12.4.6 Maximum Lift with High-Lift Devices

The procedures in Section 12.4.5 and 12.4.6 are summarized (excluding the effect of Fowler flaps) in Fig. 12.4.6.1.

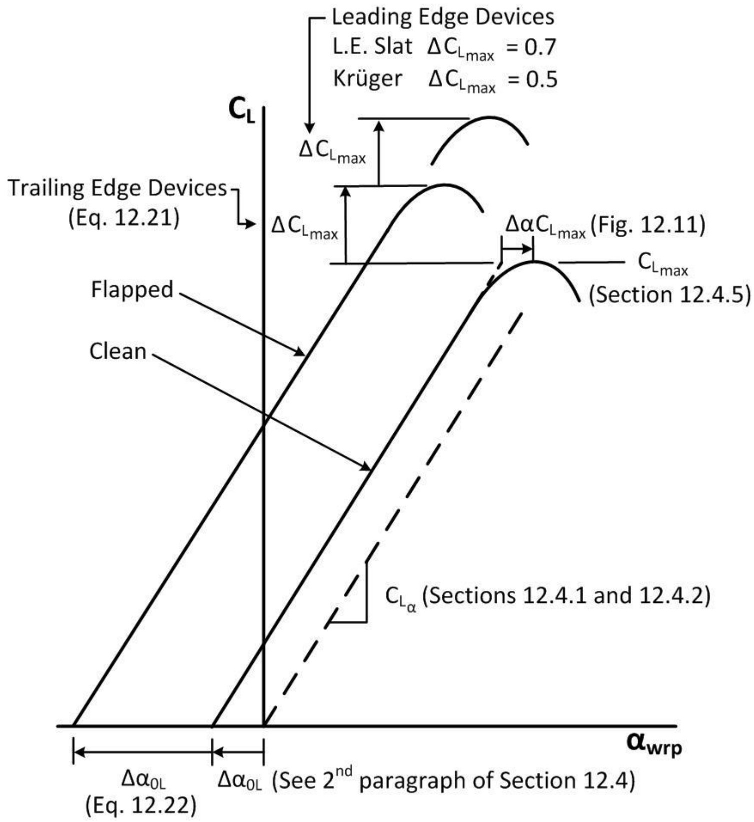

Fig. 12.4.6.1 Procedure for Plotting C_L vs. α for Clean and Flapped Condition

They will enable you to generate curves of C_{L_α} vs. α for both the clean and flapped condition. Although not stated explicitly in Raymer, the values of α are relative to the wing reference plane, designated here as α_{wrp}. The wing reference plane may refer to the wing root airfoil section reference axis (see Raymer Section 4.2.1) or the spanwise area-weighted mean value of the airfoil reference axes. For the simplified analysis in this section, the wing is assumed to have no washout (i.e., untwisted) and have a constant airfoil section.

In Raymer Fig.12.8 the value of Δy for an advanced supercritical wing may well be proprietary. Using data from Ref. 12.4.6.1, for the supercritical airfoil SC(2)-0610, Δy = 0.25 t/c and this may be used as a typical value.

An additional step is required to locate the wing at the appropriate angle of incidence on the fuselage, and generate curves of C_{L_α} vs. α_{frp}, where α_{frp} is referenced to the fuselage reference plane. The fuselage reference plane is the standard reference plane for a configuration, and it is industry practice to present C_L vs. α data using this plane as the reference.

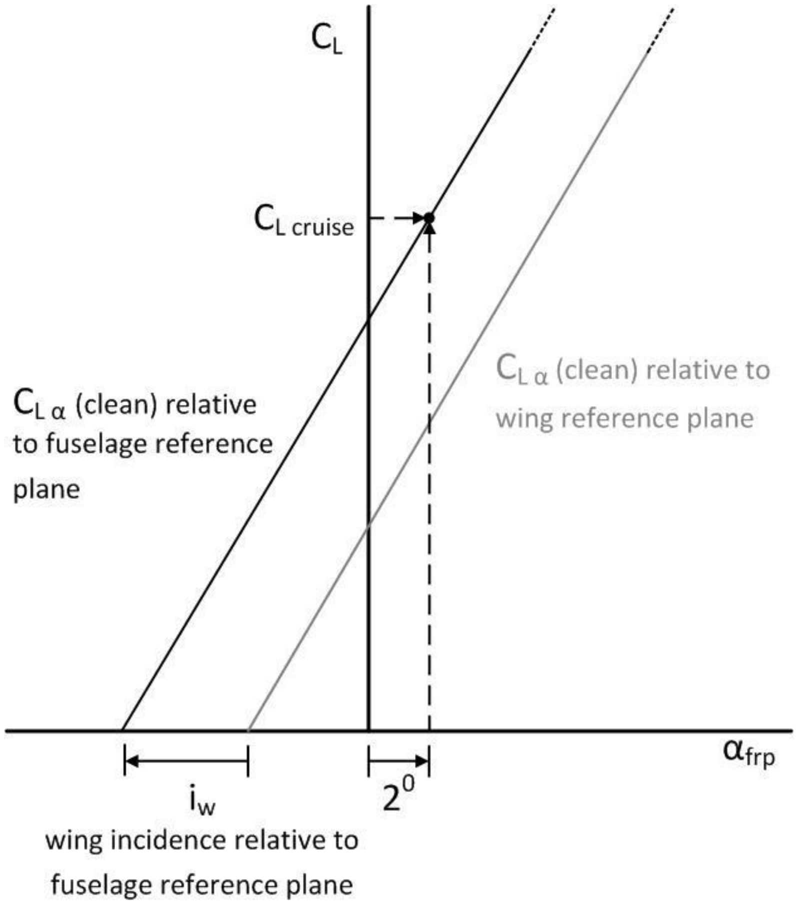

Fig. 12.4.1 Determination of Wing Incidence on Fuselage

For an airliner, some additional lift can be obtained from the fuselage if it has an angle of attack of between 0 - 2^0 at the cruise condition. The procedure therefore is:

- On the new plot of C_{L_α} vs. α_{frp}, mark a point at $\alpha_{frp} = 2^0$ and the value of C_L for the cruise condition, typically 0.5 – 0.55.
- Move the curves of C_{L_α} vs. α_{wrp} laterally so that the clean condition curve passes through this point. This is the equivalent of rotating the wing so that it is now at an angle of attack at the cruise condition which gives a 2^0 angle of attack for the fuselage.
- The value of i_w is the angular difference between the wing reference plane and the fuselage reference plane.

The foregoing is somewhat of a simplification, because the wing has many different shapes, including

– Jig shape, or the shape of the wing as it is manufactured in the jig
– One-g unloaded, or the shape of the wing without any aerodynamic load, and this shape is a function of fuel load and distribution

- One-g loaded, or the shape of the wing under one-g aerodynamic loads, and this is also a function of fuel load and distribution.

The wing also bends and twists under the effect of control surface or flap deflection.

References

12.4.6.1 Harris, C.D., NASA Supercritical Airfoils, NASA TN-2969, NASA, March 1990