drop of oil depending on ok solid ok solid present like if any ionic liquid ionic particle is there ionic solid or any other ionic particle is there in oil. So, that will create ionization of oil ok oil itself is not a ionized fluid right ok. So, three type of primary electrostatic forces three types of primary electro primary electrostatic forces static forces ok. So, one is that dipole dipolar at action two is your

dielectrophoresis and third is dielectrophoresis dielectrotro ok. So, dipolar attraction actually is the electrostatic attraction force between opposite charged ends of water droplet.

Let us say I have one electrode plus I have minus ok. Then I have water particle ok it will create bi-pole one will be minus one will be plus and if you are attracting from both side. So, it will be distorted actually ok. Normally water particle will be circularly shaped raindrop also falling circularly shaped. So, what is the reason you know that surface tension actually.

So, surface tension will try to create lower surface area lowest surface area possible ok. So, when you are creating lowest surface areas the spherical shape will create the lowest surface area. So, whenever water particle is there somewhere if you do not have any extra other forces then it will try to create circular shape spherical shape ok. Now in this case using electricity you are trying to distort the shape ok.

Instead of they are taking smallest area surface area. So, to break that smaller surface area you are creating high voltage and you are distorting it. When you are distorting possibility is that other particle will be touching and your break that emulsion emulsifying agent on the coating coating the water droplet it can break also. So, when it is breaking maybe two particle will be joining quickly ok. So, there is a purpose. So, dipolar attraction is that the electrostatic attraction force between opposite charge ends of water droplet ok.

So, one particle is here another particle is here ok. So, plus minus plus minus plus will be attracting the minus side ok. So, water will create a bipolar droplet. So, single pole not possible ok. So, it must be bipolar plus minus must be there right only plus and only minus and not possible ok. So, dielectrophoresis this is actually when you are applying constant electric field ok.

So, you are creating constant electric field plus minus ok and is trying to move let us say towards minus electrode ok negative electrode. So, this is called electrophoresis constant electric field you have applied and dielectrophoresis actually if electric field is variable. So, that is called dielectrophoresis ok and is very high voltage you have applied here ok. So, because of very high voltage actually this electric field is variable inside the system, but you can create multiple electrode and you can create uniform electric field inside the system ok. You can create uniform electric field or variable electric field because of the ok.

Now, we will discuss how this AC and DC is getting applied. So, when you are applying AC actually particle will be resonating. So, sometime we are giving one electrode plus after few

fraction of second it will be minus. So, plus minus continuously doing the particle also changing let us put it vibrating right when it is vibrating one particle is there another particle is there you will try to collide ok. So, particle not trying to move to one electrode rather locally they are trying to collide. So, that means, you will have you should have lots of particle nearby you have lots of particle nearby then particle collision rate will be higher in AC current.

So, in that case if you have higher amount of water say lower section of separator higher amount of water in that case you can use AC current and you can create collision mode you will create bigger particle it will be settling further down then from bottom you take out ok. But if you have DC DC voltage you are applying let us say high bond separator and one layer is here and another layer is here. So, lower portion water number of water molecule will be higher water droplet will be higher. So, there you apply AC voltage give resonance particle collision will be there it will be distorting particle collision will be there that rupturing possible that surface coating agent whatever emulsifying agent is there already ok. If you have already removed that emulsifying part fine if it still something is there it is coating when they are colliding is possible that they will be fusing together they will make bigger particle and V t proportional to d m square just simple you can remember that right.

So, d m square right. So, you are not changing oil viscosity or anything you are just changing particle size you are promoting collision changing particle size and particle automatically slide and if you are assisting with heater heater then heater heater is changing your oil viscosity. So, DC current where water cut is more ok. So, AC where more water cut is there ok. So, because particle will be nearby resonating colliding making bigger particles separating done, but DC when you are giving DC current what is happening DC current where water particle are sparsely distributed and you are giving 2 electrodes here.

So, let us say 1 plus 1 minus. So, plus will be attracting the minus end minus will be attracting the plus end ok. So, very high voltage you apply. So, slowly the particle will try to move towards electrodes ok. So, let us say one particle A move towards this electrode touch the electrode it got charged. So, when it got charged actually again they will be having repulsive force plus plus they will be having repulsive.

So, they will try to move in opposite direction again. So, one particle moving towards plus electrode got charged again they will have repulsive force they will try to move other direction ok. When they are moving trying to move they will possibility is that they will collide with other particle also. Because many particles are trying to move some trying to move this some other direction. So, collision rate will be there.

So, actual particle motion will be there ok. So, in that case actually low water cut system if you have then it will be effective more effective ok. So, low water cut water cut ok. So, how to create low water cut high water cut? So, separator upper layer will be have lower cut low water cut low amount of water because water is getting settled ok. Bottom part water amount higher.

So, you can create higher water cut there ok. So, in that way you can separate ok. I have more information I will explain. Yeah electrophoresis actually horizontal moves water droplet horizontally between electrodes in uniform DC field field uniform ok. Uniform DC field you created plus minus and droplets moving in one direction ok.

Again it will be moving opposite direction also ok. But dielectrophoresis actually weakest one you are trying to mix both dipolar attraction and dielectrophoresis ok. So, weakest of the three electrostatic forces is approximately half strength of the dipolar attraction forces. Polarized water droplets move in a non uniform electrostatic field non uniform electricity field ok you are creating then you are separating.