普通高等教育“十一五”规划教材
PUTONG GAODENG JIAOYU SHIYIWU GUIHUA JIAOCAI

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电气工程及其自动化专业英语教程

凌跃胜　宋桂英　黄文美　编

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内 容 提 要

本书为普通高等教育“十一五”规划教材。本书是针对高等院校电气工程及其自动化专业科技英语阅读课程的需要而编写的，内容涵盖电机与电器、电工理论与新技术、电力电子与电力传动、电力系统及其自动化、高电压与绝缘技术五个电气工程二级学科相关专业基础知识方面的内容；同时考虑到本学科新技术的发展，选用了有关的专业文献与资料。全书分 5 部分，共计 29 个单元，每单元包含课文、专业英语词汇、注释和综合练习等内容。为了提高使用者的科技英语阅读理解能力、翻译能力和写作能力，在附录部分还增加了专业英语阅读、翻译和写作知识，可根据教学需要选用。

本书主要作为高等学校电气工程及其自动化专业教材，也可作为科技人员工程技术人员学习专业英语的参考用书。

图书在版编目（CIP）数据

电气工程及其自动化专业英语教程/凌跃胜，宋桂英，黄文美编．—北京：中国电力出版社，2007

普通高等教育“十一五”规划教材

ISBN 978-7-5083-5934-2

Ⅰ．电…　Ⅱ．①凌…　②宋…　③黄…　Ⅲ．①电气工程－英语－高等学校－教材②自动化技术－英语－高等学校－教材　Ⅳ．H31

中国版本图书馆 CIP 数据核字（2007）第 112382 号

中国电力出版社出版、发行
（北京三里河路 6 号　100044　http://jc.cepp.com.cn）
汇鑫印务有限公司印刷
各地新华书店经售
*
2007 年 8 月第一版　2007 年 8 月北京第一次印刷
787 毫米×1092 毫米　16 开本　15.5 印张　375 千字
印数 0001—3000 册　定价 **24.80** 元

前　言

为贯彻落实教育部《关于进一步加强高等学校本科教学工作的若干意见》和《教育部关于以就业为导向深化高等职业教育改革的若干意见》的精神，加强教材建设，确保教材质量，中国电力教育协会组织制订了普通高等教育"十一五"教材规划。该规划强调适应不同层次、不同类型院校，满足学科发展和人才培养的需求，坚持专业基础课教材与教学急需的专业教材并重、新编与修订相结合。本书为新编教材。

科学技术的迅速发展与国际学术交流的增多，对高等院校学生专业英语的阅读、翻译和写作能力都提出了更高的要求，各院校所设置的专业英语课程作为专业英语基本技能训练，也越来越显示出其重要性。为了贴近新技术、新理论的不断发展和应用，目前使用的电气工程及其自动化专业英语教材需要更新和增加内容，以满足电气工程及其自动化专业的人才培养需要。作者根据多年从事高等院校电气工程及其自动化专业英语课程的教学实践，结合国家教委最新颁布的专业目录要求，编写了电气工程及其自动化专业的专业英语教材。

为了在选材上力求先进性，本书大部分内容材料选自国外相关专业的参考书，在编排上系统地贯穿了电气工程及其自动化专业的专业基础课程，并添加和更新了部分英语教材内容，补充了许多与工程实践相关的新知识，如电磁兼容技术、现代电力电子技术以及高压直流传输等，以达到在学习专业外语的同时，丰富和补充电气工程及其自动化专业新理论、新知识的目的。

本书由凌跃胜教授、宋桂英副教授、黄文美副教授共同编写。书中第一、二部分由黄文美编写，第三、四部分由宋桂英编写，第五部分以及附录由赵争菡编写，全书由凌跃胜教授统稿。兰州理工大学的郝晓弘教授审阅了全书，并提出了大量的宝贵意见和建议。河北工业大学杨晓光副教授、安金龙副教授，在国外工作的何仁杰博士、叶秋波博士等，为本书编写提供了很多宝贵的资料，在此表示衷心感谢。

由于编者水平有限，书中难免存在不足之处，殷切期望广大读者批评指正。

编者

2007 年 1 月

目　录

前言
Part Ⅰ　Electrical Machines and Electrical Apparatus ········ 1
Unit 1　Power Transformer ········ 1
Text A　Construction and Principles of Power Transformer ········ 1
Text B　Advantages of Balanced Three-phase Versus Single-phase Systems ········ 4
Unit 2　Direct Current (DC) Machines ········ 8
Text A　Direct Current Machines ········ 8
Text B　Elementary Knowledge of Rotating Machines ········ 11
Unit 3　Alternating Current (AC) Machines ········ 14
Text A　Synchronous Machines ········ 14
Text B　Induction Machines ········ 17
Unit 4　Variable Reluctance Machines and Stepping Motors ········ 21
Text A　Variable Reluctance Machines ········ 21
Text B　Stepping Motors ········ 24
Unit 5　Electrical Apparatus in Control System ········ 27
Text A　Relays ········ 27
Text B　Contactors ········ 30
Unit 6　Low Voltage Circuit Breaker ········ 34
Test A　Circuit Breaker and its Main Components ········ 34
Text B　Trip Units of Circuit Breaker ········ 38
Unit 7　Arcs ········ 42
Text A　What is Arc? ········ 42
Text B　Arc Control Techniques ········ 45
Unit 8　Electrical Apparatus Reliability ········ 48
Text A　Electrical Apparatus Reliability Test ········ 48
Text B　Influencing Factor Analysis of Circuit-Breaker Reliability ········ 51
Part Ⅱ　Theory and New Technology of Electrical Engineering ········ 55
Unit 1　Magnetism and Electromagnetism ········ 55
Text A　Electromagnetism ········ 55
Text B　Permeability and Saturation ········ 58
Unit 2　Electric Network Analysis ········ 62
Text A　Branch Current Method ········ 62
Text B　Network Theorems ········ 65

Unit 3 Computation of Electromagnetic Fields ········· 70
Text A Finite Element Method Used in Electromagnetic ········· 70
Text B Time Domain versus Frequency Domain ········· 73
Unit 4 Electromagnetic Interference and Electromagnetic Compatibility ········· 77
Text A Electromagnetic Interference and Electromagnetic Compatibility ········· 77
Text B Designing for Board Level Electromagnetic Compatibility ········· 80
Unit 5 Smart Materials and Applications ········· 86
Text A What are Smart Materials? ········· 86
Text B Applications of Magnetostrictive Material ········· 89
Part Ⅲ Power Electronics and Power Drives ········· 94
Unit 1 Trends in Power Electronics ········· 94
Text A Power Semiconductor Devices ········· 94
Text B Scope and Application ········· 98
Unit 2 Power Semiconductor Devices ········· 102
Text A Power Semiconductor Devices ········· 102
Text B Power Integrated Circuit and Choice for Device ········· 106
Unit 3 Phase-Controlled Rectifiers ········· 111
Text A Phase-Controlled Rectifiers ········· 111
Text B EMI and Line Power Quality Problems ········· 114
Unit 4 DC-DC Converters and its Application ········· 118
Text A Control of DC-DC Converters ········· 118
Text B DC-DC converter application ········· 122
Unit 5 Inversion: Conversion of DC to DC ········· 127
Text A Control of DC to AC Converter ········· 127
Text B Control of AC Motor Drives ········· 130
Unit 6 Design Considerations of Practical Converter ········· 135
Text A Drive Circuits ········· 135
Text B Snubber Circuits ········· 139
Part Ⅳ Power System and its Automation ········· 143
Unit 1 Fundamentals of Power Systems ········· 143
Text A Power of Single-phase Circuits ········· 143
Text B Advantages of balanced Three-phase Versus Single-phase Systems ········· 146
Unit 2 Power System Stability ········· 150
Text A Power Flow Analysis ········· 150
Text B Transient Stability ········· 153
Unit 3 Electrical Power System ········· 157
Text A Components of Power System ········· 157
Text B Electrical Energy of Power System ········· 160

Unit 4 Transmission of Electrical Energy …… 165
Text A Principal Components of a Power Distribution System …… 165
Text B Direct-Current Transmission …… 168
Unit 5 Faults and Protection on Power System …… 173
Text A Power System Faults …… 173
Text B Power System Protection …… 176
Unit 6 Power System Control …… 180
Text A Introduction of Power System Control …… 180
Text B Controlling the Power Balance between Generator and Load …… 183
Part Ⅴ High Voltage and Insulation Technology …… 188
Unit 1 Basic of High Voltage and Insulation Technology …… 188
Text A Introduction of Electrical Insulation …… 188
Text B Estimation of Electric Stress …… 191
Unit 2 Insulating Materials …… 195
Text A Dielectric Materials …… 195
Text B Applications of Insulating Materials …… 199
Unit 3 Insulation Testing of Electrical Apparatus …… 203
Text A Measurement of High Voltages …… 203
Text B Non-Destructive Testing of Materials and Electrical Apparatus …… 207
Unit 4 Testing, Planning and Layout of High Voltage Laboratories …… 211
Text A High Voltage Testing of Electrical Apparatus …… 211
Text B Planning and Layout of High Voltage Laboratories …… 215
附录 A 科技英语阅读知识 …… 220
附录 B 科技英语翻译技巧 …… 222
附录 C 英语写作方法 …… 234
参考文献 …… 240

Part Ⅰ Electrical Machines and Electrical Apparatus

Unit 1 Power Transformer

Text A Construction and Principles of Power Transformer

Transformer is an indispensable component in many energy conversion systems. It makes possible electric generation at the most economical generator voltage, power transfer at the most economical transmission voltage, and power utilization at the most suitable voltage for the particular utilization device. The transformer is also widely used in low-power, low-current electronic and control circuits for performing such functions as matching the impedances of a source and its load for maximum power transfer, isolating one circuit from another, or isolating direct current while maintaining alternating current continuity between two circuits.

Essentially, a transformer consists of two or more windings coupled by mutual magnetic flux. If one of these windings, the primary, is connected to an alternating voltage source, an alternating flux will be produced whose amplitude will depend on the primary voltage, the frequency of the applied voltage, and the number of turns. The mutual flux will link the other winding, the secondary and will induce a voltage in it whose value will depend on the number of secondary turns as well as the magnitude of the mutual flux and the frequency. By properly proportioning the number of primary and secondary turns, almost any desired voltage ratio, or ratio of transformation, can be obtained.

The essence of transformer action requires only the existence of time-varying mutual flux linking two windings. Such action can occur for two windings coupled through air, but coupling between the windings can be made much more effectively using a core of iron or other ferromagnetic material, because most of the flux is then confined to a definite, high-permeability path linking the windings. Such a transformer is commonly called an iron-core transformer. Most transformers are of this type. The following discussion is concerned almost wholly with iron-core transformers.

In order to reduce the losses caused by eddy currents in the core, the magnetic circuit usually consists of a stack of thin laminations. Two common types of construction are shown schematically in Fig. 1. 1. In the core type (Fig. 1. 1a) the windings are wound around two legs of a rectangular magnetic core; in the shell type (Fig. 1. 1b) the windings are wound around the center leg of a three-legged core. Silicon-steel laminations 0. 014mm in thick are generally used for transformers operating at frequencies below a few hundred Hz. Silicon steel has the desirable properties of low cost, low core loss, and high permeability at high flux densities (1.0 to 1.5T). The cores of small transformers used in communication circuits at high frequencies and low energy levels are sometimes made of compressed powdered ferromagnetic alloys known as ferrites.

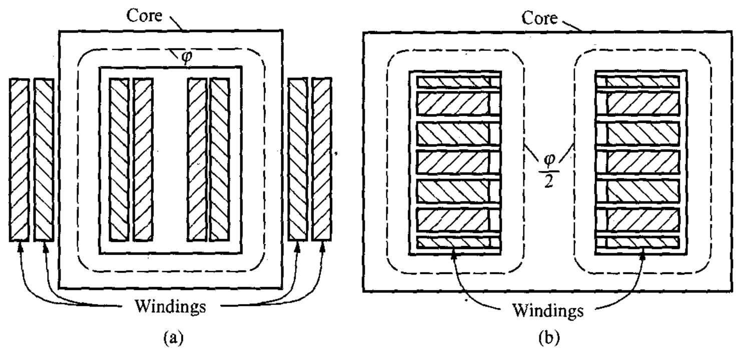

Fig. 1.1 Schematic views of
(a) core-type and (b) shell-type transformers

In each of these configurations, most of the flux is confined to the core and therefore links both windings. The windings also produce additional flux, known as leakage flux, which links one winding without linking the other. Although leakage flux is small fraction of the total flux, it plays an important role in determining the behavior of the transformer. In practical transformers, leakage is reduced by subdividing the windings into sections placed as close together as possible. In the core-type construction, each winding consists of two sections, one section on each of the two legs of the core, the primary and secondary windings being concentric coils. In the shell-type construction, variations of the concentric-winding arrangement may be used, or the windings may consist of a number of thin pancake coils assembled in a stack with primary and secondary coils interleaved.

New Words and Phrases

power transformer 电力变压器
indispensable *adj*. 不可缺少的
power transfer 电能传输，功率转换
isolate *v*. 隔离，孤立，绝缘
matching the impedance 阻抗匹配
winding *n*. 绕组
construction *n*. 结构
primary *adj*. 一次测的
secondary *adj*. 二次测的
turn *n*. 匝数
time-varying *adj*. 时变的
stack *n*. 堆，叠
eddy current 涡流
lamination *n*. 薄层，叠片
silicon-steel laminations 硅钢片
couple *v*. 耦合
loss *n*. 损耗
leakage flux 漏磁通
core type 芯式
shell type 壳式

core *n.* 铁芯
wound *v.* （wind 的过去分词）缠，绕
powdered *adj.* 粉末状的，弄成粉的
ferromagnetic *adj.* 铁磁的
alloy *n.* 合金
permeability *n.* 磁导率
interleaved *adj.* 交叉放置的
concentric coils 同心式线圈
pancake coil 扁平线圈
legs of the core 铁芯柱

Notes

1. Such action can occur for two windings coupled through air, but coupling between the windings can be made much more effectively using a core of iron or other ferromagnetic material, because most of the flux is then confined to a definite, high-permeability path linking the windings. 这样的作用也可以发生在通过空气耦合的两个绕组中，但用铁芯或其他铁磁材料可以使绕组间的耦合作用更强，因为大部分磁通被限制在与两个绕组交链的高磁导率的路径中。

2. In the core type (Fig. 1. 1a) the windings are wound around two legs of a rectangular magnetic core; in the shell type (Fig. 1. 1b) the windings are wound around the center leg of a three-legged core. 芯式（图 1. 1a）变压器的绕组绕在两个矩形铁芯柱上，壳式（图 1. 1b）变压器的绕组绕在三个铁芯柱的中间那个铁芯柱上。

Exercises

1. Answer the following questions according to the text

(1) How many types of core construction do power transformers have?

(2) Why does power transformer consist of a stack of thin laminations?

(3) What does the alternating flux amplitude depend on?

(4) What is leakage flux?

(5) In order to reduce the losses caused by eddy currents in the core, Silicon-steel laminations are generally used for transformers operating at frequencies below a few hundred Hz. Right or wrong?

2. Translate the following sentences into Chinese according to the text

(1) The transformer is also widely used in low-power, low-current electronic and control circuits for performing such functions as matching the impedances of a source and its load for maximum power transfer.

(2) By properly proportioning the number of primary and secondary turns, almost any desired voltage ratio, or ratio of transformation, can be obtained.

(3) The windings also produce additional flux, known as leakage flux, which links one winding without linking the other.

(4) In the core-type construction, each winding consists of two sections, one section on

each of the two legs of the core, the primary and secondary windings being concentric coils.

3. Translate the following paragraph into Chinese

In addition to the various power transformers, two special-purpose transformers are used with electric machinery and power systems. The first of these special transformers is a device specially designed to sample a high voltage and produce a low secondary voltage directly proportional to it. Such a transformer is a potential transformer (电压互感器). A power transformer also produces a secondary voltage directly proportional to its primary voltage; the difference between a potential transformer and a power transformer is that the potential transformer is designed to handle only a very small current. The second type of special transformer is a device designed to provide a secondary current much smaller than but directly proportional to its primary current. This device is called a current transformer (电流互感器).

Text B Advantages of Balanced Three-phase Versus Single-phase Systems

In both transformers and rotating machines, a magnetic field is created by the combined action of the currents in the windings. In an iron-core transformer, most of this flux is confined to the core and links all the windings. This resultant mutual flux induces voltages in the windings proportional to their number of turns and is responsible for the voltage-changing property of a transformer. In rotating machines, the situation is similar, although there is an air gap which separates the rotating and stationary components of the machine. Directly analogous to the manner in which transformer core flux links the various windings on a transformer core, the mutual flux in rotating machines crosses the air gap, linking the windings on the rotor and stator. As in a transformer, the mutual flux induces voltages in these windings proportional to the number of turns and the time rate of change of the flux.

A significant difference between transformers and rotating machines is that in rotating machines there is relative motion between the windings on the rotor and stator. This relative motion produces an additional component of the time rate of change of the various winding flux linkages. The resultant voltage component, known as the speed voltage, is characteristic of the process of electromechanical energy conversion. In a static transformer, however, the time variation of flux linkages is caused simply by the time variation of winding currents; no mechanical motion is involved, and no electromechanical energy conversion takes place.

The resultant core flux in a transformer induces a counter Electro-Motive Force (EMF) in the primary which, together with the primary resistance and leakage-reactance voltage drops, must balance the applied voltage. Since the resistance and leakage-reactance voltage drops usually are small, the counter EMF must approximately equal to the applied voltage and the core flux must adjust itself accordingly. Exactly similar phenomena must take place in the armature windings of an AC motor; the resultant air-gap flux wave must adjust itself to generate a counter EMF approximately equal to the applied voltage. In both transformers and rotating machines, the Magneto-Motive Force (MMF) of all the currents must accordingly adjust itself to create the resultant flux required by this voltage balance. In any AC electromagnetic device in which the resistance and leakage-reactance voltage drops are small, the resultant flux is very nearly determined by the applied voltage and frequency, and the currents must adjust themselves accordingly to produce the MMF required to create this flux.

In a transformer, the secondary current is determined by the voltage induced in the secondary winding, the secondary leakage impedance, and the electric load. In an induction motor, the secondary (rotor) current is determined by the voltage induced in the secondary, the secondary leakage impedance, and the mechanical load on its shaft. Essentially the same phenomena place in the primary winding of the transformer and in the armature (stator) windings of induction and synchronous motors. In all three, the primary, or armature, current must adjust itself so that the combined MMF of all currents creates the flux required by the applied voltage.

In addition to the useful mutual fluxes, in both transformers and rotating machines there are leakage fluxes which link individual windings without linking others. Although the detailed picture of the leakage fluxes in rotating machines is more complicated than that in transformers, their effects are essentially the same. In both, the leakage fluxes induce voltages in AC windings which are accounted for as leakage-reactance voltage drops. In both, the reluctances of the leakage-flux paths are dominated by that of a path through air, and hence the leakage fluxes are nearly linearly proportional to the currents producing them. The leakage-reactance therefore is often assumed to be constant, independent of the degree of saturation of the main magnetic circuit.

Further examples of the basic similarities between transformers and rotating machines can be cited. Except for friction and windage, the losses in transformers and rotating machines are essentially the same. Tests for determining the losses and equivalent circuit parameters are similar: an open-circuit, or no-load, test gives information regarding the excitation requirements and core losses (along with friction and windage losses in rotating machines), while a short-circuit test together with DC resistance measurements gives information regarding leakage reactances and winding resistances.

New Words and Phrases

rotating machine 旋转电机
combined action 共同作用
resultant *adj*. 合成的
link all the windings 与所有绕组交链
mutual *adj*. 共有的，相互的
gap *n*. 气隙
rotor *n*. 转子
stator *n*. 定子

proportional *adj*. 成正比的
relative motion 相对运动
counter *adj*. 相反的
EMF *n*. 电动势
voltage drop 电压降
MMF *n*. 磁动势
AC *abbr*. 交流
shaft *n*. 轴
leakage-reactance *n*. 漏电抗
constant *n*. 常数
time rate of change of the flux 磁通随时间的变化率
flux linkage 磁通链，磁链
synchronous motor 同步电动机
friction losses 摩擦损耗
windage losses 风摩耗
core losses 铁芯损耗
no-load test 空载实验
short-circuit test 短路实验
regarding leakage reactances and winding resistances 关于漏电抗和绕组电阻

Notes

1. This resultant mutual flux induces voltages in the windings proportional to their number of turns and is responsible for the voltage-changing property of a transformer. 变压器合成磁通在绕组中感应出的电压与绕组匝数呈正比，并且变压器电压变化特性取决于合成磁通。

2. Directly analogous to the manner in which transformer core flux links the various windings on a transformer core, the mutual flux in rotating machines crosses the air gap, linking the windings on the rotor and stator. 变压器铁芯磁通交链铁芯柱上的不同绕组，与此相同，旋转电机的主磁通穿过气隙与定子绕组和转子绕组交链。

3. Tests for determining the losses and equivalent circuit parameters are similar: an open-circuit, or no-load, test gives information regarding the excitation requirements and core losses. 确定各种损耗和等效电路参数的测试是相同的：通过开路或空载实验可以得到激磁参数和铁芯损耗。

Exercises

1. Answer the following questions according to the text

(1) What is the significant difference between transformers and rotating machines?

(2) What is the secondary current determined by in a transformer?

(3) In the forth paragraph, there is a sentence: In all three, the primary, or armature, current must adjust itself so that the combined MMF of all currents creates the flux required by the applied voltage. What does the three indicates.

(4) The leakage-reactance is often assumed to be constant, independent of the degree of saturation of the main magnetic circuit. Why?

(5) What tests are used for determining the losses and equivalent circuit parameters of transformers and rotating machines?

2. Translate the following sentences into Chinese according to the text

(1) The resultant core flux in a transformer induces a counter Electro-Motive Force (EMF) in the primary which, together with the primary resistance and leakage-reactance voltage drops, must balance the applied voltage.

(2) In any AC electromagnetic device in which the resistance and leakage-reactance voltage drops are small, the resultant flux is very nearly determined by the applied voltage and frequency, and the currents must adjust themselves accordingly to produce the MMF required to create this flux.

(3) In addition to the useful mutual fluxes, in both transformers and rotating machines there are leakage fluxes which link individual windings without linking others.

(4) In addition to the useful mutual fluxes, in both transformers and rotating machines there are leakage fluxes which link individual windings without linking others.

3. Translate the following paragraph into Chinese

In electronic power supplies there is often a need to isolate the output from the input and to reduce the weight and cost of the unit. In other applications, such as in aircraft, there is a strong incentive to minimize weight. These objectives are best achieved by using a relatively high frequency transformer. Thus, in aircraft the frequency of transformers is typically 400Hz, while in electronic power supplies the frequency of transformers may range from 5kHz to 50kHz.

Unit 2 Direct Current (DC) Machines

Text A Direct Current Machines

Commercial DC generators and motors are built the same way; consequently, any DC generator can operate as a motor and vice versa. The armature winding of a DC generator is on the rotor with current conducted from it by means of carbon brushes. The field winding is on the stator and is excited by direct current.

The armature winding, consisting of a single coil of N turns, is indicated by the two coil sides a and $-a$ placed at diametrically opposite points on the rotor with the conductors parallel to the shaft. See Fig. 1. 2. The rotor is normally turned at a constant speed by a source of mechanical power connected to the shaft. The air-gap flux distribution usually approximates a flat-topped wave, rather than the sine wave found in AC machines. Rotation of the coil generates a coil voltage which is a time function having the same waveform as the spatial flux-density distribution.

Although the ultimate purpose is the generation of a direct voltage, the voltage induced in an individual armature coil is an alternating voltage, which must therefore be rectified. The output voltage of an AC machine can be rectified using external semiconductor rectifiers. This is in contrast to the conventional DC machine in which rectification is produced mechanically by means of a commutator, which is a cylinder formed of copper segments insulated from each other by mica or some other highly insulating material and mounted on, but insulated from, the rotor shaft. Stationary carbon brushes held against the commutator surface connect the winding to the external armature terminals. The need for commutation is the reason why the armature windings of DC machines are placed on the rotor.

The commutator at all times connects the coil side, which is under the south pole, to the positive brush and that under the north pole to the negative brush in Fig. 1. 2. The commutator provides full-wave rectification, transforming the voltage waveform between brushes to that of Fig. 1. 3 (b) and making an available unidirectional voltage to the external circuit. By increasing the number of coils and segments, which can decrease the pulsation of the DC voltage, we can obtain a DC voltage that is very smooth. Modern DC generators produce voltages having a ripple of less than 5 percent. The DC machine of Fig. 1. 2 is, of course, simplified to the point of being unrealistic in the practical sense, but the operating principle is clear to be understood.

The effect of direct current in the field winding of a DC machine is to create a magnetic flux distribution which is stationary with respect to the stator. Similarly, the effect of the commutator is that when direct current flows through the brushes, armature creates a magnetic flux distribution which is also fixed in space and whose axis, determined by the design of the machine and the position of the brushes, is typically perpendicular to the axis of the field flux.

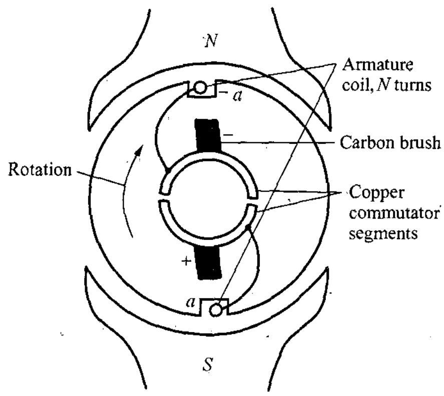

Fig. 1. 2 Schematic diagram of DC machine with commutator

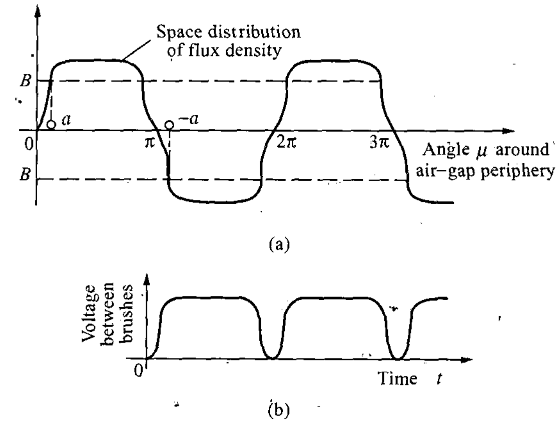

Fig. 1. 3
(a) Space distribution of air-gap flux density in an elementary dc machine; (b) waveform of voltage between brushes

Thus, just as in the AC machines, it is the interaction of these two flux distributions that creates the torque of the DC machine. If the machine is acting as a generator, this torque opposes rotation. If it is acting as a motor, the electromechanical torque acts in the direction of the rotation.

New Words and Phrases

Direct Current (DC) 直流
generator *n.* 发电机
motor *n.* 电动机
armature *n.* 电枢
armature winding 电枢绕组
excite *v.* 激励
field winding 励磁绕组
turn *n.* 匝数，圈数；*v.* 旋转
shaft *n.* 轴
flat-topped wave 平顶波
flux-density 磁通密度
rectify *v.* 调整，整定
rectifier *n.* 整流器
semiconductor rectifier 半导体整流器
commutator *n.* 换向器
mica *n.* 云母
insulating material 绝缘材料
carbon brush 炭刷
unidirectional *n.* 单方向的
pulsation *n.* 脉动
ripple *n.* 波动，波纹
torque *n.* 转矩
periphery *n.* 外围
in contrast to 和……形成对照
full-wave rectification 全波整流
space distribution 空间分布

Notes

1. The rotor is normally turned at a constant speed by a source of mechanical power connected to the shaft. 与转子轴相连接的原动机拖动转子以恒定的速度旋转。

2. The air-gap flux distribution usually approximates a flat-topped wave; rather than the sine wave found in AC machines. 气隙磁场分布接近于平顶波而不是交流电机中的正弦波。

3. This is in contrast to the conventional DC machine in which rectification is produced mechanically by means of a commutator, which is a cylinder formed of copper segments insulated from each other by mica or some other highly insulating material and mounted on, but insulated from, the rotor shaft. 这是与传统直流电机的一个对照，传统电机用换向器来完成机械整流，换向器是安装在转子轴上且与轴绝缘的由很多铜片组成的圆柱体，换向片与换向片之间用云母或其他高绝缘材料绝缘。

4. Similarly, the effect of the commutator is that when direct current flows through the brushes, armature creates a magnetic flux distribution which is also fixed in space and whose axis, determined by the design of the machine and the position of the brushes, is typically perpendicular to the axis of the field flux. 同样，换向器的作用是当直流电流通过电刷流过电枢时，电枢会产生一个空间固定的磁通分布，此磁通的轴向由电机设计和电刷位置决定，典型方向是与主极磁场的磁通方向正交。

Exercises

1. Answer the following questions according to the text

(1) A DC generator can operate as a DC motor and vice versa, right or wrong?

(2) The air-gap flux distribution in DC electric machine usually approximates a sine wave, right or wrong?

(3) The commutator of DC electric machine provides full-wave rectification, right or wrong?

(4) How to decrease the pulsation of the DC voltage?

(5) How to create the torque of the DC machine?

2. Translate the following sentences into Chinese according to the text

(1) Although the ultimate purpose is the generation of a direct voltage, the voltage induced in an individual armature coil is an alternating voltage, which must therefore be rectified.

(2) The need for commutation is the reason why the armature windings of DC machines are placed on the rotor.

(3) The commutator at all times connects the coil side, which is under the south pole, to the positive brush and that under the north pole to the negative brush.

(4) The effect of direct current in the field winding of a DC machine is to create a magnetic flux distribution which is stationary with respect to the stator.

(5) If the machine is acting as a generator, this torque opposes rotation. If it is acting as a motor, the electromechanical torque acts in the direction of the rotation.