University of Djilali Bounaama of Khemis Miliana
Faculty of Science and Technology
Department: Physics
Second year Bachelor: Physics_(2023/2024)

Tutorials. No. 1: Thermal Machines

Exercise 01: (Thermal motor/ refrigeration machine)

Consider a dithermal heat machine, where the hot source is at a temperatureT_1 and the cold source is at a temperatureT_2. The fluid of this machine exchanges heat$Q_1$with the hot source, $Q_2$with the cold source, and performs work. The fluid is assumed to behave as an ideal gas. Initially, the fluid in state A undergoes the following transformations: an isothermal compression AB at T_2, an adiabatic compression BC, an isothermal expansion CD at T_1, and finally an adiabatic expansion DA.

1. Represent this cycle on a Clapeyron diagram. Indicate the direction in which it is traversed and the sign of the work.
2. Show that: (VA/VB) = (VD/VC).
3. Determine the expressions for the heatQ_1 and Q_2exchanged by the fluid. Deduce the Clausius equality: $(Q_1/T_1) + (Q_2/T_2) = 0$.

   Provide a simple interpretation of this equality.

4. This machine is used as a refrigeration machine. Sketch the schematic diagram of this machine, indicating the directions of the exchanged heat and work.
5. Calculate the efficiency of this machine for θ_1 = 25°C and θ_2 = -15°C.
6. Calculate the heat extracted from the cold source if the machine has consumed 12 kJ of work.

Exercise 02: (Diesel motor)

We consider the following Diesel motor: the same amount of an ideal gas undergoes a reversible cycle ABCDA:

- Transformations AB and CD are adiabatic.
- Transformation BC is isobaric, during which the gas receives heat Qc from a hot source.
- Transformation DA is isochoric, in contact with the atmosphere acting as the cold source.

Given: ratio of specific heat capacities $\gamma = Cp/Cv = 1.4$, and $R = 8.314$ J/(K·mol).

The table below summarizes the data regarding the different states of the gas.

	A	B	C	D
P (Bar)	1,00			
T (K)	323	954		
V (L)	2,40		0,24	2,40

1- Copy the table above and complete it by determining the volumes, temperatures, and pressures of states B, C, and D.
2- Plot the shape of the cycle described by the gas on the Clapeyron diagram, specifying its direction.
3- Calculate the number n of moles of gas undergoing these four transformations.
4- Calculate the specific heat capacities at constant volume and constant pressure.
5- Calculate the work and heat exchanges for the gas during each of the transformations AB, BC, CD, and DA.
6- Define the thermal efficiency of the studied Diesel engine and calculate it numerically.
7- Provide the expression for the efficiency of a Carnot engine operating between two sources at equal temperatures T_A and T_C, and calculate it numerically.
8- Compare the two efficiencies. What conclusions can you draw?