GeoArch

Report 2014/23

Archaeometallurgical residues from Ffos-y-fran, Merthyr Tydfil

Dr Tim Young
4th December 2014

Archaeometallurgical residues from Ffos-y-fran, Merthyr Tydfil

Dr T.P. Young

Abstract

The submitted material comprised a small collection of residues, of which the principal components were technical ceramics from the Bessemer steelmaking process. These included two fragments of tuyère from Bessemer converters. These differed from the tuyères recorded recently from other sites in Merthyr Tydfil in possessing thirteen narrow bores, probably reflecting a different usage at Dowlais steelworks compared with the Cyfarthfa ironworks. Circumstantial lines of evidence suggest that the tuyères may date to the 1870s. Other ceramics included one, and probably two, nozzles from teeming ladles (for pouring steel into moulds).

The other submitted residues were mainly small fragments of blast furnace slags and clinker. The samples also contained small concretions, fragments of coal and coke and a fragment of asphaltic cladding.

Contents

Abstract 1

Methods 2

Results 2

References 3

Methods

All materials were examined visually, using a low-powered binocular microscope where required. The materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional. The summary catalogue of examined material is given in Table 1.

This project was commissioned by Rowena Hart of the Glamorgan-Gwent Archaeological Trust.

Results

Technical ceramics: Bessemer converter tuyères

Two unstratified mid-length fragments of Bessemer converter tuyères (**Cat. #1-2**) were recovered in the 'overbridge' area. The pieces show localised brown staining on the outside, but no slagging, vitrification or high temperature erosion, and were probably unused. The tuyère fragments are 148-149mm in external diameter. Neither fragment preserves either end – so the overall size of the tuyères is unknown. They are formed from a refractory ceramic with a very pale paste containing pale pellets (recycled ceramic?) mostly less than 2mm, but occasional 'clots' of pale ceramic of up to 20mm were observed, and angular to sub-rounded pieces of quartzite of up to 15mm. There was also a minor component of coal shale fragments of up to approximately 8mm.

There was a slightly irregular pattern of bores (Figure 1a), with thirteen bores arranged in a shape bounded by an irregularly octagonal shape that is almost square (eight holes on the margin of this shape, one centrally and one in each quadrant. Each bore is approximately 9mm diameter (3/8 inch) but slightly variable.

These tuyères differ from the numerous Bessemer Converter tuyères (Figure 1b) found recently on excavations of sites associated with the Cyfarthfa Ironworks (Cyfarthfa coke plant, Young 2014c; Cyfarthfa stables, Young 2014b, Ynysfach Ironworks, Young 2014a), which have a somewhat finer fabric and just nine bores, arranged as a regular octagon plus a central example. Unfortunately, there is little recorded detail on the early development of Bessemer converter tuyères. Dowlais Ironworks was an early licensee of the Bessemer process (from 1856), but the early development work involved a fixed converter vessel, with individual lateral tuyères (on the assumption that it employed the contemporary form employed by Bessemer). The classic design of the moveable converter with multiple basal tuyères was developed by Bessemer around, or slightly after, 1858 following the construction of his steelworks in Sheffield. At around the same work by Göran Göransson (another early licensee) of the Edsken steelworks in Sweden, adjusted the blowing arrangements of the fixed converter to provide much more air into the liquid metal, than had Bessemer's original design, allowing the process to cast steel ingots directly, rather than Bessemer's approach of casting granules for homogenising by remelting in crucibles. This increased airflow solution was subsequently applied to the moveable converters. Dowlais' successful use of the converter began in the mid-1860s, with the first Bessemer rails produced in 1865.

Young (2014a, 18) discussed what little is known of the development of the tuyère bore, and it would appear that a large number of narrow (3/8 or 5/16 inch) bores were typical of 'English' practice, whereas in America there was a preference for larger diameter bores of ½ or 5/8 inch (Howe 1890, Tables 196-198; Stoughton 1908; Macfarlane 1917, 66). Fitch (1882) described ½ and 5/8 inch bores as a new idea – and commented that they worked as well as the narrower bores, allowing for a lower air pressure to be required.

Howe (1890, Table 196) lists tuyères with thirteen holes from only two examples – from Brown, Bayley & Dixon (who were steel makers in Sheffield, in a works founded in 1872). The details of the plant of Brown, Bayley & Dixon were described in detail in '*The Engineer*' of April 5th, 1878. The tuyères of the 8 ton converters are described there as being fifteen in number, each 22 inches long and bearing thirteen 3/8 inch holes. The tuyères were mounted through the use of Holley's removable bottoms.

The description of the Brown, Bayley & Dixon plant also provides a vivid demonstration of the consumption rate (and therefore disposal of used examples; potentially 60 per day at this works) of converter tuyères:

> '*The operation of changing a block takes about half an hour, and they require about five hours to dry; but as they invariably run six or seven, and often as many as eight or nine "blows, " and as our rate of working has never exceeded fourteen "blows" in the twelve hours, the vessel with the new block is dry and ready for use by the time the other vessel requires a new one.'*

The history of the Bessemer converters at Dowlais is currently poorly documented. When the first commercial use of Bessemer steel for rails was made at Dowlais in 1865, there were two 5-ton converters in operation, with a further four planned ('*The Engineer*' 3rd November 1865). In 1870 the works were documented as having six 5-ton converters (Ince 1992, 53). By 1881 there were four 8-ton and two 6-ton converters (Ince 1992, 54). Subsequently the converters appear to have been replaced, so that in 1895 a new Bessemer works with two 15-ton converters alongside the Goat Mill (Owen 1972, 51) supplemented four older 10-ton converters.

It is possible, therefore, tentatively to propose that the narrow bores of the tuyères from the 'overbridge' site may suggest that they belong to a style of convertor with a relatively early (late-1860s or early-1870s) origin. It is not possible to determine which converters employed such tuyères, although the suggested date and the comparison with the converters of Brown, Bayley & Dixon, might indicate they were employed in the 8-ton convertors of the 1870s.

Technical ceramics: steel ladle components

An entire, and unused, steel teeming ladle nozzle was recovered, unstratified, at Pit 1 (**Cat #3**). The nozzle has an outside diameter of 114mm and a bore of 40mm diameter. The upper end shows a funnel formed by a quarter-round fillet of radius 37mm grading rom the external lip into the bore. The lower face has an internal collar of 87mm outside diameter extending 18mm beyond the outer part of the face. The overall length is 132mm. The outside has been locally fired to vitrification, with one side turned glossy brown (with central pale unaltered patch), from collar to distal end. This

suggests a pattern of vitrification from the firing process, rather than from use.

The design of bottom-draining teeming ladles for pouring the moulds following steel production in a Bessemer converter was well-established by the designs of Bessemer in the late 1850s. The same basic designs are still in use, albeit with the nozzles manufactured from different materials.

A very similar nozzle was recovered from the Cyfarthfa Ironworks Stables site (Young 2014b, #14). The nozzle from Cyfarthfa Ironworks Stables differs from the present example in being just fractionally larger overall, but in having a smaller bore (31mm).

A second, nozzle-like, slightly broken artefact (**Cat #4**), is 103mm in diameter and 133mm long. One end has a simple planar termination, the other is slightly incurved, somewhat angularly, and lacking the neat, symmetrical quarter-round fillet of nozzle described above. The bore is 48mm, widening over a maximum of 17mm and over as little as 5mm on one side. The fabric is very pale, almost white, with pellets and small rock fragments. A few larger clasts of quartzite are also present. The precise purpose of this item is uncertain; the incurving at one end is suggestive of a nozzle, but is less well-formed than usual, and the piece lacks the raised collar on the lower end typical of nozzles. Simple tubular components may be used to protect the plunger arm of the stopper of a ladle, and this may present an alternative interpretation for this piece.

Miscellaneous residues

The project produced a very small assemblage of metallurgical and other pyrotechnological residues:

Glassy blast furnace slags were recorded from contexts 176 (Settlement), 181 (Settlement) and 6010.

Clinker was recorded from Pit 1 (unstratified, in a large block and from pt070) and context 6022.

Coal and coke are present in collections from Pit 1 (021), and the Settlement (176, 181, 197, 202, 276, 407).

A fragment of a **ceramic pipe** (Cat #22) in a similar fabric to that of the tuyères and nozzles was recovered from the Settlement (176).

Firebricks are represented by a fragment from the Settlement (Cat #21) and some spalled slag from c092 (Cat #10).

None of these materials was present in the collections in a large quantity and none needs to have a genetic relationship to the site where it was found, although it is possible the clinker from Pit 1 derives from use of the boilers there.

The submitted collections also included an item labelled as ‘leather’ (Cat #48), but which proved to be a bituminous material rich in fragments of plant matter. The sheet-like form and thickness (10mm), together with the presence of the remains of three ferrous nails or tacks piercing the material in a straight line, suggest that this is probably an early asphalt cladding or roofing material. Early forms of asphaltic cladding may contain a variety of fillers, including wood pulp.

References

FITCH, T.W. 1882. *Bessemer Steel, Ores and Methods*. St. Louis, 125pp.

HOWE, H.M. 1890. *The metallurgy of steel, Volume 1*. New York.

INCE, L. 1993. *The South Wales Iron Industry 1750-1885*. Merton Priory Press, Merton. 198pp.

MACFARLANE, W. 1917. *The Principles and Practice of Iron and Steel Manufacture* (5th Edn). London, 258pp.

OWEN, J.A., 1972. *The history of the Dowlais Ironworks 1759-1936*, Merthyr Tydfil Borough Council, 80pp.

STOUGHTON 1908: *The Metallurgy of Iron and Steel.* McGraw-Hill, 537pp.

YOUNG, T.P. 2014a. Archaeometallurgical residues from Ynysfach Ironworks, Merthyr Tydfil. *GeoArch Report 2013-29.* 214pp.

YOUNG, T.P. 2014b. Archaeometallurgical residues from the Cyfarthfa ironworks stables, Merthyr Tydfil. *GeoArch Report 2013-25.*

YOUNG, T.P. 2014c. Archaeometallurgical residues from the Cyfarthfa ironworks coke plant, Merthyr Tydfil. *GeoArch Report 2014-24.*

Table 1: Archaeometallurgical residues and associated materials from Ffos-y-fran.

Cat. #	context	wt (g)	notes
	Technical ceramics		
1	u/s overbridge		Fragment of Bessemer Converter tuyère in a pale fabric, with pale ceramic pellets mostly to 2mm, but some larger (one ceramic clast is approximately 20mm), also has a temper of angular quartzite fragments of up to 13mm. The outside of the tuyère is stained pale reddish brown, as is one broken end surface. It has a slightly irregular pattern of bores, 13 in number, forming a square with slightly bowed sides 60mm across. Each bore is approximately 9mm diameter (3/8 inch) but they are slightly variable. The external diameter is 148mm and the maximum length of the fragment is 130mm.
2	u/s overbridge		Fragment of Bessemer Converter tuyère in a pale fabric, with pale ceramic pellets mostly to 2mm, and temper of angular to sub-rounded quartzite fragments of up to 15mm and occasional pieces of coal shale. The outside of the tuyère is stained pale reddish brown, as is one broken end surface. There is a slightly irregular pattern of bores, 13 in number, forming a square with slightly bowed sides 60mm across. Each bore is approximately 8 to 9mm diameter (3/8 inch) but they are slightly variable. The external diameter is 148-149mm and the maximum length of the fragment is 170mm.
3	u/s 021 Pit 1		A ladle nozzle, entire, 114mm diameter, main section 114 mm long, with 18mm extended inner collar of 87mm diameter at one end. The inner bore is 40mm. The opposite end from the collar has an approximately quarter round incurved profile of 37mm radius passing into the central bore. The fabric is coarsely gritted. The outside has been fired to vitrification, with one side turned glossy brown (with central pale unaltered patch), from the collar to the distal end. This suggests a pattern of vitrification from firing, rather than from use.
4	211 Settlement area T1		A probable ladle nozzle, broken, 103mm diameter, 133mm long. One end has simple planar surface, the other is incurved somewhat angularly. The bore is 48mm, widening asymmetrically over the final 17mm, possibly over as little as 5mm on one side. The fabric is very pale, almost white, with pellets and small rock fragments, with a few larger clasts of quartzite.
	Miscellaneous		
5	u/s 021 pit 1	36	coal
6	pit 1 u/s	4575	260x240x170mm (plus detached fragments), large block of clinker with inclusions of partially-melted shale and sandstone
7 to 8	pt063	4	2 pieces of highly sheared and polished coal
9	pt070 pit 1	62	clinker
10	92	15	maroon surface bloated ceramic - probably partially melted surface spalled from a firebrick
11 to 15	175	102	5 concretions
16	176 Settlement area	312	fragment of pale blast furnace slag, with streak of dark glass along one side.
17	176 Settlement area	38	coke
18	176 Settlement area	<1	coke
19 to 20	176 Settlement area	2	coal shale fragment and ironstone chip
21	176 Settlement area	656	vitrified and eroded end of thin firebrick, 60x75mm section, 110mm length preserved
22	176 Settlement area	84	section of fireclay pipe, c140mm external diameter, 13-15mm thick, smooth outside and pale, inside rough and dark reddish brown. Fabric resembles that of the tuyères/nozzles
23	181	6	fired clay rich in plant remains
24	181	8	burnt coal shale
25	181	4	curved shard of glassy blast furnace slag
26 to 32	181	42	7 pieces of concretion - some possibly on sheet iron, but maybe from another substrate
33	181	54	exploded black material covered in gypsum crystals - probably originally sulphidic mudstones, or superficial sulphidic concretion
32 to 35	181 Settlement T2	90	4 concretions on iron
36	181 Settlement T2	6	weathered and broken probable natural concretion
37 to 39	194 settlement t2	72	3 concretions on iron

40	197 settlement T3	<1	coke
41	197 settlement T3	4	concretion spalled from round iron object
42	202 settlement 202	2	coke
43	276 settlement T2	166	40x45x35mm, concretion with gravel and coal on iron - shape suggests it might be a large nut, but entirely concealed
44	276 T2	18	coke
45	407 settlement	2	coal
46	6010	96	dense black glassy blast furnace slag undergoing devitrification; in coal ash matrix
47	6022	2	exploded bloated ceramic fragment with some slagging - probably a bloated natural shale piece
48	u/s	146	described as leather, but is asphaltic sheet; c 10mm thick, plant fibres in dark matrix, 3 iron securing nails/tacks. Overall 210x130mm. Probably early asphalt shingle fragment (early 20th century)

GeoArch

geoarchaeological, archaeometallurgical & geophysical investigations

Unit 6, Block C,
Western Industrial Estate,
Caerphilly,
CF83 1BQ

Office: 029 20881431
Mobile: 07802 413704

E-Mail: Tim.Young@GeoArch.co.uk
Web: www.GeoArch.co.uk