高等工科院校无损检测专业规划教材

无损检测专业英语

WUSUN JIANCE ZHUANYE YINGYU

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机械工业出版社
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本书是针对高等工科院校无损检测专业英语课程的需要而编写的。全书共八章，包括无损检测与质量控制、材料缺陷的形成、射线检测技术、超声检测技术、磁粉检测技术、涡流检测技术、渗透检测技术、其他非常规无损检测技术。课文选材涵盖了无损检测的主要技术、最新发展及相关知识，具有专业知识及专业英语紧密结合的特点。每一章的内容按照每种技术的发展历史、优越性及局限性、检测原理、检测方法、检测设备及器材以及应用的逻辑关系编排，并在每章后附有无损检测相关知识、术语双解以及常用科技英语语法介绍等。本书不仅可以作为无损检测专业及相关专业（机械、材料工程、质量检验等）本科生的专业英语教材，无损检测专业专科学生也可选择性使用，还适合无损检测及相关专业的工程技术人员及管理人员使用。

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序

无损检测是一门综合性科学（边缘科学），它利用声、光、热、电、磁和射线等与物质的相互作用，在不损伤被检对象使用性能的前提下，探测其内部或表面的各种宏观缺陷，并判断缺陷位置、大小、形状和性质。无损检测的研究领域涉及物理学、材料学、力学、电子学、计算机、声学、自动控制和可靠性理论等多门学科。随着现代工业和科学技术的发展，该技术已在愈来愈多的行业得到了广泛的应用，其水平高低已在很大程度上反映了一个国家的工业和科技发展水平。

随着对无损检测技术人员在知识结构、理论基础、工程实践能力方面提出更高和更广的要求，对无损检测技术人才的培养也提出了不少新的和特殊的要求。南昌航空大学是我国最早创办无损检测本科专业的高等学校，30 年来，她为我国航空、航天、石油、化工、核工业、电力、机械等行业输送了大批无损检测专业技术人才，有力地促进了我国无损检测事业的进步和发展，也为我国无损检测教育事业的发展作出了突出贡献，在国内无损检测界享有很高的声誉。

南昌航空大学在无损检测人才培养过程中，始终关注专业教材的建设，不仅编写了一套校内教学讲义，还先后由航空工业出版社、机械工业出版社正式出版发行了《射线检测工艺学》、《电磁无损检测》、《激光全息无损检测》、《无损检测技术》等教材，推动了我国的无损检测高等教育工作。2007 年，南昌航空大学无损检测专业通过了教育部评审，批准为国家特色专业建设点。在国家特色专业建设中，他们继续把编写出版无损检测高等教育系列教材作为主要的建设任务之一。这次由机械工业出版社出版的这套教材，就是他们在原教材的基础上，结合多年来教学改革的经验体会，融入近年来无损检测技术发展成果重新编写改版的新教材。

这套教材对无损检测常规方法和几种非常规方法进行了系统介绍，不仅突出了各种检测方法的基本理论体系、方法工艺和检测技术这一架构，还对该领域的最新研究成果及应用前景作了系统介绍和分析，它既可作为无损检测高等教育的本科生教材，也可作为以无损检测为研究方向的硕士和博士研究生的参考教材，对从事无损检测专业的工程技术人员也必然会有重要参考价值。相信这套教材的出版一定会为促进我国无损检测高等教育事业和推动我国无损检测技术的发展发挥重大作用。

中国无损检测学会理事长 耿荣生

2011 年 11 月

丛书序言

无损检测是一门涉及多学科的综合性技术，其特点是在不破坏构件材质和使用性能的条件下，运用现代测试技术来确定被检测对象的特征及缺陷，以评价构件的使用性能。随着现代工业和科学技术的发展，无损检测技术正日益受到人们的重视，不仅它在产品质量控制中所起的不可替代的作用已为众多科技人员所认同，而且对从事无损检测技术的专业及相关人员提出了相应的要求。本套教材正是为了满足各方面人士对无检测技术学习和参考的需要，促进无损检测技术的进一步发展，根据高等工科院校专业课程教学基本要求，结合南昌航空大学无损检测专业30年来的教学经验，在不断探索教学改革的基础上编写的。

南昌航空大学无损检测专业是1984年经原国家教委批准在国内率先创办的本科专业，经过近30年的建设与发展，随着本科专业名称的多次调整，南昌航空大学无损检测专业归类为“测控技术与仪器”专业。但学校始终坚持以无损检测为特色，始终坚持把**“培养具有扎实理论基础和较强工程实践能力的高级无损检测技术专业人才”**作为专业的培养目标。经过多年努力，把“测控技术与仪器”（即原无损检测）专业建设成为国家级特色专业。并且，在专业教学中，在全国无损检测学会的支持下，经过多年的艰苦努力，编写了国内首套无损检测专业教材。这套教材曾被国内多所高等院校同类及相近专业采用，其中，《射线检测工艺学》和《电磁无损检测》等还由航空工业出版社正式出版。近年来，在国家特色专业建设过程中，为了紧跟无损检测技术进步对人才培养提出的新要求，我们按照新的教学计划对教材进行了重新规划和编写。本套教材不仅汇集了当前无损检测技术的最新成果，有一定的深度和广度，注重理论联系实际，而且更加注意教材的系统性与可读性，以满足各层次读者的需要。

本套教材共10册，包括《超声检测》、《射线检测》、《磁粉检测》、《涡流检测》、《渗透检测》、《声发射检测》、《激光全息与电子散斑检测》、《质量控制》、《无损检测专业英语》、《无损检测技能训练教程》。

由于无损检测技术涉及的基础学科知识和工业应用领域十分广泛，而且，新材料、新工艺的出现，以及信息、电子、计算机等新技术在无损检测中的应用十分迅速，很难在教材编写中得到及时反映，因此所编教材难免会有疏漏和不足之处，恳请读者批评指正。

本套教材在编写过程中参考了国内外同类教学和培训教材，得到了国内诸多同行专家教授的指导和支持，在此一并致谢！愿本套教材能为提高及促进无损检测专业的发展起到积极的推动作用。

无损检测专业教材编写组

2011年10月

前　　言

随着无损检测技术的日益发展以及国内外无损检测同行的交流日益频繁，无损检测从业人员对先进无损检测技术的了解和掌握也越来越迫切，相应地对于从事无损检测的工程技术人员、管理人员的专业英语阅读、理解能力的要求也越来越高。作为未来无损检测从业人员的无损检测专业在校大学生，具备阅读和翻译专业英语文献的能力，应是必备的基本素质。

专业英语课程是在大学英语课程及专业知识学习之后设立的必修课，它的作用是使学生具备一定的专业英语文献的阅读、翻译、写作能力，使学生能以英语为工具，获取专业技术方向的信息和知识。因此，专业英语教材的编写对于专业英语的教学显得尤为重要。

本教材力求突出无损检测的专业特点，以无损检测技术及方法为主体，共由八章内容构成，包括无损检测与质量控制、材料缺陷的形成、射线检测技术、超声检测技术、磁粉检测技术、涡流检测技术、渗透检测技术、其他非常规无损检测技术（包括微波检测、红外检测、声发射技术、振动分析等10种无损检测技术）。课文选材内容覆盖了无损检测的主要技术及相关知识，具有将专业知识及专业英语紧密结合的特点。每一章的内容按照每种技术的历史背景、优越性及局限性、检测原理、检测方法、检测设备及器材、应用范围的逻辑关系进行编排，有利于教师的讲解及学生的学习理解。在内容的选择上参考了大量的国外原版教材、培训资料及文献，同时注重最新无损检测技术的引入和介绍，如TOFD、ICT等技术。因此，本书不仅可以作为无损检测专业英语的学习教材，也可作为无损检测专业知识的英文读本。

由于专业英语在词汇、句法、语法上具有鲜明的特点，为了便于学生的学习，在每章后面附有科技英语的常用语法、用法介绍，包括科技英语的特点、构词法、论文写作、数学符号的英文表达等。附录不仅包括科技英语语法的介绍，对涉及无损检测技术的相关知识，如国外无损检测相关学术机构、技术标准、常规无损检测技术的物理量纲以及无损检测专业术语的中英文双解等也作了介绍。在介绍科技英语语法、用法时（如构词法、摘要写作、量纲英语表达等），均以无损检测应用为例进行说明，使得本书的“专业性”更强。课后专业术语的双语解释，不仅可以使学生掌握专业词汇，而且给学生提供了一个用英语表达专业术语的学习平台。附录中收录的英文检测报告示例，增强了教材的实用性。课文内容及附录的特色使本书不仅可以满足无损检测专业学生的学习需要，也具备一定的无损检测专业工具书的作用。

本书从课文内容、附录、练习的选材上，紧扣无损检测技术，覆盖面广，难度适中，突显了无损检测专业的特点，其讲义已在南昌航空大学无损检测专业的本科生教学中应用多年，经重新修改、补充，编写而成，是国内目前唯一一本无损检测专业英语教材。本书既可作为高等院校无损检测专业及相关专业（机械、材料工程、质量检验等）

本科生的专业英语教材，无损检测专业专科学生也可选择性使用，还适合无损检测及相关专业工程技术人员和管理人员使用。

本书是南昌航空大学所编无损检测专业系列教材之一。本书由南昌航空大学测试与光电工程学院测控技术与仪器专业（无损检测）张小海教授、金信鸿讲师编写，第1、2、8章由张小海、金信鸿编写，第3、4、5章由张小海编写，第6、7章由金信鸿编写，全书由张小海统稿。在本书编写过程中，得到了南昌航空大学卢超教授、袁丽华副教授、敖波博士及深圳职业技术学院晏荣明副教授的支持和帮助，南昌航空大学邬冠华教授任本书主审，对教材结构和内容提出了宝贵建议。在此一并表示衷心感谢。本教材由南昌航空大学教材建设基金资助。

由于编者水平有限，书中难免有不足甚至错误之处，希望广大读者批评指正。

编　者

Contents

Chapter 1 Quality Control and NDT

1.1 NDT in Industry

Flaws and cracks can play havoc with the performance of structures, so that the detection of defects in solids is an essential part of quality control of engineering systems for their safe and successful use in practical situations. This is known variously as nondestructive testing (NDT), nondestructive evaluation (NDE), nondestructive characterization, or nondestructive inspection. Quality control, quality technology, and noncontact measurements are related subjects that include or use NDT techniques. However, applications of NDT go much deeper and are much broader in scope than the detection of gross defects. They concern all aspects of the characterization of solids, their microstructure, texture, morphology, chemical constituents, physical and chemical properties, as well as their methods of preparation. There is concern for the most minute detail that may affect the future performance of the object in service, so that all properties need to be under control and all factors understood that may lead to breakdown. [1] Nor is it appropriate to rely on general statements because each study and each example needs to be treated individually, proceeding by the use of all known properties and information about the component. The abbreviation NDT will be used in this text for "nondestructive testing".

A description of the early evolution of NDT is given by Mullins and his review still covers most of the methods presently used. The established test methods include radiography, ultrasonics inspection, magnetic particle inspection, liquid penetrant inspection, thermography, electrical and magnetic methods, and visual-optical testing. In the case of radiography, X-ray and γ-ray are well established, but neutron, proton, and Compton scattering are also used and there have been recent important advances in tomography. Many of the NDT methods are highly sophisticated, yet there are many techniques that are relatively simple. One such method is visual examination, with a hand lens. The simple methods are stressed because it is important not to overlook the obvious in examining an engineering component.

Applications of NDT in industry concern metals, nonmetals, very small to very large objects, and stationary as well as moving components. In medicine, NDT includes mammography, nuclear magnetic resonance scans, general X-ray, and microangiography. Noncontact measurements using sensors are important in a wide range of subjects from geology, forensic studies, aerial temperatures, and weather surveys, to thickness measurements and art authentication. The examinations are concerned with detecting cracks, tears, imperfect welds and junctions, inclusions, tomography, and surface contamination effects without altering the piece in any way.

The operator of the tests is another important factor, and operator fatigue, as well as training, represents both an essential ingredient and a severe problem affecting all aspects of NDT. Because NDT is all-encompassing, it is most useful to have a library of as many examples or case studies as possible, all concerned with practical situations. [2]

A survey has been carried out by the Institute of Metallurgists of the many different NDT techniques used in engineering industry and found that liquid penetrant and magnetic particle testing accounts for about one-half of all the NDT testing, ultrasonics and X-ray methods about another third, eddy current testing accounted for about 10%, and all other methods accounted for only about 2%. It is not necessarily the most sophisticated method that is most suitable.

Table 1-1 is a simplified breakdown of the complexity and relative requirements of the five most frequently used NDT techniques. Table 1-2 gives a comparison of common nondestructive evaluation methods as judged by the Office of Nondestructive Evaluation, NIST, USA.

Table 1-1 The relative uses and merits of various NDT methods

Item	Test method				
	Ultrasonics	X-ray	Eddy current	Magnetic particle	Liquid penetrant
Capital cost	Medium to high	High	Low to medium	Medium	Low
Consumable cost	Very low	High	Low	Medium	Medium
Time of results	Immediate	Delayed	Immediate	Short delay	Short delay
Effect of geometry	Important	Important	Important	Not too important	Not too important
Access problem	Important	Important	Important	Important	Important
Type of defect	Internal	Most	External	External	Surface breaking
Relative sensitivity	High	Medium	High	Low	Low
Formal record	Expensive	Standard	Expensive	Unusual	Unusual
Operator skill	High	High	Medium	Low	Low
Operator training	Important	Important	Important	Important	—
Training needs	High	High	Medium	Low	Low
Portability of equipment	High	Low	High to medium	High to medium	High
Dependent on material composition	Very	Quick	Very	Magnetic only	Little
Ability to automate	Good	Fair	Good	Fair	Fair
capabilities	Thickness gauging; some composition testing	Thickness gauging	Thickness gauging; grade sorting	Defects only	Defects only

Table1-2 Comparison of some NDT methods

Method	Characteristics detected	Advantages	Limitations	Example of use
Ultrasonics	Changes in acoustic imped ance caused by cracks, nonbonds, inclusions, or interfaces	Can penetrate thick materials; excellent for crack detection; can be automated	Normally requires coupling to material either by contact to surface or immersion in a fluid such as water. Surface needs to be smooth.	Adhesive assemblies for bound integrity; lamination; hydrogen cracking
Radiography	Changes in density from voids, inclusions, material variations; placement of internal parts	Can be used to inspect wide range of materials and thicknesses; versatile; film provides record of inspection	Radiation safety requires precautions; expensive; detection of cracks can be difficult unless perpendicular to X-ray film.	Pipeline welds for penetration, inclusion, voids; internal defects in castings
Visual-optical	Surface characteristics such as finish, scratches, cracks, or color; strain in transparent materials; corrosion	Often convenient; can be automated	Can be applied only to surface, through surface openings, or to transparent material	Paper, wood, or metal for surface finish and uniformity
Eddy current	Changes in electrical conductivity caused by material variations, cracks, voids, or inclusions	Readily automated; moderate cost	Limited to electrically conducting materials; limited penetration depth	Heat exchanger tubes for wall thinning and cracks
Liquid penetrant	Surface openings due to cracks, porosity, seams, or folds	Inexpensive, easy to use, readily portable, sensitive to small surface flaws	Flaw must be open to surface. Not useful on porous materials or rough surfaces	Turbine blades for surface cracks or porosity; grinding cracks
Magnetic particles	Leakage magnetic flux caused by surface or near-surface cracks, voids, inclusions, material or geometry changes	Inexpensive or moderate cost, sensitive both to surface and near-surface flaws	Limited to ferromagnetic material; surface preparation and post-inspection demagnetization may be required	Railroad wheels for cracks; large castings

1.2 NDT in Everyday Life

NDT is well-known as a part of industrial procedures, but it is also of importance in examinations of a more general interest in everyday life. Art objects such as paintings, sculptures, furniture, pottery, and ceramics need to be authenticated, and the tests of necessity must not damage or destroy the object. The techniques used include X-ray, neutron activation analysis, and thermoluminescence. X-ray laminography has been used to examine the working of clocks and imperfections in printed circuit boards. Neutron activation analysis has been used in geological studies in situ to determine the chemical composition at depths within the earth's crust by lowering a radioactive source spectrometer system down a drill hole of diameter only 4in. The internal structure of the earth is itself analyzed using the effects of seismic waves generated by earthquakes. The use of polarized light enables examinations of large objects to be carried out avoiding the interference of scattered and reflected light as well as for stress analysis. The three-dimensional shape of large objects can be portrayed using a shadow moire technique.

Ultrasound waves can be used to detect submarines, schools of fish, and as navigational aids. Baggage control at airports as well as metal detectors utilize eddy current examination. Infrared techniques are used in detecting heat losses from buildings, the performance of steam traps, hot spots in electrical equipment, friction in mechanical systems, defects in metals, stresses in metals, as well as aerial photography. γ-ray has been used to examine lead-coated coffins from the seventeenth century. A γ-ray, using Iridium-192, of the Freedom Statue of the U. S. Capitol Building has revealed the presence and the condition of the iron skeleton of this bronze structure. Thus, NDT applies in almost all aspects of everyday life.

1.3 History of NDT

The historical development of NDT is outlined for each technique at the beginning of each chapter. In almost all cases, the bulk of the techniques have been developed in this century with very little utilization in earlier years. Table 1-3 lists some of the key events in the chronology of NDT.

Table 1-3 Chronology of early key events in NDT

BC(approx.)	Visual testing becomes the first NDT method when God creates the heavens and earth and "sees" that it is good
1800	First thermography observations by Sir William Herschel
1831	First observation of electromagnetic induction by Michael Faraday
1840	First infrared image produced by Herschel's son, John
1868	First reference to magnetic particle testing reported by S. H. Saxby. by observing how magnetized gun barrels affect a compass
1879	Early use of eddy currents to detect differences in conductivity, magnetic permeability, and temperature initiated by E.Hughes
1880-1920	"Oil and whiting" technique, forerunner of present-day penetrant test used for railroad axles and boilerplates
1895	X-rays discovered by Wilhelm Conrad Roentgen
1898	Radium discovered by Marie and Pierre Curie
1922	Industrial Radiography for metals developed by Dr.H.H.Lester
1927-1928	Electric current induction/magnetic field detection system developed by Dr. Elmer Sperry and H.C. Drake for the inspection of railroad track