Thermal Engineering: Basic and Applied
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Lecture – 08
Second Law Applied to Processes of Power Plant and Ideal Cycle of Power Plant

I welcome all to the session of Thermal Engineering and today we shall discuss about the Second Law Applied to Processes of a Power Plant. So, if we try to recall in the last class, we have discussed about the mathematical form of the combined first and second law. And if we apply this combined first and second laws to different processes in a power plant then we could establish the expression of energy transfer, whether it is in the form of heat added to the system or it is in the form of work being extracted from the system. We could establish those expression. So, we have seen that if we apply that for mathematical form to the process which is there in a boiler & also the process which is there in a turbine, and from there we could write the expression of rather the mathematical expression of heat which is added to the boiler, essentially, for the change of the thermodynamic state of the working substance. And for the turbine, we had seen that while stream is flowing through the turbine, it does work and we are getting work output.

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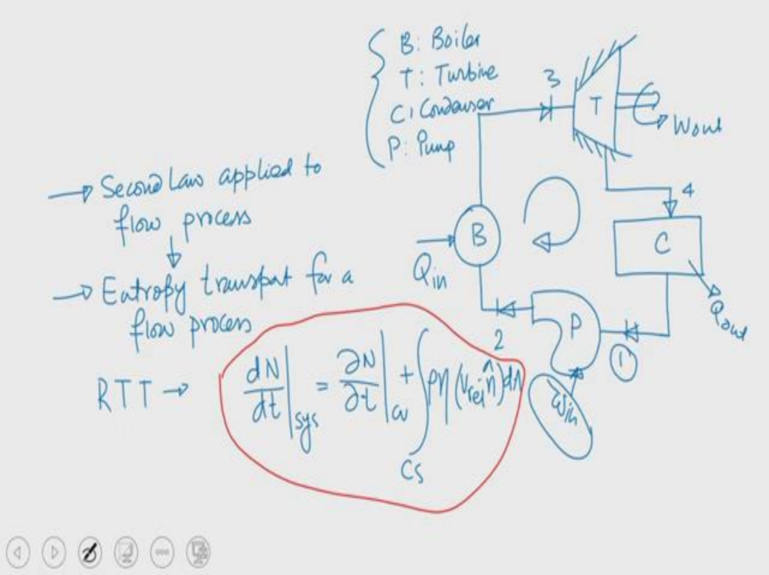

B: Boiler
T: Turbine
C: Condenser
P: Pump

→ Second Law applied to flow process
↓
→ Entropy transport for a flow process

RTT → $\left.\frac{dN}{dt}\right|_{sys} = \left.\frac{\partial N}{\partial t}\right|_{cv} + \int_{cs} \rho\eta(\vec{V}_{rel}\cdot\hat{n})\,dA$

So, just for the recapitulation again, we can draw the schematic diagram of the power plant. So, we can see only the major equipment like boiler, turbine, condenser and pump. So, this B for boiler, T for turbine, C for condenser, P for pump. So now, though, we have seen that the amount of heat which is needed to be supplied to the boiler for the conversion of steam and the amount of work that we are getting from the turbine. The mathematical expression of these two quantities we have established. I had discussed that in a similar way we also can find out the expression of this quantity which is rejected from the condenser. We have also discussed that second law of thermodynamics puts a restriction that if we need to run this plant in a cyclic manner, there must be a provision of energy rejection.

So, for this particular component that is pump, you need to know the quantity that is the amount of work that must be added to pump the condensate to the boiler and what would be it mathematical expression? So, we can consider that all the processes are ideal. So, the process is constant pressure heat addition in Boiler, it is reversible adiabatic expansion in turbine. And we have discussed that walls of the turbine are insulated so that there is no heat leakage or heat loss through the wall of the turbine and the process can be considered to be reversible adiabatic process. In condenser the process is constant pressure, heat rejection process. And the last process which is in the pump is important. Now, we will discuss about it today.

Also, we shall be discussing this part in our subsequent classes that the thermodynamic state of the working substance at 1 is liquid, in particular, it is saturated liquid. So, when this pump is supplying the saturated liquid from this condenser to the boiler and it is because of this pumping process, we need energy input that is W_{in}, in the form of work. So, what is the process? Can we represent this process as a reversible adiabatic process?

Because you know that there is no heat interaction between the system and surroundings. If we consider the pump is a system and the surrounding, so, there is no heat interaction. We also can consider the process where the condensate is pumped back to boiler and this process can be represented by the reversible isothermal process. So, basically, you know that boiler is a heat interacting device and the process is also a heat interacting process. Turbine is also a device in which there is no heat interaction between system and surroundings. Somehow, we have to admit that in reality there must be some amount of heat leakage, but while we are trying to estimate the efficiency of the cycle, we also need to estimate the efficiency or the performance of all the processes which constitute together to form the cycle.

So, this particular device Turbine is a work interacting device because we are getting work output. Similarly, this Condenser is also a heat interacting device because this is required where heat must be rejected to operate the system in a cyclic manner. What about this Pump? So, this device is not a heat interacting device but we need to supply work for this pumping. So, if it is not a heat interacting device, so, there is no heat interaction between system and surroundings. We can represent the process as the reversible adiabatic process. Can you represent the process by reversible isothermal process? Because you know that thermodynamic state of the working substance at point 1 is saturated liquid. So, while pumping, the state is getting changed and it is coming to state 2 where pressure is definitely higher and that is what our objective is.

But since it is an incompressible fluid, so, there is no change in specific volume. But can we really represent the process by a reversible isothermal process? So, as liquid is being pumped from state 1 to state 2 and it is viscous liquid, so it is because of this distributive effect, slight temperature rise will be there. So, maybe we cannot map the process by reversible isothermal process. Even if we try to represent the process by reversible isothermal process, what would be the mathematical form of this quantity W_{in} which is required to be supplied to operate this pump? So, basically till now we have discussed about the mathematical expression of this Q_{in}, W_{out} and in a similar way you also can calculate Q_{out}.I am not going to discuss that.

So, what about W_{in}? To do that we need to understand little bit about second law which is applied to the flow process. So, we shall be doing the second law applied to flow process. So, you know that if any particular process concerns a flow across the system boundary, you know that in the pumping process, there is a continuous flow from 1 to 2. So, the process concerns a flow across the system boundary. Now why do we need to go for this analysis is very important. Essentially, we are trying to apply second law to a flow process that means we are trying to look at the entropy transport for a flow process. Why? See you know that when the process is taking place inside the pump, entropy is getting changed maybe from state 1 to state 2. Now, what is the entropy transfer to that flow, that we also need to know. Why do we need to know? Because we are trying to calculate this quantity W_{in} and while you are trying to calculate W_{in} alongside the first law of thermodynamics applied to flow process, we need to know the entropy transport for a flow process.

So, I am sure that you have studied about the net change in entropy for a control mass system. So, knowing the net change of entropy for a control mass system, the expression of the net change of entropy for a control volume within a control volume can be mathematically written. If we know the net rate of change of entropy for a control mass system, we can mathematically write the expression of the net rate of change of entropy for a process across the control volume by applying the Reynolds transport theorem.

So, I would like to tell you that our concern is to express the net change of entropy for a flow process. We know, how to calculate the net rate of change or net change of entropy for a control mass system. So, if we are targeting to write the expression of the change of entropy for a flow across the control volume, then by knowing the expression of that particular quantity for a control mass system, we can write it for a control volume by applying the Reynolds transport theorem.

So, we can write the Reynolds transport theorem, just the mathematical expression, although we have discussed it but for the sake of completeness, I am again writing today.

$$\text{RTT} \rightarrow \left(\frac{dN}{dt}\right)_{sys} = \left(\frac{\partial N}{\partial t}\right)_{CV} + \int \rho n(V_{rel}.\hat{\eta})dA$$

Now, our objective is to know the mathematical expression of the change of entropy, for a process across the control volume by knowing the change of entropy for a control mass system and to do that we need to apply this transformation equation.

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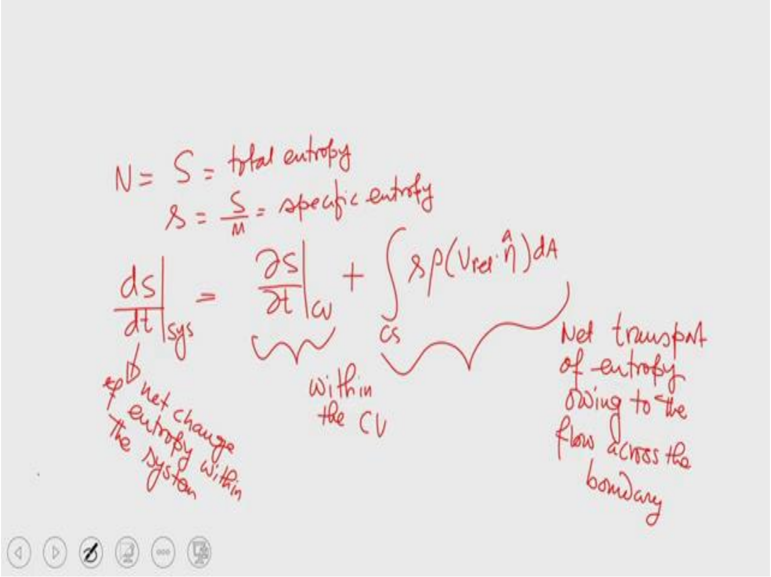

$N = S =$ total entropy

$s = \frac{S}{M} =$ specific entropy

$$\left.\frac{ds}{dt}\right|_{sys} = \underbrace{\left.\frac{\partial s}{\partial t}\right|_{cv}}_{\text{within the CV}} + \underbrace{\int_{cs} s\rho(V_{rel}\cdot\hat{\eta})dA}_{\text{Net transport of entropy owing to the flow across the boundary}}$$

net change of entropy within the system

$$\text{Here}, N = S = \text{ Total entropy}; \quad s = \frac{S}{m} = \text{Specific Entropy}$$

So, we can write that

$$\left(\frac{dS}{dt}\right)_{Sys} = \left(\frac{\partial S}{\partial t}\right)_{CV} + \int s\rho(V_{rel}.\hat{\eta})dA$$

So, if I go back to the previous slide, this

$\left(\frac{dN}{dt}\right)_{sys}$ = net change of an extensive property say N within the system

Similarly, $\left(\frac{dS}{dt}\right)_{Sys}$ = net change of entropy within the system

$\left(\frac{\partial S}{\partial t}\right)_{CV}$ = net change of entropy within the control volume

$\int s\rho(V_{rel}.\hat{\eta})dA =$ net transport of entropy owing to the flow across the boundary

So basically, the quantity in the left hand side is known because we know the change of entropy for a control mass system & by knowing this quantity, we can write the net change of entropy within CV. To do that we also need to know the net transport of entropy due to flow or owing to the flow across the boundary. Why? Because as I told you that if you try to find out the mathematical expression of W_{in} which is needed to run the pump, we need to know this. Why? I will be explaining soon.

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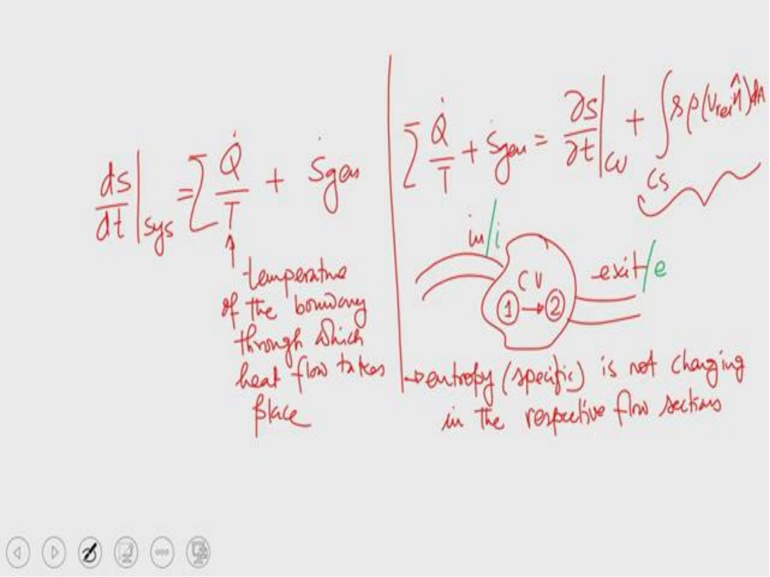

$\left.\frac{ds}{dt}\right|_{sys} = \sum \frac{\dot{Q}}{T} + \dot{S}_{gen}$

temperature of the boundary through which heat flow takes place

$\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \left.\frac{\partial s}{\partial t}\right|_{cv} + \int_{cs} s\rho(V_{rel}.\hat{n})dA$

entropy (specific) is not changing in the the respective flow sections

Change of entropy within the control mass system, $\left(\frac{dS}{dt}\right)_{Sys} = \frac{\dot{Q}}{T} + \dot{S}_{gen}$

$T =$ Temperature of the boundary through which heat transfer takes place

$\dot{Q} =$ Heat either being added to the system or being extracted from the system

Now, if we have multiple such boundaries through which heat is getting interacted between system and surroundings, we can write this the summation sign.

$$\left(\frac{dS}{dt}\right)_{Sys} = \sum \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

$$\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \left(\frac{\partial S}{\partial t}\right)_{CV} + \int s\rho(V_{rel}.\hat{\eta})dA$$

So, if we consider the control volume as shown in slide and we have an inlet to the control volume and exit to the control volume. And control volume is changing its state from 1 to 2. So, this is a flow system, so, there is flow in and there is flow out. Now, the change of entropy within the control volume is $\left(\frac{\partial S}{\partial t}\right)_{CV}$, entropy transfer due to flow in and flow out. The quantity $\int s\rho(V_{rel}.\hat{\eta})dA$ represents the change in entropy within the control volume due to the flow. So, entropy specific is not changing in the respective flow section. In that case, what we can do? We can take S out from this and we can write

$$\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \left(\frac{\partial S}{\partial t}\right)_{CV} + s\int \rho(V_{rel}.\hat{\eta})dA$$

$$\int \rho(V_{rel}.\hat{\eta})dA = \text{Mass flow rate}$$

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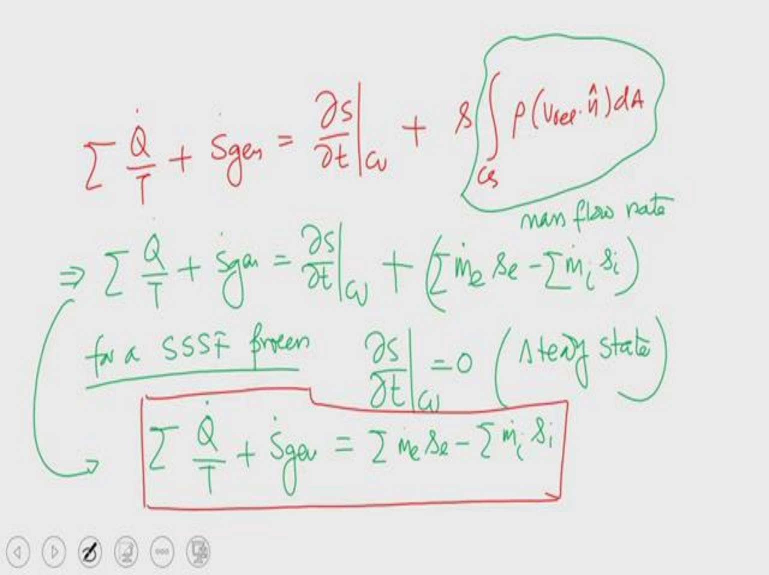

$$\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \frac{\partial s}{\partial t}\Big|_{cv} + s\int_{cs} \rho(V_{rel}\cdot\hat{n})dA$$

mass flow rate

$$\Rightarrow \sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \frac{\partial s}{\partial t}\Big|_{cv} + \left(\sum \dot{m}_e s_e - \sum \dot{m}_i s_i\right)$$

for a SSSF process $\frac{\partial s}{\partial t}\Big|_{cv} = 0$ (steady state)

$$\boxed{\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \sum \dot{m}_e s_e - \sum \dot{m}_i s_i}$$

So, for the convention, we know that for the outlet, outward normal and flow direction are in the same direction, whereas the outward normal for the inflow is opposite to the flow direction. So, considering that we can write

$$\Rightarrow \sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \left(\frac{\partial S}{\partial t}\right)_{CV} + (\dot{m}_e s_e - \dot{m}_i s_i)$$

So, basically, if the entropy which is coming in with the flow is s_i and entropy which is going out from this control volume that is s_e. So, the exit is section e and the inlet is section i. So, in this particular control volume, we have single entry single exit. It is highly possible that within this control volume multiple inlets and multiple exits can be there. In that case, we can modify this equation like this.

$$\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \left(\frac{\partial S}{\partial t}\right)_{CV} + \sum (\dot{m}_e s_e - \dot{m}_i s_i)$$

Now, if you try to recall, we have discussed that one important assumption is that in this particular plant, we are considering that all the processes are steady state steady flow process..

So, for steady state steady flow process,

$$\left(\frac{\partial S}{\partial t}\right)_{CV} = 0$$

For the steady state, there is no difference between state 1 and state 2. So, the change in entropy and steady flow, so, we have discussed about the physical significance of these two coupled keywords that is steady state, steady flow, so, this is equation.

$$\Rightarrow \text{For SSSF,} \sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \sum \dot{m}_e s_e - \sum \dot{m}_i s_i$$

So, this is the equation which we shall apply along with the first law of thermodynamics, to obtain the amount of work that should be added to the pump for the operation.

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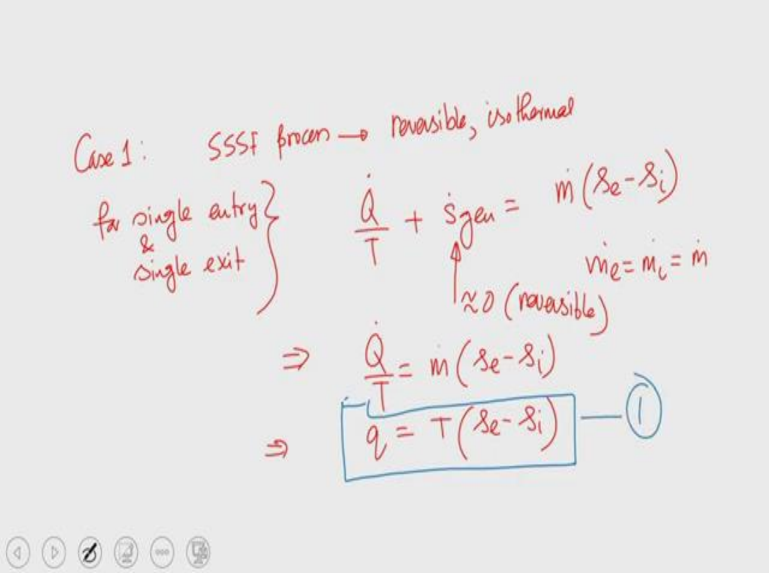

Case 1: SSSF process → reversible, isothermal

for single entry & single exit

$$\frac{\dot{Q}}{T} + \underbrace{\dot{S}_{gen}}_{\approx 0 \text{ (reversible)}} = \dot{m}(s_e - s_i)$$

$\dot{m}_e = \dot{m}_i = \dot{m}$

$$\Rightarrow \frac{\dot{Q}}{T} = \dot{m}(s_e - s_i)$$

$$\Rightarrow \boxed{q = T(s_e - s_i)} \text{ — } ①$$

Next we can discuss about two different processes.

Case-1: SSSF process but it is reversible isothermal

So, basically, we would like to discuss about a process which is steady state steady flow also which is reversible and isothermal. So below is the entropy transport equation for this steady state steady flow process.

$$\sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \sum \dot{m}_e s_e - \sum \dot{m}_i s_i$$

So, to arrive this equation we did this exercise. Now, though you are familiar with this equation because you have studied it in the thermodynamics course but I have again derived it because it will be very much needed to obtain the expression which you are looking for in today's class.

So, basically, we know that it is a single entry and single exit. So now, if we look at this particular system and we consider this pump and control volume, at any instant of time there is only one inlet and one outlet. So, basically for single inlet and single exit we can write

$$\frac{\dot{Q}}{T} + \dot{S}_{gen} = \dot{m}_e s_e - \dot{m}_i s_i$$

So if it is single entry and single exit, we know that from the mass conservation equation

$$\dot{m}_e = \dot{m}_i = \dot{m}$$

So we are trying to have the expression for W_{in} for a process which is steady state steady flow process, on the top of that we are assuming that the process is reversible and isothermal.

$$\text{If the process is reversible then,} \qquad \dot{S}_{gen} = 0$$

$$\Rightarrow \frac{\dot{Q}}{T} = \dot{m}(s_e - s_i)$$

So, this is in the rate form, so, we can write it in specific form

$$\Rightarrow q = T(s_e - s_i) - - - - - (1)$$

So, this is very important.

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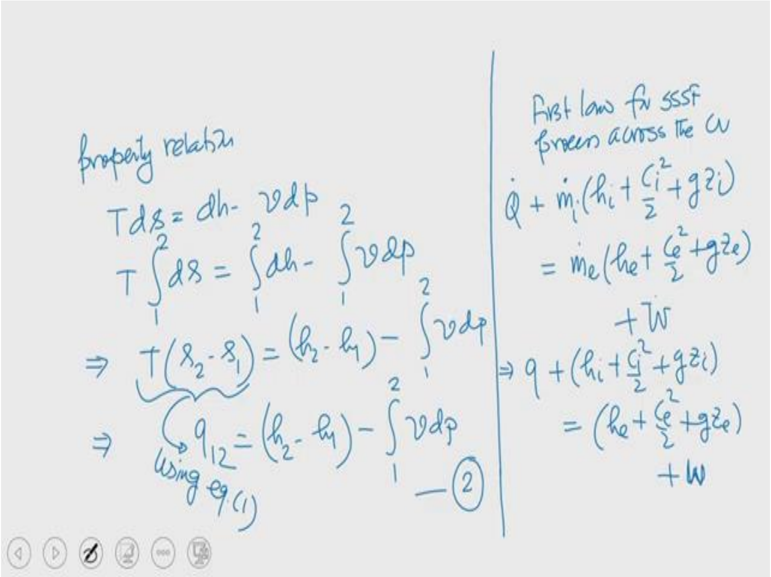

property relation

$Tds = dh - vdp$

$T\int_1^2 ds = \int_1^2 dh - \int_1^2 vdp$

$\Rightarrow \underbrace{T(s_2 - s_1)}_{\text{using eq.(1)}} = (h_2 - h_1) - \int_1^2 vdp$

$\Rightarrow q_{12} = (h_2 - h_1) - \int_1^2 vdp \quad — ②$

First law fr SSSF process across the CV

$\dot{Q} + \dot{m}_i\left(h_i + \frac{c_i^2}{2} + gz_i\right) = \dot{m}_e\left(h_e + \frac{c_e^2}{2} + gz_e\right) + \dot{W}$

$\Rightarrow q + \left(h_i + \frac{c_i^2}{2} + gz_i\right) = \left(h_e + \frac{c_e^2}{2} + gz_e\right) + w$

Now, we have to apply again the property relation.

$$\text{Property relation} \rightarrow Tds = dh - vdp$$

$$\text{But we know } Tds = du + pdv$$

But you try to understand, we are trying to establish the expression of W_{in} for a process which is there in a pump. So, in this process, pressure is changing. So, the sole objective of having this particular component in this circuit is to raise pressure from point 1 to point 2 or state 1 to state 2. So, the pressure is changing and this is a flow process. So, the thermal energy is not u rather the thermal energy for the flow process is $h = u + pv$. Hence, $Tds = dh - vdp$

So, you know that if it is reversible isothermal process, then T is not getting changed. So basically, we can write

$$T\int_1^2 ds + \int_1^2 dh - \int_1^2 vdp$$

$$\Rightarrow T(s_2 - s_1) = (h_2 - h_1) - \int_1^2 vdp$$

$$\text{From equation} - 1, \qquad q = T(s_2 - s_1)$$

$$q_{12} = (h_2 - h_1) - \int_1^2 vdp \quad ----(2)$$

First law for steady state steady flow process across the control volume

$$\dot{Q} + m_i\left(h_i + \frac{c_i^2}{2} + gz_i\right) = m_e\left(h_e + \frac{c_e^2}{2} + gz_e\right) + \dot{W}$$

$$\text{So, we have seen that,} \qquad \dot{m}_e = \dot{m}_i = \dot{m}$$

$$\Rightarrow q + \left(h_i + \frac{c_i^2}{2} + gz_i\right) = \left(h_e + \frac{c_e^2}{2} + gz_e\right) + w$$

This is the genetic expression if the control volume is changing, it is state from 1 to 2, we can write

$$q_{12} + \left(h_1 + \frac{c_1^2}{2} + gz_1\right) = w_{12} + \left(h_2 + \frac{c_2^2}{2} + gz_2\right) - - - - - (3)$$

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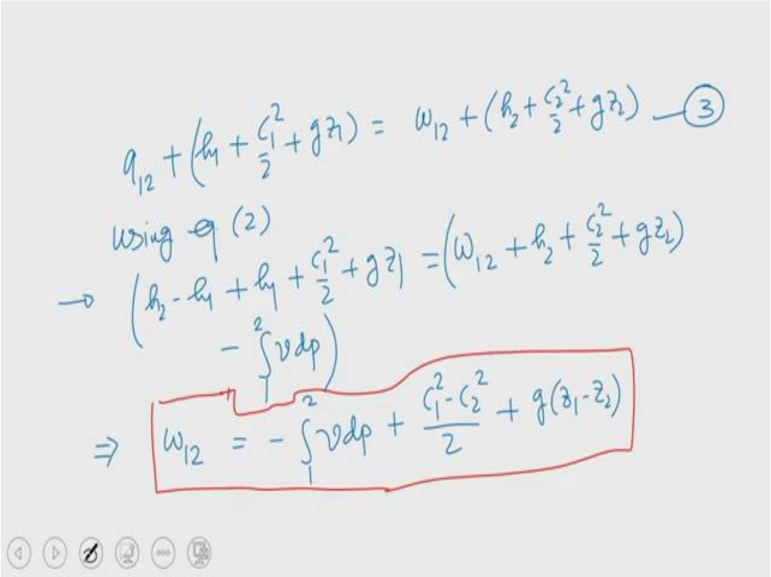

$$q_{12} + \left(h_1 + \frac{c_1^2}{2} + gz_1\right) = w_{12} + \left(h_2 + \frac{c_2^2}{2} + gz_2\right) — ③$$

using eq (2)

$$\rightarrow \left(h_2 - h_1 + h_1 + \frac{c_1^2}{2} + gz_1 - \int_1^2 vdp\right) = \left(w_{12} + h_2 + \frac{c_2^2}{2} + gz_2\right)$$

$$\Rightarrow \boxed{w_{12} = -\int_1^2 vdp + \frac{c_1^2 - c_2^2}{2} + g(z_1 - z_2)}$$

So now, using equation 2 we can write

$$\left(h_2 - h_1 + h_1 + \frac{c_1^2}{2} + gz_1\right) - \int_1^2 vdp = \left(w_{12} + h_2 + \frac{c_2^2}{2} + gz_2\right)$$

$$\Rightarrow w_{12} = -\int_1^2 vdp + \frac{c_1^2 - c_2^2}{2} + g(z_1 - z_2)$$

So, this is very important form which we wanted to have. So, what you can see? The above equation gives us the expression for the work which should be added or the energy which should be added in the form of work for a steady state steady flow process which is also reversible and adiabatic.

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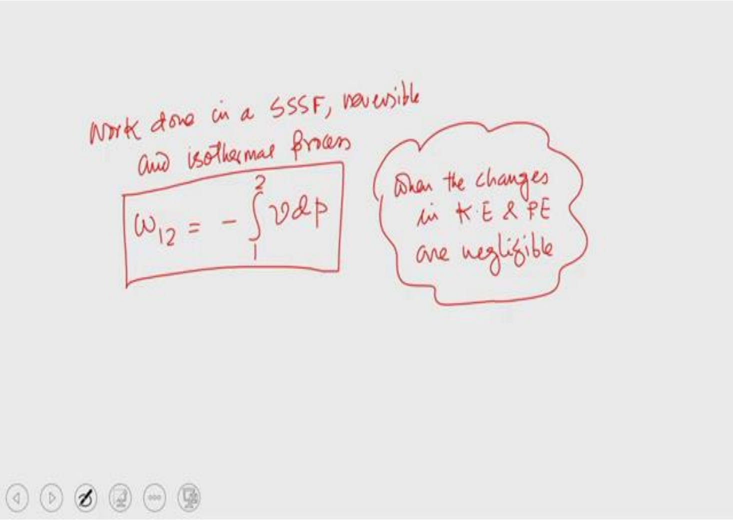

Work done in a SSSF, reversible and isothermal process

$$\boxed{W_{12} = -\int_1^2 v\,dp}$$

When the changes in K.E & PE are negligible

If we do not consider the changes in kinetic and potential energies then we can write that work done in a steady state steady flow, reversible and isothermal process,

$$w_{12} = -\int_1^2 vdp$$

This equation holds good when the changes in kinetic energy and potential energy are negligible. So, this is very important. If they are not negligible, we cannot write. If they are negligible we can write this form.

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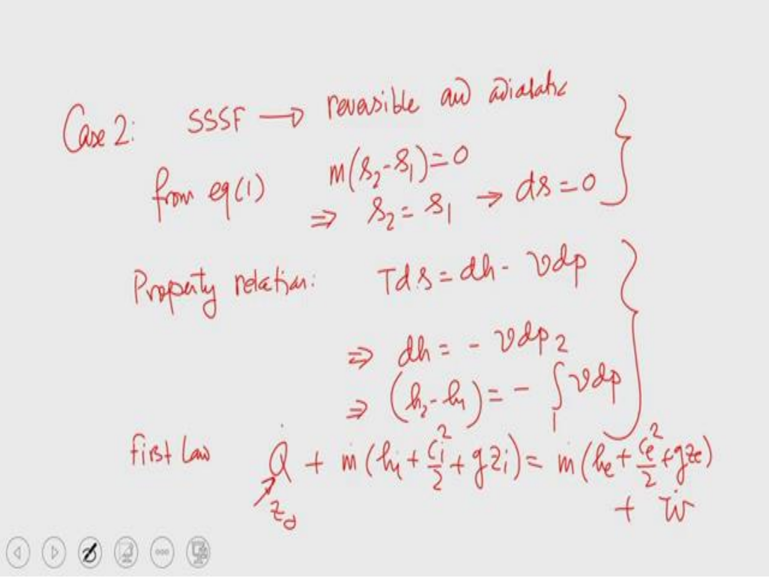

Case 2: SSSF → reversible and adiabatic

from eq(1) $\dot{m}(s_2 - s_1) = 0$

$\Rightarrow s_2 = s_1 \rightarrow ds = 0$

Property relation: $Tds = dh - vdp$

$\Rightarrow dh = -vdp$

$\Rightarrow (h_2 - h_1) = -\int_1^2 vdp$

first Law $\underset{\text{zo}}{\dot{Q}} + \dot{m}\left(h_i + \frac{c_i^2}{2} + gz_i\right) = \dot{m}\left(h_e + \frac{c_e^2}{2} + gz_e\right) + \dot{W}$

So, let us try another case.

Case-1: SSSF but now the process is reversible and adiabatic

So, when process is reversible as well as adiabatic then what would be the expression of this quantity work done?

$$\text{From equation} - 1, \text{Second Law or the flow process,} \qquad m(s_2 - s_1) = 0$$

$$\Rightarrow s_2 = s_1 \Rightarrow ds = 0; \text{Hence that is Isentropic process.}$$

Reversible adiabatic process is also called the isentropic process.

$$\text{Property Relation} \rightarrow Tds = dh - vdp$$

Why? Because pressure is changing in this is a flow process. $Tds = du + pdv$ That is applicable to any processes but in this particular process we are writing $Tds = dh - vdp$ because pressure is changing from state 1 to state 2.

$$\Rightarrow dh = -vdp$$

$$\Rightarrow \text{Change in enthalpy,} (h_2 - h_1) = -\int_1^2 vdp$$

So, this is what we can write. So, if the process is steady state steady flow process and along with that the process is reversible and adiabatic, then the process is isentropic process. So, reversible adiabatic process is isentropic process because entropy is not getting changed.

So now, let’s write the first law for reversible adiabatic process

$$\dot{Q} + \dot{m}\left(h_i + \frac{c_i^2}{2} + gz_i\right) = \dot{m}\left(h_e + \frac{c_e^2}{2} + gz_e\right) + \dot{W}$$

So, this is the rate equation. Now, the quantity $\dot{Q} = 0$ because this is reversible adiabatic process, hence there is no heat interaction between system and surroundings.

For the reversible adiabatic process, $ds = 0$ (isentropic process),

For adiabatic process that is $\dot{Q} = 0$

For single entry and single exit, we could write $\dot{m}_e = \dot{m}_i = \dot{m}$

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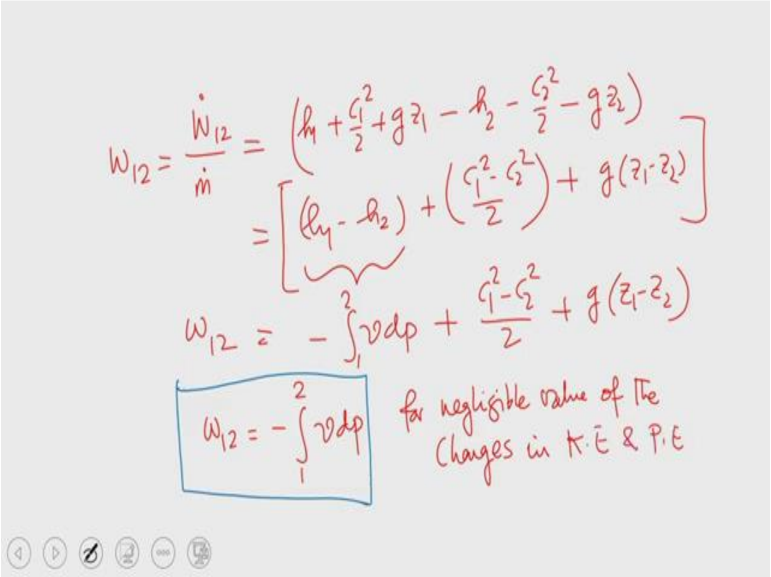

$$w_{12} = \frac{\dot{W}_{12}}{\dot{m}} = \left(h_1 + \frac{c_1^2}{2} + gz_1 - h_2 - \frac{c_2^2}{2} - gz_2\right)$$

$$= \left[\underbrace{(h_1 - h_2)} + \left(\frac{c_1^2 - c_2^2}{2}\right) + g(z_1 - z_2)\right]$$

$$w_{12} = -\int_1^2 vdp + \frac{c_1^2 - c_2^2}{2} + g(z_1 - z_2)$$

$$\boxed{w_{12} = -\int_1^2 vdp}$$

for negligible value of the changes in K.E & P.E

From the first law, we can write,

$$w_{12} = \frac{\dot{W}_{12}}{\dot{m}} = h_1 + \frac{c_1^2}{2} + gz_1 - h_2 - \frac{c_2^2}{2} - gz_2$$

$$= (h_1 - h_2) + \left(\frac{c_1^2 - c_2^2}{2}\right) + g(z_1 - z_2)$$

$$= -\int_1^2 vdp + \left(\frac{c_1^2 - c_2^2}{2}\right) + g(z_1 - z_2)$$

From the property relation $(h_1 - h_2) = -\int_1^2 vdp$

Again, if we just ignore the changes in kinetic and potential energies, then the work done even for a steady state steady flow process but the process is reversible and adiabatic can be written,

$$w_{12} = -\int_1^2 vdp$$

So, for the negligible value of the changes in kinetic and potential energies, we can write this is the expression.

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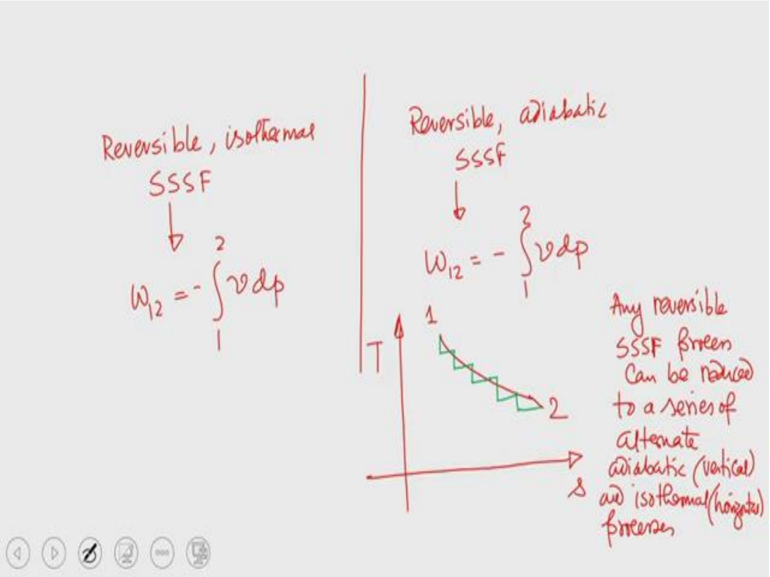

Reversible, isothermal
SSSF

$$W_{12} = -\int_1^2 v\,dp$$

Reversible, adiabatic
SSSF

$$W_{12} = -\int_1^2 v\,dp$$

Any reversible SSSF process can be reduced to a series of alternate adiabatic (vertical) and isothermal (horizontal) processes

So, for the reversible isothermal, steady state steady flow process, work done

$$w_{12} = -\int_1^2 vdp$$

For the reversible adiabatic, steady state steady flow process, work done

$$w_{12} = -\int_1^2 vdp$$

So, the expression of work done for the reversible, steady state steady flow process is generic and it does not depend whether the process is adiabatic or isothermal. So, this is what is important. So, our objective was to find out, what would be the expression of W_{in} which is added to the pump? If the process is reversible isothermal or reversible adiabatic, there will be a slight change in temperature of the flowing fluid because of the dissipative effect and considering this if we try to represent the process by the reversible adiabatic process, even then the expression of work done is remaining same that is nothing but $-\int_1^2 vdp$. Why it is so? Basically you know that for a reversible, steady state steady flow process, the expression of work done is same. It indicates that any reversible process steady state process can be reduced to a series of alternate reversible adiabatic and isothermal processes.

So, we try to represent the processes in T-s plane, So, X-axis is s & Y-axis is T. So, say a system is changing from state 1 to state 2. Now, what I was discussing that expression is same. So, basically the reversible steady state steady flow processes can be reduced to a series of reversible and adiabatic processes. So, conclusion is any such process can be reduced to a series of alternate reversible adiabatic that is vertical line and reversible isothermal that is horizontal line.

So, you know that if we try to summarize, we have discussed about the mathematical expression of the work done for both these steady state steady flow reversible isothermal and adiabatic processes. And we have seen that the mathematical expression is the same, no matter whether the process is isothermal or adiabatic.

And from there we could conclude that any such process can be reduced to a series of alternate, reversible adiabatic and reversible isothermal processes. So, this particular exercise will give us a clue about the mathematical form of the work which is needed to add to the pump for supplying the condensate from the condenser to the boiler.

So, with this, we complete our discussion on the basic of the first and second law applied to the processes which are there in the power plant. In the next class, we shall start our discussion from the ideal power cycle. So, with this I stop here today. Thank you.