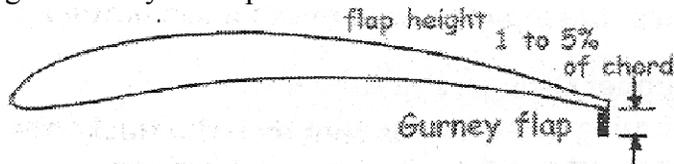


THE GURNEY FLAP

by Sergio Montes

Gurney flaps are bent strips attached to the trailing edge of an airfoil, normally no larger than about 2 to 5% of the chord. They have a profound effect on the lift but in many cases a surprisingly small effect on drag. They defy what conventional wisdom would recommend as good aerodynamic practice.

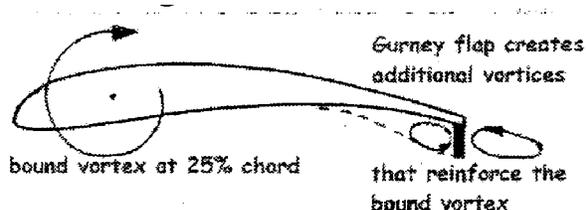


The name of this flap derives from American car driver Dan Gurney, who sought to increase the downward force of a wing fitted at the rear of his Indy car in the 1960's. He thought that he could get even more down-force by blocking the flow on the top of the wing with a dam at the trailing edge. Aerodynamicists who heard of this idea were not supportive, fearing that this dam might act like a spoiler and reduce the downward force rather than increase it.

One of the considerations in the Circulation Theory of Lift is that the flow from the upper and lower surfaces of the trailing edge must smoothly merge in the wake. It seemed reasonable to expect that the Gurney flap would interfere with this requirement.

However, a very similar scheme called the "split flap" was used on airplanes as far back as the 1930's. This is a fairly simple device consisting of a hinged plate covering the last 20% of chord on the bottom of the trailing edge. The device is deployed during landings. In the 1940's, NACA ran many two-dimensional wind tunnel tests of airfoils with and without split flaps. When the flap was deflected down 60 degrees on these airfoils, the maximum lift coefficient was almost doubled. This device looks so crude that it's hard to imagine that an aerodynamicist invented it. With time, however, it was recognized that the key to its performance was the presence of a vortex in the wake of the flap. Wind tunnel tests using flow visualization techniques show that the Gurney flap also produces this vortex.

The lifting ability of the plain wing can be attributed to its "bound vortex," which is located at about the quarter chord. The addition of another vortex at the trailing edge increases the upflow at the trailing edge, thus increasing the lift. It also speeds up the flow over the top of the trailing edge, delaying stall in this region.



As an additional benefit, the Gurney flap increases the positive pressure on the bottom surface. Comparing flap heights at 1%, 2% and 4% compared to the basic wing shows that, in addition to increasing the maximum coefficient of lift, there are other favorable effects. One is that the flap makes a symmetrical airfoil produce lift even at a zero angle of attack. This can be used to change the effective incidence of a stabilizer. Another effect is the increase of the slope of the lift curve. The increase in lift slope is the equivalent to increasing the chord of the basic airfoil by 1.5 times the height of the flap.

If the height of the flap is less than the thickness of the boundary layer at the rear of the pressure surface of a clean wing, the drag is negligible. For these wind tunnel tests, the calculated thickness of the boundary layer at the trailing edge of the model was 2.5% of the chord. Since the two smaller flaps (heights of 1 % and 2% of chord) were within the boundary layer, they produced no measurable drag penalty. For the taller flap (4% height of chord), however, the drag of the basic airfoil at zero angle of attack was increased approximately 2% -3%.

(Ed. Note: I showed this to my Aero Engineer son who commented that this was one of the things discussed in one of his aero classes, but that he's never seen it used on a full scale aircraft. The closest is the split flap on the A-4. John Steinhiemer, our local glider guru, uses it regularly on the stab of his hand and catapult glider stabs very successfully. Stan Buddenbohm uses a version of this in the shape of a wedge on the wing of some of his gliders.)