ARCHAEOLOGY DATASHEET 303

Iron: hand blacksmithing

What is blacksmithing?

The manual forming of iron and other ferrous metals to make finished artefacts (or to repair existing ones) is known as secondary smithing or, more commonly, as blacksmithing. Primary smithing is the working of raw blooms into usable iron.

Smiths undertake various tasks to achieve these goals. Iron can be hot-worked into shape. Iron can also be joined to itself, or to other pieces of ferrous metal, through the process of forge welding (also known as fire welding or hammer welding). Joining may also be effected through techniques such as riveting and brazing. The chemical composition of the iron may be changed by the smith, e.g. in the process of case hardening. For carbon steels, heat treatments (typically quenching followed by tempering) allow control over the hardness of the material and so can be used to control the properties of e.g. the working edge on a tool.

Not all blacksmiths would necessarily use all these techniques. Some smiths specialise in one particular process or one class of product, but smiths would commonly have been expected to be able to undertake many different tasks.

The forge building and its fittings

The workshop of a blacksmith is commonly known as a blacksmith's shop, smithy or forge (although 'forge' may also refer to several types of industrial facility and to the forge hearth within the smithy).

The smithy will most commonly contain a hearth with its bellows, an anvil and a water container together with places to store fuel and stock iron. Smithies may be a workplace for a single smith, but can also be industrial buildings in which many smiths work, each with their own facilities.

The hearth is the essential feature of the smithy. Forge, forge hearth and smithing hearth are often used as terms to differentiate this from other forms of hearth. The purpose of the hearth is to heat the iron to an appropriate temperature. High temperature is attained through combustion of the fuel (charcoal, coke or coal) using a strong blast of air. Iron is very easily oxidised by air at high temperatures so the fire is constructed so the iron is heated in a reducing environment. This is achieved by ensuring a sufficient depth of fuel above the zone of intense combustion within which much of the oxygen has been already used. The hearth needs to contain the fuel (without restricting the smith's access to the fire) and to provide a means for conveying the air blast into the lower part of the fuel.

Air supply

The air blast to the forge was provided by bellows. Early bellows are very poorly known, but two single chamber bellows operated out-of-phase were probably the typical early medieval form. They were initially operated by hands or feet at ground level, but with the raising of hearths elaborate lever systems allowed one operator to work the paired bellows. Stake holes close to the hearth may be the only archaeological evidence for these early forms. Paired bellows were replaced in the late medieval or early post-medieval period by the 'great bellows'. These bellows have two chambers; the lower of which is used to pump air into the upper, from which a more even blast is maintained by a weighted upper board. These remained the main source of air into the 20th century, when they were replaced by electric blowers. Cylindrical bellows were often used in the 19th century, typically as a component of a 'portable forge'. When manual smithing was undertaken on an industrial scale in 19th orè 20th century factories, then centralised blowing of multiple hearths using a steam- or water-powered fan was commonly employed.

Modern hearths are of two styles – side blast forges and bottom blast forges, depending on which direction the air blast enters the forge. Early forge hearths were entirely of the side blast type, in which the air was directed from the bellows into the fire through either a simple hole in a clay wall or through a pre-constructed tuyère. Where tuyères were used in early smithing they were ceramic. Such tuyères may be circular, rectangular or rounded with a flat base in external cross section, from 120 to 300mm wide, usually with a bore of 18-25mm at the hearth end, but widening to the rear to accommodate the bellows nose.

By the medieval period there is documentary evidence for the use of iron tuyères – essentially a slightly conical tube of wrought iron. These and later iron tuyères may be known as tuyirons. From the late 18th century onwards tuyères of cast iron with voids for carrying cooling water start to be used. The final variant of the tuyère is the cast iron 'pot' which carries the blast into the base of a bottom-blast forge.

Chronological variations

Early hearths were generally sunken (floor-level hearths). All activities in the forge were probably undertaken at a low level, with the smith kneeling. This method of working is not particularly convenient, especially when working with large objects, and raised hearths (waist-level hearths) were in use during the Roman period and again from the Middle Ages onwards.

The anvil forms the focus of the smith's activity in the forge. Anvils of stone may have been important in the Iron Age, particularly at some primary smithing sites, but even in the Iron Age anvils of iron existed. Early anvils were blocks of iron, in various shapes, that terminated in a spike which could be hammered into a large log. Over time anvils grew in size. By the later Middle Ages a variety of forms are known. The typical 'beaked anvil' was well developed by the 18th century. These later large anvils are also typical fastened to an underlying wooden block, sometimes placed on a timber substructure to spread the force.

Other features
A container of water is also an essential part of a smithy, for cooling hot tools and quenching heat-treatable steel, as well as for splashing onto the coal to control its burning and to promote coke formation. The container is commonly a trough, small tank or barrel alongside the hearth and is known variously as a bosh or slack tub.

The archaeological remains of smithies may be difficult to interpret. In early smithies distinguishing cut features within the structure may be problematic because they may all become filled with deposits rich in hammerscale and other residues. Extremely careful observation of the distribution of heat-affected surfaces may be required. The almost continuous use of a small area of floor by the smith may result in worn working hollows. Floor-level hearths vary enormously in detail, but are typically shallow rectangular pits about 1m across. Anvil locations may be marked by post-positions, or may be identifiable as a gap in the build-up of hammerscale and other detritus rather than being a cut feature.

In later smithies with raised hearths there may be no preservation of heat-affected surfaces at all. The hearth location may be represented by a stone or brick plinth, but in some cases the distribution of hammerscale across the smithy floor may be the only guide to its layout. The hearth is commonly divided from the location of the bellows by an internal wall, which may also act as a support for a hood or chimney.

Fuel
Early blacksmithing mostly employed charcoal as fuel but during the Roman period coal was used widely in Britain, and was again from the Middle Ages onwards. A soft, bituminous coal, preferably with low sulphur content, works well. The coal converts to coke as it heats up and the use of water can encourage this process. The coked coal forms a crust that also controls the passage of air through the fire. More recently fine coke (breeze) has also been used.

Residues
The heating of iron to high temperature allows it to oxidise rapidly. Outside the hearth this results in the formation of an oxidised superficial layer on the iron, which may fall from the workpiece during working and cooling, giving rise to the thin sheets of iron oxides known as flake hammerscale (similar material formed during the rolling of hot iron sheets is known as millscale). Flake hammerscale will be concentrated around the anvil. Since oxide scale prevents the proper joining of hot iron during forge welding, the smith will try to ensure the scale is molten at the point of closing the weld. The molten oxide is violently expelled when the weld is hammered and forms droplets (usually less than 2mm diameter) which chill to give the micro-residues known as spheroidal hammerscale.

Iron which is lost within the hearth typically reacts with other materials to form slag. In early smithing (using a ceramic tuyère/blowhole and charcoal fuel), the reaction is mainly between iron oxides and melted ceramic, producing a slag which chills in the hearth below the hot zone. The most typical form of the slag in this situation is the roughly plano-convex smithing hearth cake (SHC; or smithing hearth base, SHB, although it need not form in the actual base of the hearth). Such cakes may have a wide variety of internal structure depending on the temperature of the hearth, the volume of slag generated and the fluidity of the slag. Other ‘within-hearth’ slags may include isolated lumps and prills of iron-rich slag which did not coalesce to form an SHC, together with iron-poor slags where the ceramic has melted, but there has been little reaction with iron oxides.

In situations where the tuyère/blowhole was ceramic and the fuel was coal, rather similar residues result, but there is almost always some inclusion of coal shale into the SHC.

In post-medieval smithing the typical combination of an iron tuyère and coal as fuel leads to the production of slags from the reaction of iron oxides with the inorganic residue from the coal - essentially iron-rich clinker. Since the iron content of coal is very variable, such slags may be difficult to distinguish from simple coal clinker. Smithing clinkers do not usually form a neat SHC and typically contain abundant fuel fragments.

Tools
Smiths’ tools are relatively well-known archaeological finds, and in most cases bear close comparison with their modern equivalents. However, such finds of tools are rarely associated with the place of work.

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