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Internal energy of the earth's atmosphere between day and night.

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Abstract

Astrophysicist R. Edmen had shown that the internal energy of the air inside a cabin remains unaffected even if the woods are lit in the cabin. This result can be extended to the case of the earth's atmosphere between day and night, where the internal energy also does not change.

Thermodynamics books are silent as far as the internal energy of the earth's atmosphere between day and night is concerned. Many times, students have asked it in class. The answer to this can be derived from the response to the question asked by astrophysicist R. Edmen[1,2,3]. "Why do we have winter heating?" What is the rationale for our comfort? It has been explained as follows: Initially, the temperature T_1 in the room is about $0°C$, and once the woods are lit, the air in the cabin gets warmer $(T_2 \sim 20°C)$, it expands, and a part moves out through small openings around the doors and windows in the adiabatic walls, so that the mass of air in the cabin changes from m_1 to m_2; the volume V of the cabin and the air pressure P, however, remain constant. The internal energy $U = mC_VT$ of the air in the cabin is proportional to its mass m and its absolute temperature T; C_V is the specific heat at a constant volume $-$ a constant for an ideal gas. Internal energy can be evaluated using

$$PV = \frac{m}{\mu}RT; n = \frac{m}{\mu} \qquad (1)$$

Here R is the gas constant, while μ is its molar mass, and n is the number of moles of air. As the pressure in the cabin remains equal to the outside atmospheric pressure and the volume of the room does not change, there is only a change in the air mass. So,

$$m_1T_1 = m_2T_2 = \frac{PV\mu}{R} = constant. \qquad (2)$$

So, after the firewood is burned, the internal energy of the air in the cabin really doesn't change. Thus, we heat our buildings in winter to make energy available at a higher temperature, as an individual's feeling of comfort or discomfort in the room depends primarily on the relationship between room temperature and his body temperature.

The above discussion of the winter heating of a room matches the heating of the atmosphere during the day. The atmospheric air is considered a mixture of mainly two diatomic gases, oxygen and nitrogen, exerting an atmospheric pressure of 101325 Pa over the entire globe, irrespective of day and night.

During the day, this atmosphere gets heated to T_1,
expanding the air at constant pressure, whereas the atmosphere on the night side contracts as it cools down to temperature T_2, with the atmospheric pressure remaining the same.
The expanded part of the air moves towards the night side so that the mass of air changes on both sides; let it change from m_1 to m_2 during the day, whereas the volume V and the air pressure P remain unaffected. So, once again, we arrive at relation (2)

$$m_1 T_1 = m_2 T_2 = \frac{PV\mu}{R} = constant.$$

So irrespective of whether it is day or night, the internal energy doesn't change. Thus, during the day, the air is available at a higher temperature, and at night, it is otherwise.
<u>There is no conflict of interest.</u>

References

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