What Are Wortmann Airfoils??

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In this article, we will examine Wortmann airfoils, and will compare the characteristics and performance of a typical Wortmann airfoil with a comparable NACA airfoil and with a GA airfoil designed by this author.

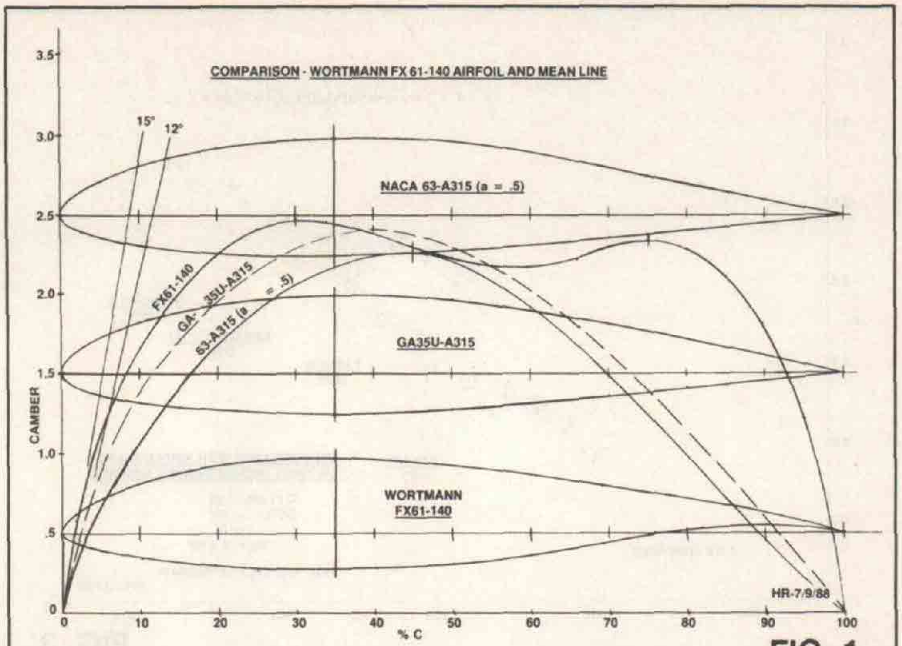

FIG. 1

The Wortmann airfoils were designed in the early 1960's by Herr Doktor F. X. Wortmann of the Technischen Hochschule in Stuttgart, West Germany. They are primarily intended for sailplane and other low Reynolds number applications. They are laminar flow sections, medium to high cambered, have relatively small leading edge radii, feature camber relief between 40% and 70% of chord and have relatively thin trailing edges. They have plenty of camber in the nose, which makes them good at low Reynolds numbers; however, the pitching moments are very high on these airfoils. This is not a big disadvantage on sailplanes, where the tail lengths are long (typically 4 to 5 chord lengths), but on general aviation applications, where typical tail lengths are 3C (3 chord lengths) and less, the resultant trim

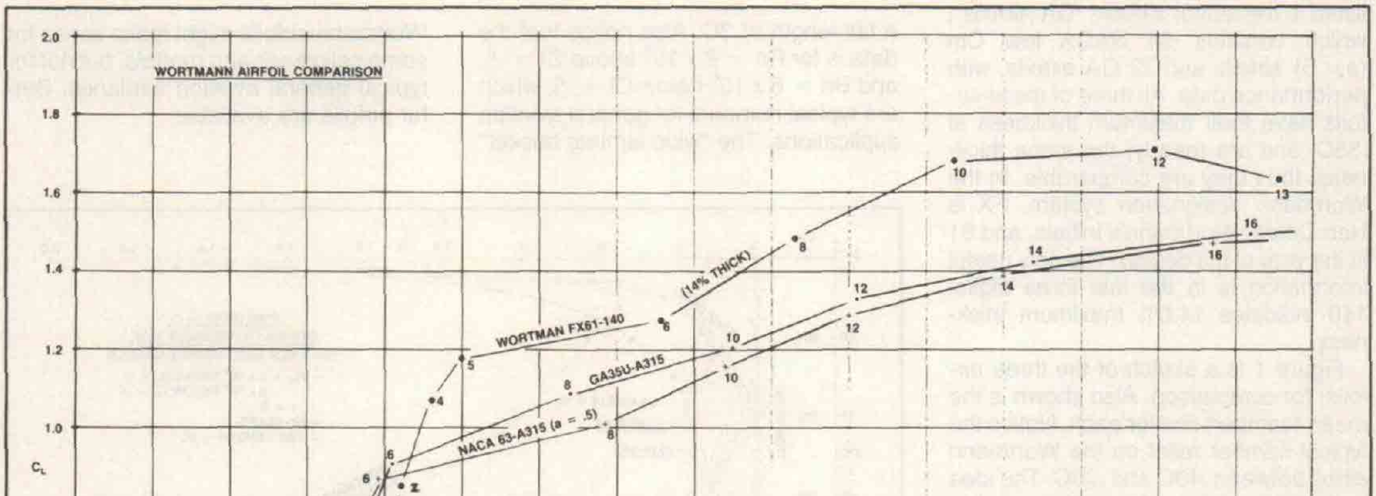

FIG. 2

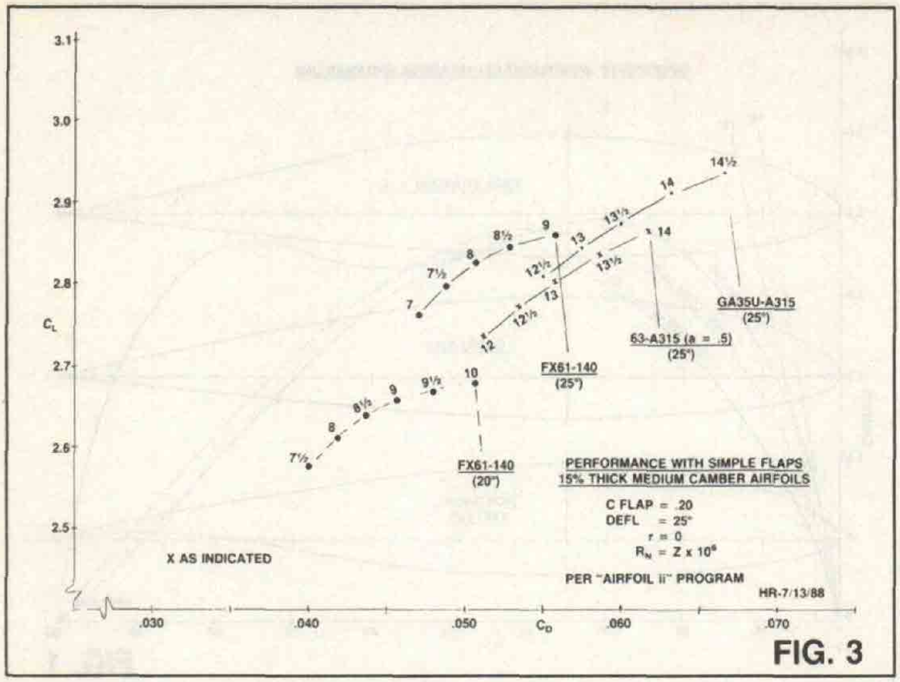

FIG. 3

drag becomes a considerable disadvantage. The only GA application that makes sense with these airfoils is for airplanes without flaps, since the high camber produces relatively high Clmax without flaps. High performance (laminar flow) GA applications without flaps are rare, however.

We selected the FX61-140 for analysis, and compared it with the NACA 63-A315(a = .5) low Cm airfoil and also with the GA35U-A315. Coordinates for these latter two airfoils are listed in the author's book, "GA Airfoils", which contains 54 NACA low Cm (a = .5) airfoils and 72 GA airfoils, with performance data. All three of these airfoils have their maximum thickness at .35C, and are (nearly) the same thickness, thus they are comparable. In the Wortmann designation system, FX is Herr Doktor Wortmann's initials, and 61 is the year of the design. The only useful information is in the last three digits; 140 indicates 14.0% maximum thickness.

Figure 1 is a sketch of the three airfoils, for comparison. Also shown is the mean (camber) line for each. Notice the typical camber relief on the Wortmann airfoil between .40C and .70C. The idea is that this region of negative camber (negative lift) will delay the trip of the laminar boundary layer to turbulent flow, thus extending the laminar flow region, reducing drag. This "double hump" camber is common to all Wortmann airfoils, and has been copied on some of the recent NASA NLF airfoils. Unfortunately, it is not a good idea, especially since it penalizes the performance with flaps (see Figure 3). Conventionally cambered airfoils have positive camber over 100% of their chord length, and are thus able to produce higher Clmax with flaps, other things being equal.

Figure 2 polar diagram presents cl vs. cd' data for the three airfoils, as determined by a computer program called "Airfoil II", the Eppler program. Notice that this is **corrected** drag data, including trim drag for a typical airplane with a tail length of 3C. Also notice that the data is for Rn = 2 x 10^6 above Cl = .5, and Rn = 6 x 10^6 below Cl = .5, which are typical numbers for general aviation applications. The "wide laminar bucket" touted by Dr. Wortmann is evident. The vertical placement of the bucket is controlled primarily by the initial camber angle, shown on Figure 1 to be about 15 degrees for the Wortmann airfoil. We feel that this is excessive, since it has placed the bucket relatively high on the chart, penalizing the high speed performance. Thus Dr. Wortmann's bucket is not as wide as he thinks it is. In contrast, the other two airfoils have the bucket in a better range. Notice the overall superior performance of the "conventional" airfoils, especially at the high speed end. The Wortmann airfoil has a better Clmax without flaps, but this is a rather meaningless parameter for an airplane with flaps. Much more important is Clmax with flaps, as shown on Figure 3. Note the excellent flap effectiveness of the GA airfoil. Figure 4 shows the poor performance of the Wortmann airfoil regarding C.P. travel and trim drag, a result of the high camber and aft loading.

From a construction standpoint, the (typical) large underside cusp on the Wortmann airfoil is a disadvantage. Also, due to the small trailing edge angle, aileron control forces would be higher, other things being equal.

Our conclusion from this study is that Wortmann airfoils might make sense for some sailplanes and models, but not for typical general aviation airplanes. Better airfoils are available.

"Designed in the early '60s, Wortmann airfoils are primarily intended for sailplane and other low Reynolds number applications."

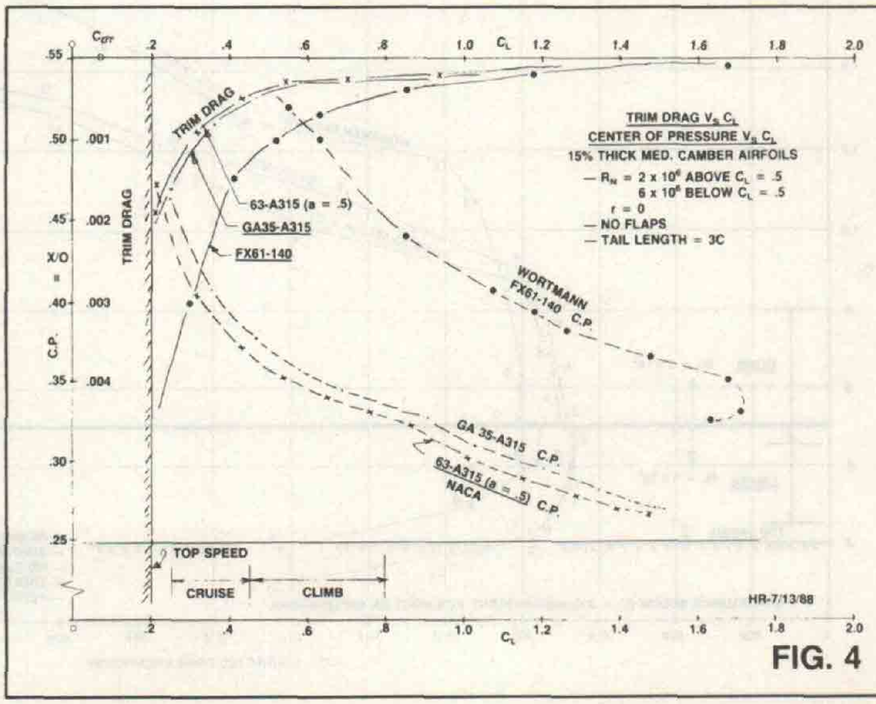

FIG. 4