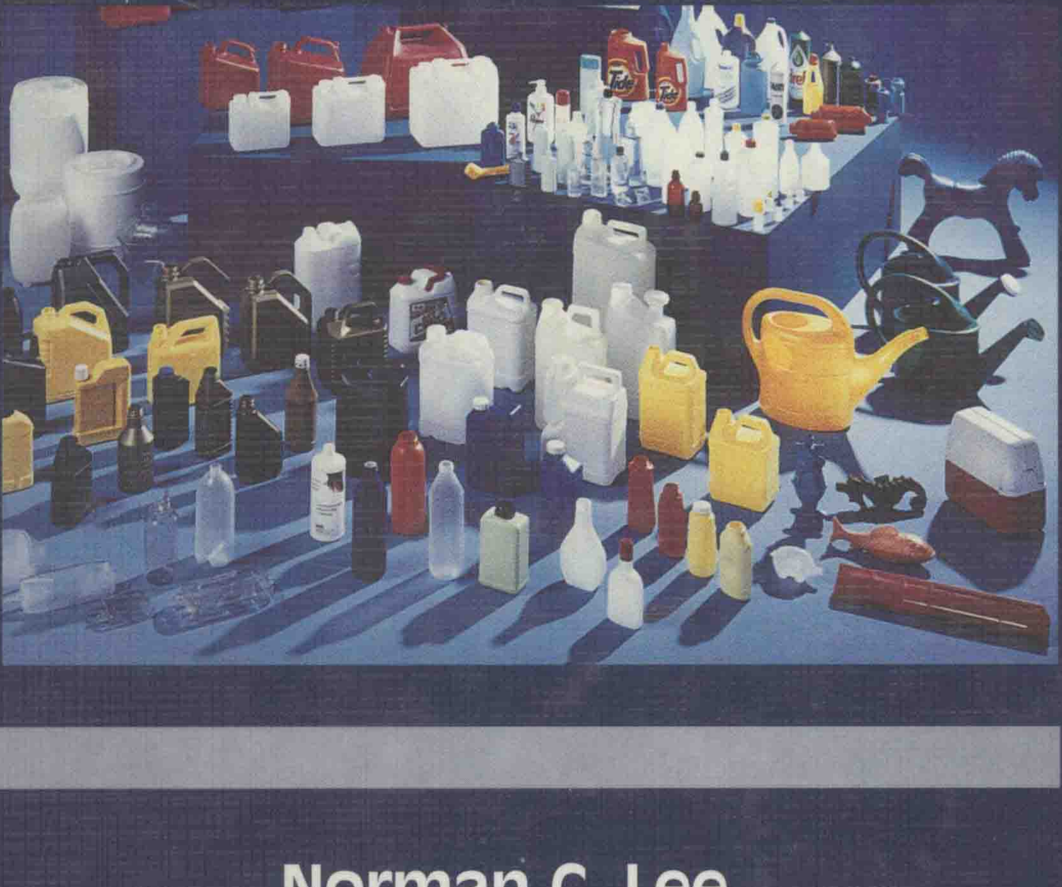
Blow Molding Design Guide



Norman C. Lee

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Blow Molding Design Guide

Hanser Publishers, Munich

Hanser/Gardner Publications, Inc., Cincinnati

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Distributed in the USA and in Canada by
Hanser/Gardner Publications, Inc.
6915 Valley Avenue, Cincinnati, Ohio 45244-3029, USA
Fax: (513) 527-8950
Phone: (513) 527-8977 or 1-800-950-8977
Internet: http://www.hansergardner.com

Distributed in all other countries by
Carl Hanser Verlag
Postfach 86 04 20, 81631 München, Germany
Fax: +49 (89) 98 12 64

Library of Congress Cataloging-in-Publication Data
Lee, Norman C., 1934–
Blow molding design guide / Norman Lee.
p. cm.
Includes bibliographical references and index.
ISBN 1-56990-227-5
1. Plastics—Molding. I. Title.
TP1130.L44 1998
668.4′12—dc21 97-43193

Die Deutsche Bibliothek – CIP-Einheitsaufnahme
Lee, Norman:
Blow molding design guide / Norman Lee. – Munich : Hanser ; Cincinnati : Hanser/Gardner, 1998
(SPE books)
ISBN 3-446-18255-1

Typeset in England by Techset Composition Ltd., Salisbury
Printed and bound in Germany by Kösel, Kempten

Lee

Blow Molding Design Guide

SPE Books from Hanser Publishers

Belofsky, Plastics: Product Design and Process Engineering
Bernhardt, Computer Aided Engineering for Injection Molding
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Foreword

The blow molding industry continues to grow and become more sophisticated; however, there is little written about basic blow molding design. The *Blow Molding Design Guide* offers a spectrum of design information useful for someone new in blow molding, learning the basics, as well as someone experienced in blow mold design looking for new approaches to resolve difficult part design issues. The list of references throughout the book is a virtual who's who in the blow molding industry.

Norman Lee has more than 25 years of experience as a design engineer in the blow molding industry. He is well known for his years of service to the plastics industry through leadership in the Society of Plastics Engineers Blow Molding Division and the Plastics Recycling Division. Mr. Lee has demonstrated his commitment to education by service on the SPE Education Committee and by instructing numerous courses in blow molding. Norman Lee was the editor for the first edition of the *Plastic Blow Molding Handbook*, still in print and a resource for many of his classes.

We believe that the *Blow Molding Design Guide* will fill a void in the blow molding industry by condensing a large collection of industry design knowledge into a comprehensive, usable text and reference.

Lewis Ferguson
Chairman
Blow Molding Division
Society of Plastics Engineers

Technical Volumes Committee
Robert C. Portnoy, Chairperson
Exxon Chemical Company

James P. Parr, Reviewer
Exxon Chemical Company

Preface

Designing plastic blow molded parts can be an extremely difficult task because of the complexities of part geometry and the molding processes. It is challenging to even experienced designers. To produce an effective design it should be:

Functional and achieve the objective for which it is intended,
aesthetically pleasing, within the limits of the process,
practical, utilizing the right material, maximizing the benefits of the process,
cost efficient, with consideration of tooling cost and methods and run quantities.

Therefore, the objectives of this book are to give the reader an understanding of plastic blow molding, materials and processes, thus enabling him to design a blow molded part that optimizes the effectiveness of the plastic materials used, process employed, as well as the function of the part. It includes the application of bottles, industrial and structural parts. It is intended to be a no-nonsense, practical hands on book, that forgoes a scientific language that most ordinary people do not understand and concentrates on real life, day to day problems faced by those working to create cost-effective blow molded parts. It is a good introduction to the overall picture, for those who then wish to delve into more detailed and academic aspects of anyone of the many processes discussed.

Because the work includes so many diverse subjects it is not possible for one individual to be an expert in them all, thus, I have relied heavily on experts in their relative fields for information and advice. These of course are acknowledged at the end of each chapter. In many cases I have drawn from the published work. I make no apologies for this, since I am not able to improve on the original work. Also, much of the matter presented is leading edge technology and development by the originators.

I also acknowledge several who have helped me put this manuscript together. Loretta Lee, graduate student at A&T State University, a UNC System in Greensboro, NC, who took it on as a Masters project. Dr. Brent Strong, Brigham Young University, reviewed the manuscript, corrected errors, and made suggestions for changes. The review committee of the S.P.E blow molding division headed by James Parr, Exxon Company, Robert Gilbert, Equistar; and Robert Read, Dow Brands, made valuable suggestions for improvement. Several diagrams were drawn by Sam Huffine, Huffine Associates, Greensboro, NC and Auto-CAD drawings by James Lee, Ashboro, NC.

Norman Lee

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1

The Basics of Blow Molding

1.1 Definition

Plastic blow molding is a process used to produce hollow component parts. It is confined to thermoplastic type resins, for example, polyethylene, polyvinychloride, polyethylene terephthalate, and engineering plastics such as polycarbonate. The three major variants of blow molding to produce blown plastic components are extrusion blow molding, injection blow molding, and stretch molding [2].

1.2 The Basic Process

The production plant for a blow molding process consists of three stages:

1. *Melting and plasticizing.* An extrusion and/or injection machine may be used to produce the melt.
2. *Parison formation* through a head and die/or injection mold.
3. *Blowing and molding.* Auxiliary air compressors provide air and a hydraulic clamp unit holds the mold.

In these major processes the first step involves the production of the tube, widely known as the parison, a term borrowed from the glass industry. The parison may be produced either by an extrusion or an injection machine. In the latter case it is usually referred to as a preform [3].

The heated parison or preform is placed inside the blowing mold, which closes and clamps around it and then the heated tube is blown against the wall of the mold molten plastic, or resin is then set to shape by being cooled, and after this cooling stage the product is ejected. In many cases the product requires subsequent finishing operations, for example, the removal of flashing, printing and labeling, filling the product, etc. Robotic handling equipment may be used to finish parts using boring and milling operations. For the basic process see Fig. 1.1 [4].

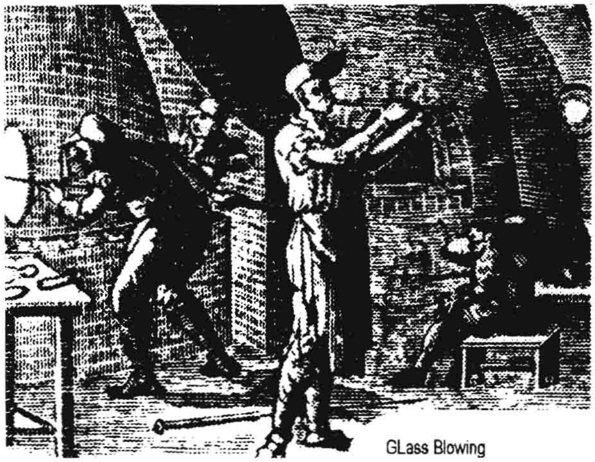

Figure 1.1 Glass blowing

1.3 History

Glass, plastics, and aluminum are three classes of raw materials existing today which are blown to form molded parts. The techniques of modern blow molding plastics grew from the art of glass blowing (Fig 1.1). The method is attributed to Syrian glass workers in the first century BC, who realized that a glass bulb on the end of a blow pipe could be shaped to many useful hollow forms, with handles and feet and decorated adjuncts added at will. During the Middle Ages, chiefly in Great Britain and elsewhere in Europe, the process was refined and sophisticated, becoming an important commercial industry [1].

1.4 Summary of Development

The modern plastic blow molding process (Fig. 1.2) originated in the 1930s, when the initial patents were granted to Plax Corporation and Owens of Illinois for automated equipment based on glass blowing techniques (Fig. 1.3). But the high cost and poor performance of plastic materials at that time discouraged rapid development. The plastic bottles offered no advantage over glass bottles; however, the introduction of low-density polyethylene in the mid-1940s (developed by ICI of England) provided the advantage of squeezability which glass could not match. In 1950 Elmer Mills was granted a patent for a continuous extrusion rotary blow molder used privately by Continental Can. In the late 1950s high-density polyethylene and commercially available molding equipment were developed and the industry rapidly expanded [4].

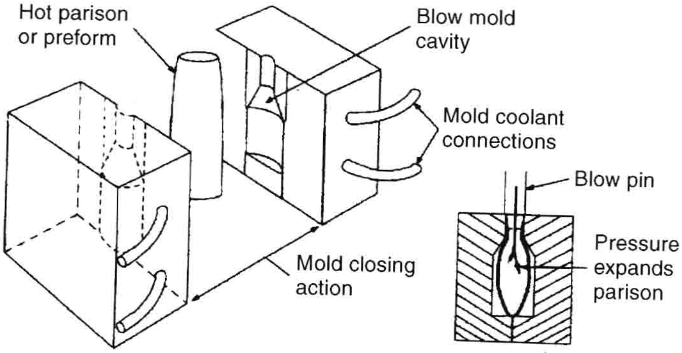

Figure 1.2 Basic blow molding process

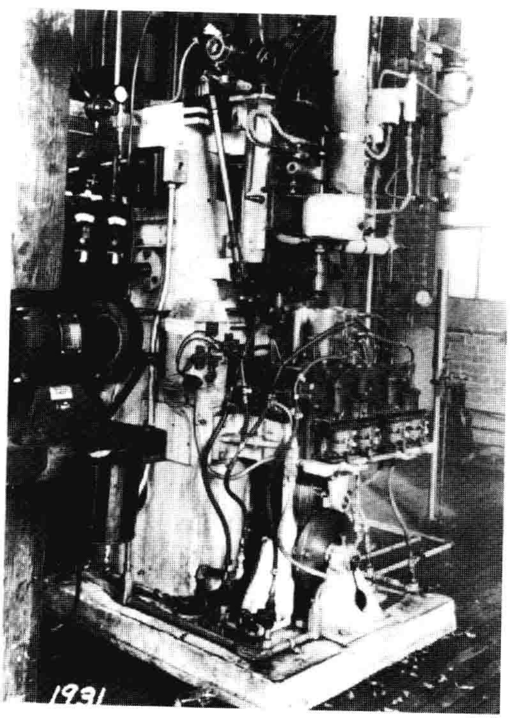

Figure 1.3 An extrusion blowmolder developed by Plax Corporation in the mid 1930s for the production of cellose acetate bottles

High-density polyethylene added considerable breadth to the design capabilities of plastic bottles; most importantly bottles could be lighter and stiffer. Commercial equipment broadened the opportunities for blow molding. Until that time, blow molding was being performed by only a few companies using proprietary technology. Because of the closely held patent situation in the United States most of the equipment development was taking place in Europe, principally in Germany. The first commercial equipment for blow molding in the United States came from Europe, and was shown at the National Plastic Exhibition in 1958. Empire Plastic, a toy company, bought a Fischer Blow Molding machine to make toy bowling pins. The engineers at Empire also converted a Reed–Prentice injection molding machine to make toy baseball bats by moving the injection cylinder up over the platen and building a head with a die and bushing. (Fig. 1.4). A later step was to build a twin head with a Rotec valve to operate and divert the material flow from one side to another (Fig 1.5). Midland Ross–Hartig gained permission from Empire to use this design to build six machines for making doll bodies for Ideal Toy Company. These were the first blow molding machines built by Hartig, which manufactured extrusion machines. The company later became Waldron–Hartig, then Battenfield–Hartig, and are now owned by Davis Standard. In that same period Paul Marcus designed and built twin head machines called Auto-Blow. During 1960 ZARN Inc. was formed in North Carolina and made milk bottles for Borden Dairy, in conjunction with Uniloy (now Johnson Controls), who built the machines and molds. To eliminate the freight cost of transporting empty bottles, in-line bottle blowing was started by a dairy in Burlington, North Carolina using the Uniloy machines and molds [3].

Of all the plastic materials that can be blown like glass, polyethylene is used in greater volume than all others combined. Although mainly still used for bottles, blow molding is increasingly used for industrial parts such as automotive rear deck air spoilers, seat

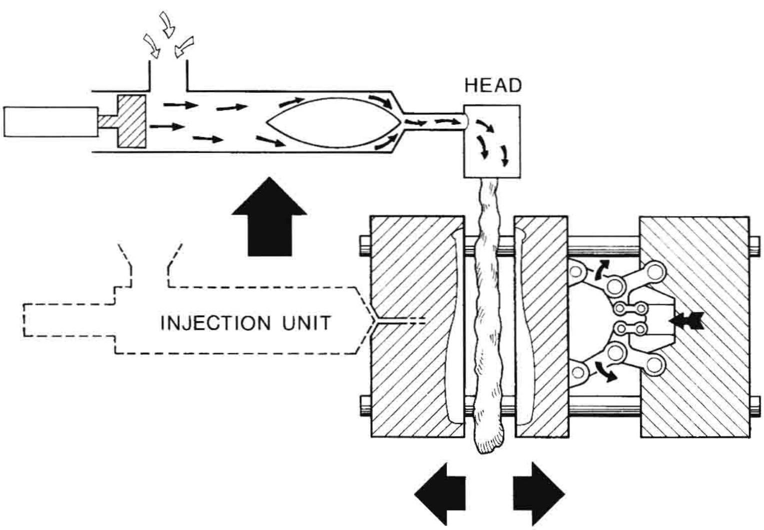

Figure 1.4 Cross-section through converted injection molding machine