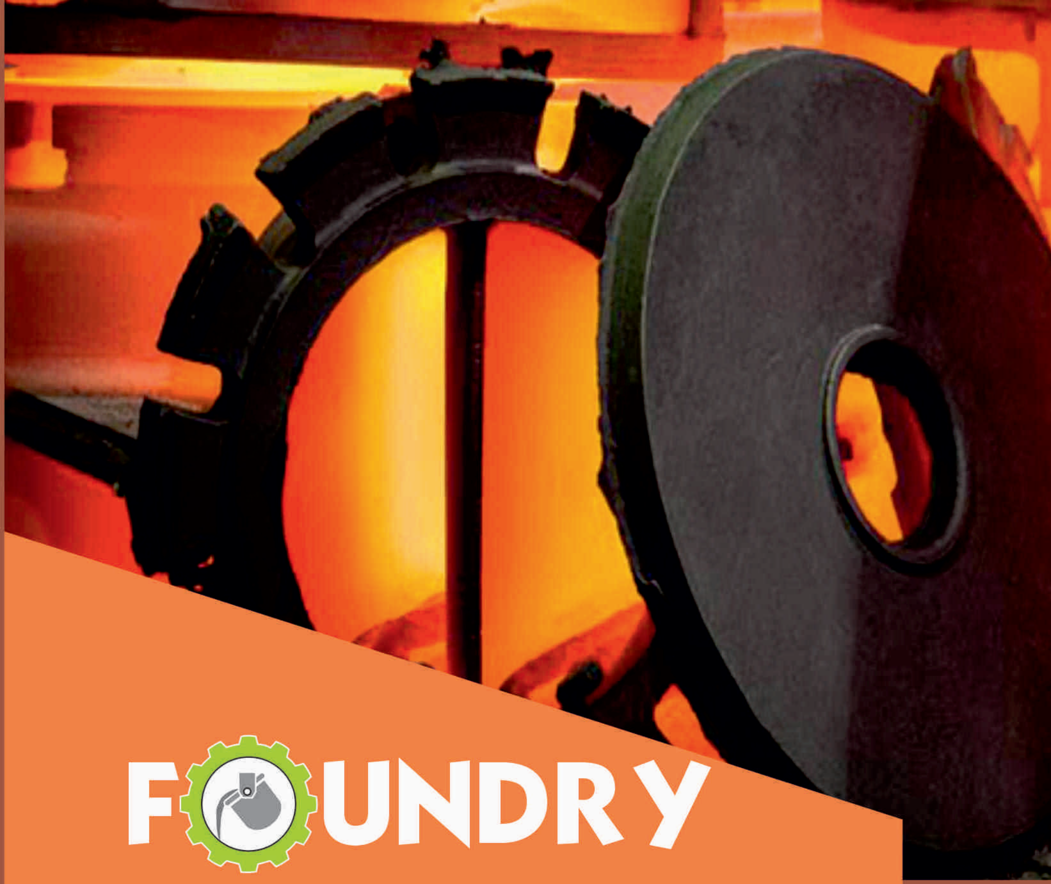

FOUNDRY ENGINEERING

Dr. N.K. Srinivasan

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FOUNDRY ENGINEERING

[A Textbook for Engineering Students of Mechanical, Metallurgical and Production Branches]

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Published by :
Romesh Chander Khanna & Vineet Khanna
for **KHANNA PUBLISHERS**
2-B, Nath Market, Nai Sarak
Delhi- 110 006 (India)

Website : www.khannapublishers.in

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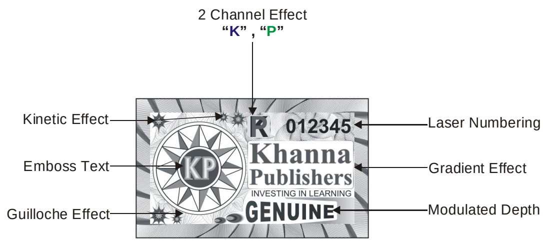

ISBN No. 978-93-87394-27-8

First Edition : 2001
Third Edition
Fourth Reprint : 2012

PREFACE TO THE THIRD EDITION

The book has been expanded based on the feedback that it has been widely used by mechanical and production engineering students, both at undergraduate and at graduate levels. Considering the requirements of local universities, a number of topics relating to casting design and production aspects have been added at several chapters. Further, sections on productivity, estimation of cost and environmental and health protection are included in chapter 14. A few metallurgical topics, for instance, austempered ductile iron, are discussed.

The encouraging comments from several engineering teachers are gratefully acknowledged. In particular, the correspondence with Prof. R. C. Creese of West Virginia University, Morgantwon, WV, USA has been very useful. Further, Prof. Creese has contributed two sections for this edition : riser design and casting costs.

—N. K. Srinivasan

Contents

1

Introduction

A well-known saying : "The shortest distance between raw material and a finished part is a casting". This statement has acquired a new meaning with the progress of deeper scientific knowledge of melting and solidification of metals, and casting design and development of newer materials. Much of the progress in foundry technology has taken place after World War II.

1.1. Advantages of Casting Method

First let us consider the advantages of metal casting as a manufacturing method, compared to other methods such as forging and welding. These are :

1. Castings weighing a few grams to several tonnes can be manufactured. Therefore size is not a limitation.

2. Castings which are required in small quantities, say 1 to 100, can be economically made. Forgings require costly dies and welding may become expensive.

3. There are several metals which can only be cast, *e.g.*, gray cast iron. They are generally brittle and cannot be forged or formed.

4. It is possible to make extremely intricate components (such as turbine blades, finned air-cooled cylinders) with good dimensional accuracy. It would be extremely costly to machine such components.

5. It is possible to make a cast-weld construction. Complicated parts can be cast as two or three pieces and then joined by welding. This affords a great flexibility in design.

1.2. Flow Sheet for Production of Castings

The general process flow sheet for casting production is shown in Fig. 1.1. The steps are described here.

Step 1. A design of the casting is made. This may involve discussion between design engineer and foundry engineer to evolve a good design at a minimum cost of casting.

Step 2. A suitable drawing of the component is prepared. A detailed pattern drawing should be made. (Indicate the surfaces to be machined and the tolerances).

Step 3. A pattern is made. Pattern may be of wood, aluminium or other metals, or plastic. Pattern has slightly different dimensions from the component drawing due to "pattern allowances".

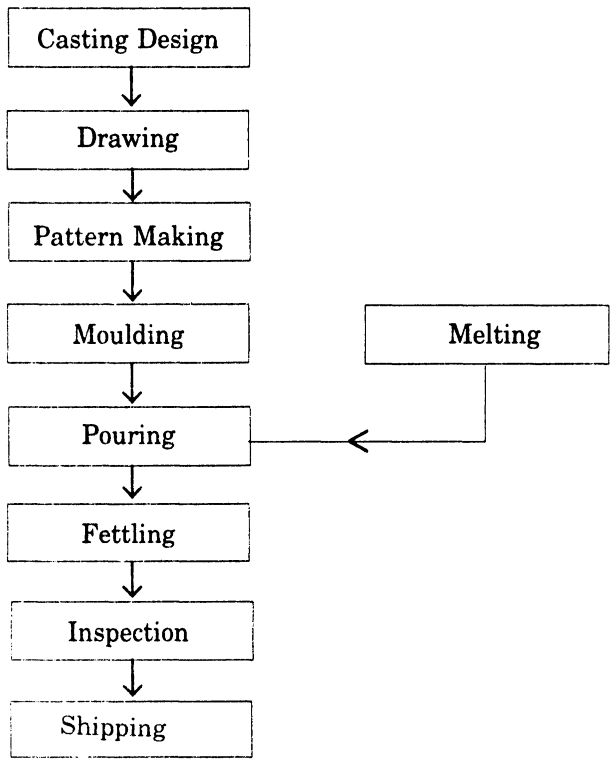

Fig. 1.1.

Step 4. Using patterns, with cores if necessary, a mould is prepared. For sand casting methods, specially prepared sands are used. For permanent mould or die castings, metal moulds or dies are required. Other methods are described later. (Sand moulds are destroyed while the casting is removed).

Step 5. Melting and Pouring : The metal is melted in a suitable furnace, alloying additions are made, composition is adjusted, and adequate 'pouring temperature' is attained. Then the metal is transferred to ladles and subsequently poured into moulds.

Step 6. Fettling : After the casting has cooled, it is taken out of the mould. Unwanted portions such as sprue, runners and risers, are cut and removed. The surface of the casting is cleaned.

Step 7. The casting may require certain heat treatment. Then it is inspected. Inspectors check the dimensions, mechanical properties, soundness or pressure-tightness, as required, and may employ non-destructive tests such as ultrasonic flaw detection, dye penetrant test, X-ray or gamma ray radiography.

Step 8. The approved castings are weighed, packed and shipped.

1.3. Classification of Foundries

Foundries may be classified on the basis of nature of work undertaken. Jobbing foundries cater to the needs of a wide variety of customers ; therefore size of the castings made and the compositions melted may range widely from one day to the next. Captive foundries, on the other hand, cast specific components for their own manufacturing units. Since these foundries have long-term contracts, it is easier to plan the production.

Foundries are also classified according to the metals cast : for example, ferrous foundries, non-ferrous foundries, aluminium foundry, grey iron foundry and brass foundry.

Foundries may be named according to the degree of mechanisation/automation employed : small foundries with complete manual work to semi-mechanised to mechanised or automated foundries.

Certain foundries confine themselves to production of high quality precision castings.

1.4. History

Foundry industry has a venerable history. Art of metal casting was practiced in ancient India and China. Moulds were made of stone or clay. Investment casting process seems to have been known from ancient times in India.

Founding practice, perhaps, grew into a craft from 13th century. The early foundrymen in Europe were casting church bells by loam moulding using sweep moulds. The first cannon was cast in bronze in 1313 by a monk in Ghent. Italians, at the time of Cellini, started making statues using lost-wax (investment) process.

Biringuccio (1480—1539) was the first to study principles of founding and write in considerable detail. He became the head of the foundry in Vatican. During the subsequent centuries, foundry became a well-known craft and several guilds were established.

In 1730, Abraham Darby of Coalbrooksdale, Shropshire in England, used coke for melting iron. John Wilkinson made the first metal-shell cupola. He employed a steam engine to blow air.

In the nineteenth century, many developments took place. Asa Whitney, in 1847, developed the annealing process for chilled car wheels used for railway coaches and freight cars. Seth Boyden in Newark, New Jersey, invented the process for 'black-heart' American malleable iron.

Around 1950 ductile iron was developed by International Nickel Company, U.S.A., and British Cast Iron Research Association, as a new cast material.

1.5. Process Selection

We shall be describing several casting methods—green sand moulding to investment casting techniques. Each method is best suited for certain materials and specific components, though a given component can be made by more than one method of casting. The most important factors to be considered while selecting a casting process or moulding method are :

size of the casting,

number of castings required,

minimum section thickness,

dimensional accuracy,

surface finish,

composition of the cast alloy, and

properties and structure of the casting.

1.6. Applications of Castings

Typical components as castings made by different casting processes are as follows :

Sand casting machine beds, machine frames, pump housing, motor housing, bearing blocks, cylinder blocks, paper making rolls, bells, valves.

Shell moulding finned cylinders, valve bodies, impellers, cutters.

Centrifugal casting tubes, pipes, cylinder liners, wheels.

Plaster moulds tyre making moulds, metal patterns.

Permanent moulds pistons, cylinders, dies, wagon wheels, brass valves.

Die casting electrical boxes, zinc parts for type writers, sewing machines, cameras, toys, door handles, hand tools, domestic appliances.

Investment casting turbine blades, wave guides, milling cutters, impellers, jewelry.

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2

Patterns

A pattern can be defined as full-size model of the casting, used to produce a mould cavity into which liquid metal is poured.

Patterns can be non-expendable (permanent) or expendable. A wooden or metal or plastic pattern is non-expendable and can be used for producing a number of moulds. A wax pattern, used for investment (Lost-wax) process, or a polystyrene (foam plastic or 'thermocole') pattern employed in full-mould process, is destroyed during the casting process. These are called expendable patterns. We shall consider in this chapter non-expendable patterns.

2.1. Types of Patterns

The most common types of patterns are as follows :

1. Simple patterns—single or loose patterns and split patterns, gated patterns,
2. Matchplate patterns,
3. Special patterns or pattern devices.

Simple Patterns: The simplest type of pattern is the flat-back pattern. In this, the mould cavity will be either entirely in the drag or entirely in the cope (Fig. 2.1).

The *split patterns* are more commonly used. Consider a solid cylindrical part. The two halves of the pattern are moulded in cope and drag. They are kept together in position by dowel pins (Fig. 2.2). (Cope is the top half of the moulding box or flask while drag is the bottom half of the flask).

Gated Patterns: A pattern piece for the gate may be attached to the pattern to reduce the moulding time—to save the time required for cutting the gates by hand. If a number of patterns are joined to a common gating system, the moulding work can be greatly reduced. Fig. 2.3 shows four patterns attached to a common gating in a gated pattern. Further, the use of a follow board is also shown. Four holes are drilled through a wooden plate and the patterns are positioned on the board with the gating system.

Matchplates Production efficiency can be greatly increased by the use of matchplates. In this, patterns are fastened on a plate or

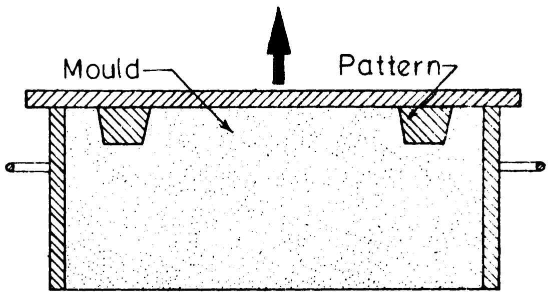

Fig. 2.1.

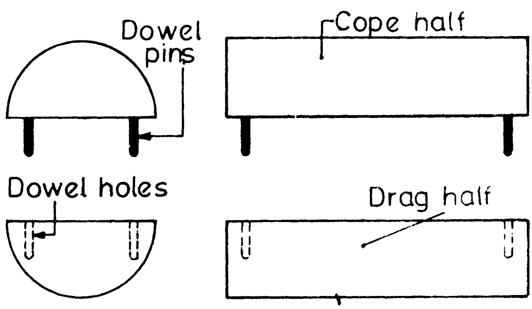

Fig. 2.2.

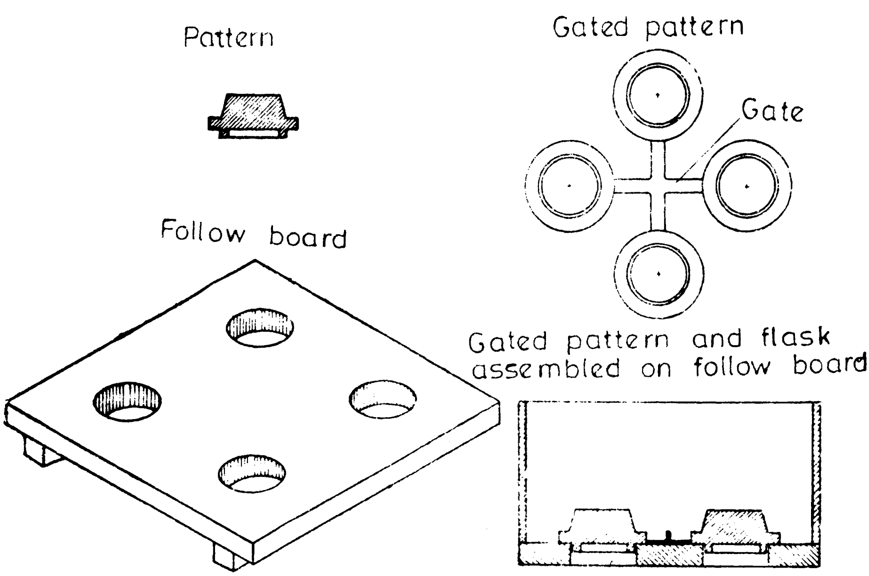

Fig. 2.3.

cast as a plate-like casting (Fig. 2.4). Matchplates are essential in many cases for machine moulding. Sometimes they are suited for producing large number of small castings by hand moulding as well. Besides, the dimensional accuracy of castings can be greatly improved by the use of matchplates.

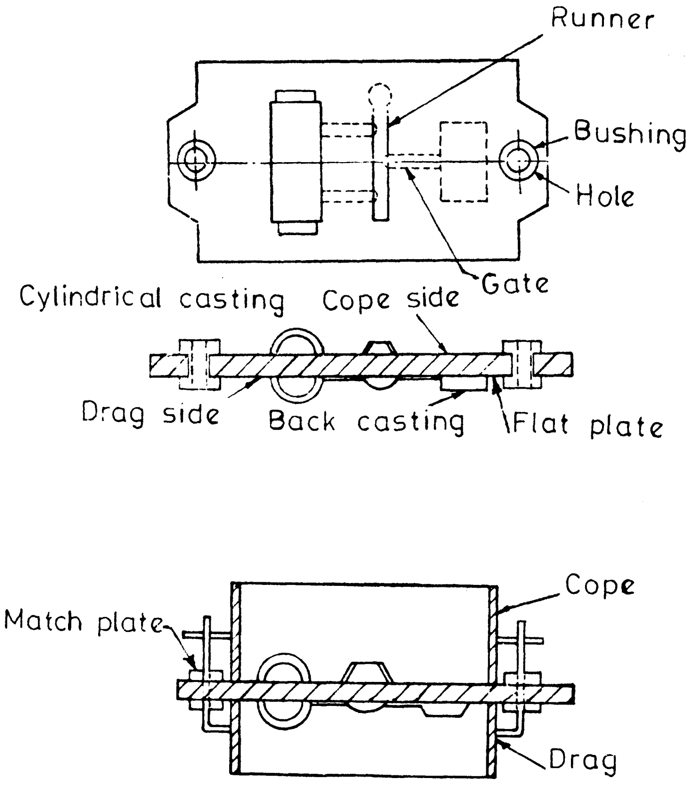

Fig. 2.4.

Vibrators attached to matchplates provide better lifts, reduce the draft necessary, eliminate swabbing and produce castings of greater dimensional accuracy due to a more uniform rapping.

Flat-back and split patterns are conveniently fastened to a standard or *universal matchplate* that will fit standardised moulding boxes. It is possible to mount several patterns on the same plate. Further, if the two halves of the pattern are symmetrical, they may be mounted on one side of the matchplate—the plate must be used twice, once for cope and once for drag.

Matchplates are invariably made of aluminium alloy, although wooden or steel plates are sometimes used. Aluminium alloy matchplates are usually made by sand casting or plaster-mould casting. (Metal strips can be fastened along the circumference of a wooden matchplate to reduce wear).

Cope and drag patterns These are split patterns. The cope and drag halves and mounted on separate plates. A great advantage is that cope and drag can be moulded separately on two machines, and then assembled. This type of pattern plates is used on high-speed or automatic moulding machines of high production rate. They are also used for very large moulds.

Special Deyices

Loose pieces: Overhanging bosses, for instance, on a bearing frame casting, may be moulded using a loose piece. (Fig. 2.5). A loose piece is held on the pattern by a pin or with a dovetail slide. After ramming moulding sand securely around the loose piece, the pin, if used, should be withdrawn. Later, when the pattern in withdrawn, the loose piece remains in the mould. The loose piece is then carefully rapped and drawn out.

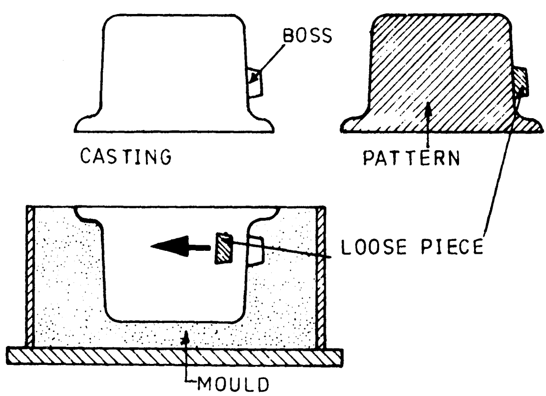

Fig. 2.5.

Use of cores: Cores can be used for making an internal hole as well as an external contour. For instance, a grooved pulley can be made using a dry-sand core. (Fig. 2.6). A split pattern is used. The riser can also be moulded with a piece attached to the pattern. The pattern involves two core prints, one for the hole in the hub and one for the groove of the pulley.

Match or follow board: Match is a device used for moulding when parting line is irregular. This can be made of green-sand, hard-sand, plaster or wood. The term follow board is used for a wooden match. Use of match greatly produces the moulding time. A green-sand match with pattern is shown in Fig. 2.7. The pattern should first be supported on a mould board by placing suitable piece of wood under the elevated end. After ramming, roll over and form the drag. Upon this drag, a green-sand match is now rammed up. The match can be used a number of times.

A follow board can be a flat board with holes or cut-out portions to mount the patterns. The surface of the board forms the surface.

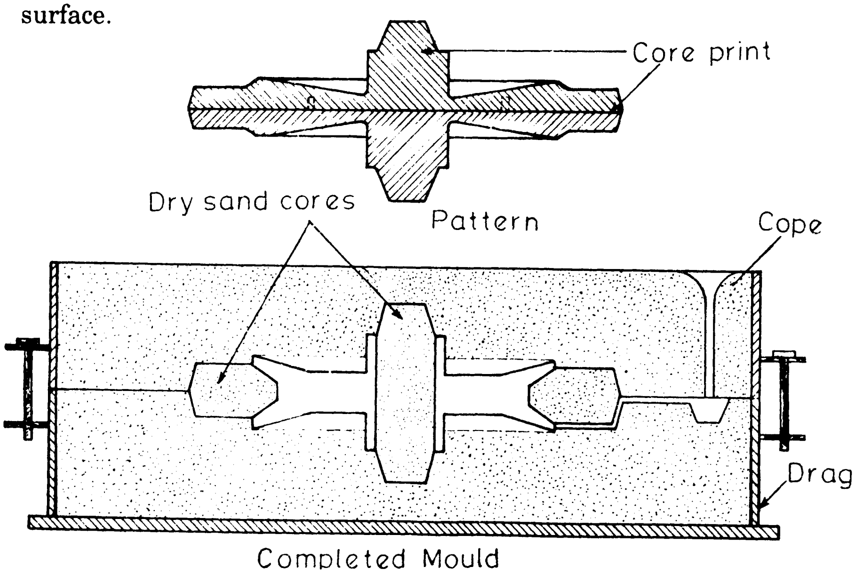

Fig. 2.6.

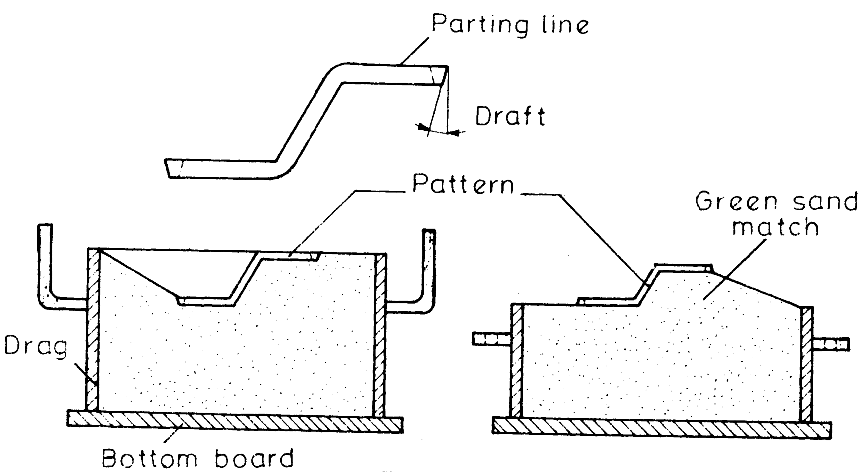

Fig. 2.7.

FOUNDRY ENGINEERING

About the Book

The first part of this book caters to the needs of beginners and describe various casting processes and give certain methods of practice while the second part is intended for advanced students and research workers and compile numerous data and research findings exist.

The book is, however designed particularly as a text for engineering students of mechanical, metallurigical and production branches—emphasizing basic concepts and will also be useful for practicing engineers and for training programmes in industries.

Inside the Book

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