Surface Facilities for Oil and Gas Handling

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Drilling And Completion-02

I said like drilling when you are doing you will have one mud, mud means fluid sometimes this is called drilling mud or drilling fluid also they say drilling fluid. You have seen this drilling for your metal making a hole in the wall or metal drilling you have seen.

So, it will be having like one screw type thing, one screw type thing will be there and you rotate it continuously and give pressure and you make a hole on wall or metal or anywhere like wood. This was a similar mechanism actually when you are going for offshore or onshore drilling for oil and gas. You have one long pipe and the pipe will have one at the end one cutter will be there called a drill cutter or drill bit.

So, continuously you give a little bit of pressure and rotate it when you are rotating what is happening is this cutter will be cutting the rock, the earth's surface, this upper surface of earth very softer rock will be there, but if you go in here the rock strength will be stronger. So, in that case, you must have a proper drill bit rotating continuously and it will be cutting, but again when it is cutting you may have noticed when you drill any wall with your normal drilling machine or any metal it will be generating lots of heat. If you are not removing heat it can break actually. So, in your oil and gas drilling operation, what you do you inject liquid or fluid or drilling mud. So, the drilling mud will this drill pipe inside the hole will be there inject lots of fluid and it will be passing through the drill bit and it will be moving up and it will take lots of heat. The purpose of drilling mud is to cool it and lubricate also. So, drilling mud purpose is getting lots of friction it will be getting heated up friction means heat. Finally, any form of energy's final form is heat when you are converting one form to another form of energy.

So, the final form of energy loss is happening like you may have studied like thermodynamic equation thermodynamic laws second law first law you can remember. So, in the second law, you have learned that energy loss will be there when you are converting one form to another form of energy. So, that loss will be converted into heat final form of any energy is heat. So, whenever you are drilling final form will be heat whatever you do finally, generates heat lot of friction will cause rock cutting, breaking there heat generation is there. So, you have to remove the heat. For that, you are giving high-velocity drilling fluid. So, that heat will be dissipated as the drilling fluid will take the heat and it will be lubricating also. So, that friction will be reduced lubricating lubricating like you are driving a cycle.

So, if you do not drive your cycle for like 6 months you will be locked down. I think you can remember several days you do not drive your cycle and the cycle will be making noise

it will be very difficult to drive. So, in that case, what you do is you go to the cycle shop they will be putting some thick fluid or some grease or some engine oil sort of they will be putting on your cycle. So, that is lubricating oil long chain hydrocarbon, not short chain long chain hydrocarbon that will create lubricating effect. So, that lubricating effect will reduce friction. In that case, also you are reducing friction using your drilling mud cooling another work is that whenever you are cutting a rock lots of small gravels will be created by a broken rock or drill cutting. So, the drill cutter will be cutting. So, this is cutting or drill cutting or rock cutting whatever terms you use.

So, that rock if it is getting deposited then the drill bit will get clogged there. So, you have to remove that rock particle. How will you remove it? The drilling mud will go through this hole of this drill pipe and when it is going up it is going through this hole and it is going from outside how it is like this like I have one well boar and my drill pipe is here and my drill bit is here and liquid or drilling mud is coming and it is cutting continuously this rock and this drilling mud will be moving up. So, the drilling mud you are pumping through the drill pipe, this is drill pipe, and this is an annular area. Annular means you cut a hole drill pipe is here. So, in between the drill pipe and your home, the space is called the annular area. So, mud will be moving up through the annular area. So, mud when it is moving up will take all the cuttings and also small rock particles that you created that will be moving using moving by your drill mud. So, it will be removing drill cutting another task is hydrostatic pressure.

What is hydrostatic pressure? Hydrostatic pressure means whenever you cut the well bore. So, what happens is they say surface rock is there and after that maybe one formation zone is there and pressure is very high at the formation zone and you cut it and you reach the formation zone where high-pressure fluid is there. So, high-pressure fluid will try to move toward the drill pipe and all the annular areas. Now if you do not control that high-pressure fluid well bore to your surface coming through your annular or drill pipe then an accident can happen. So, to prevent that you change the drilling mud density in such a way that whatever pressure is there in the well bore reservoir you create more pressure here or almost equal pressure.

So, whatever pressure you have that pressure will not force fluid to go up. So, drill mud will control all these flow phenomena. If the reservoir is controlling flow phenomena then it is dangerous actually if gas is there oil is there then suddenly it will be gushing out and if there is any fire source then the whole thing will burst. So, in that case, you are maintaining hydrostatic pressure drill cutting removal you are doing cooling work you are doing lubricating you are doing some other purpose also there for the cake formation other things we will not discuss in detail. So, you see the left side picture I have taken from Encyclopedia Britannica here you see the drill cutter here drill bit is here drill bit and fluid is coming through this you see this arrow already given this is drill pipe is shown here drill pipe and fluid is moving up through the annular area and from where the fluid coming you see one pump is here left side mud pump.

So, a mud pump will be pumping fluid drilling mud at a very high velocity or high pressure mud pump normally will be reciprocating because very high pressure you have to create.

So, normally it will be a multi-cylinder reciprocating pump maybe triplex, simplex, or quadruplex that sort of reciprocating pump will create very high pressure later I will discuss why a centrifugal or axial pump is the reciprocating pump. So, a quadruple pump can create very high pressure. So, the high-pressure pump you are creating delivers high-pressure fluid through this ah mud hose then it will go through the drill pipe Kelly means the top section of the drill pipe one conduit or pipe called Kelly the top section. So, that will be rotating continuously actually and Kelly will be connected to a drill pipe.

So, fluid is going through this. Then when you are returning, the returning fluid will go directly to this shell shaker this vibrating screen is called a shell shaker. So, continuously it will vibrate whenever drill mud comes back it will have lots of rocks. So, this shell shaker or vibrating screen has lots of pores that will be there when you are continuously shaking like this. So, sand particles or bigger particles will be standing over this shell shaker or screen and liquid will be falling.

You separate the top part you are cutting you do not need you use your handle separately and the liquid you got liquid you put in your mud pit. Why mud pit you have to put a mud pit you are giving settling time. So, rocks small particles debris anything is there there will be getting settled in a mud pit. So, from the mud pit after settlement, you pump it again then you will circulate. So, this is a continuous circling operation.

So, pump to the hose to Kelly drill pipe drill bit annular area then again it is coming to shell shaker area the sander also will be there hydro cyclone or the sander may be there then it will go to its mud pit then again mud pump the circulation will go on. And many cases you have to change drilling fluid properties. For example, sometimes you have to increase density decrease density increase viscosity decrease viscosity one we are not discussing here in detail. Because our focus is different for this course because all topics are different also small topics. So, that someone coming the first time. So, they should remember those terms especially if they do not know someone like learning the first time they should understand terms like drill cutting mud terms whatever you are using those terms you should not make a petroleum engineer.

So, you have to go through Wikipedia and some other sources and you have to be familiar with the terms. So, drilling stage, in the previous slide you have seen we have a weld bore and we have drill pipe and you have their cutter this is drill pipe and this is your rock you already removed material from here. Now, you must have one wellhead during drilling operation you can have one wellhead. So, the well head will allow accessing your well bore putting your tubing everything, but at that time your Christmas tree may not be there and there you will have one BOP also. What a is BOP or blowout preventer blowout preventer?

So, blow out preventer what does it do like say you are drilling and suddenly you got one area that is very high pressure maybe high pressure and having gas. If you have cap rock and when you are drilling first time so, the cap rock top portion may have gas accumulated. So, you suddenly drill and you get very high-pressure gas. So, high pressure what will they do they will try to move this move up ok through maybe your drill pipe or through the

annular area and if suddenly you get that much of high pressure there is a kick. So, if the driller or the engineers who are working if they find some kick there suddenly the pressure is getting changed.

So, what will they do they will change their drilling fluid density or other parameters. So, that they can control the kick and they can continue drilling, but in some cases that is not possible to control. So, there will be one mechanical arrangement called a blowout preventer. So, a blow-out preventer means a sudden kick is there, but if drillers or those engineers working there are unable to handle the blow-out preventer the mechanical arrangement will take action. So, suddenly it will close the whole pipe in some cases it will cut the whole operation and stop the whole fluid flow.

So, there we know outflow if something is going out gas or oil if there are any fires or anything then a blast can happen. So, that happened actually in deep water horizon. So, suddenly fluid gushed out and they could not control it I was reading their report and they they found that everything was designed nicely, but their IC engine internal combustion engine was there. So, an internal combustion engine should have a certain specific fuel-air ratio. So, that engine will be working properly, but what happened because of gushing out fluid -gas. So, the gas changed the air-fuel ratio and it entered the engine. So, the engine did not function properly because it got more fuel than required fuel. This is whatever gas we are coming there is also fuel and the engine had its fuel. So, all together the ratio changed and a fire started once the fire started no one can control it immediately and when you are working offshore actually your life is also linked with that you cannot run away. You are working on semi submersible platform and you are thinking some other engineers will be working I will be sleeping for today. So, not possible your life is also linked there. So, all engineers were involved they started working, but finally, 11 engineers died immediately I think. Then after that British Petroleum and other organizations they handle I think they are getting production now. So, the blow-out preventer will be activated when drillers are unable to control the kick.

So, when you are drilling a hole. So, the hole can be completely vertical your life is easier if you have a land well and you are drilling completely vertically. So, life is beautiful you do not have any tension, but in many cases, you will not get sufficient production. So, you have a very thin layer of formation area. So, you want to get more production. So, a thin area means your wellbore connectivity and your reservoir only this one, but if you have to get more production what a smart engineer will do they will make a horizontal hole like this.

So, their connectivity between the wellbore and reservoir will be longer possible. So, they will get more production. So, to increase production they will go horizontal in some cases they will go for multilateral wellbore. What is multilateral? You drill a vertical wellbore then you make branches some can go horizontal some can be vertical some anything ok many options possible why let us say you have one formation area here? This one and you want to get some production, but you found a further deeper also there is another formation area you have to get production from there.

So, you can get one from production here and another from production. So, again if things like one wellbore offshore area you cannot drill many wellbores in offshore areas one platform is there like a huge expensive platform you have built. You should go multilateral and you can access many reservoir areas and many formation areas and you can get your more product production. In some areas, accessibility is one issue. So, in that case, you can go horizontal you can create a ship wellbore you can create other ships wellbore also.

For example, here rough or remote locations where accessibility difficult desert areas may be there or maybe forestry area, or maybe the ocean area is their offshore area.
So, one platform is there you cannot buy many platforms because it is very expensive. So, you create only one platform and you try to access all the nearby reservoir areas is there. In an under city, for example, I gave the example IIT Madras will not allow you to drill here. So, you have to go maybe Marina Beach or somewhere else then you drill there and you access IIT Madras will not know also.

But if it is coal normally you have to inform IIT Madras that they will have to vacate because coal means you have to remove the material in oil and gas normally you are not removing the material only liquid you are moving all right. Geologic isolation some fault is there. So, you have to check the fault area and you have to drill accordingly. So, the wellbore shapes can be like this completely vertical. You create a vertical wellbore you perforate here maybe it will be a slanted wellbore based on your reservoir condition productivity your target.

So, Bombay High initially drilled vertical wellbores later they went horizontal also to get more production actually and you can create almost L-shaped. Sharp corners are not possible, but almost L shaped well wellbore you can create you can create like little bit up you can create multilateral. There are lots of branching you can create you can go horizontal you can create multiple branching like this horizontal horizontal you can create horizontal maybe a shaped many shapes you can create. So, every engineer will have their own policy and reservoir condition many parameters are there to decide. Randomly you cannot say I will be going for horizontal wellbore or vertical wellbore. So, there will be several parameters to decide that. So, those reservoir engineers and other engineers will decide this is the possible way and they will instruct the drill engineer this is the case. So, if you drill that way then the driller will take action casing and cementing when you are going for drilling. So, first, you drill a very wide hole then you put one casing which is called conductor pipe or conductor casing then you cement it. So, I am hatching this one this means this is area cemented area then you put another casing this is called surface casing again you cement this is called surface casing, and then again you put another casing.

So, gradually you are reducing in diameter you are making everything safe initially you drill a few feet you put a conductor casing then after that, you drill another little bit more maybe 200 feet or something then you put one surface casing. So, when you are putting surface casing you are preventing oil and gas not to not allowing oil and gas to invade into your aquifer zone where drinking water will be there or trees will be surviving there. So, you cannot allow oil and gas to go there. So, that is why you are putting surface casing. So, surface casing again you cement then there will be again another casing.

So, several stages of safety you are putting it will nearby surface area. Then you are putting surface casing then you are putting intermediate casing intermediate. After intermediate again you are putting another casing. There is a final casing that will be called production casing. So, that one you can perforate this called production casing. So, the conductor casing or conductor pipe will have a larger diameter maybe 36 inches sort when it is going to production casing it will be like 5 inches 5 and a half inches.

You can see that gradually it will be reduced one by one and the purpose of conductor casing is it prevent unconsolidated sediments from entering into the board. And if you go to the surface casing. So, it will protect the freshwater zone you cannot contaminate during the production stage or any stage. It will be attached to BOP also during drilling operation and it will be giving its structural integrity it will be connecting to another type of casings fine.

And production casing set across the reservoir. So, the production casing will be connected to the reservoir at the bottom within which the primary completion components are installed primary completion components. For example, your sand
control equipment will be there perforation and all this artificial lifting mechanism all be there at the production area. An intermediate casing will be very long its function is only just to support. So, well work completion once drilling is done you will be completing well work. So, when you are completing it will be cementing then you will be perforating then you will be fracking hydrofracking will be there acid fracking will be there maybe in some cases you will be putting additional lifting mechanisms also those are part will be those will be part of the completion process.

Many big companies will have separate teams of completion engineers, but very small companies will have only drilling people who will be doing all the jobs. So, when you are going for completion there will be two types of completion: lower completion will be upper completion lower completion like you have a drilled hole and upper completion will have like a wellhead, Christmas tree and you will have a choke also. So, those will be part of upper completions and lower completion will be like creating here sand control. The sand control mechanism will have perforation will be there your putting another mechanical arrangement will be there. So, whenever going for lower completion there will be barefoot completion like you have consolidated sand.

So, in that case, you may not put any casing without casing also you can get production that is called barefoot completion. In some cases pre-drilled slotted liners, you have weld bore like this and you have put some pipe with lots of slots. Pipes with lots of holes are called pre-drilled slotted liners. This is a pre-drilled slotted liner this is bare-foot completion cemented perforated in many cases like you have a well bore and you have casing you put cement unconsolidated sand may be there. So, that sand will not enter into the weld bore then you perforate you make big holes.

So, this is called cemented and perforated. So, put casing or pipe sometimes we say drill pipe casing metal pipe tubing also metal pipe. They take oil and gas and use specific terms.

Sometimes those terms will be very odd, but they are used, for example, rat hole, mouse hole, and monkey board. So, lots of terms will be there if you read then you will get those idea the idea of the terms. Here also casing is metal pipe tubing metal pipe drill Kelly ah then drill pipe all metal pipes.

So, the casing is a metal pipe. So, you put metal pipe you put cement all around. So, you drill a hole put metal pipe put cement here. So, that pipe will not move and there will be no leakage also. Then when you put the pipe and cement no fluid can enter into the weld bore. So, what you do you put lots of holes. So, there is some mechanism called the perforation mechanism you create perforation and you create connectivity between the reservoir and your weld bore. So, that fluid will be entering your weld bore slowly. So, one option is that cement completely and perforate and you get production. Another option open a hole sand control system. So, the sand control system is so, why sand control? Sand control means let us say you have a reservoir you drill a hole and you have tubing or casing whatever you put then whenever you are getting oil and gas production.

So, some small sand particles also can come into the well bore. If a large amount of sand is coming that is a problem, the problem is that it will block everything. You have one pipe and sand also coming. So, sand because a higher density than water gas, or oil. So, sand will be getting accumulate at the bottom. So, when it is getting accumulated slowly it will be blocking the path when it is blocking.

So, fluid say oil or gas will not enter into a well bore and it will not go up. So, reservoir pressure sometimes will be very high it will push oil and gas and it will create natural flow automatically fluid will be coming to your surface. In many cases reservoir pressure may not be sufficient in that case you may need some extra energy from an artificial lifting mechanism or EOR technique enhanced oil recovery technique to increase river pressure or fluid pressure. So, that it can go to the surface and reservoir if there is a lot of sand there then you have to control the sand there only otherwise sand will come it will block your path or sometimes it will erode metal pipes. If hydrogen sulfide is there hydrogen sulfide means H2S, H2S plus water will create acid H2S03, H2S04 is acidic gas, sour gas they say. If H2S is there again sand also comes corrosion and erosion will occur together then the whole metal system and your whole production system will get hampered. So, you have to avoid sand you have to avoid H2S, but if H2S is coming cannot do anything but you have to handle you have to select material property and you have to design such a way that the whole system will be stable in longer duration without leaking without any problem. But if you have sand then you have to put some sand control equipment at the bottom so the fluid will be coming but sand can be prevented. You create small small net so the sand can be stopped there and liquid or gas can enter into the wellbore. So, very small net actually so that is called sand control equipment.

In many cases, there will be open hole sand control equipment so it is an open hole and you put some sand control equipment stand-alone screen on another screen. In many cases you put a cased hole let us say the casing is there you put cement also again sand control equipment again because steel sand coming. You caused it, the cased metal pipe you put

cement also then you perforate and you connected with reservoir and you are getting production still sand is coming. So, in that case, sand coming then it will be blocking the whole thing so you put some sand control mechanism so that sand can be stopped there. So, your productivity can be maintained and again there is no ideal sand control mechanism.

If you want to prevent all sand that means you have to stop the whole production.Because there will be sand particles which will be coming with liquid whatever you know water, oil, the gas you get and any wellbore whenever getting a production you get oil, water, gas, sand ok. When water is free it will come in one wellbore life it will be producing more water than any other fluid ok? So, water will be coming and sand will be coming based on the consolidation of your sand control equipment and if you put very good sand control equipment means you are reducing your productivity.

That means you have to put a very small net size very small. So, in that case, your fluid also will get resistance sand also will get resistance fluid also will get resistance. So, your productivity will go down actually, but if you want to get more production you have to get in many cases people will try to take sand they will say ok allow sand will handle on the surface. So, there will be some engineers, but not in every case, some engineers will be very confident they will do that sort of work, but all engineers cannot do that. Again when you are a production engineer so you have to give maximum productivity money finally. So, your company boss will say how much money you are getting if you are asking for every time the separator is getting blocked because of sanding then they will replace the engineer.

Because I am paying you 2 lakh 5 lakh rupees per month and every time I am replacing my separator system. So, that is not good. So, you have to create that optimization of how much sand control equipment you put in and how much sand you can accept. So, that my productivity will be stable and will get more benefit to the company. So, you have to go.