**Surface Facilities for Oil and Gas Handling**

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**Introduction to Pumps-03**

Good morning everybody. Today I will start topic on Priming Food Valve Suction Delivery in Total Head and some other topics also there with some calculations. So, previous lectures we have discussed about centrifugal pump, positive displacement pump, we have seen the difference using our characteristic curves like centrifugal pump will have HQ curve like this, but progress positive displacement pump will have vertical line almost vertical ok. So, positive displacement pump can deliver very high amount of pressure or head while centrifugal pump will have limited head ok. Now, we have seen the NPSH requirement centrifugal pump will have higher NPSH or net positive suction head requirement. So, net positive suction head two type one will be net positive suction head available, one will be net positive suction head required, required will be given by company, but available you have to make it available.

So, whenever talking about NPSH available. So, this available sometime you put some suffix a or we many way we put the notation N P S H a or small a. So, does not matter if we are writing NPSH available ok. So, NPSH available depends on your inlet suction pipe this is pump, this suction pipe length, pipe diameter, length diameter, fluid vapour pressure, the fluid vapour pressure is very low like if you are increasing temperature vapour pressure will be changing.

So, in that case also NPSH will be getting affected very long pipe NPSH will get affected, diameter of the pipe friction will be increasing. So, NPSH will get affected if pipe friction is very high or if you have sharp bends maybe many bends like this in pipe ok sharp bends, then again your NPSH will be available will be lower ok. And if you have you are changing temperature temperature will be changing vapour pressure that will be affecting, the other parameters may be like if you have some fittings here maybe some joining of two pipes. So, there will be again pressure drop or pressure loss, if entry

is not designed properly sharp entry is there or narrow entry is there. So, in that case also there will be lots of pressure drop.

So, lots of pressure drop means actually it will be reducing your NPSH available. If company is asking keep NPSH 5 meter NPSH required 5 meter, then your available must be more than 5 meter not equal to ok. Whenever if you are maintaining equal to whenever running pump actually NPSH available going down because fluid will be flowing. So, that time because of pipe friction and other losses your NPSH available going down. So, you must maintain some higher amount of NPSH available than required ok.

So, NPSH available or NPSH required when you are talking about. So, you should remember one cavitation cavitation parameter sigma equals P minus PV divided by half rho V square ok. And sigma ok P means pressure PV is vapour pressure rho V means V means velocity kinetic head ok. Now if sigma less than 0, so cavitation will be occurring. So, and cavitation is linked with NPSH means inlet pressure is you are maintaining low.

So, vapour will be created or small small bubbles will be created when pump is running when pump is running the small bubble created. Now pump will be delivering at high pressure. So, bubble will be collapsing again when creating and collapsing happening. So, lots of metal particle will get removed noise will be coming vibration will be happening. So, pump whole pump can fail or after certain operation pump will be eroded completely.

So, cavitation is having negative impact in your fluid mechanics systems. For example, your valve your choke your well head your pump everywhere if cavitation probability is there you have to remove that probability. So, how to change it you have to check specific instrument for example, diffuser is there where low pressure is happening is there is it because of fluid viscosity fluid temperature or any fluid very high velocity or whatever points I raised here length diameter vapour pressure whether those creating low pressure if low pressure is getting created then you have to redesign the whole system maybe or you have to increase maybe inlet pressure somewhere some pressure is there. So, that way you can avoid cavitation. So, cavitation is having negative impact on your fluid mechanics systems piping systems pumping systems your valve systems your choke systems priming.

Now prime the centrifugal pump when it is running actually you are creating my eye is there impellers like this you have seen yesterday I have shown you one actually impeller when it is rotating at very high speed. So, fluid will be sucked from eye and it will be exiting ok from this channel these are the impeller blades these are blades these are blades ok. So, what is happening first near eye fluid particle will get accelerated when it is going out towards exit it will be getting further accelerated and fluid particle will go out ok. Now this is having one volute casing casing ok and pipe will be coming like this ok. Now if pipe is not filled with the liquid what will happen? So, impeller will try to push fluid out and fluid means liquid particle high density particle.

So, high density particle will be touching each other and it will be sucking lower fluid from suction pipe. Now if there is no liquid so, only gas particles are there air particles are there air particles then it is very low. So, it will not create enough momentum ok when it is not creating enough momentum it will not be able to sucking the fluid ok. So, that will be a problem. So, during starting stage actually you have to fill the pump with liquid.

So, there is called priming ok fill pump before starting ok. So, before pump you have to fill otherwise it will not start delivering fluid ok. Once started delivery after that priming there is no meaning ok only before starting you have to fill the system ok. Now foot valve what is foot valve pump is there? So, in many cases many like say you are you have drilling mud pump drilling mud and you have to pump out the water ok. So, in that case you fill the pump, but when you are filling from top there will be some hole here actually from the top ok.

So, you are filling you are filling, but pump water will be going out. So, there will be one foot valve actually like this ok one way valve ok. When you are filling valve will be closing and your filling will be occurring ok. So, and when pump will be starting. So, valve will be open the path it will be like this.

So, fluid will be entering and this is a lots of pores will be there ok. So, fluid will be going through this and it will going through this ok. And when started pumping the valve will be opening path and it will be delivering fluid, but when if you switch on switch off

the pump valve will be closing the path. So, all the suction pipe will be filled with liquid. So, when next time you are starting it will help actually.

Otherwise if you do not have that valve foot valve what will happen you fill from top it will be drained out ok then your pump starting will be a problem. So, priming will not occur. So, if you want to do proper priming then you should have one foot valve actually ok. So, suction means this side is suction because you are sucking fluid this is suction side ok. And delivery side means fluid is delivering outside total head ok.

So, total head is like this like I have pump here I am not drawing any pump I am just writing pump ok. So, pump is sucking fluid from my tank ok. Now it is delivering to a level of here ok. So, this is my suction side pump center line to water level ok, suction head or suction side you can say suction this is delivery. And pump center line is like this pump center line like this here ok.

So, pump center line is here here also I have pump center line I am not drawing exact pump I am just box I have pump ok. Now this side the pressure is called suction head ok, because net positive suction head you I told the term the suction head. So, this side pressure is suction. So, it is when you are calculating suction NPSH it is not related to delivery it is related to suction ok. So, that is why suction what is there net positive suction head and this is delivery side.

So, there is delivery h s maybe when put I can put h d delivery ok. So, total head h s plus h d ok h equals h s plus h d, but there will be some losses just ignore for the time being. So, pump when you are giving electricity. So, pump will be sucking plus delivery. So, total energy suction side how much energy required delivery side how much energy required.

So, total energy is h d ok. If you have friction loss and other losses that also you have to include ok. So, power in what in what what will be P equals rho Q h g by eta, eta is efficiency and units are like this rho means meter cube per volume per meter cube kg per meter cube kg per meter cube, Q means meter cube per second and h means your meter head how much head is delivering g already you know 9.81 meter per second square ok.

P in hp if I see P in horsepower ok, horsepower then rho Q h 3 9 6 3 9 6 0 eta. So, this term will be coming ok.

Overall efficiency I already told that pump hydraulic efficiency will be there and motor efficiency will be there. So, if you multiply these two it will be calling overall efficiency. So, eta pump or hydraulic efficiency into eta motor efficiency ok. This is overall efficiency electrical to water delivery or liquid delivery and many time I think I have been writing water.

So, it can be any liquid. So, it may be your oil you know oil field application or normal water oil field means you are handling water also some cases. So, that can be water also high pressure low pressure any time, but you have to check vapor pressure whether it is creating cavitation or not ok. So, you design a certain pump for your water application and you want to apply for your let us say petrol pumping, petrol you have and you have pump to pump into system. So, petrol will be evaporating quickly. So, in that case it will be quickly giving that vapor and cavitation right.

So, that will be detrimental that will have a detrimental effect. So, in that case you have to check how much the NPSC required how much you have accordingly you can select a pump heat calculation. So, now you have seen centrifugal pump it is having one impeller one casing and it is having a suction pipe one delivery pipe ok. Before starting you must do priming. So, during priming your suction valve or foot valve will be closing the path and when pump is running it will be automatically opening and it will be delivering fluid ok.

Now it can be have radial impeller or axial impeller mixed flow impeller. So, normally we will be using radial or mixed flow impeller axial impeller normally we do not use. Now how to calculate head now if you have very low head. So, in that case you can use multiple stages for example, electric submersible pump I have shown you already. So, you have multiple stages 1 2 3 4 and you can develop very high amount of head ok.

But if you are let us say if you want to replace sucker rod pump and using a ESP system a randomly you cannot do because you have to check other properties also whether well bore is capable of taking that pump or you have electrical input facilities and many other

parameters are there. I have another course artificial lifting system may in NPTEL. So, if you are interested you can go through that course video lectures I think it should be available freely in YouTube. So, you can watch that also the details of pump different types of pumps pump fundamentals also explained in that course. So, here in one lecture one lecture means one week lecture I will be giving only a few things not details, but if you go through that NPTEL artificial lift lecture you will find more details in that about pumping systems.

So, overall efficiency first overall efficiency already you have seen eta mechanical sorry motor into eta hydraulic or pump ok. So, you can write in this way also water power water means how much water delivery ok water power divided by shaft power ok. So, rho already this formula is given. So, impeller diameter head relationship head equals eta u square by 2 g eta hydraulic efficiency or pump efficiency ok eta pump efficiency. u is impeller impeller speed tip speed you can say tip speed ok.

And how to calculate the tip speed omega into r omega angular velocity ok angular velocity. So, how to get omega 2 N pi by 60 ok and what is N? N equals rpm. So, revolution per minute it will be given in the problem or you may be measuring also using tachometer. So, speed measuring instrument is called tachometer ok. A fluid measuring instrument called flow meter pressure measuring normally barometer or pressure sensor we can use the term.

So, you should remember the names ok. So, measuring a tachometer speed sensor many time in bike they say speedometer also, but normally in laboratory I use tachometer ok. One light sensor will be there it will be change checking the speed how much speed we are getting and flow meter you are getting fluid flow rate ok. Barometer you can get pressure or pressure sensor will have ok. What are the flow meter measuring instrument use? So, N is rpm we are using tachometer we can measure this one ok. Now, what other parameters are there in the formula? Formula will have G, G value already you know 9.

81 meter per second square if you are using different types of energy value will be different ok. So, normally centrifugal pump efficiency will be 60, 70 percent ok. So, if you if I do not give any value and if I ask just put any guess value. So, we just take any guess value between 60 and 70 ok, but if I am taking online exam in that case I will give you give exact value otherwise if I give class exam. So, in that case I will ask guess any value and do.

So, you should have proper guess means within 60, 70 you are guessing this is ok ok. You should not say like a 30 percent or 90 percent or 100 percent ok except I specify take 100 percent efficiency. And centrifugal pump I said like stage number of stage right of stages. Let us say one stage is having 10 meter head.

So, 10 stages 10 into 10 100 ok. So, how to calculate ok. So, let us say one simple problem. A pump delivers water to 100 meter 100 meter one building heightless 100 meter it is delivering ok. And efficiency 70 percent ok. The impeller diameter 6 inch 6 inch impeller diameter in ignore other losses other losses piping losses and other losses ignore.

Then dia of impeller ok ignore other losses ignore other losses. So, calculate number of stages and rpm is given let us say 1400 rpm. So, how do you do first you have to use this formula ok. H equals eta I have given percentage 70 percent.

So, 0.7 u, u how to calculate? u have to calculate omega into r right fine. Then 0.7 into omega means 2 n pi 2 n pi by 60 into r whole square divided by 2 g ok. So, from here you get 0.7 2 g into 2 into n n means 1400 into r r value is your inch is given ok.

So, here you have to convert into meter ok. So, 6 inch means 150 millimeter approximately 150 millimeter. So, 150 divide 1000 then divide by 60 whole square ok. So, some value will be coming are you calculating anyone? So, can you give value there? 5.

6 5 meters. 5.6 meters 60. No h how how how much you get? .

Because step by step it is shown. 17.8 1 meter. 78 meter h. 1 7 17. 1 7 ok. So, from there you are getting h 17 about 17 meter. So, number of stages equals 100 divided by 17.

So, about 6 stages correct ok. Now, we will move towards positive displacement pump. We have discussed now centrifugal pump. Now, the I said that there are two type

basically two types of pumps centrifugal and positive displacement or basically reciprocating type. So, the positive displacement may have different type for example, diaphragm pump, reciprocating type, progressive cavity pump, screw pump, vane pump many other different types also possible or mix up of all these things. So, a few few slides I will discuss on basically reciprocating type pump because if I have to discuss everything it will be whole course.

So, I have to limit within a few minutes. So, this one I will try to discuss. Reciprocating pump actually you have seen in your oil and gas, sucker rod pump. If you see any oil and gas related picture you will be seeing this beam pump or sucker rod pump the same thing actually reciprocating pump. So, on piston will be reciprocating and you will get a fluid flow and that will be giving very high flow rate a very high head, but low flow rate ok. So, positive displacement or reciprocating type pump there are differences like simplex, duplex or double throw pump, triplex or triple or three throw pump, four cylinder, five cylinder, single acting, double acting.

So, many types of reciprocating pump also available. Again I am not discussing everything maybe I will try to teach only the single acting and double acting part. And if you want to know further about different types of positives displacement pump and simplest, duplex everything then you have to go to my NPTEL lecture, artificial lift. NPTEL lectures NPTEL course artificial lift. There I have given all details of different types of pumps used for artificial subsurface application, but the fundamental part you can study study there. So, if I say diaphragm pump, diaphragm pump means like I will have one diaphragm and if I have one piston this one soft material this is diaphragm ok.

And if I valve air one valve going out one valve in. So, continuously if you push up and down. So, fluid will be getting delivered. So, there is called diaphragm pump it has having different application in chemical industry. So, our lungs also one diaphragm pump actually you see you are pumping it right you are putting in putting out ok. So, we do not have any valve here, but there is also one diaphragm actually softer material you are not mixing with other fluid.

Reciprocating pump roadside cycle pumper right where electricity not there. So, people pumping cycles this is reciprocating pump you are using same thing actually for your

sucker rod pumping systems ok. Progressive cavity pump I have already shown you one model progressive cavity pump also single screw pump. So, that is also used for very high viscosity fluid pumping systems.

The screw pump ok, PCP also a screw pump. So, this single screw, but you can create multiple screw double screw also. Vane pump many time it is being used for refrigeration application for your household refrigeration normally they will be using vane pump. Scrawl pump is there vane pump many other types of pumps will be available ok for positive displacement side. Again I said reciprocating type also having different types among this single acting double acting there are two types.