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Enquiries relating to the contents should be addressed to the Honorary Editor: Professor Ronald Tylecote, Yew Tree House, East Hanney near Wantage, Oxford OX12 0HT.

Enquiries concerning subscriptions to the Society, back copies and publications sold by the Society, should be sent to Ian Standing, Rock House, Bowens Hill, Coleford, Gloucestershire GL16 8DH.

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Cover illustration

Abbey Tintern Furnace (SO 513002) has been extensively excavated through the combined efforts of the Gwent County Council, the Manpower Services Commission, the Welsh Development Agency and the Forestry Commission. The excavation was directed by John Pickin (who produced this conjectural drawing) and substantial remains were found of the furnace and associated wheelpit together with foundation evidence of the cast, blowing, bridge and charcoal houses. A leat system serving the furnace wheel and a set of stamps was also discovered and corroboration of three distinct phases of industrial activity on the site, which was in production between 1669 and the 1820s.

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The production of wrought iron in Finery Hearths
Part 2: Survey of remains

Alex den Ouden

Several sites exist in Europe, where remains of the hearth fining methods described previously can still be seen and studied. Of course, the remains are of varying importance, ranging from integrated, fully restored forges to exhibits of equipment. In this survey only the most important sites in the author's view are included; so omissions are to be expected!

Waterhammers and their technology form a trade in themselves, closely related to mill-wrighting. The development of the several types of waterhammers is closely bound to the evolution of the forges, but no tie exists between the type of forge, eg Walloon, German, etc and the specific type of hammer used in that forge[1]. Information on remaining waterhammers is condensed into a separate paragraph, which offers just some examples of the various types that have been used in forges producing wrought iron and steel.

The German forge

In **Sweden** several sites with important remains of German forges exist.

The old forge at *Havla*[2] was modernized in 1799 and in 1809. It then comprised a German hearth, two belly helve hammers and a Widholm blowing engine[3]. In the 1850s the forge was adapted to the Franche-Comté method by altering the hearth and a new – Bagge – blowing engine was installed. In 1883 two Lancashire hearths were added and the Franche-Comté (formerly German) hearth was modified again to become a chafery hearth. (Lancashire forge type 3). The exterior of the forge was at that time changed radically by the addition of a mechanical workshop and a new sparkchamber and chimney for the Lancashire hearths. Still later, the Lancashire hearths were fitted with Lagerwall rabbling devices, driven by the blowing engine waterwheel. The forge was blown down in 1924. It has been restored and now contains one Lancashire hearth with Lagerwall device; two hammers; one hearth reconstructed as a German hearth; the Bagge blowing engine and all fittings from the last period of operation.

At Riddarhyttan, at the site of an old copper smelting works, an 1820 Widholm blowing engine remains.

The forge at *Angelsberg* was built in 1840 as a German forge with two hearths, two belly helve hammers and a Bagge blowing engine[4]. In 1856 in this forge too, the Franche-Comté process was adopted by changing the hearths. In the 1880s two Lancashire hearths were built to replace these. The rest of the equipment of the forge was not changed. No chafery was built (Lancashire forge type 2). The original chimney was altered by addition of a sparkchamber at its foot. The forge was blown down early in the 20th century; it has been restored to its last working condition. Its lay-out and exterior are very typical of a Swedish German forge – where one imagines the Lancashire hearths were replaced by German hearths.

So, although no integral Swedish German forge remains, one can construct a creditable picture of a typical Swedish German forge from the period 1800 and 1850 from these sites.

In **Germany**, the situation is less clear-cut. The puddling process caused a fundamental change in the factors determining the suitability of a site for a forge[5]. Most of the old localities would no longer do for production of wrought iron. The German forge in Germany always was rather strongly diversified, not only producing iron, but also working it into tools for customers in the neighbourhood. So, in the 1830s, many of the old German forges specialized in forging work, buying their iron from puddling forges. This, coupled with the need for efficiency, resulted in changes in the forge, obliterating the typical iron production function.

In **Western-Germany**, at *Lendringsen*, a forge remains with one German type hearth, two general forging hearths and one belly helve hammer with its waterwheel. No bellows nor blowing engine remain.

In **Eastern-Germany**, near *Annaberg-Buchholz*, the Frohnauer hammer stands fully restored. It has one hearth with a set of bellows and a tilt of three tail helve hammers.

It is difficult to determine in how far the hearth construction is typical for a German forge of this type dated to around 1800 and 1750, respectively.

In **Austria**, no integrated German forge remain. In the technical museum at *Wien* an interior of a forge dating back to the 'Stuckofen'-era[6], ie to before 1750, is reconstructed from original equipment. The forge has a German hearth with tools; no bellows nor blowing engine[7]; but a single tail helve hammer with its waterwheel missing. The set-up is typical of a German forge fining and faggotting steel and wrought iron from 'Massl' and 'Kraglach'[6].

In the 'Eisenmuseum' at *Steyr* the interior of a scythe-smithy of the same period is reconstructed from original equipment. In such a smithy at least one German hearth was present, used mainly for faggotting of steel, but occasionally also for fining[8]. The smithy at Steyr contains one German hearth with two sets of single bellows. The bellows-drive mechanism is present – its waterwheel is missing. There is a tail helve hammer used for faggotting also without its waterwheel. The smithy also contains several hearths, a second waterhammer, and various other pieces of equipment related to scythe-making.

In the period shortly after 1750 the 'Stuckofen' were replaced by blast furnaces. At first 'Deutschhammer' were built. These combined a blast furnace with two German hearths[9] under one roof.

At *Kendlbruck*, some remains of such a works can be seen. The forge was started in 1756 and was finally laid down in 1830 – although some rebuilding took place in 1838[10]. The remains comprise the blast furnace body complete with stack lining and a large chimney on top of the blast furnace; several walls from which a general lay-out can be reconstructed and the common chimney of two 'side-to-side' German hearths. No hammer or watercourses remain, however. The hearths are just empty shells without any detail.

From about 1775, blast furnaces and fineries were generally

built separate, due to the scarcity of charcoal [11]. No example of a separate finery which is usually larger, remains in Austria.

The Walloon forge

Relatively few remains of the Walloon process can now be studied on site.

In **Belgium**, at *Saint Hubert*, a small 'affinerie' or forge can be seen. It is part of a small-scale charcoal blast furnace complex, built 1768 and in use up to 1830 with many interruptions. The forge building is restored, but no interior remains.

At *Liège*, original equipment from Walloon forges is shown in the 'Musée du Fer et du Charbon' Exhibited are: a finery hearth and a chafery hearth, both with two sets of bellows. The driving arrangements for the bellows as well as the pig iron supply are missing. The hearths date from the last quarter of the 18th century. Also a 17th century belly helve shingling hammer and a 19th century belly helve drawing hammer are shown. From these two sites a creditable picture of a typical Walloon forge can be composed.

At *Osterby*, **Sweden**, the famous 'Double Bullet' Walloon forge has been fully restored. The Walloon method was introduced at Osterby in 1627 [12]. The forge underwent a major modernization in 1794 and was finally blown out in 1906[13]. It has been restored to the situation existing after 1837, when a new Bagge blowing engine was installed, and now comprises a complete finery hearth with pig iron supply; a chafery hearth; a belly helve hammer and the Bagge blowing engine both with their waterwheels; the 'labbit' or smiths' dwelling and the charcoal storage shed.

The Swedish Lancashire forges

In Sweden quite a number of Lancashire forges remain. Those at *Angelsberg* and *Havla*, mentioned in the paragraph on German forges, are representative of the types 2 and 3, respectively. But of the large scale forges several fully restored examples can also be studied.

At *Korsa*, some remains of a type 4 forge are exhibited on site. These comprise a Lancashire hearth; a gas producer and condenser of a Lundin regenerative reheating furnace (ca 1860) [14]. The remains are isolated exhibits from several periods in the life of the forge (1860 - 1930). It takes some imagination to form a general picture from these; too much is missing. Unique however is the extensive collection of tools.

A similar forge, in this case completely restored, can be seen at *Stromsberg*. Three Lancashire hearths with waterdriven Lagerwall rabbling devices; a nose helve shingling hammer and an Ekman *charcoal* reheating furnace are combined with one belly helve waterhammer; one large and two small steam hammers for bar drawing and finishing. Steam is generated by waste gas boilers fed with combustion gases from the Lancashire hearths. This forge represents the transition from type 4 to 5. In this form the forge operated from 1902 to 1920.

A type 5 Lancashire forge is sited at *Karlholm*. This has six Lancashire hearths with two waste gas boilers and steam engine driven Lagerwall rabbling devices; a nose helve shingling hammer; a two-stand two-high rolling mill (roughing and rough bar; with waterturbine); a *charcoal* fired Ekman reheating furnace; two belly helve waterhammers and two steam hammers for bar drawing and finishing. No blowing engine remains. The forge was newly built 1880[15], and blown out in 1931. It has been restored to its last working condition.

No type 6 *Lancashire* forge is to be found in Sweden. Equipment of the type 6 *puddling* forge however is collected in the museum at *Surahammar* – although not in situ. It has a complete collection with a wood fired puddling furnace with waste heat boiler; a nose helve shingling hammer; a *wood* fired Ekman reheating furnace; a three-stand two-high rolling mill (for roughing and railway wheeltyres); two three-high medium mills; a four-stand small section mill; tools and a Bagge blowing engine. The exhibits are not shown in their original lay-out. They generally date from the period 1860 - 1880.

Apart from the puddling forge equipment a Lancashire hearth with Lagerwall rabbling device has also been re-erected at *Surahammar*. At *Munkfors*, in the fully restored open hearth shop there, a further two Lancashire hearths are shown as isolated exhibits.

Hammers

Waterhammers are divided according to their mode of operation into tail, belly and nose helve types. A battery of several tail helve hammers driven from one waterwheel via one shaft is called a 'tilt'. Belly helve and nose helve hammers only existed in single types, ie each hammer had its own waterwheel.

	site	number	waterwheel	appr date
Tail Helves				
single	Steyr, A	2	no	1750
	Wien, A	1	no	1750
	Hasloch, W-G	2	yes	1800
tilt with 2 hammers	Rotz, W-G	1	yes	?
tilt with 3 hammers	Annaberg-Buchholz, E-G	1	yes	1750
	Theuern, W-G	1	yes	1850
Belly Helves				
specifically shingling	Liège, B	1	no	17th c
	Havla, S	1	yes	1830
	Angelsberg, S	1	yes	1840
specifically drawing	Karlholm, S	1	yes	1750
	Stromsberg, S	1	yes	1750?
	Havla, S	1	yes	1799
	Karlholm, S	1	yes	1800?
	Angelsberg, S	1	yes	1840
	Korsa, S	3	yes	1860
	Liège, B	1	yes	19th c
	Gimo, S	1	yes	?

general purpose	Lendringsen,W-G	1	yes	18th c
	Osterby, S	1	yes	1794
Nose Helves				
specifically shingling	Surahammar, S	1	yes	1845
	Karlholm, S	1	yes	1850
	Korsa, S	1	yes	1860
	Munkfors, S	1	no	1874
	Stromsberg, S	1	yes	1875?
	Ullfors, S	1	no	1875?
	Soderfors, S	1	no	1875?
specifically drawing	Korsa, S	1	yes	1860
Steam Hammers				
	Osterby, S	1		1880
	Karlholm, S	2		1880
	Stromsberg, S	3		1900
	Vikmanshytte,S	1		1900?

Notes and References

NB **Sources: Roman numbers refer to items in the bibliography: arabic numbers to pages.**

1 The factors determining the choice of hammer are:

a. existing water conditions (flow and drop);

b. power demand, ie scale of operations;

c. type of production, eg exclusively bars for export; mixed production of bars and tools etc.

2 All sites mentioned are shown on the maps included

3 A Widholm blowing engine consists of a vertical wooden frame with 2 or 3 sets of single wooden bellows on top and an iron crankshaft in bearings at the bottom. The engine is powered by a waterwheel.

4 The Bagge blowing engine has a wooden frame. This presumably derives from an older (Widholm?) blowing engine.

5 The main requirements of the old German forge were access to charcoal and waterpower – those of the puddling forge access to coal and transport.

6 In a 'Stuckofen', a loup of steel consistency – with carbon varying throughout the loup – and some liquid pig iron are produced. The former is called 'Massl' or 'Stuck', the latter 'Kraglach' or 'Graglach'. The 'Stuckofen' is charged at the top with alternate layers of charcoal and ore. There is just one tuyere, which from time to time during a melt is reset at a higher level to accommodate the growing loup at the furnace bottom. The loup was dragged out after removal of the tuyere wall. A total cycle took about 20 hrs, of which the effective blowing time was 15 hrs. The maximum weight of the loup was about 1000 kg.

7 Just a blast tube – this leads to the speculation that perhaps the forge was equipped with a Wackler blowing engine. This type of blowing engine is water-wheel driven. It consists of a vertical wooden frame holding an iron crankshaft ($2 \times 180^{\circ}$) and – on top – 2 square sectioned wooden boxes, the cylinders containing wooden pistons. The cylinders hang in bearings and rock with the lateral movement of the connecting rods. They are double-acting. No windchamber is used.

8 Especially in times of interrupted sales of scythes, etc.

9 Occasionally one. Such works were called 'halbe Hammer'.

10 The site was bought in 1836 to obtain its charcoal rights. Transfer of these was only allowed after bringing back the Kendlbruck plant to working order. The rebuilt Kendlbruck furnace never did actually work.

11 Strict regulation of charcoal production and allocation was necessary and forges and mines and blast furnaces had to be separated by rather long distances: VIII, 148.

12 XXIV, 90.

13 IX, 84.

14 Two nose helve hammers with pitch-back wheels for shingling and drawing; one belly helve hammer with a pitch-back wheel for rough drawing; two belly helve hammers with overshot wheels for drawing and finishing.

15 The Lagerwall rabbling devices were installed at a later date.

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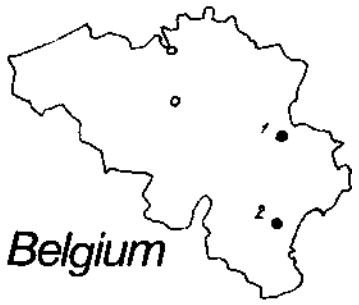
The Author

Alex den Ouden was trained as a mechanical engineer and physicist. He has been working in design and research, then became a free-lance industrial archaeologist.

Reference maps

1 Korsa
2 Karlholm
3 Stromsberg
4 Soderfors
5 Ullfors
6 Osterby
7 Gimo
8 Vikmanshytte
9 Angelsberg
10 Riddarhyttan
11 Surahammar
12 Munkfors
13 Havla



1 Liège
2 St Hubert

1 Lendringsen
2 Hasloch
3 Theuern
4 Rotz
5 Annaberg-Buchholz

1 Wien
2 Steyr
3 Kendlbruck