CHAPTER II

FOUNDRY INDUSTRY : AN OVERVIEW
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2.1 HISTORY AND DEVELOPMENT OF FOUNDRY
2.2 TYPES OF FOUNDRIES
2.3 TECHNOLOGY IN FOUNDRY INDUSTRIES
2.4 PLANT LAYOUT FOR FOUNDRIES
2.5 RAW MATERIALS FOR FOUNDRY
2.6 PRODUCTION PROCESS IN FOUNDRY INDUSTRIES
2.7 QUALITY CONTROL SYSTEM IN FOUNDRY INDUSTRIES
2.1 : HISTORY AND DEVELOPMENT OF FOUNDRY

Foundry work is a branch of engineering that deals with the melting of metals and the pouring of molten metal into moulds from which castings are obtained. Modern communication and lighting systems would be impossible without castings. Modern civilization would not be so far advanced as it is today if it were not for the foundry and its products. The foundry industry is a progressive one, always looking ahead and, as it improves, so will civilization casting is one of the most ancient method used in foundry. Foundry practice includes such basic production processes as melting of metal, manufacture of moulds, pouring of the metal into moulds, solidification, shakeout and fettling of the castings. The history of foundry traced back to the ancient period in which metallic objects in the form of coins, arrows, and household articles were in use, as observed from the excavations of Mohenjodaro and Harappa. One of man’s first operations with metal was melting the ore and pouring it into suitable moulds. The casting process is said to have been practiced in early historic times by the craftsmen of Greek and Roman civilizations since then the role of metals has acquired unique significance.

It was at this time that lost wax process made its impact, subsequently a still greater application of metals figured in armory and war material. The superior quality of metals and the absence of any impurities in them emphasise the ability and precise quality control of the refining process even in those days.

The greatest breakthrough in the application of metals for gunnery and other arms took place possibly at the time when Alexander was contemplating victory over the entire Eurasian continent. Since then the whole art of metal founding has emerged as an exact science. Today, we have a variety of moulding processes and melting equipment and a host of metals and their alloys. And though the techniques and methods of production have changed considerably, the basic principles still remain almost the same.
"In United States the total number of [Ferrous and Non-Ferrous] foundries are more than 6000. In India, there are more than 2000\(^1\) ferrous and non ferrous foundries. Today Indian ferrous foundries possess a total capacity of 2,50,000 tonnes".\(^1\)

"In Karnataka there are 168 Ferrous and Non-Ferrous Foundries in 2004-2005".\(^2\)

In India, Chittaranjan Locomotive Works, Asanol, Durgapur, Bilai and Rourkela Steel Plants. Heavy Electricals Ltd., Bhopal. and Hindustan Machine Tools, Bangalore are big foundry industries.

2.2 : TYPES OF FOUNDRIES

The foundry is a commercial setup for manufacturing castings. Foundry may also be known as a collection of materials, fuel, fluxes, and tools to produce castings. Broadly foundry can be categorized on the basis of production pattern and Metals to be cast which is shown in Chart 2.1

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\(^2\) Office of the Directorate of Industries and commerce, Banaglore.
Chart- 2.1: Types of Foundries

Captive Foundry: is an integral part of some manufacturing organization, where all the castings made are consumed mainly in the products being manufactured by that organization.

Jobbing Foundry: normally produces small number of castings of a given type for different customers. Such type of foundries may also have facilities for mass production.

Production Foundry: is highly mechanized and can produce castings economically on mass scale.

Semi-production foundry: is a combination of jobbing foundry and a production foundry as regards its nature of work is concerned.
Steel foundry: Steel foundry produces plain carbon steel, low and high alloy steels.

Grey cast iron foundry: is a highly mechanized and can produce castings of grey colour in nature.

Malleable iron foundry: can produce castings to be hammered or pressed into shape and easy to influence.

Ductile iron foundry: can produce castings to be drawn into fine standards and easily moulded.

Light metals foundry: Aluminium and magnesium alloy foundry can produce light metals.

Copper, Brass and Bronze foundry: Copper, Brass and Bronze foundry require the alloys of german silver, aluminium phosphor, bronze and manganese bronze brass to produce the metals.

Lead, Tin and Zinc base foundry: Lead, Tin and Zinc base foundry require the alloys of tin, antinomy, copper zinc, solder, bitannia metal and bronze to produce the metals.

On the basis of metal casting, foundries may be classified as ferrous foundries and non-ferrous foundries. The iron group which includes all irons and steels are called ferrous metals [ferrous means iron], while the others are called non-ferrous. Ferrous foundries may be further classified as steel foundry, grey cast iron foundry, malleable iron foundry and ductile iron foundry. Non-ferrous foundries may be classified as Light metals foundry, copper, brass, and bronze foundry and lead, tin, and zinc base foundry.
2.3 : TECHNOLOGY IN FOUNDRY INDUSTRIES

Mechanisation implies the utilization of machinery to accomplish the work previously done by hand. Mechanised foundries range between simple roller-tract systems to very complex and partially automatic installations. Mechanized foundries deal with large quantities and seek for every small economy to reduce the final cost. Foundry mechanization could become possible because of the following two developments.

1) Machines were designed and fabricated for sand mixing, moulding and core making.

2) These machines were integrated with material handling equipments so that continuous processing could be accomplished in the foundries.

Mechanization lead to increased production, improved quality and reduction in production costs. Measures that aim to improve working conditions in the shop with an eye to ensuring a safe, healthy, and happy life for the worker, deserve enthusiastic support. In a mechanized foundry castings are knocked out of the moulds on a vibratory grid at knock out station, sand passes down in to a hopper through the grid and the castings vibrate off into the cooling trays. The sand on a conveyor passes through the reconditioning chamber, and mixing plant and is then delivered by an overhead belt conveyor into hoppers situated above the moulding machines.

After the moulds [i.e. cope and drag] and cores have been assembled again on a conveyor, they are carried to casting station where the molten metal is poured by the ladles suspended from light cranes running along monorail runways, moulds filled with molten metal are cooled as they pass through cooling tunnel and eventually reach the knockout station and a new cycle foundry cycle starts.
2.4 : PLANT LAYOUT FOR FOUNDRIES

The plant layout for foundries is depending on size of the organization. The general layout map of foundry industries shown in chart 2.2.
Chart 2.2: Layout of a Manual Foundry.

“Plant layout may be defined as the arrangement and co-ordination of equipment work centers, floor area, and facilities specified from flow sheet to achieve maximum efficiency of functioning of plant in combination of man, material and machine”. Plant layout may also be considered as a floor plan for determining and arranging the required equipments and machines in one best place to obtain the quickest flow of material at the lowest cost with least handling of materials in processing.

The proper layout leads to improve the manufacturing process, quality control, material handling, minimum equipment investment, effective use of available area, improved utilization of labour, employee morale and efficiency in plant services.

Planning a Foundry layout

In order to realize the maximum potential of a layout for a new foundry a systematic procedure must be followed. The final layout can be no better than the data upon which it is based certain steps if followed assure the collection and analysis of the necessary supporting data.

The steps in planning a Foundry Layout are shown in chart 2.3

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Chart 2.3: Steps in Planning a Foundry Layout.

1. Analysis of the product to be produced
2. Determination of the process and work place required to manufacture the product
3. Preparation of layout planning chart
4. Determine Work Stations
5. Analyse storage area requirements
6. Establish minimum aisle widths
7. Establish office requirements
8. Consider personnel facilities and services
9. Survey plant services
10. Provide for future expansion

Prepare layout Plan
Analysis of the product to be produced

This includes annual tonnage, the type of castings and their range of sizes, weights and composition and maximum weight of single casting.

Determination of the process and work place required to manufacture the product.

Before the details of layout are decided, various processes such as green sand, skin dried, dry sand machine moulding, shell moulding, CO₂ moulding process, etc should broadly be considered first to suit the casting requirements. For each manufactured product operation sheets are developed showing only the sequence of operations.

Preparation of layout planning chart

It tabulates and combines the various factors to be provided in the final layout. The various factors to be incorporated are, selection of machine and equipment, balance etc, determination of requirements of equipments and method and load of material handling, assessment of manpower requirements, the flow process showing all operations, moves, shortages and inspections in sequence, and standard time required for each operation obtained by time studies or earlier standards.

Determine work stations

Work stations are determined by the consideration of requirement of machine, operator, material and service area.

Analyse storage area requirements

In general, three types of storages i.e. storage of raw material, in process storage and finished goods storage are considered. Before beginning the actual layout, both the size and the location of the storage area should be studied with relation to production activities.
Establish minimum aisle widths

Aisle widths should be carefully determined as these are mainly dependent upon materials handling equipment, work station clearance required, and pedestrian traffic.

Establish office requirements

These will depend upon the scope of operational activities. The exact requirements of space should be worked out and provided in the layout.

Consider personnel facilities and services

Allow for such items as first aid, lockers, and parking etc.

Survey plant services

These include utilities such as compressor room, pump house, waste disposal, equipment maintenance, cooling, dust extraction, and ventilation.

Provide for future expansion

This may include sufficient provisions for addition of new product line or for increased production of the existing product.

Prepare layout plan

The location of all plant and equipment, work stations, facilities, storage spaces, aisles etc. should be clearly indicated on this plan.

2.5 : RAW MATERIALS FOR FOUNDRY

Raw materials for foundry are classified in to four categories. They are as follows:

1) Metals and Alloys

2) Fuels [for melting metal]

3) Fluxes

4) Refractories
1) Metals and Alloys

Metals are divided into two groups ferrous and non ferrous. The iron group which includes all irons and steel are called ferrous metals (ferrous means iron), while the others are called nonferrous.

Basic raw material required to make castings are pig iron and scrap iron.

a) Pig Iron Pig iron is the basic raw material from which all cast iron, wrought iron and steel are made. It is obtained by extracting metal by melting. The different grades of pig iron are, foundry pig, malleable pig, forge pig, basic pig and acid pig.

b) Scrap Usually some scrap iron is proportionate to the pig iron to give certain desired specifications to the cast iron.

Alloys Raw material

These are the basic alloys to be added to form the end product such as ferro silicon, ferro manganese, inoculant, graphite, etc.

Special Alloys

“These are the alloys required to make the end product as per the required grade to maintain hardness, microstructure, chemical composition etc such as Fe si magnesium alloy, nickel alloys, copper etc.

Non Ferrous Metals and Alloys

The non ferrous metals are generally used for parts requiring considerable fabrication and properties. The important non-ferrous metals are copper, zinc, brass, tin bronze, gun metal, aluminium, magnesium, nickel and lead.

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German silver, aluminium phosphor bronze, silica bronze, manganese 
bronze brass, bronze bell metal, and gun metal are alloys of the copper.

Alloys of the tin are solder, bitannia metal, bronze and gun metal.

Alluminium bronze, alnico, duralumin, nickeloy are alloys of the 
aluminium.

The important nickel alloy is monel metal.

Tin, antimony, copper zinc, silver, alkali metals, and bismuth are 
alloys of the lead.

2) Fuels Fuels for melting metals are coal, coke, gas, oil and electricity.

3) Fluxes A flux is a low melting point material. The types of fluxes are 
limestone, sodium carbonate, nitrogen, helium, chlorine, magnesium and 
charcoal.

4) Refractories Important raw materials of refractories are magnesia [mgo], 
chrome [cr203], pure silica or silica and alumina, silicon carbide [sic], 
Thoria, and beryllia, etc.

Refractories in the non-ferrous foundry

Prefired crucibles of material such as fire clay, fire clay graphite 
magnesite and silicon carbide are generally used.

The ordinary cast non ferrous alloys include alloys of nickel, copper, 
aluminium, magnesium, zinc, and others.
2.6 : PRODUCTION PROCESS IN FOUNDRY INDUSTRIES

The principal steps involved in production of castings from design to finished product are shown in Chart 2.4. In general the casting process consists of six stages, viz (1) Pattern making (2) Moulding and Core making (3) Melting and Casting (4) Fettling (5) Heat treatment and Finishing and (6) Inspection and Testing.
Chart-2.4: Principal steps involved in production of castings.

1) **Pattern Making**

First a pattern is designed and prepared as per the specifications of casting and depending on the moulding process employed. The material of pattern may be selected depending on factors such as number of castings to be produced, possibility of repeat orders, and the surface finish required pattern shop is also responsible to make core boxes required for making cores and other items.

2) **Moulding and core making**

The mould is prepared in sand [either by hand or by machines] with the help of pattern to form a cavity of the desired shape. Hollow portions of the casting are obtained by the use of cores prepared separately in core boxes. The moulds and cores are dried and baked to impart strength and then assembled for pouring of molten metal.

3) **Melting and casting**

The metal of correct composition melted in a suitable furnace is taken into ladles and poured into the moulds. The casting is allowed to solidity in the mould and then finally taken out of breaking the moulds.

4) **Fettling**

The casting obtained from the moulds carry sand particles adhering to the surfaces and unwanted metal in the form of gates and risers and thus the castings are not suitable for immediate use or machining. Therefore, the unwanted sand particles and metal are removed in fettling section and the surface of casting becomes clean and uniform.
5) Heat treatment and finishing

Castings are given heat treatment depending on the properties required.

6) Inspection and Testing

Finally the casting is tested and inspected to ensure the casting to be defectless and confirming to the desired specifications.

2.7 : QUALITY CONTROL SYSTEM IN FOUNDRY INDUSTRIES

Inspection comprises all those operations which check the quality of the castings. Inspection provides information required for quality controlling in the foundry systematic collection and interpretation of quality data is generally channeled through an inspection department which is a vital element in an integrated quality control system extending throughout the manufacturing sequence. A concept of organization for inspection and quality control as suggested by quilter is presented in Chart. 2.5. A modern quality control organization is concerned with a great deal more than the routine testing in relation to specified limits much data is obtained by the use of highly sophisticated techniques and more detailed treatment is required in interpreting the results.
The Following tools are used in the effective quality control of foundries.

1) A set of control charts, including statistical analysis of sampling frequency and methods must be determined.

2) All incoming raw materials should be considered as possible control items.

3) Melting stock and scrap should be checked and sorted according to a routine specification, as fluxes, coke, sands, clays, and binders.

4) Sometimes a chemical check is adequate, but often a physical or performance acceptance test should be made.

5) Quality control tests for incoming new sands should include a chemical analysis of SiO₂ content and a cumulative curve showing grain size and distribution also, some measure of clay content for natural sands.

6) Other tests that can be made to control mulled sand quality, such as flowability, hot strength and deformation etc, these are primarily useful for research and development work and need only be used as an occasional statistical routine test.

7) Cores should be tested for compressive or shear strength, permeability and color as routine control checks, the oil or resin should be given an incoming service test and core ovens should be carefully controlled by thermocouples properly placed to be sure baking is uniform throughout the oven.

8) Next to sand, flasks are common equipment for all moulders and core makers. Flask quality must always be controlled, preferably by routine checks made at reasonably frequent intervals.

9) Molten metal can be checked for quality by rapid chemical analysis at proper intervals and by certain quick tests at the furnace.

10) A fracture test can be used to check the carbon content of steel and to determine the presence or absence of grass in bronze. A more accurate and rapid test for carbon in steel is the magnetic or hardness characteristics of a small quenched specimen.

11) Slag tests are useful, particularly for steel making in open-hearth and electric furnaces.

12) Fluidity tests, in which metal from the furnace is poured or sucked by controlled vacuum in to a flow channel of suitable size, are very useful.

13) A very important and simple quality control tool for molten aluminium is vacuum under this tool hydrogen gas seriously impairs the strength and ductility of aluminium alloy castings, and it is very important to
determine its presence in the melt. For small gas contents the test can be made quantitative by making a quick density test of a special type specimen.

14) There are many other specific items of foundry operation and materials meriting quality control, to indicate the importance of developing specifications for performance and raw materials acceptance, it is equally important to keep and use quality control records.

15) Penetrant methods for crack detection are most suitable for non ferrous metals and austenitic steels.

16) The value of the quality-control program should also be recognized and implemented by occasional management conferences.