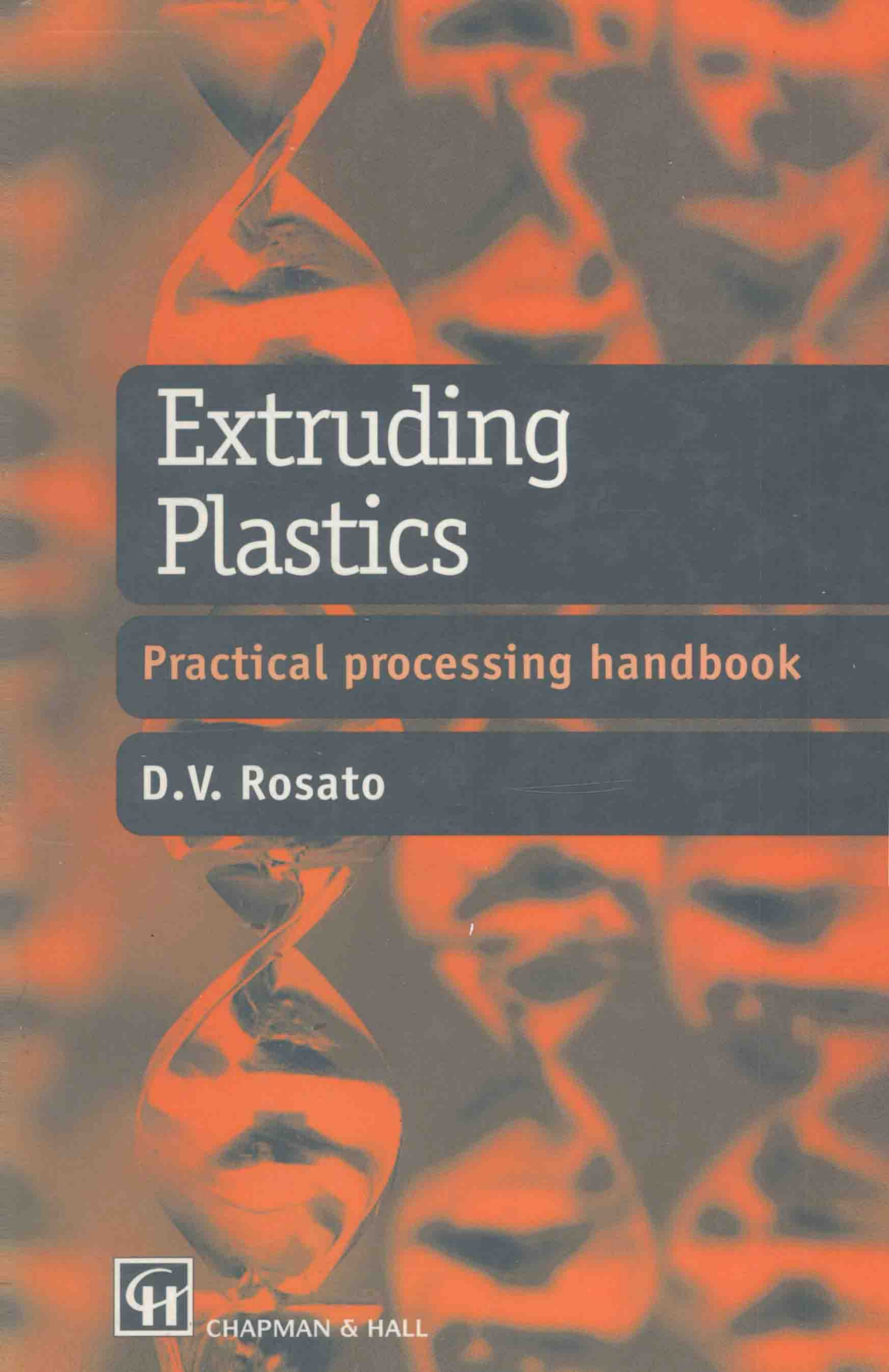

Extruding Plastics

Practical processing handbook

D.V. Rosato

CHAPMAN & HALL

Extruding Plastics

A practical processing handbook

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Extruding Plastics

Preface

Worldwide, extrusion lines successfully process more plastics into products than other processes by consuming at least 36 wt% of all plastics. They continue to find practical solutions for new products and/or problems to meet new product performances.

This book, with its practical industry reviews, is a unique handbook (the first of its kind) that covers over a thousand of the potential combinations of basic variables or problems with solutions that can occur from up-stream to down-stream equipment. Guidelines are provided for maximizing processing efficiency and operating at the lowest possible cost. It has been prepared with an awareness that its usefulness will depend greatly upon its simplicity and provision of essential information.

It should be useful to: (1) those already extruding and desiring to obtain additional information for their line and/or provide a means of reviewing other lines that can provide their line with operating improvements; (2) those processing or extruding plastics for the first time; (3) those considering going into another extrusion process; (4) those desiring additional information about employing the design of various products more efficiently, with respect to both performance and cost; (5) those contemplating entering the business of extrusion; (6) those in new venture groups, materials development, and/or market development; (7) those in disciplines such as nonplastics manufacturers, engineers, designers, quality control, financial, and management; and (8) those requiring a textbook on extrusion in trade schools and high schools or colleges.

Only a few theoretical concepts are included. Persons dealing with practicalities will find the theoretical explanations enlightening and understandable. Theorists will gain insight into the practical limitations of equipment, plastics, and people. There are various excellent books that provide detailed theoretical analysis; they are listed in the Reference section. However, this review of the industry's operating experiences presented with 387 figures and 128 tables will help make extrusion lines operate more efficiently and expand their capabilities. These experiences establish empirical analyses that, in turn, develop theoretical concepts.

The book's practical approach provides for the novice and experienced

personnel a description of extrusion advances and trends. This leads to 'streamlining' processing lines by anticipating and understanding problems that could occur, what causes them, how to eliminate them, and/or how to take corrective action. The content is arranged to provide a natural progression from simple to complex situations. It correlates materials, equipment, process controls, product requirements, and people. Thus, one learns how to avoid 'preventable' down-time and/or unacceptable products. A step-by-step approach is used to simplify and understand practical fundamentals that interrelate processes with plastics-to-products.

This comprehensive book explains in a clear, concise, simple format the different extrusion processes that produce many different commodity and engineered plastic products. Included are: (1) flexible-to-rigid-to-foam-to-decorative constructions; (2) both simple and complex shapes; (3) processing virgin and/or recycled plastics; (4) procedures for start-ups and shut-downs; (5) postforming in-line, troubleshooting, and so on. A target has been to open up new possibilities in the art of extruding, with the goal of approaching zero defect processing.

It is essential to re-emphasize what is reviewed in the text, namely that all data and information presented on equipment and plastics are to be used as guides. Obtain the latest, most complete, information from suppliers.

Information is derived from the author's experience as well as personal contacts with industry worldwide, including many industry people, and industry sources, as is evident by the references listed at the end of this book. Every possible care has been taken to ensure that the content of this book is correct. While the information contained is believed to be true and accurate, no one, including the editor, contributors, sources, and publisher, can accept any legal responsibility for any errors, omissions, operating risks/damages, or other factors. All information is provided in good faith but without legal responsibility. This book will serve to help people understand the process of extrusion and that includes maintaining the highest degree of safety and avoiding injury to personnel and damage to equipment.

Information contained in this book may be covered by US and worldwide patents. No authorization to utilize these patents is given or implied; they are discussed for information only. Disclosures are neither a license to operate nor a recommendation to infringe any patent. No attempt has been made to refer to patents by number, title, or ownership.

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Chatham, MA., USA
December, 1997

Contents

1

The complete extrusion process

OVERVIEW

The extrusion processes offer the advantages of complete versatile plastic processing techniques unsurpassed in economic importance by any other process. Worldwide, extruder lines are the largest converters of plastics and can be considered the most important production machinery in the plastic industry. Commercially, extrusion lines are targeted to give advantages with regard to operating cost (output per hour). The two main reasons that make them attractive to the processors and markets are their almost unlimited range of applications and their continuous production capabilities to meet new market challenges [1]. There are also batch or noncontinuous processing of plastics (Chapter 18) that include injection blow molding (Chapter 15), injection molding (Chapter 18), and the major market of compounding plastic materials (Chapter 17).

This book provides practical information that affects processing performances when changing individual variables during extrusion as well as on the important up-stream and down-stream equipment. The variables all relate to the common factors of temperatures, pressures, and times which, in turn, relate to the manufacturing output rates and costs. Each chapter in this book contains important information on different variables and the behavior of plastics during processing. Detailed information in one chapter that applies elsewhere will not be repeated in subsequent chapters. Thus, to gain the maximum benefit from this book, review or examine all chapters. The table of contents and index provide helpful cross references. Advantages and disadvantages as well as troubleshooting guides are provided throughout this book. The information presented comes from many worldwide industry sources, individuals and companies that include those listed in the Reference section at the end of this book.

All processes fit into an overall scheme that requires the interaction and

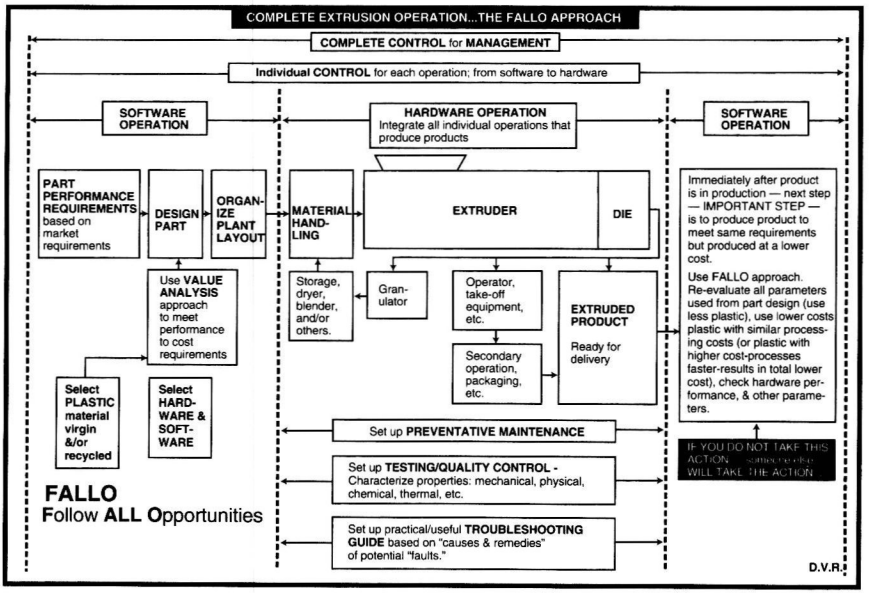

Figure 1.1 The FALLO approach.

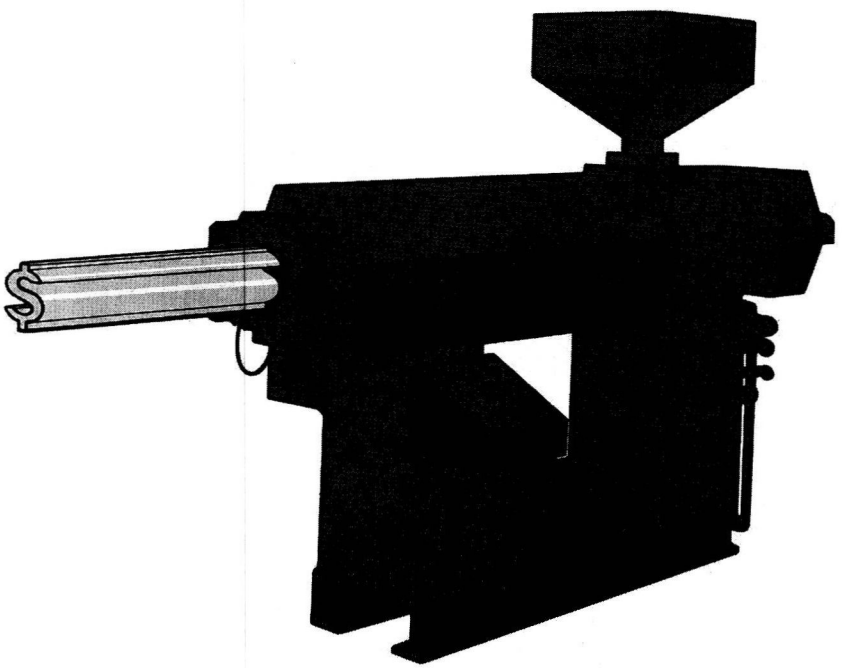

Figure 1.2 Extruders provide products used worldwide with profits.

proper control of different operations. An example is shown in Fig. 1.1 where the block diagram pertains to any process system. The FALLO (Follow ALL Opportunities) approach makes one aware that many steps are involved in processing and all must be properly understood and coordinated [1–6]. Basically the FALLO approach consists of: (1) designing a product to meet performance and manufacturing requirements at the lowest cost; (2) specifying the proper plastic material(s) that meet product performance requirements after being processed; (3) specifying the complete equipment line by (a) designing the die 'around' the product, (b) putting the 'proper performing' extruder 'around' the die, (c) setting up auxiliary equipment (up-stream to down-stream) to 'match' the operation of the complete line, and (d) setting up the required 'complete controls' (such as testing, quality control, troubleshooting, maintenance, data recording, etc.) to produce 'zero defects;' and (4) purchasing and properly warehousing plastic materials. Using this type of approach leads to maximizing the product's profitability (Fig. 1.2).

Plastics, predominantly thermoplastics (TPs) (Chapter 3), are usually

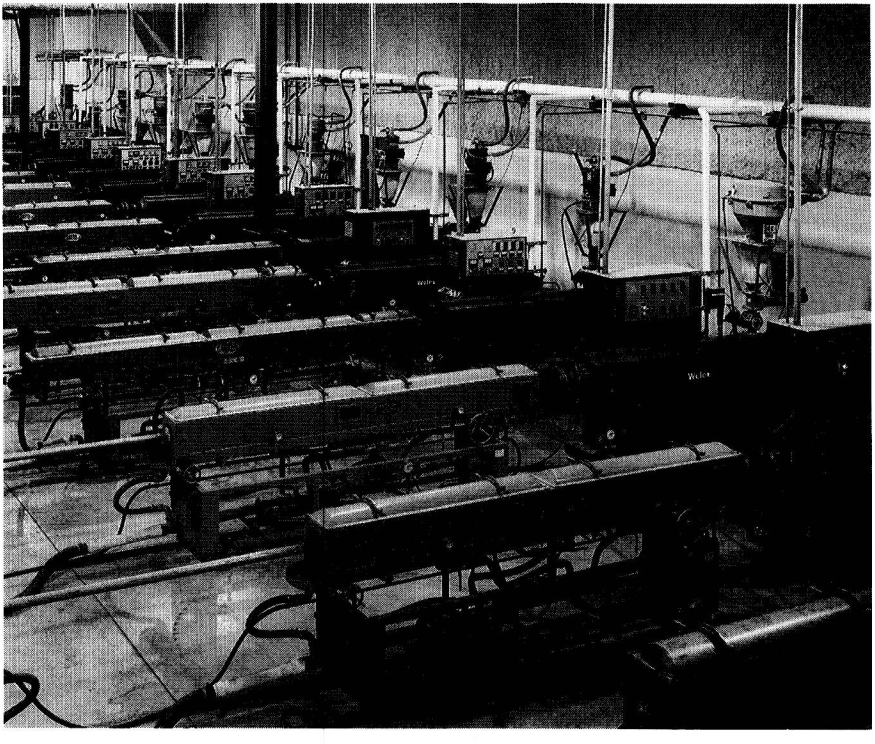

Figure 1.3 Double 'H' Plastics Co. with 14 complete pipe/profile lines with Welex extruders and Gonair/Gatto coolers.