MARINE ENGINEERING

By

Prof. Abdus Samad

IIT Madras

Lecture32

Cascade view and Meridional view

So cascade, whenever you are talking about turbine, so turbine on which angle, because this is very complex shape and whenever you analyze fluid flow through turbo machine or turbine, so we assume that this is a very complex flow situation. And whenever you are describing turbine and you are drawing 2D figure on your paper, it is very difficult to express. from which direction you are looking at? If you are looking at top and only this portion you are looking at, okay? am looking at this airfoil i'm seeing and i am looking at airfoil so two airfoil i can see actually so three and four almost hidden okay or i can make like this i can cut half and i can make it flat so i can see all four airfoils like this okay like instead of blades instead of putting on one circular circular hub i can make on flat hub and i can put blade one blade two blade three blade four if i have many blade i can put many blades also

this is called cascade view okay this is called cascade view okay and this cascade view when you are drawing we can show rotor stator also okay what is rotor rotor means in pump you can remember rotor means rotating and stator means which is not rotating static stator okay so one turbine also will have rotor and stator why you say i have fluid flow from here fluid is coming from here okay Now I have one stator here, I have turbine blade here, this may be my turbine blade, case in shape turbine blade also possible. I made several turbine blade and I made on a flat plate instead of circular hub and I will have many stator also. what will it do? It will give proper angle.

So, fluid is coming like this. It will be exiting like this. So, when momentum is getting transferred or changed or direction is changing, so when fluid is changing direction, it will be giving energy to turbine blade. When turbine blade, this is rotor, These are stator, rotor, stator, stator vane or nozzle.

We say stator vane or stator nozzle or stator blade also sometimes we say stator blade, blade, rotor blade. We say rotor blade. Now, stator blade what will do? It will turn the fluid and will give proper angle of attack, proper angle of attack to rotor. So, the rotor will be extracting sufficient amount of energy from the fluid.

Stator purpose is not to extract energy. It will be giving only the direction. So, stator not harvesting energy, not extracting energy, extracting energy. giving only direction, giving only direction rotor extracting energy and so rotor is extracting energy, so rotor is output will be proper angle or not we do not care, rotor purpose is to get energy. If I have many rows of rotors, one stage, in a pump I told one rotor and one stator is called one stage.

So, here also this is one stage, stage 1. Now, if I have another stage of rotor and fluid is coming like this, that means it is not getting proper angle to enter into the second stage. what I will do? I will put another stage of stator So, then this fluid will be coming, the stator will be deflecting them, it will go to rotor, again it will give energy and it will go out.

So, stator is like this, I am drawing stator, you can see stator, rotor, stator, rotor, okay stator blade will be giving angle rotor will be harvesting energy again stator blade will be there rotor will be harvesting energy okay so one stator one rotor stator rotor it will be there so one stage stator rotor second stage again stator rotor stage two third stage also stage three third stage also will have stator rotor so first stage stator will give angle it will go to rotor, rotor will harvest some energy, energy will be reduced, it will go to stator again, stator will give proper angle, stator is not harvesting energy, again it will go to rotor, rotor will harvest energy, it will give to stator. So, several stages possible, 5, 6, 7, 8 stages also possible. And I told already that blade shape can be airfoil type or crescent type or many other type also possible.

okay this is called cascade view okay one stage so from like blade one blade two blade three blade four blade you are putting on flat plate and you are passing flow through the passage passage means between space between rotor and two rotors okay so these are passage you can see passage okay now uh another term is there meridional view meridian view means I have rotor, stator, rotor, stator and I am looking at side along with my shaft. Shaft means the shaft will be rotating. Shaft will be rotating the whole system. Shaft will be giving torque to the whole system and it will be rotating.

So I can draw like this. I have I can draw like this. and I will have you see this is my rotor this is rotor this is my stator i will be putting different hashing line stator okay so rotor stator not rotating okay not no rotation rotor rotation okay so rotor will be connected to

shaft and it will be rotating continuously and stator not rotating so what will do stator is here rotor is here so stator will be giving my proper angle rotor will be harvesting rotating and harvesting energy another stator is there the stator will be giving proper angle again another rotor will be rotating another stator another so one rotor stator one called stage stage one this is rotor stator stage two stage

And all rotor can be on a same shaft, common shaft. The stator is not fixed on shaft, rather it can be fixed on housing because it is not rotating. Stator is not rotating. Rotor only rotating. So, rotor will be on common shaft.

And fluid can be flowing like this. This is a 2D meridional view. So, 2D and right here 2d uh cascade view so velocity triangle so whenever we're discussing for turbine even pump also we draw a velocity triangle then we try to calculate how much power it can extract so velocity triangle will tell uh tell what will be what should be your angle or angle of attack proper blade angle, then how much energy you can extract, what should be flow velocity.

So, those relationship will be calculated from the trigonometry of that is called velocity triangle. Let us say frame motion or turbine speed blade speed u relative velocity, relative velocity means when fluid is flowing through the passage, fluid through the passage, this turbine u velocity or omega into r omega rotational speed r means radius omega into r and relative fluid velocity this should not be same actually there must be some difference that is called relative velocity so relative velocity let us say w and absolute velocity absolute fluid velocity is v so v u and v will not be same so that is why w term will be coming So, velocity triangle, let us say stator I have like this. I have stator like this and I have rotor like this because fluid will be going this and it will be going like this.

Rotor will be like this. Rotor will be like this. This is air file shape actually. You can draw properly. Then rotor stator

So, rotor u equals omega r, omega means angular velocity, r means radius. And which radius? Mean radius, mean radius of the rotor. Velocity. Now, if I draw velocity triangle, it will be looking like this, u, u, v,

and w x theta direction so we'll try to solve one simple problem we'll see okay so let's see one simple problem an office disk fan a diameter of 30 centimeter so let's say office fan is having like this diameter 30 and rotates 200 rpm n equals 200 rpm so omega equals 2 n pi by 60, 2 n pi by 60 and entire fan, air enters, so air velocity given 3 meter per second, but relative to the axis, this is axis, the relative velocity w we have to calculate, w we have to

calculate. so again you draw the velocity triangle let us say turbine blade u equals omega into r and v we have 3 meter per second air velocity so i have to calculate relative velocity okay so you u you get omega into r equals 200 into 2 pi by 60 into 0.3 by 2, 3.14 meter per second and w relative velocity equals v square plus u square. So, you get 3 square plus 3.14 square.

So, it is becoming 4.34 meter per second. So, this is your answer.