Surface Facilities for Oil and Gas Handling

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Produced Water Treatment-03

Good morning everybody, today I will start ah the topic Hydrocyclone Offshore Disposal System and A few numerical problems. So, how to solve it, how to design or size the ah offshore disposal ah how to size this skimmer for vertical horizontal for rectangular cross section. Now, ah in previous lectures we have seen that there will be horizontal skimmer, vertical skimmer and some skimmer can have rectangular cross section ok. Now, after skimmer you got the fluid which should be disposed for further, but if you are offshore structure. So, there will be disposal technique different, if you have onshore system the disposal system will be different. Offshore actually will be having long pile structure or case and structure there you are disposing .

Now, there will be hydrocyclone some steps. So, how what is hydrocyclone, how it is working we will explain . So, hydrocyclone is called an enhanced gravity separator. So, using gravity separator you have seen this static system and because of density difference or gravity difference fluid is moving upward or downward maybe water will be downward and oil will be upward.

But when you are using hydrocyclone so, it is easy it will be using a specific technique which will be enhancing the separation rate. So, how does it work? So, normally it will have one cylindrical section and it will have one inlet section and one exit section here ok. And I will draw like this so, that you can understand easily. I will remove this one ok. So, this is called hydrocyclone.

So, this is hydrocyclone. So, hydrocyclone will have one inlet port, one exit port for oil oil exit and water exit . So, this is one cylindrical section and it is having one mixing section also you are creating lots of vortex or vortices inside the system and that will be

separating oil and gas. How it is working? Let us say top inlet section if I take top view it will look like this. One hole is here another hole is here I will make like this.

No it is not lucky ok. From tops view if I take from here so, it will look like this. This is central hole this is oil exit path, this is oil exit if I am taking looking at from top and it is your inlet ok and fluid is entering tangential. So, tangential entry so, fluid entry tangential ok. So, it will be touching the surface and it will be move entering.

So, it will be rotating actually. So, tangential entry so, because of high velocity it will be rotating and normally pressure will be requiring 100 psi ok. If it is having lower than 100 pressure upstream pressure upstream of the system then you have to use one pump. So, you need extra energy to increase the pressure ok. So, if you do not have pressure the fluid will not come into very high velocity we need very high velocity to create.

And work it will be working well with more than 20 microns oil droplet size. If you have less than 20 microns it will be difficult to separate ok. So, it will be like 10 to 20 you can say I will write 10 to 20 more than 10 microns ok. Rejection rate the two definitions are here reaction is reject fluid rate divided by total inlet fluid rate and pressure drop ratio PDR equals delta P between inlet and reject ok. And del P inlet water inlet to water outlet.

So, inlet means here and water outlet is here this ratio. So, let us say P 1 P 2 P 3. So, inlet to outlet pressure ratio will be like P 1 P 2 okdel P between inlet to reject inlet means P P 1 divided by P 3 ok this ratio is called pressure drop ratio. And reject ratio is the reject fluid by total fluid inlet inlet fluid rate. So, reject ratios P 3 by P total inlet fluid P 1.

So, reject ratio normally it will be 1 to 3 percent very small amount of oil will be there. So, that is why the reject ratio will be 1 to 3 percent ok and reject ratio proportional to PDR. So, you should remember this small small relationship because when if I give all objective questions. So, this will be very important factor. Hydrocyclones are excellent coalescing device primarily treating device followed by downstream skim vessel.

So, what happens upstream you have two phase three phase separator heater heater then you are putting on hydrocyclone then you have a skimmer tank it is not the last one. So, upstream separators hydrocyclone you are removing oil and oil content further then you

are sending to skimmer then you are disposing . So, followed by downstream skim vessel advantage no moving part you can see there is no moving part actually. If I have sufficient pressure if I will say 100 pressure PSI pressure is already here. So, I do not need any extra pump.

So, there is no moving element. So, I already explained you know that in engineering system if I have relative moving element and life will be lower. So, in that case we do not have any relative moving element it is just fluid is flowing machine is not moving right there is no part inlet or exit or anything is not moving. So, life will be longer, but if you have any pump then pump life will be coming into picture ok. So, if you have more than 100 PSI pressure will be cheaper actually and you do not need any extra pumping mechanism.

So, it is very simple system, but if you have pressure lower then in that case you have to increase pressure with a pump. So, that will be costing and it will be reducing reliability also ok. So, insensitive to motion modular design ok. Insensitive motion means offshore situation let us say where waves and tides are there because of that the system offshore platform will be moving actually ok. When it is moving little bit of motion is there.

So, this system is insensitive to motion. So, it will be working well in offshore applications ok. Onshore also you can apply there is no issue offshore also you can use. Modular design lower operating cost if inlet pressure is available ok. Operating cost will be lower because there is no investment actually you just want design done, but if you it this cost will be increasing if you use more pumping system then pumping means electric consumption will be there pump life will be there 2, 3 years, 4 years right.

So, that will be costing money. So, disadvantages if pump is required pump is required then cost will be increasing and sand issue sand means fluid is flowing at very high velocity. So, at high velocity you can remember high velocity erosions rate will be higher ok. Erosion rate higher means your life will be lower system life ok. So, if you have lower sand this is better if I larger amount of sand is there then you have to check whether erosion is happening or not.

If erosion happening then maybe you have to replace the system frequently. Typically

one well bore will be producing about 30 years ok. So, that figure and hydro cyclone should be placed vertically actually ok. I will draw again this one like this. So, it will be like this and there will be one almost flat section then this is cylinder you can see upper one right and then one conical section must be there then fluid is entering tangentially I told you fine and this is your exit this is water out actually .

This is oil out oil is going from top and how it is working I will explain entry and fluid will be entering I already told that it is tangential entry. So, it is rotating right. So, rotating and what will happen fluid is rotating and because of gravitational force it will be going down also ok. It is rotating and moving down like toilet flush chamber is rotating and going down right. So, here also rotation it will be going down then what is happening then why oil is also not going down.

So, what is happening at very high velocity water particle will try to touch the external surface ok because density higher ah in V square formula you can see centimeter force right you can remember the school books. So, that centimeter force because of that centimeter force water will be touching the outer surface and oil will try to touch, but it will not get space because water will take the space because oil lighter density. So, oil will try, but it will not go. So, oil will be rotating around the center ok. So, oil will be rotating around the center actually .

Now you have got separated oil and water inside the system. Now you put this pipe long pipe from top and suck the fluid. So, water you are getting from top and oil water as oil you are getting from top water you are getting from bottom and this is entry this is using based on your centrifugal force. So, and it is assisted by gravity right when it is rotating it is going down also because of gravity is going down. So, which is going down high-density fluid if you have sand, sand also will go down.

So, if you have two density two fluid may be solid and fluid two phase or single phase or multi component fluid and density difference is there rotate at very high velocity. So, high density fluid will be trying to create larger radius lower density fluid will try, but high density fluid take the space largest space lower will be rotating at the center area you suck that lower fluid separately ok. So, oil water you got separated like this ok. So, this way hydro cyclone will work fine this is hydro cyclone principle ok. So, the terms they are

using here we should remember also this is entry means oily water oil plus water small amount of water may be 2000 milligram per liter right and out may be 800 milligram per liter because amount of what oil reduced of oil in water of oil in water and tangential entry entry is tangential and oil rejection this is oil rejection they say oil rejection cylindrical salt chamber this is salt chamber this section cylindrical salt chamber this is swaddling continuous rotating this is cylindrical salt chamber andsome conical section may be there fine tapered section this is tapered or conical and this is cylindrical tail section this is tail section tail downstream outlet this water outlet OUTLET outlet .

So, this is actually clean water clean or you can say clean cleaner water because we are not removing 100 percent. So, some still traces will be there that is why they are saying like clean I can say cleaner this is better term. Now if you have low pressure let us say 100 psi pressure is required I said . Now you want to increase pressure. So, what type of pump will be using? So, pump there will be several types of pumps I will discuss later.

So, one type of pump called progressive cavity pump progressive cavity pump. So, what is progressive cavity pump? Actually it is single screw pump if you want to know details about this one. So, you can follow my lecture artificial lift artificial lift NPTEL lecture I have already recorded the video will be available to you. So, there progressive cavity pump I explain details 2 and half hours 3 hours. So, it is actually single screw pump it is called no shear pump why no shear pump this is positive displacement no shear pump positive displacement type .

It is for positive displacement type no shear pump the shearing what is this issue of shearing? Shearing is like centrifugal pump you have centrifugal pump will be rotating at very high velocity when it is rotating by velocity the oil particle what let us say I have 500 micron size oil particle. So, because of high velocity and huge turbulence inside pump the particle be broken when particle broken it is getting too small particle. So, separation from any device will be difficult because your main purpose to increase particle size, but very high velocity pump like centrifugal pump it will be giving shearing action because of high turbulence the particle will be broken it will create very tiny particle. So, tiny particle again use separation like will be difficult. So, in that case you use progressive cavity pump progressive cavity pump what does it do? The function of PCP is like this it will take certain amount of fluid and because of pump rotor rotation that fluid will be transferred slowly.

So, it will not disturb the flow whatever captured flow is there it will not disturb it will take flow and it will move. Like our heart working this is also on pump actually this is the oldest pump you can say and longest duration of survival of the pump right. In Japan if you see Ikigai if you read the book 120 years common people living there. So, their heart is working for 120, 30 years right. So, there is a longest duration longest serving pump.

So, in that case also it will take certain amount of fluid again it will deliver. When it is like beating it will take certain fluid it will be delivered. So, it is not shearing if it is shearing then your RBC or WBC will be broken. So, you will not survive. Similar way this PCP also it will take certain amount of fluid it will deliver it is not pulse it is not pulse in the that sense like like this it will be rotating.

So, that is also creating small small pulses, but it takes small fluid transfer, transfer, transfer. So, it will be delivering like this ok. So, details you can go through my lecture ah there will be lots of YouTube videos also if maybe you can go through it. So, the shearing pump non shearing pump actually. So, particle will not get sheared it will not create smaller particle whatever particle size there same particle will be there, but you are increasing pressure .

So, PCP you can use single screw pump or other type pump also will be there maybe you can use, but they have given example progressive cavity pump. I am I am stressed here also because I have already recorded lecture in YouTube. So, you can look at . So, ah this hydro cyclone it is having disadvantage it is at a means they have no moving part I already told ok moving part is there this problem.

So, there is no moving part here. So, minimum maintenance and operation possible. Then their compact design reduces weight and space requirement. So, it is very compact design it is just giving rotation for example, if you say flotation chamber, desorbed gas or dispersed gas whatever. So, they will take larger space, but in hydro cyclone system if you see it is very smaller actually very compact . So, it will not take lots of deck space ah they .

So, those can be used for offshore application which is not taking space the offshore space is one problem because you have small platform you have to put everything their engineers will be working. So, their food and all the arrangement must be there oil separation system. So, everything will be there on single platform. So, their space constraint is one ah issue there ok. So, their hydro cyclone can be used safely because space very small space is required they are insensitive to motion.

So, it will be suitable for offshore application like say shaking of offshore platform because of the wave and wind. So, it is fine because high velocity fluid is moving and it is separating their insensitive motion their modular design. So, you can use one by one one separator two separator three separator and very simple design you can see only cylindrical section is there inlet and outlet is there. So, it is very cheaper also modular design possible and they offer lower operating cost if you have higher pressure. If you have lower pressure than 100 psi then most only you will be requiring one pump and again pump any pump you should not use rather you should use non shearing pump ok one example is progressive cavity pump or single screw pump.

So, there will be multiple screw pump also you can use, but they have given example PC. So, just you should remember ok and disadvantage it is basically disadvantage that one if pressure is low then you need extra extra energy to pump it ok. So, that is the basic disadvantage and another sand so, disadvantage is that the advantages disadvantages like pump required and sand is one issue ok. So, basically two disadvantage they have reported others are very nice I mean there is no moving element and there is no electrical requirement actually.

So, it is very simple system ok. Now, we will go to offshore disposal system. So, offshore disposal system it will have ah it will have certain equipment. So, produce water should not be dumped directly into the sea after treatment ok there are environmental regulations all the companies must follow if someone is not following it will be their problem ok rain water equipment wash down water needs to be disposed off ok. So, some produce water you are disposing and rain water and other thing also like you have big floatation unit and other unit. So, rain heavy rain is there so, rain will be entering actually you know floatation unit and other.

So, you have to handle that one also and many ah platforms they will have their own oily water production also that also they must dispose. So, they should have certain equipment which will be used for all type of disposals things ok. A disposal device dispose the water deep enough below the sea surface and away from the wave action. Wave action means like if you see ocean surface ok ocean surface and ocean bed sea bed sea bed and this is ocean surface or ocean surface ocean surface I can write ah I will write ocean surface ok.

So, what happens ocean surface there will be wave ok wave tidal wave will be there tidal variation of water and there will be local waves per second few per minute few waves will be coming if you go to any local sea beaches you will see waves are coming right.

So, and wave effect will be around 20 meter or something ok. So, your disposal pile or pipe will be coming below the wave action ok and what happens during wave wave actually particle be rotating like this. If you see actually mid ocean waves wave particles are not moving actually nearby coast if you go water coming to you. So, particle moving there, but if you go deeper water. So, there particle are not moving particle will be just rotating in local areas ok.

One is rotating local area and if you are disposing let us say in this area ok. So, what will happen this water will be mixed up again and again. So, they want to avoid that one. So, they will be longer pipe and they will be disposing ok and your platform will be working here and some pipe will be coming like this longer ok.

This is called disposal pile. Common device disposal pile are skim pile, SP special type of pile actually serpentile pipe. So, company some company has given the name SP pile.