Documentation of the waterwheels and the wood-construction of two trip hammers for a possible reconstruction in Olofsfors Bruks trip hammer forge

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RIKSANTIKVARIEÄMBETET

At the triphammer mill in Olofsfors Bruk there are three waterdriven hammers in different sizes as well as a waterdriven blast machine.

This documentation is about the waterwheels and the wood-construction of the small hammer (striking weight ca. 150 kg) and the big hammer (shingling hammer, striking weight ca. 700 kg). The wooden construction of the two hammers has survived, but is in a very poor condition. The waterwheels are differently constructed because of the size difference of the hammers. In this documentation the hammers will be referred as the large and the small hammer.

The blast machine and the middlesized hammer (bar iron hammer, striking weight ca. 350 kg) has already been reconstructed using modern techniques. Because of that, it is very difficult to say anything about the original wooden construction. This also goes for the water channel of the overshot waterwheels, which were reconstructed at the same time, or the position of the sluices that regulate the amount of water which drops onto the waterwheel.
At Olofsfors Bruk in the hut another old waterwheel can be found which is in better condition than the others, this was used for running a tail helve hammer. Also parts of the old water channel that leads to it has survived. Details from this can give clues to how the original water channel at the trip hammer forge was constructed, even though as it is a tubular construction in comparison to the one at the trip hammer forge which is an open construction.

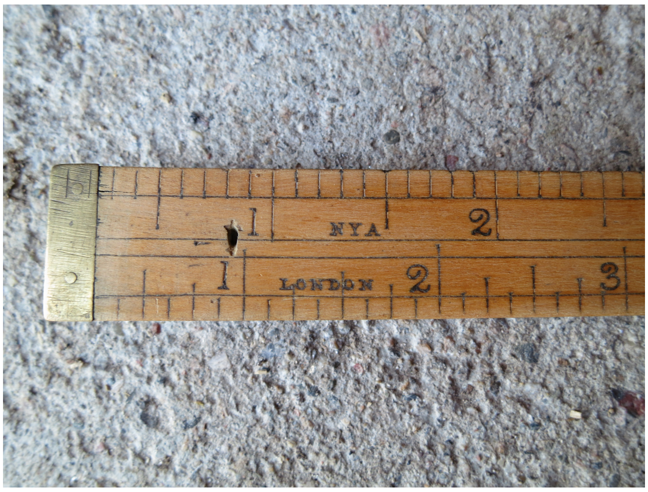
Because of the bad condition of the wood construction of the small and the big hammer it was difficult to take proper measurements.

In 1878 the hammers were brought to Olofsfors from other smithies in the area. It´s guessable that the waterwheels were built between 1878 (establishing of the smithy) and 1916 (shutdown).

At this point in time, four different measuring systems were used in Sweden.

- the old Swedish inch (12 inch = 1 feet, 2 feet = 1 ell, 1 inch = 2,475 cm)
- 1855 the new Swedish inch was introduced (10 inch = 1 feet – the foot-measure had stayed the same like it was with the old Swedish system, so that only the inch-measure itself has changed; 1 inch = 2,969 cm)
- 1889 the metric system became the trading-measure
- as well l before as after the introduction of the metric system the English inch was parallel used for measuring (1 inch = 2,54 cm, 12 inch = 1 feet, 2 feet = 1 ell)

Exempel for a ruler from that time (sample from the Robertsfors Bruksmuseum):



The iron production and further refining in Sweden was often based upon English technology, especially in Olofsfors where the founders John Jennings and Robert Finlay had Irish roots. This was the base for the assumption that the waterwheels in Olofsfors was built with the english measuring system. Experimenting with all four measuring-systems has shown that the English inch matched best. Because of this, all the measures on the drawings will be shown in the english inch. With help of a translation-scale these measures can be easily converted to millimeter.

There is reason to believe that the waterwheel to the smaller hammer is a few years older than the wheel for the large one. All the shovels on both wheels has iron brackets to help hold them in. The shovels on the small waterwheel are also fastened with wooden pegs, that has the same function as the iron brackets, but on the big wheel, these pegs cannot be found. This leads the to the conclusion that the iron brackets were probably fastened subsequently.

The waterwheel to the small hammer has a diameter of ten feet (3,048 meter), the width of the waterchambers is four and a half feet (1,372 m), the axle has a cross section of two feet (0,610 m) and a length of 24 feet (7,315 m).
The waterwheel of the big hammer has a diameter of ten feet and eight inches (3,251 m), the width of the waterchambers is two times two feet and nine inches, total of five and a half feet (1,676 m). The axle has a cross section of two and a half feet (0,762 m) and a length of 23½ feet (7,163 m).
The waterwheel of the big hammer is wider and has two compartments of shovels instead of one, to be able to take more water and to move more weight.
The small hammer has a five-armed cogwheel (wheel with five lifting arms/Ertel) and the big hammer has a four-armed cogwheel.

Despite the fact that the waterwheels are at least 100 years old they are in surprisingly good condition. This indicates that the selection of wood was done with outmost care. In case the waterwheels are to be reconstructed in a way that will last for a long time it is very important to choose the right wood.
For the construction of the waterwheel as well as for the beams of the axle it is advised to use pine full of resin and only use the heartwood. For the boards of the shovels it is recommended a resinous pine (extremely resinous wood - „fat wood"). The pine should be slow grown. The tight year-rings provides a durable wood.
It is impossible to say anything about the tools used for manufacturing the wheels, because the surfaces are in a too bad condition to find any sure traces after them.

There was a waterdriven sawmill existing in Olofsfors, so it is guessable that all the wood came from that sawmill.

Regarding the wooden construction beneath the axlebearings and also for the hammer and stand there is a detailed description in the writing of Jonas Bagge from 1843 „Beskrifning på en ny konstruktion af tackjernshammarställningar." There is also described in great detail of how to build the foundation and strong recommendations about the wood selection.
The foundation is either not visible or in very poor condition. You can see some parts of the foundation (see picture below), but unfortunately you can not see what type of construction it is and no sure measurements can be taken. It is possible that some details would become visible during an excavation.

How to fix, install and adjust the hammer and the other wooden-parts is also explained by Bagge (page 16-17). The explanation is very precise and detailed. It´s very interesting how Bagge explains the wood-selection for the helve that holds the hammer: this beam should be made out of a birch that has not been hewn, because a birch that stays in it´s natural form has the biggest possible static elasticity. As well that birch should be neither too old nor too young, means the year-rings should be neither to wide nor too tight.
On the big hammer the pushers (spring logs) are preserved. The spring logs function was to stop and rebound the hammer after it was lifted by one of the lift arms. They were probably made from two sprucelogs. These should also retain as much of their natural shape as possible to have the largest possible elasticity.

The axles are made out of four beams. The beams to the big hammers axle have two different dimensions: 16 x 16 inch and 14 x 14 in. This axle tapers slightly towards the inner part of the smithy. With great certainty a conclusion can be made that all the top ends of the logs is laid in direction towards the smithy and that the root ends of the logs are all pointed towards outwards. This is a detail that differs from Bagges description, he described that the four beam should be lain so that two tops and two roots should be directed towards each way. The small hammers axle has three different dimensions on the beams, one is 11 x 11 in, one is 10 x 10 in and the remaining two are 10 x 11 in. Also this axle tappers slightly towards the inside.
The way to join the beams together for an axle is described in detail in Bagges book (page 10-13). The axle has been covered with boards between the waterwheel and the liftarmring so it has an octagonal shape. The axles are held together by iron rings.

How to affix the bearing pin in the axle is also well described by Bagge (page 14-15). It is remarkable that all wedges were soaked in wood-tar before they were forced into the end grain, and the sides of the wedges are konvex, please see the drawing and photo.

The bearings for the axles are out of stone. Information about this also can be found in Bagges scripture.

The drawings give an adequate explanation of how the waterwheels are constructed. A waterwheel is in an almost constant wet condition and this might cause the wood to warp into the opposite direction of what it usually does during a drying process. That’s why the positioning of the heart in the wood is vital. In the drawings I have transferred how the yearrings are positioned in the original pieces that are still left.
The round segments of the water wheel are made out of two pieces and are affixed with three wooden pins, see drawing and photo.

The cuts between these two segments overlap and are joined with two rows of pegs. These pegs have a conical head on one side and are locked in with a wedge on the other side, see the drawing and photo.

The shovels are made out of three boards and two of them are joined together with wooden pins, see the drawing and photo.

A number of iron brackets secure or stabilize the entire construction. I would propose to put wood-tar on each connection where wood meets wood and iron meets wood.

The position of the original sluices is not visible anymore. In the drawing they have been placed like they have been in the reconstruction.

Explanation of technical terms by Sebastian Reichlin:

Blast machine	a 3-cylindric machine that guarantees that air comes to the hearths and furnaces
Small hammer*	ca. 150 kg weight of the hammers head for smaller dimensions and easier works
Iron bar hammer	for forging the raw-material to iron-bars ca 350 kg weight
Shinglinghammer	for squeezing of the bloom - the new made iron out of the finery, hammerweight ca 700 kg
Mill race	facility to provide the waterwheels with water
Sluices*	regulation of the water for the waterwheels
Helve	a tree trunk used as the shaft of the hammer
Bearing pin*	iron bar in the center of the axle functioning as part of the
bearing	

* no official terms

Attachement:

- drawings of the small and the big hammer
- drawings of details from iron-parts
- CD with all photos that could be useful for a reconstruction
- CD with scans from the drawings