THEORETICAL ASPECTS AND PRACTICAL US AGE OF HOERNER WING TIP

AN EFFICIENT WING TIP-WHAT'S NEEDED?

Dr. Hoerner showed that the efficiency of a wing tip depends on six critical areas. His findings were:

1. The tip must be as thin as possible but still maintain a round leading edge.

2. A blending of wing top and bottom surfaces along a straight line.

3. The edge formed at this blend to be as thin as possible.

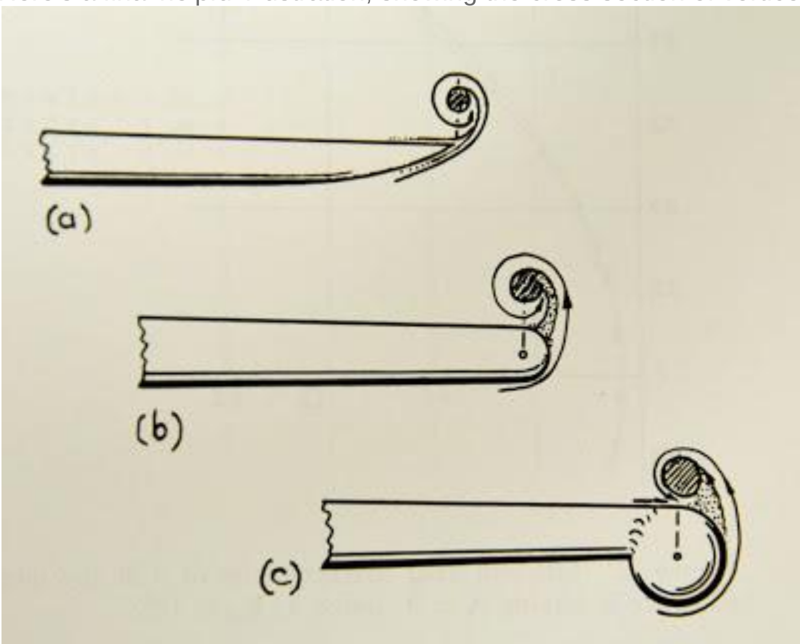
4. Obtain a sharp trailing edge leading to a corner, this corner to be in a straight a line as possible with the entire wing trailing edge.

5. The top of the tip to remain in a level plane with the top of the wing.

6. The bottom plane to be brought up in a convex curve.

The primary reasons for this design are as follows: A square wing tip gives the greatest wing area for the least span. A smoothly finished, thin, leading edge provides for the best possible airflow over the tip. The convex underside accelerates the speed of the air passing under the tip to a velocity more equal to that of the air flowing over the top of the tip, thereby creating streamline flow. This flow reduces turbulence, which markedly decreases the size and intensity of tip vortices. By having a deep, straight trailing edge we are moving the point at which the vortex begins away from and behind the main surface of the wing, which means less drag and better control. By keeping the outermost point of the wing in a level plane with the wing top surface, we effectively increase wing dihedral angles. (Gain lateral stability.)

Here's a final helpful illustration, showing the cross section of vortices with sharp vs round wingtips:



Decreased vortice size with Hoerner wingtips (a) vs round (b) or wingtip tanks (c)

HOERNER WING TIP VS ROUNDED WING TIPS (Construction tips added)

In spite of all the varieties, according to Dr. Hoerner, it looks like the sketch shown in Figure l(a), at least this is the shape he seems to favor over several others investigated by him. In plain view it looks pretty much like the tip on the Schweizer 2-22. However, from the front (looking aft) it is straight across the top, essentially right out to the extreme end, from nose to trailing edge the lower surface sweeps upward to meet the upper surface in such a manner as to create a fairly sharp edge. If you took a perfectly blunt; squared-off tip and curved the bottom surface upward until it cut right through the top you would end up with a platform shape very similar tip that is shown in figure 1(a). What the Horner wing tip (and all other good wing tips) tries to do is to hold the vortex cores that whirl off the tips as far apart as possible and in addition delay their starting to a point as far as aft on the chord as possible.

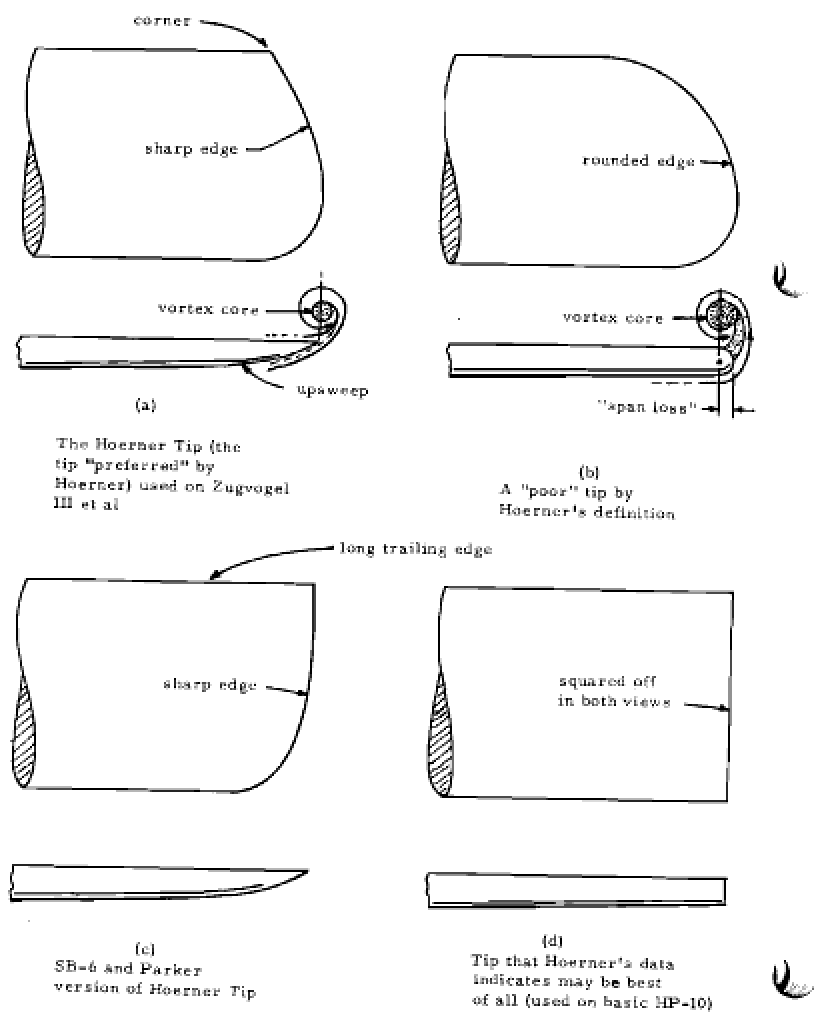
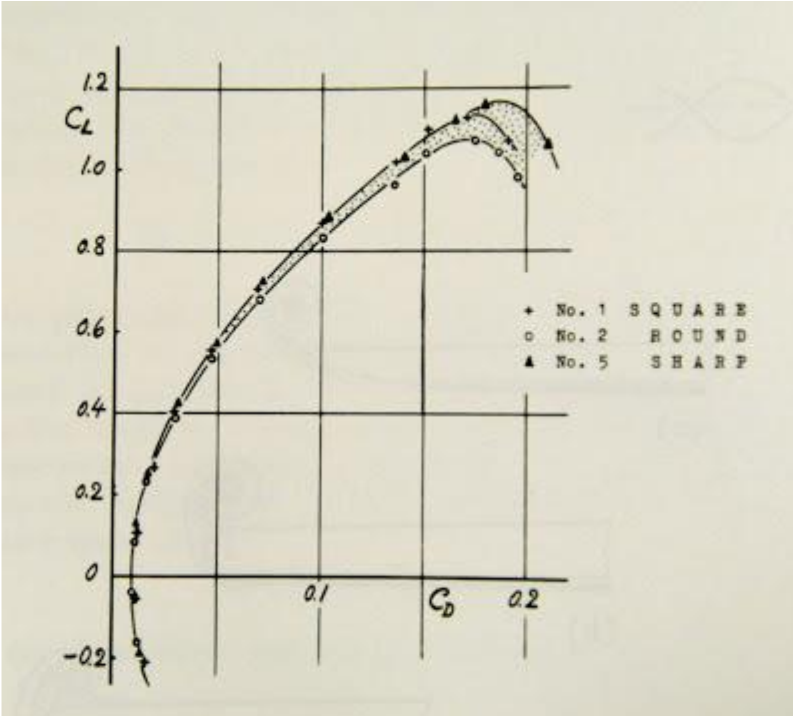


FIGURE 1 - TIP SHAPES

* sharp wingtips reduce the size of the vortice -- which is what the Hoerner wingtip is all about

* the addition of the Hoerner wingtip spreads the trailing edge, adding span, and further separating the vortice

* sharp wingtips have less drag at higher angles of attack, which is where ultralights spend more time at than higher speed airplanes



The illustration shows, on the top right hand side of the curve, the slightly higher coefficient of lift achieved with the Hoerner wingtips. Square wings are close behind, with round wings falling off considerably.

WHAT'S ALL THIS MEAN?

The wing will seek the region of low pressure above the wing by "spilling over" these ends. This spillage creates vortices or regions of turbulence which roll inboard and backward at the tips. The vortices absorb energy and increase drag, also since they roll directly over the ailerons they hamper stability and handling. From elementary physics we know if we can reduce the magnitude of these vortices, the plane will have more energy available to pull itself through the air. Also, if we redirect the position of the vortices away from the ailerons we will gain stability and control.

THE PROOF: (ADVANTAGES)
- Increase range 1-2% at no additional fuel cost.
- Increase rate of climb.
- Increase cruising speed.
- Reduce distance required for take off, resulting in a 10-20% quicker take off.
- Lower stall speed with more positive aileron control.
- Increase the overall stability of the aircraft.
- Improved appearance with a more aerodynamic profile.

DISADVANTAGES OF HOERNER'S WING TIP

- Usage of Hoerner's wing tip doesn't give the ability to attach winglets to it which is a must for long range and large commercial flights.

- At higher speeds and with larger wings the wingtip vortex would be comparatively larger, and would still "spill over" onto the lifting surface with Hoerner tips (they would be an improvement over a "plain" rounded wingtip, but winglets are a further improvement over the Hoerner-style tip). There's a crossing point where the winglet becomes more efficient than the Hoerner-style tip, but where that is depends on aircraft/airfoil design, expected cruise speeds, etc.

- For small aircraft the improvement offered by winglets is often less than the drag penalty caused by their weight (which also reduces allowable payload). For larger aircraft that fly long distances, the proportion of the aircraft's weight that is due to the winglets is much smaller than it is for small aircraft, so they don't have this problem and that makes winglets a viable strategy.

- The point of a winglet is basically to deflect the wingtip vortex away from the lift-producing part of the wing, granting an increase in effective wing span without the added form drag of actually making the wing longer. The winglet itself creates some form drag though, and it adds weight. On most small aircraft the potential improvement in wing efficiency doesn't exceed the weight and form drag that result from adding the winglet. What you will find on many small aircraft are Hoerner-style wingtips (either installed at the factory or added later through a STC modification). At lower speeds these have aerodynamic benefits similar to winglets, but without the additional form drag, and usually little or no added weight.