Engineering Thermodynamics
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Week-03
Lecture-14
Energy Analysis of Closed System

Welcome to this video. We were discussing the Energy analysis of closed systems. We also discussed boundary work in the previous lecture. We will discuss some problems and processes in this video. We will also discuss some examples of problems. Let's move ahead. There is a process called polytropic process as we saw in the previous lectures Expansion and compression process is there in which These are common processes Usually these processes Work on many devices But in a specific process The relation of pressure and volume is in this form Means V to the power n is constant. Now you must have noticed some examples. For example, if n is 1, then PV is equal to C. some processes follow this. This means that when we do this the temperature is constant, that is also a polytropic process, but n is 1. So, this has been generalized and many types of systems can be included in this. If you pay attention, then this is like if we understand it through the graph, then this is the P and V diagram and this is initial state, final state and this is your process. And we call this process Pb to the power n is equal to constant.

$$PV^n = C$$

Now,

$$W_b = \int_1^2 P dv = \int_1^2 CV^{-n} dv = C\,\frac{{V_2}^{-n+1} - {V_1}^{-n+1}}{-n+1} = \frac{P_2V_2 - P_1V_1}{1-n}$$

Ideal GAS PV = mRT

$$W_b = \frac{mR(T_2 - T_1)}{1-n} \qquad n \neq 1$$

So, this is a generic expression that we can use. But it is not necessary that you have to remember it, or you can derive it. And when n is 1, as I said earlier, then your PV is equal to C. And if PV is equal to C, then it will happen when the temperature is constant. So normally, the pressure-volume relation comes out like this in the temperature constant. But for the ideal gas, it comes out clearly. And if you consider it in this relation, then this is your simple P1V1 and if you replace P with 2, then you get this relation we had done this problem in the previous lecture as well so that is the same thing if you take the ideal gas in this, then it can be easily obtained if you are talking about the ideal gas on the basis of temperature and the constant pressure process is $P\Delta V$ we have done this before as well and what is the boundary work in the constant work process? So, this is the summary of the last lecture. Now we will try to understand this more using the example. This is the polytropic process. So, this is your gas, which is a piston cylinder, and this cylinder has weights on it. So, the total weight is so much that the initial pressure is 200 kPa and the volume is 0.04 m3. Now let's put a burner here, which is your burner. This will expand the volume and it will become 0.1 m3 but since its weight is constant, it will work on constant pressure. In this case, if you want to get work done, how will you do it? It is simple. As we said earlier, in the work done process, Wb is simple, PdV will come, 1 to 2. And here the pressure is fixed, so this is V2 minus V1. And V2 is also given, V1 is also given, and pressure is also given. So, this is your 200 kPa. 1 minus 0.04-meter cube you can write it in kilo joules, and it comes out as 12 kilo joules So this is the first part. Now the second question is, if we consider that the initial state is similar, i.e. 0.04 m3 or 200 kPa, but the burner is burning in such a way that the piston is rising, but we have also gradually removed the weights. is done satire is a key is cut temperature constant So we will always consider this air as an ideal gas. So, if we consider this air as an ideal gas, then P1 is equal to mRT. If we consider this air as an ideal gas, then this temperature is constant. This means that if we talk about polytropic, then P1 is equal to constant, and n is equal to 1. So, this is the process of polytrophic process on n equal to 1.

$$W_b = \int_1^2 P dv$$

$$= P_1 V_1 \ln \left(\frac{V_2}{V_1}\right)$$

you put values on this 200 kPa 0.04 m3 and your value is 0.1 divided by 0.04 and you can convert it to kilo joules And this is also called 7.33KJ The special thing is that we have considered it as Pb is equal to mRT So we took a C and derived the expression which we derived from here So we considered the same expression in the future Now let's see the third part of this In this part, you are given that the system is the same The heat transfer that we are considering is done at this rate, which is in the case of this particular burner. It is happening that the process is following this expression. PV1.3 is equal to constant. So, in this process, as we said in this case, PV is equal to constant. Now, the way we are changing the weights, or the process is complete, PV 1.3 is equal to constant. So again, it is a polytropic process. And in this, the ratio of volume is the same. The final volume is the same. V2 is 0.1 m3 and V1 is 0.04 m3. Right? and initial pressure is 200 kg so, the question is how to calculate this and in this as this is a constant, you can notice that V1 is 1.3 and P2 V2 is 1.3 which means P2 is V2 by V1 1.3 So this will be V1 by V2, V1 by V2, 1.3 and this will be P1. So, 200 kPa. times v1 is 0.04 and this is 0.1 this is 1.3 so this is 60.77 kPa so you have got P2 so you can remove its boundary work this is your PDB which is a generic statement for polytropic process this one statement. P2 V2 minus P1 V1 divided by 1 minus n. So, either you can use it directly or you will have to solve it and it will come out. 1-n is 1.3 so if we add values to it will be 60.77 x 0.1-200 x 0.04 1-1.3 kPa cube which is 6.41 kJ polytropic process and 1.3. Well, a project example. We are free. Baga is a question. Agar, you consider Kiki. Is me. initial state same as you considered that this is a piston, and your P is equal to 200 kPa There are weird things here. But in this section, it says that the piston is attached with a pin, which it cannot move. If the pin is attached here, it is not moving. This means that this is the volume of the constant. And it says that we are transferring heat from this way. Now it is that the heat is transferred from the system. So, the heat is transferred from the system by this way So, the pressure is 100 kPa from P2 to P1 So, what will be the Wb in this case? So, in this case, since WB is PDV, since the volume is constant, it will be zero So, the work will be zero in this case We are assuming that this is a quasi-equilibrium process, so these are your 4 parts in this question. So, if you look at it like this, its works are different. So, these 4 questions can be presented in the PV diagram. 4 m3 and final volume is 0.1 m3 the pressure constant in A so this is A and this is process and the second problem is because the work was more than C so this was PV is equal to constant and this was PV 1.3 and this is your constant volume So these are the 4 problems that we solved using different conditions but you can understand that these were all polytrophic processes So I hope that the questions that we took helped you understand the concept of boundary work better and we will move forward with this energy balance as the next lectures will focus on this so see you again in the next lecture till then.