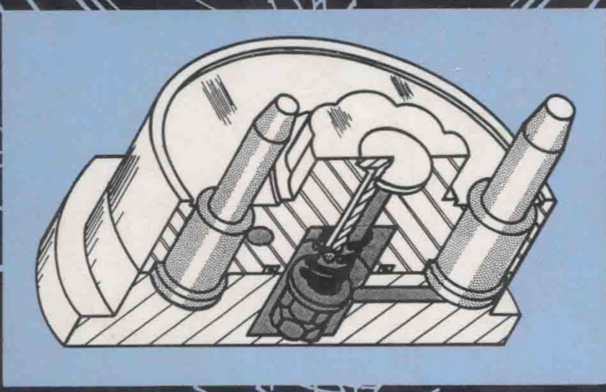
FOURTH EDITION

INJECTION MOULD DESIGN

AN INTRODUCTION AND DESIGN MANUAL FOR THE THERMOPLASTICS INDUSTRY



R.G.W. PYE

Longman Scientific and Technical in Association with the Plastics and Rubber Institute

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A textbook for the novice and a design manual for the thermoplastics industry

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Fourth Edition

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INJECTION MOULD DESIGN

A textbook for the novice and a design manual for the thermoplastics industry

To Trina
For her encouragement and indulgence

Preface

The primary object of the first edition of this book was to provide a handbook on design for mould draughtsmen and designers in industry. In addition to fulfilling this function, the book has been used increasingly by the novice as an introductory guide, because it progresses in simple stages from the consideration of basic principles and components to more detailed explanation of the more complex types of special purpose mould.

When the publishers asked me to consider another edition of this work, I had no hesitation in recommending that the new extension be used primarily to help the beginner. In this respect the chapter on worked examples has been enlarged from three to twenty examples in order to cover all of the basic designs discussed in the preceding chapters.

Secondly, as there has been a rapid increase in the use of standard parts in the mould making industry since the publication of the previous edition, the chapter on this subject has been completely rewritten. In addition, the use of standard parts has been included in various chapters which relate to specific designs.

The revised edition has been divided into three sections: elementary mould design, intermediate mould design, and aspects of practical mould design. Part One covers mould-making methods including standard mould parts. Other primary considerations such as feed systems, parting surfaces and mould cooling are also covered. Part Two progresses to specific designs such as splits, side-core, unscrewing, underfeed, and hot-runner types. Part Three is included primarily for the novice, and includes chapters on topics such as procedure for designing an injection mould, checking mould drawings and worked examples etc.

In this edition, for size limitation reasons, no attempt has been made to include the more theoretical aspects of mould design. Topics such as computer aided design, aspects of rheology, heat transfer, fluid flow, etc., have been excluded. It is the author's intention to include these important theoretical subjects in a companion volume which is now in preparation.

R.G.W. Pye
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Wherever possible, the individual designer and/or company has been credited with a specific design or device mentioned in the book. This leaves the author to acknowledge the contribution of the many thousands of anonymous designers who between them, over several decades, have formed the basis of modern injection mould design.

It should be pointed out that many of the designs and devices described and illustrated in this book are the subjects of valid patents.

Contents

PART ONE

Elementary mould design

1

Mould making

1.1 GENERAL

A competent mould designer must have a thorough knowledge of the principles of mould making as the design of the various parts of the mould depends on the technique adopted for its manufacture.

This chapter is included primarily for the beginner who does not have a background knowledge of the various machining and other mould making techniques. To cover the topic of mould making thoroughly would require a companion work equal in size to this monograph and therefore this introduction to the subject must, of necessity, be superficial. However, we hope that the very fact that it is included in a monograph on design will emphasise the importance of mould making as a subject and will also encourage the beginner to a further and more complete study in this field.

The majority of moulds are manufactured by the use of conventional machine tools found in most modern toolrooms. From the manufacturing viewpoint we classify the mould into two parts (i) the *cavity* and *core*, and (ii) the remainder of the of the mould. The latter parts is commonly referred to as *bolster work*.

The work on the cavity and core is by far the most important as it is from these members that the plastics moulding takes its form (see Chapter 2 for definitions).

The work on the cavity and core can further be classified depending upon whether the form is of a simple or a complex nature. For example, the cavity and core for a circular or rectangular box-type moulding is far simpler to make than a cavity and core to produce, say, a telephone handset moulding. The mould parts for the simple form are produced on such machine tools as the lathe and the milling machine, whereas the more complex form requires the use of some kind of copying machine.

The bolster work is not as critical as the manufacture of the cavity and core forms but, nevertheless, accuracy in the manufacture of the various parts is necessary to ensure that the mould can be assembled by the fitter without an undue amount of bench-work.

Now, while the bolster work is always produced on conventional machine tools, the cavity and core, particularly the former, can be produced by one of a number of other techniques. These include investment casting, electro-deposition, cold hobbing, pressure casting and spark machining.

1.2 MACHINE TOOLS

The purpose of any machine tool is to remove metal. Each machine tool removes metal in a different way. For example, in one type (the lathe) metal is removed by a single point tool as the work is rotated, whereas in another type (the milling machine) a cutter is rotated and metal is removed as the work is progressed beneath it.

Which machine tool is to be used for a particular job depends to a large extent upon the type of machining required. There is, however, a certain amount of overlapping and some machine tools can be utilised for several different operations. In the illustrations which follow, typical machining operations are illustrated but it must not be assumed that the particular machine tool is restricted to the operation shown.

The machine tools which will be found in the modern toolroom are as follows:

(i) *Lathes* for turning, boring and screwcutting, etc.
(ii) *Cylindrical grinding machines* for the production of precision cylindrical surfaces.
(iii) *Shaping and planing machines* for the reduction of steel blocks and plates to the required thickness and for 'squaring up' these plates.
(iv) *Surface grinding machines* for the production of precision flat surfaces.
(v) *Milling machines* for the rapid removal of metal, for machining slots, recesses, boring holes, machining splines, etc.
(vi) *Tracer-controlled milling machines* for the accurate reproduction of complex cavity and core forms.

In addition to the above list of major machine tools there is, of course, ancillary equipment without which no toolroom would be complete. This includes power saws, drilling machines, toolpost grinders, hardening and polishing facilities, etc.

1.2.1 Lathe

The primary purpose of the lathe is to machine cylindrical forms. The contour is generated by rotating the work with respect to a single-point cutting tool. For machining the outside surface, the cutter is moved parallel to the axis of rotation. This operation is called *turning*. Alternatively, metal may be removed from the inside of the work in which case the operation is called *boring*. When the tool is moved across the face of the work it is called *facing*.

The principal parts of the lathe are illustrated in Figure 1.1. The workpiece is secured at one end in a chuck and supported at the other end by a *centre*, fitted in the tailstock. The chuck is mounted on the headstock spindle and driven by an electric motor via a gearbox and transmission system (the last two items are not shown). The headstock and tailstock are both attached to the machine bed, and the position of the tailstock is adjustable to accommodate various lengths of workpiece.

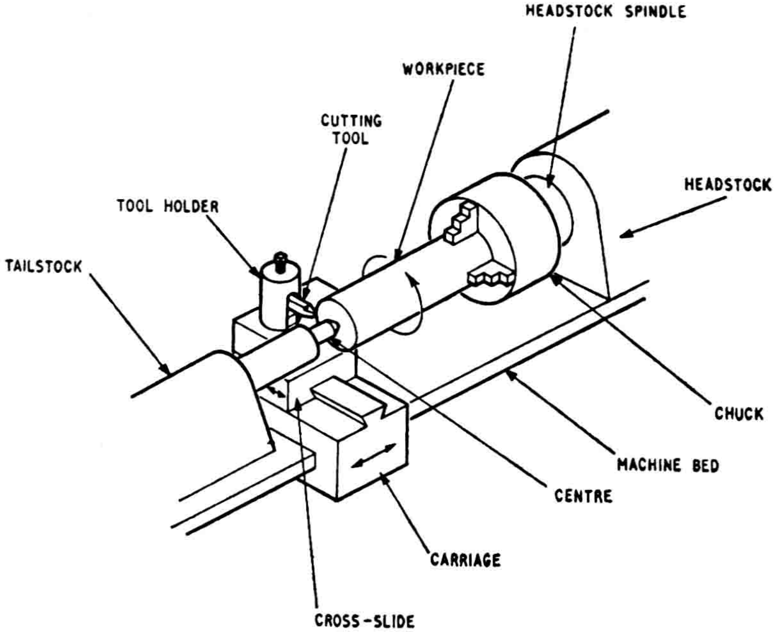

Figure 1.1–Lathe

The cutting action is by means of a single-point cutting tool mounted in a toolholder. The cutting tool is positioned, prior to the commencement of the cutting operation, so that the cutting point is in line with the axis of the work. The tool can be moved, primarily, in two directions. For normal turning and boring, a longitudinal movement is required and this is achieved by moving the carriage along the slideways of the bed. For facing the end of the work-piece, a transverse movement is required and this is achieved by moving a cross-slide along the slideways of the carriage. Note that these slideways are at right angles to the bed slideways. Both the longitudinal and transverse movements can be power operated.

The speed of the carriage (or cross-slide) relative to the rotational speed of the work is adjustable and this, together with the depth of cut chosen, determines the finish obtained on the work. For rough machining a relatively deep cut with a fast feed is used, but for finishing a shallow cut with a fine feed is required. When a large amount of metal has to be removed, a number of successive roughing cuts are made until the required diameter is approached. The part is then finished to size with one or two finishing cuts.

The lathe is extremely versatile and is used for making a large variety of mould parts. For example, guide pillars, guide bushes, circular support blocks, ejector rods, ejector rod bushes, push-back pins, etc., are all manufactured on the lathe. In addition to this bolster work the cavity and core are also produced on a lathe if the moulding form is cylindrical.

Turning is a relatively fast machining operation and for this reason moulds for circular components are cheaper to produce than corresponding moulds for components of any other form.

Internal and external thread forms are also easily generated, when required, as for example on the end of an ejector rod (Figure 3.7). A slight complication arises if the thread is required on the core (see Figure 11.18) or in the cavity (Figure 11.50) to produce a complementary moulded thread as shown. In these cases it is necessary to make some allowance for the plastics material shrinkage on the mould thread pitch (i.e. the mould thread pitch must be machined slightly larger than required to allow for the material shrinkage on cooling).

To describe the manufacture of a typical mould part, we take a guide pillar (Figure 1.2) to illustrate the sequence of operations.

The first step is to cut off a suitable length of steel bar and mount this in the lathe chuck. The end of the bar is faced and subsequently

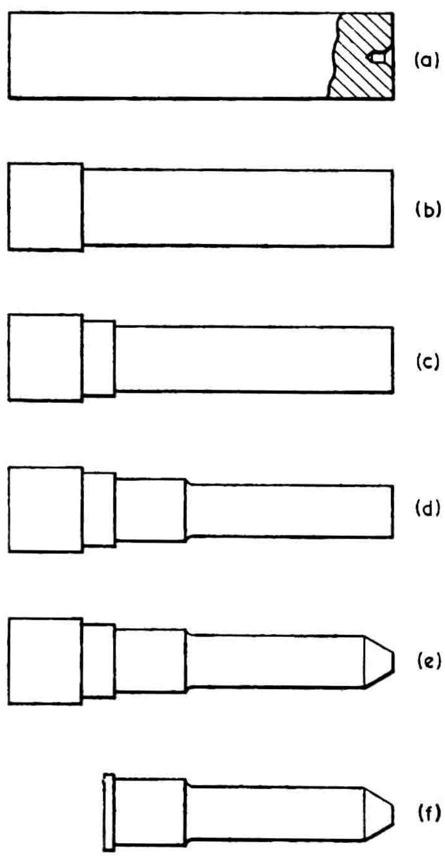

Figure 1.2—Stages in manufacture of guide pillar