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Article Review On Thermodynamics

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Abstract: Thermodynamic is a branch of physics which deals with the energy and work of a system. It was born in the 19th century as scientists were first discovering how to build and operate steam engines. Thermodynamics deals only with the large scale response of a system which we can observe and measure in experiments. Small scale gas interactions are described by the kinetic theory of gases. The methods complement each other; some principles are more easily understood in terms of thermodynamics and some principles are more easily explained by kinetic theory.

Keywords: thermodynamic, kinetic theory.

I. INTRODUCTION

A description of any thermodynamic system employs the four laws of thermodynamics that form an axiomatic basis. The first law specifies that energy can be transferred between physical systems as heat, as work, and with transfer of matter. The second law defines the existence of a quantity called entropy, that describes the direction, thermodynamically, that a system can evolve and quantifies the state of order of a system and that can be used to quantify the useful work that can be extracted from the system.

In thermodynamics, interactions between large ensembles of objects are studied and categorized. Central to this are the concepts of the thermodynamic system and its surroundings. A system is composed of particles, whose average motions define its properties, and those properties are in turn related to one another through equations of state. Properties can be combined to express internal energy and thermodynamic potentials, which are useful for determining conditions for equilibrium and spontaneous processes.

With these tools, thermodynamics can be used to describe how systems respond to changes in their environment. This can be applied to a wide variety of topics in science and engineering, such as engines, phase transitions, chemical reactions, transport phenomena, and even black holes. The results of thermodynamics are essential for other fields of physics and for chemistry, chemical engineering, corrosion engineering, aerospace engineering, mechanical engineering, cell biology, biomedical engineering, materials science, and economics, to name a few.

This article is focused mainly on classical thermodynamics which primarily studies systems in thermodynamic equilibrium. Non-equilibrium thermodynamics is often treated as an extension of the classical treatment, but statistical mechanics has brought many advances to that field.

II. HISTORY

The thermodynamicists of the original eight founding schools of thermodynamics. The schools with the most-lasting influence on the modern versions of thermodynamics are the Berlin school, particularly Rudolf Claudius's 1865 textbook The Mechanical Theory of Heat, the Vienna school, with the statistical mechanics of Ludwig Boltzmann, and the Gibbs Ian school at Yale University of Willard Gibbs' 1876 and his book On the Equilibrium of Heterogeneous Substances which launched chemical thermodynamics.

The history of thermodynamics as a scientific discipline generally begins with Otto von Guericke who, in 1650, built and designed the world's first vacuum pump and demonstrated a vacuum using his Magdeburg hemispheres. Guericke was driven to make a vacuum in order to disprove Aristotle's long-held supposition that 'nature abhors a vacuum'. Shortly after Guericke, the Anglo-Irish physicist and chemist Robert Boyle had learned of Guericke's designs and, in 1656, in coordination with English scientist Robert Hooke, built an air pump. Using this pump, Boyle and Hooke noticed a correlation between pressure, temperature, and volume. In time, Boyle's Law was formulated, which states that pressure and volume are inversely proportional. Then, in 1679, based on these concepts, an associate of Boyle's named Denis Papen built a steam digester, which was a closed vessel with a tightly fitting lid that confined steam until a high pressure was generated.

Later designs implemented a steam release valve that kept the machine from exploding. By watching the valve rhythmically move up and down, Papen conceived of the idea of a piston and a cylinder engine. He did not, however, follow through with his design. Nevertheless, in 1697, based on Papen's designs, engineer Thomas Slavery built the first engine, followed by Thomas Newcomer in 1712. Although these early engines were crude and inefficient, they attracted the attention of the leading scientists of the time.

The fundamental concepts of heat capacity and latent heat, which were necessary for the development of thermodynamics, were developed by Professor Joseph Black at the University of Glasgow, where James Watt was employed as an instrument maker. Black and Watt performed experiments together, but it was Watt who conceived the idea of the external condenser which resulted in a large increase in steam engine efficiency. Drawing on all the previous work led Said Carnot, the "father of thermodynamics", to publish Reflections on the Motive Power of Fire (1824), a discourse on heat, power, energy and engine efficiency. The book outlined the basic energetic relations between the Carnot engine, the Carnot cycle, and motive power. It marked the start of thermodynamics as a modern science.

The first thermodynamic textbook was written in 1859 by William Rankin, originally trained as a physicist and a civil and mechanical engineering professor at the University of Glasgow. The first and second laws of thermodynamics emerged simultaneously in the 1850s, primarily out of the works of William Rankin, Rudolf Clausius, and William Thomson (Lord Kelvin). The foundations of statistical thermodynamics were set out by physicists such as James Clerk Maxwell, Ludwig Boltzmann, Max Planck, Rudolf Clausius and J. Willard Gibbs.

Clausius, who first stated the basic ideas of the second law in his paper "On the Moving Force of Heat", published in 1850, and is called "one of the founding fathers of thermodynamics", introduced the concept of entropy in 1865.

During the years 1873–76 the American mathematical physicist Josiah Willard Gibbs published a series of three papers, the most famous being On the Equilibrium of Heterogeneous Substances, in which he showed how thermodynamic processes, including chemical reactions, could be graphically analysed, by studying the energy, entropy, volume, temperature and pressure of the thermodynamic system in such a manner, one can determine if a process would occur spontaneously. Also Pierre Durham in the 19th century wrote about chemical thermodynamics. During the early 20th century, chemists such as Gilbert N. Lewis, Merle Randall, and E. A. Guggenheim applied the mathematical methods of Gibbs to the analysis of chemical processes.

III. CLASSIFICATION OF THERMODYNAMICS

Branches of thermodynamics the study of thermodynamically systems has developed into several related branches, each using a different fundamental model as a theoretical or experimental basis, or applying the principles to varying types of systems.

1. Classical thermodynamics

Classical thermodynamics is the description of the states of thermodynamic systems at near-equilibrium that uses Macroscopic, measurable properties. It is used to model exchanges of energy, work and heat based on the laws of Thermodynamics. The qualifier classical reflects the fact that it represents the first level of understanding of the subject as it Developed in the 19th century and describes the changes of a system in terms of macroscopic empirical (large scale, and Measurable) parameters. A microscopic interpretation of these concepts was later provided by the development of statistical Mechanics.

2. Statistical thermodynamics

Statistical mechanics, also known as statistical thermodynamics, emerged with the development of atomic and molecular Theories in the late 19th century and early 20th century, and supplemented classical thermodynamics with an interpretation of The microscopic interactions between individual particles or quantum-mechanical states. This field relates the microscopic Properties of individual atoms and molecules to the macroscopic, bulk properties of materials that can be observed on the Human scale, thereby explaining classical thermodynamics as a natural result of statistics, classical mechanics, and quantum Theory at the microscopic level.

3. Chemical thermodynamics

Chemical thermodynamics is the study of the interrelation of energy with chemical reactions or with a physical change of state within the confines of the laws of thermodynamics. The primary objective of chemical thermodynamics is determining the Spontaneity of a given transformation.

4. Equilibrium thermodynamics

Equilibrium thermodynamics is the study of transfers of matter and energy in systems or bodies that, by agencies in their Surroundings can be driven from one state of thermodynamic equilibrium to another. The term 'thermodynamic equilibrium' Indicates a state of balance, in which all macroscopic flows are zero; in the case of the simplest systems or bodies, their Intensive properties are homogeneous, and their pressures are perpendicular to their boundaries. In an equilibrium state there Are no unbalanced potentials, or driving forces, between macroscopically distinct parts of the system? A central aim in Equilibrium thermodynamics is: given a system in a well-defined initial equilibrium state, and given its surroundings, and given its constitutive walls, to calculate what will be the final equilibrium state of the system after a specified thermodynamic Operation has changed its walls or surroundings.

5. Non-equilibrium thermodynamics

Non-equilibrium thermodynamics is a branch of thermodynamics that deals with systems that are not in thermodynamic

Equilibrium. Most systems found in nature are not in thermodynamic equilibrium because they are not in stationary states, and are continuously and discontinuously subject to flux of matter and energy to and from other systems. The thermodynamic Study of non-equilibrium systems requires more general concepts than are dealt with by equilibrium thermodynamics.

Many natural systems still today remain beyond the scope of currently known macroscopic thermodynamic methods.

II. LAWS OF THERMODYNAMICS

Thermodynamics is principally based on a set of four laws which are universally valid when applied to systems that fall within

The constraints implied by each. In the various theoretical descriptions of thermodynamics these laws may be expressed in seemingly differing forms, but the most prominent formulations are the following.

1. Zeroth law

The zeroth law of thermodynamics states: If two systems are each in thermal equilibrium with a third, they are also in thermal Equilibrium with each other.

This statement implies that thermal equilibrium is an equivalence relation on the set of thermodynamic systems under consideration. Systems are said to be in equilibrium if the small, random exchanges between them (e.g. Brownian motion) do not lead to a net change in energy. This law is tacitly assumed in every measurement of temperature. Thus, if one seeks to decide whether two bodies are at the same temperature, it is not necessary to bring them into contact and measure any changes of their observable properties in time.[28] The law provides an empirical definition of temperature, and justification for the construction of practical thermometers.

The zeroth law was not initially recognized as a separate law of thermodynamics, as its basis in thermodynamically equilibrium was implied in the other laws. The first, second, and third laws had been explicitly stated already, and found common acceptance in the physics community before the importance of the zeroth law for the definition of temperature was realized. As it was impractical to renumber the other laws, it was named the zeroth law

2. First law

Opening a bottle of sparkling wine (high-speed photography). The sudden drop of pressure causes a huge drop of temperature. The moisture in the air freezes, creating a smoke of tiny ice crystals.[29][30][31]The first law of thermodynamics states: In a process without transfer of matter, the change in internal energy, ΔU of a thermodynamic system is equal to the energy gained as heat, Q, less the thermodynamic work, W, done by the system on its surroundings $\Delta U = Q - W$

Where,

ΔU denotes the change in the internal energy of a closed system (for which heat or work through the system boundary are possible, but matter transfer is not possible), Q, denotes the quantity of energy supplied to the system as heat, and W denotes the amount of thermodynamic work done by the system on its surroundings. An equivalent statement is that perpetual motion machines of the first kind are impossible; work W done by a system on its surrounding requires that the system's internal energy U decrease or be consumed, so that the amount of internal energy lost by that work must be resupplied as heat Q By an external energy source or as work by an external machine acting on the system (so that Us recovered) to make the system work continuously.

For processes that include transfer of matter, a further statement is needed: With due account of the respective fiducially reference states of the systems, when two systems, which may be of different chemical compositions, initially separated only by an impermeable wall, and otherwise isolated, are combined into a new system by the thermodynamic operation of removal of the wall, then, U0=U1+U2

Where,

U0 denotes the internal energy of the combined system, and U1 and U2 denote the internal energies of the respective separated systems. Adapted for thermodynamics, this law is an expression of the principle of conservation of energy, which states that energy can be transformed (changed from one form to another), but cannot be created or destroyed.[33]Internal energy is a principal property of the thermodynamic state, while heat and work are modes of energy transfer by which a process may change this state. A change of internal energy of a system may be achieved by any combination of heat added or removed and work performed on or by the system. As a function of state, the internal energy does not depend on the manner, or on the path through intermediate steps, by which the system arrived at its states.

3. Second law

A traditional version of the second law of thermodynamics states: Heat does not spontaneously flow from a colder body to a hotter body. The second law refers to a system of matter and radiation, initially with in homogeneities in temperature, pressure, chemical potential, and other intensive properties that are due to internal 'constraints', or impermeable rigid walls, within it, or to externally imposed forces. The law observes that, when the system is isolated from the outside world and from those forces, there is a definite thermodynamic quantity, its entropy that increases as the constraints are removed, eventually reaching a maximum value at thermodynamic equilibrium, when the in homogeneities practically vanish. For systems that are initially far from thermodynamic equilibrium, though several have been proposed, there is known no general physical principle that many versions of the second law all express the general irreversibility of the transitions involved in systems approaching thermodynamic equilibrium.

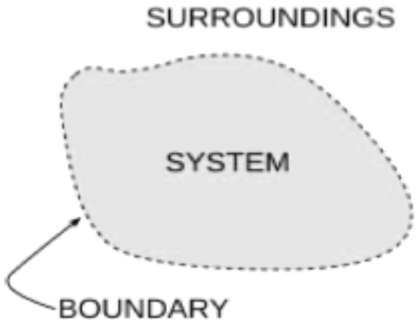
In macroscopic thermodynamics, the second law is a basic observation applicable to any actual thermodynamic process; in statistical thermodynamics, the second law is postulated to be a consequence of molecular chaos.

4. Third law

The third law of thermodynamics states: As the temperature of a system approaches absolute zero, all processes cease and the entropy of the system approaches a minimum value. This law of thermodynamics is a statistical law of nature regarding entropy and the impossibility of reaching absolute zero of temperature. This law provides an absolute reference point for the determination of entropy. The entropy determined relative to this point is the absolute entropy. Alternate definitions include "the entropy of all systems and of all states of a system is smallest at absolute zero," or equivalently "it is impossible to reach the absolute zero of temperature by any finite number of processes". Absolute zero, at which all activity would stop if it were possible to achieve, is −273.15 °C (degrees Celsius), or −459.67 °F (degrees Fahrenheit), or 0 K (kelvin), or 0° R (degrees Rankin).

V. SYSTEM MODELS

A diagram of a generic thermodynamic system An important concept in thermodynamics is the thermodynamic system, which is a precisely defined region of the universe under study. Everything in the universe except the system is called the surroundings. A system is separated from the remainder of the universe by a boundary which may be a physical or notional, but serve to confine the system to a finite volume. Segments of the boundary are often described as walls; they have respective defined 'permeabilities'. Transfers of energy as work, or as heat, or of matter, between the system and the surroundings, take place through the walls, according to respective permeability's.



States and processes

When a system is at equilibrium under a given set of conditions, it is said to be in a definite thermodynamic state. The state of the system can be described by a number of state quantities that do not depend on the process by which the system arrived at its state. They are called intensive variables or extensive variables according to how they change when the size of the system changes. The properties of the system can be described by an equation of state which specifies the relationship between these variables. State may be thought of as the instantaneous quantitative description of a system with a set number of variables held constant.

A thermodynamic process may be defined as the energetic evolution of a thermodynamic system proceeding from an initial state to a final state. It can be described by process quantities. Typically, each thermodynamic process is distinguished from other processes in energetic character according to what parameters, such as temperature, pressure, or volume, etc., are held fixed; Furthermore, it is useful to group these processes into pairs, in which each variable held constant is one member of a conjugate pair.

Several commonly studied thermodynamic processes are:
Adiabatic process: occurs without loss or gain of energy by heat
Isenthalpic process: occurs at a constant enthalpy
Isentropic process: a reversible adiabatic process, occurs at a constant entropy
Isobaric process: occurs at constant pressure
Isochoric process: occurs at constant volume (also called isometric/isovolumetric)
Isothermal process: occurs at a constant temperature
Steady state process: occurs without a change in the internal energy

VI. APPLICATION

1. Cooking food
2. Refrigeration and air conditioning
3. Power generation
4. Home heating system
5. Melting of ice cube
6. Sweating in a crowded room
7. Generation of electrical energy in thermal power plant
8. Internal combustion engine
9. Oven operation
10. Solar thermal system

VII .Conclusion

Thermodynamics deals with energy changes in chemical or physical processes which enable us to study these changes quantitatively to make successful predictions. For such purposes, the universe is divided into systems and surroundings.

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