ARCHAEOLOGY DATASHEET 304
Foundries

What is a foundry?

A foundry is a specialist industrial facility for casting metals. This is not normally taken to include early locations for casting of non-ferrous metals, for which the handling of metal in small quantities in crucibles did not require any specialised structures. The term foundry is not normally used where the casting is undertaken as part of metal smelting.

A foundry can vary from a discrete industrial operation (anything from a single room to a large factory), through to a single component of a much larger integrated metalworks. Most often the term is used not just to describe the particular location or building where the casting took place, but to refer to the whole plant, including all the subsidiary buildings and operations. The building for casting may be known by more specific terms such as melt shop. The other parts of a foundry (depending on the particular metal and product) may include facilities for:

- preparing moulds (perhaps including such process as making wooden patterns, sand preparation, mould making and mould drying)
- handling the raw materials (metals, fuels, sand etc)
- cleaning castings by blasting abrasives
- finishing castings by grinding or turning (which often require a steam-engine or other source of power)
- heat-treating castings
- assembling finished products.

A history of foundries

The earliest operations given the name foundry in Britain are of medieval age. During this period industrial-scale production of cast copper-alloy tablewares, bells (although many church bells were cast on site) and dress accessories became common. Details of the furnace arrangements in early foundries are unclear, with both open hearths to heat crucibles for small metal volumes and some use of reverberatory furnaces for larger volumes (as needed for casting bells).

By the 16th century complex crucible furnaces had evolved and, coupled with new approaches to brass-making, it is likely that quite elaborate foundries existed to satisfy rising demand, but the archaeological evidence for this period is generally poor.

The casting of iron artefacts also became common during the 16th century, but in the initial period after the introduction of the blast furnace in the late 15th century artefacts were mainly cast directly from the melting furnace. The first separate iron foundries probably appeared by the mid-17th century. This separation of the production of cast iron from its casting into artefacts allowed iron foundries to become established away from centres of iron production, and by the 19th century their distribution was widespread.

The furnace technology of the early iron foundries remains largely unknown, although it is clear that air furnaces (reverberatory furnaces with induced draught) were the dominant melting furnaces during the 18th century, mainly using coal for fuel. Small charcoal-fired shaft furnaces had probably also been employed from as early as the 16th century, but the generally-accepted date for the adoption of tall shaft furnaces burning coke (cupola furnaces) is the last decade of the 18th century (following Wilkinson’s patent of 1794). In the 19th century the cupola furnace became almost universal and evolved from solid-bottomed furnaces to raised, drop-bottom, varieties. Some use of air furnaces continued through the 19th century, particularly where very large volumes of cast iron were required.

The technology of non-ferrous foundries evolved too in the post-medieval period, with the widespread use of a variety of crucible furnaces, sometimes referred to as ‘pit furnaces’. Pit furnaces use an air draft produced by a chimney to draw heat from a firebox onto the crucible. In many designs the firebox may be in a cellar below the working floor, with the heat passing upwards to the crucible, then horizontally along a flue below the floor connected to the base of the chimney (broadly similar in design to furnaces for making crucible steel; see HMS Datasheet 302). The crucible in such a furnace can be accessed through a grating or cover in the workshop floor.

Many foundries of traditional design survived well into the 20th century, despite the challenges of new techniques and materials. Electrical heating of furnaces became progressively more common and gas fired furnaces are also widely used. New materials include cast steel and aluminium.

Structural remains

Non-ferrous foundries

Most non-ferrous foundries employed crucibles for handling the molten metal. These could be heated in a variety of furnaces; many of post-medieval date employed a low level firebox (often in a cellar), with flues connected to the chimney. Reverberatory furnaces were employed for non-ferrous foundries, but they are extremely poorly-known archaeologically as they were above-ground structures.

Ancillary structures may include buildings for mould making and workshops for finishing castings. Mould making processes may include the grinding, grading, cleaning and mixing of the mould-making materials. Workshops for pattern-making may also be present – but may contain few identifying features. Drying ovens for moulds may be more recognisable and may include room-sized ovens.

The finishing processes may include machine shops, often represented by buildings with rows of plinths as machine bases, taking power from a common drive (with either steam- or water- power).

Ferrous foundries
The structural remains of the melting furnaces may be rather slight. Air furnaces (like other forms of reverberatory furnaces such as reheating, balling and puddling furnaces) would require regular reconstruction to replace the refractory materials. They tend therefore to be constructed in ways to facilitate this, with an insubstantial brick sub-structure. In contrast, the associated chimneys would be substantial permanent structures, designed to have the more ephemeral furnaces constructed either directly against them, or connect by a flue. In large works requiring significant amounts of steam power, the flues might pass from furnace to chimney via waste heat boilers. Although early cupola furnaces were solid-based, later ones were supported above ground by iron legs. Cupola furnaces require a forced draught, so some provision for mechanical blowing is to be expected, although not necessarily immediately adjacent to the furnaces.

The furnaces are usually positioned around the margins of the moulding shop. In the case of air furnaces, the chimneys will usually have a structural relationship with the melting shop building; for cupola furnaces, the emission of hot gas from their tops usually means they are positioned to allow suitable ventilation – either by placing them immediately external to the moulding shop or in a central location with venting through the roof.

The moulding shop of most ferrous foundries comprises a deep sand bed, within which may be discrete, often brick-lined 'casting-pits' to hold large moulds. Groundwater control is clearly an issue with moulding shops, particularly those with deep casting pits, so careful sub-casting floor drainage may also have been constructed.

Ancillary mould-making and finishing facilities are broadly similar to those of non-ferrous foundries (see above).

Archaeometallurgical residues

Non-ferrous foundries
For early sites, both investment (lost-wax) casting and casting in ceramic piece moulds was common, the choice of technology depending on the size and number of castings being made. Casting residues tend to be dominated by oxidised-fired ceramic mould fragments, though their inner surfaces are normally blackened (reduced-fired). Later sites show the move to other piece mould processes – typically sand box moulding, similar to that employed in the ferrous foundries. These moulds are not normally preserved, but may be evidenced by abundant sand deposits. Spills of metal into the crucible furnace or onto the floor may be preserved as small prills and blebs. Residues from the fireboxes of crucible furnaces will be rather non-diagnostic clinker, unless contaminated by spilled metals.

Ferrous foundries
The residues produced by ferrous foundries have received rather little attention.

Cupola furnaces may be worked either with or without the use of a flux. For very low-volume melts (heats) a cupola may be worked without flux. The resultant slags are typically agglomerates with coke lumps and iron prills bound by a dark glassy slag, whose chemical composition may approach that of the coke ash. These slags may form lenticular masses, produced in part by the dumping of the furnace contents after pouring, through the drop-bottom.

Cupolas used to produce a large heat, or used on a more continuous basis, may have an increased tendency for the clinkery fuel residue to bridge the furnace and prevent proper movement of the charge. Use of a flux may prevent this occurring, or a fluxed charge may be used to clean-out the cupola. Where fluxing (usually with limestone) is undertaken, the slag volumes are increased and may require tapping, often continuously. The tapped cupola slags are also typically dark and glassy, but lack the large fuel fragments of the unfluxed slags. The escape of air blast through the slag-tapping hole may lead to the generation of a spatter of slag droplets, with similar morphology and magnetic properties (but very different chemical composition) to spheroidal hammerscale (see Datasheet 303).

The processes used to finish the casting may lead to a wide variety of residues, in many cases similar to those from other types of engineering works. They may include deposits containing abrasive powders (sand, copper slag, natural emery and artificial abrasives), swarf from machining (turning, milling or boring) as well as residues from any hot-working that may have been required.

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