Surface Facilities for Oil and Gas Handling

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Introduction to Pumps-01

Good morning, today I will start the topic Pumps, Compressors, and Primeables. This is a very vast topic. So, I will try to compress to put into one week lecture. Ah pump first I will start with the pump, what is the pump? Pump is actually when you are delivering fluid from one point to another point and again you are adding energy to the fluid. How you are adding energy? They say your fluid is here and you want to lift here they say you have Burj Khalifa ok. And you want to lift fluid from ground floor here to here because there will be lots of residential building and business units.

So, you have to deliver fluid. So, how you deliver? You have to add energy to the fluid. So, that fluid static head will be increasing ok. Ah or you have hostel or you have in residential houses there will be over a tank.

So, over a tank you have to fill with water, you need to add certain amount of energy. So, which energy will be coming through pump and from where it is coming? Maybe it will be coming from prime mover or electrical ah motor ok. So, pump normally there will be two type centrifugal pump, reciprocating pump and if I say compressor, compressor also it is also similar like pump ok. Ah it will have reciprocating ah and centrifugal type compressors. Now, many time you have heard the term turbine, many time you have heard the term pump, fan, blower.

So, what are these things actually? So, if I see adding fluid adding energy to fluid is done by pump ok. But when you are taking energy from fluid, so this is turbine taking energy from fluid from fluid is called turbine ok. So, using this definition actually you can see this adding energy to the fluid. So, ceiling fan at home at summer time you can use you normally use ceiling fan, low speed fan on your head ah it is rotating is axial type ceiling fan this is actually pump. Pumping means you are delivering energy to the fluid.

Again blower, blower also will be doing same thing you are adding energy to the fluid. But if you see prop ah if you see turbine, turbine is gas turbine, steam turbine, wind turbine you have

seen maybe. So, these are extracting energy from fluid. So, just opposite of pump is turbine actually ok. So, you should not get confused ah, but if you see propeller of less embedded propellers or aircraft propeller, propeller actually you are adding energy to the fluid.

So, actually it will be coming under ah pump category ok, but ah aircraft engine there will be gas turbine. So, there will be turbine systems ok. So, first you differentiate the pump and turbine. Trim turbine means you are taking energy from fluid, but in your fluid surface production operation cases normally you are giving energy to the fluid you are not taking energy from fluid ok. When you are transferring fluid from well head to choke to ah separator 1, separator 2 or maybe you are compressing gas.

So, every time you are energy adding energy to the fluid liquid, water, liquid, oil or gas ah normally you are not extracting energy from that fluid. If you are burning and changing chemical ah doing some work or you are giving some chemical reaction that story is different, but physical transformation happening less phase change occurring or compressing decompressing in that case you are using the term pump and you are using for surface production operations ok. And ah I every time I give one example this oldest pump and which works more than 80 years, 190 years, 120 years if you read the book of Ikigai the good life how to lead a good life and happy life Ikigai. So, the people in Japan ah they will be living more than 120 years also ok. Ah their heart running 120 years.

So, this is oldest pump and it is running more than 120 years right. So, this is the oldest God made the pump ah. So, during blood if it is stopping for a moment 1 minute 2 minute your gun ok. So, so this is the oldest type of pump is reciprocating pump actually it is come continuously ah giving like compression decompression is doing and it is increasing pressure to the fluid and fluid is getting delivered to your brain to your toe to your finger everywhere right and it is ah that is why you are surviving ok. This one reciprocating time pulse ah type positive displacement pump ok.

It is no there is no centrifugal pump in heart it is only reciprocating type later I will discuss about reciprocating and centrifugal difference. Here one picture I have taken from one Bollywood or Indian movie this Pippli life. So, this is actually a reciprocating pump in Indian household or Indian rural areas if you see this hand pump is used normally. So, this is called reciprocating type pump reciprocating type pump ok ah type pump ok. Reciprocating type pump and it is manually your operating.

So, speed will be very low and flow rate also very low ok. Ah, but it is good for household

applications or normal rural applications even in many cases agriculture applications also will be there, but many cases there will be centrifugal pump where you need higher flow rate higher flow rate you need. So, you are using centrifugal pump for lower flow rate you are using this one. So, this is lower flow rate ok. So, reciprocating type pump used for household applications this is lower flow rate applications, but it can develop very high amount of pressure or high amount of ah very high.

If ah pump it the pump can lift a very high ah tall building or very high head we say head means like how much pressure it is developing if you convert into water column height. So, that will be called head. So, water column height like h h rho g ok that much pressure you are developing ok. So, if you know the pressure then you can calculate h. So, h equals p by rho g ok you can convert how much water column height you can develop.

So, that is called head ok. So, ah reciprocating pumps can develop very high amount of head, but flow rate is very low, but in other words centrifugal pump I will ah define later. So, that will have very higher amount of flow rate, but head will be little bit lower. So, there are applications where you can use centrifugal pump or reciprocating pump I will explain later ok. And reciprocating a centrifugal pump weight use ah normally centrifugal pump will have higher volume flow rate.

So, where ah you want to handle high amount of fluid. So, in that case normally you use centrifugal pump, but you will you want to develop very high amount of pressure. For example, gas lift application you are injecting very high pressure fluid or let us say mud motor you want to inject very high amount of ah that mud mud pump. So, high amount of high pressure fluid may be lower amount a high pressure fluid you want to pump. So, in that case normally you will be using reciprocating or positive displacement type pump.

So, these are called positive displacement also ok. Positive displacement displacement type pump ok this hand pump you can see this one hand pump it will ok one rod is going. So, the rod will have going there and there will be one piston actually piston with valve ah ok. So, with piston will have valve arrangement also . So, it will be designed such a way.

So, that one way it will be delivering fluid. So, when it is you are lifting the handle handle of the system this is handle ok. So, when you are lifting it will not be delivering when you are pushing down it will be delivering ok. So, one stroke only it is delivering. So, it is pulsating flow it is giving pulsating flow.

So, it is giving pulsating flow ok. Pulsating means one time delivering, two time delivering, three time delivering in heart also you have pulsating flow actually. So, ah previous days ah older days when there was no electronic ah that temperature sensor. So, that time doctors will be checking the pulse here pulse here means heart is beating. So, that heart beat will be giving fluid in pulse manner ok.

So, if you press it this area this one. So, doctor will be counting how many bits they are getting here. So, based on that they will decide whether ah the patient is having any fever or not ok. This is called pulse setting flow ok this is not a smooth flow, but if you are using centrifugal pump or some other type pumps are there which will be giving continuous flow there in that case you will not get any pulse ok. So, pulsating flow is having their own positive negative aspect.

So, normally in oil industry you need continuous fixed amount of fluid to deliver ok. Then if you have reciprocating pump then how to make it continuous that also I will discuss here ok. So, I said like positive displacement, reciprocating, centrifugal. So, let us see the difference. So, basically pumps ok, pumps actually adding energy pumps actually adding energy to the fluid ok.

So, now, pump basically two types one will be positive displacement type another way hydrokinetic or hydrodynamic ok, hydrokinetic also say kinetic pump we say ah kinetic pump ok. So, positive displacement pump basically there will be two types one will be rotary reciprocating. Reciprocating time what like your heart you know right it is reciprocating or pulsating thing or you have any reciprocating pump you have seen in industry I will discuss later. Another rotary type rotary type actually like PCP if you ah understand the progressive cavity pump for your artificial lifting application in oil and gas industry this is rotary type pump. So, there are several other types also there gear pump is there, vane pump is there, lobe pump is there, skew pump is there and maybe many other ah different variations of pumps will be available.

Ah Reciprocating will be single cylinder, axial piston, ah multi cylinder, simplex, duplex many types will be there. So, because our time is limited for this lecture for this week 12. So, I will not discuss everything rather I will discuss only positive displacement, reciprocating type ok single cylinder. And ah for hydrodynamic or hydro kinetic ah pump I will be using the centrifugal thing ok centrifugal basically radial blade, radial blade, radial blade pump. So, axial flow ah and mixed flow I will not discuss ok.

So, when I will discuss in detail so that I will understand what is centrifugal what is axial. So, I will I will show some pump here ah. So, I say rotary, rotary means like progressive cavity pump

I told. So, progressive cavity pump will have like one rotor if you can remember ah your artificial lifting system PCP, PCP will have one rotor one stator. Stator means this is not rotating rotor will be going inside this one and it will be rotating.

If you see this stator, stator is having one hole. So, this rotor will be going inside this one ok. And inside there is ah elastomer coating here this is metal solid and inside this one elastomer coating. So, when rotor is rotating inside continuously. So, fluid will be delivered from one point to another point ok.

So, the whole rotor this metallic rotor will go inside this one ok. You see the inside a through hole is there ok. This through hole this rotor will go and if you rotate it, it will create certain cavity and the cavity will be progressing slowly ok. So, it will be creating almost continuous flow ok. But this is very low speed pump ah normally this is called actually this is called screw pump or single screw.

So, this is single screw pump. Single screw pump means another name is the progressive cavity pump ok. So, it is having speed normally 300 rpm ok. So, PCP will have normally 300 rpm and this is very good for very high viscosity applications. For example, you have very thick fluid can ah let us say toothpaste grease or that sort of very thick fluid where other pump are ah pumps will be failing to deliver you use PCP it will be delivering without any problem ok. But there will be certain limitations also, but very high very thick fluid where viscosity very high you can use this progressive cavity pump safely ok.

So, reciprocating pump ah I am not showing here ah I will show some centrifugal pump ok. You see the centrifugal hydro hydro kinetic pump or centrifugal pump. Centrifugal pump will have one impeller and impeller will be rotating inside one casing or a volute casing ok. So, this is called volute casing if you see any centrifugal pump it will be drawn like this also even in actually also it will be looking like this and my impeller this will be inside this one ok. So, impeller will be like this and impeller will be rotating.

So, ok so, impeller will have like 7 8 blades this is 6 to 8 about 6 to 8 blades for liquid applications ok about 6 to 8 blades how many blades it is having 1 2 3 1 2 3 4 5 5 blades are there ok. So, this is one this is called impeller if it is impeller rotating continuously inside one casing. So, it will be delivering or it will create very high volume flow very high pressure or high velocity will create that high velocity will be reduced using one diffuser ok. So, the diffuser this area actually will act as a diffuser. So, diffuser purpose is to reduce kinetic energy and to develop

static head kinetic head or dynamic head I can write dynamic head and it will be developing static head ok.

So, what happens in impeller when impeller is rotating at very high speed it will be sucking fluid here through this channel and it will be delivering at very high velocity ok. So, this is called impeller impelling or it is taking fluid from this area is called impeller eye ok. This area this entry area will be called impeller eye ok and these are impeller blades ok. I am drawing you see this impeller blades ok there will be 6 to 8 blades normally, but 5 for example, my impeller is having 5 blades. So, within that range we cannot get like 100 to 100 blades 6 to 8 blades will be ok for normal application this is 6 inch blade actually we purchase from local shop and we cut this one for a academic demonstration purpose.

So, that is one can see these are called blades ok you see this these are called blades ok and this is called impeller eye the fluid will be entering through this this is my shaft this is my shaft actually ok my finger you can see my finger is shaft if I rotate shaft my impeller will be rotating ok. So, when it is rotating at very high velocity what will happen this fluid particle will be leaving because at very high velocity if you rotate something the fluid will be trying to go away like cycle mud guard you have right cycle when you if you drive cycle very high speed and if you do not have mud guard all mud will be going on your head and all back right. So, because this splashing ok the particle will be trying to going away from the center to the for the for this distance ok and it is having some guide channel you see the blades are there solid metal ok these are this will be acting as a guide channel ok. So, if you rotate at high speed so fluid will be sucked here this at impeller eye this is impeller eye it will be going through the channel it will be exiting when it is exiting it will have very high velocity. So, very high velocity if you take directly to pi when you deliver actually there will be loss of losses.

So, what you do after when you get very high velocity fluid you have to reduce the fluid velocity and you have to increase your pressure if you remember the Bernoulli's formula if if you change the velocity pressure will be changed ok. So, you reduce pressure so velocity will be so it reduce velocity so pressure will be increasing. So, it will happen so this will be inside one casing. So, this is casing you can see this volute casing or casing they say ok this is casing actually this outer circular section I am drawing you see this ok this is called casing ok. So, casing will be collecting all the fluid whatever going out from the system ok and all the fluid will be going out through this ok.

So, and fluid entering here ok. So, where fluid entering fluid entering at impeller eye this hole is there my finger and this area you see some gap is there ok. So, this gap area fluid entering it will

go through this channels it will be going at very high velocity going out and this is inside one casing. So, casing will be collecting all the fluid and it will be delivering ok when it is delivering it will be reducing velocity it will be developing pressure. So, how it will do this special shape called diffuser, diffuser shape will be like this ok. So, when fluid is entering you see this wider section is there exit portion I have drawn like this wider ok.

So, narrow then wider so narrow wider means it will reduce fluid velocity increasing fluid fluid head static head or pressure ok. So, diffuser purpose it will reduce fluid dynamic head and increase static head ok impeller eye purpose is to allow fluid to enter ok and shaft purpose to give rotational torque ok. This is shaft, shaft will be giving rotational torque fine and these are called impeller blades impeller blades. So, actual what is the actual impeller shape and size you see this one. If it is the same thing we cut we redesigned again and using some softer material.

So, this is a lighter weight this is purely metal. So, I cannot throw it ok this is lighter metal we have designed this one and in our laboratory in my laboratory actually I tested this one I did not test this one because I want to modify different shapes size and I want to explain in class. So, I thought let us cut it and so that it will be good for student to understand. So, here you see this impeller eye ok this one impeller eye and this hole is there this is shaft hole ok and blades you cannot see here so, blades 1 2 3 4 5 blades will be there 5 or 6 blades will be there I think 3 5 blades are there. So, now, this blade will be like going like this if you see it is going out ok it is going like curve will be there going going going going all I have been marking possible let me check.

So, no not not visible. So, it is going like this impellers ok. So, it is fluid sucking it is delivering directly again one thing is that it is going in this direction fluid and fluid is taking turn 90 degree ok it is taking turn 90 degree. You see this again fluid entering here shaft is there. So, it is it cannot enter through this this solid metal is here ok fluid going there taking directly 90 degree turn. So, this is called radial blade radial axial means fluid will be going axial it will go like if you see ceiling fan on your head like in summer time you use.

So, ceiling fan will have axial flow or wind turbine you have seen axial flow. So, turbine will be there. So, axially air will be passing it will not be taking turn 90 degree ok, but in this case fluid is taking turn 90 degree ok. So, when you are taking turning to 90 degree this head or pressure development will be very high ok, but if it is having purely axial the wind turbine or ceiling fan they cannot develop very high pressure actually pressure difference will be very low it is just small amount of fluid delivering on your head.

So, that you can feel cold ok. So, the purpose is to just create turbulence and give small amount of fluid blast actually, but here this purpose is to increase high pressure. So, that is why you are

giving 90 degree turn ok. So, this is called impeller ok, the whole thing is called impeller ok. The term you should remember this is called impeller this is called blade impeller eye ok. And this is shaft, shaft will be there because I did not bring my shaft another impeller is there.

So, the shaft is there ok. So, so many types of pumps are there, but I cannot discuss in this class ok. So, I will be discussing only reciprocating and centrifugal. Centrifugal means basically this one because I have done experiment. So, I will be showing experimental procedure and everything ok.

Experimental setup. So, this one was done in my laboratory actually at IIT Madras. So, how I did experiment? You see first you see the line diagram, line diagram I had one tank ok. Tank is having one inlet suction pipe, my pump is here ok. So, from pump fluid is was delivered and it went back to the same tank ok

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This is continuously circulating same fluid. So, why I am showing this one because I used different fluid like drilling fluid, we use crude oil for pumping and we want to check what is the performance of pump. Instead of water if you are pumping crude oil different viscosities or different slurries are there in bentonite if you mix then what will be the performance. So, a few PhD students has done some research and they got degree also, they did design optimization and playing with different viscosities. So, ok now suction pipe this is called suction pipe.

So, from pump I will show this one I said this one impeller eye. So, one casing is here. So, from casing one pipe will go ok. So, pipe will go to tank, tank or water supply section ok. So, from water supply fluid will enter then it will be delivering it will go out of this impeller, volute will be there, then diffuser will be there, diffuser will be delivering to delivery pipe. So, where is my delivery pipe? This is my delivery pipe you see this part ok.

So, this is outer part of impeller is delivery pipe and if I link with this my actual experiment what I had I have done in my laboratory this is tank ok. This is you can see this one as it is and this is the suction pipe here is my suction pipe ok and this is the pump this pump was there tested here ok and this is my delivery pipe. Delivery pipe is going through this this this this again water is falling back water or oil or bentonite whatever you take bentonite slurry not bentonite, bentonite slurry. And whenever you are going for an experiment it should have certain purpose

our purpose was to design redesign the whole impeller system what will be the best impeller or design best design for certain fluid application.

They say if you have high viscosity you have slurry. So, what will be the best impeller what is the best design this one. So, when you are doing experience you need some data you need to you need to compare original impeller was this one and you modified to this one ok. So, when you are comparing so, you need how much flow rate you are getting how much head or pressure you are developing ok. So, for flow rate we had flow meter ok then we had pressure gauge flow control valve was there you see this flow control valve and motor must be there and motor was control using VFD or variable frequency drive variable frequency drive or VSD you can say variable speed drive ok. So, variable frequency drive we use because we are going to check with different rpm also if I change frequency of electricity then my motor speed will change motor speed change means pump impeller rotation will be changing.

So, impeller rotation is directly linked with my flow rate ok if I change speed my flow rate will change. So, that is why we purchase VFD. So, here you can see one VFD we had you see left side picture variable frequency drive we had. So, that was supplying electricity to motor motor was connected to my pumping system using shaft ok. So, shaft was delivering power or torque ok shaft what is the purpose of shaft? Shaft is shaft will be transferring torque actually basically torque ok.

Then we had one speed sensor how much speed you are getting because sometime motor will have certain speed let us say for 1500 rpm, but because of load pump may not rotate at the same rpm because if you are overloading pump. So, motor speed will be lower actually ok motor will try to catch 1500, but actual speed will be little lower ok. So, there will be some slippage in motor. So, pump motor slippage or slip what it calls slip ok. Then you got torque pump impeller rotating shaft is connected here motor to shaft rotating when it is giving delivery fluid.

So, you must check how much pressure we are developing. So, pressure gauge must be there ok. So, flow meter must be there ok. So, this was the whole experimental setup then from that why we calculated what did you find.