Principle of Hydraulic Machines and System Design
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Lecture – 04
Pump casing, efficiencies, problems

So, we will continue our discussion on Principle of Hydraulic Machines and System Design. So, here I will discuss about the pump casing efficiencies and problems. Before I would go to discuss about the Pump casing, efficiencies and if I take of a numerical problem, I will recapitulate the few important things that we have discussed in the last lectures. One is essentially the effect of inlet swirl.

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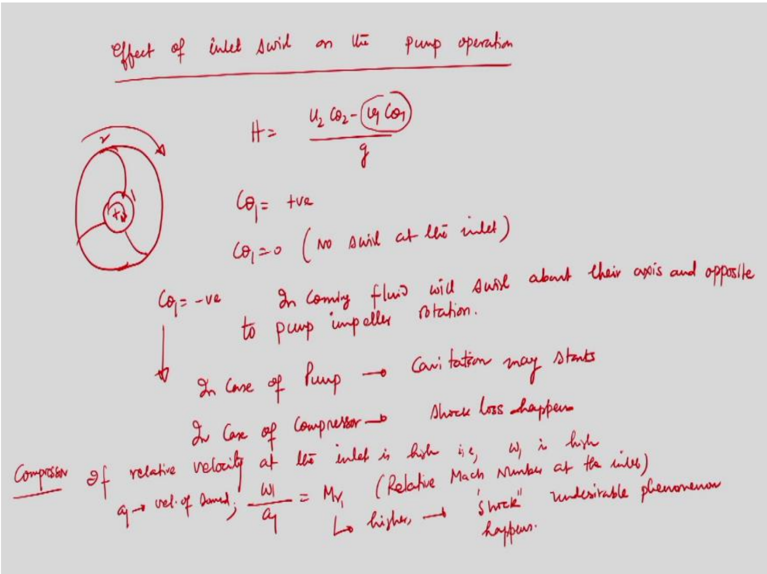

So, that is the effect of inlet swirl on the pump performance rather pump operation.

So, this is very important we have seen that in a radial flow pump, we have a swirl at the inlet of the pump that is if I draw the impeller. So, if I draw the pump impeller and suppose assuming that pump is rotating in the clockwise direction. And if I draw the velocity angle at the inlet that is 1 and 2; so, this is the blade, and if I draw the velocity angle at the inlet and we have seen that the head developed by the pump can be expressed in terms of $(u2\ C_{\theta 2} - u1\ C_{\theta 1})/g$.. We have seen that the component $C_{\theta 1}$ that is swirl component at inlet play a big role on the total head development by the pump total head developed by the pump.

So, we have discussed that if $C_{\theta 1}$ becomes positive then no problem, but head developed by the pump will be less, I mean relatively lesser because this quantity will be deducted from the u2 $C_{\theta 2}$. Now if $C_{\theta 1} = 0$ that is purely radial inlet no swirl component that is no swirl at the inlet. And we have seen that incase head developed by the pump will be relatively higher than the case where $C_{\theta 1}$ is positive, but still this case might lead to another problem. I mean might leads to another problem like if $C_{\theta 1} = 0$. Then to make c 1 in a perpendicular, then we have to have a relatively higher. We rather we will have a relatively higher relative velocity at the inlet ah, but still it is sometimes considering no swirl at the inlet pumps are designed to have no swirl at the inlet.

But the problem is in $C_{\theta 1}$ becomes negative, that is when $C_{\theta 1}$ is negative that is in coming flow. So, this is the case when incoming fluid incoming fluid. I mean fluid will swirl about their axis and opposite to the pump impeller rotation. And we discussed now that if $C_{\theta 1}$ positive; that means pump will have swirl definitely, but incoming swirl will have a axis of rotation. Rather it will incoming swirl will incoming fluid will have swirl sorry incoming fluid will swirl about their axis and in the direction, which is you know same of the pump impeller direction.

But when $C_{\theta 1}$ is negative, then incoming fluid swirl about the axis and opposite to the pump impeller rotation; that is very important that is opposite to and opposite to pump impeller rotation right. So; that means, there are 3 different cases $C_{\theta 1}$ positive, I mean head developed by the pump will be relatively lesser, but still we do not have any problem with that because may be head developed the pump for a given other you know conditions I mean that is blade velocity and although also the blade angle are is remaining fixed.

But we also have seen that by changing the blade angle at the outlet, we can still have a different head developed head development by a pump. But here by making $C_{\theta 1}$ that is by changing you know swirl component of velocity that is whether we are having swirl at the you know inlet or no swirl. We can control the head will be the head that will be developed by the pump. So, whenever $C_{\theta 1}$ is negative that is incoming fluids swirl about the axis of rotation and that to opposite to the direction of pump impeller rotation.

In that case, we have seen that to make; if we draw the velocity rectangle, we have seen that in the last lecture that relative velocity at the inlet will be higher. And if relative velocity becomes higher pressure might fall. And if pressure falls the vapour pressure at that temperature, then local boiling may takes place and this situation will leads to a different you know you know an undesirable phenomenon of cavitation that is very you know harmful to the pump operation.

So, that we have discussed. Now we will discuss that if we have you know higher inlet higher you know absolute velocity at the inlet, then this will lead to another problem as if we consider you know compressor. So, we have seen that if $C_{\theta 1}$ that is negative that is if incoming fluid will if incoming fluid swirl about their axis and opposite to the impeller axis then, in case of a pump we have seen that in case of pump cavitation may cavitation, which is cavitation which may start. Because cavitation is an undesired phenomenon as far as the pump operation is considered because it destroys rather it erodes some material from the impeller.

Normally in case of a pump it occurs at the eye of the impeller that is at the entry of the impeller. So, cavitation is not desirable phenomenon. So, if $C_{\theta 1}$ become negative that you would like to have higher ahead from higher head will be developed by the pump, we are at the same time we are inviting of course, by making $C_{\theta 1}$ negative, at the same time we are inviting of the problem of cavitation, but in case of a compressor, in case of a compressor if $C_{\theta 1}$ is become negative in case of a compressor it cause shock loss happens.

So now, in case of a compressor if the relative velocity at inlet in case of a compressor; if in case of a compressor if relative velocity at the inlet is higher, if relative velocity at the inlet is high. That is w 1 is high, then w1/a1 which is you know relative Mach number at the inlet, that is relative Mach number at the inlet. So, this is not you know related to the present for the present course that is not related to the hydraulic machine, but since I am discussing about the effect of $C_{\theta 1}$ on the pump operation. So, I will discuss all though it is not within the which is within the syllabus of this particular course.

So, if in case of a compressor, if the relative velocity at the inlet becomes high at there is w one high, then w1/a1 that is relative Mach number a1 is velocity of sound. Relative Mach number at the inlet which will be high; so, relative Mach number will be high this will be higher. And in case of a compressor when relative Mach number at the inlet becomes high in case of a compressor, shock loss shock rather shocks which is again an undesirable phenomenon happens in case of a compressor.

So, we have seen that that if these components of absolute velocity inlet at the inlet of the pump becomes negative, that is if the fluid swirls about their axis and opposite to the pump impeller rotation. Then in case of a pump cavitation may occur which is not a desirable phenomenon at all. And in case of a compressor although it is not included in this course, but still I am discussing although it is, but in case of a compressor; if the relative velocity at the inlet is high that is I mean the relative Mach number at the inlet will be high and it will lead to a shock which is again an undesirable phenomena for the compressor operation ok.

So, we need to have you know you know very judicial selection that whether you will go for I mean what would be the head development. Because if we can develop a higher head from a particular pump, then of course, pump efficiency will increase. At the same time, we have to keep in mind that at the cost of higher head development we should not invite any other undesirable phenomenon that might give rise to drastic problem for the pump operation.

Next I will discuss about you know we have discussed about the effect of inlet swirl at the inlet outlet.

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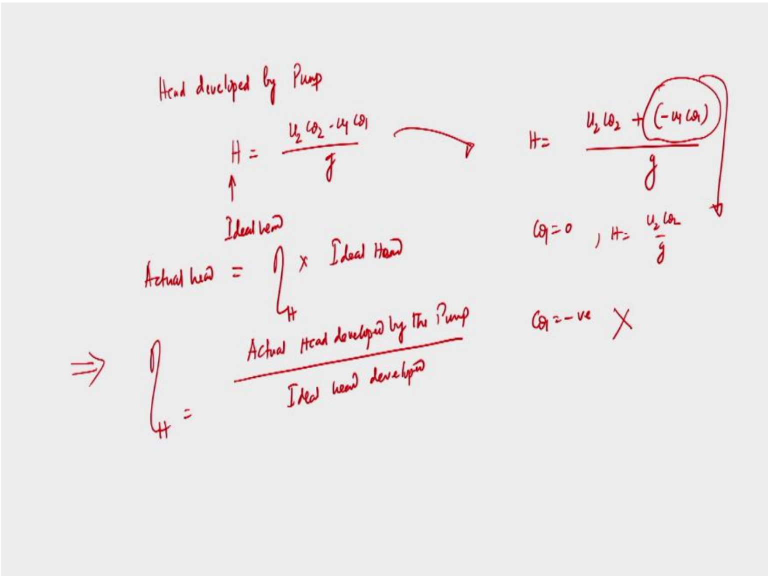

We have seen that the head developed by a pump, if I try to predict using Euler equation that can be expressed you know head developed by pump. If I try to predict using Euler equation, then it becomes H = $(u2\ C_{\theta 2} - u1\ C_{\theta 1})/g$. And of course, this is the ideal head because while calculating this head from the first law first principle and we did not take into account the losses. So, this is ideal head, actual head will be always less than this head. And that is why, we have defined one efficiency that is hydraulic efficiency sometimes it is known as manometric efficiency of the pump.

$$\eta = \frac{Actual\ head\ developed\ by\ the\ pump}{Ideal\ head\ developed}$$

So, this is the ideal head. And actual head actual head that will be developed by the pump will be always less than this ideal head. And will be multiplied by one factor and that factor is known as hydraulic efficiency or manometric efficiency. And there thereby we have defined hydraulic efficiency of the pump is you know actual head developed by the pump; actual head developed by the pump to the ideal head developed by the same pump. So, from this it is clear that the actual head developed by the pump will be always less than the ideal head fine.

Just we will try to recapitulate again that if I even look at the expression, I mean whatever we have expression of head develop by the pump you know predicted by Euler. Then I can see from here that the head developed by the pump can be tuned by changing the component of swirl at the inlet. Because h can be written in terms of $(u2\ C_{\theta 2} - u1\ C_{\theta 1})/g$. So now, this component that is swirl at the inlet it is a very important as far as the head being developed by the pump is concerned.

So now of course, I can increase head developed by the pump by changing the even by changing the tangential velocity at the outlet and for that we need to have a higher impeller diameter or higher rotating speed. So, that is not quite easy know meaning full, because if I would like to have higher head developed higher head will be developed by the pump by changing it is speed.

Then again I need to put more energy because pump will run either by an electric motor or by a diesel engine. Whatever it is in that case it is we need to you know put more energy input energy. Or else we need to have a higher impeller diameter; then again it is not very you know suggestive. Because we have a limitation of space because, we cannot increase the impeller diameter arbitrarily because of space and also because pump impeller is you know placed in a sap and there are bearings.

So, if I increase the pump impeller diameter it towards will increase and it will create a thrust on the bearing ah. So, radial thrust will be there axial thrust will be there and that will try to deteriorate the bearing life. So, considering all those aspects we can tune the head development even if I talk about the ideal head being developed by the pump I can tune that inlet swirl to obtain or rather to vary the head being developed.

So, there might be 3 cases that probably I have discussed that probably $C_{\theta 1}$ might be 0, can be 0 a case where there is no swirl at the inlet. In that case head developed by the pump is u2 $C_{\theta 2}/g$. This is the best possible case because again I am telling swirl inlet swirl 0 is again you know basically ideal case. Because it is really difficult to have a difficult to have no swirl at the inlet because swirl fluid flow is again, I mean this is again a case ideal case, but still that will be the best possible case.

And if I have a positive $C_{\theta 1}$ one that is always true I mean that we have discussed that positive $C_{\theta 1}$ means rotation of the fluid element rotation of the fluid that interest to the impeller will have a same direction of rotation to the impeller rotation; that means, if impeller rotation is the clockwise direction fluid entering to the pump through the pipeline will have also the clockwise direction. In that case we have a positive $C_{\theta 1}$ and in that case, we can see that it that fellow I mean u2 u1 $C_{\theta 1}$ always will try to reduce the head being developed.

So, this is not a favorable case, but on the other hand we might have a negative, I mean negative swirl at the inlet; that means, $C_{\theta 1}$ itself is a negative value that is $C_{\theta 1}$ will be a negative value. That is again possible because if I just try to change the rotation I mean whenever fluid is entering to that impeller that fluid will have a rotation which is different to different you know direction to the rotation of the pump impeller; that means, if pump impeller rotation in the clock wise direction fluid try fluid will enters I mean into the impeller with a rotation which is in a counter clockwise direction. So, in that case you may have a negative swirl, if that have a negative swirl then from the Euler equation, you can see that the head developed by the pump can be increased.

But maybe we can increase head by changing the inlet swirl at the you know by changing the swirl component at the inlet by making it a negative, but at the same times we are inviting another problem of having another undesirable phenomenon which is known as cavitation. Because if I increase swirl velocity at the inlet negative swirl, I mean then the absolute velocity at the inlet will increase because the blade speed or tangential velocity will remain same because of this fixed inlet diameter. If that relative velocity increases pressure will fall and if pressure falls below the vapour pressure at that temperature local boiling will takes place vapor bubble will generate and it will eventually leads to an undesirable phenomenon which is known as cavitation that we will discuss later.

Till now we have seen that by tuning $C_{\theta 1}$ we can also change. So, that is why $C_{\theta 1}$ negative is not a desirable case at all. So, maybe we can increase head by making it negative value, but at the same times we are inviting another problem of having cavitation. So, what is done we can now look into this expression and we can if I write this expression in a bit different from rather, I am recapitulating we have discussed in that in my lectures as well.

So, if I try to draw the velocity triangle at the for radial flow pump.

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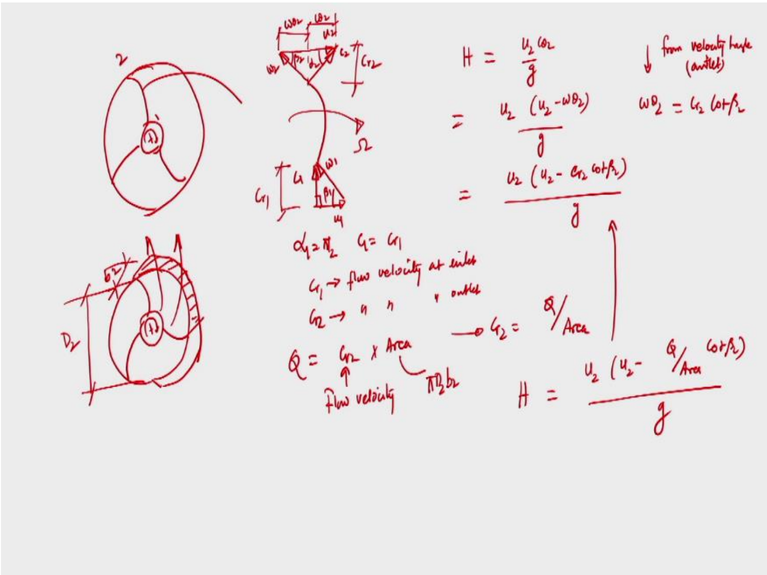

Suppose we have a radial flow pump and if I have a backward curved vane. Let us say if I have backward curved vane then if I take out this blade if it is 1, if it is 2, if I take out this blade and if I draw you know velocity triangles at the inlet and outlet and if I make that you know inlet swirl is 0. So, this is perpendicular, and this is the u1. This is w1 and this is absolute velocity c1 this is perpendicular α 1 and this is β1.

So, $\alpha\ 1 = \ \pi/2$ hat is c1=Cr1. That is flow velocity at the inlet and outlet velocity triangles will be like this. So, this is u2. This is w2, this is u2, this is c2, and this is known as Cr2 that is flow velocity at the outlet. So, flow velocity at the inlet is equal to the absolute velocity at the inlet and flow velocity at the outlet is Cr2. And this is you know $C_{\theta 1}$. And the component of relative velocity in the tangential direction is $W_{\theta 2}$. So, this is $\beta 2$ this is and α 2 blade is or impeller is rotating let us say with an angular velocity omega in the clock wise direction.

$$H = \frac{u_2 C_{\theta 2}}{g} = \frac{u_2(u_2 - W_{\theta 2})}{g} = \frac{u_2(u_2 - C_{r2} \cot\beta 2)}{g}$$

now, Cr2 is the flow velocity. So, Cr1 is the flow velocity at the inlet flow velocity at inlet and Cr2 is the flow velocity at outlet. If I now draw the impeller it is another 3-dimensional view, then it looks like this. I mean if it is a backward impeller is having backward spacing vane. So, suppose it is rotating with an angular velocity omega. So, impeller will have a weed like this and this width is b. So, and if the diameter of the impeller outlet diameter is D Capital D or D2 and it is b2 then you know area into flow velocity that will be discharged. So, water will try to go out like this from this passage from this flow passage.

Q = Cr2 * Area

$$H = \frac{u_2(u_2 - \frac{Q}{area} * \cot\beta 2)}{g}$$

Why I am recapitulating because from this expression I can see that even for the inlet swirl I can change rather I can you know tune the head being developed by pump by changing $\beta 2$.

So, if I tried to plot h versus q again for different values of $\beta 2$ if I try to plot.

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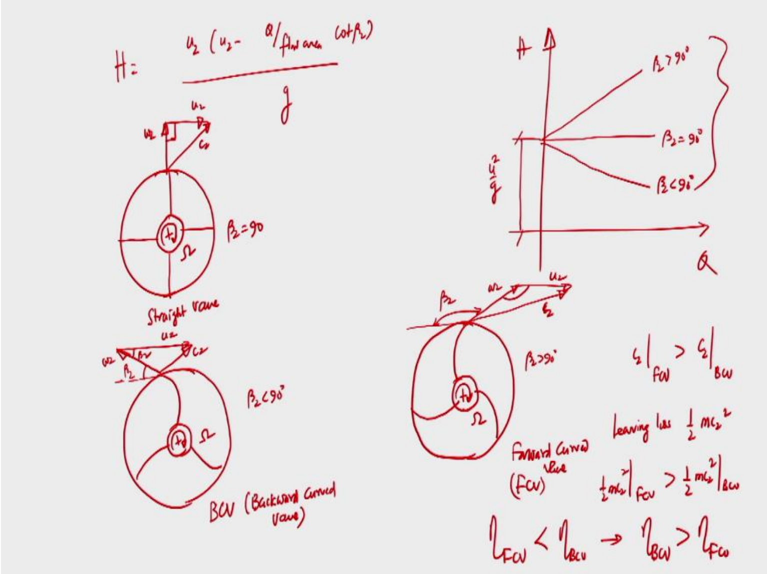

So, if I try to plot you know h vs q for 3 different values of β that is as I discussed that there might be forward curved vane backward curved vanes. So, when vanes are inclines in the direction of rotation of the impeller then these are known as forward curved vane, when vanes are inclined away from the direction of rotation of the impeller those are known as backward curved vane that depends upon the blade angle and the outlet $\beta 2$. So, for beta 290 degree we only will have u_2^2/g.

So, this is u_2^2/g when $\beta 2 = \pi/2$. So, this is a case when $\beta 2$ = 90 degree. If $\beta 2$ greater than 90-degree head developed by the pump will increase that is clearly seen from this expression. So, this is $\beta 2$ greater than 90 degree. And for $\beta 2$ less than 90-degree head developed by the pump will increase decrease. So, this 3 are the cases.

Now, if I keep on changing $\beta 2$, then probably the vane orientation will change and it will have different (Refer Time: 21:46) together. So, it will be a backward curved vane or forward curved vane depending upon or relative to the rotation of the impeller. So, for $\beta 2 = 90$ degree, it is straight vanes. If I plot the radial flow impeller of a radial flow pump let us say this is an impeller of a radial flow pump. So, pump is rotating in a clockwise direction for all the cases, if I assume it and if $\beta 2$ is 90 degree; then it is straight vanes like this.

This is straight vane that is $\beta 2 = 90$ degree; that means; here this will be the relative velocity at the outlet. This is w2 this is u2 and this is c2 and $\beta 2$ = 90 degree. So, this is called straight vane. Straight vane and if I try to plot $\beta 2 <$ 90 degree that what will be the case I can now see from this schematic or plot.

So, suppose again impeller of a radial flow pump which is rotating at an angular velocity omega in the clock wise direction because we need to consider by changing the blade angle at the outlet, we can have different name of the vanes you know, but relative to the rotation of the impeller.

So, if the impeller is rotating at an angular velocity omega in the clockwise direction if $\beta 2 <$ 90 degree, then the vanes will be like this that can be cleared. That will be cleared if I draw the velocity triangles. So, here velocity triangles will be like this. So, this is c2 this is u2, this is c2 and this angle is $\beta 2 <$90 degree and this is w2. As I said that all angles are measured with the tangential direction. So, here $\beta 2$ < 90 degree. So, what I can see from the shape of the vane is that this is backward curved vane; this is backward curved backward curved vane backward curved vane bcv.

And here I can see that the head developed by the pump will decrease with increasing q. And another case, if I plot it that $\beta 2 >$ 90 degree; so, if I plot $\beta 2 >$ 90 degree again another impeller, so, this is the case again impeller is rotating at an angular velocity omega in the clockwise direction. And $\beta 2$ >90 degree. So, I need to see what you will know blade safer blade profile.

And in that case, it is again rotating with clockwise direction at an angular velocity ω. And in that case, this will be w2 and since angle is measured with the tangential direction, these will be $\beta 2$. And $\beta 2$ is greater than 90 degree in that case this is the relative velocity tangential velocity at the outlet and this is the absolute velocity at the outlet c2 this is c2 this is u2 and this is w2.

So, this $\beta 2$ angle is greater than 90 degree in that case and known as forward curved vane forward curved vane or FCV in short. So, what I can see that by changing the blade angle at the outlet, we can manipulate the head being developed by the pump rather we can vary the head developed by the pump.

And if I change the blade angle from 90 to greater than 90 or 90 to less than 90 degree the shape of the blade changes relative to the rotation of the impeller. So, if I have considered rotation of the impeller in the clockwise direction for all the cases, then it is coming from

$\beta 2 = 90$-degree straight vane. $\beta 2 < 90$ degree it is backward curved vane and $\beta 2 > 90$ degree is forward curved vane.

Now, although for forward curved vanes I mean the impeller equipped with the few forward curved vanes you can see from the graph that with increasing you know discharge head developed by the pump is increasing, but at the same time (Refer Time: 25:37) closely if you see the you know the velocity triangles at the outlet that we have drawn all the cases.

So, the relative you know the absolute velocity c_2 for the forward curved vane is higher or much greater than absolute velocity leaving the blade for at the outlet for the backward curved vane. And that is why leaving loss there is very important leaving loss of energy that half m c 2 square of forward curved vane is greater than half m c 2 square of backward curved vane. The leaving loss that is the energy leaving with the water for the forward curved vane is much higher than the backward curved vane.

On the other hand, ah, for the forward curved vane the head developed by the pump is always higher. Now question is it is very important. So, there is you know we need to select judicially I mean we need to have a judicial selection of the pump vanes. So, what is what is important aspect? Should we go for a higher head by changing the blade angle ah. So, that it will be a forward curved vane, or we should remain stick to the backward curved vane compromising the head developed by the pump that is very important.

It is seen that the leaving loss is so, high. So, the relative rise in head by making the blade angle greater than 90 degree, that is for the forward curved vane is not very you know efficient. So, considering these aspects since the leaving loss is high for the forward curved vane although the head developed by the pump will be higher since the leaving loss. So, the relative increment of the leaving loss is higher than the relative rise in head and that is why efficiency of the forward curved vane are always less than efficiency of the backward curved vane.

On the other hand, that is, if I can say that the efficiency of the backward curved vane is much higher than the efficiency of the forward curved vane. So, we have seen that the if I make the blade angle in such a way that the blade profile will be forward, I mean blade profile will be in the direction of the rotation of the impeller, in that case head developed by the pump will increase at the same time leaving loss will be so, high that the relative rise in head is no longer important as compared to the you know increment. Let us you know severe or stringent increment of the leaving loss. And that is why efficiency of the backward curved vanes is higher than the efficiency of the forward curved vane.

Another important aspect is that although efficiency of the backward curved vanes is higher than the forward curved vanes.

$$\eta_{bcv} > \eta_{fcv}$$

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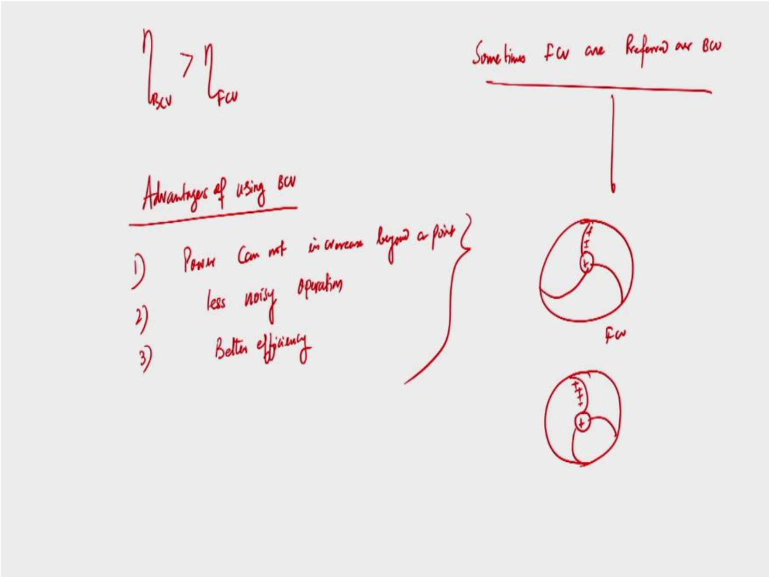

Although efficiency of the backward curved vane is higher than the efficiency of forward curved vane, sometimes these forward curved vanes are preferred. So, sometimes these forward curved vanes are preferred. They are preferred over backward curved vane. So, why I will write? So now, we have seen that efficiency of the backward curved vanes are higher, I mean this higher about the forward curved vane because there are few advantages of using backward curved vane. So, if I list down those advantages.

So, advantages of using backward curved vane. First of all, number one is power cannot go beyond a particular point. So, power cannot increase beyond a point. Number 2 is you know; this is less noisy operation that is also important less noisy operation. And number 3 is better efficiency. So, considering all these 3 points, considering all these 3 points backward curved vanes are you know normally someone should look for, but as I said that fine, efficiency of the backward curved vanes are higher than the forward curved vane that is true because although the head developed by the pump is in backward forward curved vane will be high, but there will be a stringent say leaving loss, but sometimes forward curved vanes are preferred.

Because there is industry that I have discussed that there is industry, if I use you know forward curved vane you know if I use if I use forward curved vane. Then that is if impeller is rotating in this clockwise direction and then ah. So, if there are industries you know where dust probability of deposition of dust particle over the blade surface is very high. So, the blade profile itself will allow to remove the dust particle from the blade surface and if the corrosion with the blades and erosion of the blade material can be prevented this is for forward curved vane.

On the other hand, if we use backward curved vane suppose if I use backward curved vane in those industries where there is a probability of deposition of dust particle on the blade surface. And in that case what is happening you know if the deposition of dust particle in this surface.

So, the blade surface does not allowed to blade you know designed at in such a way that the design it should not should not allow dust particle to go away from the surface, as a result of with either probability of you know corrosion and the erosion. That is why you know sometimes forward curved vanes are preferred over the backward curved vanes.

Next we proceed to discuss about pump casings and of course, we will take up a numerical problem to solve I mean what would be the operation. So, now we will discuss about the one small problem. Before I go to discuss about the pump casing I will discuss one numerical problem, one small problem I will discuss.

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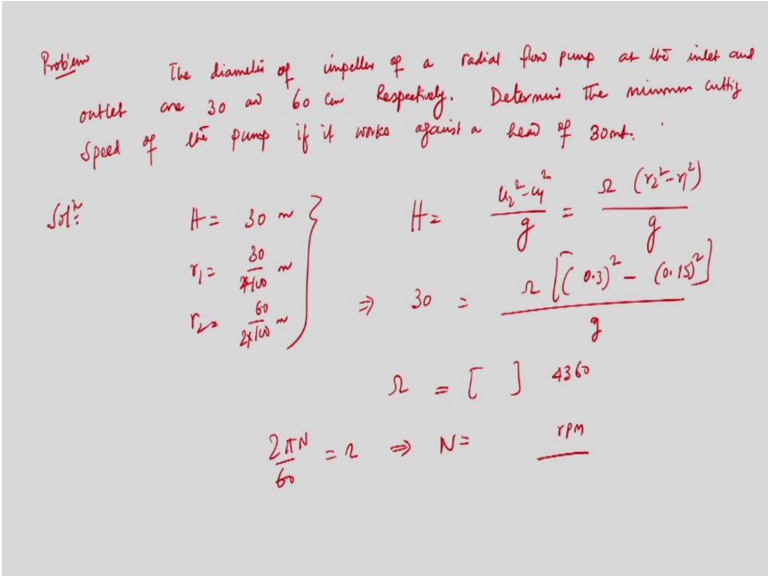

I will write that the problem is the diameter the diameter of impeller of a radial flow pump of a radial flow pump at the inlet and outlet at the inlet and outlet are 30 and 60 centimeters respectively.

So, the diameter of a diameter of impeller of a radial flow pump at the inlet and outlet of are 30 and 60 centimeter respectively. Determine the minimum cutting speed of the pump if it works against a head of 30 meter. Determine the minimum cutting speed of the pump, if it works against a head of 30 meter. So, we need to calculate. So, we have to solve this problem. Problem is given that the diameter of the impeller of a radial flow pumps are given both are the inlet and outlet and we have to find out minimum cutting speed if the pump cutting speed of the pump if it works against a head of 30 meter.

So now we know that we have seen that in a purely radial flow machines, that are a radial flow pump purely radial flow machines we can we have seen that the head developed by the pump can be written in terms

$$H = \frac{{u_2}^2 - {u_1}^2}{g} = \frac{{r_2}^2 - {r_1}^2}{g}\ \omega$$

$$\omega = \frac{2\pi N}{60}$$

there we can calculate n what will be the value of n. So, omega is calculated for 4 3 6 0 and n is calculated. So, we have to calculate, what is the value of n rpm. So, this is a problem because this radial purely radial flow machines. So, diameter of the impeller at the inlet and outlet are given.

So, we can express that that is what I have derived that for a purely radial flow machines the head developed by the pump can be written in terms of $\frac{u_2{}^2 - u_1{}^2}{g}$, that is where head is developed only by because of the (Refer Time: 35:17) force and we can obtain the what will be the minimum cutting speed if it was against a head of 30 meter.

Ok. So now, we will go to see what the pump casing will be. So, we will discuss about the pump casing. First and again then we will discuss about you know we will take up another one problem for the axial flow machines. So, we will discuss about pump casing. So, very important is pump casing.

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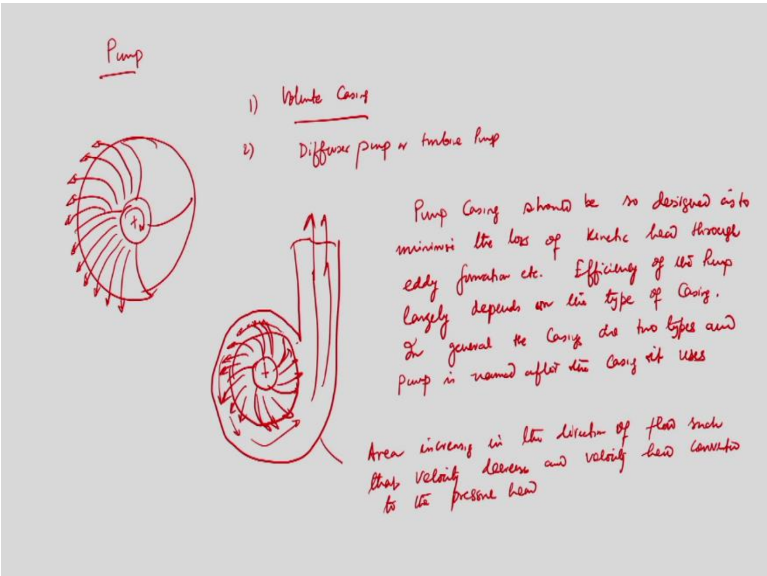

So, we have seen that impeller this is pump impeller. So, this if I draw the impeller of a pump radial flow pump it is like this. And if we draw the backward curved vane, so, like this. So, this is the impeller of a radial flow pump.

Now, this is there are different cases because we need to surround this impeller by something because, whenever fluid is coming out from the impeller. So, we have to guide the working fluid which is coming out because pump is essentially used to develop a head. Depending upon the requirement we can select whether we should go for radial flow pump axial flow pump or the positive displacement pumps. So, whenever water is coming out from the pump impeller, we need to guide the water. So, that it will move in a direction and it will have it will give rise to a total head.

So now we need to surround this impeller sometimes pump impellers are not surrounded this is you know not you now surrounded. So, depending upon the fluid pump needs to handle. So, there are normally 2 type of casing we are using. One is known as volute casing volute casing. So, that is whenever we are using impeller. So, impeller will rotate, and it will try to provide some it will convert as I said within pump energy is you know absorbed. So, we need to run pump using a electric motor or diesel engine. So, whenever pump is running, it provides it transferred mechanical energy into to the fluid to increase it is stored energy either by increasing velocity or pressure.

Now whenever fluid is coming out from the pump impeller need to guide that fluid. So, that all the fluid will pass through a particular path and it will eventually give us a total head. So, we need to surround this pump by some arrangement which is known as casing. So, casing is nothing but the arrangement which surrounds the pump impeller. So, there are 2 types of casing one is volute casings, and another is diffuser another is d you know volute casings and one is diffuser pump or turbine pump guide vanes; diffuser pump or turbine pump.

So; that means, casing is an arrangement which surrounds the pump impeller. So, that the water is coming out from the impeller can be guided can be you know directed to a particular path. So, that it will move, and total head being imparted by the machine to the working fluid will be can be developed. So now, pump casing, there are 2 casing one is called volute casing and then is diffuser vanes. So, there will be guide vanes. So, we will discuss.

So, I will write that in case. So, I will draw the casing. So, first of all I will draw one volute casing. So, if I draw the impeller. So, water is coming out. So, water is flowing or passing through the passage between the blades, is coming to is directed in this directed to this path. And eventually it goes to the and eventually it goes to the delivery point through some other arrangement piping system. So now, very important is this point is known as torque this is torque. So now, I will write that there are some you know important aspects while designing the pump casings. So, not only that we will design and we will just we will have an envelope and we will put that over the you know pump impeller is not like that. It will direct the fluid which is coming out from the impeller. Not only that since the entire objective of the pump is to develop the head. So, we need to ensure that whenever water is coming out from the pump impeller. So, we need to convert the velocity head into the pressure head. Because entire purpose is to develop the head; so, that is why in the direction of flow I mean whenever water is coming out in the direction in the direction of the flow passage, we have seen that area is gradually increasing.

So, in the direction of the flow passage you know area is gradually increasing. This is a conduit I mean this is a I mean pump casing which is an arrangement which surrounds the pump impeller, but it is designed such a way that, in the direction of a flow passage its area gradually increasing. The objective is to you know, convert the velocity head into the pressure head. So, as area increases velocity will decrease and it will be converted to the pressure head. So, that the total objective of the head developed by the pump can be you know satisfied.

So, I am writing pump casing is very important. Pump casing should be designed should be. So, design designed should be; so, designed as to minimize the loss of kinetic head through eddy formation etcetera. Efficiency of the pump efficiency of the pump largely depends on the type of casing on the type of casing. In general, these are some guidelines in general the casing are 2 types and pump is named after the casing use it uses.

So, these are some guidelines. As I said you that the casing is not only that simple thing, so, it is designed there are some design you know aspects that it not only surrounds the impeller, but it is designed such a way it minimize the loss of kinetic head through formation eddy formation etcetera. Also it we because as I said that the entire objective of pump is to develop a head.

So, we had we need to keep in mind that whenever water is flowing through that area, I mean in the casing then we need to convert the velocity head of the water into the pressure head. So, that the head developed by the pump can be satisfied can be met the demand. So, the head developed by the pump can meet the demand you know of the system.

So, these are guidelines pump casing should be.; so, designed. So, as to minimize the loss of kinetic energy thorough eddy formation etcetera, efficiency of the pump largely depends on the type of casing in general to the in general the casings are 2 types and pump is named after the casing it uses. So, one is volute casing, I mean here this is very important here as

I said you that area increasing in the direction of flow such that velocity decreases and velocity head converted to the pressure head; that means, this is a volute casing. In the direction of flow area gradually increases. So, that the velocity can be reduced, and the velocity head can be converted to the pressure head. So, this is volute casing.

And again, I am telling this casing design is very important. As I that is what I have written that is to minimize the eddy formation minimize the loss of kinetic head through eddy formation etcetera and efficiency largely depends. Because as I said you that whenever water is coming or it is flowing through the passage between the blades and if we can directly guide them, if we can properly guide that water into the casing path. So, that that velocity head can be converted to the pressure head. So, that the pump the head developed by the pump can meet the demand of the system because we are installing a particular pump to meet the system demand.

So, very importantly as I said in the first lecture the radial flow pumps are normally used in places where we recover you know you know relatively moderate to high head and discharge is low. So, we do not require very high discharge. Normally we go for axial flow pump where we require high discharge, but radial flow pumps are used in those places where we require you know low discharge and moderate to high head.

So, we are installing a particular pump. So, whenever, we are designing a pump we need to keep in mind that rather we are selecting a particular pump we need to keep in mind that the head developed by the pump should meet the demand of the system. Maybe whenever we install a particular pump it cannot meet the demand of the system then it will not it will not work for a long period. I mean is very difficult to you know operate that particular pump in the in the system.

So, this is the volute casing. Another is that as I said you that volute casing and we have written that in general casings are 2 types and pump is named after the casing is used. So, one is called diffuse diffuser or diffuser pump or turbine pump. So, volute casing is very one type another is there are some guide vanes or diffusers. So, I will draw that what is you know guide vanes and diffuser pump turbine or turbine pump.

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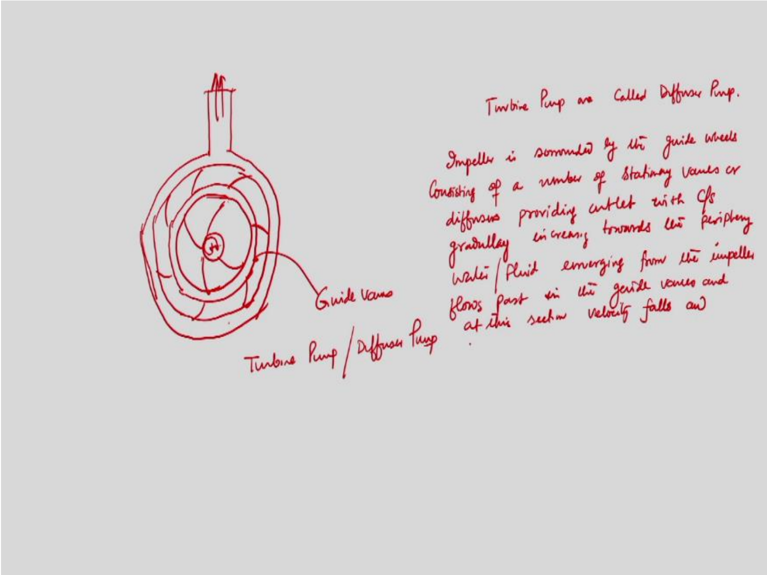

So, if I draw again a pump impeller and this is how and then it will be surrounded by one another arrangement which is. So, and then we will have another ultimately water is flowing out from this path. So, this is known as guide vanes. And this is diffuser pump or turbine pump. This is diffusion diffuser pump or turbine pump right. So, this is a special arrangement this is special arrangement. So, this is maybe rotating in this direction and whenever water is coming out from the passage between 2 blades of impeller, it is now guided by the guide vanes.

So, whenever water is coming out from the impeller and it is entering the guide vanes, the guide vanes is having again gradually whenever it is flowing through the guide vanes gradually having increasing area. So, that guide vanes you know minimize the losses through kinetic energy minimize losses of the kinetic energy through eddy formation etcetera. And then water is coming out and it is again going to the places where we required, we need to supply.

So, I am writing as a few general aspects of this particular pump that turbine pump turbine pump are called diffuser pump. So, this is turbine pump or diffuser pump. So, here impeller I am writing, impeller is surrounded by the guide wheels or guide vanes, guide wheels guide wheels consisting of consisting of a number of stationary blades. Stationery vanes or diffuser stationary vanes or diffusers or diffusers providing outlet with cross section gradually increasing towards it is gradually increasing towards the periphery.

So, in case of volute casing we have seen that there are no guide vanes right. Water is an water whenever it is flowing in the passage of between 2 guide to the between 2 blades of the of the impeller, it is directly coming out and whenever it is coming out in the casing is designed such a way that whenever water is water is flowing through the casing the casing area is gradually increasing. So, that the total velocity head can be arrested, and it can be converted to the pressure head.

, but in case of a turbine pump or diffuser pump you know kind of this is a special kind of arrangement special kind of casing arrangement. And this is it is known as diffuser pump or turbine pump and the type of casing as I said you that 2 type of casing and pump is named after the casing it uses. So, it will diffuse the casing. So, impeller is surrounded by the guide vanes consisting of a number of stationary vanes or diffuser providing outlet with cross section gradually increasing towards the periphery.

So; that means, these vanes this guide vanes or stationary vanes this is a guide wheels which consisting of a number of stationary blade. These blades are stationary not moving and whose cross section is gradually increasing towards the periphery right. Water now water or fluid I will write water or fluid, emerging from the impeller from the impeller flows fast in the guide vanes, guide vanes and at the section across the velocity and at this section velocity falls and pressure built up.

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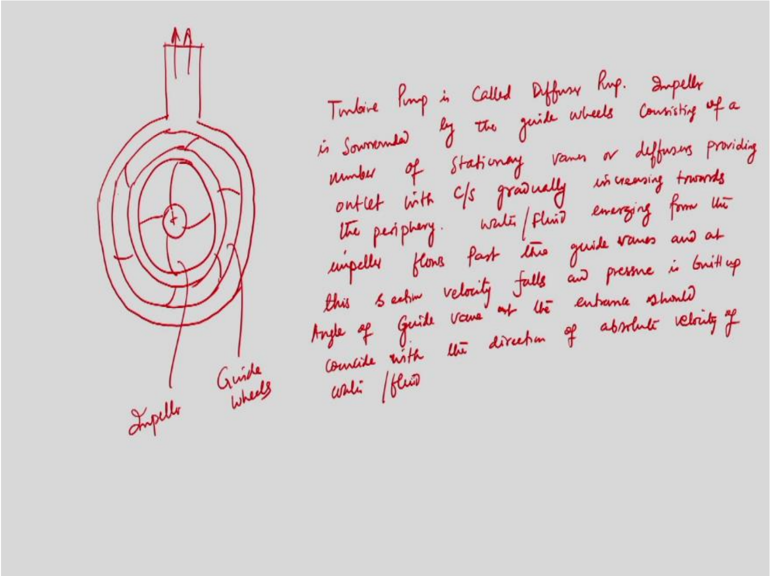

So, another is turbine pump which is called as turbine pump or diffuser pump. Impeller is surrounded by the guide wheels consisting of a number of stationary vanes or diffuser providing outlet with cross section providing out outlet with cross sections gradually, increasing gradually increasing towards the periphery.

So, we have discussed the volume volute casing. In volute casing we have seen that impeller is surrounded by special arrangement where that is casing of course, and the casing path is gradually increasing. Whenever fluid is coming out from the passage between 2 blades of an impeller and it is entering into the casing and the area in the flow passing the casing is gradually increasing. So, that the velocity head can be arrested, and it can be converted to the pressure head because entire purpose is to develop the total pressure and to meet the system demand.

Now turbine pump is another case another kind of you know diffuser pump. As I said you those casings are of 2 types and pump is named after the casing it uses. So, it is gradually increasing towards the periphery. And water or fluid whatever it is any kind apart from water pump might be installed places where we have to use, we need to permit to handle another fluid.

So, water or fluid emerging, you know from the impeller, from the impeller or coming out from the impeller flows fast flows fast the guide vanes. Guide vanes and at this section and at this section velocity falls and pressure is built up. Pressure is built up angle of guide vane angle of guide vane at the entrance should coincide with the direction of absolute velocity of water absolute velocity of water or the fluid.

So, as I discussed that in case of a volute casing, we had the casing is designed such a way that whenever water is coming out or emerging from the impeller it is an it is passing through the casing area is gradually increasing. So, velocity is converted to the pressure head. In case of a diffuser casing where pump is used after pump is named after it after the casing it uses. So, it is a kind of we are having this is impeller and this is an guide vanes. Or this is guide wheels and this is pump this is pump impeller this is pump impeller.

So, impeller is initially surrounded by a guide vane and the guide vanes is surrounded by another kind of arrangement and through which water is finally, going to the different places going to different places. Now here instead of casing the guide vanes are designed. As I discussed that you know guide wheels consisting a number of stationary blades just these blades are not moving stationary blades providing outlet with cross sections gradually increasing.

So, whenever water is coming out from the impeller and entering to the guide vanes entering the passage between 2 vanes of a guide wheels, then it since it area gradually increasing. So, velocity falls and pressure increase and finally, whenever water is coming out from the guide vanes, and it is discharging to the outside where water or fluid is conveyed through different other arrangement like pipe piping system. And ultimately goes to different places where we need to supply.

. So, this is all about the casing because there are 2 type. One case we need we do not have any guide vanes only we have a impeller is surrounded only by the casing when casing path itself provide a gradual increasing area essentially to arose the velocity head. While in case of a diffuser type of casing where instead of directly instead of surrounding the impeller directly to the casing that impeller is initially surrounded by a diffuser you know guide wheels which consist a number of stationary vanes. And which you know the stationary vanes providing outlet with cross section gradually increasing. So, that the whenever water is emerging from the impeller and it is entering to the guide vanes it velocity falls and pressure increases.

One important thing that a angle of the guide vanes at the entrance because whenever water is coming out from the impeller and it entering to the guide wheels or guide vanes the angle of the guide vanes or angle of the guide vanes at the entrance should coincide with the direction of absolute velocity of water. Otherwise there will be a shock loss. So, that is not a desirable again for the pump operation. So, with this I stop here today. And I will continue in the next class.

Thank you.