

**Plastics
Processing
Technology and Health Effects**

Radian Corporation

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PLASTICS PROCESSING

Technology and Health Effects

by

Radian Corporation

McLean, Virginia



NOYES DATA CORPORATION

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PLASTICS PROCESSING

Foreword

This book presents a detailed analysis of the plastics processing industry, which includes operations that convert polymers and resins into consumer products. Analytical elements include industry definition, raw materials, products, manufacturers, environmental impacts, and occupational health effects.

Polymer processing operations appeared shortly after the discovery of the early plastics, since methods were needed to turn the plastics into usable items. The earliest processing operations were simple molding operations that were patterned after an early form of compression molding which was used to form billiard balls during the 1860s. In recent times, the discovery and development of polymers and processing operations have proceeded hand in hand. In some situations, copolymers and special formulations have been developed to make the plastic suitable for a desirable fabricating operation. Processing equipment is consistently being modified to accommodate various polymers and copolymers.

For the purpose of this analysis, the Plastics and Resins Processing Industry has been divided into 11 segments, some of which are made up of a number of different processes: calendering, casting, coating, compounding, extrusion, finishing, foam (expandable bead, extruded thermoplastic, multicomponent thermoset, and structural), laminating, molding (blow, compression, injection, reaction injection, rotational and transfer), reinforced plastics, and thermoforming.

The plastics processing industry is made up of about 10,000 processors, with many plants, most of which are small and located in or near urban centers. A compounded annual growth rate of 6% is projected through 1990. Products of plastics processing operations are used as substitutes for wood, metal, glass, leather, or natural fibers. Primary uses of plastics are packaging, construction, housewares, transportation, electric and electronic products, paints, furniture, appliances, and toys.

Plastics processing operations produce air emissions, wastewater, and solid waste resulting from both polymer and additive raw materials. Many processing operations do not produce all three waste streams. Particulate emissions made up of polymer and additive fines are possible during feeding, loading and blending of dry materials, part trimming, and grinding of thermoplastic scrap for recycle. Volatile emissions are possible from operations in which polymers and additives are heated. Most process-related wastewater produced during polymer processing operations is generated from direct contact cooling of newly formed plastic products. Contamination of wastewater results from material washed or leached from the polymer. Solid waste is produced by the collection of particulates from feeding, handling, and grinding operations and by trimming of parts. Thermoplastic scrap may be recycled, but thermoset scrap must be disposed of.

Worker exposure to harmful chemical substances and physical agents depends on the materials being handled, plant design, and effectiveness of engineering controls and personal protective equipment and clothing. These factors are essentially plant-specific and are highly variable throughout the industry.

This book is organized by types of processing, and will be a valuable overview of this industry.

The information in the book is from *Industrial Process Profiles for Environmental Use: The Plastics and Resins Processing Industry*, prepared by Radian Corporation for the U.S. Environmental Protection Agency, July 1985.

The table of contents is organized in such a way as to serve as a subject index and provides easy access to the information contained in the book.

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1. Industry Description

INTRODUCTION

The Plastics and Resins Processing Industry is a large, diverse industry that uses polymers and resins produced by the plastics and resins production industry and produces a wide variety of plastic consumer products.

The polymer and resin raw materials* are supplied to the industry in the form of powders, pellets, and emulsions. The dividing line between polymer production and processing occurs during an operation termed compounding or formulation. Before being processed, all polymers and resins must be blended with the appropriate additives to make them well suited for their intended product use. Compounding operations can occur immediately following the polymer's production, just before or during the processing operation, or partially at both stages. Some large-volume producers of resins produce and process the polymer at the same facility. This is particularly true of fast, continuous process operations such as calendaring and the casting of sheet materials. Typically, plastics are processed at locations other than those where the polymers and resins are produced. Plastics processors purchase resins that are best suited for their processing step from either the polymer producers or compounders.

Polymer processing operations appeared shortly after the discovery of the early plastics, since methods were needed to turn the plastics into usable items. The earliest processing operations were simple molding operations that were patterned after an early form of compression molding which was used to form billiard balls during the 1860's. In recent times, the discovery and development of polymers and processing operations have proceeded hand in hand. In some situations, copolymers and special formulations have been developed to make the plastic suitable for a desirable fabricating operation. Processing equipment is consistently being modified to accommodate various polymers and copolymers.

For the purpose of this analysis, the Plastics and Resins Processing Industry has been divided into 11 segments. Some of these segments are made up of a number of different processes. A delineation of the processing operations covered in this analysis is presented in Table 1. All of the

*The terms polymer and resin are frequently used interchangeably when describing the inputs of the plastic and resins processing industry. The term resin, which is more specific and is widely accepted, is used herein.

TABLE 1. POLYMER AND RESIN PROCESSING OPERATIONS

- Calendering
- Casting
- Coating
- Compounding (Formulation)
- Extrusion
- Finishing
- Foam
 - Expandable Bead Foams
 - Extruded Thermoplastic Foams
 - Multicomponent Thermoset Foams
 - Structural Foams
- Laminating
- Molding
 - Blow Molding
 - Compression Molding
 - Injection Molding
 - Reaction Injection Molding
 - Rotational Molding
 - Transfer Molding
- Reinforced Plastics
- Thermoforming

operations shown in Table 1 are concerned with the actual formation of the end product except for compounding and finishing. The compounding step, as indicated above, typically takes place immediately before the forming operations, whereas finishing involves further processing such as machining and decorating of the formed product.

More than 64 percent of the plastics products produced in the United States are processed by two major processing operations: Extrusion and Injection Molding. The following is a breakdown by percentage of the processing operations based on 1976 statistics:[72]

- Extrusion, 41 percent;
- Injection Molding, 23 percent;
- Blow Molding, 7 percent;
- Coating, 7 percent;
- Calendering, 3 percent;
- Foams, 2 percent; and
- All Others, 17 percent.

The listing for coatings includes those resins used for paints and primers.

Discussions of each of the polymer processing operations (in alphabetical order) follows in Sections 2 through 20. These include four forming operations (Sections 8 through 11), six molding operations (Sections 13 through 18), and nine other specific operations (Sections 2 through 7, 12, 19, and 20). The commentary on foaming and molding operations is preceded by introductory discussions.

In summary, the Plastics and Resins Processing Industry deals with those operations that convert polymers and resins supplied by the Plastics and Resins Production Industry into consumer products. The plastics and resins production industry is covered in a companion volume, Polymer Manufacturing-Technology and Health Effects.

INDUSTRY DEFINITION

The most recent data (June 1982) show that the plastics processing industry is made up of almost 9,400 processors with 10 or more employees. The 1977 Census of Manufacturers (the most recent survey presenting a complete set of industry statistics) showed that the industry employed 468,000 workers, an average of fewer than 50 employees per plant. The census data also indicate that more than 5,800 establishments in the industry had fewer than 20 employees. The four largest companies produced only 7 percent of the total industry shipments, which were valued at \$37 billion. These plants produce a wide variety of products, and they range in size from small one-process and one-polymer operations to large, multi-faceted facilities. Processing facilities tend to be located near the sales centers of the United States so that finished consumer products need not be transported over long distances. Therefore, a large percentage of the plastics processing facilities are located in Connecticut, Massachusetts,

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New York, New Jersey, Pennsylvania, Ohio, Michigan, Illinois, and California. Thus the industry is made up of many plants, most of which are small and located in or near urban centers.

The plastics processing industry has grown to its present size over the past 60 years. Much of this growth has taken place in the latter 10 to 20 years. In this period, the volume growth has been accompanied by a continuously expanding number of products requiring the use of new chemicals. As the plastics processing industry has grown, there has been an increasing interest on the part of Federal agencies that have regulatory responsibilities pertaining to this industry. Studies are continually being performed to determine the safety of certain plastic products (such as kitchenware) for food and drug packaging and consumer usage. The Environmental Protection Agency and the Occupational Safety and Health Administration have been concerned with a number of potential problems in the plastics processing industry and have investigated the potential effects of formaldehyde containing polymers and certain additives such as plasticizers and fillers.

Because of the inert nature of most plastics, the use and handling of the polymer itself and the related waste streams are generally not of primary concern (formaldehyde products being the exception). Most environmental and health effects problems that do arise during fabrication are due to the use of additives in the polymer formulations. Some of these additives are suspected carcinogens or are potentially hazardous if improperly handled.

All polymers that are produced must be processed in one way or another before they are useful as products. Thus it is reasonable to assume that the plastics processing industry in the United States will grow at a rate comparable to that of plastics production. At the present time, it is expected that the plastics industry will continue to grow at a compounded annual growth rate of 6 percent well into the late 1980's. Over the years, the actual rate will probably fluctuate up and down as a whole, depending on the overall state of the U.S. economy. An increased consumer demand for plastic products throughout the economy could lead to significant increases in processing. This is particularly applicable to the automotive and construction industries, where plastic goods are used extensively.

Furthermore, the plastics processing industry will most likely be unaffected by the influx of Middle Eastern polymers into the domestic plastics market. If the demand for plastics products exists, plastics processors will continue to operate, regardless of the origin of their polymer feed. The processing of polymers into final products will continue to be performed close to the consumer market centers because of the high cost of transporting finished products.

RAW MATERIALS

The raw materials for the Plastics Products Industry are the basic resins and additives. The resins comprise the highest volume input to an industry whereas additives are added in relatively small amounts but play an essential role in determination of the properties of the end products.