

The Perfect Armor Improved: Water Hardened Leather

Some years ago, I wrote an article on how to make hardened leather armor using beeswax. Since then I have concluded that although the method I described works reasonably well for SCA purposes—I have fought in my wax hardened klibanion for a good many years now—it is quite unlikely that it is the method used in period for armor.

I reached that conclusion for three reasons:

1. Beeswax is a lubricant. Furthermore, stiffening the leather makes it easier to cut—just as it is easier to slice meat if it is half frozen. So although wax hardened leather provides protection against the sort of blunt weapons we fight with, it would be of very limited usefulness against sharp swords, arrows, and the like.
2. Although I have found no period descriptions of the process for hardening leather, the period term for hardened leather is “cuirboulli,” which translates as “boiled (or cooked) leather.” That is not the natural way of describing the wax hardening process.
3. I have found an entirely different way of hardening leather which does fit the term and which produces armor that is much better protection against real weapons. This article describes that process. As it happens, in addition to being a better guess at what was done in period, it is also a somewhat better technology for making SCA armor.

How to Water Harden Leather

Take a piece of vegetable tanned leather. Immerse it in water long enough to get it soaked—ten minutes will do. Heat a pot of water to 180°. Immerse the leather in the hot water. Watch it.

In about a minute, the leather will begin to darken, go limp, and curl up. If you pull it out at that point, it will have shrunk a little, thickened a little, and be stretchy, like a thick sheet of rubber; at this point it can be stretched and formed. In a minute or two the stretchiness will go away, but the leather will still be flexible. Over the course of the next few hours it will become increasingly stiff. You will end up with a piece a little thicker and a little harder than what you started with.

The longer you leave the leather in the hot water after the process has started, the more it shrinks, the more it darkens, the thicker it gets—and the harder the final piece will be. A sufficiently long immersion gives you something that feels like wood. Unfortunately, when the piece gets harder and stiffer it also gets more brittle. If I were making lamellar armor to defend myself against real weapons, I would use a long immersion and plan on replacing a few cracked lamellae after each fight. For SCA purposes I normally leave the leather in the hot water for about thirty seconds after the process starts. This gives me, very roughly, shrinkage to about 7/8 of the original dimensions, an increase in thickness of about 25%, and a piece that is hard but not totally inflexible.

The process is very sensitive to the temperature of the water, so you will want an accurate thermometer. The timing and the result also depend to some degree on the particular piece of leather. Instead of trying to work entirely by the clock, experiment with pieces of scrap until you have a reasonably good idea of how the leather looks at various stages in the process and how it comes out when finished, then judge the progress of your piece in part by time and in part by appearance.

You can also harden leather in boiling water—considerably faster. In my experience, about a twenty second boil gives shrinkage to 7/8ths, about a forty second gives you a shrinkage to 2/3 and roughly doubles the thickness. That has the advantage of not requiring a thermometer.

It has two disadvantages. First, the faster process is harder to control precisely. Second, the hotter water produces a less uniform hardening—you tend to get pieces where the surface is harder and more brittle than the interior, eventually producing surface cracks. I therefore prefer the lower temperature process. I have not done any extensive experimentation on what happens at intermediate temperatures.

Easy Projects

Making flat pieces such as lamellae or scales is easy. Because it is hard to predict the exact amount of shrinkage, you may want to first water harden the whole piece of leather, then flatten it under a cutting board or something similar for a few minutes, then cut out your lamellae with a utility knife and add holes with a leather punch; at this stage in the process the leather can still be cut fairly easily.

If I want my lamellae slightly curved in the horizontal direction, to provide a little additional stiffness and to better fit my body, I take a cooking pot with a diameter of a foot or more, line up the lamellae around it while they are still flexible, tie them on with a strip of rag, and let them dry that way.

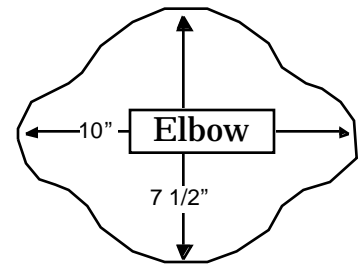
Making a vambrace, a rerebrace, or any other piece that is curved but not stretched—any shape you could make from a sheet of paper—is equally easy. Cut the piece of leather a little bigger than you think you need (remembering to allow for shrinkage), harden it. Wrap a towel around your forearm to protect it from heat and provide extra thickness to allow for padding (or wear your gambeson, if it covers your arm). Tie the piece of leather around your arm with strips of cloth (string will leave marks on the leather). Leave it there for fifteen minutes or so. Untie it and take it off, being careful to keep the shape—at this point the leather is still fairly flexible. Trim off any surplus. Leave it somewhere to dry. Instant vambrace.

Harder Projects

One advantage of water hardening is that when the piece comes out of the water it is stretchy—more so than leather that has been soaked for a much longer time in cold water, as described in my earlier article. This makes it possible to form pieces. You must work quickly, since the stretchiness goes away in a minute or two.

Elbow cops are easy. Start with a roughly oval shape, about 10” by 7.5”, as shown in the figure. Find two bowls, diameter about 6.5”, that will nest together. When the piece comes out of the hot water, put it into one of the bowls, forcing it down with your fingers to stretch the leather into the bowl, then put in the other bowl, so that the leather is being stretched between the two.

Finally, take out the inside bowl and make sure that the leather is fitting into the other with no folds, crinkles, etc.—if necessary smooth those out with your fingers. Let the leather dry. Sew on straps and you have an elbow cop. For a knee cop, do the same thing, making the piece about 14” x 7.5” and using about 7.5” diameter bowls. Details will vary according to the size of your elbow and knee and how thick your padding is going to be.

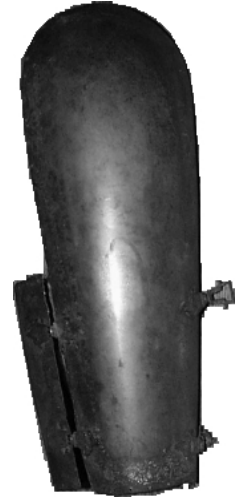


A bazuband—the Islamic forearm and elbow piece described in the previous article and shown here—is a more complicated shape. There are four ways to try to make it.



1. Use your arm, wrapped in a towel, as the mold. This will probably work better with two people, giving you three hands to stretch leather. I have not yet tried doing the initial stretching that way, although I usually put the piece over my arm for the final adjustments.

2. A positive form. Get something roughly the shape of the inside of the bazuband. A steel bazuband is ideal if you happen to have one lying around, but lots of other things will do. For a less precisely designed form, but one somewhat easier to obtain, use a wine bottle with relatively steep shoulders.

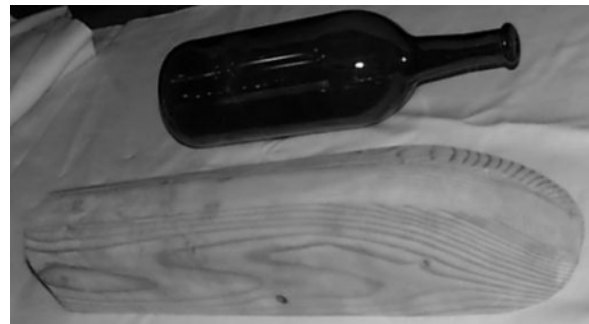


With a positive form, you take the leather out of the hot water and stretch it over the form. I find that it helps to tie the wrist end of the leather around the form with strips of cloth, then do the stretching at the elbow end, which is where it is most needed. then tie that down to the form with strips of cloth. This is like making an elbow cop with only one bowl, by stretching the leather over the bowl—but harder. You may find it useful to do some preliminary stretching over a rounded corner of the kitchen table, or something similar.

3. A negative form. Get something shaped like the outside of the bazuband and stretch the leather into it—like forming your elbow cop in the inside of a bowl. This seems to be easier than 2.

4. Nested forms. This is the best way—once you have the forms. I’ve done it using a pair of steel bazubands. They don’t have to be steel—once you have made a cuirboulli bazuband you are happy with, you can use it as your negative form for the next one, nested onto whatever form you used to make it.

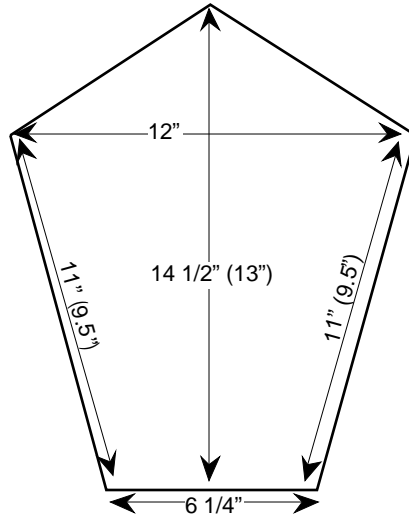
Alternatively you could make both positive and negative forms out of wood—by the next version of this article, I may have finished that project, using lengths of 2x4 sandwiched together and pegged. In theory, you end up with forms that can be made narrower, for thin people’s arms, by removing the central piece, or wider, for big people’s legs, by adding another piece.



Dimensions

The figure on the next page shows a piece of leather intended for a bazuband and top and bottom views of the completed piece; numbers in parentheses were measured after shrinkage. My wrist circumference is 7.5” and my arm is 9” from the wrist to the tip of the elbow, 8” from the wrist to the inside of the bend of the elbow. You can experiment with different starting shapes and forms to make different sorts of bazubands.

After doing your best to stretch the leather over or into your form, you may discover that your best was not good enough—the edge of the leather at the elbow won’t fit against the form without wrinkling.



Simple Fixes



There are two possible solutions. One is selective shrinkage. Put the edge of the elbow end back into the hot water for another minute or two, until it starts to get darker and shrink. With luck, you can tighten the wrinkles away. A simpler solution, shown to the left, is to pinch the tip of the elbow end, giving you one elegant fold instead of several inelegant wrinkles. Hold the pinch closed with a clamp while the leather dries and stiffens.

After discovering how simple the technology is it may occur to you, if you are a parent, that cuirboulli armor is just what your five year old would like for Christmas—and considerably less expensive than the latest Playmobile castle. The idea is not new. The pictures below show two father/son pairs of bazubands—one Indian, possibly 18th century, and one a little more recent.



Doing without Bicycle Tires and Heater Hose

A simpler stretched leather project is shield edging. Start with a strip about 3 inches wide and long enough to go around your shield after allowing for shrinkage—or several strips that add up to enough length if you prefer. When the leather goes limp, pull it out of the water and stretch it tightly around the shield; it will form itself to the shield edge in a fashion wondrous to behold. To completely eliminate non-period materials from your shield, use many layers of scrap wool to provide padding between the wood and the leather.

Further Details

For SCA fighting, you should probably start with at least 8 ounce leather, which the hardening process will thicken to about 10 ounce. 12-14 ounce is better—but harder to stretch over forms. In general, you will want thicker leather over vulnerable points such as knees and elbows—which means either starting with thicker leather or leaving your leather in the hot water longer to get more shrinkage.

Sometimes something will go wrong; you pull the piece of leather intended for a bazuband out of the water only to discover that it has shrunk too much to fit your form, or that a thin section you didn't notice has shriveled up, ruining the piece. All is not lost. Flatten the piece out and cut it into lamellae. Enough mistakes and you have a free klibanian.

One minor problem with the process is that the leather gradually turns the water you are using brown. For a simple project, such as making lamellae, this may be tolerable; you can stir the piece of leather to the top of the pot every ten seconds or so to check its condition. For something more complicated, such as a bazuband or greaves, you may want to heat fresh water for each piece—which is a nuisance but makes it easier to see what you are doing.

For the Future

I am fairly sure that water hardened cuirboulli, starting with 14 oz leather, would be adequate for gauntlets but I have not yet made any. Starting with even thicker leather I could probably make a workable helmet—but I doubt I could talk the marshals into letting me use it. I do, however, plan to fight at Pennsic this year wearing my brand new cuirboulli cup.

Cuirboulli can also serve a variety of more peaceful purposes. Think of it as a medieval plastic—literally true, if you take “plastic” in its general sense and consider the condition of the leather immediately after it comes out of the water.

