Principle of Hydraulic Machines and System Design

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Lecture – 20
Pumping system design – III

We will continue our discussion on the Principle of Hydraulic Machines and System Design. So, we are discussing about the Pumping System Design. So, today will discuss one another aspect that, that is probably we have discussed that from any adjusting pump house if we need, relatively higher amount may be that amount is not been that amount is not possibly to supply by the existing pumps. So, what we need to do it for that case that is what we will discuss today.

So, this schematic tells us that you know pumping system, whenever pumps are connected in a pumps are installed in a house pump house, depending upon the requirement that is very much process specific, we connect pumps either in parallel or series normally what we need to do, it is seen that from the normally practice normally whenever our designer design the pumping system. It is always advisable to you know we will have a few pumps, although the net demand or net requirement will be met by a particular pump.

But will be met by a particular pump, but for by given pump, but it is always advisable to keep at least another standby pump only to have a flexibility in operation. On the other hand if the pumps are you know run by electric motor in that case, we again we have to have one another pump that will be operated by IC engine that the diesel engine, only to have again you know safety for the entire system, because if electricity supplied is you know stops them probably enters water supply will be interrupted and for that to mitigate that, you know demand during that crisis period, we need to have one pump that will be run by diesel engine.

So, with that today will continue let us say that the requirement of the system, because may be because of some new equipment or may be a new processed plant, requirement of the system is becoming double or may be higher than the present system requirement. So, the industry people always will try to get that amount of sub water from the existing pump house, because as I said many a times that installation of pumps in a new pump house rather construction of a new pump house, we will have a two different cost..

First one is of course, associated with the construction of the house itself and second one is because again we need to imply another operator to operate the pump in new house, and for that again we will have a running cost. So, it is not suggestive rather advisable to have a new pump house of course, if the space and other requirement is there in the existing pump house, then only you can go for that otherwise of course, we have to go for new pump house.

So, if the demand is increasing let us say by double or may be higher than that, then may be demand is such that by running two pumps again in parallel we are unable to meet the demand. So, what we have to do again we have to install new pump. Now, as I said you that the new the new requirement the additional requirement may coming from new process plant all are new equipment.

So, whenever we are supplying that additional amount. So, whenever you are supplying whenever you are transporting the traditional amount to a new process plant or two new or new equipment of course, system is resistance will differ. So, in that case what we do? So, to continue that again we will draw a schematic and we will explain briefly, that how we can design that system.

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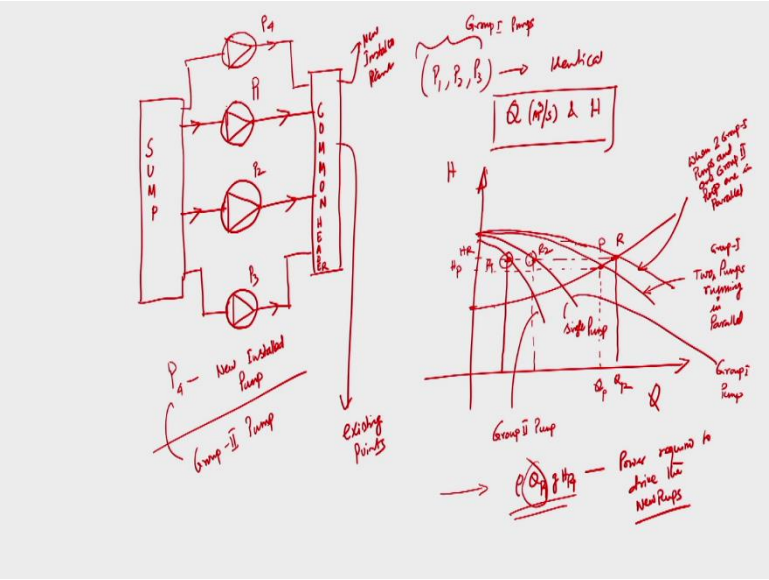

So, suppose we have a sump so, in that case we have one sump this is reservoir or sump from higher, may be two pumps connected, these two pumps are connected, and they are supplying water to a common header.

So, this is known as common header, and as I said you that to have rather to increase the safety of the system again, we have to have another pump that will be operated by diesel engine. So, maybe we are having another pump of same capacity, but the pump will be you know the pump will be operated by one diesel engine.

So, that is only for to bring the safety of the system. Now, as I said you that may be situation demand is now increased, to supply additional amount in different another newly installed plant or newly installed equipment such that, that even though running the existing two pumps let us say the pump is P 1 2 and this is P 3 so, if one pump P 1 P 2 and P 3 are identical, all the pumps are identical. Because they are may be each of them are delivering Q meter cube per second that is discharge against a head of H against a head of H. So, all these pumps are identical may be all the pumps are radial flow pump.

Now, as I said you that even by running two pumps at a time that is 2 Q is not sufficient to meet the demand, because of the new installed plant or new installed equipment. So, what you have to do again we have to install another pump. Now my question is suppose if I draw the curve HQ curve So, since all the pumps are connected to common header and from there may be our another line is connected to different parts of the different, you know places that they are supplying water at different places.

So, if I know what the objectives are so, we need to operate two pump in parallel so, that the discharge by both the pumps will be just double. So, suppose HQ curve for a given pump is like this. So, if I for any pump P 1 P 2 and P 3, P 3 separate from all together because that you operated by diesel engine only to bring out the safety of the system.

Now, if P 1 and P 2 both the pumps are connected in parallel only to have higher discharge may be and then what will be the head discharge characteristics both are identical may be will get. So, this is two pumps running in parallel and this is single pump. So, now, question is if the system resistance curve is like this then of course, this will be our operating point. So, the head or discharge corresponding to this point, head and discharge corresponding to this point P so, this is Q P and this is H P. So, head and discharge corresponding to this corresponding to these points are the rated discharge and rated head that we are going to get from a system.

Now, may be this amount is not sufficient to supply to meet the demands. So, what we have to do again we have to install another pump, should we go for the same pump or may

be depending upon the requirement we have to install another pump. Now, question is as I said long back that whenever installing another pump, it is not possible that will get the same pump from the manufacturer. So, we have to have another radial flow pump and the pump will be of you know same speed and if we install thus another new pump with the in parallel with the existing pumps and both the pumps are now connected in parallel..

Now, suppose this is newly installed pump and, this is now connected to the common header. So, this is P4 so, P4 is the newly installed pump, this is newly installed pump.

So, this pump P4 is a newly installed pump and that is connected with the existing pump house. So, what we have to do so, may be by running two P1, P1 P2 P3 are you are calling this let us say group one pump. So, these are I am calling group 1 pumps and P4 is another pump that is group two pump. So, by running two pumps in parallel of group one pump is not able to meet the demand. So, what we have done we have installed another pump group two pump and, that is being connecting in parallel with the existing pump and it is connected with the common header.

Now, so, if I install new pump and if the let us say the demand is such that that the P4 pump is supplying, let us say head is narrow set of head is narrow, or nearly equal to the existing pump house existing pumps or, but we need may be a little bit amount of water we need to get from the existing pump. So, if the HQ curve of the new pump is like this say set of head is nearly equal nearly equal so, like this.

Then if we add this one so, this is for group two pump, this one for group one pump, two the two group two group 1 pumps are running in parallel in that case again our head system resistance will be you have to know you know if we run all the pumps in parallel, then again the total HQ curve that is whenever two group 1 pumps and 1 group pumps are connected in parallel, then HQ curve will be like this.

So, this is the curve this is the curve, when 2 group 1 pump pumps and 1 group 2 pump group 1 group 2 pump are in parallel. So, now, our new design point will be same, if I now will discuss a few aspects. So, whenever the new pump is installed may be from the common header, now we are connecting two different branch line, one is going to the newly installed plant, newly installed plant. And another is supplying to the existing points.

So, although the all pumps are running in parallel, but the entire system will follow the least system resistance out of this two difference two resistance, because one is going to the newly installed plant one route, another route through which your supplying water to the existing points. Now, I do not know the system resistance in which is more so, that is what is big problem. Now so, if this is the system resistance and if this is the least system resistance then of course, the operating point now will be shifting to another point that is let us say R. So, now, this will be the Q P Q R and the head will be almost Q R H R.

Now, if I press back from this operating point to the individual pump, there may be this is the discharge supplied by the group 2 pumps and this is the discharge supplied by the group 1 pumps individual group 1 pumps. So, this is the point by at and the head and discharge corresponding to points is the discharge and head supplied by each of the group 1 pumps..

And this is the point corresponding you know head and discharge corresponding to the points are the head and discharge, that will be supplied by group two pumps rather newly installed pumps. My question is find because in that case we are assumed that the system is it will so, all the pumps running you know connected in parallel, they will run if and only if all of them are expressing a experiencing a safe same system in existence, this is very important we need to know. So, whenever you are connecting pumps in parallel and, they will run each of them will run if all of them are experiencing the same system based on which they are connected.

So, now as I said you if I press back from this newly operated operating point to the individual pump HQ curve and the points how they are intersecting, now the head and discharge corresponding to this point, let us say this is R 1 and this is R 2. The head and discharge corresponding to R 1 that is the head and discharge that will be supplied by the newly installed pump. It might so, happens that the discharge corresponding to point is so, high that the power requirement that depends highly equal to $\rho Q g H$.

So, discharge is so, high may be head is manageable the head that is supplied by the pump is fine, but the discharge is so, high that the power that is input power requirement from the electric mode may become high and pump trips. So, if this is power that is the power requirement rather Q_{R1}, I will write in a in a more accurate manner. So, ρ Q_{R1} g H_{R1} that is the power required to drive the new pumps.

So, this is the power required to drive the new pumps. So, what we have to do. So, if this amount so, I do not know if Q_R is so, high that may be fine, whenever pump manufacturer is supplying pump, it is clearly written that pumps should be available to deliver from 25 percent to 125 percent of the discharge from its you know best designed points anyway.

So, if the Q_{R1} and H_{R1} and these are very H_{R1} is fine that the head is fine, but if Q_{R1} is very high may be one not expecting that amount of Q from the pump 2. So, if this power requirement is very high and that power is not able that power will come for electric motor and, if that power is goes the power goes beyond the electric power up power supply the electric motor then pump will trip and that is very unreal phenomena.

So, of course, we have installed may be you have installed 1 pump new, newly added pump only to get the additional requirement, but because of this unreasonable phenomenon we are not able to supply this additional requirement and pumps would trips and it has been seen many a times by the industrial engineer that they are seeing this kind of problem so; that means, because what while you are getting, because as I said you we do not know the because water is now from a common header water is now convert if water is convert to define a route to define branch lines..

So, I do not know which one is the least resistance of the system, that it is quite you know common and it is obvious that whenever pumps are connected in parallel, they will run if and only if all of them are experiencing the same system resistor systems. So, and it is also to the they will also start minimum resistor systems. So, I do not know if the existence system becomes minimum so, these will happen. And for that pump two may trips if the you know power requirement is go power requirement goes coming those beyond to the you know electric supplied for the electric motor in that case what we have to do.

So, this is very deep problems. So, now, I will briefly discuss you know it is very you know in short, but how we can get rid out from this problem that the how we can get rather how we can eliminate these kind of problem. So, what I will do?

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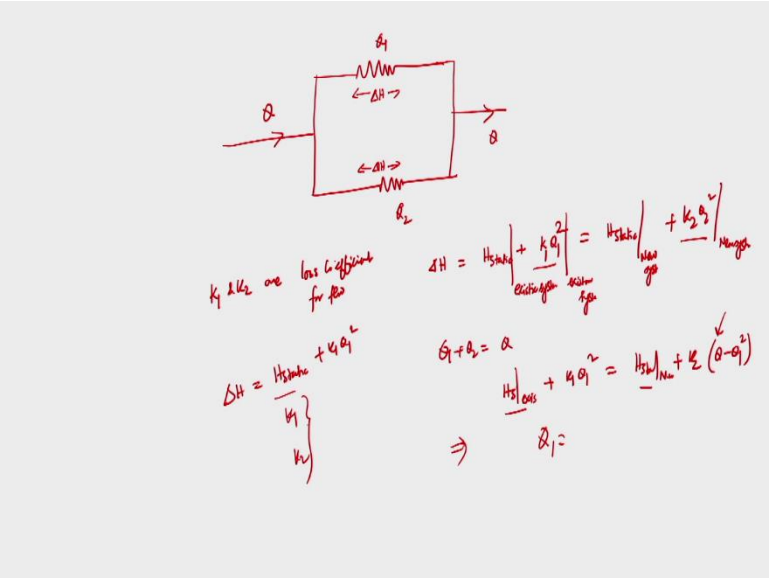

Now, so as I said you that we can have a very you know simple analogy that what I said that may be we are supplying Q amount and that Q amount is now may be divided into Q 1 and Q 2 and we are getting additional total Q amount. So, Q 1 should go to the newly installed plant, or newly installed equipment and Q 2 will go to the existing system. But since all the pumps are you know are running in parallel. So, all of them will be experiencing same head let us say delta H otherwise they should not run.

So, if this is the case. So, then what I can do so, delta H experienced by the existing pump house let us say because, now we are having two different system one is the existing system, let us say that will be what that should total dynamic head will be equal to

$$H_{dynamic} = H_{static} + k\,Q_1{}^2$$

So, this is new system so, this is the condition based on which these two pumps will run. Now, my question is where K_1 and K_2 K_1 and K_2 are loss coefficient of flow, loss coefficient for flow. So, may be Q 1 is going to the new system and Q 2 is going to the old system so, I know what is the amount of Q_1 and Q_2 I can calculate this total static height, because I know the elevation level between the pump house and the new system and the existing system. So, I can calculate the H static in both the cases, only thing I need to what should be the K 1 and K 2.

$$\Delta H = H_{static} + K_1 {Q_1}^2$$

$$H_{static} + K_1 {Q_1}^2 = H_{static} + K_2 \left(Q^2 - {Q_1}^2\right)$$

So, solving this I can calculate because I know the total Q requirement for both the plants, now I have calculated K 1 and K 2, I know the static height for both the system now I can calculate Q 1 so, from this analysis, we can calculate what is the amount of water being supplied by the pump to the new pumping new system so, and once I know the Q 1 then I can easily calculate Q 2.

From there you will have a fair estimate about whether while this you know plants that are new plants are existing plants are getting proper amount or not, if that is not the case then what we have to do we have to design the system; that means, if Q 1 is less then we have to know that the new system is having the higher resistance. And because of what entire system is following the least system resistance that is the system resistance of the existence system.

And since it is following the existence system resistance and, if I press back that point to the new pump house and new pump H Q curve and, discharge corresponding to the point become may become so, high that the power input that the power required to operate the pump is high, whether that goes beyond the you know electric motor power and pump trips.

So, in that case knowing Q 1 and Q 2 I can calculate that fine, whether that whether both the points are getting desired amount or not, if they are not getting then again we have to regain the system, by how by altering this system resistance; however, we can alter the system resistance, in a existing pump house sorry in existing systems we can alter system resistance, because this $K_1 {Q_1}^2$ and $K_2 \left(Q^2 - {Q_1}^2\right)$ static height, we cannot have any alteration this very difficult because once they are installed we cannot change.

Only we can change that is the K 1 loss resistance of flow by changing the valves, or fittings etcetera. Again what we can do see in a install plant valve, we going to have valve we need to have a flow control, again pipeline frictional resistance we cannot change, because once points you know one pipes are installed or once pipes are led down, how we can alter the pipe diameter all those thing, again it requires huge cost. So, what we can do

another should so, another one expect is to provide some orifice plate only to kill the resistance or to increase the resistance.

So, either we can from the existing system you can increase resistance to bring out the resistance equal to this new system are at the or, we what we can do we can reduce the resistance of the new system and to going out thus equal system equal is test to news existence system.

So, but the good suggestion is that we have to reduce or we have to bring down the system resistance of the new system, as well as we have you know increase the system resistance for the existence system so, that we can bring up at a particular level. So, that the both the pumps I mean both all the pumps will run against system smoothly, without having a or without having any trouble as well as the system will get the equal amount of discharge. .

And this is what the new an important design aspect of the pumping system, as I said you that I can eliminate I can reduce a system by providing by eliminating one valve, if it is not required or some fittings by resigning, or sometimes if I need to increase the system resistance, then in suppose in if the existing system we need to increase the system resistance, how we can increase only by providing orifice plate..

So, if I provide orifice plate it can be designed, that the orifice plate if I provide that will kill some amount of head and some amount of head being developed and it will increase the system resistance. So, this is all about the design aspect for pumping systems, if we increase if would like to add a new pumps with the existing pumps and the new pumps will run in parallel and, sometimes it happens that in newly installed pump or newly added pump you know trips immediately it starts to run. So, we need to investigate from where the problem is coming and then we need to sort out the problem by suitably a calculating the system resistance and system design, fine with these I stop here and I will continue with the next day with a next topic.

Thank you.