Concepts of Thermodynamics
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Lecture – 68
Supplementary Lecture: Problem Solving with the Aid of a Computer

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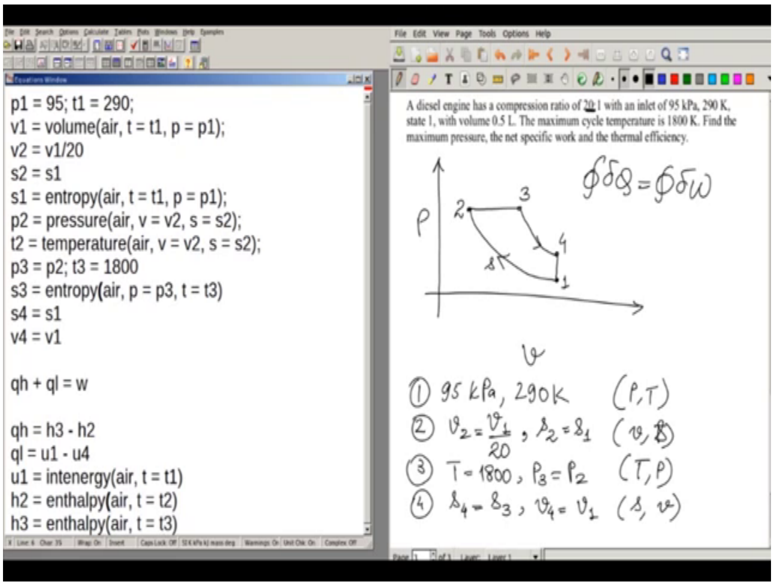

Hello and welcome to this session in which we are going to analyse a diesel engine. So, we have been given that we have a diesel engine with a compression ratio of 20 is to 1 ratio. So, let me first draw the p v diagram. So, we have a compression like this and then a heat addition at constant pressure and then an isentropic heat rejection, an isentropic expansion and followed by heat rejection. So, 1 to 2 is the isentropic compression, 2 to 3 is the constant pressure heat addition, 3 to 4 is the isentropic expansion and 4 to 1 is the heat rejection.

So, state 1 is given as 95 kilo Pascal 290 Kelvin slightly below the atmosphere because it is a suction process. State 2 so, because compression ratio is given as 20 is to 1 the specific volume at state 2 will be 1 20th the specific volume at state 1 ok. Moreover, the entropy at state 2 will be the same as the entropy at state 1 because it is an isentropic process; it is an isentropic compression process.

A state 3 because we are adding heat so, state 3 will be at a temperature of 1800 Kelvin which is the maximum temperature given. And, the pressure at point 3 will be the same as pressure at point 2. Coming to state point 4 the space, the entropy at state point 4 will be equal to the entropy at state point 3. And, the specific volume at state point 4 will be equal to specific volume at state point 1.

So, the first point is quantified in terms of the pressure and temperature, the second in terms of specific volume and entropy, third in terms of temperature and pressure and the fourth in terms of entropy and specific volume. Let us proceed to the computer and see what we can get out of this.

So, p 1 is 95 t 1 is 290, so I have set the units in e s to be in Kelvin, v 1 will be the volume of air at t equal to t 1 and p equal to p 1. As per the information about the compression ratio v 2 will be v 1 by 20 and s 2 equal to will be equal to s 1 where, s 1 equal to entropy of air t equal to t 1 and p equal to p 1 so far so good. So now, with the help of s 2 and v 2 we can find out p 2; p 2 is pressure of air at v equal to v 2 and s equal to s 2.

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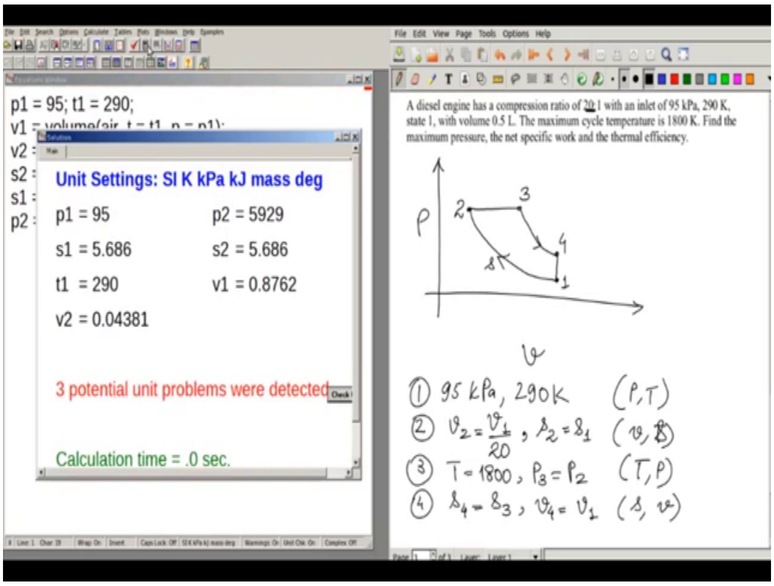

So, let us see what the pressure is; so, the pressure comes out to be approximately 5.9 mega Pascal that is a lot of pressure. So, p 3 will also be correspondingly equal to p 2 and t 3 will be also equal to 1800 Kelvin. So, then s 3 will be entropy of air at p equal to p 3 and t equal to t 3 and s 4 will be equal to s 1, v 4 will be equal to v 1.

So, now that we have all the points let us find out the network. So, if you recall the first law for a cycle closed integral of the total heat added will be equal to the closed integral of the total work done. So, because of this we can write qh plus ql will be equal to the network where, we will account for the sign of q appropriately. So, the heat added is during the process 2 to 3. So, q h will be equal to h 3 minus h 2 because it is a constant pressure process. The heat addition will not be simply the difference in the internal energies. So, this should have been covered in theory class.

In case of a constant pressure process the heat added will be equal to the difference in enthalpies and not the internal energies because, you are already accounting for the constant pressure work as p v. So, u plus p v will become h, this should be clear by now, but the q l will be equal to u 1 minus u 4 because, the heat rejection is going on during process 1 to 4. So, during 1 to 4 the process is constant volume and a as a result it will be simply u 1 minus u 4. So, the task now remains is to find the internal energies and the enthalpies.

So, u 1 will be intenergy air, t equal to t 1. So, let us write down the expression for t 2 because, we will need the temperature to find out the internal energy at point 2 or rather the enthalpy at point 2. So, h 3 is simply known because the temperature at point 3 is given as the highest temperature achievable in the cycle which is t 3 which is 1800 Kelvin.

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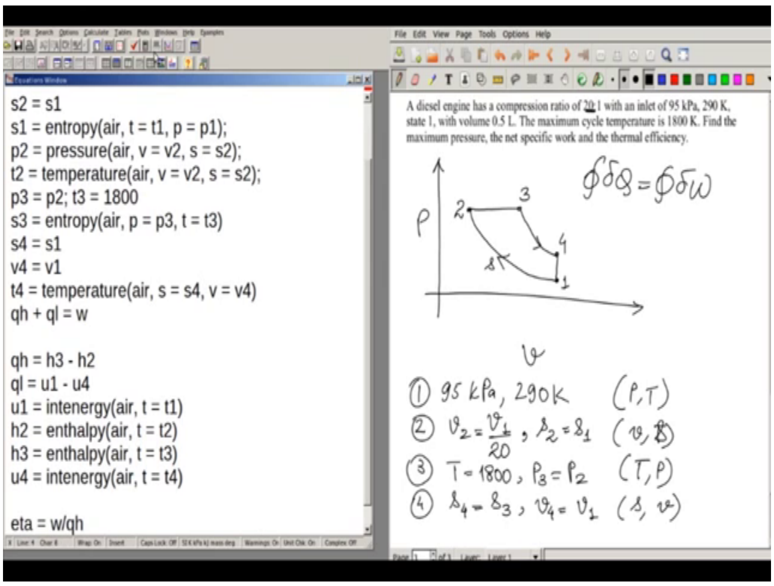

And u 4 is the; so t 4 we can find out using s 4 and v 4. So, with the help of this and the heat we have eta is equal to w by q h, this defines the thermal efficiency.

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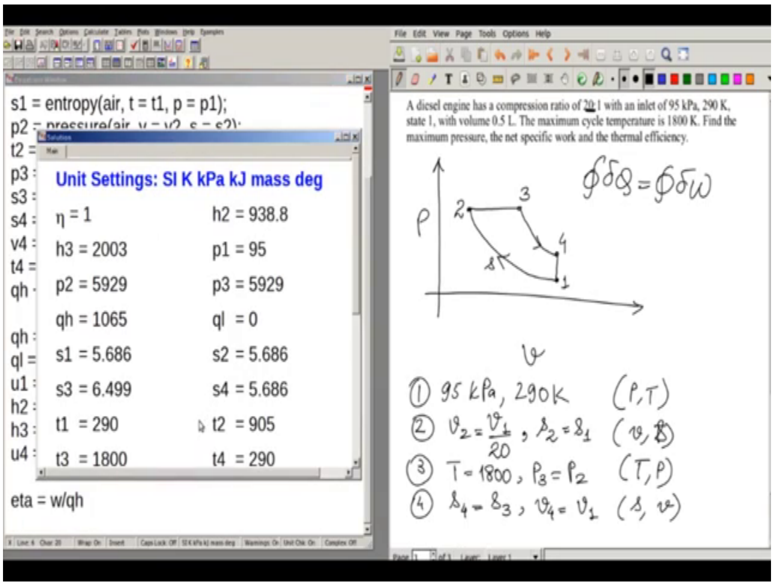

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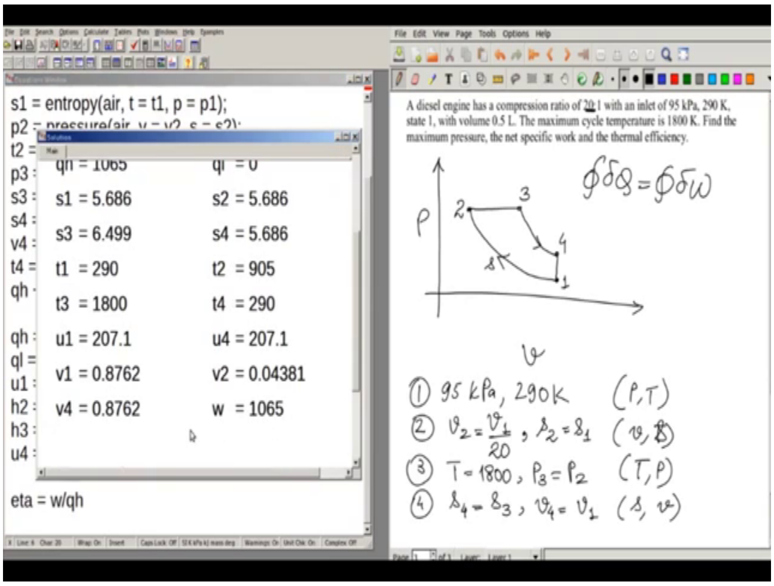

So, the net specific work of the engine is 1065; there seems to be a small mistake because, q l appears to be 0. So, let us have a look what is wrong. So, t 4 has come out surprisingly to be 290.

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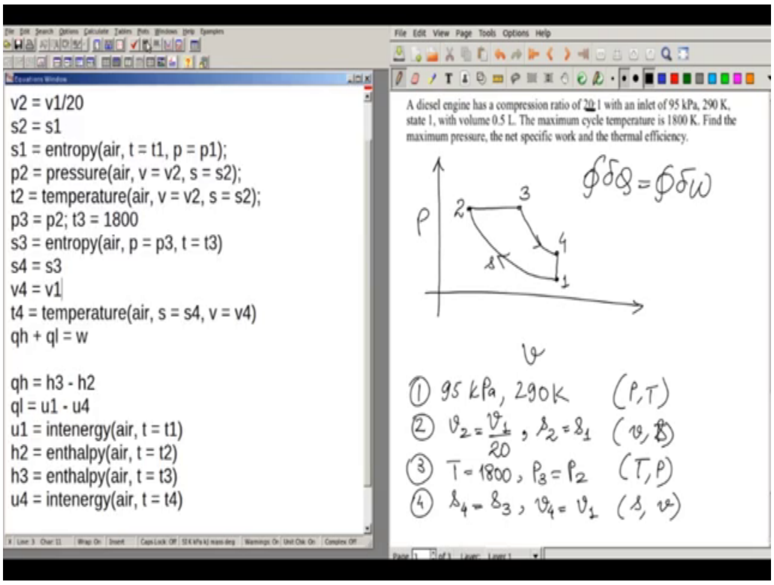

So, let us see what is wrong. So, this is the mistake s 4 is not equal to s 1 rather it is equal to s 3. So, because this is small mistake we were able to get points 4 and 1 identical ok. So, the q l is equal to minus 430. So, we already seen that we are did not account for the sign and rotate simply s q h plus q l. But, because q l is negative we understand that the process from 4 to 1 is losing heat instead of gaining heat.

The heat gained is 1065 kilo Joule during process 2 to 3, as a result the work is 634.1 kilo Joule per kg and the thermal efficiency of the cycle is 5956 percent. So, with this we conclude this session on diesel engine and I hope it will be clear on how to solve such kinds of questions in as and when you encounter them. So, with this we close the session I will see you next time bye.