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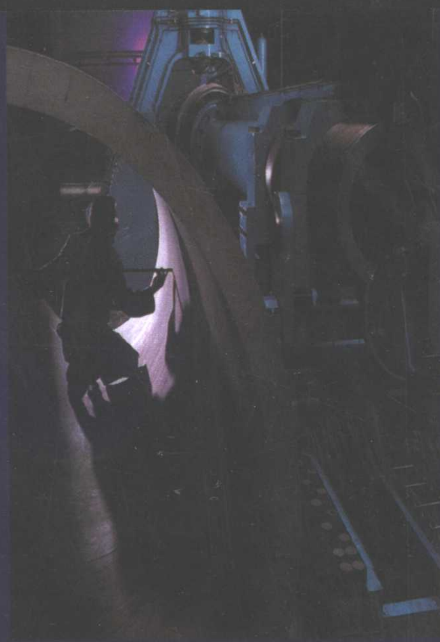
普通高等学校机械设计制造
及其自动化专业新编系列教材



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机械工程专业英语

Jixie Gongcheng Zhuanye Yingyu

武汉理工大学出版社

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内容简介

本书是为适应高等学校机械类专业英语的教学需要而编写的。主要内容包括:材料与热加工、机械零件、机床、切削技术与液压技术、机械电子学等,并编有附录材料。本书在编写中,从机械专业出发,注意现代机电技术的发展,按照从金属、钢铁到机器,从热加工到冷加工,从机器零部件到整台设备,从机械到机电一体化,以至将机、液、电子技术相结合的顺序来组织编写。在附录材料中涉及到英文科技文献和专利文献的查阅与检索,英文科技论文写作方法的介绍等,为广大读者进行有关科技交流活动提供了最大的方便。本书可供高等学校机械类专业师生及有关工程技术人员使用。

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普通高等学校
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编审委员会

出版说明

高等学校的教材建设向来是学科建设和教学改革的重要内容，其对教学过程和教学效果的重要影响是教育界所公认的。但教材建设与教学需要之间的矛盾永远存在也是一个客观的事实。正因为如此，教材建设才具有永恒的意义。特别是在这世纪交替的时期，中国的高等教育所面临的两个重大变革——高等学校本科专业目录调整和高等学校管理体制及布局结构调整，都对高校的教材建设提出了更高的要求。随着专业的合并，新专业的专业面拓宽，原有老专业的教材明显不能适应新专业的教学要求；调整后高校规模扩大，招生人数增加，对教材的需求也随之激增。在新的专业目录中，机械设计制造及其自动化专业与原有专业目录有了较大的变化，涵盖了原有的9个专业。相应的专业业务培养目标、教学要求、课程设置、学时数要求、主要实践性教学环节等都有了不同程度的变化。为适应新专业的培养目标和教学要求，武汉理工大学出版社在经过全面、细致和深入调研的基础上，组织编写了这套面向全国普通高等学校的新的系列教材。

本套教材面向全国普通高等学校，在保证内容要反映国内外机械学科最新发展的基础上，以满足一般院校的本科专业教学要求，实现专业的业务培养目标为基本原则。遵照全国高校机械工程类专业教学指导委员会制订的专业培养方案和教学计划设置课程体系，突出“系列”的特色，首批编写、出版的21种教材可基本满足一般院校本科教学需要。编写中强调各门课程之间的联系和衔接，强调教材整体风格的统一和协调，力求在加强基础、协调内容、适当降低难度、努力拓宽知识面向、适应科技发展、更新内容并大力引入多媒体教学手段等方面取得进展，以形成特色，更好地满足不同学校的教学需求。

本套教材集中了全国30多所著名大学的专家、教授和中青年教学骨干，分别担任系列教材的主编、主审和参编，组成了一个阵容强大、结构合理的编审委员会。特别是第二届全国高校机械工程类专业教学指导委员会主任委员杨叔子院士欣然出任编审委员会名誉主任，更增加了编审委员会的权威性。正是由于编委会成员务实、高效的工作，全体编审人员高度的责任心和严谨的治学精神，本套教材才能在这样短的时间内完成编写、出版的任务。杨叔子院士亲自为系列教材作序，更使全套教材光彩倍增！但我们深知，院士为一套教材作序，在国内是十分少见的，这充分体现了杨院士对教学改革及教材建设的热切关注和积极支持。这既是杨院士对编委会此前工作的鼓励和肯定，同时也是对编委会今后工作的指导和鞭策。我们一定不会辜负杨院士以及全国众多院校师生的期望。本套教材首期21种出齐后，一方面我们将在使用教材的广大师生提出意见和建议的基础上不断修订和完善，同时还将根据学校教学改革和课程设置的需要及时增补新的教材，使这套教材真正成为既能满足学校当前教学需要，又能起到推动专业教学内容和课程体系改革作用的一套精品教材。

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序

20世纪，人类文明达到了前所未有的高度。由于相对论、量子论、基因论、信息论等科学技术成就的取得，现在人类在物质领域已深入到基本粒子世界，在生命科学领域已深入到分子水平，在思维科学领域则主要是数学和脑科学的巨大进步。科学技术的迅猛发展，促使科学技术综合化、整体化以及人文和科技相互渗透、相互融合的趋势加速。

近20年来，我们在经济战线上坚持市场取向的改革，实行以公有制为主体、多种所有制经济共同发展的基本经济制度，进行经济结构的战略性调整，推动两个根本性转变以及全方位、多层次、宽领域的对外开放，致使我国的经济体制也发生了巨大的变革。随着社会主义市场经济体制的建立和不断完善，社会对人才需求的多样性、适应性要求不断增强。

在人类即将跨入21世纪的时候，我国高等教育战线在教育要“面向现代化，面向世界，面向未来”的思想指引下，开展了起点高、立意新、系统性强、有组织、有计划、有步骤的教学改革工程。伴随着教学改革的不断深入，素质教育的观念、大工程的观念、终身教育以及回归工程的观念日益深入人心，人们对拓宽本科教育口径、加强和扩展本科教育共同基础的要求日益强烈。

1998年8月，教育部正式颁布了新的普通高等学校本科专业目录，专业总数由原来的500多种减少至249种。新专业目录的颁布，突破了传统的、狭隘的专业教育观念，拓宽了人才培养工作的视野，为人才培养能较好地适应科学技术和社会进步的需要创造了条件。许多学校也都以专业调整、改造和重组为契机，大力调整人才知识、能力和素质结构，拓宽基础，整合课程，构建新的专业平台，柔性设置专业方向，不断深化人才培养模式的改革。

教材建设是学校的最基本建设之一。教学改革的深入发展必然要求有相适应的教材。为适应新的专业培养目标和教学要求，组织编写出版供“机械设计制造及其自动化”新专业的教学用书，特别是系列教材就显得十分迫切和重要了。武汉理工大学出版社的领导和编辑们为改变目前国内已出版的机械类专业教材普遍存在的内容偏深、知识面偏窄的倾向，决定面向全国普通高等学校机械工程类专业的学生出版一套系列教材，这是一个非常好的决策。他们的这一决定也得到了全国几十所院校机械工程系的领导和众多专家、教授的积极响应和大力支持，并提出了许多建设性的意见，其中一些教授如合肥工业大学校长陈心昭教授、燕山大学校长王益群教授、江苏理工大学校长蔡兰教授、西安交通大学副校长束鹏程教授、西北工业大学常务副校长杨海成教授等还非常乐意地承担了该系列教材的主编、主审及编审委员会工作。

编写教材除了应该具有针对性外，还应努力编出特色。根据武汉理工大学出版社和教材编审委员会的决定，该系列教材将完全按照第二届全国高校机械工程类专业教学指导委员会提出的机械设计制造及其自动化宽口径专业培养方案中所设置的课程来编写，这就保证了该套教材可以具有课程体系新、专业口径宽、改革力度大的特点，并可以满足不同院校办出各自专业特色的需要。

按照教材编审委员会的规划，该套教材首批将推出21种，包括机械工程概论、画法几何及机械制图、画法几何及机械制图习题集、机械原理、机械设计、理论力学、材料力学、工程热力学、工程材料、机械制造技术基础、材料成型基础、工程测试、数控技术、机械工程控制基础、液压与气压传动、机械CAD/CAM、机械工程项目管理、机电系统设计、现代设计方法、精密与特

种加工、机械工程专业英语等，涵盖了机械设计制造及其自动化专业的主要专业基础课和部分专业选修课而形成系列，因而可以较好地满足该专业的教学需要。也正是由于是系列教材，各门课程之间的联系和衔接在教材的策划、组织和编写过程中，都可开展充分的讨论和进行仔细的协调，因此有利于保证整套教材风格统一，内容分配合理，既相互呼应，又避免不必要的重复。

我殷切地希望，这套教材在加强基础、协调内容、适当降低难度、努力拓宽知识面向、适应科技发展、更新内容和大力引入多媒体等现代教育技术手段上取得进展，真正成为能满足普通高等学校本科生需要的优秀教学用书，在众多的机械类专业教材中，争芳斗艳，别具特色。

按照武汉理工大学出版社的计划，这套系列教材首批将在2001年秋季全部出齐。金无足赤，人无完人，书无完书。我相信，在读者的关心与帮助下，随着这套教材的不断发行、应用与改进，必将促进机械设计制造及其自动化专业教学用书质量的进一步提高，推动机械类专业教学内容和课程体系改革的进一步深入。

只木独秀难成林，千紫万红才是春！

面向21世纪，希望无限，谨为之序。

中国科学院院士、华中科技大学教授
全国高校机械工程类专业教学指导委员会主任委员　杨叔子

2000年11月18日

前　言

本书是按“普通高等学校机械设计制造及其自动化专业（本科）系列教材”的出版计划而组织编写的。

本教材适合于普通高等学校机械工程类专业高年级学生学习专业英语课程使用。全书共分为三大部分，第一部分（第一章至第五章）为课文部分，共54课。第二部分（第六章）为阅读材料，共13课供自由阅读。第三部分（第七、八章）为附录部分，介绍了英文科技文献与专利文献的查阅、检索以及英文科技论文的写作等。在内容上，我们从机械工程专业出发，注意到现代机电技术的发展，按照从金属、钢铁到机器，从热加工到冷加工，从机器零部件到整台设备，从机械学到机电一体化技术，以至将机、液、电子技术、计算机技术相结合的顺序来组织编写，循着机械制造过程的自然顺序，做到由浅入深，由简到繁，循序渐进。在编写中，我们侧重于阅读技巧与翻译的训练，希望学生通过本书的学习后能较顺利地阅读与翻译机械专业的英文科技资料或用英文来撰写机械专业论文或报告，同时也能较顺利地查阅检索到所需的英文科技文献资料或专利文献资料。

参加本书编写工作的有太原重型机械学院刘岩副教授（第一章）、武汉理工大学李璨教授（第二、三章），广东工业大学司徒忠教授（第四章）、谢秀红老师（第五章及第六章一至五课）、李希红老师（第六章六至十三课）以及洛阳工学院徐顺利副教授（第七章、第八章）。全书由司徒忠教授、李璨教授担任主编，广东工业大学黄运尧教授及广东省包装机械研究所李翠琼高工担任主审。黄运尧教授还为本书单独编写了《参考译文》一书，以供读者参考使用，并与本书同时发行。

本书在编写过程中，广东工业大学谢秀红、李希红两位老师作了大量的文稿整理工作，同时全书亦得到黄运尧教授的热心支持与指导。在此特向他们表示衷心的谢意。

由于本书编写时间仓促，难免会有缺点与错误，请读者予以批评指正。

编者

2000年12月

CONTENTS

CHAPTER 5 MECHATRONICS

CHAPTER 6 READING MATERIALS

CHAPTER 7

CHAPTER 8

CHAPTER 1 MATERIALS AND HOT WORK

Lesson 1 Basic Concepts in Mechanics

Work is defined as force multiplied by the distance over which the force acts. Work is measured in metre-kilograms. A metre-kilogram equals the work done by a force of one kilogram acting through a distance of one metre. For example, if a work task involves lifting a 300-kilogram machine two and one-half metres into a truck, then 750 metre-kilograms of work is required. Since no humans can lift 300 kilograms directly, a device must be employed to modify the required effort into something manageable. One common device is an inclined plane—in this case, a loading ramp that slopes from the ground to the truck, If the ramp were 10 metres long and friction forces were negligibly small, then 75 kilograms of force would be required to roll the machine up the ramp. [1] The total work is still 750 metre-kilograms (10 metres multiplied by 75 kilograms), but the effort has been modified so that the maximum force required is only 75 kilograms.

A device that decreases the necessary applied force while increasing the distance over which the smaller force acts is called a force multiplier. [2] Machines can also multiply speed and distance. A broom is an example of a speed and distance multiplier because it converts input force and distance at the handle into a lower force and larger distance at the sweeping end. [3] Since the larger distance at the sweeping end is covered in the same time as the input distance, then the speed is also increased. In addition to modifying forces and distances, machines can also change the direction of motion.

Efficiency and mechanical advantage are used to gauge the performance of mechanical machines. Efficiency is defined as the useful mechanical output work, expressed as a percentage of the input work. Efficiency is always less than 100 percent because of friction between moving parts. If someone actually wheeled the machine of the initial example up the ramp, they might discover that it required 84 kilograms. The nine-kilograms difference is the force required to overcome the resistance of the wheels and bearings. Under these conditions the machine would have an efficiency of 89 percent. If they slid the refrigerator up the ramp without wheels, the required force could be 215 kilograms or more, which corresponds to an efficiency of less than 35 percent. Ideal mechanical advantage neglects friction and is equal to the distance the input force travels divided by the useful distance the load travels. For force-multiplying machines, the input distance is greater than the load distance and the ideal mechanical advantage is greater than 1. In the loading ramp example, the ideal mechanical advantage is 4, since the input distance is 10 metres (the length of the ramp) and the useful load distance is two and one-half metres (the vertical distance the load travels). An inclined plane is always a force-multiplying machine. For speed-multiplying machines the input distance is less than the load distance and the ideal mechanical advantage is less than1. Machines that simply change the direction of motion have an ideal mechanical advantage equal to 1. The actual mechanical advantage includes friction and is equal to the actual output force divided by the actual input force. The actual mechanical advantage in the loading ramp example is about 3. 6 with wheels and about 1. 4 without wheels.

Words and phrases

mechanics *n.* 力学
modify *v.* 修改,调解,变更
manageable *a.* 可控制[管理]的
incline *v.*(使)倾斜
ramp *n.* 斜板,斜坡[道]
slope *v.*(使)倾斜
friction *n.* 摩擦
roll *v.* 滚动
multiplier *n.* 放大器,乘法器
broom *n.* 扫帚
convert *v.* 转变[化]
handle *n.* 手柄[把]
sweep *v.* 扫荡[描],掠过
efficiency *n.* 效率
gauge *vt.* 测[计]量,校验
bearing *n.* 轴承
ideal mechanical advantage 理想的机械效益
neglect *vt.* 忽略

Notes

[1] One common device is an inclined plane—in this... would be required to roll the machine up the ramp. 句中 that slops...the truck 是一定语从句,修饰 the loading ramp;if...ramp 为条件虚拟语句。全句可译为:"普通的装置是一个斜面——在这个例子中,是一个倾斜在地面和卡车之间的承载斜板,如果斜板有10m 长,摩擦阻力忽略,那么就需要 75kg 的力,将机器滚上斜板。"

[2] A device that ... is called a force multiplier. 本句的结构为 A device is called a force multiplier,其中 that decrease ... the smaller force acts 为 that 引导的定语从句,修饰 A device,在这个定语从句中又套了一个由 which 引导的定语从句,修饰 the distance。故本句译为:"使所需的作用力减少,同时使这个较小的作用力所通过的距离增加,这样的装置被称为力放大器"。

[3] A broom ... larger distance at the sweeping end. 其中 convert ... into ... 表示"把……转变成……"。全句译为:"扫帚就是一个速度和距离放大器的例子,因为它把在手柄上输入的力和距离在扫帚的尾部转变成较小的力和较长的距离。"

Lesson 2 Basic Assumption in Plasticity Theory

The purpose applying plasticity theory in metal forming is to investigate the mechanics of plastic deformation in metal forming processes. Such investigation allows the analysis and prediction of (a) metal flow (velocities, strain rates and strains), (b) temperatures and heat transfer, (c) local variation in material strength or flow stress and (d) stresses, forming load, pressure and energy. Thus, the mechanics of deformation provides the means for determining how the metal flows, how the desired geometry can be obtained by plastic forming and what are the expected mechanical properties of the part produced by forming. [1]

In order to arrive at a "manageable" mathematical description of metal deformation, several simplifying (but reasonable) assumptions are made:

1) Elastic deformations are neglected. However, when necessary, elastic recovery (for example, in the case of springback in bending) and elastic deflection of tooling (in the case of precision forming to very close tolerances) must be considered.

2) The deforming material is considered to be a continuum (metallurgical aspects such as grains, grain boundaries and dislocations are not considered).

3) Uniaxial tensile or compression test data are correlated with flow stress in multiaxial deformation conditions.

4) Anisotropy and Bauschinger effects are neglected.

5) Volume remains constant.

6) Friction is expressed by a simplified expression such as Coulomb's law or by a constant shear stress. This will be discussed later.

The behaviour of metal under compressive stress is more complex. This can be seen from an analysis of what happens when a cylindrical sample is compressed between two platens. Plastic deformation commences when the stress on the workpiece attains the yield stress of the metal. As the height of the sample decreases it spreads outwardswith an increase of cross-sectional area. This movement takes place against a frictional force between the ends of the workpiece and the platens. [2] The deforming metal is subject to the complex stress system .

The stress system has altered from single, uniaxial to three-dimensional or triaxial. There is one applied stress from the platens and two are induced by the friction reaction. If there was no friction between the platens and the workpiece, then yielding would occur under a uniaxial compressive stress exactly as in the case of tensile loading. [3] The yield stress in compression would then coincide exactly with the yield stress in tension. The presence of friction, however, alters the situation and a higher stress is required to cause yielding. Many attempts have been made to find a mathematical relationship between the tensile yield stress and the values of stresses in a triaxial system just at the point of yielding. [4] No single relationship has been found which covers all cases of plastic yielding under all cases of triaxial loading for all metals. A number of theories of plastic yielding have been suggested, each of which has validity in a limited field. Before these can be considered, it is necessary to study the triaxial stress system and to develop methods of solving problems using both mathematical and graphical techniques.

The most convenient technique available is Mohr's Circle for three-dimensional stress and when this can be manipulated with ease the intricate aspects of plastic yielding can be studied.

Words and phrases

assumption *n.* 假定
plasticity *n.* 塑性
investigate *v.* 调查,研究
deformation *n.* 变形
metal forming process 金属成型工艺[过程]
strain (rate) *n.* 应变(速率)
strength *n.* 强度
stress *n.* 应力
yield stress 屈服应力
flow stress 流动应力
tensile stress 拉(伸)应力
compressive stress 压(缩)应力
shear stress 剪(切)应力
geometry *n.* 几何形状
elastic *a.* 弹性的
springback *n.* 回弹
bending *n.* 弯曲,折弯
precision forming 精密成型
tolerance *n.* 公差
continuum *n.* 连续(体)
metallurgical *a.* 冶金(学)的
grain *n.* 晶粒
dislocation *n.* 位错
(uni-, tri-, multi-)axial *a.* (单、三、多)轴(向)的
anisotropy *n.* 各向异性
cylindrical *a.* 圆柱体的
cross-section *n.* 横截面
platen *n.*(工作)台板,模板
coincide with 一致,相符
validity *n.* 正确有效,合法
with ease 轻(而)易(举)的,很容易的

Notes

[1] Thus, the mechanics of deformation ... produced by forming. 此句中 how ..., how ... and what ... 引导的并列从句做动名词 determining 的宾语;分词短语 produced by forming 是 the part 的后置定语。全句可译为:"因此,变形机理提供了确定金属如何流动的方法,怎样通过塑性成型获得所需的几何形状,以及用成型方式生产的零件具有什么样的机械性能。"

[2] This movement take place against ... the platens. 其中 This movement 指塑性变形,介词 against 表示"反对","克服",该介词短语表示状态。句子译为:"克服了工件两端面与模板间的摩擦阻力,产生塑性变形。"

[3] If there was no friction ..., then yielding would occur .... 本句为虚拟语气,as 引导的比较状语是一个省略句,应为 as the yielding occur in the case of ...。整句译为:"若模板与工件间无磨擦,工件就在单向压应力下发生屈服,正像其受到拉伸载荷的情形一样。"

[4] Many attempts have been made to find ... the point of yielding. 可译为:"为了找到拉伸屈服应力与三向应力状态下产生屈服时的应力值之间的定量关系,已经做了很多尝试。"

Lesson 3 Optimization for Finite Element Applications

As engineers work with increasingly complex structures, they need rational, reliable, fast, and economical design tools. Over the past two decades, finite element analysis has proven to be the most frequently used method of identifying and solving the problems associated with these complicated designs.

Because most of the design tasks in engineering are quantifiable, computers have revolutionized the highly iterative design process, particularly the procedures for quickly finding alternative designs. But even now, many engineers still follow a manual trial-and-error approach. Such an approach makes designing-even for seemingly simple tasks more difficult because it usually takes longer, requires extensive human-machine interaction, and tends to be biased by the design group's experience.

Design optimization, which is based on a rational mathematical approach to modifying designs too complex for the engineer to modify, automates the design cycle.[1] If automated optimization can be done on a desktop platform, it can save a lot of time and money.

The goal of optimization is to minimize or maximize an objective, such as weight or fundamental frequency that is subject to constraints on response and design parameters.[2] The size and/or shape of the design determine the optimization approach.

Looking at optimization as part of the design process makes it easier to understand. The first step includes preprocessing, analysis, and postprocessing, just as in customary finite element analysis (FEA) and computer-aided design (CAD) program applications (the difference in CAD lies in building the problem's geometry in terms of the design parameters). In the second step, the optimization objective and response constraints are defined. And in the last step, The repetitive task of design adjustment is automated. Optimization programs should allow engineers to monitor the progress of the design, stop it if necessary, change the design conditions, and restart. The power of an optimization program depends on the available preprocessing and analysis capabilities. Applications for 2-D and 3-D need both automatic and parametric meshing capabilities. Error estimate and adaptive control must be included because the problem's geometry and mesh might change during the optimization loops.[3]

Revising, remeshing, and reevaluating models to achieve specific design goals start with preliminary design data input. Next comes the specification of acceptable tolerances and posed constraints to achieve an optimum, or at least improve, solution. To optimize products ranging from simple skeletal structures to complicated three-dimensional solid models, designers need access to a wide variety of design objectives and behavior constraints. Additional capabilities will also be needed for easy definition and usc of the following: weights, volumes, displacements, stresses, strains, frequencies, buckling safety factors, temperatures, temperature gradients, and heat fluxes as constraints and objective functions.

Moreover, engineers should be able to combine constraints from different types of analyses in multidisciplinary optimization. For example, designers can perform thermal analysis and transfer temperatures as thermal loads for stress analysis, put constraints over maximum temperature, maximum stress, and deflection, and then specify a range for the desired fundamental frequency. The objective function can represent the whole model or only parts of it. Even more important, it should reflect the importance of the different portions of the model by specifying weight or cost factors.

Words and phrases

optimization *n.* 优化,优选(法)
finite element 有限元
iterative *a.* 反复的,迭代的
alternative *n. a.* 交替(的),可供选择的
manual *a.* 手动的,人工的
trial-and-error 试凑法
bias *vt. n.* (使)偏向[重,差]
a desktop platform (计算机)桌面平台
constrain(t) *v. n.* 强制,约束
response *n.* 反[响]应,灵敏度
parameter *n.* 参数
parametric *a.* 参数的
preprocess *vt.* 预(先)加工,预处理
mesh *n. v.* 网格,啮合
capability *n.* 能力,性能,容量
loop *n.* 环,回路,循环
pose *v.* 提出,摆出……姿态
model *n.* 模型,样品
displacement *n.* 位移,排量,替换
buckling *n.* 弯[翘]曲,挠度
factor *n.* 因素
gradient *n.* 坡[梯]度,斜率
flux *n.* [电、磁、热、光]通量,流量
multidisciplinary *a.* 多学科的
deflection *n.* 偏移[转,离],挠曲

Notes

[1] Design optimization, which ... the design cycle. 句中 too ... to ... 结构的基本意思是"太……以致不能……",本句可译为:"优化设计是以理论数学的方法为基础,改进那些对于工程师来说过于复杂的设计,使其设计过程自动化。"

[2] The goal of ... and design parameters. 译:"优化的目的就是要将对象极大化或极小化,例如,重量或基频这些在频响和设计参数方面受约束的对象。"

[3] Error estimate and adaptive control must ... might change during the optimization loops. 译:"因为在优化过程中,问题的几何条件和网格会改变,所以优化程序必须包含错误估计和自适应控制。"

Lesson 4 Metals

Why does man use metals still so much today when there are other materials, especially plastics, which are available? A material is generally used because it offers the required strength, and other properties, at minimum cost. Appearance is also an important factor. The main advantage of metals is their strength and toughness. Concrete may be cheaper and is often used in building, but even concrete depends on its core of steel for strength.

Plastics are lighter and more corrosion-resistant, but they are not usually as strong. Another problem with plastics is what to do with them after use. Metal objects can often be broken down and the metals recycled; plastics can only be dumped or burned.

It is known that metals are very important in our life. Metals have the greatest importance for industry. All machines and other engineering constructions have metal parts, some of them consist only of metal parts.

About two thirds of all elements found in the earth are metals, but not all metals may be used in industry.[1] Those metals, which are used in industry, are called engineering metals. The most important engineering metal is iron (Fe), which in the form of alloys with carbon (c) and other elements, finds greater use than any other metal. Metals consisting of iron combined with some other elements are known as ferrous metals;[2] all the other metals are called nonferrous metals. The most important nonferrous metals are copper (Cu), aluminum (Al), lead (Pb), zinc (Zn), tin (Sn), but all these metals are used much less than ferrous metals, because the ferrous metals are much cheaper.

Not all metals are strong, however. Copper and aluminum, for example, are both fairly weak—but if they are mixed together, the result is an alloy called aluminum bronze, which is much stronger than either pure copper or pure aluminum. Alloying is an important method of obtaining whatever special properties are required: strength, toughness, resistance to wear, magnetic properties, high electrical resistance or corrosion-resistance.[3]

Different metals are produced in different ways, but almost all the metal are found in the form of metal ore (iron ore, copper ore, etc.). The ore is a mineral consisting of a metal combined with some impurities. In order to produce a metal from some metal ore, we must separate these impurities from the metal, that is done by metallurgy.

Methods of extracting, producing and treating metals are being developed all the time to meet engineering requirements. This means that there are an enormous variety of metals and metallic materials available from which to choose.

Words and phrases

toughness *n.* 韧性
corrosion *n.* 腐蚀
dump *v.* 倾倒，堆放
recycle *v.* 反复[循环]利用
copper *n.* 铜
aluminum *n.* 铝
bronze *n.* 青铜(器)
alloy *n.* 合金
wear *v.* 磨损
metallic *a.* (含)金属(制)的
specification *n.* 操作规程，技术要求，说明书
extract *vt.* 提炼，萃取