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Steelmaking ceramics and other archaeometallurgical residues, Cyfarthfa Ironworks Stables, Merthyr Tydfil

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Steelmaking ceramics and other archaeometallurgical residues, Cyfarthfa Ironworks Stables, Merthyr Tydfil

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Abstract

The material contains an assemblage of technical ceramics associated with Cyfarthfa Steelworks (approximately 1882-1919). A small quantity of slag was also present.

The technical ceramic assemblage all derives from equipment installed in the 1878-1882 conversion of the Cyfarthfa works into a steelworks. There are sixteen fragments of used Bessemer converter tuyères and three ceramic components from the nozzle system of the steel ladle. All these ceramic components would have had very short lifespans, perhaps a maximum of just 3 days, and so were made, used and discarded, in very large quantities. Such items have been found widely on other sites of the Cyfarthfa works (the cokeworks and Ynysfach ironworks) well away from the location of the Bessemer plant (which was on the east bank of the Taff, opposite the blast furnaces), suggesting their widespread dispersal around the Cyfarthfa estate. These occurrences all include very similar, but not identical, tuyères, which differ signficantly from examples from the Dowlais works - the other steelworks in Merthyr Tydfil at this period. In addition to these items from the steel plant, there were two fragments of 'honeycomb' bricks probably from the Cowper's regenerative hot blast stoves, which provided the hot blast for the blast furnaces of the steelworks period.

A very small quantity of slag was also submitted, including both blast furnace slags and clinkery slag probably from the Bessemer plant. None is compatible with an origin in the (presumably farriers) small forge known to have been on the stables site.

The technical ceramic assemblage should date to the period between 1882 and 1919.

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Methods

The submitted material has been visually examined and catalogued. As an assessment, the materials were not subjected to any high-magnification optical inspection, nor to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional.

The examined materials are listed in Table 1.

This project was commissioned by Dr Amelia Pannett of Archaeology Wales.

Results

Bessemer converter tuyères

The Bessemer Convertor tuyères from the Cyfarthfa Stables all appear to have been used. They have a maximum surviving length of 300mm, with none showing an original distal termination. The tuyères narrow from c.155mm diameter at 300mm above the base, 160mm diameter at 160mm, to a point c.40mm above the base, at which they flare outwards with a simple rounded angle to a basal diameter of c. 180mm. The bores are in the standard Cyfarthfa pattern with eight bores forming a circle with a diameter of 85mm,

with 30-40mm centres (slightly irregular), and with one central bore. Each bore is of 8-9mm diameter (3/8 inch) widening towards 15mm from about 25mm from the base (occasionally to as wide as 20mm diameter). The fabric comprises rounded silica grit in particles of up to 6mm, set in a pale paste, the whole having a slightly off-white cream colour, where fresh, but discolouring to a dark grey in some of the more heavily altered examples.

The tuyères differ (Table 2) in detail from the examples of Type 1 from the Cyfarthfa coking plant (Young 2014c), which show a slight 'knee' to the profile of the basal external flare, rather than being a simple sub-conical taper. The coking plant examples also appear to have somewhat less flared bores close to the basal surface, but the bores are of a 12mm (1/2 inch) diameter, not the 9mm (3/8 inch) of the stables examples. The unused Type 2 tuyère from the coking plant is entirely different and may possibly not have been a functional tuyère. The tuyères differ from those found at Ynysfach ironworks only in very slight detail; the bores of the Ynysfach tuyères were very slightly coarser (in the range of 10-12mm) and did not have a basal flare,

The tuyères also differ markedly from those from Dowlais Ironworks found at Ffos-y-fran (Young 2014b), which bear thirteen bores of 9mm (3/8 inch) diameter.

Ladle ceramics

Three items of ladle ceramics were recovered:

- **a ladle nozzle**. The cylindrical part was 120mm long. There was a raised internal collar at one end, 93mm diameter and 18mm tall. The other end had a quarter circle internal (re-entrant) fillet of radius 45mm.

- **a ladle stopper**. This was 115mm overall diameter, with 24mm main bore. One end has an internal raised collar, 75mm diameter and 15mm high; the other end has a 108x35mm sub-hemispherical boss, with a 35mm bore to a step at approximately 45mm internally. The parallel-sided cylindrical section of the stopper was 79mm long.

- **a possible ladle stopper rod tube**. This piece was a hollow tube, elliptical in cross –section, possibly as a result of unintentional deformation before firing, 117x98mm externally, with bore 48x44mm. The bore was slightly eccentric, causing the wall thickness to be 27mm and 32mm on opposite sides along the long axis of the elliptical section. A135mm length survived, with neither end being original.

None of these pieces appeared to have been used, and with the apparent deformation of the stopper rod tube, they may have been rejects from the brickworks

The forms of these pieces corresponds very closely to those of the components of the steel teeming ladle stopper system as conceived by Bessemer in the 1850s, in which the teeming ladle was used to fill the ingot with a steady flow of steel from the ceramic nozzle set within the flat base of the ladle. The stopper was applied into the top of the nozzle when required by a rod system enclosed in protective ceramic tubing.

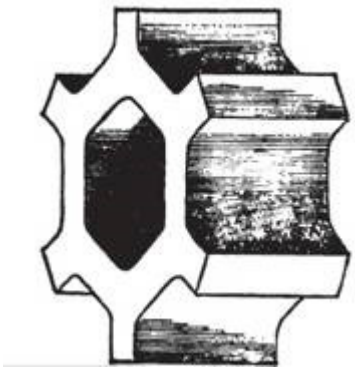
The only other teeming ladle nozzles described from Merthyr Tydfil area are one certain and one probable example from the Ffos-y-fran project (Young 2014) – and likely to have been for the Dowlais Steelworks. These nozzles are similar in general form to the example here, but have wider internal bores of 40mm and 48mm (compared with the 31mm bore of the present example). The larger size of the Ffos-y-fran examples may be associated with the larger size of the Dowlais converters during the later period of the steelworks there (Dowlais had 10 ton as well as 8 ton converters in the late 1880s and added two 15 ton converters in 1895 (Owen 1972, 51), in comparison to Cyfarthfa which persisted with its 1882 8-ton converters..

Honeycomb bricks

Two fragments of polygonal, 'honeycomb' 'checker' bricks, were 150mm tall, with 50mm thick webs, and 196mm between opposing curved faces in the 'Y' at either end of a straight web section.

These bricks were used for heat exchange inside hot blast 'Cowper Stoves'. Turner's (1896, 119-120) description matches the present examples almost exactly:

> *The honeycomb brick employed for the regenerator of the modern Cowper stove is illustrated in Fig. 32, and is designed, when the bricks are placed together, so as to form hexagonal gas passages, all of which have walls of Stourbridge or other refractory fire-clay, 2 inches in thickness. Each brick is 6 inches in height, and weighs about 32 lbs. In plan these bricks consist of a hexagonal air passage, the greater diameter of which is 7 inches, surrounded by a wall of fireclay 2 inches thick; at each of the six comers of this hexagonal wall, a short projecting wall 2 inches square and 6 inches high is attached in the direction of the longer diameter, the whole forming one brick. The projections are so arranged that, on placing the bricks into position side by side in the stove the whole of the interior is divided into upright hexagonal air passages, with a larger diameter of 7 inches, and with fireclay walls 2 inches thick. The bricks are made by pressing the clay into a column of the required shape by suitable machinery, and cutting off horizontal slices from this column each 6 inches high; these are dried and baked in kilns before use. The bricks were formerly reamed separately by hand, but this method has been replaced y that just described.*



(Turner 1896, Fig. 32)

Firebricks

Three fragments of slagged and corroded firebrick with a 75x115mm cross section are of indeterminate origin within the works.

Blast furnace slag

Seven fragments of blast furnace slag with a total weight of 3.07kg, were dominantly glassy with colours ranging from green to almost black, becoming a khaki colour where devitrified. The larger pieces show flow lamination. Small amounts of blast furnace are difficult to assign to a process, but dominantly glassy assemblages are typically (although not always) from cold blast technology.

Cyfarthfa retained some use of the then old-fashioned cold blast right up until conversion to steel production (after 1878), but these materials might be very much earlier.

Clinkery slag

Two very large clinker-like blocks (16.5kg and 6.3kg), together with 3.5kg of small fragments were strictly of indeterminate origin without further analysis. Their composition, however, including clasts of highly heat altered refractory and highly vesicular slag bound by a dark ferruginous slag, suggests that they may be residues from the Bessemer plant, rather than being examples of earlier forge slags or of true clinkers.

Discussion

The assemblage of steelmaking ceramics adds to knowledge of the materials employed at the Cyfarthfa Steelworks.

The assemblage from the stables adds to knowledge gained from similar assemblages at Ynysfach Ironworks (Young 2014a) and at the Cyfarthfa coking plant (Young 2014c), whilst also standing in contrast to the assemblage of ceramics from the Dowlais Steelworks from Ffos-y-fran (Young 2014b).

Interestingly, the three assemblages of Bessemer converter tuyères (from Ynysfach Ironworks, the Cyfarthfa Ironworks stables, and the Type 1 tuyères from the Cyfarthfa coking plant) all differ in subtle details of manufacture (including the form of the bore close to the basal surface, the bore diameter and the shape of the flange), suggesting a variation over time even within a basic standard design (Table 2). The present examples are very similar to those from Ynysfach except in fine detail, whereas those from the coking plant had a distinctly wider diameter bore. It is not possible to determine a chronological order for these variations, although it would seem likely the wider bore examples might be later than the narrower bores.

In a wider view of Bessemer plant design in the late 19th century, there appears to be little documented use of nine-bore tuyères in other works. Cyfarthfa Steelworks was designed by Edward Williams of Bolckow, Vaughan and Co, Middlesbrough (Ince 1993), who had then only just recently tried the Gilchrist Thomas process (1879). Fitch (1882) described ½ and 5/8 inch bores as a new idea – and commented that they work as well as the narrower bores, allowing for a lower air pressure to be required. In part, he described these larger bores in association with developments around the Gilchrist Thomas (Martin) process of basic steelmaking. It is thus clear that around 1880 the larger bore tuyères were receiving attention. A full discussion of the contemporary discussion surrounding tuyère bore area and size was given by Young (2014a, 18), but in summary it would appear that although the larger bore may have been a new idea at that period, the small number of bores, and their arrangement, reflects only a very slight alteration from the Bessemer designs of the 1860s with their seven perforations.

Stoughton (1908) stated that 3/8 inch diameter holes were typical in England, whereas American works employed holes of between 3/8 and 5/8 inch.

In summary, it would seem that the converter design implemented by Bolckow, Vaughan and Co at Cyfarthfa, was rather conservative in many aspects. Since the three samples of tuyères provided by the assemblages at from Ynysfach, the coking plant and the stables are very similar, then it appears likely the original design was maintained, supporting the documentary evidence that the 8 ton converters of 1882 were maintained until the end of the plant in 1919. In the intervening years converter design and size had moved on rapidly, contributing to the obsolescence of the Cyfarthfa Steelworks in the early 20th century. It is possible that the wider bores of the tuyères from the coking plant site may represent an attempt to improve the original arrangement slightly at some point in the lifetime of the steel works.

The steelworks ceramics items are an important addition to understanding and should therefore be retained and deposited as a part of the site archive in its eventual repository.

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Table 1: Summary catalogue of archaeometallurgical residues from the Cyfarthfa stables site

wt	no	notes
	16	fragments of Bessemer converter tuyère. They are a maximum of 180mm diameter at base. The basal flared section is c. 40mm tall; they then have a gentle taper, such that they are of 160mm diameter at 160mm above base and 155mm diameter at 300mm above. The bores may flare to 20mm on the base from approximately 25mm above (most examples have lesser and more gradual flare to 15mm). They have the standard Cyfarthfa pattern of 8 bores, at 30-40mm centres (slightly irregular), ideally on a circle with diameter 85mm, with one centrally; each bore 8-9mm (3/8 inch).
	1	ladle stopper: 115mm overall diameter, with 24mm main bore. One end has internal raised collar, 75mm diameter, 15mm high, other end has 108x35mm sub-hemispherical boss 35mm bore to a step at approximately 45mm internally. Parallel sided section 79mm long.
	1	ladle nozzle: cylindrical part 120mm long, raised internal collar one end 93mm diameter and 18mm tall. Other end has quarter circle re-entrant fillet of radius 45mm indent. Bore 31mm diameter.
	1	ladle stopper tube?: elliptical 117x98mm, with bore 48x44mm; slightly eccentric wall, 27mm and 32mm thick on long axis.135mm length surviving
	2	Cowper stove honeycomb ‘checker’ bricks: fragments of polygonal bricks,150mm tall, 50mm thick webs,196mm between opposing curved faces 'Y' either end of straight section
	3	fragments of firebrick with 75x115mm section
22800	2	large blocks of clinkery slag with refractory fragments.
3480		one bag of clinkery slag fragments
2185	1	block of flow laminated glassy blast furnace slag, khaki where devitrified, transparent dark green where still glassy
888	6	glassy blast furnace slags. Some green, but four pieces are almost black

Table 2: Comparison of Bessemer converter tuyères from Merthyr Tydfil.

Locality	Number	Number of bores	Bore diameter	Bores near base	External flare	Length
Ynysfach Ironworks (Young 2014a)	2	9	10-12mm (<1/2 inch)	Not flared	Angled	>260mm, distal end not seen
Cyfarthfa Coking Plant (Type 1) (Young 2014c)	9	9	12mm (1/2 inch)	Flare to 15-20mm in 25mm above base	Sigmoidal knee	>240mm>
Cyfarthfa Coking Plant (Type 2) (Young 2014c)	1	9	9mm (3/8 inch)	Not flared	Slight angle	227mm
Cyfarthfa Ironworks Stables	16	9	9 mm distally (3/8 inch)	Flare to 15-20mm in 25mm above base	Angled	>300mm, distal end not seen
Ffos-y-fran, 'Overbridge' site (Young 2014b)	2	13	9mm (3/8 inch)	n/a	n/a	>160mm, neither end seen

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