I Remember Smelting with Sven and Yorgi

Over the last decade, there has been a dramatic increase in those interested in the historic North European methods of direct process iron smelting. There remains very limited archaeological materials to base this work on, and any living tradition is long past. Of course as modern experimenters we bring modern attitudes, such as employing the scientific method, to our efforts. The world view of the Norse at the turn of the first millennium would have been quite different. Of special interest is the group of explorers under Leif Ericson, as indicated by the remains found at L'Anse aux Meadows, Newfoundland. Just what kind of knowledge might those men have possessed? What might the physical remains indicate about the conduct of those who undertook this first iron smelt in North America.

This article was prepared as a concept exercise. How might information have been transmitted from one generation to another in historic times?
This was intended as a set of *verbal* instructions, delivered to a group of workers who had at least watched a previous bloomery iron smelt.
The core method and the tools required are only generally described.

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Now, this is what I remember from smelting with my uncles Sven and Yorgi * :

You first will need to build a bellows, one larger than the one a blacksmith uses. This bellows should have each plate about one span wide at the hinge and a span plus a hand at the handle end. The plates should be three spans long. The lift on the bellows needs be about two spans (A). A bellows such as this will make the right kind of air for a smelter.

There are a few other special tools that you will need to forge out before smelting iron:
- A long rod, about the size of your little finger with flattened corners. This needs to be long enough clear down the inside of the tuyere tube, at least three spans long.
- A heavy rod, about the size of your thumb with a short chisel tip on one end of it. This needs to be long enough and heavy enough to drive down inside the whole smelter from the top, perhaps two ells. It may be needed to pry free the bloom.
- A heavy rod with a short flat hook on one end, that about the length of three

fingers. This can be set to a wooden handle, but the last two or three spans must be of iron. It is used to hook under the hot bloom inside the furnace.
- Very large tongs, with good long handles. This needs to be big enough to pick up the bloom, and to do so down inside the smelter.

You will need a good pile of charcoal, depending on how big a bloom you want to make. As the charcoal for the smelter can not be too big, make your charcoal using sticks about two fingers wide. After it is cold, break the pieces so they are no longer than that same width. You will need at least 30 or 40 buckets (B) of charcoal, double that much for a big smelt. When you start adding charcoal to the furnace, make sure you add from the top of the pile. (C)

You will need to gather some bog iron ore. It is sometimes hard to find. Reach down along the edge of a stream, running your hand between the roots and the gravel. When you feel something like hard clay, pull this out and with luck it is good ore. Not all ore is as good as others. One way to test an ore is put a piece in your mouth. Eventually all the iron will melt away, leaving just the sand behind on you tongue. In this way you can tell how much of your lump of ore is actually the iron you want.
You need at least a bucket of ore to get any iron bloom at all (D) , so it is best to gather two or even four times that much.
It is best if you roast the ore first. Make a wood fire on a fresh bed of sand. Once the fire is well lit, put a row of wood splits across the fire. On to this pile your dry ore. Once the fire has burned cold, you can pull out the roasted ore from the ashes. The pieces should not be too large, break apart any much bigger than the thickness of your thumb.

You need to build the furnace out of clay. It should be at least a span wide on the inside, maybe a bit wider. The walls should stand so tall that you can just touch your knuckles to the floor of it, with the top of the wall to your arm pit when you reach inside (E).
Now, depending on just how you build it, will tell you how thick to make the walls. If you do not have much clay, you can dig back into a bank of earth. Then your walls just need be thick enough to hold the fire in, about two fingers thick. If this furnace is to stand up on its own, it is better to make the thickness of the walls at least three fingers, even better four.
If you want this furnace to last for several smelts, or to keep from cracking, it is best to mix your clay with some chopped straw. Cut your straw with a hand axe to pieces the width of your hand, and mix the same amount of clay and straw. If your clay is too wet, you can add some beach sand to make it stiffer.

The best thing to do is let your furnace stand for a day or two to let the clay harden. To keep the walls from sagging, fill the new furnace with dry sand or ashes. This is easy to scoop out to clear the furnace before you start the smelt. If the furnace stands on its own, laying some flat stones around the outside will make it keep its shape. Put some sand mixed with ashes into the spaces between the stones and the walls.

Once the walls have started to harden, two holes should be cut. One is a door right at the bottom of the furnace. It should be about the size of your hand with fingers outstretched. The other hole is for the air pipe, which should be part way around from that door. This hole is made just big enough for your bellows tube to fit. It should be two hands above the base. It is best if this hole is cut so the pipe will sit at an angle, pointing down inside the furnace, roughly one quarter off from square (F) It is best to set your air pipe in place before the clay is too dry.

Now this tube is best to be separate from that which comes out of your bellows. The tuyere can be made separately of clay, forged from iron, even hammered from copper. (G) It is best if the tuyere is the shape of a long narrow taper. The smaller end, inside the furnace should have an opening about the width of your thumb or a bit less . Your tube should sit so it is about two fingers proud of the inside wall of the furnace. Pack soft clay around it to seal the hole tight.

It is best to warm the furnace gently with small pieces of wood to dry all the water out of the clay. This works best if you open the door in the base to let the air in. This fire may burn a good part of a day, until no more steam comes off the outside walls of the furnace.

Once the furnace is dry, it is time to set the bellows in place, attaching it to the tuyere. The furnace door is shut, and the furnace filled with charcoal. Now the bellows man will start to pump, and keep pumping with the same strokes for all of the smelt. There should be one full push down of the bellows bag for each beat of his heart. (H) The furnace will burn slowly at first, but still it should be kept full to the top with charcoal constantly.

You will know when it is time to start adding ore by looking for the fire to come up to the top of the furnace. The glowing charcoal should be seen about one hand down from the top before you start.
Now you add ore by the double hand full, one measure for each bucket of charcoal. Do not place the ore on in a big pile, but add it a bit of a time, all

through the charcoal. For the first four or five buckets, add only one measure of ore. Once this has been done, and if your fire is burning hotly, you can start adding a bit more ore to each bucket of charcoal. (I)

As the smelt grows, it is important to listen to the air in the tuyere. If the sound becomes faint, check to see if the tube is starting to be plugged. Quickly break away the slag with a rod if this happens. If you hear a bubbling sound, look to see if there is too much liquid slag forming. You may need to open the furnace door and poke a hole in the bottom to let the extra slag run away.
This all continues until all your ore is done. Make sure to keep a couple of buckets of charcoal for the last steps.

Once all the ore is used, add at least one more full bucket of charcoal to cover over it as it falls inside the furnace. Then you let the furnace burn down inside until most all the charcoal is gone.
The best way to pull out the iron bloom is out of the top of the furnace. You might have to scoop some last burning charcoal out of the furnace, until you can just see the liquid pool of slag. Then take a log to hammer on the top of the bloom, which you will see sitting inside the slag pool, just under under the tip of the tuyere. This should allow you to use the bloom hook to grab under the free edge of the bloom and pull it loose from the slag. (J)

Now reach down quickly and pull the white hot bloom over to the stump, where your hammer men are waiting. Quickly hammer over the surface, knocking off any slag, which cools quickly. Then stronger blows will compact the bloom to a solid lump. If you have not broken your furnace, and if you added fresh charcoal when the bloom is pulled, you should be able to re-heat the bloom as you need to keep working it. Often the last step is cutting the bloom with an axe. This will let you see how solid your bloom is. The easier a solid bloom can be cut into, the softer the iron is and better for forging.

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Notes:

Through this set of instructions, the measurements given are based on the dynamics of the human body (in this case, the author's):
thumb (thickness) = 2.5 cm
two fingers (width) = 4 - 5 cm
hand (width, across palm) = 9 - 10 cm
span = 20 cm

ell = about 80 cm (a cloth yard)

A) Bellows
This is a modified Norse Double Bag bellows :
Plates - 20 to 30 cm wide and 65 cm long
Loft - 45 cm
Volume - roughly 10 - 12 litres per stroke
Rate = roughly 70 strokes per minute

B) Buckets
This refers to a 'standard water bucket'. In our experiments, this has been a basic 5 litre metal bucket. The weight actually varies, depending on just how dry the charcoal has been. Typically about 1.8 kg.

C) Charcoal Size
Our charcoal for this furnace size is graded by double screening. The pieces are broken up to fit through a 1.5 cm grid, then the fines are screened off using a . 5 cm screen. 'Pull from the top of the pile' should naturally remove the larger pieces and leave the fines behind.

D) Ore Amounts
Our own experiments have shown that in smelters of the size indicated here, roughly 8 kg of ore (roughly a standard bucket as bog ore) is needed to 'kick start' the reaction. Primarily this is the formation of the initial slag bowl in the bottom of the smelter.
As you increase ore amounts, running the smelt reaction longer, there is a significant increase in yield against ore amount. A small ore smelt may only return 20 - 25 %, while at volumes closer to 40 - 50 kg returns of 45 - 55 % are possible.
Note that an overall iron content of at least 45% is required for the bloomery process to result in any significant bloom. Obviously the higher the iron concentration (and reduction in contained slice) the higher the potential yields.

E) Furnace Size
Our standard furnace is roughly:
20 - 30 cm interior diameter
5 - 8 cm wall thickness (depending on construction, as suggested)
65 - 70 cm wall height

F) Setting the furnace
The description is for our standard, here with a small tap arch (about 20 long

and 10 high) cut into the base. The tuyere is set in a fashion which has proved ideal for furnaces of this type:
15 cm above the base
set to 22.5 degrees down angle
protrudes 5 cm beyond the inner wall

G) This may be a bit more information than would be provided. Likely the tuyere would just be made of a standard material, to a standard shape, and set in a standardized manner. These three aspects link into an ideal chain.

H) This section left quite deliberately vague.
There are several different ways to set up the bellows for the ease of the operator, and allowing for quick access to the tuyere for clearing blockages. The ideal air volume is a function of first bellows size (given here) and pumping rate. Working for extended shifts, our experience is that a pumping rate of roughly 60 - 75 strokes per minute is typical. The bellows described thus has been measured to produce 500 - 600 litres per minute on average. This volume is ideal for this furnace. Note that by insisting the bellows operator maintain a steady rhythm, the modern concept of working to time points is discarded.

I) A standard long handled scoop has long been the base measure in our experiment series. It thus maintains a standardized volume, but the weight changes considerably with different density ores. Bog iron ore, especially when roasted dry, has a relatively low density. A 'double handful' is an amount of roughly 250 - 300 gms.
The addition sequence is again based on long experience. Normally specific additions of ore are determined by measuring the burn rates of specific bucket volumes of charcoal. Here the stress is on 'this is the normal sequence'.

J) The sequence described here is for a top extraction. It also describes an ideal situation, one rarely encountered at a smelt! The phase 'repeat as required' might be included in a modern training manual. The inclusion of the long heavy bloom chisel in the tools list is specifically required to pry reluctant blooms free of the slag mass. Key to easily extracting the bloom is the ability to work extremely fast, something not obvious to first time workers.

* Sven & Yorgi

Sven & Yorgi are two semi mythical characters within DARC, originally created as comic relief by Kevin Jarbeau (R) & Dave Cox (L).

Sven (Kevin) is dark of feature, thin and wiry, full of nervous energy, and ‘bitter & twisted’.
Yorgi (Dave) is large and blond, big of heart but not the brightest (goofy).
As a pair, they have many ‘adventures’, often the schemes envisioned by Sven go badly wrong, and Yorgi just blunders along (often into trouble).

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