Remelting Bloom Iron for Phosphorus Reduction

For those of you new to this issue, there has been increasing interest in changing the character of bloom iron through remelting, as described by Ole Evenstad in Norway 1790. He describes remelting bloom iron twice; once in a shallow hearth to make it "purer", and again in a deeper hearth to make steel. I have been experimenting with this for several years now- today I finished the most careful and conclusive experiment on the first melting to "purer"iron that I've done yet. In keeping with my New Year's resolution, I'm writing up this experiment this afternoon, rather than at some indefinite time in the future, which often means never!

I have become reasonably convinced over the years that the purpose of the first remelt that Evenstad describes is to reduce phosphorus (or mitigate the effects of it), as P would be common in the bog ores he was using. This set of experiments finally satisfies me this is so.

I started with a nice and dense, but very high phosphorus bloom from smelt #156. I make a lot of blooms with phosphoric ore that is all around wonderful, but this one had enough phosphorus to be a bit troublesome to forge, and quite brittle. I had cut this bloom into 2 quarters and 4 eighths, pie wise. Here is an eighth of the raw bloom that remains, so you can see the general character of the bloom:

Then I remelted a quarter bloom from smelt #156, weighing 4.4 lbs, in a hearth with the tuyere 1¼" above the hearth floor. After remelting and (and slightly flattening) the resulting bloom weighed 2.5 lbs. I scored the bottom of this remelted bloom, and folded it, thus welding it face to face, and drew it to a ¾' x 2" x 5" bar that weighed 1.83 lbs. I sliced a cross section of this bar for a metallographic sample at this point.

I then took another bloom quarter from smelt #156, weighing 5.25 lbs, and folded this raw bloom face to face as I did with the remelted bloom, and drew to a bar approx. ¾" x 1 ¾" x 12'', and weighed approx. 3.5 lbs. I cut a cross section from the central section of this bar for metallography.

Examined under the microscope, the remelted bar (referred to now as**156-R**) showed no perceptible reduction in slag content from the raw bloom sample (now **156).** Indeed, if anything, **156-R** had a greater slag content.

Hold on, here's where it gets good. …

I drew a piece of each sample to a bar approx. 5/16" square and 12" long, and performed 3 cold twist tests on each bar. My standard test is to mark off 1 ½" of 5/16" bar, and twist to failure, counting the revolutions and examining the fracture. The result:

Details for each sample:

Raw Bloom(Bar 156)- This iron was very soft under the hammer. As I forged it down, it developed several longitudinal splits, especially along the corners. I welded them up as best I could as I went. When twisted cold, all three twists snapped at ¼ turn, showed the crystalline fracture typical of very high P iron, and showed several welding flaws as well.

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Remelted Bloom (Bar 156-R)- This iron was much more resilient under the hammer. It split less, and welded up more easily. When twisted cold, one twist broke at ¾ turn, and the next two broke at 1 ¼ turns. The first showed a ductile fracture with a tiny zone of crystalline fracture, and the second two a nice ductile fracture throughout.

Conclusions etc. -- I think this experiment demonstrates very well and succinctly that the first remelt described by Evenstad mitigates the effect of phosphorus.

The total amount of phosphorus in the iron is probably reduced by this method. We have a little bit of XRF analysis on other experiments that indicate this is so, and I think that's the main thing that's going on here.

It may also be that the remelt introduces a little bit of carbon that inhibits grain growth. Spark test was inconclusive here, we may be able to see that metallographically and we may not.

Perhaps both are at play.

Anyway, it works.