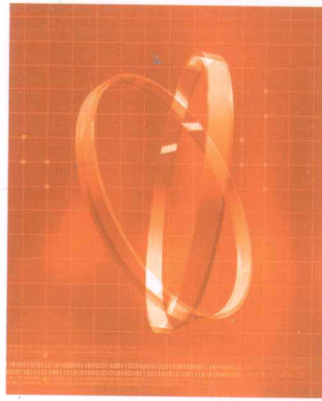

能源与动力工程专业英语

（第4版）

主　编　吕　薇　李瑞扬

English in Energy and Power Engineering

哈爾濱工業大學出版社

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内 容 提 要

本书涵盖了能源与动力工程专业的主要分支学科，以培养能源与动力工程专业学生的专业英语阅读能力为主要目标。全书共分七部分，主要内容为：流体力学与流体机械，热力学与传热，燃料及燃烧，空调与制冷，锅炉，涡轮机，环保与腐蚀，以及参考译文等，书后附录中还给出了常用缩写词和常用英文计量单位换算。本书具有较强的实用性和知识性，高等院校能源与动力工程专业的本科生和研究生可根据其选修方向有针对性地学习相关单元内容。

本书既可作为高校能源与动力工程专业学生的专业英语教材，也可供从事相关专业的工程技术人员学习、参考之用。

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第 4 版前言

《能源与动力工程专业英语》(原书名:《热能与动力工程专业英语》)一书自 2000 年 1 月出版以来,受到广大高校师生和相关专业技术人员的欢迎。目前国内已有多所高校将此书作为能源与动力工程的专业英语教材,并在教学中收到良好效果。本书已修订 4 次,重印 7 次,读者反馈意见较好,为了进一步满足教学要求和读者需要,增强本书的科学性和实用性,综合各校使用的情况,在保证本书基本体系和主要内容不变的前提下,此版做了如下修改:

(1)第一、四、五部分内容做了替换;

(2)为了突出内容的完整性,在内容编排上进行了适当增减和调整,充实了更能突出反映本学科发展的相关内容;

(3)对各课生词及译文进行了核准和调整。

由于参与修订本书的人员及分工有变,书中各部分的负责人员、主编、主审等都发生了变化。全书由英文原文、参考译文及附录组成,英文部分共分七部分,其中第一部分由陈伟锋编写,第四部分由苏宝焕编写,第五部分由姜姗、李瑞扬编写,第二、三、六部分及参考译文部分由吕薇编写,第七部分、附录等由李瑞扬编写。全书由吕薇、李瑞扬主编,由李九如、王芳主审。

由于编者水平有限,对书中的不足之处,请广大读者批评指正。

编　者

2016 年 6 月

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参考译文

1

Fluid Mechanics and Fluid Machines

1.1 The Viscosity of Fluids

Of all the fluid properties, viscosity requires the greatest consideration in the study of fluid flow. The nature and characteristics of viscosity are discussed in this section, as well as dimensions and conversion factors for both absolute and kinematic viscosity. Viscosity is that property of a fluid by virtue of which it offers resistance to shear. Newton's law of viscosity states that for a given rate of angular deformation of fluid the shear stress is directly proportional to the viscosity. Molasses and tar are examples of highly viscous liquids; water and air have very small viscosities.

The viscosity of a gas increases with temperature, but the viscosity of a liquid decreases with temperature. The variation in temperature trends can be explained by examining the causes of viscosity. The resistance of a fluid to shear depends upon its cohesion and upon its rate of transfer of molecular momentum. A liquid, with molecules much more closely spaced than a gas, has cohesive forces much larger than a gas.

Cohesion appears to be the predominant cause of viscosity in a liquid; and since cohesion decreases with temperature, the viscosity does likewise. A gas, on the other hand, has very small cohesive forces. Most of its resistance to shear stress is the result of transfer of molecular momentum.

As a rough model of the way in which momentum transfer gives rise to an apparent shear stress, consider two idealized railroad cars loaded with sponges and on parallel tracks, as in Fig. 1. 1. Assume each car has a water tank and pump so arranged that the water is directed by nozzles at right angles to the track. First, consider A stationary and B moving to the right, with the water from its nozzles striking A and being absorbed by the sponges. Car A will be set in motion owing to the component of the momentum of the jets which is parallel to the tracks, giving rise to an apparent shear stress between A and B. Now if A is pumping water back into B at the same rate, its action tends to slow down B and equal and opposite apparent shear forces result. When both A and B are stationary or have the same velocity, the pumping does not exert an apparent shear stress on either car.

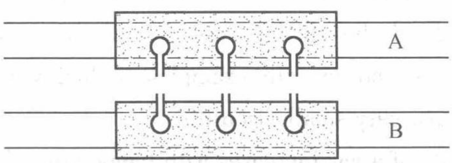

Fig. 1. 1 Model illustrating transfer of momentum

Within fluid there is always a transfer of molecules back and forth across any fictitious surface drawn in it. When one layer moves relative to an adjacent layer, the molecular transfer of momentum brings momentum from one side to the other so that an apparent shear stress is set up that resists the relative motion and tends to equalize the velocities of adjacent layers in a manner analogous to that of Fig. 1. 1. The measure of the motion of one layer relative to an adjacent layer is $\frac{du}{dy}$.

Molecular activity givesthe rise to an apparent shear stress in gases which is more important than the cohesive forces and since molecular activity increases with temperature, the viscosity of a gas also increases with temperature.

For ordinary pressures viscosity is independent of pressure and depends upon temperature only. For very great pressures, gases and most liquids have shown erratic variations of viscosity with pressure.

A fluid at rest or in motion so that no layer moves relative to an adjacent layer will not have apparent shear forces set up, regardless of the viscosity, because du/dy is zero throughout the fluid. Hence, in the study fluid static, no shear forces can be considered because they do not occur in a static fluid, and the only stresses remaining are normal stresses, or pressures. This greatly simplifies the study of fluid static, since any free body of fluid can have only gravity forces and normal surface forces acting on it.

The dimensions of viscosity are determined from Newton's law of viscosity. Solving for the viscosity μ, and inserting dimensions F, L, T for force, length, and time, shows that μ has the dimensions $FL^{-2}T$. With the force dimension expressed in terms of mass by use of Newton's second law of motion, $F = M \cdot LT^{-2}$, the dimensions of viscosity may be expressed as $ML^{-1}T^{-1}$.

The SI unit of viscosity, the Newton-second per square meter ($(N \cdot s)/m^2$) or the kilogram per meter per second ($kg/(m \cdot s)$), has no name. The U. S. customary unit of viscosity (which has no name) is

1(lb · s)/ft^2 or 1 slug/(ft · s)(these are identical). A common unit of viscosity is the cgs unit, called the poise; it is 1 (dyne · s)/cm^2 or 1 g/(cm · s). The SI unit is 10 times larger than the poise unit.

The viscosity μ is frequently referred to as the absolute viscosity or the dynamic viscosity to avoid confusing it with the kinematic viscosity υ which is the ratio of viscosity to mass density:

$$\upsilon = \frac{\mu}{\rho} \tag{1.1}$$

The kinematic viscosity occurs in many applications, e. g. in the dimensionless Reynolds number for motion of a body through fluid, VL/ν, in which V is the body velocity and L is a representative linear measure of the body size. The dimensions of ν are L^2T^{-1}. The SI unit of kinematic viscosity is 1 m^2/s, and the U. S. customary unit is 1 ft^2/s. The cgs unit, called the Stoke, is 1 cm^2/s.

In SI units, to convert from ν to μ it is necessary to multiply ν by ρ, the mass density in kilograms per cubic meter. In U. S. customary units μ is obtained from ν by multiplying by the mass density in slugs per cubic foot. To change from the Stokes to the poise, one multiplies by mass density in grams per cubic centimeter, which is numerically equal to specific gravity.

Viscosity is practically independent of pressure and depends upon temperature only. The kinematic viscosity of liquids, and of gases at a given pressure is substantially a function of temperature.

Words and Expressions

viscosity [vɪ'skɑsətɪ] *n.* 黏性

characteristic [ˌkærɪktə'rɪstɪk] *n/adj.* 典型的,特有的

dimension [dɪ'menʃn] *n/v.* 规模,尺寸,在……上标尺寸

resistance [rɪ'zɪstəns] *n.* 电阻,阻力,抵抗,抗力

shear [ʃɪə(r)] *v/n.* 剪切,穿越,大剪刀

angular [ˈæŋgjələ(r)] *adj.* 有角的,用角测量的,角度的
deformation [ˌdiːfɔːˈmeɪʃn] *n.* 变形,形态损伤
proportional [prəˈpɔːʃənl] *n/adj.* 比例的,比例项,比例量
cohesion [kəʊˈhiːʒn] *n.* 凝聚,内聚,(各部的)结合
molecular [məˈlekjələ(r)] *adj.* 分子的,由分子组成的
stationary [steɪʃənri] *n/adj.* 固定物,不动的,静止的,不变的
momentum [məˈmentəm] *n.* 动量,要素
velocity [vəˈlɑsəti] *n.* 速率,速度,周转率
apparent [əˈpærənt] *adj.* 易看见的,可看见的,显然
kinematic [ˌkɪnɪˈmætɪk] *adj.* 运动的,运动学的
dimensionless [dəˈmenʃənləs] *adj.* 无量纲的,无因次的

1.2 The Continuum Hypothesis, Density and Specific Volume of Fluid

Obviously there are gaps between the fluid and all substances molecules. In fluid mechanics, the macrofluid is consisted of a large number of molecules, the physical quantities of macrofluid (such as pressure, velocity and density) is the statistical average of the action and the behavior of most fluid molecules. In 1753, the continuous media was first proposed as macrofluid model by Euler. The real fluid is considered as no-gap continuous media, called the basic assumption of continuity fluid of fluid or the continuum of fluid.

In dealing with fluid-flow relations on a mathematical or analytical basis, it is necessary to consider that the actual molecular structure is replaced by a hypothetical continuous medium, called the continuum, for example, velocity at a point in space is indefinite in a molecular medium, as it would be zero at all times except when a molecule occupied this exact point, and then it would be the velocity of the molecule and not the mean mass velocity of the particles in the neighborhood. This dilemma is avoided if one considers velocity at a point to be the average or mass velocity of all molecules surrounding the point, say, within a small sphere with radius large compared with the mean distance between molecules. With n molecules per cubic centimeter, the mean distance between molecules is of the order $n^{-1/3}$ cm. Molecular theory, however, must be used to calculate fluid properties (e. g. viscosity) which are associated with molecular motions, but continuum equations can be employed with the results of molecular calculations.

In rarefied gases such as the atmosphere at 50 mi above sea level the ratio of the mean free path or the gas to a characteristic length for a body or conduit is used to distinguish the type of flow, The flow regime is called gas dynamics for very small values of the ratio; the next regime is called slip flow; and for large values of the ratio it is free molecule flow. In this text only the gas-dynamics regime is studied.

The quantities density, specific volume, pressure, velocity and acceleration are assumed to vary continuously throughout a fluid (or be constant).

The density ρ of a fluid is defined as its mass per unit volume.

Density $\rho=\frac{\text{mass}}{\text{volume}}$, that is Eq. (1.2).

$$\rho=\frac{m}{V} \tag{1.2}$$

To define density at a point, the mass Δm of fluid in a small volume ΔV surrounding the point is divided by ΔV and the limit is becomes a value ε^3 in which ε is still large compared with the mean distance between molecules. For water at standard pressure (760 mmHg) and 4 ℃ (39.2 ℉), $\rho=1.94$ (slug · s)/ft^3, or 1 000 kg/m^3.

The specific volume v_s is the reciprocal of the density ρ ;it is the volume occupied by unit mass of fluid. Hence

$$v_s = \frac{1}{\rho} \tag{1.3}$$

Words and Expressions

hypothesis [haɪˈpɑθəsɪs] *n.* 假设,假说
gap [gæp] *n.* 间隙
macrofluid [ˈmækrəˈflʊ(:)ɪd] *n.* 宏观流体
continuity [ˌkɒntɪˈnjuːəti] *n.* 连续性,继续
analytical [ˌænəˈlɪtɪkl] *adj.* 分析的,分析法的,善于分析的
structure [ˈstrʌktʃə(r)] *n.* 结构,构造
radius [ˈreɪdiəs] *n.* 半径范围,半径
continuum [kənˈtɪnjuəm] *n.* 连续统一体
rarefied [ˈreərɪfaɪd] *adj.* 纯净的,稀薄的

1.3 Prefect Gas

In this treatment, thermodynamic relations and compressible-fluid-flow cases have been limited generally to perfect gases. The perfect gas is defined in this section.

The perfect gas, as used herein, is defined as a substance that satisfied the perfect-gas law. And that has constant specific heats p is the absolute pressure; v_s is the specific volume; R is the gas constant; and T is the absolute temperature.

$$pv_s = RT \tag{1.4}$$

The perfect gas must be distinguished from the ideal fluid. An ideal fluid is frictionless and incompressible. The perfect gas has viscosity and can therefore develop shear stresses, and it is compressible according to Eq. (1.4).

Equation(1.4)is the equation of state for a perfect gas. It may be written Eq. (1.5).

$$p=\rho RT \tag{1.5}$$

The units of R can be determined from the equation when the other units are known. For p in pascals, ρ in kilograms per cubic meter, and T in degrees Kelvin(K) (℃+273).

Real gases below critical pressure and above the critical temperature tend to obey the perfect-gas law.

As the pressure increase, the discrepancy increases and becomes serious near the critical point.

The perfect-gas law encompasses both Charles' law and Boyle's law states that for constant pressure the volume of a given mass of gas varies as its absolute temperature. Boyle's law (Isothermal law) states that for constant temperature the density varies directly as the absolute pressure. The volume V of m mass units of gas is mv_s; hence

$$pV=mRT \tag{1.6}$$

Certain simplications result from writing the perfect-gas law on a mole basis. A kilogram mole of gas is the number of kilograms mass of gas equal to the molecular weight. e. g, a kilogram mole of oxygen O_2 is 32 kg. With $\bar{v}_s$ being the volume per mole, the perfect-gas law becomes

$$p\bar{v}_s=MRT \tag{1.7}$$

If m is the molecular weight. In general, if n is the number of moles of the gas in volume V.

$$pV=nMRT \tag{1.8}$$

Since $nM=m$ Now, from Avogadro's law, equal volumes of gases at the same absolute temperature and pressure have the same number of molecules; hence their masses are proportional to the molecular weights. From Eq. (1.8) it is seen that MR must be constant, since pV/nT is the same for any perfect gas. The product MR, called the universal gas constant, has a value depending only upon the units employed.

The specific heat C_V of a gas is the number of units of heat added per unit mass to raise the temperature of the gas one degree when the volume is held constant. The specific heat C_P is the number of heat units added per unit mass to raise the temperature one degree when the temperature is hold constant. The specific heat ratio k is $\frac{C_P}{C_V}$. The intrinsic energy U(dependent upon p, ρ, and T) is the energy per unit mass due to molecular spacing and forces. The enthalpy (h) h is an important property of a gas given by Eq. (1.9).

$$h = U + pV \tag{1.9}$$

C_P and C_V have the units kilocalorie per kilogram per Kelvin (kcal/(kg · K)) or Btu per pound mass per degree Rankine. One kilocalorie of heat added raises the temperature of one kilogram of water one degree Celsius at standard conditions. One Btu of heat added raises the temperature of one pound mass of water one degree Fahrenheit. Because of these definitions of kilocalorie and Btu, the numerical values of C_V and C_P are the same in both systems of units. R is related to C_V and C_P by Eq. (1.10).

$$C_P = C_V + R \tag{1.10}$$

In which all quantities must be in either mechanical or thermal units. If the slug unit is used, C_P, C_V, and R are 32.174 times greater than with the pound mass unit.

Words and Expressions

thermodynamic [θɛ:məʊdaɪ'næmɪk] *adj.* 热力学的,使用热动力的

substance ['sʌbstəns] *n.* 物质,材料,实质,内容

frictionless [f'rɪkʃnles] *adj.* 无摩擦的,光滑的

incompressible [ˌɪnkəm'presəbl] *adj.* 不可压缩的

Kelvin [ˈkelvɪn] *n.* 绝对温标,开氏温标
discrepancy [ˈdisˌkrepənsi] *n.* 矛盾,差异,不符合之处
kilocalorie [ˈkɪləʊˌkælərɪ] *n.* 千卡,大卡(热量单位)
prefect gas 理想气体

1.4 Fluid Flow

Fluid mechanics deals with the behaviour of liquids and gases. The liquid is either at rest or in motion. Fluid at rest is fluid statics; examples such as water in a container or reservoir of water behind a dam. Fluid at rest has weight and exerts pressure. Fluid in motion is fluid dynamics. Examples are rivers, flow in pipes, flow in pumps and turbines. The fluids that are commonly studied are air and water. External flow is study of fluid flow over car, aeroplane, ships and rockets. Flow in pipes, impellers of pumps are referred to as internal flow. Compressible flow is when density does not remain constant with application of pressure. Incompressible flow is the density remains constant with application of pressure. Water is incompressible whereas air is compressible. Compressibility criteria is Mach number.

The chapter deals with the concept of momentum and Newton's second and third law of motion. With the knowledge of continuity equation and momentum equation, Bernoullis and Eulers equations are derived. With the help of second law of Newton force acting by a jet on stationary and moving plate is obtained. The impact of jet on vanes has direct application on hydraulic turbines.

Scope of Fluid Mechanics

The dimensional analysis deals with the units of measurement in SI units both fundamental and derived units, and non-dimentional quatities.