Curiosity Number 23. Airfoil definitions – a curiosity that has arisen, but why?

W.H. Mason, May 21, 2018

This one came about while I was looking at the Go 623 airfoil discussed in Curiosity 2. It turns out that in modern times most textbooks claim that the airfoil should be defined with the reference chord line being the straight line between the trailing edge and the nose of the airfoil at the leading edge. This seems to be a modern convention not connected to the history of airfoil definitions. I have no idea why this has happened. It doesn't make a lot of sense.

In Curiosity 2 we saw that the Go 623 and Clark Y airfoils are very similar. The conventional definitions show that the lower surface is flat over the aft portion of the airfoils. As given in Riegels, *Aerofoil Sections*, English translation, Butterworths, London, 1961, the Clark Y and Go 623 are flat from 30% aft. This makes construction and alignment simple. The Clark Y has a maximum thickness of 11.7%, while the Go 623's max thickness is 12%. Unfortunately, the historical coordinates are a little too crude for use in modern airfoil analysis codes. Looking for "better" coordinates I found some enhanced and smoothed coordinates on the UIUC airfoil web site. That airfoil had been rotated to the apparent current convention. It turns out I had to rotate these enhanced coordinates by 2.0045° to approximate the historical values. When the airfoil is rotated to produce a chord line through the nose the characteristic flat surface is hard to see.

Now we'll look at some figures. Figure C23-1 compares the Go 623 and Clark Y using the original coordinates. The lower surface ordinates around 10% chord for the G0 623 look a little rough for analysis. That's why I went looking for other coordinates.

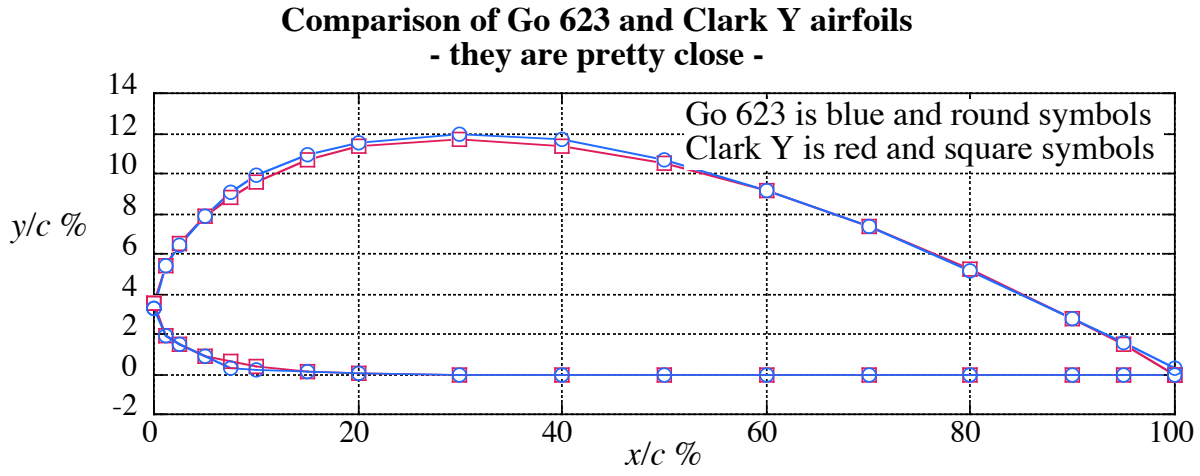

Figure C23-1. Comparison of Go 623 and Clark Y airfoils (not to scale).

Why is this important to point out? There are many NACA Reports that present aerodynamic results that use the original "flat bottom" airfoil definitions. Just a few examples using the Clark Y airfoil in my collect are NACA R 427, R 428 and R 431. If you use these results you need to understand the proper airfoil reference lines.

To complete the story, take a look at Whitcomb's Supercritical Airfoils. To get the lift he wanted he added aft camber. This led to airfoils with the trailing edge below the chord line. Figure C23-2 is taken from NASA TP 2969, 1990. For the airfoil shown the coordinates are defined with the trailing edge about 4.6% below the chord line.

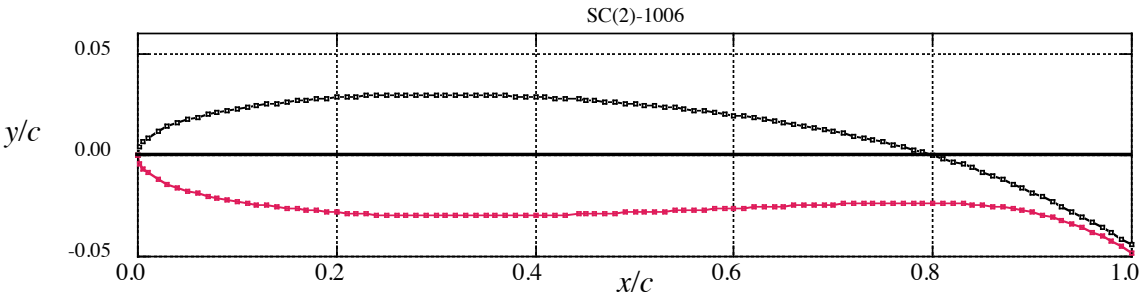

Figure C23-1. Whitcomb SC(2)-1006 airfoil (from NASA TP 2969). Not to scale.

To conclude, there is nothing mandating that the airfoil reference chord line go from the nose point to the trailing edge. I've shown two examples where the historical coordinate definitions don't follow this peculiar new convention.