Concepts of Thermodynamics
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Lecture – 67
Supplementary Lecture: Problem Solving with the Aid of a Computer

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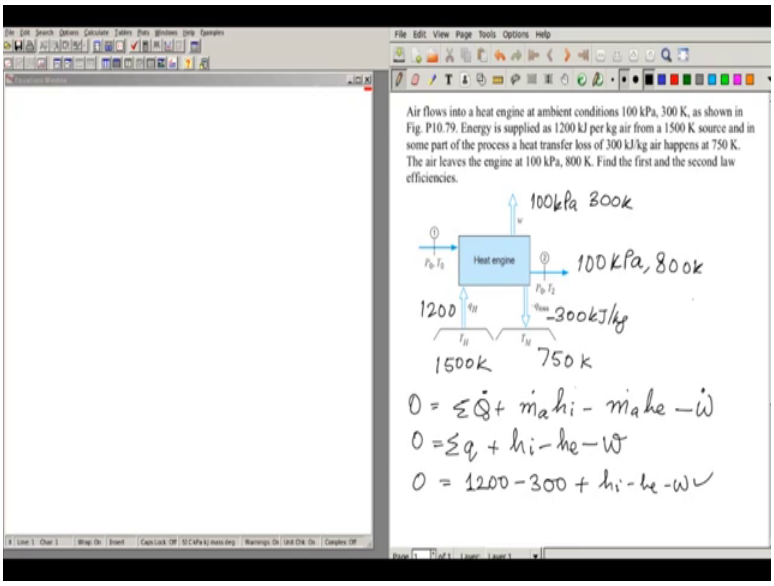

Hello and welcome to the session in which we are going to solve problem 10.79. In which we have ambient conditions as 100 kilo Pascal and 300 Kelvin. Energy is supplied as 1200 kilo joule per kg air from a 1500 Kelvin source. So, this thing is at 1500 Kelvin and the energy supplied is 1200 kilo joule per kg. In some part of the process, heat transfer loss so, the loss is 300 kilo joule per kg and this happens at 750 Kelvin. The air leaves the engine at 100 kilo Pascal and 800 Kelvin. So, we have to find out the first and the second efficiencies.

So, because it is a loss I will write this as minus 300 kilo joule per kg. So, if you write down the first law for a steady state steady flow process with all the heat transfers accounted for. We have 0 is equal to summation of Q dot plus m dot air hi minus m dot air he minus w dot, where we have neglected the kinetic energy and potential energy changes as air passes from state 1 to state 2. If we divide by the mass of air we have 0 equal to summation of q plus hi minus he minus w. This is equal to 0 equal to 1200 kilo joule per kg minus 300 kilo joule per kg plus hi minus he minus w. So, this will yield the work done during the process.

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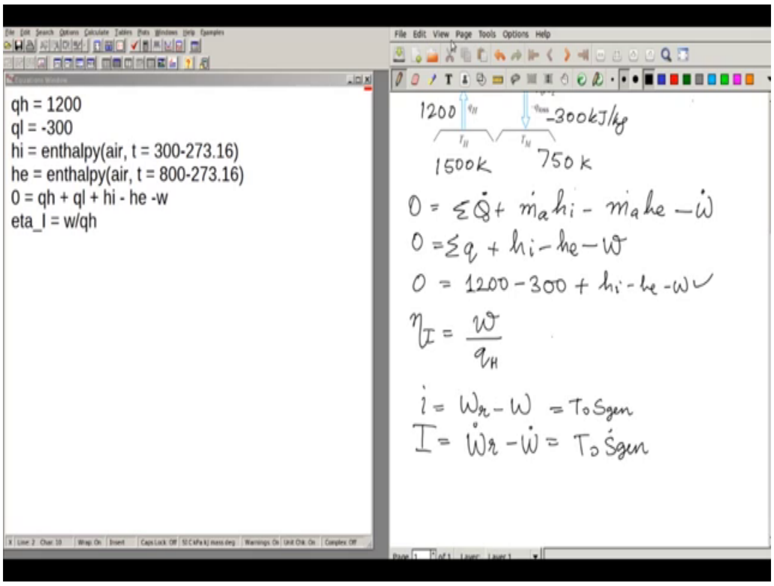

So, the definition of the first low efficiency, this is equal to the work obtained during the process by the amount of heat input to the process. So, this should be divided by q H. So, let us go to a computer and see what the calculation tells us.

So, we have qh equal to 1200, ql equal to minus 300, hi is the enthalpy of the inlet air. So, because air is considered as an ideal gas, the enthalpy is simply a function of temperature and in this case it is 300 Kelvin rather is if we make it 10 degree Celsius it is this, he is the enthalpy of air at t equal to 800. So, then we write down the balance the first law for the steady state steady flow process. So, it is q h plus q l plus h i minus h e minus w and eta i or eta 1 is equal to w by qh.

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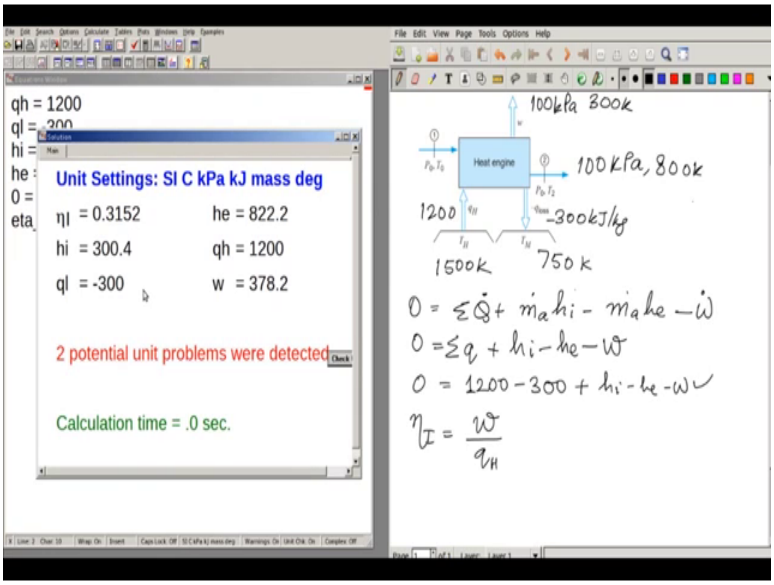

So, if you solve this we obtain the first law efficiency as 0.3152. Now, coming to the second law efficiency the way to do it is that, we first find out the reversible work and then we compared the work obtained during this actual process against the benchmark of the reversible work. So, how do you find the reversible work? We note from our studies that the irreversibility is defined as the w reversible minus w which is nothing, but T 0 into S gen. So, if you write down the. So, this is written in a per unit mass basis. So, this should be small i rather if I write it down as this which is w dot reversible minus W dot is equal to T 0 S dot gen ok. So, how do we find the expression for T 0 S dot gen?

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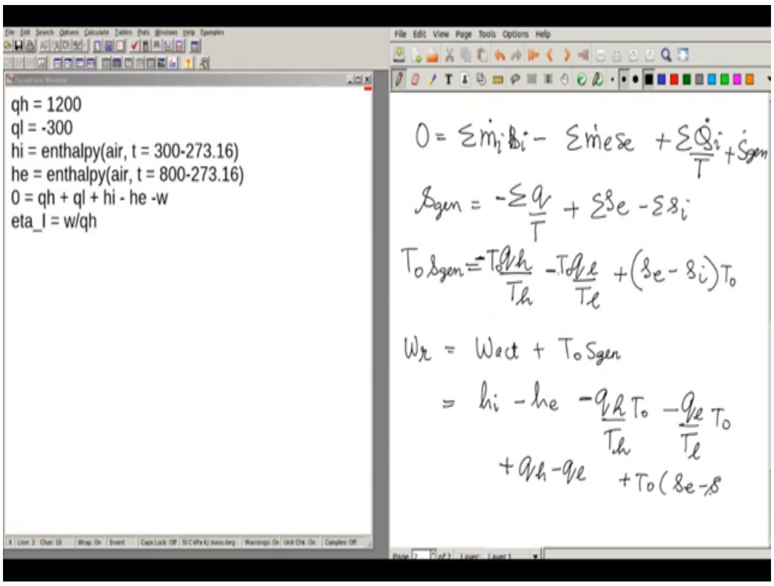

So, we have for the steady state steady flow process 0 is equal to summation of m dot i si minus summation of m dot e se minus summation of Qi by T 0 Qi dot plus S dot gen. If I divide by the mass flux then I have simply s gen is equal to summation of q by T plus se minus si. In this case this will be q h by T h plus q l by T l plus se minus si. See if I do T 0 into s gen this will be simply multiplied by T 0.

So, w reversible if we look at this particular formula this will be w actual plus T 0 into s gen, where w actual I mean already we have it, but still just to go through the derivation w actual will be h i minus h e plus should have been plus. So, pardon me that sign mistake was there. So, this is all minus it is a very anyway. So, minus q h by T h multiplied by T 0 minus q l by T l there are T 0 plus q h minus q l plus T 0 se minus s i.

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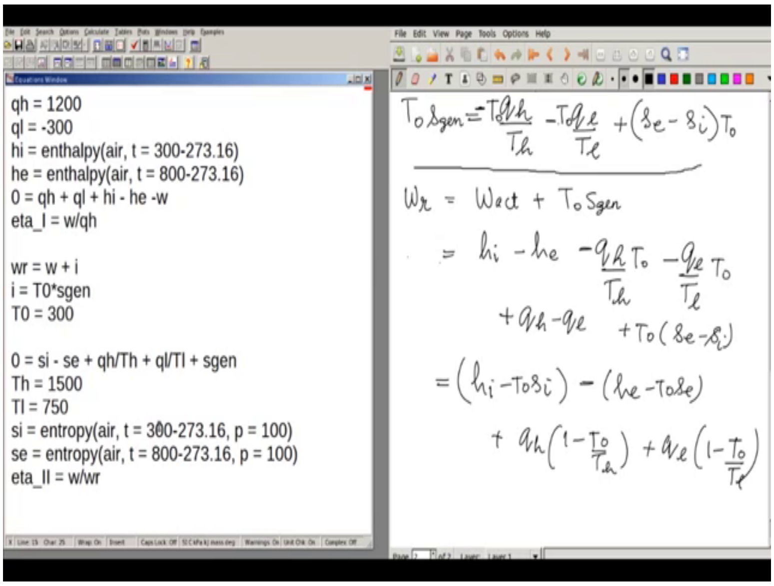

And this gives us the classical formula that we have which will be nothing, but h i minus T 0 si minus of h e minus T 0 se plus q h 1 minus T 0 by T h plus q l 1 minus T 0 by T l and so, on where all the temperatures are; obviously, in Kelvin.

However this expression in mind let us go ahead and encode this into the computer. So, for this I knew now need to just work with this particular equation because once T 0 s gen is known, I can simply add the w actual to find the w reversible ok. So, the very first equation is w reversible is equal to w plus the irreversibility, where irreversibility is equal to T 0 multiplied by sgen where T 0 in this particular case let us go and look into the problem what is T 0, it is 300 Kelvin. So, T 0 is 300 we need all the temperatures in

Kelvin now. So, now let us write down the expression for s gen. So, 0 is equal to si minus se plus q h by T h minus rather plus q l by T l. So, for those of you who are wondering how I have written a positive sign despite q being a lost.

The fact is I have accounted for the negative sign already in this expression. So, I do not need to account for a negative sign over here the sign is already conveyed ok. So, this expression will give me sgen; however, T h and T l have to be defined. So, T h is 1500 Kelvin T l is 750 Kelvin, si is the entropy of air at t equal to the given conditions and p equal to 100 kPa; se is the entropy of air at t equal to the given temperature at exit and the given pressure at exit.

So, the given pressure is also; so, the yeah like this both the pressures are at atmospheric pressure. So, the inlet and the exit of the heat engine are at 100 kilo Pascal. So, that gives us the entropy at the inlet and exit; unlike the enthalpy the entropy is a function of both pressure and temperature as you might have seen in theory class.

So, with this we should now be able to obtain sgen let us see yes we do have s gen. So, then we also have the irreversibility and w reversible. So, the eta second law should now be equal to w by w reversible let us see what the value is, it comes out to be 0.6719.

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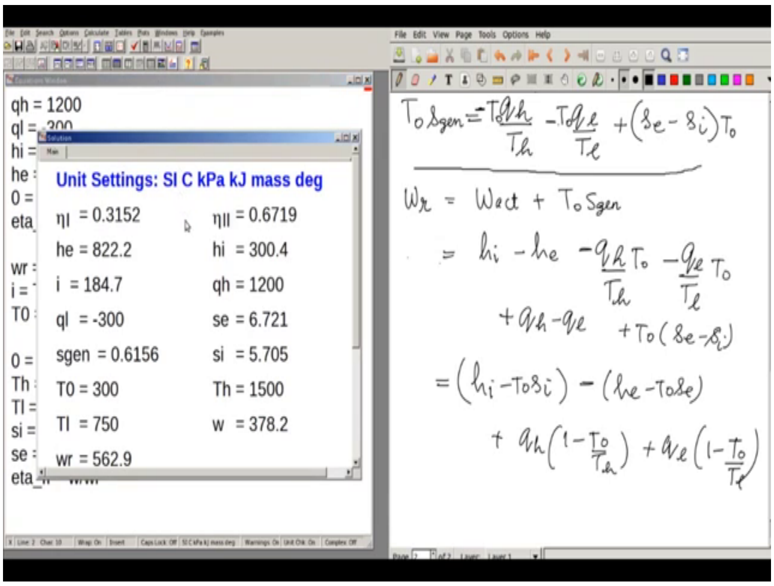

So, essentially of the possible 562.9 kilo joule per kg one is able to only make use of the 378.2 kilo joule per kg. Implying that you are only able to use 67.2 percent of the total work that you could have hypothetically obtained if you were to convert all the processes into a reversible process, implying the sgen of the total cycle should be 0. So, the derivation and the problem should make the ideas of the first law and second law efficiency very clear and with this not I end this video, I will see you next time.