MARINE ENGINEERING

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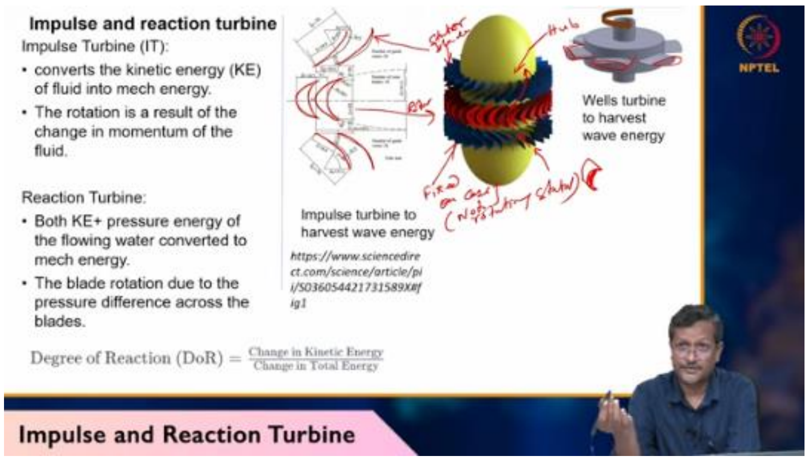
Lecture33

Impulse and Reaction Turbine

So impulse turbine, so I said like impulse turbine, reaction turbine can be used for a steam turbine system or a machinery. what is impulse turbine? An impulse turbine converts kinetic energy of fluid into mechanical energy. The rotation is a result of change of momentum. So when fluid is flowing through this, you can see I have drawn already this impulse turbine actually.

This is one turbine blade. This is another turbine blade. this is my guide vane this is my guide vane this is my guide vane this is my guide vane and here you can see the same turbine in three-dimensional picture we have drawn here like this okay these are impulse turbine blades and complete blade is looking like this you can see all right so complete blade is looking like this so there will be several maybe 35 36 blades okay all around this hub this is hub this is hub okay on hub the symposium blades are fixed the stator blade these are stator blade stator blade so stator blade actually this one also and this is rotor blade this is rotor okay rotor blade will be on the hub and when hub is rotating the yellow part is rotating the red part also will be rotating but stator this will be fixed on your casing because casing if we show them three dimension you cannot see here so that's why casing is not shown here so stator will be fixed on casing on casing and stator is not rotating okay rotor is only rotating

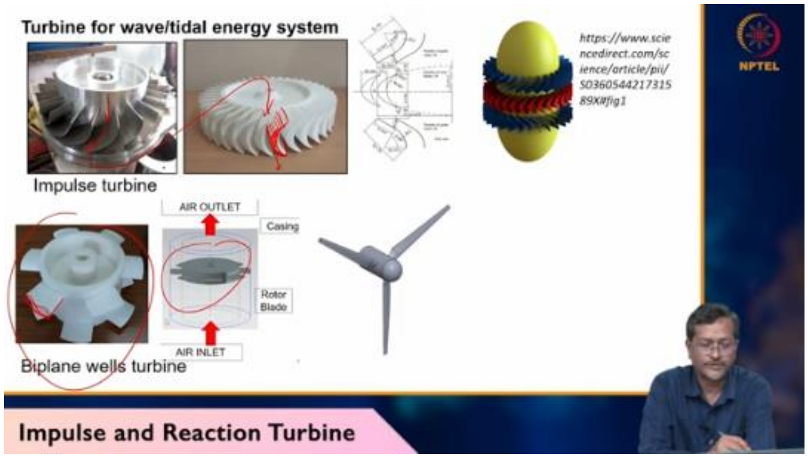
and what is happening so fluid you can see this i'm drawing a pen fluid will be going like this it will it will give energy to this blade then again it will be exiting so rotor blade will be getting energy stator blade will be guiding the fluid and if i have multiple rotor blade rows so one rotor blade rows another row in between there will be guide vane so guide vane will be changing angle give proper angle to rotor blade so guideline purpose not to harness energy rather to give angle to rotor blade total blade will be only housing energy okay and another turbine here i have shown because in my laboratory we have work on this both turbine impulse turbine and reaction turbine the worst i mean actually symmetric blade turbine the symmetric blades are there you can see this airfoil shape is there these are the blades these are the whole blade is here and symmetric shape is here So, normally eight blade turbine we design. In symmetric weld turbine blades, this is actually reaction turbine. So, in reaction turbine fluid will be passing through the blade passage, these are passage, through this passage blade fluid will be flowing and will be rotating in this direction, rotation like this.



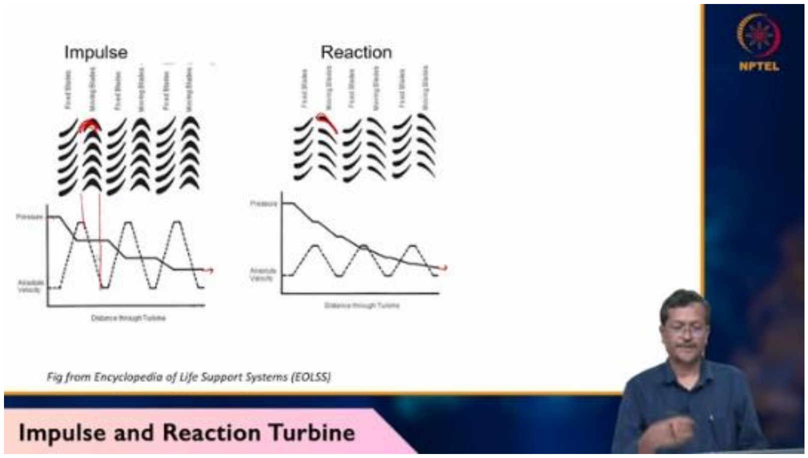
This system rotation direction is this, rotation direction okay and in between two blade we call passage okay so two blade space this space is called a passage in reaction turbine both kinetic energy and pressure energy of flowing water or fluid it will be converted to mechanical energy so well serving will be harvesting energy and it will be taking energy kinetic energy plus pressure energy from fluid blade rotation due to the pressure difference across the blades but impulse turbine we basically harness kinetic energy so more kinetic energy more energy will harness from impulse turbine here some picture from a laboratory actually we designed this 3d impulse turbine blade this is impulse turbine actually you can see this impulse turbine blade is like this creation shaped okay these are blade from my laboratory. I have around 36 blades we have and this is a guide vane.

guide vane you can see axial flow will be coming like this and it will be turned and after turning what it will do, it will be entering to this blade actually. one guide vane, one turbine. So, we made guide vane using metal and the rotor blade using softer material, 3D printing we use and Guide band will be guiding my flow and it will be given to rotor and rotor, after rotor also there will be guide band rows. So, I am not showing everything here.

In below picture, I can see one biplane wells turbine and there also we designed this one, we tested in our laboratory at IIT Madras. So, there also, this is a new type of turbine. So, this is called biplane wells turbine. This is normal wells turbine I have shown before. So, these are actually wave energy harvesting turbine and this is called tidal turbine.



Now, impulse turbine weld turbine, this is taken from energy cyclopedia of life support system, ULSS. Here, impulse turbine like crescent shaped blades are there, you can see here and reaction turbine blades are like this, airfoil shaped, you see right side, left side both. and impulse turbine pressure going down gradually in reaction turbine also pressure is going down gradually you can see bottom pictures but absolute velocity what is happening impulse turbine inside turbine rows actually velocity going down you are giving very high velocity and fluid is transferring energy to blade after that fluid velocity will be reducing okay but your pressure is constant but in reaction turbine what is happening let us see inside blade what is happening in reaction turbine also velocity is going down but pressure also going down because reaction turbine is harnessing energy from both so both are going down but impulse turbine only velocity going down okay so so application of equation of motion conservation of mass momentum okay Now, whenever you are solving any fluid dynamic problem, so you have to remember mass conservation, momentum conservation and energy conservation equations.

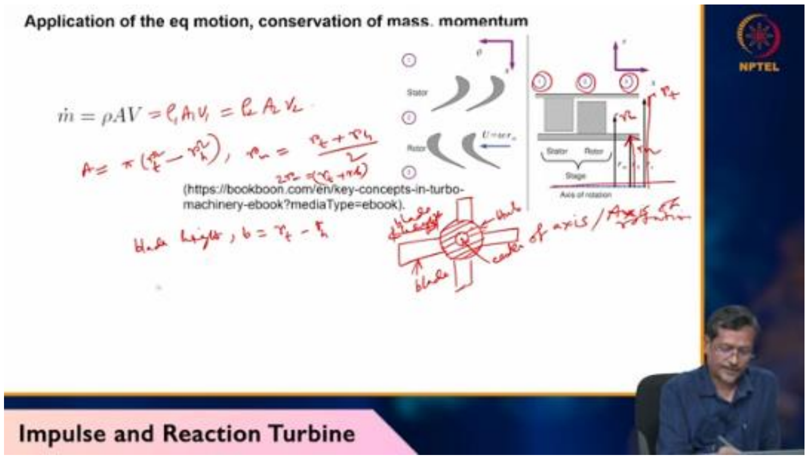


So, if there is heat transfer happening, normally energy conservation equation will be solved. If heat transfer is not there, so normally we will be solving momentum and mass conservation equation. this is mass conservation which is mass you cannot destroy so rho av so if i have turbine inlet 1 you see right side picture turbine inlet at 1 exit at 3 in between section is 2 so in that case i can write like rho 1 a 1 v 1 equals to root 2 a 2 v 2 okay so whenever fluid is flowing through turbine mass will not get destroyed so must inlet mass and out outlet mass you have to check same mass you have to get at outlet also if you are not getting then you maybe you have done some calculation mistake and your uh let's say i have one turbine you can see this turbine this this shaft is here but hub is here okay so i have one turbine here turbine hole is here and turbine hub is here my blade is here okay yes i am drawing four blades on turbine and this is my hub so blades are placed on hub okay this is my hub and blade is placed on hub so this is hub

and this is center of axis center of axis or axis only and these are blade okay this is blade height okay so this right side picture you can see my axis of rotation or center of axis of center of axis I can write axis of rotation axis of rotation so from axis of rotation hub radius is rh and tip radius blade maximum distance from axis is called tip tip radius so r tip and whenever fluid is flowing it is not flowing through hub okay so we have to calculate mean radius mean radius of the blade so rm this is rm mean radius of the blade okay So, A, so at inlet, what is the area of flow? Area of flow equals pi RT square minus R hub square. You see hub radius and tip radius in between that space, that will be used for your fluid flow.

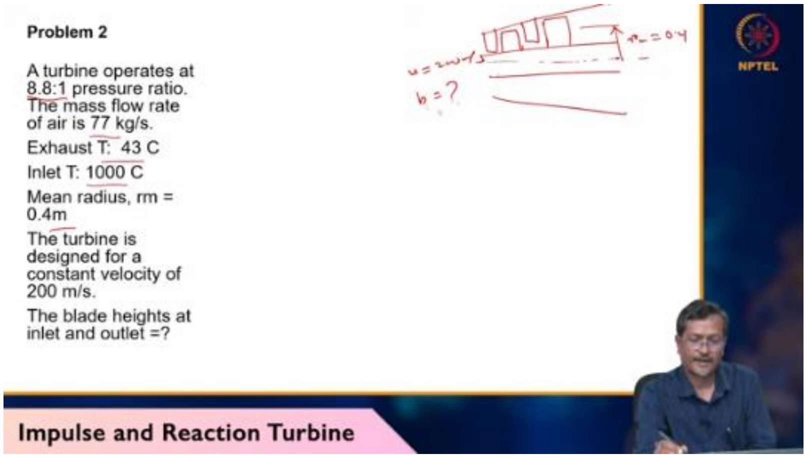
So, that is why the fluid flow area is RT square minus RH square. So, mean blade radius rm mean blade radius is rt plus rh by 2. Now 2rm equals rt plus rh. Now blade height, blade height b equals rt minus rh.

Therefore, A equals pi RT, you can see here RT plus RH, RT minus RH equals pi RT plus RH means 2RM, RM into RT minus RB, so 2 pi RMB. Whenever you have turbine, I say turbine expands steam. So turbine, this is my axis of rotation. This is my hub and my stator is here. Then my rotor will be on hub.



Again stator will be there, rotor will be on hub. and normally this is expanding so okay so normally this turbine will be expanding so my hub rotor is stator is here rotor is here stator is here rotor is here so gradually my rotor size will be increasing or stator size also will be increasing a turbine operates at 8 is to 8.8 is to 1 pressure ratio the mass flow rate 77 kg exhaust temperature 43 inlet temperature given mean radius also given means center axis to mean radius 0.4 the turbine design constant velocity u equals 200 meter per second so b you have to find at inlet and outlet. So, here B and at left side and right side you have to find.

So, to solve this problem, we have to calculate P by rho equals RT, R equals 287, we have to give R value also, j per kg, kgk. So, 287, so P1 equals 8.8 bar it was 8.8 into 10 power 5 Pascal P 2 equals 1 bar equals 1 into 10 power 5 Pascal T 1 equals 1000 plus 2 7 3 equals 1 2 7 3 K T 2 equals 4 7 3 degree centigrade equals 7 3 0 K So, rho 1 equals P1 by RT1 equals 8.8 into 10 power 5, 287 into 1273, 2.41 kg per meter cube. Rho 2 equals P2 RT2, 1 into 10 power 5, 287 into 1710.



0.49 kg per meter cube so M dot equals rho AV equals rho 2 pi RM B V implies B equals M dot rho 2 pi RM V therefore B 1 equals 7 7 2 pi 2 pi into 0.4 into 200 into 2.41 equals 0.06 b 2 equals 7 7 2 pi 0.4 200 into 0.49 so it is coming 0.31 so this is the answer thank you very much for listening to the lecture next day we will start next topic on steam table and enthalpy calculation thank you very much