

高 / 等 / 学 / 校 / 教 / 材 /

包装工程专业系列教材

包装工程概论 (双语)

Fundamentals of Packaging
Engineering

陈满儒 编



化学工业出版社
教材出版中心

高等学校教材
包装工程专业系列教材

包装工程概论(双语)

Fundamentals of Packaging Engineering

陈满儒 编



化学工业出版社
教材出版中心

· 北 京 ·

(京)新登字 039 号

图书在版编目(CIP)数据

包装工程概论(双语)/陈满儒编. —北京: 化学
工业出版社, 2004. 12

高等学校教材. 包装工程专业系列教材
ISBN 7-5025-6406-3

I. 包… II. 陈… III. 包装-工程技术-高等学
校-教材 IV. TB48

中国版本图书馆 CIP 数据核字 (2004) 第 127399 号

高等学校教材
包装工程专业系列教材
包装工程概论 (双语)
Fundamentals of Packaging Engineering

陈满儒 编

责任编辑: 杨 菁

责任校对: 郑 捷

封面设计: 于剑凝

*

化学工业出版社 出版发行
教材出版中心

(北京市朝阳区惠新里 3 号 邮政编码 100029)

发行电话: (010) 64982530

<http://www.cip.com.cn>

~*~

新华书店北京发行所经销

北京兴顺印刷厂印刷

三河市前程装订厂装订

开本 787mm×1092mm 1/16 印张 16 1/4 字数 400 千字

2005 年 1 月第 1 版 2005 年 1 月北京第 1 次印刷

ISBN 7-5025-6406-3/G · 1632

定 价: 30.00 元

版权所有 违者必究

该书如有缺页、倒页、脱页者, 本社发行部负责退换

前 言

20 世纪 80 年代初期, 依照发达国家包装工程高等教育的发展模式, 我国的一些大学相继创建了包装工程本科专业。20 多年来, 我国包装工程专业的办学规模、层次及其办学水平都有了很大的提高。进入 21 世纪以来, 随着我国包装科学技术的迅速发展, 随着我国从包装大国向包装强国迈进政策的实施, 迫切要求从事包装的专业技术人员努力提高自己的能力与素质, 更有效地学习和应用国外先进的包装技术。

国内各大学的包装工程专业自建立以来都开设有专业英语类课程, 这对巩固学生的基础英语水平, 拓宽知识面, 提高对国外技术资料的阅读应用能力起到很好的促进作用。为了贯彻教育部关于“本科教育要创造条件使用英语等外语进行公共课和专业课教学……”的文件精神, 一些学校在包装工程专业教学中开始用双语教学替代原有的专业英语教学。这种不是就英语学英语, 而是通过英语来学习专业知识, 将专业英语学习与专业知识学习融合一起的方法有利于学生第一时间用英语阅读和吸收英语原版专业科技信息打下基础, 有利于增强他们用英语进行专业交流的实际能力。然而, 国内尚缺少能全面反映包装工程学科特点、内容适当、系统性强、可供学生和专业技术人员选用的包装工程双语教材或读本, 影响了本专业双语教学的水平提高及其规范化。

包装工程是一门综合性的交叉学科, 内容非常丰富, 涉及面广。本书的选材力求在有限的篇幅内尽可能涵盖包装工程的学科领域。

本书由五个方面的内容组成, 即: 透视包装; 包装材料和容器; 包装印刷与装潢; 包装动力学和运输包装; 包装机械。

为方便学习理解, 书后列出了专业词汇与术语的中英文对照表。本书既可作为包装工程专业本科生技术基础课双语教学或专业英语教学用书, 也可作为从事包装工程及相关专业的技术人员提高业务及其专业英语应用水平的学习参考书。

在编写该书的过程中, 得到了加拿大莫哈克学院包装设计专业 Walter Soroka 教授、美国威斯康星-斯陶特大学包装专业 Robert Berkemer 教授、美国密歇根州立大学包装学院 Bruce Harte 教授和美国罗彻斯特大学包装科学系 Daniel Goodwin 教授等的大力支持, 在此一并致谢。

由于编者的水平所限, 本书难免存在缺点和错误, 敬请读者批评指正。

编 者

2004 年 10 月于陕西科技大学

TABLE OF CONTENTS

UNIT ONE PERSPECTIVE ON PACKAGING	1
Lesson 1 A History of Packaging	1
What is Packaging?	1
Primitive Packaging	2
From Rome to the Renaissance	3
The Industrial Revolution	5
The Evolution of New Packaging Roles	5
Packaging in the Late 20th Century	7
Modern Packaging	8
Waste Management and Environmental Issues	11
The Modern Packaging Industry	15
Lesson 2 Packaging Functions	17
Introduction	17
The Contain Function	18
The Protect/Preserve Function	19
Food Preservation	19
The Transport Function	31
The Inform/Sell Function	31
UNIT TWO PACKAGING MATERIALS AND CONTAINERS	33
Lesson 3 Paper and Paperboard	33
Introduction	33
Representative Papermaking Machines	33
Machine Direction and Cross Direction	36
Surface or Dry-End, Treatments and Coatings	37
Paper Characterization	38
Paper Types	40
Paperboard Grades	42
Paperboard Cartons	43
Lesson 4 Corrugated Fiberboard Boxes	46
Historical Perspective	46
Corrugated Board	47
Properties and Tests	52
Corrugated Boxes	55
Carrier Rules	58
Stacking and Compression	60
Lesson 5 Metal Containers	64

Background	64
Common Metal Container Shapes	65
Three-Piece Steel Cans	67
Two-Piece Cans	69
Impact Extrusion	71
Aerosols	73
Lesson 6 Glass Containers	75
Glass Types and General Properties	75
Bottle Manufacture	77
Bottle Design Features	80
Lesson 7 Plastics in Packaging	83
Introduction to Plastics	83
Extrusion	87
Injection Molding	91
Extrusion Blow Molding	92
Injection Blow Molding	93
Thermoforming	94
Other Forming Methods	96
Recognizing Molding Methods	97
Lesson 8 Flexible Packaging Laminates	98
Laminates	98
Aluminum Foil	99
Vacuum Metallizing	101
Other Inorganic Coating	103
Laminate Structural and Physical Properties	104
Flexible Bags, Pouches and Sachets	106
Sealability	109
Barrier Properties	110
Laminating Processes	112
Specifying Laminates	116
Examples of Laminates	116
UNIT THREE PACKAGE PRINTING AND DECORATING	118
Lesson 9 Color	118
Introduction	118
Color Perception	118
Color Terminology	119
Viewing Color	120
Lesson 10 Graphic Design in Packaging	121
Introduction	121
Demographics and Psychographics	121
The Retail Environment	122

Fundamental Messages	123
Equity and Brand Names	126
Graphic Design Basics	127
Typography	127
Lesson 11 Package Printing	128
Introduction	128
Printing Methods	129
Relief Printing	130
Lithography	134
Gravure Printing	136
Comparing Flexography, Lithography and Gravure	137
Other Package Decoration Techniques	138
Printing Inks	141
UNIT FOUR PACKAGING DYNAMICS AND DISTRIBUTION PACKAGING	143
Lesson 12 Shock, Vibration and Compression	143
Shock	143
Quantifying Shock Fragility	146
Cushioning Against Shock	149
Vibration	151
Compression	155
Estimating Required Compression Strength	161
Lesson 13 Mechanical Shock Theory	162
Introduction	162
The Free Falling Package	162
Mechanical Shock Theory	164
Shock Duration	167
Shock Amplification and the Critical Element	168
Lesson 14 Test Method for Product Fragility	170
Shock; Damage Boundary	170
Vibration; Resonance Search & Dwell	174
Lesson 15 Seven Steps for Cushioned Package Development	175
Introduction	175
Step 1 Determine Product Fragility	176
Step 2 Determine Conditions	177
Step 3 Calculate Cushion Requirements	177
Step 4 Recognizing Design Constraints	180
Step 5 Design Prototypes and Test	182
Step 6 Consider Vibration Effects	182
Step 7 Monitor Performance If it works, question it	184
Lesson 16 Distribution Packaging	184
Short History of Distribution Packaging in the USA	184

Functions and Goals of Distribution Packaging	185
The Cost of Packaging	185
The Package Design Process	186
Taking a Total System Approach to Package Design	186
The 10-Step Process of Distribution Packaging Design	189
A Final Check	191
Package Design Project Checklist	191
The Warehouse	192
Unit Loads	193
Lesson 17 Computer Aided Packaging System	196
Introduction to TOPS Pro	196
Using TOPS Pro	199
UNIT FIVE PACKAGING MACHINERY	205
Lesson 18 General Overview	205
Automated Production	205
The New Production Line	206
Speed	208
Straight-Line and Rotary Systems	209
Changeovers	209
Machine Controls	211
Developing Custom Machinery	212
Upgrading Existing Equipment	212
Lesson 19 The Packaging Line	212
The Packaging Line	213
Line Organization	213
Packaging Materials	214
Machine Capabilities	214
Line Balancing	215
Material and Container Characteristics	215
Personnel	216
Lesson 20 Filling Systems	216
Introduction	216
Liquid Filling	218
Dry Product Filling	232
Resources	245
Glossary of Packaging Terms	246

UNIT ONE PERSPECTIVE ON PACKAGING

Lesson 1 A History of Packaging

What Is Packaging?

Packaging is best described as a coordinated system of preparing goods for transport, distribution, storage, retailing, and use of the goods. It is a complex, dynamic, scientific, artistic, and controversial business function, which in its most fundamental form contains, protects/preserves, transports, and informs/sells. Packaging is a service function that cannot exist by itself; it needs a product. If there is no product, there is no need for a package.

Packaging functions range from those that are technical in nature to those that are marketing oriented (Figure 1.1). Technical packaging professionals need science and engineering skills, while marketing professionals need artistic and motivational understanding. Packaging managers need a basic understanding of both marketing and technical needs, mixed with good business sense. This unusual skill spread makes the packaging industry a unique career choice.

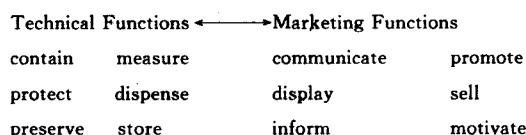


Figure 1.1 Packaging encompasses functions ranging from the purely technical to those that are marketing in nature

Packaging is not a recent phenomenon. It is an activity closely associated with the evolution of society and, as such, can be traced back to human beginnings. The nature, degree, and amount of packaging at any stage of a society's growth reflect the needs, cultural patterns, material availability and technology of that society. A study of packaging's changing roles and forms over the centuries is, in a very real sense, a study of the growth of civilization.

From an individual perspective, change often seems to be that which has already happened, but society is changing daily—meeting new challenges, integrating new knowledge, accommodating new needs and rejecting systems proven to be unacceptable. These changes are inevitably reflected in the way we package, deliver and consume goods.

Because the science of packaging is closely connected to everything we do as a society, it should come as no surprise that the packaging industry is always in a state of change. Entire sectors can become obsolete, or new industries generated by the discovery of a new material,

process or need. For example, a whole new packaging sector was born with a single tragic tampering incident (the Tylenol episode of October 1982). Society suddenly required tamper-evident closure systems.

Until the 1950s, motor oil was delivered in bulk to service stations, which in turn measured it into 1-quart glass jars. The advantages of premeasured oil in metal cans swung the entire trade into metal cans. By the late 1960s, foil/fiber composite cans had replaced metal cans, and by the late 1970s, plastic bottles had replaced fiber cans.

Similarly, milk delivery went from glass bottles to today's variety of plain and aseptic paper cartons, plastic bottles and flexible bags, each packaging method offering its own particular advantages.

How oil or milk will be delivered tomorrow is open to speculation. Packaging choice can probably reflect an increasing need for environmentally acceptable packaging that will generate minimal waste. The relative costs of petrochemicals, wood pulp, and metal will likely govern choices. And finally, the way we buy and consume oil or milk will have a significant impact. No option can be ignored; it is not difficult to imagine a scenario where milk is delivered in refillable aluminum cans.

Primitive Packaging

We don't know what the first package was, but we can certainly speculate. Primitive humans were nomadic hunters/gatherers; they lived off the land. Such an existence has severe limitations. It takes considerable land area to support the wild animals and vegetation needed to feed a single person. Social groupings were therefore small, probably restricted to family units.

These early humans would have been subject to the geographical migrations of animals and the seasonal availability of plant food. This meant that humans followed their food sources around and quite often went hungry. Such an extreme nomadic existence does not encourage property accumulation beyond what can be carried on one's back.

Nonetheless, primitive people needed containment and carrying devices, and out of this need came the first "package". It was most likely a wrap of leaves, an animal skin, the shell of a nut or gourd, or a naturally hollow piece of wood. Fire was carried from camp to camp, and evidence suggests that the role of fire-bearer and the "packaging" of fire carried a mystical significance.

Let's jump ahead to 5000 B. C. , a time of some domesticated plants and animals. While the forage or hunt was still important, a reasonable food supply was available in a given vicinity. This evolutionary stage, which supported larger social groups, gave birth to small tribal villages. Storage and transport containers were needed for milk, honey, seed grains, nuts, and dried meat. Villages with access to different resources traded with their neighbors, requiring transport containers.

Fabricated sacks, baskets, and bags, made from materials of plant or animal origin, were added to the primitive packaging list. Wood boxes replaced hollow logs. Clay from a

riverbank would have initially been shaped into containers and allowed to dry in the sun. This was fine for dry products, but wet products quickly converted such containers to mud. Some impatient Neolithic genius, probably trying to hurry the slow process of sun-drying, placed a clay bowl in a fire. Much to his or her pleasure, the fire-dried clay pots were more durable and held their shape when filled with water. Thus was born the pottery and ceramic trade.

Legend has it that Phoenician sailors who used salt blocks to protect their fire from wind on the sandy Mediterranean coast discovered a hard inert substance in the fire's remains. By 2500 B. C. , glass beads and figures were being made in Mesopotamia (today's Iraq). The earliest hollow glass objects appeared in Mesopotamia and Egypt in about 1500 B. C.

Ancient Egyptian glass containers were core-formed. Hot strands of glass were wrapped around a core of clay and dung (Figure 1. 2). Wavy patterns could be introduced by dragging a stick across the soft hot glass. Rolling the glass against a smooth surface flattened and smoothed the strand lines. When the glass was cool, the core was dug out of the container.

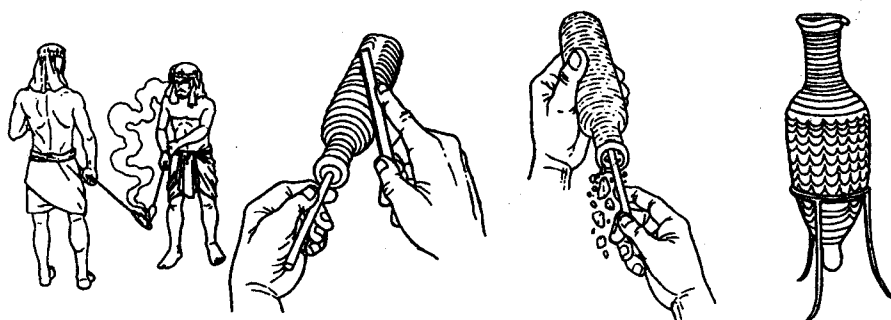


Figure 1. 2 Forming a hollow glass vessel around a core

Along with metal, these glass containers were the ancient packaging materials. Many centuries would pass before modern materials such as paper and plastics expanded the packager's portfolio.

While the printing arts and extensive packaging laws were still in the distant future, law that affected packaging were being enacted as early as the Greek city-state period (about 250 B. C.). For example, olive oil, at that time packaged in amphora (large clay jugs with elongated or pointed bottoms), was marked with a stamp identifying the city-state where it was produced, the time of pressing and the person responsible for it.

From Rome to the Renaissance

As time went on, cities were established, trade flourished across the European and Asian continents, and conquering armies frequently sallied forth to plunder some other region's wealth. While the world witnessed many societal changes, the corresponding changes in packaging related mostly to the quality and quantity of existing packaging practices.

An important packaging event, attributed to the Romans in about 50 B. C. , was the invention of the glass blowpipe. The blowpipe was a hollow steel rod on the end of which was

placed a gob of molten glass. By blowing into the opposite end, the glassblower could inflate the gob into a hollow vessel in a variety of shapes and sizes. The glassblower could shape the vessel freehand by alternately blowing and shaping, or blow the glass bubble into a cup mold with pre-existing decorations.

The blowpipe's invention brought glass out of noble households and temples. Roman glass beakers decorated with chariots and gladiator contests—apparently sold as souvenirs and mementos of such events—are reasonably common.

The origin of the first wooden barrel is not clear, but it also probably had its start at this time, possibly in the Alpine regions of Europe. The barrel was destined to become one of the most common packaging forms for many centuries.

With the Roman Empire's collapse in about 450 A. D., Europe was reduced to minor city-states and squabbling kingdoms at best, and downright barbarity at worst. Many established arts and crafts were forgotten or became stagnant. The 600 years following the fall of Rome were so devoid of significant change that historians refer to them as the Dark Ages.

Any progress came from the Far East and from Arabic nations newly inspired by the Muslim faith. In China, Ts'ai Lun is credited with making the first true paper from the inner bark of mulberry trees. When the Muslims sacked Samarkand in about 950, they carried the secret back to Europe. The Egyptians had been making a similar sheet product by weaving together the split stalks of papyrus reeds. By pounding, pressing and drying the woven strips, they created a useful sheet material. Centuries later the name "paper" was given to the Chinese invention made of matted plant fibers.

Printing from woodcuts—the ancient parent of the printing process known as flexography—also originated in the Far East. The oldest existing printed objects are Japanese Buddhist charms dated to 768. The oldest existing book is the *Diamond Sutra*, found in Turkistan and printed in 868.

The European world awoke in about 1100. Neglected crafts were revitalized, learning and the arts were revived and trade increased, and by the 1500s, the great age of exploration was well under way. The art of printing was born in this period.

Fundamental social structures had not changed significantly. Most of the population lived off the land, sometimes as freeholders, but more typically as serfs who owed their existence and part of everything they produced to a higher power. For the most part they ate what they raised, found or caught. At this level, consumer needs were nonexistent.

Shops and stores where a person could buy goods did not exist as we know them. Although money as an exchange medium was available, much of the population never saw any. Manufacturing was strictly a custom business, and what we have called packages to this point were personally crafted, as were most goods. Packages, where they existed, were valuable utensils, and were rarely disposable in the manner of a modern package.

Since there was no retail trade, concepts of marketing, advertising, price structures and distribution were irrelevant. Population levels were not large enough to support mass production, even in the most limited sense.

The Industrial Revolution

Encyclopedia Britannica describes the Industrial Revolution as "the change that transforms a people with peasant occupations and local markets into an industrial society with world-wide connections". This new type of society makes great use of machinery and manufacture goods on a large scale for general consumption.

The Industrial Revolution started in England in about 1700 and spread rapidly through Europe and North America. Some characteristics of this revolution included the following.

- Rural agricultural workers migrated into cities, where they were employed in factories.
- Inexpensive mass-produced goods became available to a large segment of the population; the consumer society was born.
- Factory workers needed commodities and food that were previously produced largely at home.
- Many new shops and stores opened to sell to the newly evolving working class.
- By necessity, some industries were located in nonagricultural areas, requiring that all food be transported into the growing urban settings.

These changes increased the demand for barrels, boxes, kegs, baskets, and bags to transport the new consumer commodities and to bring great quantities of food into the cities. The fledgling packaging industry itself had to mechanize in order to keep up with the growing demand. With large segments of the population living away from food production points, it became necessary to devise ways of preserving food beyond its natural biological life.

The Evolution of New Packaging Roles

For most of recorded history, people lived in rural communities and were largely self-sufficient. Bulk packaging was the rule, with the barrel being the workhorse of the packaging industry. Flour, apples, biscuits, molasses, gunpowder, whiskey, nails and whale oil were all transported in barrels. Packaging served primarily to contain and protect. Individual packaging was of little importance until the Industrial Revolution spurred the growth of cities. The new industrial workers needed to be fed by a separate agricultural system and supported in most of their nonfood needs by the manufacturing skill of others.

City dwellers did not have a farm's storage facilities, and so quantities purchased tended to be small and trips to the shop more frequent. This was an open opportunity to create individual packages in the amounts that people preferred to purchase. In practice, it took many years for this to happen, and even today the transformation is not complete.

Initially, shops simply adapted the bulk delivery system to consumer selling. The shopkeeper received apples and biscuits in barrels, cheese in large rounds and herbs or medicines in glass jars. He or she would measure and portion these items, often into a container provided by the purchaser. The shopkeeper sold mostly unfinished product.

Medicines, cosmetics, teas, liquors and other expensive products were the first

prepackaged products, along with awkward items such as tacks or pins. The latter were often wrapped in paper, and the expression "a paper of pins" accurately described the product. In time, many products were sold in a "paper" .

Products were sold generically. Cheese was cheese, oatmeal was oatmeal, and lye soap was lye soap. Sometimes identifying marks were made with a blackening brush or with a hot branding iron on the barrel or cask to show origin or manufacturer. In time, certain brand marks became associated with quality products. As individual packaging began to develop, quality producers wished to identify their particular product as a guarantee of quality or composition. The brand mark was carried from the bulk package to unit packages or labels. It was an early form of product branding, as well as the origin of the term "brand name" .

The first brand names were inevitably those of the maker. Yardley's (1770), Schweppes (1792), Perrier (1863), Smith Brothers (1866) and Colgate (1873) are a few of the personal names that have survived to this day.

Most packages that existed in the mid-1800s were for higher cost goods, and the evolving printing and decorating arts were applied to these early "upscale" packages. Similarly, it was realized that the papers used to wrap a product for sale were easily imprinted with a brand mark, with some message of instruction or a description of the product's virtue. Many early decorations were based on works of art or national symbols or images. Labels were printed with ornate and elaborate scrolls, wreaths, and allegorical figures or impossibly flawless and shapely ladies (some things are difficult to change). These often combined typography in a dozen type styles.

Early food can labels had to appeal to simple country folk, so pictures of pastoral life, barnyards and fruit on the a branch were commonly used. Sometimes the label graphics had little to do with the contents, and sometimes the same graphic was used on unrelated products. Another popular practice was to display the gold medals won at one or another of the great national and international fairs held frequently at the time. Many early labels were so attractive that they were saved for decorative use.

A packaging milestone was set in 1877 when the American Cereal Company chose a symbol to represent or trademark their product. The Quaker personage represented purity, wholesomeness, honesty, and integrity—value that by extension also applied to the product. It was perhaps one of the earliest forms of what designers refer to as the "persona", a description of the package or product as if it were a person.

After an intense advertising campaign, the company convinced a fair proportion of the population to ask for Quaker Oats rather than just oatmeal. The Quaker figure's success possibly inspired other companies to adopt fictitious personages to represent their products, among them were the Cream of Wheat smiling chef (1893) and the National Biscuit Company's boy in a raincoat (1899).

Package decoration follows national art styles and trends. Between 1890 and about 1920, decoration followed the art nouveau style popular in that period. This was followed by a period of art deco graphics and designs.

The first plastic, based on cellulose, was made in 1856, but packaging applications were still a long way off. In 1907, phenol formaldehyde plastic, later known as Bakelite, was discovered. Bakelite's major packaging application was for closures. A few years later, in 1911, a machine was built to manufacture continuous cellulosic film. DuPont chemists perfected the cellulose casting process in 1927 and called their product cellophane. Cellulose films dominated the clear film market until the advent of polyethylene and polypropylene. Bakelite was largely displaced by the newer thermoplastics in the 1960s.

In earlier days, craftspeople sold their own wares and were able to explain the available choices or how best to use a product. Now the shopkeeper was not there to aid or influence the consumer's purchase. Stores with thousands of products were staffed by persons who had little or no knowledge of the product and their applications. The consumer was face to face with the package, and the package's motivational and informational roles became critical:

- The package had to inform the purchaser.
- The package had to sell the product.

Package design and graphics were suddenly much more than a pretty picture, and a whole new profession, package design, was born. The transformation from bulk packaging to individual packaging and from general stores to supermarkets continued, interrupted only briefly by the shortages of the Second World War.

Packaging In the Late 20th Century

The birth rate after the Second World War and into the 1950s was so imposing that it earned its own name: the baby boom. Demographics, the study of population structure and trends, was universally realized to be an important factor in designing products and packages.

Fast-food outlets made their appearance in the 1950s and created a demand for new kinds of packaging. The consumer met disposable single-service packaging for the first time, while the fast-food outlets demanded the bulk delivery of ready-to-cook food portions in their own special type of packaging. Later, two other factors joined the fast-food outlets boom to influence packaging: increased levels of public health care and a rapidly growing trend toward eating out rather than at home. Today, this market is large enough to form its own sector, sometimes called the HRI (hospital, restaurant, and institutional) market.

The 1950s also saw the growth of convenience and prepared food packages, such as cake mixes, TV dinners, boil-in-bag foods and gravy preparations. A rapidly growing technology added petroleum-derived plastics to the package designer's selection of packaging materials.

The coming-of-age baby boomers were the largest identifiable population segment in the late 1960s, and this was reflected in a major youth orientation in packaging and products. Sexual morality shifted significantly in the 1960s to allow more suggestive and provocative messages. In the 1960s, this was mostly confined to "cheesecake", images of scantily clad women aimed at selling products to men. Its counterpart, "beefcake", did not become common until the more liberated 1980s. Today both tactics are under increasing criticism as inappropriate methods of promoting goods.

Consumerism and a concern for the environment became important factors at this time for those who watched for future trends.

The 1970s and early 1980s brought numerous changes, many of them legislated. Child-resistance closures were mandated for some products. Tamper-evident closures were brought in for others. Labeling laws required listing of ingredients. International agreements were signed to phase out the use of ozone-depleting chlorofluorocarbons (CFCs). Standards for the acceptance of new packaging materials were raised.

Microwave ovens became a common household feature, and a significant effort went into devising products and packaging specifically for the microwave. A new health awareness meant not only changes in consuming habits and nutritional labeling but also opportunities for entire new food lines. Yogurt became the "in" food. Bottled water became big business.

The last decades of the 20th century witnessed rapid change. The population aged, and many social habits changed. Families became smaller. Single-person households became common. The domestic housewife became a relic of the past as both partners in a marriage sought professional careers or higher income levels. For the modern urban dweller, "convenient" and "fast" became the operative words. Marketers recognized a whole subclass of people who know only how to boil water or turn on the microwave. If it wasn't ready in five minutes, they didn't want it. If it took more than one dish, their interest wandered.

Modern Packaging

1. Changing Needs and New Roles

Looking back, historical changes are understandable and obvious. That all of them have had an impact on the way products are bought, consumed and packaged is also obvious. What is not so obvious is what tomorrow will bring. Yet, it is to the needs, markets, and conditions of tomorrow that packaging professionals must always turn their attention.

The forces that drove packaging during the Industry Revolution continue to operate today. The consumer society continues to grow and is possibly best described by a 1980s bumper sticker, "Born to Shop". We consume goods today at a rate 4 to 5 times greater than we did as recently as 1935. Most of these goods are not essential to survival; they constitute what we may call "the good life".

In the second half of the 20th century, the proliferation of goods was so high that packaging was forced into an entirely new role, that of providing the major purchase motivation rather than presenting the goods itself. On a shelf of 10 competing products, all of them similar in performance and quality, the only method of differentiating became the package itself. Marketers aimed at lifestyles, emotional values, subliminal images, features, and advantages beyond the basic product itself—anything that would make a shopper's hand reach for *their* product rather than the competitor's. In some instances, the package has become the product, and occasionally packaging has become entertainment.

Globally, the trend toward urbanization continues. Providing increased tonnages of high-quality food to massive city complexes at affordable prices is a problem that continues to

challenge packagers. A new concern is the removal of the debris generated by a consumer society and the impact that these consumption rates have on the planet's ecology.

The makeup, needs, styles, perceptions and wishes of the consuming public are always changing. The packaging professional must be aware of and keep up with these changes or be lost to history.

2. Packaging and the Modern Industrial Society

The importance of packaging to a modern industrial society is most evident when we examine the food-packaging sector. Food is organic in nature, having an animal or plant source. One characteristic of such organic matter is that, by and large, it has a limited natural biological life. A cut of meat, left to itself, might be unfit for human consumption by the next day. Some animal protein products, such as seafood, can deteriorate within hours.

The natural shelf life of plant-based food depends on the species and plant part involved. Pulp fruit portions tend to have a short life span, while seed parts, which in nature have to survive at least till the next growing season, have a longer life. Stalks and leaves separated from the living plant are usually short-lived.

In addition to having a limited natural shelf life, most food is geographically and seasonally specific. Thus, potatoes and apples are grown in a few North American geographical regions and harvested during a short maturation period. In a world without packaging, we would need to live at the point of harvest to enjoy these products, and our enjoyment of them would be restricted to the natural biological life span of each.

It is by proper storage, packaging and transport techniques that we are able to deliver fresh potatoes and apples, or the products derived from them, throughout the year and throughout the country. Potato-whole, canned, powdered, flaked, chipped, frozen, and instant—is available, anytime, anywhere. This ability gives a society great freedom and mobility. Unlike less-developed societies, we are no longer restricted in our choice of where to live, since we are no longer tied to the food-producing ability of an area. Food production becomes more specialized and efficient with the growth of packaging. Crops and animal husbandry are moved to where their production is most economical, without regard to the proximity of a market. Most important, we are free of the natural cycles of feast and famine that are typical of societies dependent on natural regional food-producing cycles.

Central processing allows value recovery from what would normally be wasted. By-products of the processed-food industry form the basis of other sub-industries. Chicken feathers are high in protein and, properly milled and treated, can be fed back to the next generation of chickens. Vegetable waste is fed to cattle or pigs. Bagasse, the waste cane from sugar pressing, is a source of fiber for papermaking. Fish scales are refined to make additives for paints and nail polish.

The economical manufacture of durable goods also depends on good packaging. A product's cost is directly related to production volume. A facility building 10000 bicycles per year for local sale could not make bicycles as cheaply as a 3-million-unit-a-year plant intended to capture the national facility. Both would fail in competition against a 100-million-unit