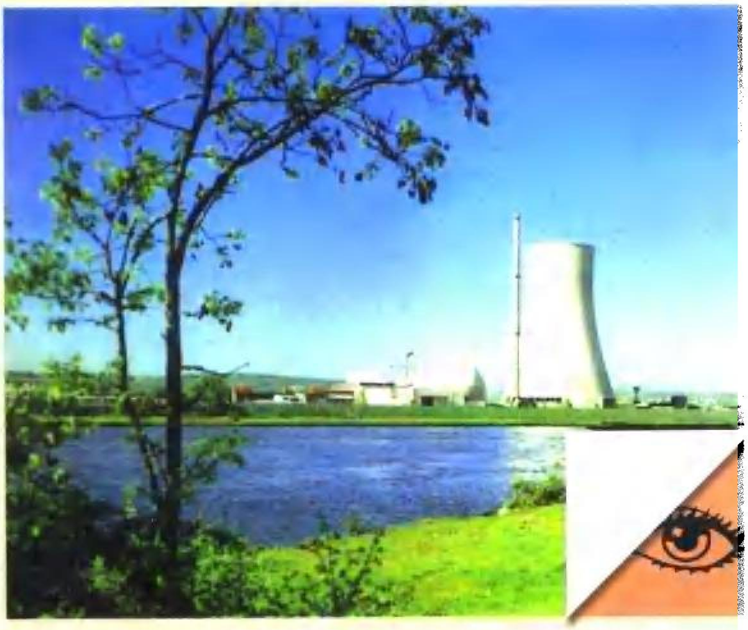
专业英语阅读丛书

热能与动力工程
专业英语

ENGLISH IN

GY AND POWER ENGINEERING



李瑞扬　主编

哈尔滨工业大学出版社

热能与动力工程专业英语

主　编　李瑞扬
副主编　夏新林　赵玉晓
主　审　吕　薇

哈尔滨工业大学出版社
哈尔滨

内容提要

本书涵盖了热能与动力工程专业的主要分支学科，以培养热能与动力工程专业学生的专业英语阅读能力为主要目标。全书共分八个部分，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，制冷与空调，锅炉设备，涡轮机，环保、腐蚀及部分参考译文等，书后附录中还给出了《常用缩写词》和《常用计量单位换算》。本书有较强的实用性和知识性，高等院校热能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。

本书既可作为高等学校热能与动力工程专业学生的专业英语教材，也可供从事有关热能与动力工程专业的工程技术人员学习、参考之用。

热能与动力工程专业英语
Reneng yu Dongli Gongcheng Zhuanye Yingyu
李瑞扬　编
*
哈尔滨工业大学出版社出版发行
哈尔滨工业大学印刷厂印刷
*
开本 850×1168　1/32　印张 11.375　字数 275 千字
2000 年 1 月第 1 版　　2000 年 1 月第 1 次印刷
印数 1～5 000
ISBN 7-5603-1451-1/H·142　定价：14.00 元

前　言

原国家教委颁布的“大学英语教学大纲”把专业英语阅读列为必修课而纳入英语教学计划，强调通过四年不断线的英语教学，使学生达到能顺利阅读专业英文刊物的目的。据此精神，编写了这本《热能与动力工程专业英语》教材，以满足高等院校热能与动力工程及有关专业学生的专业英语教学的需要和从事上述专业的工程技术人员学习英语的要求。

本书涵盖了热能与动力工程专业主要的分支学科，包括如下几部分：流体力学与流体机械，热力学与传热，燃料及燃烧，制冷与空调，锅炉设备，涡轮机，环保、腐蚀等。

书中课文内容比较新颖，文体规范，难度适中。为了适应专业英语教学的要求，书中内容既对学生学过的课程进行了必要的覆盖，又有所拓宽和延伸，力求反映热能与动力工程方面的现状和发展趋势，既可提高读者英语阅读水平，又能使读者了解本学科的专业知识。为了使读者阅读方便和便于理解，对书中每部分英文内容都给出了两篇以上的参考译文。

为便于读者阅读本书和其他英文资料，本书将常出现的英文缩写词和英、美的一些常用单位换算列在了附录中。

全书由英文、译文和附录组成，英文部分共分七部分，其中第一部分、第六部分由赵玉晓编写，第二部分、第四部分由夏新林编写，第三部分、第五部分、第七部分及附录等由李瑞扬编写，参考译文部分由李瑞扬、夏新林、赵玉晓编写。全书由李瑞扬统编，由吕薇主审。

由于编者水平有限，对书中的不足之处，恳请广大读者批评指正。

编者

1999 年 8 月

Contents

Part Ⅰ Fluid Mechanics and Fluid Machines

Part Ⅱ Thermodynamics and Heat Transfer

Part Ⅲ Fuels and Combustion

Part Ⅳ Refrigeration and Airconditioning

Part Ⅴ Boiler

Part Ⅵ Turbine

Part Ⅶ Environmental Protection, Corrosion and Others

参考译文

Part Ⅰ
Fluid Mechanics and Fluid Machines

1.1 Definition of a Fluid and Classification of Fluid Flow

A fluid is a substance that deforms continuously when subjected to a shear stress, no matter how small that shear stress may be. A shear force is the force component tangent to a surface, and this force divided by the area of the surface is the average shear stress over the area. Shear stress at a point is the limiting value of shear force to area as the area is reduced to the point.

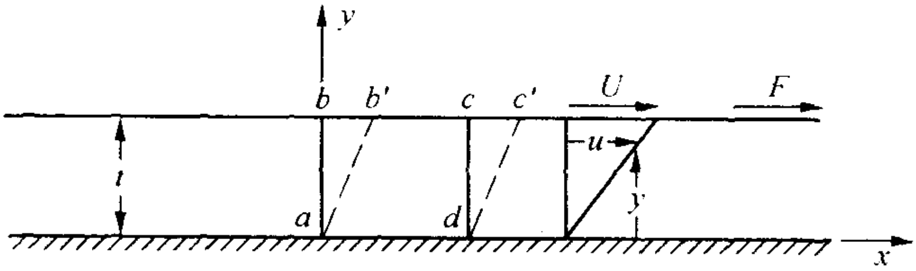


Fig. 1-1 Deformation resulting from application of constant shear force.

In Fig. 1-1 a substance is placed between two closely spaced parallel plates, so large that conditions at their edges may be neglected. The lower plate is fixed, and a force F is applied to the upper plate, which exerts a shear F/A on any substance between the plates. A is the area of the upper plate. When the force F causes the upper plate to move with a steady (nonzero) velocity, no matter how small the magnitude of F, one may conclude that the substance between the two plates is a fluid.

The fluid in immediate contact with a solid boundary has the same velocity as the boundary, i.e., there is no slip at the boundary. This is an experimental fact which has been verified in countless tests with various kinds of fluids and boundary materials. The fluid in the area *abcd* flows to the new position *ab'c'd*, each fluid particle moving parallel to the plate and velocity u varying uniformly from zero at the stationary plate to U at the upper plate. Experiments show that, other quantities being held constant, F is directly proportional to A and to U and is inversely proportional to thickness t. In equation form

$$F = \mu \frac{AU}{t}$$

in which μ is the proportionality factor and includes the effect of the particular fluid. If $\tau = F/A$ for the shear stress,

$$\tau = \mu \frac{U}{t}$$

The ratio U/t is the angular velocity of line *ab*, or it is the rate of angular deformation of the fluid, i.e., the rate of decrease of angle *bad*. The angular velocity may also be written $\mathrm{d}u/\mathrm{d}y$, as both U/t and $\mathrm{d}u/\mathrm{d}y$ express the velocity change divided by the distance over which the change occurs. However, $\mathrm{d}u/\mathrm{d}y$ is more general, as it holds for situations in which the angular velocity and shear stress change with y. The velocity gradient $\mathrm{d}u/\mathrm{d}y$ may also be visualized as the rate at which one layer moves relative to an adjacent layer. In differential form,

$$\tau = \mu \frac{\mathrm{d}u}{\mathrm{d}y} \tag{1-1}$$

is the relation between shear stress and rate of angular deformation for one-dimensional flow of a fluid. The proportionality factor μ is called the viscosity of the fluid, and Eq. (1-1) is Newton's law of viscosity.

Materials other then fluids cannot satisfy the definition of a fluid. A plastic substance will deform a certain amount proportional to the force, but not continuously when the stress applied is below its yield shear stress. A complete vacuum between the plates would cause deformation at an ever-increasing rate. If sand were placed between the two plates, Coulomb friction would require a finite force to cause a continuous motion. Hence, plastics and solids are excluded from the classification of fluids.

Fluids may be classified as Newtonian or non-Newtonian. In Newtonian fluid there is a linear relation between the magnitude of applied shear stress and the resulting rate of angular deformation (μ constant in Eq.1-1). In non-Newtonian fluid there is a nonlinear relation between the magnitude of applied shear stress and the rate of angular deformation.

An ideal plastic has a definite yield stress and a constant linear relation of τ to $\mathrm{d}u/\mathrm{d}y$. A thixotropic substance, such as printer's ink, has a viscosity that is dependent upon the immediately prior angular deformation of the substance and has a tendency to take a set when at rest. Gases and thin liquids tend to be Newtonian fluids, while thick long-chained hydrocarbons may be non-Newtonian.

For purposes of analysis, the assumption is frequently made that a fluid is nonviscous. With zero viscosity the shear stress is always zero, regardless of the motion of the fluid. If the fluid is considered to be nonviscous, it is then called an ideal fluid.

Fluid flow may be classified in many ways, such as steady or nonsteady, rotational or irrotational, compressible or incompressible, and viscous or nonviscous.

Fluid flow can be steady or nonsteady. When the fluid velocity at any given point is constant in time, the fluid motion is said to be steady. That is, at any given point in a steady flow the velocity of each passing fluid particle is always the same. At some other point a particle may travel with a different velocity, but every other particle which passes this second point behaves there just as this particle did when it passed this point. These conditions can be achieved at low flow speeds, a gently flowing stream is an example. In nonsteady flow, as in a tidal bore, the velocities are a function of the time. In the case of turbulent flow, such as rapids or a waterfall, the velocities vary erratically from point to point as well as from time to time.

Fluid flow can be rotational or irrotational. If the element of fluid at each point has no net angular velocity about that point, the fluid flow is irrotational. We can imagine a small paddle wheel immersed in the moving fluid. If the wheel moves without rotating, the motion is irrotational; otherwise it is rotational. Rotational flow includes vortex motion, such as whirlpools.

Fluid flow can be compressible or incompressible. Liquids can usually be considered as flowing incompressible. But even a highly compressible gas may sometimes undergo unimportant changes in density. Its flow is then practically incompressible. In flight at speeds much lower than the speed of sound in air (described by subsonic aerodynamics), the motion of the air relative to the wings is one of nearly incompressible flow.

Fluid flow can be viscous or nonviscous. Viscosity in fluid motion is the analogy of friction in the motion of solids. In many cases, such as in lubrication problems, it is extremely important. Sometimes, however, it is negligible. Viscosity introduces tangential forces between layers of fluid in relative motion and results in dissipation of mechanical energy.

Words and Expressions

component	[kəm'pəunənt]	*n*. (组成)部分,成分
tangent	['tændʒənt]	*a*. 正切的,相切的

space	[speis]	*v.*	把……分隔开,留间隔
magnitude	['mægnitjud]	*n.*	大小,量值
slip	[slip]	*n.*	滑动,滑动量
stationary	['steiʃənəri]	*a.*	固定的,稳定的
inversely	[in'və:sli]	*ad.*	相反地
angular	['æŋgjulə]	*a.*	角形的,用角度量的
adjacent	[ə'dʒeisənt]	*a.*	接近的,邻近的
yield	[ji:ld]	*n.*	屈服(点),极限
vacuum	['vækjuəm]	*n.*	真空
Newtonian	[nju'təuniən]	*a.*	牛顿的
linear	['liniə]	*a.*	线性的,直线的
thixotropic	[ˌθiksə'trɔpik]	*a.*	触变性的
hydrocarbon	['haidrəu'ka:bən]	*n.*	碳氢化合物
nonviscous	['nɔn'viskəs]	*a.*	非粘性的
plot	[plɔt]	*v.*	作图(表示)
ordinate	['ɔ:dinit]	*n.*	纵坐标
irrotational	[ˌirəu'teiʃənl]	*a.*	不旋转的
incompressibly	[ˌinkəm'presəbli]	*ad.*	不可压缩地
waterfall	['wɔtəfɔ:l]	*n.*	瀑布
tidal	['taidl]	*a.*	潮汐的
bore	[bɔ:]	*n.*	激浪
rapid	['ræpid]	*n.*	急流
erratically	[i'rætikəli]	*ad.*	不稳定地,无规律地
vortex	['vɔ:teks]	*n.*	涡流,漩涡
whirlpool	['hwə:lpu:l]	*n.*	漩涡
dissipation	[ˌdisi'peiʃən]	*n.*	消耗,消散
shear stress			剪切力,切应力
parallel to			与……平行
proportionality factor			比例系数
relative to			相对于,关于
Coulomb friction			库伦系数
take a set			凝固,硬化

1.2 Historical Development of Fluid Mechanics

The science of fluid mechanics began with the need to control water for irrigation and navigation purposes in ancient China, Egypt, Mesopotamia, and India. Although these civilizations understood the nature of channel flow, there is no evidence that any quantitative relationships had been developed to guide them in their work. It was not until 250 B.C. that Archimedes discovered and recorded the principles of hydrostatics and buoyancy. In spite of the fact that the empirical understanding of hydrodynamics continued to improve with the development of fluid machinery, better sailing vessels, and more intricate cannal systems, the fundamental principles of classical hydrodynamics were not founded until the seventeenth and eighteenth centuries. Newton, Daniel Bernoulli, and Leonard Euler made the greatest contributions to the founding of these principles.

In the nineteenth century, two schools of thought arose in the treatment of fluid mechanics, one dealing with the theoretical and the other with practical aspects of fluid flow. Classical hydrodynamics, though a fascinating subject that appealed to mathematicians, was not applicable to many practical problems because the theory was based on inviscid fluids. The practicing engineers at that time needed design procedures that involved the flow of viscous fluids; consequently, they developed empirical equations that were usable but narrow in scope. Thus, on the one hand, the mathematicians and physicists developed theories that in many cases could not be used by the engineers, and on the other hand, engineers used empirical equations that could not be used outside the limited range of application from which they were derived. In a sense, these two schools of thought have persisted to the present day, resulting in the mathematical field of hydrodynamics and the practical science of hydraulics.

Near the beginning of the twentieth century, however, it was necessary to merge the general approach of the physicists and mathematicians with the experimental approach of the engineer to bring about significant advances in the understanding of flow processes. Osborne Reynolds' paper in 1883 on turbulence and later papers on the basic equations of liquid motion contributed immeasurably to the development of fluid mechanics. After the turn of the century, in 1904, Ludwing Prandtl proposed the concept of the boundary layer. In his short, convincing paper Prandtl, at a stroke, provided an essential link between ideal and real fluid motion for fluids with a small viscosity and provided the basis for much of modern fluid mechanics.

The development of fluid mechanics in the twentieth century may be divided into four periods.

Low speed aerodynamics, 1900 ~ 1935

The first development of fluid mechanics was closely associated with aeronautical science. Because of the stringent requirement on weight, one needs reliable theoretical prediction to practical problems. As a result, one has to combine the essential features of old hydrodynamics and hydraulics into one rational science of fluid mechanics. Some of the important developments in these periods are: (a) Prandtl's boundary layer theory; (b) Kutta-Joukowski's wing theory to explain the phenomenon of air lift; (c) the theory of turbulent flow by von Kármán and others. In this period, the velocity of the fluid flow is low and the temperature difference in the flow is small. Consequently, we may neglect the compressibility effect of the fluid. Both the gas and the liquid may be treated by the same method of analysis. There is practically no difference in principle for hydrodynamics and aerodynamics.

Aerothermodynamics, 1935 ~ 1950

The speed of the gas flow was gradually increased from subsonic to supersonic speed. The compressibility effect of the gas is no longer negligible. We have to treat gas and liquid separately. For gasdynamics, we have to consider the mechanics of the flow simultaneously with the thermodynamics of the gas. Hence the term of aerothermodynamics was suggested for this new branch of fluid mechanics. In this field the most important parameter is the Mach number. However, the temperature range of the gas or air was still below 2 000K and the air may be considered as an ideal gas with constant specific heat. The molecular structure has very littly influence on the gas flow and we may use the same formula to deal with monatomic gas and polyatomic gas. Many new phenomena, such as shock wave, supersonic flow, etc., were analyzed in this period.

Physics of fluid, 1950 ~ 1960

This is the start of the space age. The speed of the flow and the temperature of the fluid are high enough so that we have to consider the interaction of mechanics of fluid with other branches of physics and that the molecular structure of the gas has a large influence on the fluid flow. We have to consider the influence on dissociation, ionization, and thermal radiation. New subjects such as aerothermochemistry, magnetogasdynamics, and plasma dynamics, and radiation gasdynamics have been extensively studied. We have to deal with the whole physics of fluids.

New era of fluid mechanics, 1930 and on

In the above three periods, our main interests are still the flow of fluids which consists of liquid, gas, or plasma only. During the recent years, the interest of many technical developments is so broad that we have to deal with flow problems beyond those of fluid alone. For instance, we have to deal with the mixture of solid and fluid, the so-called two-phase flow. In many rheological problems, the fluids behave partly as ordinary fluid and partly as solid. In the above three periods, we treat the fluid flow problems mainly according to the principles of classical physics. In many new problems of fluid flow, we have to consider the principles beyond those of classical physics such as superfluid for which the quantum effects are important even for macroscopic properties (quantum fluid mechanics); relativistic fluid mechanics in which the relativistic mechanics should be used because the velocity of the flow is no longer negligible in comparison with the speed of light. We are also interested in bio-fluid mechanics in which we study the interaction between the physical science of fluid flow and biological science. Modern developments in fluid mechanics, as in all fields, involve the use of highspeed computers in the solution of problems. Remarkable progress has been made in this area, and there is an increasing use of the computer in fluid dynamic design.

It should be noted that even though we divide the development of modern fluid mechanics into the above four periods, there are overlaps in time for these periods as far as the study of various subjects are concerned. For instance, the study of turbulent flow of low speed fluid flow which was one of the major subjects in the first period is still a very active research subject at the present time and many basic problems are far from being solved yet.

Words and Expressions

hydrostatics	['haidrəu'stætiks]	*n.* 流体静力学
buoyancy	['bɔiənsi]	*n.* 浮力