W. H. Mason, Dec. 10, 2014

**Curiosity Number 1. The behavior of an unswept wing above "stall"**

In looking at low speed lift above stall for an unswept wing, I looked at the famous figure from John Anderson and Allen Winkelmann. This study examined the drooped leading edge concept introduced about midway out the span to improve post-stall characteristics for GA airplanes.

We are just looking at the undrooped baseline case in these figures. The work at Maryland included both wind tunnel and computational simulations. In addition, the figure shown in Anderson's textbook, and subsequently also in Bertin and Cummings, is for the case of increasing angle of attack. The papers included results illustrating the fairly large hysteresis, as expected.

In looking at Figure 1 here, it seemed curious that the lift continued to increase above 45 degrees alpha. Why? It seems that the lift component of the normal force ought to start decreasing. This was particularly true for the computational simulation, which can be described as a nonlinear lifting line theory. Figure 1 is from Anderson's textbook. The experiment starts to "level off" at 45 deg. alpha.

There is an NACA Report that contains data for a similar test. Note that this report contained tab data so it was easy to find $C_N$ given $C_L$ and $C_D$. Figure 2 shows the comparison between $C_L$ and $C_N$ for the test that's very similar to the configuration tested at Maryland. In this case the normal force looks very similar to what Anderson calls the lift.

**Could it be that the Maryland simulation is actually normal force and not lift?**

**Can anyone duplicate the results with modern CFD?**

**Explain the physics of the $C_L$ increasing as shown in the Anderson simulation if it is real.**

A.E. Winkelmann, J.B. Barlow, J.K. Saini, J.D. Anderson, Jr., and E. Jones, "The Effects of Leading Edge Modifications on the Post-Stall Characteristics of Wings," AIAA Paper 80-0199, Jan. 1980.

John D. Anderson, Jr., Stephen Corda and David M. Van Wie, "Numerical Lifting Line Theory Applied to Drooped Leading-Edge Wings Below and Above Stall," *Journal of Aircraft*, December 1980.

Montgomery Knight and Carl J. Wenzinger, "Wind Tunnel Tests on a Series of Wing Models Through a Large Angle of Attack Range, Part I – Force Tests," NACA R-317, 1928.

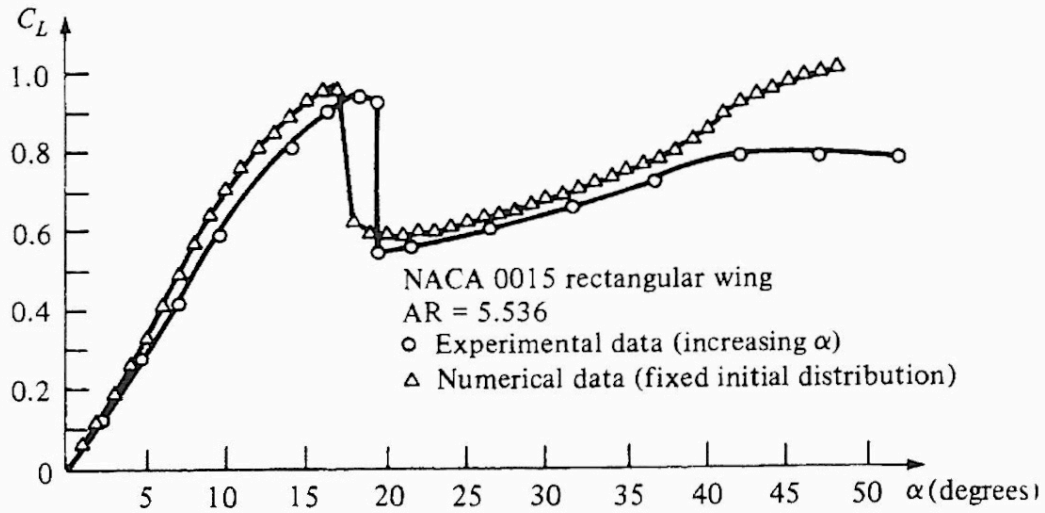


**Figure 5.28** Lift coefficient versus angle of attack; comparison between experimental and numerical results.

Figure 1. The high angle of attack case as presented in Anderson's aerodynamics textbook.

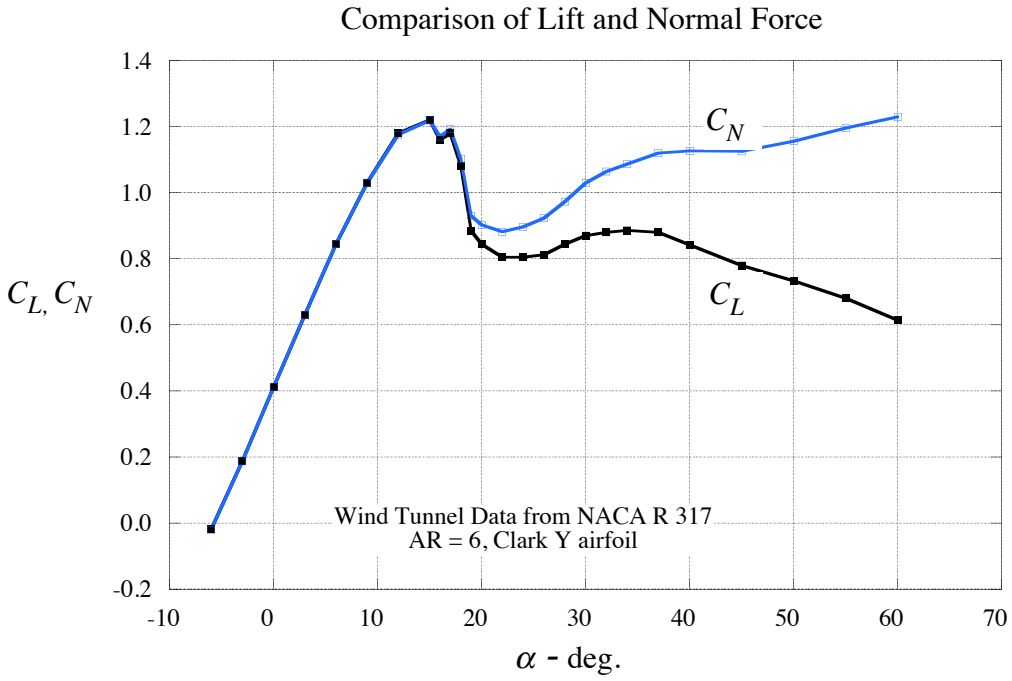


Figure 2. Comparison of $C_L$ and $C_N$ from the NACA WT Test.