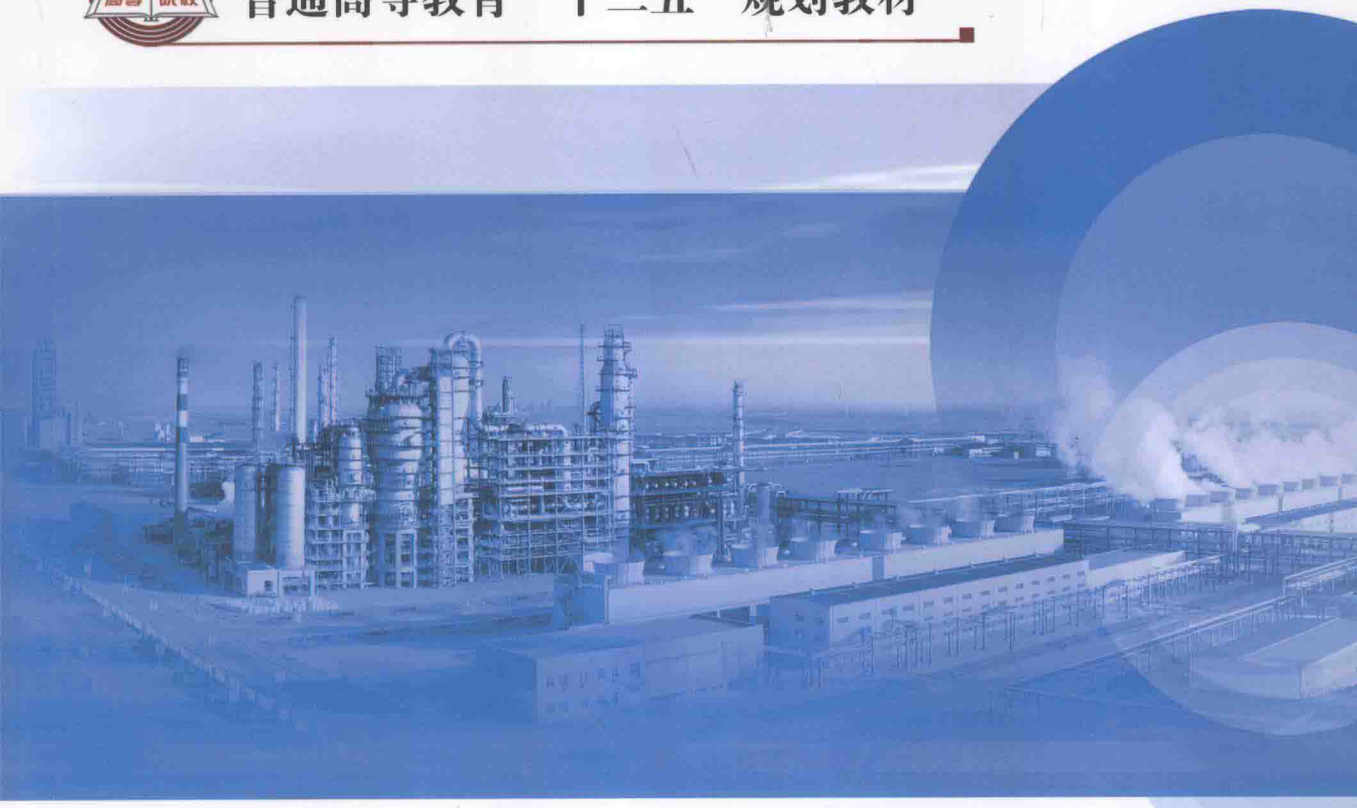
普通高等教育“十二五”规划教材



石油化工过程系统概论

Introduction to Petrochemical Process System

（双语教材）

马廷霞　编著

中国石化出版社
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内 容 提 要

(Abstract)

本书为普通高等教育“十二五”规划教材，系统地介绍了石油化工的基础知识和基本原料、石油化工产品、石油化工产品的评定指标和计量参数及石油化工生产中的主要工艺过程。全书共8章，主要内容包括：原油的一次加工、原油的二次加工、高辛烷值组分的生产与燃料的清洁技术、碳一系列产品的生产、碳二系列产品的生产、碳三系列产品的生产、碳四及以上烃系产品的生产。

本书内容丰富，注重理论和实践相融合，以培养应用型高级工程技术人员为目的，突出针对性、实用性及双语教学的特点，可作为高等院校过程装备与控制工程专业或相关专业双语教材，亦可作为炼油化工企业职工培训教材。

This book is the proposed textbook of the 12th Five-year Plan for regular higher education and systematically introduces the basic knowledge and main raw materials for petrochemicals, petrochemical products, evaluation indices and metering parameters of petrochemicals and the main engineering process of petrochemicals. The book consists of 8 chapters and the main content includes: the primary processing of crude oil, the secondary processing of crude oil, the production of high octane components and cleaning technology of fuels, the production of C_1 series product, the production of C_2 series product, the production of C_3 series product and the production of C_4 and hydrocarbons series product.

This book introduces the knowledge of petrochemical engineering comprehensively and attaches great importance to combining the theory and practice, it is aimed at training the practice-oriented advanced engineers and technicians and has the characteristics of purposefulness and practicability, it is written both in Chinese and English and can be used as the textbook for the college students who major in Process Equipment and Control Engineering, it can also be used as training materials for the technicians of the refining and petrochemical enterprises.

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前　言
(Preface)

石油炼制工业生产汽油、煤油、柴油等燃料和化学工业原料，是国民经济最重要的支柱产业之一，关系国家的经济命脉和能源安全，在国民经济、国防和社会发展中具有极其重要的地位和作用。

本书针对炼油化工系统主要装置的生产工艺过程，不仅介绍了石油化工过程中的主要设备系统的构成，还系统地介绍了从原油到油品、化工产品的生产过程，强调了石油化工的基础原料和基本原料、石油化工产品、石油化工产品的评定指标和计量参数及石油化工生产中的主要工艺过程。全书共8章，详细地介绍了原油的一次加工、原油的二次加工、高辛烷值组分的生产与燃料的清洁技术、碳一系列产品的生产、碳二系列产品的生产、碳三系列产品的生产、碳四及以上烃系产品的生产，使学生对炼油化工系统有一个系统、全面的认识，以培养应用型高级工程技术人员为目的，为进一步对相关设备系统进行综合分析、运用和研究提供基础。

在本书的编写过程中，编者除了从大量中外文献中搜集有关资料外，还重点参考了兰州炼油厂炼油系统相关文献资料，并结合多年从事教学、科研工作的体会，编撰成书。在此向所有参考文献的作者表示诚挚的感谢。

本书注重理论与实际的紧密结合，内容丰富、翔实，针对性和实用性强，不仅可作为大专院校炼油化工方向的教材和炼油化工企业的职工培训教材，对从事石油化工工艺研究的人员也具有一定的参考价值。

本书采用中英文双语编著，文中使用了大量石油化工常用的专业词汇和术语，对读者熟悉石油化工工艺过程中的专业词汇具有重要的学习价值。

本书由西南石油大学马廷霞副教授编写，由唐愚副经理及杨振岗副教授审稿，西南石油大学外语学院的李雪、唐月两位研究生参与了部分内容的翻译。此外，在本书的编写过程中，得到了西南石油大学梁政教授的大力支持和帮助，并提出了不少宝贵意见，在此表示衷心的感谢。

由于编者学识有限，书中难免存在不妥之处，敬请读者批评指正。

The petroleum refining industry produces the petroleum, kerosene, diesel and raw materials for the chemical industry, is one of the most important main industries for the national economy and is crucial to the lifeline of national economy and security of energy resource. It plays a very significant role in the national economy, national defense and social development.

This book introduces the technical process of the refining and petrochemical factories' main equipment and plants. It not only introduces the basic structure of the refining and petrochemical factories' main equipment and plant, but also systematically explains the producing process of

the refining and petrochemical factories from crude oil to oil products and chemical products. During the explanation the author attaches great importance to the basic materials and main materials, petrochemical products, evaluation indices and metering parameters, as well as main technical process of petrochemical production. The book consists of 8 chapters and the main content includes the primary processing of crude oil, the secondary processing of crude oil, the production of high octane components and cleaning technology of fuels, the production of C_1 series product, the production of C_2 series product, the production of C_3 series product and the production of C_4 and hydrocarbons series product. The purpose of the book is to enable the students to have a systematic and comprehensive understanding to the refining and petrochemical industry, and it is aimed at training the practice-oriented advanced engineers and technicians, so as to lay good foundation for the students who are to make comprehensive analysis, operate and carry out further study of the relevant equipment and plants.

During the compiling of this book, the compiler has successfully finished this book, with the help of plenty references from The Basic Theory's Training Handbook of Petrochemicals compiled by Human Resource Department of Lanzhou Petrochemicals Co., Ltd. and teaching and research experience of many years. The compiler hereby expresses her gratefulness to all the authors whose articles or books have helped her compiling.

This book has attached great importance to the close connection of theory and practice and has the characteristics of abundance in knowledge, purposefulness and practicability. It can not only be used as the textbook for the college students who major in refining and petrochemicals, but also be used as training textbook for the engineers and technicians in the refining and petrochemical factories, and at the same time it is useful to the researchers who are making study on the petrochemical technical process.

This book is written both in Chinese and English and many petrochemical terms and technical vocabularies are applied. It will greatly help the reader to master the petrochemical terms and technical vocabularies of the refining and petrochemical industry.

This book is compiled by Madam Ma Ting Xia, the associate professor from Southwest Petroleum University, the Chinese version has been proofread by Mr. Tang Yu, the deputy manager from Southwestern Pipeline Company, the English version has been proofread by Mr. Yang Zhen Gang, the editor from Gansu Educational Press; Miss Li Xue and Miss Tang Yue, who are two postgraduate students from Southwest Petroleum University, have carried out some parts of Chinese to English translation work. And last but not least, during the compiling of this book, Professor Liang Zheng from Southwest Petroleum University has provided great support and help. He has also given a lot of valuable advice, the compiler hereby expresses her great thankfulness to Professor Liang.

Limited by the knowledge of the compiler, it is hard to avoid some shortcomings in this book, therefore any opinions and corrections would be appreciated.

目　　录
(Contents)

第 1 章　绪论（Introduction）

石油化工是指以石油和天然气为原料，生产石油产品和石油化工产品的加工工业。

石油产品又称油品，包括各种燃料油（如汽油、煤油、柴油等）、润滑油以及液化石油气、石油焦炭、石蜡、沥青等。生产这些产品的加工过程通常被称为石油炼制，简称炼油。

石油化工产品是以炼油过程提供的油品经过进一步化学加工获得的。生产石油化工产品的第一步是对原料油和气（如汽油、柴油、丙烷等）进行裂解，生成以乙烯、丙烯、丁二烯、苯、甲苯、二甲苯为代表的基本化工原料。第二步是以基本化工原料为原料生产多种有机化工原料（约 200 种）及合成材料（如合成塑料、合成纤维、合成树脂、合成橡胶等）。有机化工原料继续加工可制得更多品种的化工产品，习惯上不属于石油化工的范围。在有些资料中，把以天然气、轻汽油、重油为原料合成氨、尿素，甚至制取硝酸也列入石油化工的范围。

Petrochemical industry refers to the processing industry which uses the oil and gas as the raw materials to produce oil products and petrochemicals.

Petroleum products are also known as oils, including all sorts of fuel oil (such as gasoline, kerosene, diesel oil, etc), lubricating oil, liquefied petroleum gas, petroleum coke, paraffin wax, asphalt and so on. The process of manufacturing these products is usually called petroleum processing, or oil refining for short.

Petrochemicals are obtained from the further chemical processing of oil products, which are produced from oil refining process. The first step of producing petrochemicals is to split the raw oil and gas (such as gasoline, diesel oil, propane, etc) for producing of the basic chemical raw materials such as ethylene, propylene, butadiene, benzene, toluene and xylene. The second step is to use the basic chemical raw materials to produce a variety of organic chemical raw materials (about 200 species) and synthetic materials (such as synthetic plastic, synthetic fiber, synthetic resin, synthetic rubber, etc.). Through the further processing of organic chemical raw materials, more kinds of chemical products could be produced. Generally, this kind of processing is not included in the petrochemical industry. However, according to some sources, the process of using natural gas, light gasoline and heavy oil as raw materials to make ammonia and urea is regarded as the petrochemical industry, even making nitric should be also included.

1.1　石油化工基础知识（Basic Knowledge on Petrochemical Industry）

1.1.1　石油化工的发展（The Development of Petrochemical Industry）

石油化工的发展与石油炼制工业、以煤为基本原料生产化工产品及三大合成材料的发展有关。石油炼制起源于 19 世纪 20 年代。20 世纪 20 年代汽车工业飞速发展，带动了汽油工

业的发展。为扩大汽油产量，以生产汽油为目的的热裂化工艺开发成功，随后，40 年代催化裂化工艺开发成功，加上其他加工工艺的开发，形成了现代石油炼制工艺。为了利用石油炼制的副产品气体，1920 年开始以丙烯为原料生产异丙醇，这被认为是第一个石油化工产品。20 世纪 50 年代，在裂化技术基础上开发了以制取乙烯为主要目的的烃类热裂解技术。裂解工艺的发展为石油化工提供了大量原料。同时，一些原来以煤为基本原料生产的产品陆续改由以石油为基本原料，如氯乙烯等。在 20 世纪 30 年代，高分子合成材料大量问世。按工业生产时间排序为：1931 年为氯丁橡胶和聚氯乙烯，1933 年为聚乙烯，1935 年为丁腈橡胶和聚苯乙烯，1937 年为丁苯橡胶，1939 年为尼龙 66。第二次世界大战后石油化工技术继续快速发展，1950 年开发了腈纶，1953 年开发了涤纶，1957 年开发了聚丙烯。石油化工高速发展的原因是：有大量廉价的原料供应(50～60 年代，原油每吨约 15 美元)；有可靠的、可持续发展的生产技术；产品应用广泛，且开拓了新的应用领域。原料、技术、应用三个因素的综合，实现了由煤化工向石油化工的转换，完成了化学工业发展史上的一次飞跃。20 世纪 70 年代以后，原油价格上涨(1996 年每吨约 170 美元)，新工艺开发趋缓，石油化工开始向新技术、高效能、低能耗、多产品等方向发展。一些发展中国家大力兴建石化工业，使发达国家所占比重下降。2009 年，全世界原油加工高达 52 亿吨，其中，化工类产品用油约占总量的 10%。截至 2009 年底，我国的原油一次加工能力已从 2000 年的 2.76 亿吨、2005 年的 3.245 亿吨，猛增到 4.77 亿吨，稳居世界第二。

The development of petrochemical industry is related to the development of oil refining industry, chemical products made from coal and the three synthetic materials. Petroleum refining industry originated in the 1820s. In the 1920s, the rapid development of automotive industry promoted the development of the gasoline industry. In order to expand gasoline production, the thermal cracking process aimed at producing gasoline was successfully developed. Soon after, the successful development of catalytic process in the 1940s and other relevant processes have made the modern petroleum refining process come into being. In order to make effective use of by-product gas of petroleum refining, isopropyl alcohol has been used as raw materials to produce propylene since 1920, and the propylen was considered as the first petrochemical product. In the 1950s, on the basis of cracking technology, the hydrocarbon thermal cracking technology was developed to produce ethylene. The improvement of cracking technique had provided a large quantity of raw materials for petrochemical industry. At the same time, some products which used to be made from coal gradually began to be taken from oil, and the vinyl chloride is one of them. In the 1930s, polymer composite materials appeared in large quantities. Chronologically, the petrochemical products can be listed as follows: the neoprene and PVC in 1931; the PE in 1933; the nitrile rubber and polystyrene in 1935; the styrene-butadiene rubber in 1937; the nylon 66 in 1939; after the World War II, the petrochemical technology developed rapidly and the acrylic, polyester and polypropylene were respectively developed in 1950, 1953 and 1957. The reasons for the rapid development are as follows: the cheap and abundant supply of the raw materials (crude oil is about $ 15 per ton in 1950s to 1960s); the reliable and sustainable development of production technology; the wide range of applications of the products and the opening-up of the new application areas. The combination of the three influencing factors, namely, raw materials, technologies and applications, had achieved the transformation from coal chemical industry to petrochemical industry, and this transformation has

made a great leap in the history of the chemical industry. After the 1970s, the price of crude oil (about $ 170 per ton in 1996) increased the development of the new techniques began to slow down and the petrochemical industrialists focused on producing the products with the new technology, high performance, low-energy consumption and multi-production possibility. Some developing countries began to be fully committed to the development of the petrochemical industry, and it had made the proportion of the developed countries in this field decline significantly. In 2009, the quantity of the crude oil products in the world has reached 5.2 billion tons 10% of which are for the chemical industry. By the end of 2009, the processing capacity of the crude oil in China had soared to 477 million tons, from the total number of 276 million tons in 2000 and that of 324.5 million tons in 2005, ranking second in the world.

1.1.2 石油化工的基础原料和基本原料(The Basic Petrochemical Raw Materials and Raw Materials)

基础原料是指用来加工化工基本原料和产品的天然资源。通常指石油、天然气、煤以及空气、水、盐、矿物质和金属矿等自然资源。这些天然资源来源丰富，价格低廉，但经过一系列的化学加工以后，就可得到很多高价值且便于利用的化工基本原料和化工产品。

基本原料是指自然界不存在，需经过一定加工得到的原料。石油化工的基本原料有五类：烷烃(甲烷)、烯烃（乙烯、丙烯、丁烯和丁二烯)、炔烃（乙炔)、芳香烃(苯、甲苯、二甲苯)及合成气。

烷烃主要用作燃料。天然气和沼气(主要成分为甲烷)是近来广泛使用的清洁能源。

乙烯多用于生产聚乙烯，约占乙烯耗量的45%；其次还用于生产二氯乙烷和氯乙烯，乙烯氧化制环氧乙烷和乙二醇。另外，乙烯烃化可制苯乙烯，乙烯氧化可制乙醛，乙烯也可合成酒精、制取高级醇等。

丙烯主要用于生产聚丙烯，也可制丙烯腈、异丙醇、苯酚和丙酮、丁醇和辛醇、丙烯酸及其脂类以及环氧丙烷和丙二醇、环氧氯丙烷和合成甘油等。

丁烯的利用是以混合丁烯为原料生产高辛烷值汽油组分为主，约占丁烯消费量的60%，另有11%的混合丁烯用作工业或民用燃料。用作石油化工原料的丁烯仅占丁烯消费量的29%，其中正丁烯主要用于丁二烯的生产，其余用于生产顺丁烯二酸酐和仲丁醇、庚烯、聚丁烯、乙酸酐等。

丁二烯是合成橡胶和合成树脂的重要单体。丁二烯可生产顺丁橡胶、丁苯橡胶、丁腈橡胶、氯丁橡胶，也可生产聚丁二烯、ABS、BS等树脂。此外还可生产丁二醇、己二胺(尼龙的单体)。

炔烃主要用于合成氯乙烯、乙酸乙烯酯、卤代烯烃、乙醛、丙烯腈、乙烯基醚、乙烯基乙炔、聚乙炔等原料。

苯的最大用途是作为生产苯乙烯的单体原料，约占世界苯消耗量的50%。环己烷和苯酚也是苯的重要消费领域，二者各占苯消费量的15%和18%。此外，苯胺、烷基苯、顺丁烯二酸酐也都是苯的重要衍生物。

由化工基本原料出发，可以合成一系列化工中间产品和最终产品。主要包括：石油燃料、石油溶剂与化工原料、润滑剂、石蜡、石油沥青、石油焦等6类。其中，各种燃料产量最大，约占总产量的90%；润滑剂品种最多，产量约占5%。以石油为原料制取基本化工原

料的主要途径如图 1-1 所示。

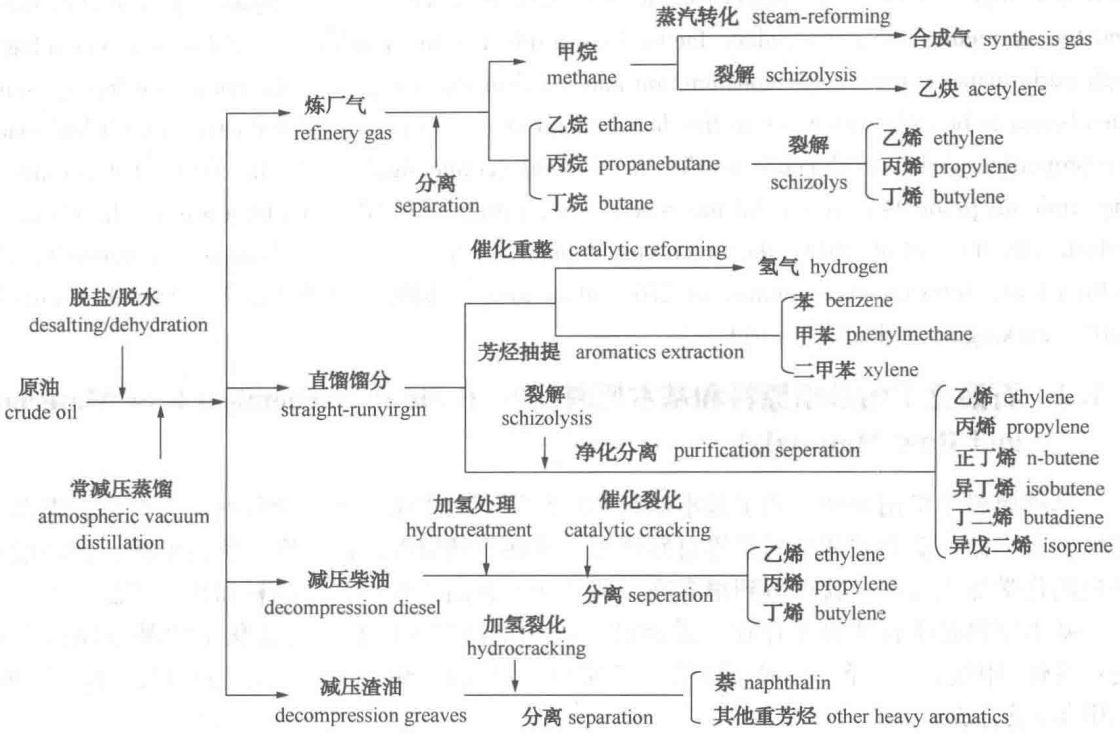

图 1-1　以石油为原料制取基本化工原料的主要途径

(The Main Way to Produce Basic Chemical Raw Materials by Using Petroleum as Raw Materials)

天然气化工利用的主要途径为：

(1) 转化为合成气($CO+H_2$)，再进一步加工制造合成氨、甲醇、高级醇等。

(2) 裂解生成乙炔、炭黑。以乙炔为原料，可以合成多种化工产品，如氯乙烯、乙醛、醋酸、醋酸乙烯酯、氯化丁二烯等。炭黑可作橡胶补强剂、填料，是油墨、涂料、炸药、电极和电阻器等产品的原料。

(3) 通过氯化、氧化、硫化、氨氧化等反应转化成各种产品，如氯化甲烷、甲醇、甲醛、二硫化碳、氢氰酸等。

湿天然气经热裂解、氧化、氧化脱氢或异构化脱氢等反应，可加工生产乙烯、丙烯、丙烯酸、顺酐、异丁烯等产品。天然气的化工利用如图 1-2 所示。

在化工企业生产中，除必须消耗原料来生产目的产品外，还要消耗一些辅助材料，通常将这些材料和原料一起统称为原材料。化工生产中常用的辅助材料有助剂、添加剂、溶剂、催化剂等。

The basic raw materials refer to the natural resources used for processing basic chemical raw materials and products, which usually includes the oil, gas, coal, air, water, salts, minerals and metal ores. These natural resources is abundant in source and cheap in price, and through a series of chemical processing, many different kinds of basic raw materials and chemical products, which contain high value and are able to be conveniently used, can be obtained.

The feedstock refers to the materials which do not exist in the nature and have to be obtained

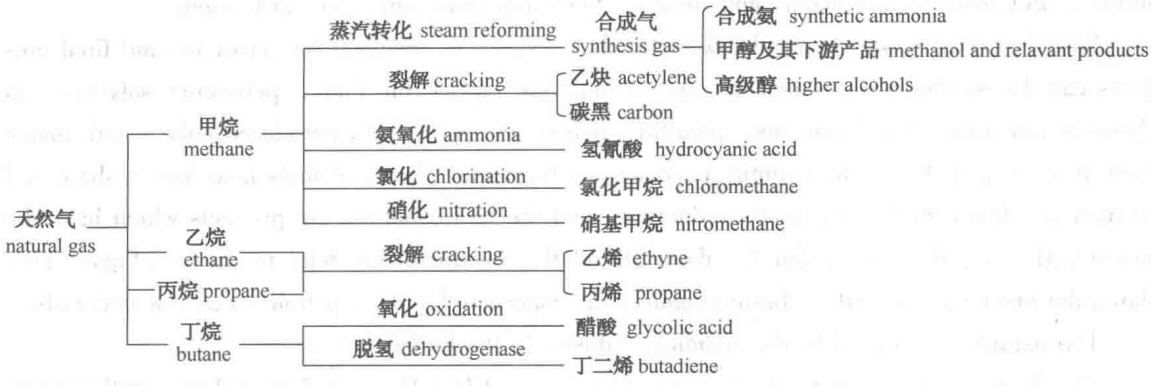

图 1-2　天然气化工利用的主要途径(The Main Way to Use Gas in Chemical Industry)

through certain processing procedures. The basic raw materials for petrochemical industry have five categories: alkanes (methane), olefins (ethylene, propylene, butylene and butadiene), alkyne (acetylene), aromatics (benzene, toluene, xylene) and synthesis gas.

Alkane is mainly used as fuel. Natural gas and biogas (mainly methane) are the two main kinds of clean fuels which are now popularly used.

The vinyl is mainly used for the production of polyethylene, accounting for about 45% of the ethylene consumption, and it is also used to produce dichloroethane and vinyl chloride, ethylene oxidation production of ethylene oxide and ethylene glycol. Besides the above-mentioned products, the alkylated ethylene can be used to make styrenem, and the oxidated ethylene can be used to make acetaldehyde; and the ethylene can also be synthesized to alcohol and to make the higher alcohols.

Propylene is mainly used for the production of polypropylene, and it can also be made into acrylonitrile, isopropyl alcohol, phenol and acetone, butanol and octanol, acrylic acid and lipids as well as propylene oxide and propylene glycol, epichlorohydrin and synthetic glycerine, etc.

The Buteneis is mainly to be used to produce high octane gasoline components by using the mixed butene as its raw materials, which accounts for 60% of butene consumption; while another 11% of mixed butene is used as industrial or domestic fuels. Among the total butane consumption, the butene which is used as raw materials for petrochemical industry only accounts for 29%, of which n-butene is mainly used for the production of butadiene, and the rest components are used for the production of maleic anhydride, sec. -butyl alcohol, heptene, polybutene, and acetic anhydride.

Butadiene is an important monomer for synthetic rubber and synthetic resin. Butadiene can be used to produce polybutadiene rubber, butadiene-styrene rubber, nitrile butadiene rubber, polychloroprene rubber, and some resins such as polybutadiene, ABS, BS. In addition, batadiene can also be used for the production of butanediol, hexamethylene diamine (the monomer of nylon).

Alkynes are mainly used for synthesizing some raw materials like chloroethylene, vinyl acetate, alkenyl halide, acetaldehyde, acrylonitrile, vinyl ethers, vinyl acetylene, polyacetylene and so on.

The benzene is mostly used as the monomer raw materials for producing styrene, accounting for about 50% of worldwide benzene consumption. Benzene is also used for making cyclohexane and phenol. They respectively account for 15% and 18% of the total benzene consumption. In addition,

aniline, alkylbenzene and maleic anhydride are also important derivatives of benzene.

Based on some basic chemical raw materials, a series of chemical intermediates and final products can be synthesized, which mainly include six types: oil fuels, petroleum solvents and chemical raw materials, lubricants, paraffin, petroleum asphalt and petroleum coke, and among these products, as far as the quantity is concerned the various kinds of fuels take lion's share and account for almost 90% of the total production; and the lubricants are the products which have the widest varieties and they account for about 5% of the amount of the total production. Figure 1-1 shows the main way to produce basic chemical raw materials by using petroleum as raw materials.

The natural gas is used in the chemical industry in the following ways:

(1) To transform the natural gas into synthesis gas ($CO + H_2$), and then obtain synthetic ammonia, methanol, higher alcohols through further processing.

(2) To obtain acetylene and carbon soot through cracking. To use acetylene as a raw material, a variety of chemical products can be synthesized, such as vinyl chloride, acetaldehyde, acetic acid, vinyl acetate and chlorinated butadiene. Carbon soot can be used as rubber reinforcing agents and fillers, which is also the raw materials for producing inks, paints, explosives, electrodes, resistors and some other products.

(3) To transform into a variety of products including chlorinated methane, methanol, formaldehyde, carbon disulfide and hydrocyanic acid through chemical reactions such as chlorination, oxidation, vulcanization, and ammonia oxidation.

After thermal cracking, oxidation, oxidative dehydrogenation or isomerization dehydrogenation reaction, wet natural gas can be processed into the ethylene, propylene, acrylic acid, maleic anhydride, isobutene and other products. The process of chemical utilization of natural gas is shown in Figure 1-2.

During the process of making chemical products, some supplementary materials are also consumed besides the regular main raw materials, usually these supplementary materials are also regarded as the raw materials. The mostly-applied supplementary materials include auxiliaries, additives, solvents, and catalysts, etc.

1.1.3 石油化工产品(Petrochemical Products)

石油产品种类繁多，用途各异。为了和国际标准相一致，我国参照 ISO 8681 标准，制定了 GB 498 标准体系，将石油产品按其主要性能和用途分为五大类，见表 1-1。

表 1-1 石油产品的分类(The Classification of Petroleum Products)

GB 498 标准		ISO 8681 标准	
序号	定义	Class	Designation
1	燃料	F	Fuels
2	溶剂和化工原料	S	Solvents and raw materials
3	润滑剂、工业润滑油和有关产品	L	Lubricants, industral oils and related products
4	蜡	W	Waxes
5	沥青	B	Bitumen

按照石油产品用途，又可分九类：

(1) 石油燃料类　包括汽油、喷气燃料、煤油、柴油和燃料油等。

（2）溶剂油类　包括石油醚、橡胶溶剂油和油漆溶剂油。

（3）润滑油类　包括内燃机润滑油、齿轮油、车轴油、机械油、仪表油、压缩机油和汽缸油等。

（4）电气用途类　包括变压器油、电容器油和断路器油等。

（5）润滑脂类　包括钙基润滑脂、钠基润滑脂、钙钠基润滑脂、锂基润滑脂和专用润滑脂等。

（6）固体产品类　包括石蜡类、沥青类和石油焦类等。

（7）石油气体类　包括石油液化气、丙烷和丙烯等。

（8）石油化工原料类　包括石脑油、重整油、AGO 原料、戊烷、抽余油和拔头油等。

（9）石油添加剂类　包括燃料油添加剂和润滑油添加剂等。

根据产物的不同，石油加工过程可分为四种类型：

（1）燃料油型　生产用作燃料的汽油类产品，如汽油、煤油、轻重柴油和锅炉燃料等。

（2）燃料-润滑油型　除生产各种燃料油外，还生产各种润滑油。

（3）燃料-化工型　以生产燃料油和化工原料及化工产品为主，例如某些烯烃、芳烃和聚合物的单体等。

（4）燃料-润滑油-化工型　它是综合型石油化工过程，既生产各种燃料、化工原料及产品，同时又生产润滑油。

Petroleum products have a wide range of categories and each category has its own specific use. In order to be consistent with international standards, China formulated the GB 498 standard system referring to the ISO 8681 standard, which divides petroleum products into five categories according to their main properties and functions shown in Table 1-1.

As far as the use is concerned, petroleum products fall into nine categories:

(1) Petroleum fuels　It includes gasoline, jet fuel, kerosene, diesel and fuel oil, etc.

(2) Solvent oils　It includes petroleum ether, rubber solvent oil and paint solvent oil.

(3) Lubricants　It includes the internal combustion engine lubricating oil, gear oil, axle oil, mechanical oil, instrument oil, compressor oil and cylinder oil, etc.

(4) Electrical uses　It includes transformer oil, capacitor oil and breaker oil, etc.

(5) Greases　It includes calcium-based grease, sodium based grease, calcium and sodium based grease, lithium grease, and special grease, etc.

(6) Solid products　It includes the class of paraffin wax, asphalt and petroleum coke, etc.

(7) Oil and gases　It includes liquefied petroleum gas, propane and propylene, etc.

(8) Petrochemical raw materials　It includes naphtha, reformate, the AGO raw materials, pentane, raffinate and topping oil, etc.

(9) Oil additives　It includes fuel oil additives and lubricant additives, etc.

As far as the final products are concerned, the oil processing can be classified into four types.

(1) Fuel oil type　To produce petrol products used as fuel, such as gasoline, kerosene, light and heavy diesel and boiler fuels.

(2) Fuel-lubricating oil type　In addition to the production of various fuel oil, various kinds of lubricating oil are also produced.

(3) Fuel-chemical type　This type of processing is mainly applied to produce fuel oil, chemical

raw materials and chemical products, such as certain olefins, aromatics and polymer monomer.

(4) Fuel-lubricating oil-chemical type It is an integrated petrochemical process not only producing various kinds of fuels and chemical raw materials and products, but also lubricating oil at the same time.

1.1.4 石油化工产品的评定指标和计量参数(Assessment Indicator and Measurement Parameters of Petrochemical Products)

1. 原油评价试验 (Evaluation Test of Crude Oil)

加工一种原油前，先要测定原油的颜色与气味、沸点与馏程、密度、黏度、凝点、闪点、燃点、自燃点、残炭、含硫量等指标，即为原油评价试验。

Before processing a crude oil, it is firstly required to measure the color and odor of the crude oil, boiling point and distillation range, density, viscosity, solidifying point, flash point, ignition point, self-ignition point, carbon residue, sulfur content and other indicator. The whole process is named evaluation test of crude oil.

2. 馏程(Distillation Range)

馏程是指油品在规定条件下，从初馏点到终馏点(即干点)蒸发的温度范围。通常把一定沸点范围内的馏出物称为馏分。馏程是用来判断石油产品中轻重组分组成多少的指标。

Distillation range refers to the range of the petroleum products' evaporation temperature which starts from the initial boiling point and ends at the final boiling point (dry point) under specified conditions. Usually the products distillated at a certain boiling point range are called the distillated fraction. The distillation range is an indicator to determine the proportions of the light and heavy components in petroleum products.

3. 重度、密度、比重(相对密度)[Severe, Density and Specific Gravity (relative density)]

单位体积的物料所具有的重量，称为重度，单位为 N/m^3。单位体积内所具有的物质质量称为密度，单位为 g/cm^3。比重是指物质的重量与同体积的纯水在 4℃时的重量之比，也称为相对密度。液体比重是指相同体积的液体重量与水的重量之比，无量纲。

The weight of material in per unit of volume is known as severe, and its unit is N/m^3. The material's mass in per unit of volume is called density, and its unit is g/cm^3. Specific gravity refers to the ratio between the weight of the substance and the weight of the same volume of pure water at 4℃, which is also called relative density. The hydrometer is the ratio between the weight of the same volume's liquid and water, and it is dimensionless.

4. 黏度(Viscosity)

流体流动时，相邻流体层间存在着相对运动，则该两流体层间会产生摩擦阻力，称为黏滞力。黏度是用来衡量黏滞力大小的一个物性数据。黏度有动力黏度和运动黏度之分，动力黏度的单位是帕斯卡·秒(Pa·s)，运动黏度是在工程计算中，物质的动力黏度与其密度之比，其单位为 m^2/s。在石油工业中还使用“恩氏黏度”，它不是上面介绍的黏度概念，而是流体在恩格拉黏度中直接测定的读数。黏度是大多数润滑油划分牌号的依据。

When fluid flows, there is a relative motion between the adjacent fluid layers and it will produce frictional resistance between the two fluid layers. This frictional resistance is known as the vis-

cous force. Viscosity is a physical property data which is used to measure the viscous force. Viscosity is classified into dynamic viscosity and kinematic viscosity, and the unit of dynamic viscosity is Pascal · second (Pa · s); kinematic viscosity is the ratio between substance's dynamic viscosity and density in engineering calculations, and its unit is m^2/s. Engler viscosity is also used in the oil industry, but it is different from the above-mentioned viscosity. It is fluid's readings which are directly measured in the Engler viscosity. Viscosity is the basis of most of the lubricant oils to classify its grades.

5. 凝点(Solidifying Point)

凝点是评价油品使用环境的指标。是指在规定条件下，油品冷却到停止流动时的最高温度。

Solidifying point is the indicator to evaluate the environment of the oil product. It is the maximum temperature at which the oil product stops the flow because of the cooling under specified conditions.

6. 闪点(Flash Point)

闪点是表示石油产品蒸发倾向和安全性的指标。是指在规定条件下，加热油品所产生的蒸气和空气组成的混合物，遇火即发生瞬间闪火时的最低温度。

Flash point is an indicator to show the evaporation tendency and safety of the petroleum products. It refers to the minimum temperature to make the mixture of the steam of heating oil and air flash fire when touching flame under the specified conditions.

7. 燃点 (Ignition Point)

燃点即着火点，是指火源接近可燃物质使其发生持续燃烧的最低温度。燃烧必须具备三个条件：一要有可燃物质，如 H_2、煤炭等；二要有助燃物，主要是氧气和氧化剂(氯酸钾、高锰酸钾)；三要有着火源，即有明火或温度达到着火点。

Ignition point is also called kindling point. It refers to the minimum temperature at which the combustible materials can make continuous burning when they are placed close to a fire source. Burning must meet three conditions: the first is a combustible material, such as H_2, coal, etc.; the second is a combustion enhancer, which is mainly oxygen and oxidant (potassium chlorate, potassium permanganate); the third is an ignition source, that is, to provide an open flame or make temperature high to reach the ignition point.

8. 自燃点 (Self-ignition Point)

自燃点是指可燃物质与空气混合后不需要明火而自行着火的最低温度。

Self-ignition point refers to the minimum temperature at which the combustible material can self-ignite after mixing with air without an open flame.

9. 水分(Moisture)

水分是指油品中的含水量，以质量量百分数表示。油品中应防止水分混入，当燃料混进水分后，在低温使用时，会凝成小冰块而造成油路阻塞，影响供油。

Moisture refers to the water content in oil, indicated with mass percentage. The oil products should be prevented from mixing with water. When mixing with water, the fuel will condense into small ice blocks and cause oil blocking at the low temperature, and finally hamper the oil supply.

10. 实际胶质 (Existent Gum)

实际胶质是判断油品安定性的指标。它是在规定条件下，测得燃料中蒸发残留物的胶质

含量，用 mg/100mL 表示。它具有黏附性，常用来评定汽油或柴油在发动机中生成胶质的倾向，从实际胶质大小可判断油品能否使用和继续贮存。

Existent gum is the indicator to judge the stability of oil. The way to measure the existent gum is to measure the gum level of evaporation residues in fuel under specified conditions, indicated with mg/100mL. It has adhesiveness and usually is applied to assess the tendency of the gasoline or diesel to generate glial in engine. From the actual size of the gum in the oil products, the judgment can be made if the oil products are suitable to be used and stored.

11. 饱和蒸气压（Saturation Vapor Pressure）

饱和蒸气压是评价汽油蒸发性能、形成气阻的可能性以及储运中损失轻质馏分倾向的重要项目。是在一定温度下，油品在试验装置中气液两相处于平衡时，液面蒸气所具有的最大压力。饱和蒸气压是液体的一项重要物性参数，如液体的沸点、液体混合物的相对挥发度等都与之有关。

Saturation vapor pressure is an important indicator for evaluating gasoline's evaporative performance, the possibility of forming air resistance and the tendency of losing light distillation during storage and transportation. It refers to the maximum pressure upon the vapor at the liquid surface at a certain temperature when the gas and liquid of the oil product reaches to the equilibrium in the test device. Saturation vapor pressure is an important physical parameters of the liquid, and it is related to the liquid boiling point, the relative volatility of liquid mixtures and other relevant properties.

12. 辛烷值（Octane Number）

辛烷值是表示汽油在汽油机中燃烧时的抗爆性指标。常见标准异辛烷值规定为 100，正庚烷的辛烷值规定为零，这两种标准燃料以不同的体积比混合起来，可得到各种不同抗爆性等级的混合液，在相同的发动机工作条件下，与待测燃料进行对比，抗爆性与样品相等的混合液中所含异辛烷百分数，即为该样品的辛烷值。汽油辛烷值大，抗爆性好，质量也好。通常烃类辛烷值高低排列顺序为：芳烃>环烷烃>异构烷烃>正构烷烃。

The octane number refers to the antiknock indicator of gasoline when it is burning in gasoline engine. The common standard of isooctane number is 100, and the octane number of heptanes requires being zero. When these two standard fuels are mixed together in a different volume ratio a variety of antiknock liquid mixtures with different ratings can be gained, and these different mixtures can be compared with the fuel to be tested under the same engine working conditions. The isooctane percentage contained in the liquid mixture, which has the same antiknock with the sample, is the octane number of the sample fuel. The larger the octane number of gasoline becomes, the better of its antiknock capacity and quality is. Normally, the octane number of hydrocarbon sizes down as following order: aromatics, cycloalkanes, isoparaffin, n-alkanes.

13. 十六烷值（Cetane Number）

十六烷值表示柴油在柴油机中燃烧时的自燃性指标。常将纯正十六烷的十六烷值定为 100，纯甲基萘的十六烷值定为零，以不同的比例混合起来，可以得到十六烷值 0 至 100 的不同抗爆性等级的标准燃料，并在一定结构的单缸试验机上与待测柴油进行对比。烃类十六烷值高低排列顺序是：正构烷烃>异构烷烃>环烷烃>芳香烃。

The cetane number refers to the spontaneous combustion indicator when diesel is burning in