MARINE ENGINEERING

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Lecture31

Turbine aerodynamics

So, already I told that airfoil will have one lift, one drag. So, parallel to CD maybe or FDFL, lift force, drag force. So, our target should be to reduce drag force, increase lift force so that for example, aircraft it will be moving up. So, let us draw one airplane wing. so this is airplane and airplane if you look properly this is actually airfoil shaped all the airplane will have this if I take the cross section of a wing it will look like this okay so these are called airfoil shaped next time you fly by airplane so just you look at it airfoil shaped okay and many airfoil connected together it becoming whole wing okay

and this is leading edge this is trailing edge te i am writing short form trailing edge for te leading edge for le now whenever i am talking about pressure surface suction surface so lift force this side will be pressure surface actually pressure surface so pressure surface side i will have higher pressure my pressure will be lower sorry this is suction pressure suction surface this is suction surface so P will be lower pressure will be lower and velocity will be higher fluid velocity will be higher but suction surface this is pressure surface pressure surface P will be higher velocity will be lower. When airfoil generates slips, it deflects air downward. You see airfoil when fluid is flowing over it, it is deflecting air downward actually.

So, when it is deflecting air downward what will happen? air will be pushing the airfoil up so that air can move at straight path okay so air will try like this air or any fluid will be trying to lifting up the airfoil or hydrofoil okay so airfoil will be moving downward will be forcing downward so the airfoil will be giving downward force to air and air will be giving upward force to airfoil So, equal and opposite force should be upward on the airfoil. So, both force will be balanced, so in that way you are getting lift actually. Angle of attack, so another term will be coming angle of attack.

So, first another term you have to remember leading edge to trailing edge connection this straight line is called chord line. And another line will be the camber line. I will write on better fair file here. So, one line will be there just average of upper surface and lower surface called camber line. So, another line will be like this straight line connecting to leading edge trailing edge A to B maybe.

So, this is called chord line. the angle of attack, angle of attack means fluid direction is here, my chord line is here. flow direction is this one. This angle is for angle of attack. So, angle of attack should be proper.

For example, 5, 10 degree angle, 15 degree maximum possibly angle of attack will be optimal. If very low angle of attack is there, you will get more drag. If very high angle of attack is there, maybe there will be flow separation. What is flow separation? Flow separation is that whenever airfoil is moving in air or air is moving over airfoil, so both are same actually.

Air is moving over airfoil or airfoil moving inside air, both are same. in that case, let us say initially my air is like this. It is touching whole surface. There is no flow separation. but my angle of attack increase or flow velocity increases at very high rate so what will happen so fluid will be moving and at certain stage there will be lots of vortex will be created okay so this is flow separation okay so whenever any airfoil is designed

uh the scientists will be considering this flow separation point if flow is getting separated quickly then it will not get lift rather let's say airplane moving up and you make very large angle nose angle so in that case flow will be separated and flight will be falling down quickly okay so that's why flight whenever it is going through running runway to lift it up so it will have proper angle if it is not having proper angle or It is not getting proper angle of attack actually. then what will happen? This flight can fall down quickly. you should have optimal angle of attack.

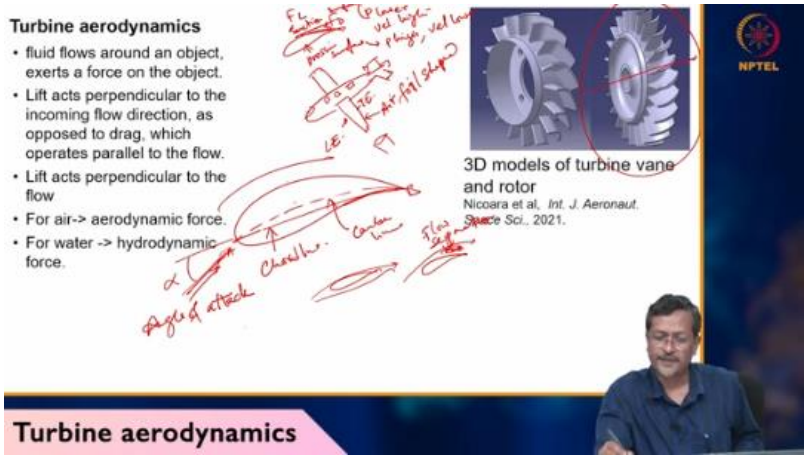
Then you will get proper lift. whenever you are designing a turbine also, turbine also having airfoil. turbine airfoil also should have proper angle. if you have proper angle, then you will get proper lift. You see this picture right side top left corner.

You see this axis is here. but turbine blades are making certain angles right with axis so these are actually angle of attack will be here okay so that proper angle of attack design engineers will be considering so they will try to maintain proper angle of attack if there is no proper angle of attack it will get very low lift or very low energy or lift will be producing

or it will give quick quickly lift will be almost zero okay so this airplane will be falling or your turbine will not have proper power output for air whenever you are getting any force from turbine we call aerodynamic force for water we are getting force we call hydrodynamic force and shape of airfoil it can be symmetric symmetric means like upper surface and lower surface pressure surface and suction surface both will be same like mirror image draw a quad line, draw a quad line and upper and lower, you see quad line is mirror, then upper and lower will be same. So, it is called symmetric airfoil.

And if I have, I do not have such thing, I have curved like thing, then asymmetric, asymmetric or cambered. cambered airfoil so cambered airfoil is generated to get more lift stalling okay so whenever airfoil is moving in air okay I told already one line is their chord line, another line will be their camber line. Camber line is average, the distance between top surface and bottom surface will be same and it will be also curved, but chord line is straight line. Now, initially let us say you maintain certain angle of flow alpha, then the fluid is touching the whole surface.

is touching the whole surface. When fluid is touching whole surface, actually you will get more torque or more power or more lift. But if you increase angle of attack or increase flow velocity, in that case what will happen? After a certain time, fluid will not be able to touch the surface. So, there will be one vortex creation here.



So, vortex creation means fluid is trying to touch, but it is unable to touch. So, what will happen? It will not get proper lift. So, when proper lift is not there, then there can be destruction or low torque you can get. And airflow gives maximum lift in a given air speed is limited by its boundary layer separation.

It is called boundary layer separation. When boundary layer separates, when angle of attack increases, a circulating flow creates. boundary layer separation will be occurring when angle of attack increasing or flow velocity is too high. in that case, a circulating fluid will be created.

that fluid will not give enough lift. This is called stalling. This condition of boundary layer separation and creating vortex is called stalling. At angle of attack above this value, lift will be dropped. So, lift coefficient formula, lift coefficient formula CD, L is called lift force, lift force L equals half rho V square SCL.

This is lift coefficient CL. Air density rho density V equals air velocity, air velocity or airfoil velocity, air velocity S the planform of the projected area, that whole area how much area it is covering that is called planform, planform of the projected area. And lift coefficient already I have written C L, C L is the lift coefficient, so drag coefficient drag coefficient cd okay so if i have any spherical body and fluid is flowing over it so my cd value will be 0.47 cd equals if i have semicircle like this hemisphere okay so in that case cd will be 0.42 i have square so cd will be

1.05 i have asymmetric airfoil 0.04 so cd drag force equals cd equals to drag force fd rho u square a so okay fd is elliptical cell so fn i should write okay is the reference area reference area u is the flow speed or you can write v flow velocity and rho air density okay so this is the formula for cd lift force and drag force fd is a drag force fd drag Dregfus.