STEAM-FORMING SHEET BALSA AIRFOILS

by Joe Wagner

For more than 30 years I've been designing, building, and flying airplane models that use "single-surface" sheet balsa wings. The airfoil I chose for these is the McBride B-7. It was designed over 75 years ago especially for slow-flying model airplanes. It's been thoroughly tested by now; Cox and Mattel both used it often in their plastic ready-to fly airplanes.

My wings (and some of my stabilizers too) were steam-formed over a hardwood mold. (Molds made from hot-wire-cut foam may also be used, but they're not as durable. My basswood mold has lasted more than a quarter of a century.)

After you've made (or acquired) an accurate mold, here's how to form wings on it.

First obtain (or assemble) a rectangular sheet balsa blank large enough for a complete wing. Sand the underside of this as smooth as you can. (It's much easier to do this now than later, when the undersurface has a concave curve.)

With short lengths of masking tape near each tip, attach the sheet balsa blank to the mold so that the front edge of the blank is exactly even with the front edge of the mold. That's important. The mold is shaped such that it can form airfoils of any chord between about 2 to 7 inches, but the curvature for all sizes must begin at the same leading edge position.

Now cover the sheet balsa blank with a piece of sopping-wet denim. I use material salvaged from the leg of a worn-out pair of jeans.) Denim works best for this because it holds more water than any other common fabric. Smooth it out over the wood - then iron it dry, (A "Monokote iron" can be used for this, but a clothes-pressing iron works better because of its larger "heat sink" capacity.)

The steam produced by the ironing will penetrate the sheet balsa and make it conform nicely to the mold contour. If you are constructing a wing more than 1/8" thick, it's best to re-soak the denim after the first iron-dry procedure and do the steaming again. Double-steaming 3/16"-thick wings makes certain that the hot steam penetrates the wood thoroughly.

Now the sheet balsa wing blank has the same curvature as the mold. But it's not yet dimensionally stable! Another step is needed to achieve that.

With the sheet balsa blank still taped to the mold, cover it with a piece of white poster-board the same size as the blank. Then wrap the whole "package" snugly with cloth tape. I like to use "elastic bandages" of the sort intended for supporting strained knees. These are expensive, but they make sure that uniform pressure is exerted over the mold-balsa-poster-board "package". Leave this undisturbed for at least a day - two or three are better in humid climates. (The poster-board prevents the cloth wrapping from making "imprints" in the surface of the wood.)

This 24-hour-minimum "stabilization period" is to let the moisture content of the balsa equalize throughout the wood thickness. If you DON'T do this, the wing airfoil will change after the blank is taken off the mold.

Now to finish the wing. Remove the blank and cut the wing plan-form to shape. (I like parabolic curved outlines. It's hard to make these with conventional construction, but quite easy with steam-formed wings.) Sand the leading edge radius, using the full material thickness. That's because the sharper the leading edge of a wing, the more abruptly it will stall. (High-efficiency model wing airfoils stall suddenly when their angle of attack exceeds about 6 degrees.)

Now put the shaped wing back on the mold, holding with tape at the tips again. Shape and sand the upper surface. This is easier to do with the wing firmly supported. (My hardwood airfoil-forming mold has a block screwed to its underside, so I can clamp it solidly in a vise.)

I use a razor plane to taper the aft portion of

the airfoil, so that the trailing edge is slightly under 1/16" thick. Then the entire wing upper surface can be smooth-sanded to a uniform airfoil contour.

Now for dihedral! It's easiest to add that with the mold supporting the wing. My customary method uses a butt joint at the center. Incidentally, because of the airfoil's curvature, the wing panel edges at this center joint will not be a straight line. I obtain the proper shape by trial-and-error fitting, and sanding as required to make a neatly-fitted butt joint between the wing panels.

I reinforce the wing center junction by adding "top center-section sheeting" the same width as the fuselage. This is tapered (by block-sanding) to less than 1/32" thickness on the underside of both edges, to provide an accurate "scarf joint reinforcement" when it's glued onto the dihedralled wing's center. (Do that too with the wing supported by the mold.)

I usually add a small "fairing block" to the wing center-section at the leading edge, to cover the open gap at the front of the reinforced dihedral joint. And for safely, I dope a fabric strip across the underside of the dihedral joint. This works: I've built maybe a dozen wings this way and none of them has ever failed, even in fast spiral dives and "extreme aerobatics" with my "Starling" R/C design.

I finish all my steamed-airfoil wings with dope. I have no experience with iron-on film or fabric covering on one of these. But judging from my many unsatisfying results with these coverings on flat sheet balsa, I strongly advise against them. Dope - or doped-on tissue or silk- never comes loose from sheet balsa in ugly blisters or wrinkles.

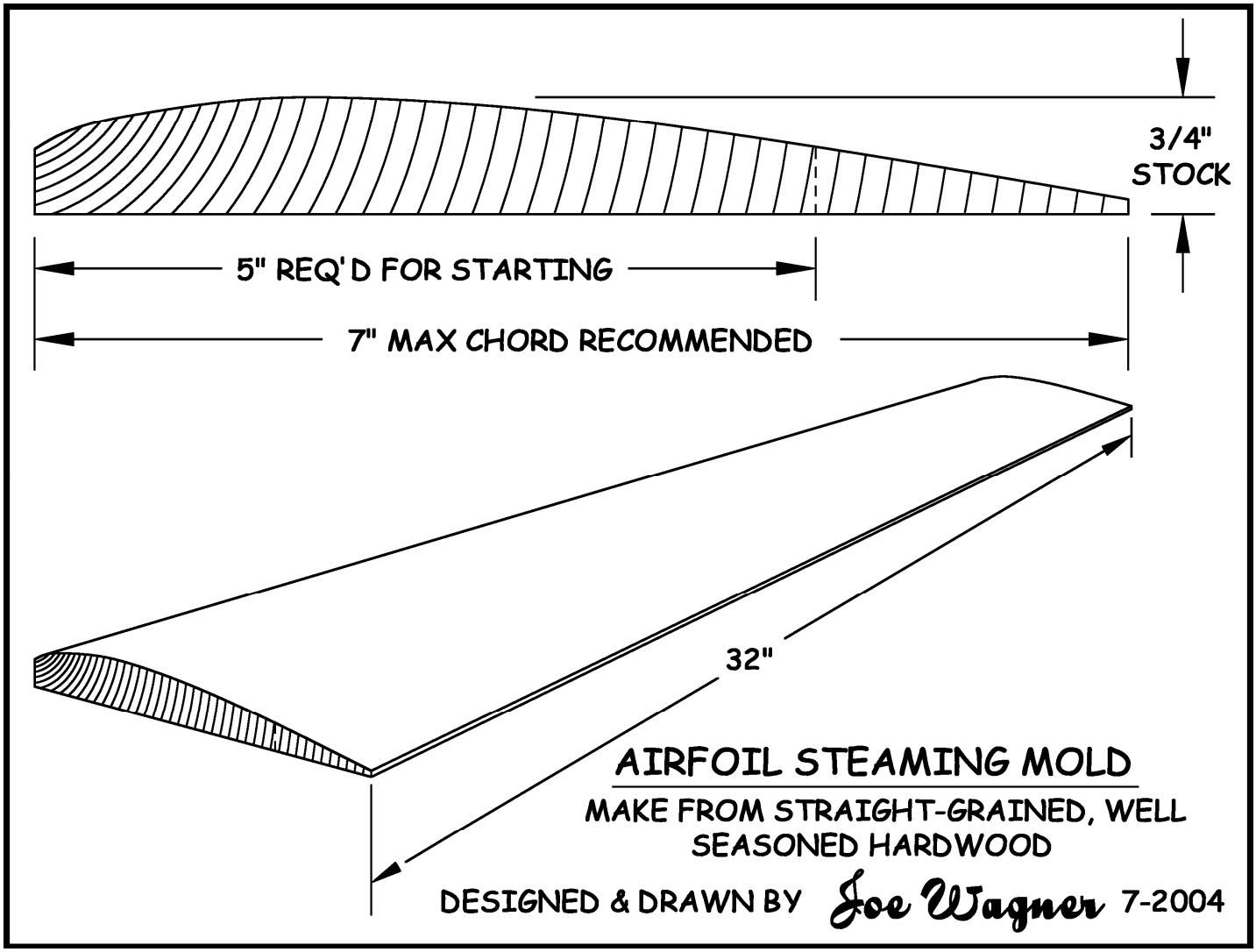
Besides, most iron-ons are HEAVY. I stay with the old-fashioned covering techniques: those have stood the test of time.

One further development of this steamed-airfoil wing that I've tried is thickening the leading edge radius to improve stall resistance. I did this to a previously-finished wing, by stripping off 1/8" from the leading edge (to produce a square front edge); then gluing to its bottom surface a strip of tapered balsa "trailing edge stock", thick edge forward.

When that was dry I sanded the front edge square again, then added a strip of 1/8" X 3/8" hard balsa all along that. When dry, I re-shaped the new wing leading edge to a smooth radius - now about three times as big as the original.

This definitely reduced the stall sensitivity of the airfoil. It had another effect that I should have anticipated but didn't. I made the modification to a one-piece model - one without removable wings. And I forgot that changing the airfoil in the way I've just described also reduced the effective angle of attack of the wings.

That changed the flight performance, because the original design settings were optimum for this rather low-powered 2-channel R/C biplane. (My Osprey, published in Model Airplane News.) However, using a throttle-equipped .10 engine to replace the original reed-valve Cox .049 "Black Widow" fixed the problem, and made the airplane much more fun to fly too.



AIRFOIL STEAMING MOLD

MAKE FROM STRAIGHT-GRAINED, WELL SEASONED HARDWOOD

DESIGNED & DRAWN BY Joe Wagner 7-2004