W. H. Mason, Dec. 11, 2014

Curiosity Number 3. Post Stall Aerodynamics. More to learn about subsonic aerodynamics.

Before the confluence of events of this fall I'd mainly looked at airfoil data in the alpha range presented in Abbott and von Doenhoff. The data goes a couple of degrees past stall and always shows a drop in lift. Because of some questions people had for me, and the peculiar "dip" in the data from *Curiosity 2* and a re-look at the results in *Curiosity 1*, I started looking at other airfoil data, with an interest in the post-stall behavior. I'm collecting a few figures in hopes of generating some comments about the physics of what I see. I'm curious. I would welcome a simple physical explanation. Otherwise I'll have to see if I can do it myself!

Loftin collected data and presented it for a variety of airfoils. The stated reason was that it was needed by helicopter designers. I've included it as Figure. 1.

Data for the NACA 0012 was collected over the entire alpha range by Critzos and Heyson, and the key figure is included as Figure 2.

Windmill aerodynamic testing was done for the Dept of Energy. I picked two figures to illustrate the results. Figure 3 is labeled as infinite aspect ratio, while Figure 4 is labeled as AR = 6.

Observations:

In Figure 1 the trends are roughly the same for all the airfoils, and they all appear to reach a C_L higher than the "stall" C_L. Loftin presents the results without any interpretation.

In Figure 2 the same basic trend is observed for the 0012, but the second "$C_{L\max}$" is not necessarily higher than the original. The 2nd "$C_{L\max}$" occurs at about 45° alpha.

Figure 3 is for 2D and shows a similar trend, where the second local maximum occurs at about 45°. Its value is less than the first max. Figure 4 is for an AR = 6 case, and doesn't demonstrate a rebound in lift, but "levels off" before starting to decrease. This is somewhat similar to the wind tunnel data presented by Winkelmann and Anderson in *Curiosity Number 1*.

William Devenport had noticed this previously, and when I mentioned it to him he said that wall interference could be an issue. Considering the blockage at these alphas that certainly is an issue.

Where does this leave us?

What's the physical explanation for this type of post-stall behavior?

Can this be computed?

Sources

Laurence K. Loftin, Jr., "Airfoil Section Characteristics at High Angles of Attack," NACA TN 3242, August 1954.

Cris C. Critzos and Harry H. Heyson, "Aerodynamic Characteristics of NACA 0012 Airfoil Section at Angles of Attack from 0° to 180°," NACA TN 3361, January 1955.

C. Ostowari and D. Naik, "Post-Stall Wind Tunnel Data for NACA 44XX Series Airfoil Sections," SERI/STR-217-2559, January 1985 (done for the U.S. Department of Energy)

Thanks to Joe Derlaga for sending me a couple of the references.

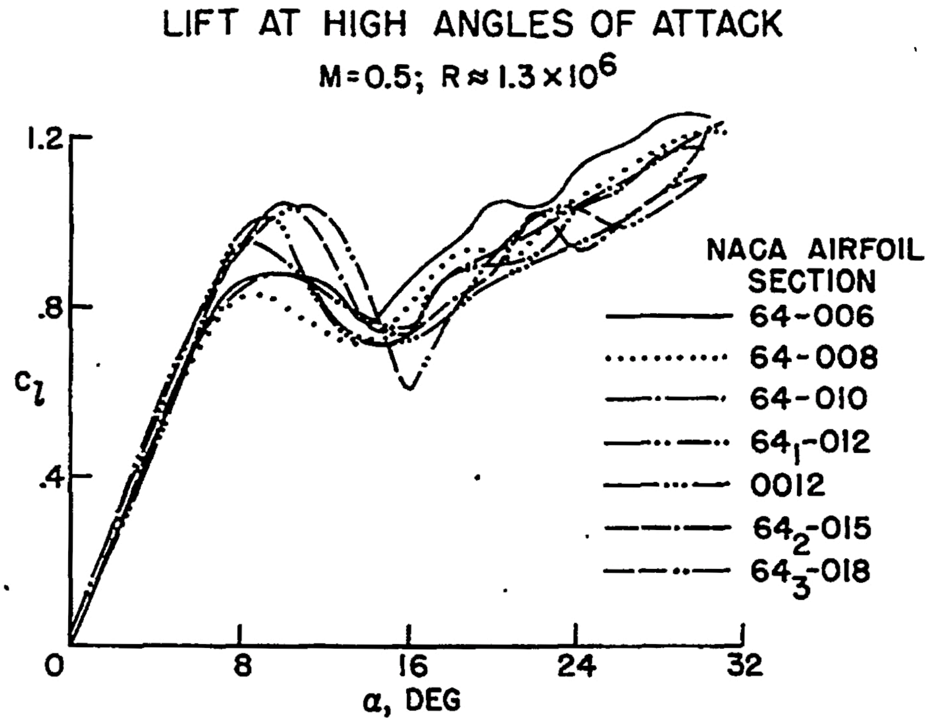

Figure 1. Loftin's collection of airfoil data (NACA TN 3241)

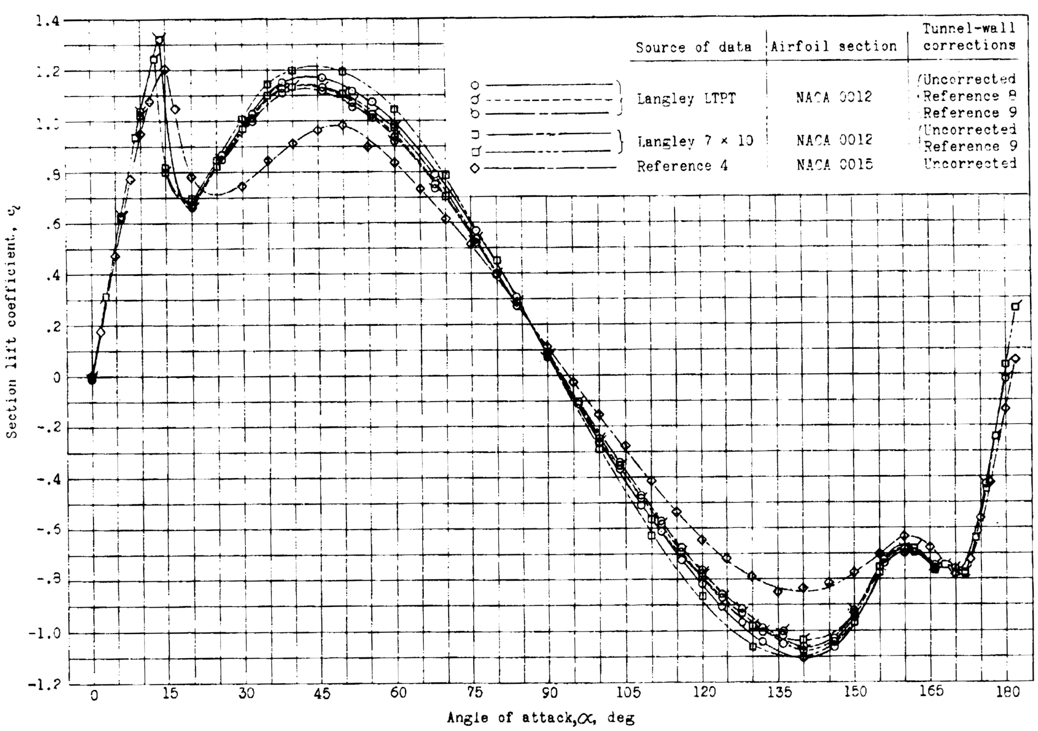

Figure 2. The 0012 over the full alpha range (NACA TN 3361.)

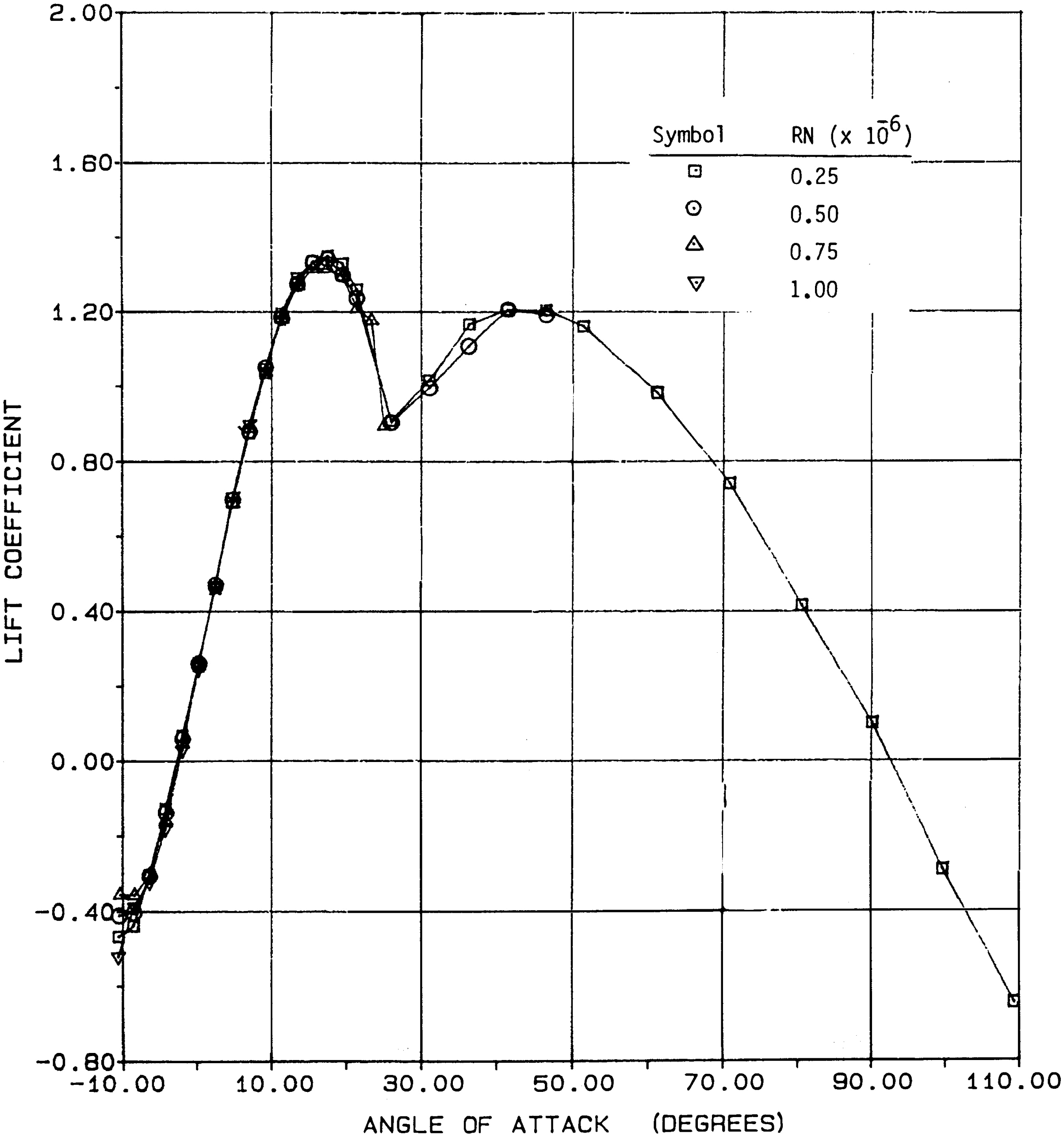

Figure 3. NACA 4412 lift for a “2D” case. (DOE data)

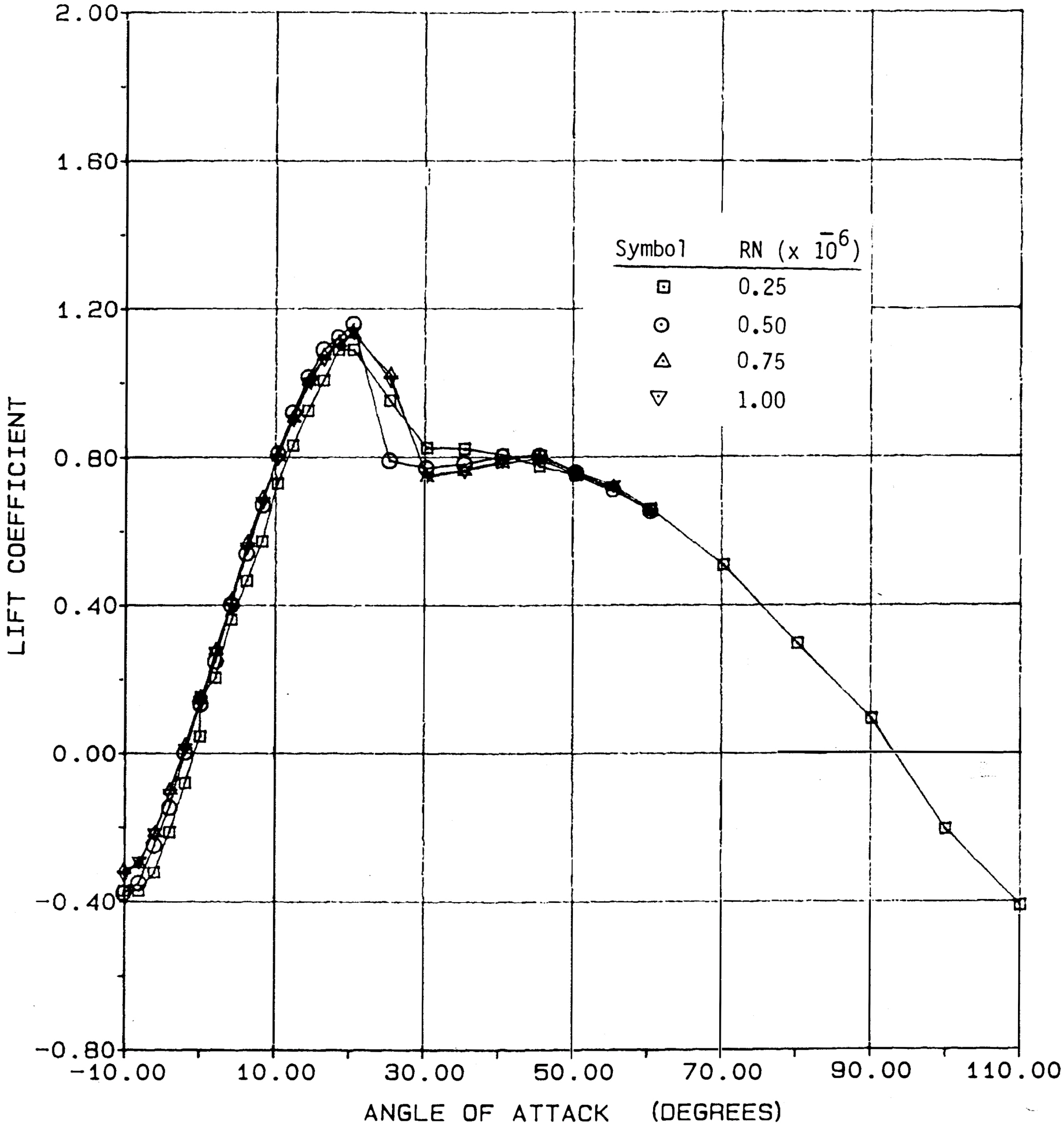

Figure 4. NACA 4412 lift for an AR = 6 case. (DOE Data)