TERMODINAMIK SISTEMALARNING TAJRIBALARDA O‘RGANILISHI

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Annotatsiya. Maqolada fizikaning bo‘limlaridan biri bo‘lgan Termodinamikada asosiy tushuncha bo’lgan termodinamik sistemalar haqida yoritilgan. Termodinamika oliy ta’lim muassasasi o’quv dasturining predmeti, termodinamikani o’qitish metodikasi fizika o`qituvchisining kasbiy tayyorgarligining asosi, termodinamikani fan sifatida o`qitish metodikasining mazmuni va vazifalari, termodinamika o`qitish metodikasi fanini o`rganish metodikasi kabi qator masalalarida fikr yuritiladi.

Tayanch so’zlar: termodinamika, issiqlik hodisalari, ma’ruza, laboratoriya ishlari, mashg’ulot, o’qitish, fizika metodikasi, metodlar, samaradorlik, baholash, dars.

ЭКСПЕРИМЕНТАЛЬНОЕ ИЗУЧЕНИЕ ТЕРМОДИНАМИЧЕСКИХ СИСТЕМ

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Аннотация. В статье описаны термодинамические системы, являющиеся основным понятием термодинамики, одного из разделов физики. Термодинамика – предмет учебной программы высшего учебного заведения, методика преподавания термодинамики – основа профессиональной подготовки учителя физики, содержание и задачи методики преподавания термодинамики как науки, методика обучения ведется наука термодинамика.

Ключевые слова: термодинамика, тепловые явления, лекция, лабораторная работа, обучение, преподавание, методика физики, методы, эффективность, оценка, урок.

EXPERIMENTAL STUDY OF THERMODYNAMIC SYSTEMS

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Abstract. The article deals with the elements of thermodynamics, which is one of the branches of physics. Thermodynamics is the subject of the curriculum of the higher educational institution, the method of teaching thermodynamics is the basis of the professional training of a physics teacher, the content and tasks of the method of teaching thermodynamics as a science, and the method of learning the science of thermodynamics. is conducted.

Key words: thermodynamics, thermal phenomena, lecture, laboratory work, training, teaching, physics methodology, methods, efficiency, assessment, lesson.

Introduction. A thermodynamic system is a physical body (a set of bodies) capable of exchanging energy and (or) matter with other bodies (with each other)[1]; a macroscopic physical system isolated (real or mentally) for study, consisting of a large number of particles and not requiring the use of microscopic characteristics of individual particles for its description[2], “a part of the Universe that we select for study”[3]. The unit of measurement for the number of particles in a thermodynamic system is usually the Avogadro number [4] (approximately 6•1023 particles per mole of substance), which gives an idea of what order of magnitude we are talking about. There are no restrictions on the nature of the material particles that form a thermodynamic system: these can be atoms, molecules, electrons, ions, photons, etc.[6]. Any earthly object visible with the naked eye or with the help of optical instruments (microscopes, spotting scopes, etc.) can be classified as a thermodynamic system: “Thermodynamics deals with the study of macroscopic systems, the spatial dimensions of which and their lifetime are sufficient to carry out normal measurement processes.” [5]. Conventionally, macroscopic systems include objects with sizes from 10−7 m (100 nm) to 1012 m. The convention of the lower limit is due, among other things, to the fact that for thermodynamics it is not the size of the object that is important, but the number of particles that form it. A cube of an ideal gas with an edge of 100 nm under normal conditions contains about 27,000 particles.

The working fluid, the idea of which is used in technical thermodynamics, is an example of a thermodynamic system.

From a thermodynamic point of view, an absolutely solid body is a single particle and for this reason, regardless of its size, it does not belong to thermodynamic systems.

Galactic and metagalactic systems are not thermodynamic.

Any part of a thermodynamic system is called a subsystem.

To describe a thermodynamic system, macroscopic parameters are used that characterize not the properties of its constituent particles, but the properties of the system itself: temperature, pressure, volume, magnetic induction, electrical polarization, mass and chemical composition of components, etc.

Each thermodynamic system has boundaries, real or conditional, separating it from the environment, which means all bodies not included in the thermodynamic system. Sometimes, instead of the environment, they talk about a thermostat [5], i.e., a medium with such a high heat capacity that its temperature does not change during heat exchange with the system under study. By default, it is assumed that the environment is large enough and therefore its parameters do not depend on the processes occurring in the system under consideration. In addition, it is usually assumed that the environment is in a state of thermodynamic equilibrium and its characteristics do not depend on time and spatial coordinates.

It is important that the composition of the thermodynamic system includes all particles present in the region of space allocated for study. The fact is that in thermodynamics, sometimes a real physical system is mentally divided into independent subsystems of objects with special properties, and the same volume is considered as occupied simultaneously by two or more virtual quasi-independent (weakly interacting with each other) partial subsystems of particles of different nature (for example , a gas mixture is characterized by the partial pressures of its constituent gases; in gas plasma there are simultaneously ions and free electrons with their significantly different partial temperatures - ion and electron; subsystems of phonons and magnons are distinguished in the crystal; The subsystem of nuclear spins of a paramagnetic substance is characterized by its own partial spin temperature, which can take negative values on the Kelvin scale). This formal technique allows you to introduce partial characteristics for the subsystem of particles under consideration, which are not necessarily directly related to the physical system as a single whole (see, for example, Negative absolute temperature).

Thermodynamic systems are the subject of study in thermodynamics, statistical physics and continuum physics.

Methods. Systems are distinguished by internal processes using the following methods:

• passive, in which there is a redistribution of available energy, for example thermal, tending to an equilibrium thermodynamic state;

• active, in which one type of energy is converted into another, for example chemical into thermal, tending to a non-equilibrium thermodynamic state

Based on the nature of interaction with the environment, systems are distinguished:

• isolated, unable to exchange either energy or matter with the external environment;

• adiabatically isolated, not capable of exchanging matter with the external environment, but allowing the exchange of energy in the form of work. Exchange of energy in the form of heat is excluded for such systems;

• closed, unable to exchange matter with the external environment, but capable of energy exchange with the environment;

• open, capable of exchanging matter (and, therefore, energy) with other systems (external environment);

• partially open, exchanging matter with the external environment, but not all constituent substances take part in material exchange (for example, due to the presence of semi-permeable partitions).

Results. According to the state parameters used for the thermodynamic description of the system, they are distinguished: simple systems, simple open systems and complex systems.

A simple system (simple body, thermal deformation system) is an equilibrium system whose physical state is completely determined by the values of two independent variables - functions of the state of a simple body, for example, the values of temperature and specific volume or pressure and specific volume.

Simple bodies are isotropic bodies (isos - equal, tropos - direction, in general - equality of the characteristics of the state and physical properties of the body at all its points and in all directions), in particular: gases, vapors, liquids and many solids that are in thermodynamic equilibrium and not subject to surface tension, gravitational and electromagnetic forces and chemical transformations. Studies of simple bodies in thermodynamics are of the greatest theoretical and practical interest.

Simple open systems differ from simple systems in their ability to exchange substance with the environment. For a thermodynamic description of such systems with independent components, independent state parameters are required, including the mass (amount of substance, number of particles) of each independent component;

Complex systems are all thermodynamic systems that do not fall within the definitions of simple systems and simple open systems. Complex systems usually include dielectrics, magnets, superconductors, elastic solids, phase interfaces, systems in a gravitational field and in a state of weightlessness, electrochemical systems, and equilibrium thermal radiation. Some authors also include simple open systems among complex ones. For a thermodynamic description of such systems as an elastic rod/thread or spring, phase interface, thermal radiation, only one independent state parameter is needed.

The figure shows one of the options for classifying thermodynamic systems (Fig. 1).

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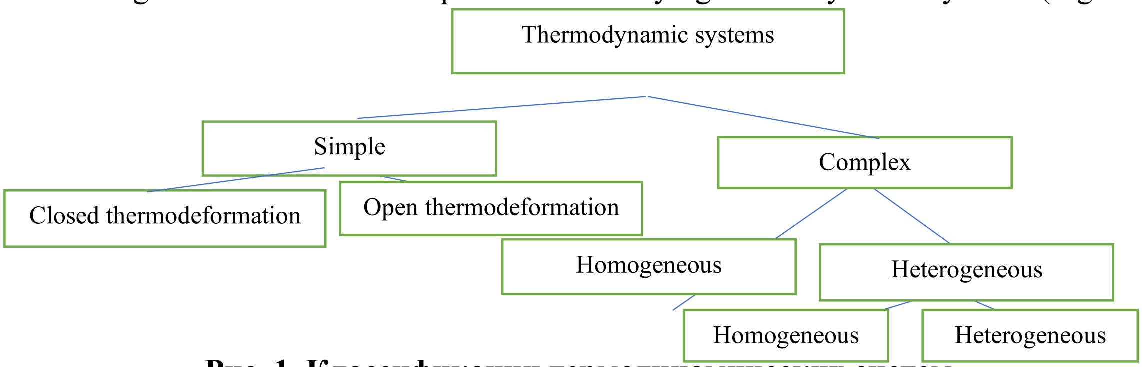

Рис. 1. Классификации термодинамических систем

This means that if the substances included in the system in the considered range of conditions (pressure, temperature) do not chemically interact with each other, then the system is called physical. If the substances of the system react with each other, then they speak of a chemical system.

Discussion. The actual isolation of a thermodynamic system from the environment is carried out through walls (interfaces, partitions, shells): movable and stationary, permeable and impermeable to matter (there are also semi-permeable partitions). The Dewar flask (Fig. 2) is a good example of an adiabatic (thermal insulating) shell. A partition that does not interfere with heat exchange, that is, is not adiabatic, is called diathermic (heat-permeable).

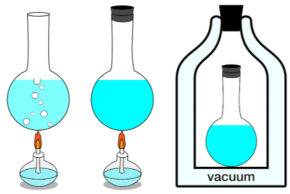

Fig. 2. A liquid in a flask without a stopper is an open system, the boundaries are formed by the walls of the flask and the liquid-atmosphere interface; the contents of a flask closed with a stopper are a closed system, the boundaries of the system are the walls of the flask and the stopper; the contents of a flask placed in a Dewar flask and closed with a stopper - an isolated system

Since for open systems the interpretation of the concepts of “work” and “heat” loses its unambiguity, the idea of adiabaticity loses its definiteness. In order to restore certainty and maintain the equivalence of the idea of adiabatic insulation as prohibiting heat exchange, and adiabatic insulation as allowing energy exchange only in the form of work, for open systems a third form of energy transfer is added to heat and work - the energy of redistribution of the masses of the substances composing the system, and the properties of adiabatic shells are supplemented with the requirement that the shell is impermeable to the substance. Unfortunately, this method of restoring the unambiguous interpretation of the concept of “adiabaticity,” which is widely used in technical thermodynamics, simultaneously makes the concept of adiabaticity useless from a practical point of view in the case of open systems, so the concept of “adiabaticity” is not used in the chemical thermodynamics of such systems.

Conclusion. And so, in a thermodynamic system, it is called homogeneous if there are no interfaces between any of its parts and, therefore, the properties of the system continuously change from point to point. A homogeneous system with identical properties at any point is called homogeneous. Examples of homogeneous systems are solutions (gas, liquid and solid). A gas phase of great extent along the gradient of the gravitational field (for example, the earth’s atmosphere on a cloudless and windless day) is an example of a heterogeneous homogeneous phase.

In thermodynamic systems it is called heterogeneous if it consists of several homogeneous parts with different properties (Fig. 3). On surfaces separating homogeneous parts of a heterogeneous system, at least one thermodynamic property of the substance changes abruptly. Often (but not always) the interface is visible.

The homogeneous part of a heterogeneous system is called a phase. Less strictly, but more clearly, phases are called "homogeneous parts of the system, separated from the remaining parts by visible interfaces." An example is the "ice - water - moist air" system. A homogeneous system contains only one phase; a heterogeneous system consists of two or more phases. The number of phases in a heterogeneous system obeys the Gibbs phase rule (Fig. 4). The same substance in a solid state of aggregation can have several phases (orthorhombic and monoclinic sulfur, gray and white tin, etc.).

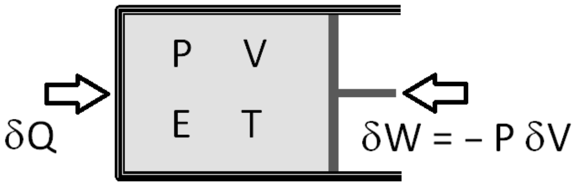

Fig. 3. The simplest closed thermal deformation system - gas in a cylinder with a piston

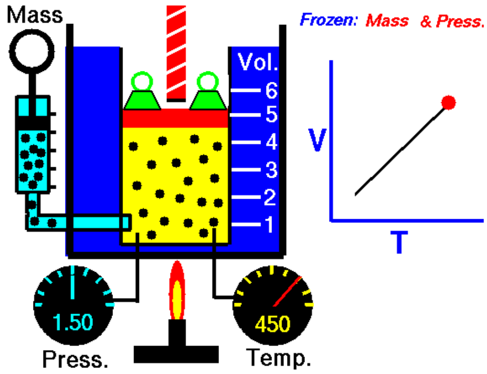

Fig.4. Gas in a cylinder with a piston is a closed thermal deformation system; everything outside the yellow-colored space is the external environment

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