MARINE ENGINEERING

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Lecture24

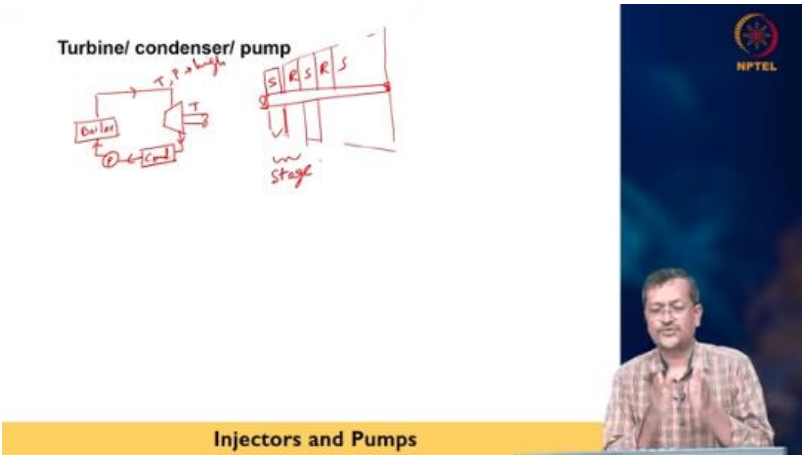
Injectors and Pumps

So, I said like one Rankine cycle we have will have one turbine, one boiler, then one pump, then condenser and I have to show all the arrow direction also and this is turbine. Now, turbine I am showing in specific shape I have drawn. Why? What is happening? This is temperature, pressure, high. And turbine what happens?

The turbine will have one shaft. the turbine will have different stages. The initial stage will have a lower, smaller blade height. Then once you go towards the exit, you will have a larger blade height. blade height will be increasing actually.

So, one rotor, one stator, rotor, stator. I will draw like this stator, rotor, stator, rotor. similarly, this side also will be there, this is the shaft. initially, the turbine is getting very high temperature, high-pressure steam. small volume is there.

After the turbine's first stage, this is called the stage. In the pump, I told them that one rotor and stator would be one stage. here also have one stator and rotor, this is called the stage. So, first stage will have a smaller size, diameter will be smaller. And next stage will be larger diameter, further diameter larger, larger, larger.



So, diameter will be gradually increasing. That is why whenever we draw turbine, we draw like this. So, this diameter D inlet may be, D outlet may be. And whenever you are talking about steam turbine, there will be several stages. Normally 3, 4, 5, 6, 7, many stages will be there.

So, that they can get maximum amount of energy from the steam. So, energy loss will be more and performance will be more. Energy loss will be minimized and performance will be maximized. That is why this turbine is drawn like this. But if we draw a compressor, here I am not using it, but in a later stage, I will use it.

The compressor will be drawn the opposite way. Compressor I will draw like this. I will be drawing like this. compressor means you are compressing volume you are taking you are compressing but turbine if i draw i will draw like this okay so you should follow this common notation people are using okay this is compressor this is turbine okay compressor also may have many stages so later stage when i will discuss about gas turbine so there i will discuss about compressor and turbine both together Now, turbine will have normally axial turbine.

detail, later we will discuss. normally it will be axial turbine. For the axial turbine, I already told that axial turbine, wind turbine, this axial turbine. one vertical axis is there, vertical pillar like thing is there. Then one axis shaft will be there.

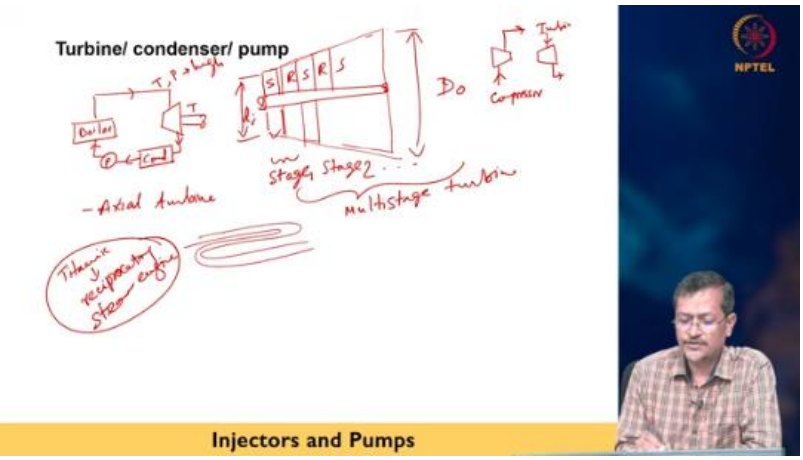
shaft around it will be rotating. fluid will be flowing axially of the shaft. parallel to the shaft. So, this is called axial turbine. But I had shown you the pump that is radial.

fluid is coming and directly changing the direction that will be radial turbine. radial turbine also possible. normally axial turbine will be used. And this is multi-stage because stage 1, stage 2, many stages will be there. this is multi-staging possible, multi-stage turbine.

Now, if you watch the movie Titanic, so you may have noticed that some pistons moving up and down. That is actually not turbine driven system, that is called marine engine or reciprocating steam engine. So, the Titanic movie or old engines, those are reciprocating steam engine. Later we will discuss how this reciprocating steam engine works. Although the majority of the steam engines have been replaced, but still some are in operation.

So, we will discuss this turbine thing basically. this turbine related steam engines are getting replaced, but still very large systems they are using turbine system because little or no vibration, low weight, minimum space requirement. they can make very compact system also. And they can use waste heat or the heat also for running the system. And condenser.

condenser is basically some pipe will be there. I already discussed that heat exchanger section. multiple turns of pipes will be there and heat will be going out from the pipe. Inside if steam is there, outside let us say ambient temperature is there. heat will be coming from hot to cold body.

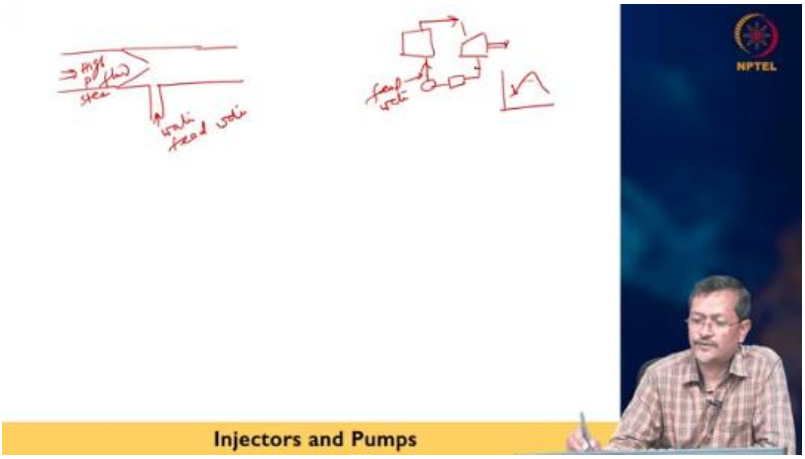


this is called condenser. or heat exchanger simple term is heat exchanger condenser is an heat exchanger condenser is a heat exchanger okay now next is pump is there so where is the pump pump before boiler one pump will be there pump that pump can be a centrifugal pump or jet pump previously people were used to using one ejector eject what is ejector pump so this is called feed water injector okay feed water injector called ejector so ejector pump is like this i have one venturi or one pipe is here okay and you reduce the pipe size like this and you create such a system like this okay so you pass very high-pressure steam

through this channel so when steam is passing through the narrow channel the velocity will be very high okay at this location maybe a b c just i put name nearby a velocity will be very high when velocity is very high pressure will be lower so when low pressure is there low pressure will be sucked from this one so this is primary fluid uh better i'll draw another slide and I'll explain so injector I'll draw injector is like this one pipe is here and you reduce size make a nozzle and make another arrangement okay like this so high pressure fluid high pressure fluid or steam okay and this is water feed water feed water means i have one boiler okay so boiler fluid is circulating right fluid is circulating like this, the pump delivering to the boiler, so that water is called feed water, this feed water. Now, this feed water, boiler pressure is very high, you can see the TS diagram, boiler pressure is higher, but pump pressure, intake pressure is lower. but still pump is delivering to fluid to the boiler so how they are doing so they are using steam boilers producing steam high pressure seeing that same steam they are creating one jet okay and when high pressure steam passing through

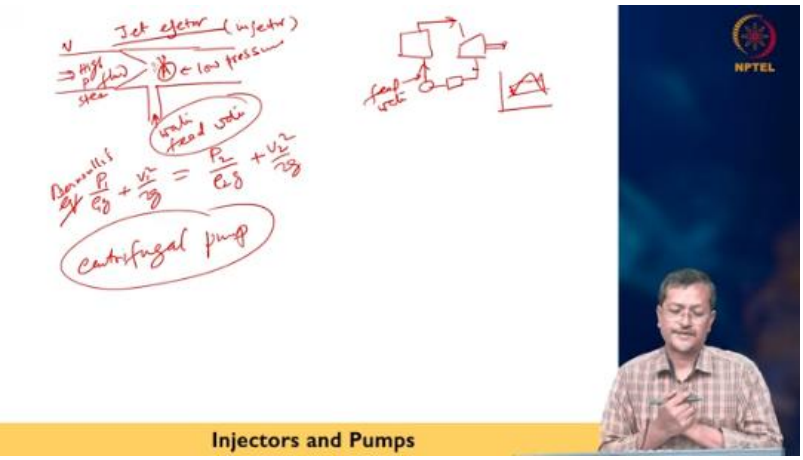
this small narrow channel it will increase velocity let us say initially velocity v here velocity v

So, what will happen? P y rho g plus v square by 2 g equals P 1 v 1 rho 1 P 2 rho 2 g plus v 2 square 2 g. You can see pressure, let us say assume density constant. Now, if pressure is changing, let us say initial pressure P, velocity v, velocity changing, upstream the larger diameter pipe pressure is high okay now fluid is flowing through narrow channel so narrow channel means velocity will be increasing when velocity increasing pressure will be dropping actually when pressure is dropping this location a i marked here location a will be a low pressure this is ejector z jet ejector injector okay boiler water injector the high low pressure water will be injected into boiler using ejector okay so you are creating very low pressure high high velocity high pressure fluid is there you create narrow channel narrow channel means fluid will be same amount of fluid going through small channel when it is going through small channel pressure will be dropping when pressure is dropping the water feed water will be sucked



feed water will be sucked and it will go to the boiler. So, this way this jet ejector works. Now, newer systems they remove this one and they are using centrifugal pump. Centrifugal pump I already discussed in previous lecture that there will be radial type centrifugal impeller. So, using radial pump we inject high pressure water or feed water into boiler.

But still many people are using this jet type ejector. So, you create narrow channel, fluid velocity increase, velocity increases, their pressure will be dropping because Bernoulli's equation, this is Bernoulli's equation. So, Bernoulli's equation says if pressure increases, velocity will be decreasing or vice versa. This is actually an energy equation. So, when velocity increased, pressure reduced.



So, feed water will be sucked and to be delivered to your boiler.