A NEW WING TIP WITH IMPROVED LIFT, DRAG AND STALL PERFORMANCE

by Robert P. Atkinson

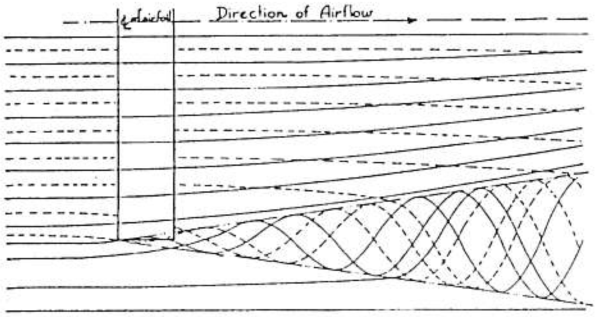
Improvements in aircraft performance and the saving of lives, may be possibe, simply, from improvements in wing tip design.

After inspecting hundreds, perhaps thousands of aircraft during about ten years at the annual EAA Oshkosh Conventions, I asked myself, "What is the best shape for a wing tip?"

I have patented other high speed aerodynamic supercharger improvements, which have much in common to wing air flow. These improved the performance of many WW II fighters, so the wing tip is a logical problem to study. It is apparent that my solution has been used by the birds, as I have observed while beachcombing.

Figure 1, taken from my 1933 textbook, shows the normal flow pattern over and under a wing having a square tip. The trailing vortices and downwash that occurs aft of the trailing edge, are the result of the mixing of the upper and lower airstreams. There is a downwash reaction due to the lift. For a given lift, the greater the span of this downwash, which contains the trailing vortices, the less the induced drag, due to the lift. This is demonstrated by the high peformance of a sailplane which has a very large span.

My effort is to eliminate the losses caused by the air on the lower surface, from flowing around the tip onto the top surface, by causing this air to continue on the lower surface till it reaches the trailing edge Then the flow over the top surface can be controlled for maximum efficiency.



Solid lines indicate direction of flow over upper surface of the airfoil; the dash lines indicate the flow under the airfoil.
Plan View of Air Flow About an Airfoil

FIGURE 1.

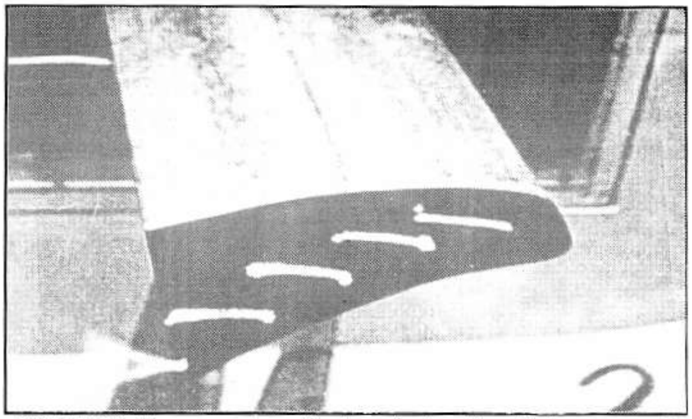


FIGURE 2. Flow over top of wing of wing tip at 4 degrees and 100 mph.

The elliptical tip is generally considered to be a good tip, however it also generates a tip vortex that starts ahead of the trailing edge, as shown by Horner in Reference 1. It then progresses inboard slightly as it approaches the trailing edge. Hence the induced drag is increased slightly, because the span of the trailing vortices is reduced.

Other designs have been made, such as the incorporation of a fence at the tip; however this causes additional drag, and the air flows over the fence.

My approach is: First, prevent the vortex from forming; thus eliminating the resulting drag of this wasted energy. Figures 2 and 3 show the tufts, in the wind tunnel at 100 mph, on both surfaces of the tip. They do not wrap around the tip. Since there is no vortex with this design, I call this the Atkinson "NOVORT TIP". This test was run with the plan-form tip contour DESIGN "A", shown in Figure 6. Photos were taken at 2 degree increments, from 0 degrees to 16 degrees, angle of attack.

Figure 7 shows an alternate DESIGN "B" which may be used to simplify the constsruction.

Second, to achieve increased efficient lift from the tip area, the top surface is recontoured to agree with the principle stated by Dr. R. T. Jones, in Reference 2, i.e., "No lifting principle or system has yet been devised that approaches the remarkable efficiency of a conventional, well shaped, smooth airfoil". Since this revised tip area has the same cross-section contour as the basic wing airfoil, it is logical that the L/D (lift to drag ratio) will be improved.

Figure 2 shows that the air flows over the top surface at a slight angle of 10 degrees inboard, from the axial direction. The airfoil sections along this tip are the same as the basic wing except for chord, and are canted with a 10 degree inboard angle' to the longitudinal axis, to conform to the flow direction. This achieves increased efficient lift as stated by R. T. Jones. (See Figure 6, Sections A, B & C.

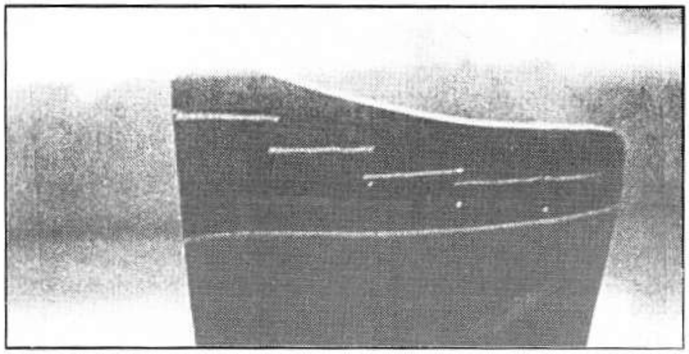


FIGURE 3. Flow under bottom of wing tip a 4 degrees and 100 mph.

This testing was done on the 18" x 6" model in Figure 4. These photos were taken in the wind tunnel at the facilities of ICFAR, (INDIANAPOLIS CENTER FOR ADVANCED RESEARCH) in May 1979.

Unfortunately, the lift and drag measurements could not be made, as the equipment was not yet available.

The third advantage resulting from this design is the fact, as mentioned, that the trailing vortices extend fully to the trailing edge tips, hence this achieves the minimum possible induced drag for this geometric span.

The fourth advantage of the NOVORT TIP, is believed to be an improvement in the wing's stall/spin characteristics, as compared to other wing tip designs. Studies of airfoil performance reports from various wind tunnel facilities throughout the world, show that the contour of the leading edge, and especially the upper surface forward of the 40% point, is extremely sensitive with respect to the wing's stall characteristics, as well as the lift and drag performance. It is obvious from a visual examination of nearly all winy tips in service, that the radius of curvature of the tip leading edge is much sharper than that of the basic wing.

It is very possible that serious accidents may be prevented by such a change. Figure 5 shows a typical modern wing tip where it is noted that the air which strikes the leading edge of the tip, encounters a sharp radius of curvature at the stagnation point. Consequently, when operating at high angles of attack, this will initiate a premature stall. This is especially serious if there is unequal flow over the tips due to a sideslip or cross wind, and only one tip stalls, which may upset the flow over the remainder of that wing, thus initiating a spin. This may have been the cause of some fatal crashes.

To Summarize: It is indicated that the NOVORT TIP will improve the L\D ratio as well as improve the safet.y characteristics of an airplane.

The above information was presented to the members of Chapter 172 of the Expermental Aircraft Assn. on July 9, 1992. Several of them will use the NOVORT TIP on their aircraft now under construction.

A Disclosure Document has been filed on the NOVORT TIP with the U.S. Patent Office.

ProposedFuture Efforts

It is recommended that additional studies and tests be made by interested parties, such as NASA, the Universities which have the facilities, and others on this design approach. The following factors should be considered.

Make lift and drag wind tunnel measurements.

Reynolds No. effects, if any, due to the diminishing chord of the 10 degree airfoil section along the tip.

Variables affecting the indicated 10 degree flow angle, such as wing loading, aspect ratio and air speed.

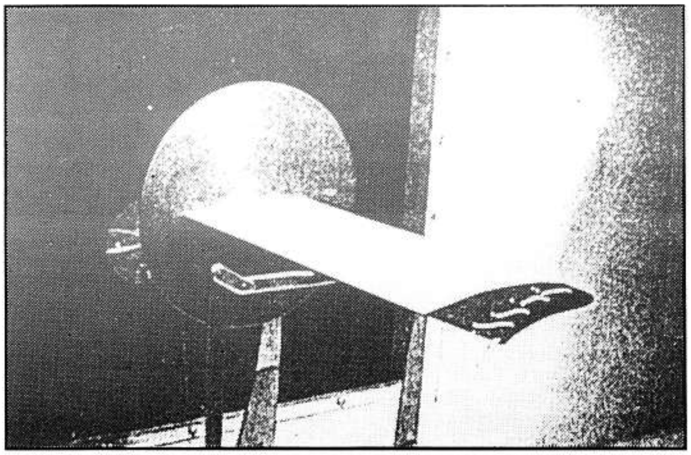


FIGURE 4. Installation of 6" X 18" model at ICFAR Wind Tunnel - 0 mph.

Flow pattern on the under side of the wing, and possible improvement of the contour of the tip planform.

Advantages of this design on aileron control, stall and spin at high angles of attack.

Acknowledgments

This work could not have been done without the generous cooperation of the Indianapolis Center For Advanced Research, which is greatly appreciated.

Purdue University was most helpful and generous in permitting me to use their wind tunnel on a weekend to test this model. Unfortunately I was evaluating a design modification, to the above described one, which turned out to be one of my worst ideas. I am indebted to Prof. George M. Palmer and Dr. Bruce Reese for their generous help.

BIBLIOGRAPHY REFERENCES

1) "Fluid-Dynamic Drag". Dr.-Ing. S.F. Hoerner

2) *Soaring* Magazine. Oct. 1979. Pg. 26. Dr. R. T. Jones, Sr. Staff Scientist, NASA Ames Research Center.

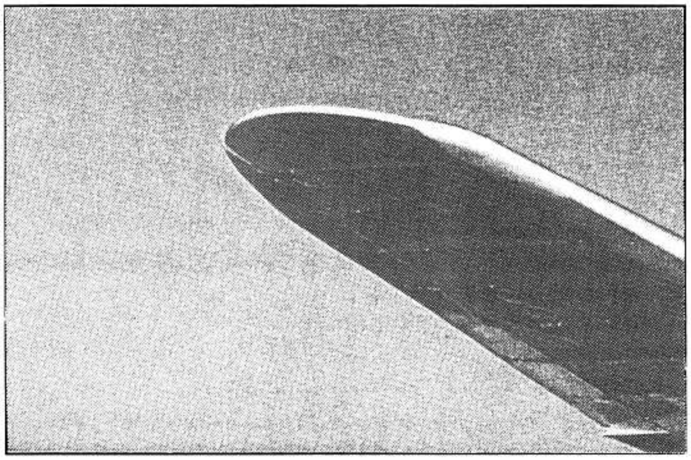


FIGURE 5. Typical wing tip showing sharper L.E. radius than on basic airfoil of wing.

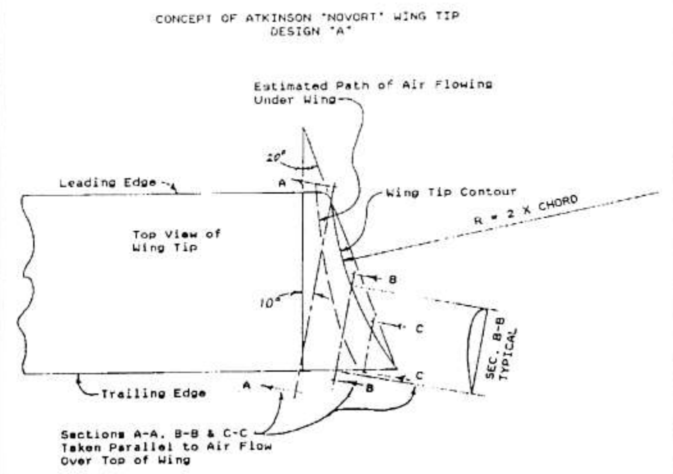


FIGURE 6.

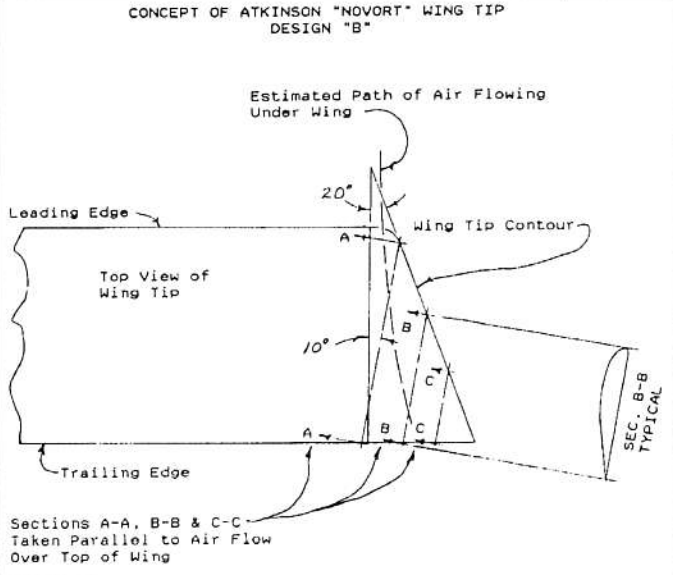


FIGURE 7.