卓越系列·教育部高职高专油气工程类
教指委推荐教材

热能与动力工程专业英语

English in Thermal Energy and Power Engineering

主编　胡月红

天津大学出版社
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前　言

近年来，随着国民经济的增长，我国能源动力领域发展迅速，大多数工作岗位的技术含量越来越高，对操作人员的素质和技能要求也随之提高。

本教材是为高职高专学生在完成基础英语的同时，进一步提高其对本专业英语的听说读写能力和实际应用能力而编写的。本教材的重点是使学生掌握一定的专业词汇，能够理解和翻译简单的外文文献资料，能够书写本专业一般的科技论文的英文摘要，能理解本专业进口设备的英文说明书，能够与他人进行简单的专业方面的英语交流，从而为学生在学习、交流、求职以及今后的工作等各方面打下一定的英语基础。

在编写过程中，重点考虑到以下几个方面。首先是职业教育的应用性特征要求教材基于生产实践并具备较强的实用性，以学生就业为导向，以实用、够用为度；其次是专业的发展变化要求教材有一定的前瞻性，比如随着循环流化床锅炉的发展和应用，教材中增加了这方面的内容；另外是高职高专学生的英语基础普遍较差，为了便于学生理解，在每章内容前面都配有中文概述。

本教材由清华大学热能工程系杨海瑞副教授主审。全书按 30 学时考虑，分别包括热工基础理论、锅炉、汽轮机、循环流化床锅炉、热电厂、热工仪表及测量、单元机组运行、环境保护 8 个单元的内容，每章内容前配有中文概要，课文后附有生词表及泛读材料。文章选自各类书刊、科学文献等，参阅了阎维平、李瑞杨等编著的同类教材。

由于时间仓促，编者水平所限，书中难免存在疏漏和不妥之处，恳请广大读者批评、指正。

编　者

2007 年 12 月

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Thermodynamics and Heat Transfer

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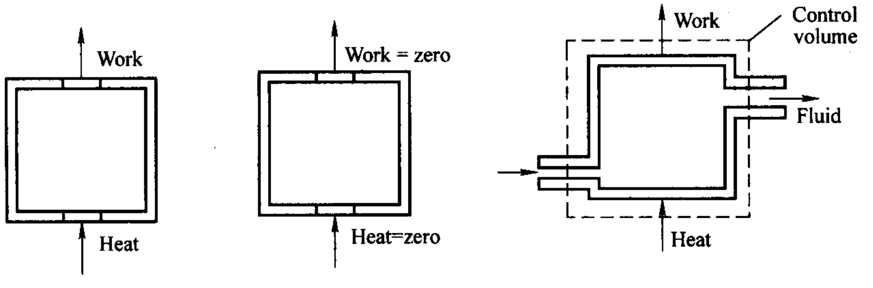
1.1 Basic Concepts of Thermodynamics

1.1.1 Thermodynamic Systems

Most applications of thermodynamics require that the system and its surroundings be defined. A thermodynamic system is defined as a region in space or quantity of matter bounded by a closed surface. The surroundings include everything external to the system, and the system is separated from the surroundings by the system boundaries. These boundaries can be either movable or fixed, either real or imaginary. A thermodynamic system exchanges matter and energy (heat or work) with surroundings.

Acorrding to the nature of the boundaries, we can classify a thermodynamic system as a closed system, an open system, or an isolated system. When the boundaries of a system are such that the system cannot exchange matter with the surroundings, the system is called to be a closed system (Fig. 1-1(a)). The system, however, may exchange energy in the form of heat or work with the surroundings. The boundaries of a closed system may be rigid or variable, but the mass of a closed system cannot change. Hence, the term control mass sometimes is used for this type of system. When the energy crossing the boundaries of a closed system is zero or substantially so, the system may be treated as an isolated system(Fig. 1-1(b)).



(a)Closed system (b)Isolated system (c)Open system

Fig. 1-1 Types of systems

In most engineering problems, matter, generally a fluid, crosses the boundaries of a system in one or more places. Such a system is known as an open system(Fig. 1-1(c)). The boundaries of an open system are so placeable that their location does not change with time. Thus, the boundaries are enclosed by a fixed volume, commonly known as the control volume.

Sometimes a system may be a closed system at one moment and an open one the next. For example, considering the cylinder of an internal combustion engine with the boundaries at the inner walls, with the valves closed, the system is a closed one. However, with either or both of the valves open, the system becomes an open one.

Regardless of a system is a closed system or an open one, if only no (or practically no) heat crosses the boundary, such a system is also defined as an isolated system(adiabatic system).

1.1.2 Thermodynamic Properties

A property of a system is any observable characteristic of the system. The state of a system is defined by listing its properties. The most common thermodynamic properties are temperature(T), pressure(P) and specific volume (V) or density (ρ). Additional thermodynamic properties include entropy, stored forms of energy and enthalpy.

Frequently, thermodynamic properties combine to form new properties. Enthalpy(h), a result of combining properties, is defined as:

$$h=U+PV \tag{1-1}$$

where U—internal energy

P—pressure

V—specific volume

Each property in a given state has only one definite value, and every property always has the same value for a given state, regardless of how the substance arrived at that state.

A process is a change in state that can be defined as any change in the properties of a system. A process is described by specifying the initial and final equilibrium states, the path(if identifiable)and the interactions that take place across the system boundaries during the process. A cycle is a process, or more frequently, a series of processes wherein the initial and final states of the system are identical. Therefore, at the conclusion of a cycle all the properties have the same value they had at the beginning.

Energy is the capacity for producing an effect, and can be categorized into either stored or transient forms. Stored forms of energy include:

Thermal (internal) Energy, U—the energy (possessed by a system) caused by the motion of the molecules and/or intermolecular forces;

Potential Energy, P. E.—the energy (possessed by a system) caused by the attractive forces existing between molecules, or the elevation of the system;

$$P.E. = mgz \tag{1-2}$$

where m —mass

g —local acceleration of gravity

z —elevation above a horizontal reference plane

Kinetic Energy, K. E. —the energy (possessed by a system) caused by the velocity of the molecules:

$$K.E. = mv^2/2 \tag{1-3}$$

where m —mass

v —velocity of the fluid streams crossing system boundaries

Chemical Energy, E_c—energy (possessed by the system) caused by the arrangement of atoms composing the molecules.

Nuclear(atomic) Energy, E_a—energy (possessed by the system) from the cohesive forces holding protons and neutrons together as the atom's nucleus.

Transient energy forms include:

Heat, Q—the mechanism(that transfers energy across the boundaries of systems with differing temperatures), always in the direction of the lower temperature.

Work, W—the mechanism that transfers energy across the boundary of systems with differing pressures(or force of any kind), always in the direction of the lower pressure; if the total effect produced in the system can be reduced to the raising of a weight, then nothing but work has crossed the boundary. Mechanical or shaft work, is the energy delivered or absorbed by a mechanism, such as a turbine, air compressor or internal combustion engine.

Flow work is energy carried into or transmitted across the system boundary because a pumping process occurs somewhere outside the system, causing fluid to enter the system. It can be more easily understood as the work done by the fluid just outside the system on the adjacent fluid entering the system to force or push it into the system. Flow work also occurs as fluid leaves the system.

$$\text{Flow work(per unit mass)} = PV \tag{1-4}$$

where P is the pressure and V is the specific volume, or the volume displaced per unit mass.

1.2 The Fundamental Laws of Thermodynamics

1.2.1 The First Law of Thermodynamics

Energy can be changed from one form to another, but it cannot be created or destroyed. The total amount of energy and matter in the Universe remains constant, merely changing from one form to another. The First Law of Thermodynamics (Conservation) states that energy is always conserved, it cannot be created or destroyed. In essence, energy can be converted from one form into another.

It is typical for thermodynamics texts to write the first law as equation:

$$Q=\Delta U+W \tag{1-5}$$

where Q—heat added to the system

ΔU—change in internal energy

W—work done on or by the system

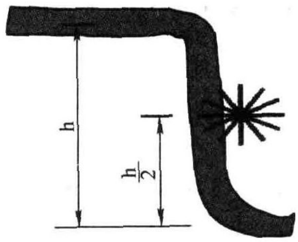
It is the general statement of the first law of the thermodynamics, of course—the thermodynamic expression of the conservation of energy principle.

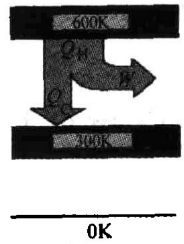
In the context of physics, the common scenario is one of adding heat to a volume of gas and using the expansion of that gas to do work, as in the pushing down of a piston in an internal combustion engine, or as in the steam turbine. In the context of chemical reactions and process, it may be more common to deal with situations where work is done on the system rather than by it.

1.2.2 The Second Law of Thermodynamics

The second law of thermodynamics is a general principle which places constraints upon the direction of heat transfer and the attainable efficiencies of heat engines. In so doing, it goes beyond the limitations imposed by the first law of thermodynamics. Its implications may be visualized in terms of the waterfall analogy.

If you are constrained to put your waterwheel half-way up the waterfall, then you can extract at most half of the available energy





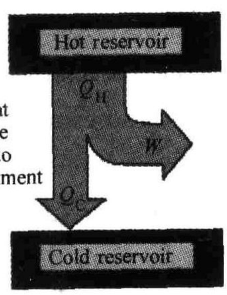
If a 600 K heat engine must exhaust heat at 300 K, then it can be at most 50% efficient

The maximum efficiency which can be achieved is the Carnot efficiency.

Second Law of Thermodynamics: It is impossible to extract an amount of heat Q_H from a hot reservoir and use it all to do work W. Some amount of heat Q_C must be exhausted to a cold reservoir. This precludes a perfect heat engine.

This is sometimes called the "first form" of the second law, and is referred to as the Kelvin-Planck statement of the second law.

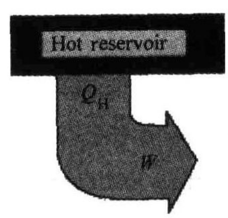
All real heat engines lose some heat to the environment



Efficiency

$$= \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H}$$

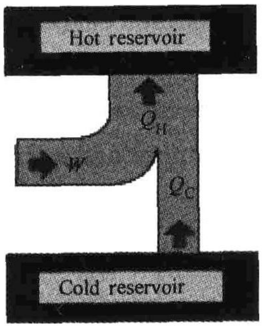
Maximum for the Carnot cycle

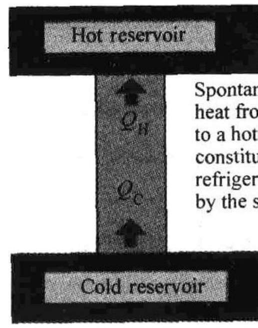


Extracting heat Q_H and using it all to do work W would constitute a perfect heat engine, forbidden by the second law

Second Law of Thermodynamics: It is not possible for heat to flow from a colder body to a warmer body without any work having been done to accomplish this flow. Energy will not flow spontaneously from a low temperature object to a higher temperature object. This precludes a perfect refrigerator. The statements about refrigerators apply to air conditioners and heat pumps, which embody the same principles. This is the "second form" or "Clausius statement" of the second law.

All real refrigerators require work to get heat to flow from a cold area to a warmer area





Spontaneous flow of heat from a cold area to a hot area would constitute a perfect refrigerator,forbidden by the second law

1.3 General Characteristics of Heat Transfer

From the study of thermodynamics, you have learned that energy can be transferred by interactions of a system with its surroundings. These interactions are called work and heat. However, thermodynamics deals with the end states of the process during which an interaction occurs and provides no information concerning the nature of the interaction or the time rate at which it occurs. The objective of this section is to extend thermodynamic analysis through study of the modes of heat transfer and through development of relations to calculate heat transfer rates.

What is heat transfer? Heat transfer (or heat) is energy in transit due to a temperature difference. Whenever there exists a temperature difference in a medium or between media, heat transfer must occur.

How is heat transferred? Heat is transferred from one region to another by three modes: conduction, convection and radiation. When a temperature gradient exists in a stationary medium, which may be a solid or a fluid, we use the term conduction to refer to the heat transfer that will occur across the medium. In contrast, the term convection refers to heat transfer that will occur between a surface and a moving fluid when they are at different temperatures. All surface of finite temperature emit energy in the form of electromagnetic waves. Hence, in the absence of an intervening medium, there is net heat transfer by radiation between two surfaces at different temperatures.

In conduction and convection, heat transfer takes place through matter. For radiant heat transfer, there is a change in energy form from internal energy at the source to electromagnetic energy for transmission, then back to internal energy at the receiver. Whereas conduction and convection are affected primarily by temperature difference and somewhat by temperature level, the heat transferred by radiation increases rapidly as the temperature increases.

Extensive Reading

Heat and Work

When hot tea is poured into a cold cup, the tea is cooled and the cup is warmed; a lump of ice cools a glass of lemonade as itself warms and melts. From these and many other everyday examples we learn that heat passes readily from a hot body to a colder one, but not in the opposite direction. This fact is important in the study of thermal energy, and is rather grandly known as the "Second Law of Thermodynamics". This law was announced in about 1850 by two men. One was Lord Kelvin, a famous British scientist. The other discoverer was Rudolph Clausius, a professor of physics in Berlin, and he stated the law thus: "heat cannot of itself (that is without the performance of work by some external agency) pass from a cold to a warmer body". We shall see that it follows from this law that the heat energy in the world is continually becoming less useful to us.

Thermodynamics is the part of science that deals with changes between heat energy and mechanical work. We have already touched on its first law although we did not call it by that name: it is the law that came from the experiments of Joule and others, and it states that: "When work is transformed into heat, or heat into work, the quantity of work is mechanically equivalent to the quantity of heat." This is one particular way of saying that energy is neither gained nor lost, but only changed from one kind to another.

There is another way in which heat energy becomes less useful to us. As Clausius stated the second law of thermodynamics, it says that energy has to be supplied to transfer heat from a cold body to a hot one. Lord Kelvin put the law the other way round by pointing out that heat energy can be used to drive all engine to do mechanical work only by supplying heat to the engine from a high temperature source, and taking it from the engine at a lower temperature. For instance, a steam turbine(Fig. 1-2)may take steam from its boiler at about 900 ℉, and give it up to its exhaust condenser at 212 ℉ , the boiling point water.

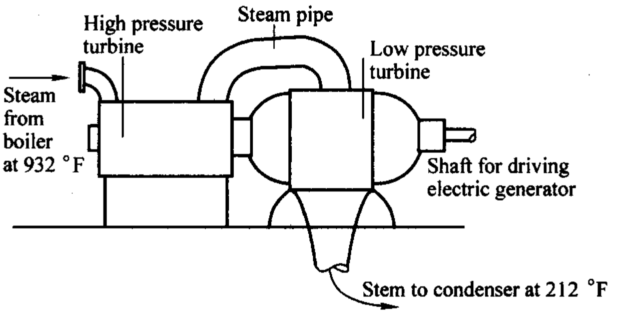


Fig. 1-2 Steam turbine

Steam is supplied by the boiler at a temperature of 932 ℉, and leaves the exhaust pipe at 212 ℉. The heat energy of the steam is partly converted into mechanical energy which drives all electric generator

New Words and Expressions

thermodynamics *n.*	热力学
thermodynamic system	热力系统
entropy *n.*	熵(热力学函数)
thermodynamic properties	热力参数
enthalpy *n.*	焓
transient *a.*	【物】瞬变的
thermal *a.*	热的
kinetic *a.*	动力(学)的，动力的
cohesive *a.*	内聚的
cohesive forces	内聚力
shaft work	轴功
specific volume	比容
saturation *n.*	饱和(状态)
saturated *a.*	饱和的
flow work *n.*	流动功
equilibrium state	平衡状态
elevation *n.*	高度
acceleration *n.*	加速，加速度
adiabatic process	绝热过程
cyclic process/cycle	循环
categorize *v.*	把……分类
configuration *n.*	构造，结构
quasi-static process	准静态过程
reversible process	可逆过程
closed system	封闭系统
open system	开放系统
isolated system	孤立系统
adiabatic system	绝热系统

Part Ⅱ　Boiler

● 中文概要

1. 锅炉的分类及发展趋势
2. 燃料的特点及燃烧过程
3. 煤粉炉的组成设备和工作过程
4. 炉膛、水冷壁的结构特点
5. 过热器、再热器的结构及运行特点
6. 省煤器、空气预热器的结构及运行特点
7. 对流受热面的腐蚀及磨损问题

2.1　Introduction

2.1.1　Types and Classification of Steam Boiler

Boilers use heat to convert water into steam for a variety of applications.