Principle of Hydraulic Machines and System Design
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Lecture – 19
Pumping System Design – II

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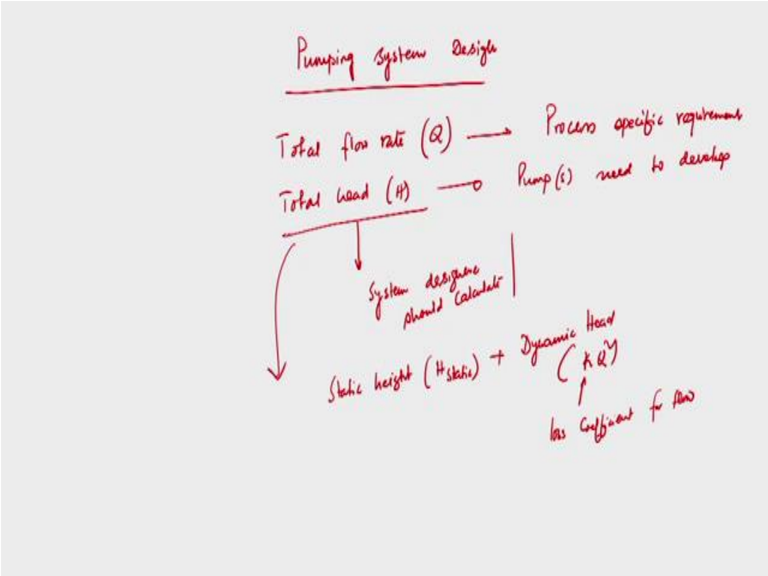

We will continue our discussion on Pumping System Design. So, as we have discussed that, there are several aspects, which a pumping system designer should consider while he or she is designing a system. So, again I am writing a pumping system design is very important, pumping system design. So, as I said that, whenever someone pump design and pumping system design, these two are not same. So, whoever is designing a pump, he or she should know the requirement from the system engineer, that what should be the head and discharge, based on that he will decide it, what will be the you know blade angle at the inlet outlet, what will be the impeller diameter, whether he or she will be using what kind of casing, those things would you know based on the input from the system designer.

So, while you are talking about pumping system design, because we are not going to discuss about pump design. So, pumping system design there are two important quantities which are very important.

I mean to the system designer that is, you know total flow rate that we expect from a pumping system, total flow rate Q and as I said that, this is very much processed specific, because it varies from process to process. If we talk about a pumping system, rather if you think about designing a pumping system for power plant industry, we might recover different quantities of water. On the other hand, if you think about designing a pumping system, for it is cement industry or any other you know industries then there we know requirement of water may varies.

So, depending upon the process someone should calculate, what should be the total flow rate that we need from the pumping system, rather the pump should deliver this amount of water to different points that is different issue all together. So, this is the total volume flow rate, that is very important and that is very much process specific and system designer should know this information from the process people. So, this is process specific requirement.

As I said and another important quantity is the total head that pump needs to develop. So, total head H, that pump or pumps pump or pumps need develop, pumps need to develop. So this is the quantity a system designer should calculate, because depending upon the level of pumping house level has pump houses situated or located and the other places or we need to supply water their location, we need to calculate what should be the static height as well as and to deliver water at those desired points, how much pipe rather, how long pipe will require and what are the bents; I mean whether we need to insert 45 degree bents, 90 degree bents and how much fittings will be required. Based on that the system designer should, calculate what will be the total head that the pump needs to develop.

So, this essentially a system designer, a system designer should calculate this one. How? Because, this is having two parts, as I have discussed many a times that it is having, one is static height that is H static, plus another is dynamic head, that varies K in to Q square, where K is loss coefficient, of flow this is loss coefficient, for flow.

So, the total heads, that should be developed by the pump is having two components, one is static height, and another is dynamic head. Static height is fixed, because that is one I was discussing that knowing the location or level of pump house as well as the you know distribution of water; I mean places are used to distribute, what are their location if we calculate the difference of the height between these two locations will give you the static height.

On the other hand, the dynamic head will essentially depend upon the frictional losses and losses due to presence of bents, valves because many a times, we need to put valve for controlling the output. So and this is very common. So, the presence of valve also will import some amount of you know loss rather that, we need to take in to account while a calculating the total head loss. So, knowing these two quantities, total flow rate and total head, a system designer now suits like that what kind of pump should be suitable for this operation.

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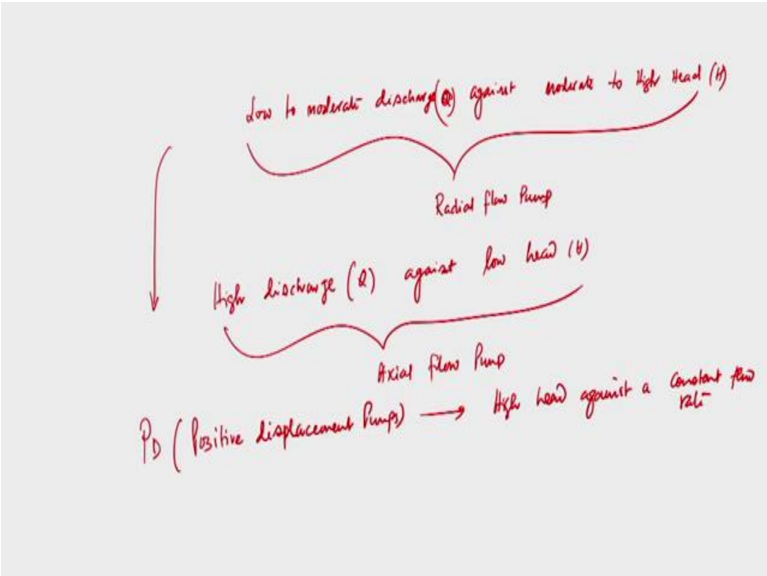

And in a very beginning, I discussed that you know that if we require, if we require low to moderate, low to moderate discharge against you know moderate to high head, moderate to high head then of course, we need to go for radial flow pump that is what, I have discussed and this is very much suitable for domestic purposes or sometimes in industries this pumps are used.

On the other hand if we require, you know if we require, high discharge, that is high Q against, against. So this is, this is Q, this is H against below head H then designer should consider axial flow pump. Sometimes again we need to go for positive displacement that, we will discuss in detail about their operation and principle and constructional feature.

So, PD pump or sometimes it is, sometimes they are known as PD pump or positive displacement pump. So, this positive displacement pumps normally they are used for developing very high head against constant flow rate. This is very important because, positive displacement pump will deliver your high head, but the flow rate will be flow rate will remain constant. So, if that is the case then we have to go for positive displacement pump.

So, depending upon the requirement of the process and depending upon the layout; I mean a process layout; that means, higher we need to apply water and their level difference also you know pipe line routing, I mean higher we can you know place, how we can place pipes, valves, fittings to supply water at the different locations. Based on that designer should calculate the total head requirement and process itself will dictate the how much amount of water we need to supply from the pumping system.

Knowing these two quantities, system designer should call you know select, what kind of pump is suitable for that particular case. Now this is the several aspects, now how someone will calculate the total head that is very important. So, this is very important in a sense that practicing engineer and design engineer, it is not always possible to follow that that fluid mechanics.

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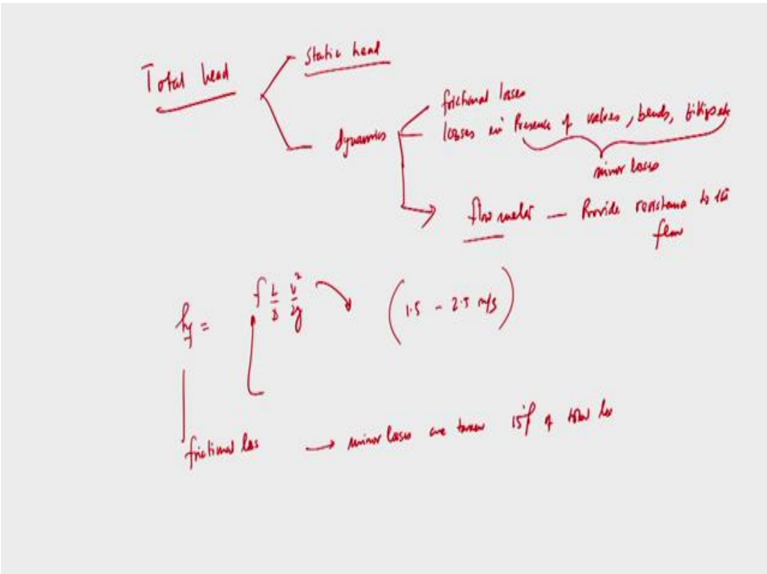

So, while you are calculating the total head is very important as I said, you am not going to talk about, total flow rate because this is very much processed specific requirement.

So, that will be dictated by the process people. So, total head while you are calculating total head, this total head is having two components as I said, one is static height that is also fixed because, we have nothing to do it depends upon the we know layout I would, I know where the pump house should be located and the I mean desired points, I where we need to supply water. So, thus had difference between these two locations are rather the locational, you know difference between the height of different locations, will you know give rise to the static head that is also fixed.

But what is the important is the dynamic head and that was essential depends upon the frictional losses. While fluid is flowing through the pipe, then losses in presence of valves, bents, fittings, etcetera. So this is normally, we call it minor losses normally, we call it minute losses and also this is very important.

Because sometimes, we need to put flow meter, sometimes we need to put flow meter to calculate whether the, how much quantity of water being discharged by the pump and that flow meter essentially will, provides some resistance to the flow and that that and for that to overcome that resistance again, we need to have some amount of head from the pump.

So, this flow meter also provides some resistance, also provide resistance to the flow to the flow and for that we need to know that so, this dynamic head loss, while you are while you are calculating, we need to consider these three aspects. So, knowing these three aspects, how we will calculate frictional losses in pipe? As I said, you a frictional loss is calculated based on Darcy -Weisbach equation for flow through a pipes.

$$h_f = \frac{fL\,V^2}{2gD}$$

Now, L is the length of the pipe, if you know the diameter of the pipe D and f is the frictional factor, while v is the recommended velocity through the pipe. Normally, from my experience, what although I have worked over a very small period, the recommended speed of you know water rather the flow velocity through pipe is normally 1.5 to 2.5 meter per second and this is dictated by several design because, it should not load the pipe material. So, depending upon this and also we need to provide some support, because when water is flowing through the pipe then, we need to provide some support from the ground to keep to hold the pipe in place. So, that is why this is the recommended velocity. So, based on this velocity, I mean we need to know, what should be the Reynolds number because you know, it is laminate that then we can calculate 64/RE or it is always highly turbulent.

So, we need to calculate that from this Moody's diagram. So, normally this friction factor is calculated from the Moody's diagram, because pipe it is very difficult to have a smooth pipe. So, it should have roughness. So, knowing the roughness and the Reynolds number, we can calculate frictional factor from Moody's diagram. But it is what is we know we need how are we calculate from fluid mechanics, but the practicing engineer or design engineer normally they do not go for calculating, this frictional head loss using Darcy-Weisbach equation; I mean, they calculate using this equation, but they are having their own handbook, from there they calculate that if recommended speed is like this then, if the diameter of the pipe is this, then what should be the head loss per 100 you know meter if the flow velocity is this.

So, there are some handbook from there they calculate, but essentially that handbook is prepared you know, but data tabulated in on this handbook are based on this equation. So in using this we calculate the frictional head loss. So, the frictional head loss is calculated, whether we are going to calculate using our you know this Darcy equation or sometimes, if you follow that pump you know pumping system design handbook that, you know everything that losses is ready made available.

Because if I know that recommended speed and if I know diameter then for 100-meter length what should be the frictional head loss that we calculate using that book. So, this we obtain from frictional head loss. Now, whatever the minor losses? Again minor losses if you would like to consider that because of the presence of valves, bents, bents might be 45 degree, 90 degree and it maybe again 60 degree.

So, depending upon the bents and also the valves and also there are some fittings, you know some kind of you know, converging convergent portion there will be some diverging portion, there will be some losses. So, again if we look at our basic prevalence that flow through your convergent section, divergent section we need to calculate the losses. So this normally it is it is advisable to calculate exact losses using the those formula that is there in fluid mechanics book, but sometimes this minor losses are taken, because minor losses are taken, 15 percent of the total head loss.

So, minor loss are taken 15 percent of the total loss and this is not very bad assumptions, because sometimes if we take minor losses are 15 percent of the total loss if see, question is considering 15 percent of the total head loss to be the minor losses. Now if we design the pumping system and it so, happens that our calculation is, you know underestimating the head loss then, pumps will have a pumping operation you have trouble, but it is seen that normally 15 percent consideration of 15 percent of the total loss to be the minor losses and that that is quite you know comfortable to the pumping system design.

So, that is why and that is taken from wide experience of the system designer. So, minor losses are taken of the 15 percent of the total losses, total loss and flow meter, whenever flow meter is there sometimes and we need to calculate, what should be the loss. So, again we need to calculate that and whenever we are supplying, whenever we are purchasing a flow in kilometer the loss coefficient will be there if you know the velocity then from there, we can calculate the total loss.

So, knowing the all this losses and static height someone has to calculate total head weight developed by the pumps.

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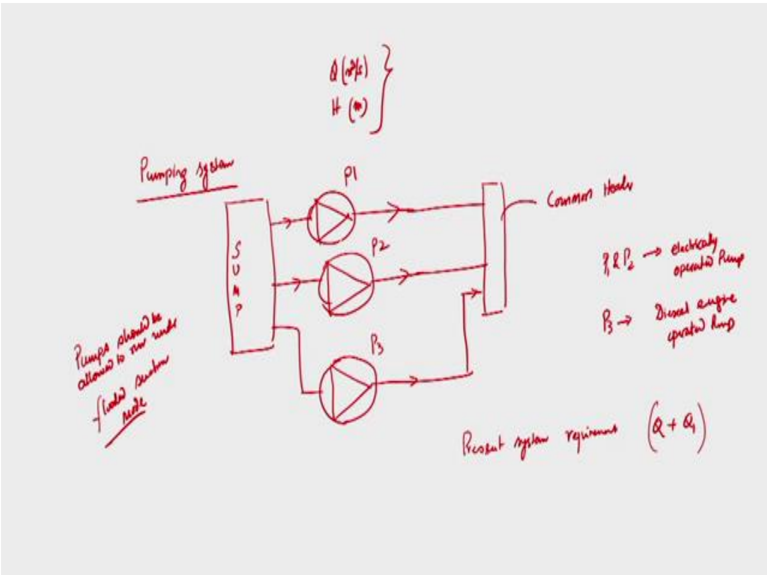

So, this is one aspect now, I will discuss one another important aspect is that sometimes, this is very important aspect, I will discuss that it is always recommended you know pumping system that suppose our requirement in a in a particular processer requirement is cube meter cube per second, cube meter cube per second and head is H meter. So, if this is our requirement from a pumping system and say a particular pump can deliver Q meter cube per second against a head of H. So, only one pump should be installed in the pumping which is not recommended.

So, while you are talking about a pumping system, while you are talking about a pumping system a good designer pumping system, a good designer always try to put at least two or three pumps once you remain as a standby mode because, one if you, if you have only one pump, pump may start null functioning because of so, many other reasons so, if one pumps starts null functioning then it will be interrupted, water supply should be interrupted and that if it is interrupted there are industries, it will create, I mean that interrupt some of the water supply will leads to a severe damage.

So, to safe the entire you know system at least a designer should consider that there will be at least one stand by pump to prevent the total system. So, while we are talking about pumping system design may be we are taking water from a sump if it is a sump. So and we will have at least two pumps at least we will have two pumps. To supply water and all of them will supply water to the common header and that is the common header.

So, this is known as common header and from the common header, the branch lines will be connected to different places where you need water now. So find, so this is let us, say pump 1, P1 and this is pump 2, P2. So, while that drawing from a reservoirs sump and I have discussed that normally, it is always advised, advisable to have a design or pumping system rather, pumping pumps should be allowed to run under flooded suction mode.

So, pump should be allowed to run, pumps should be allowed to run, under flooded suction mode, flooded suction mode. What is flooded suction mode? That is the impeller axis should always be below eh you know water level. So, that the you know like if we have a negative suction mode then, it might happen that we need to sometimes remove air and if by doing so, pairing operation. So, it is recommended that you will have a flooded suction mode.

So, now normal practices that this pump should run, the pump should be you know you know driven by electric motor. So, again our designer, another aspect of pumping system a good pumping system design is to that, fine we have two pump, may be one is 10 by 1 is operating and we may have interchangeability flexibility so, that we can have a after running certain hours of one pump, we can give we can allow pump to be under rest and then we can operate another pump.

Only to have a interrupt, you know continuous supply of the water. Now again it is advisable that, because when you are running pump is in electric motor. So, because of you know sudden stop of electricity supply although, we are having two pumps, but because of stop of electricity supply, we cannot supply water to the desired points.

So, again a designer should look in to look in to this aspect and that is, why another pump, I mean the pump of same capacity at some same head should be the there in the system and that pump should be that pump should run using diesel engine. So, this pump again and it will also connect to be connected to the common header. So, this pump let us say P 3.

So, now P1 and P2 may be these are the electrically operated pump, electrically operated pump. While P3 is the pump, which is operated by diesel engine so this is diesel engine operated pump, why because as I said, you because of sudden stop of supply of electricity both the pumps although, they are capable of supplying water then there are no problem from pump side, but still because of stop of supply of electricity pump, may you know stop and we may have you know disturbances in the water supply water supply. So, that should not be the case.

So, that is why we need to again put another pump, that is this operate that should be operated by diesel engine and that is in emergency. So, this is known as sump. So, this is sump from where, we have connected this 3 pump and all of them are supplying water to a common header and from the common header again that, there will be a few branch lines from here water should be distributed in many in different points.

I would like to now discuss another important point, that needs a few you know analytical methodology, suppose let me discuss about the problem. So, suppose find these three pumps are there and these three pumps are identical pump and may be, one pump can the running only running by one pump, we can supply the desired amount of water to be different you know points. So, that is fine.

So, we have two different another pumps that, will remain as a standby mode sometimes, we need to have flexibility because of as, I said because one pump may start null functioning and also it is advisable to give at least up to time you know you know that is called rest that pump otherwise, pump may start malfunctioning and another pump, that is operated by diesel engineering should be there of only take in to account that sometimes, it may happen that electricity should not be there.

So, this is overall the situation, now my question is this, three pumps have been installed in a pumping pump house. So, you know whenever system is designed and it is designed keeping in mind that, there should be provision of installing another pump in future.

If a system demands more amount of water to be supplied from the pumping system. Probably I have discussed in one of my lectures that, never you know industry people will, you know one that we should have another new pump house because, installing new pump house rather, you know construction of new pump house is of course very costly, we need to have you know at a time cost.

And on the other hand, if we have another pump house then again, we need to you know imply another operator to look after that pump using operation and for that again, we that will again that will lead to another you know cost. So, considering this aspects, whenever a pumping system designer is designing a pumping system is he or she should keep in mind that, provision should be there to install a few more, more pumps in future if system demands more amount of water or I mean either instead more amount of water or sometimes it might, so happens, that ok.

The head that is been developed by that present pump resisting pump is not sufficient to cater water in a place I mean or newly installed some equipment. So, we have to have, we have to provide, higher head. So, now, question is whenever, it is quite it is normally seen that normally, a head developed by a pump. So, suppose this all these three pumps are identical pumps. So, they are providing that with their H 2 characteristics are same.

Now, depending upon a system resistance, they will fix up their operating point and we will get the desired head and discharge. Now it might so happen, that the system requirement is now instead of Q, it is Q 1 Q plus something else. So now present system requirement is; so, if because of some installation of new plant or new equipment, the present system requirement, if present system requirement is Q plus let us say Q 1 and this Q plus Q 1 amount cannot be supplied even by operating two identical pumps in parallel.

So, this situation might happens that, to meet the present system requirement, because of installation of a new plant or new equipment the system requirement is Q 1 Q plus Q 1 which is of course, greater than Q and this amount is such that, it is not possible to supply from the existing pump even by running two pumps in a parallel mode. So, then again we have to have an another pump, I mean to meet that short fall of water.

So, while we are connecting another pump, with the in parallel with the existing pump that; that means, this amount is, this amount is such that even if I run, this two pumps in parallel mode, we are not having to meet, the we are not in a position to meet the demand; that means, again we need to install another pump and that pumps to run in parallel with the existing two pumps. So in that case, we have to now fix up, what should be the head and what should be the discharge that we are looking for the new pump not only that, the newly installed now newly installed plant or newly installed equipment, that may not be in the exact location, I mean the that may not have the same resistance with the resistance that with the previous system resistance.

So, after installing new equipment or new plant, the system resistors might differ and as I as I told, I do not know that whether I told you or not that pumping system, whenever we are connecting pumps in parallel, they will try to always follow the least resistance of the system. So, may be you are installing a new pump, that should be connected in parallel with the parallel operation of another two pumps, but if the resistance of that system is even much higher then, the previous system resistance than that pump may start you know null functioning at a pump tripping may occur.

So, if this kind of situation occur then, how we can you know get rid of this problem that, I will discuss by taking a analytical methodology and today I will stop here and I will probably continue this kind of analytical methodology, how we can get rid of this problem, by doing a very simple methodology and that should a pumping system designer should know as a remedy. So, we will discuss that aspect in my next lecture.

Thank you.